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1

CARP BROODSTOCK MANAGEMENT PRACTICES IN WEST BENGAL: FARMER'S EXPERIENCES AND LOCAL INNOVATIONS

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INTRODUCTION

Carps attain maturity in confined water but do not breed spontaneously in captivity. Rivers and flowing waters are known as the natural breeding grounds for carps and they spontaneously breed during south-west monsoon months of June to September (Basavaraja, 2007). The shallow zones of the flowing waters serve as breeding grounds and subsequent natural seed collection points. Considering these factors, the farmers conceptualized the idea of bundh breeding by simulating natural breeding environment. Two types of bundhs, *viz.* dry bundh and wet bundh have been used for carp seed production since long back in Midnapore and Bankura districts of West Bengal and Chhattarpur district of Madhya Pradesh (Mookerjee *et al.*, 1944 and Dubey, 1969). Another technique for artificial seed production is hypophysation. West Bengal has been remaining one of the pioneering states to adopt hypophysation technique widely for induced breeding of carps after the first successful attempt made in India (Chaudhuri and Alikunhi, 1957). These two techniques of carp seed production have gained rapid popularity among West Bengal farmers and thus the State has become the highest producer of carp fry contributing around 55% (12.5 billion) of India's production of over 22 billion in 2005-06 (Eknath and Jena, 2008). Hapa breeding technique of induced spawning was practised during 1960s and 70s with invariably less spawn recovery due to its exposure to open environment. Development of eco-hatchery technology during 1980s eliminated this problem and since then it has been the most important technique for carp seed production.

Broodfish is a prerequisite for all induced breeding programmes. Success of induced carp breeding depends mainly on the state of mature spawners. The brood fish may be

raised in the farm or collected from rivers, reservoirs and lakes. At present, due to less or non-availability of broods from natural waters, farmers have to depend solely on spawners grown in confined environment. As it is a fact that 'healthy mother gives birth to healthy child', vitality, survival and growth of hatchlings are directly influenced by the condition of parent fish. As a result, the aspect of broodstock management has assumed great importance to the fish breeders.

COMMONLY CULTURED AND INDUCED BRED CARP SPECIES OF WEST BENGAL

Indian major carps

Catla, *Catla catla*: Catla is the fastest growing species among Indian major carps. It grows upto 1.5-2.0 kg after one year. It is widely distributed in the natural waters of India, Bangladesh, Pakistan, Nepal and Myanmar (Jhingran and Pullin, 1985 and Reddy, 1999).

Rohu, *Labeo rohita*: It is regarded as the tastiest among all Indian major carps. It does not grow as fast as catla and attains about 800-900 g at the end of first year. Its availability is similar to that of catla.

Mrigal, *Cirrhinus mrigala*: It is the slowest growing species among the Indian major carps and bottom feeder. Its growth in the first year is about 700 g.

Exotic carps

Silver carp, *Hypophthalmichthys molitrix*: The Chinese carp was introduced in India during 1959 from Japan and Hongkong (Jhingran, 1991). It feeds on phytoplankton and is an important candidate species in semi-intensive composite culture. It has high growth rate and grows upto 1.0-1.5 kg after first year.

Grass carp, *Ctenopharyngodon idella*: Another Chinese carp, Grass carp, also known as 'White Amur' in Russia was introduced in India in 1959 from Hongkong (Alikunhi and Sukumaran, 1962). It has got culture acceptance due to its feeding habit of grazing on aquatic weeds and thus is used in composite carp culture. It shows very high growth rate and can grow over 2 kg in a year.

Common carp, *Cyprinus carpio*: *C. carpio* var. *communis* was introduced in India in 1939 and 1957 from Sri Lanka and Thailand, respectively (Jhingran, 1991). Its omnivorous bottom feeding habit makes it suitable for composite culture.

Silver barb, *Puntius gonionotus* syn. *P. javanicus*: It was introduced to India in 1972 from Indonesia to evaluate its biological control ability for aquatic weeds (Jhingran, 1991). The fish attains marketable size of 300 g in 4-5 months and grows up to 1.0 kg in a year (Shetty *et al.*, 1989).

Medium carps

Calbasu, *Labeo calbasu*: It is known as black rohu. With its omnivorous feeding habit it can grow 450 g in the first year. It is an inhabitant of Indian rivers.

Bata, *Labeo bata*: This carp is an omnivorous bottom feeder. It is endemic to north Indian rivers upto Godavari. It is included in the farming with Indian major carps in different parts of the country.

Olive barb, *Puntius sarana*: This fish is found in eastern Indian natural waters including Ganga river basin (Payne *et al.*, 2004). Due to its declining natural stock and high consumer preference, commercial fish breeders have started producing seeds through induced breeding.

CARP BROODSTOCK MANAGEMENT- FARMER'S EXPERIENCES

Traditional method

During the initial stages of adoption of induced breeding technology, farmers used to collect mature broods from natural waters like rivers, lakes and reservoirs. The broodstock requirement also increased manifold gradually due to establishment of large numbers of hatcheries across the country. Stocks from natural waters have become either non-available or little available due to several reasons. Then the hatchery owners have felt the necessity to collect spawners from culture ponds or raise them in their farms. Broodfishes from composite carp culture are separated and used for breeding. The breeders have started broodstock rearing in separate ponds in the farm itself. They follow carp polyculture system for parent fish rearing also. The well grown and bigger ones are segregated and maintained in separate ponds. Traditional feed mixture of rice bran and groundnut or mustard oil cake (1:1) is used as supplementary diet. No much special care for broodstock rearing is paid and as a result reproductive performance for spawning response, hatching percentage, spawn recovery etc. becomes poor.

Farmers' innovative approaches

Day by day the art of induced breeding technology gets refined at farmers level for each and every aspects. Bengal farmers have been very much advance to modify the technology as per their farm and hatchery conditions. Many small innovations have been made by 564 fish hatcheries running in the state (Bhattacharya, 2008), starting from broodstock management, hatchery operation to seed rearing, grow-out culture. Here some notable innovative approaches devised for broodstock management are mentioned.

Extension of breeding seasonality

Earlier breeding season for inducing fish in captivity was restricted to June to August. Farmers with their broodstock management skills are now able to extend this season from April to September.

Multiple spawning of same broods

Initially the broodstock were used only once per season for breeding purposes. Multiple spawning technique is well adopted. Now, with more understanding about broodstock management, maturation and spawning techniques, the farmers of West Bengal use the same broodstock two or three times per season at an interval of 45 days for both Indian major carps and exotic carps (Chattopadhyay, 2003). This is one of the reasons why today West Bengal is the leading seed producer in the country.

Stocking

Farmers maintain stocking rate around 2000-3000 kg/ha which is within the rate described by Jhingran (1991). Fishes are reared in polyculture mode with provision of proper feed dispensing system like use of basket/ bags at different water level.

Feed management for broodstock

Feeding management in broodstock ponds is given much importance. It is believed that feed is one of the most crucial factors for augmenting fish maturity. In addition to natural pond production, the traditional feed mixture of rice bran and oil cake in equal proportions is used as supplementary feed at 3% body weight. This type of supplementary diet is continued till 3-4 months prior to start of breeding season. After that rice bran is gradually reduced and totally replaced with boiled broken rice. They assume that use of deoiled rice bran in diet would lead to accumulation of abdominal fat that hinders in advancement of maturity. Now-a-days, deoiled rice bran is used depending on its availability. Another feed ingredient, bakery by-product is also used in broodstock diet in place of rice bran. Especially for catla brood, folic acid and vitamin E are added for balancing the nutrients. Brood fish are sometimes fed with feeds containing additives like molasses and eggs known to improve the quality by providing some of the essential nutrients (Nandeesha, 2007).

Acclimatization of broods

From one month before the commencement of breeding, netting with chatjaal is performed weekly in broodstock ponds and the broods are kept in hapa for some duration to acclimatize them slowly for breeding fitness.

Advancing maturity

Farmers experience that maturity of catla among Indian major carps comes at later stage of breeding season. To advance the maturity stage pituitary extract injection is administered in a single dose at 1 mg/kg body weight one month ahead of breeding season.

Handling of multiple spawners

The broods to be used in multiple spawning are not bred by stripping. Hapa breeding is followed with spontaneous spawning. Spent fishes are treated with prophylactic chemicals. Sometimes aeration is arranged in brood ponds.

Avoidance of inbreeding

Awareness has developed among hatchery owners regarding deleterious effects of inbreeding. As a result they try to procure broods from far away farms where their own hatchery produced seeds are not cultured. Sometimes, old stocks are replaced with natural water stocks, if available.

IMPROVED BROOD HUSBANDRY METHOD

The spawner's state depends upon the care, in terms of feeding and environment management, provided on them during the maturing stage. For traditional carp breeding, the breeders restrict their management activities only for shorter period just before the onset of monsoon. Whereas, improved brood husbandry technique includes pre-monsoon, monsoon and post-monsoon care of parent fishes.

Rearing pond condition

The sites with drought and flood prone history should be avoided to construct ponds. The site must get sufficient sunlight and wind movement. Water and soil should be of good quality and the soil should have strong water retention capacity. For easy management purpose, it is advisable to have smaller rectangular ponds of 0.2-0.5 ha area with 1.5-2.0 m average water depth. Pond bottom should be flat for easy catching of fish by netting. Soil should be of loamy in nature with some bottom mud necessary for maintenance of water fertility as it supports growth of plankton and benthos which are the most preferred food for carps.

Pond preparation

Broodstock pond should be prepared well after removing excess bottom mud which is storehouse of obnoxious chemicals like organic acids, hydrogen sulphide, methane etc. Pond preparation steps include liming of pond bottom, removal of aquatic weeds, weed fishes and predators, fertilization. Suitable piscicides such as mohua oil cake at 200-250 ppm or bleaching powder (30% chlorine level) at 30 ppm rate are used. In combination of urea and bleaching powder, the amount of bleaching powder is reduced to half with urea applied at 10 ppm level and the urea should be applied 24 hours before the application of bleaching powder (Janaki Ram *et al.*, 1988).

For fertilization cattle dung 5000-8000 kg, single super phosphate 200-250 kg, urea 75-100 kg and muriate of potash 50 kg/ha/year are applied. One fourth of the total amount is applied as basal dose and the rest amount is splitted in monthly applications. Liming is carried out based on the pH of culture pond.

Sources and state of brood fish

The brood fish may be grown in the farm or collected from natural waters. But due to poor availability of brood fishes from natural water, it has become inevitable to grow them at farm itself following proper management protocols. Healthy individuals are selected to ensure the production of healthy offspring. Transportation of brood fishes from far distances for induced breeding may result in injury and subsequent secondary infections may lead to mortality. Therefore, it is better to raise broodstocks at the composite fish-seed farm itself. Parent fish should be 2-3+ years old. Care of brood stock is started almost 5-6 months earlier to the spawning season. However, for raising good quality broodstock at farm, it is better to collect fast-growing healthy yearlings with known genetic history of the parent fish and these young ones are kept in quarantine for 1-2 months (Routray *et al.*, 2007). It is advocated to avoid collection of stocking materials from wastewater or industrial effluent fed culture systems.

Stocking

Judicial stocking in brood fish pond is essential for raising of quality spawners. Indian major carps and Chinese carps may be stocked together in same pond at 1500 kg/ha (Gupta and Rath, 2006). As common carp needs no hypophysation for induced breeding, they can be grown separately. The fishes are stocked in the ratio of 3:2:2:2:1 for catla, rohu, mrigal, grass carp and silver carp, respectively (Gupta *et al.*, 1990). The broods are raised here upto 2+ years age group following standard pond management protocols (Sinha, 1972 and Gupta *et al.*, 1990).

Sometimes spent brooders of preceding breeding season are reared as 'prospective brood' and they are used as initial stock for multiple breeding programme. Prospective broods are reared for a few months in different ponds at a stocking density of 1000 kg/ha (Gupta and Rath, 2006). In principal brood system, broods are reared in such a manner that one species contributes 60% of the population out of the 5 aforesaid species combination and other 4 species contribute 10% each. For example, in catla principal brood system, catla only contributes 60% of the population and rest of the species, *viz.* rohu, mrigal, grass carp and silver carp contribute 10% each.

Management during rearing

Separate ponds with sufficient plankton population are used for rearing of prospective brood. These broods should be checked and treated with potassium permanganate solution

(5 ppm) at regular intervals to avoid secondary infections. Partial water exchange with oxygen rich water is suggested at monthly basis. The environment plays an important role in the regulation of reproduction in many animals, including fish (Chaudhuri, 1997). Proper management is required towards maintenance of optimum pond environmental condition which affects spawner's maturity. One or two months prior to the breeding season, 25% water replenishment is done for 3-4 times in a month maintaining feeble flow lasting for 3-4 hours during each filling. This kind of management procedure is preferably required during summer months. Under this management system, advance maturity can be achieved 2-3 months ahead of monsoon. Fishes should be checked periodically for maturity stage and parasitic infection, if any. When condition of brood fish is not satisfactory and they are somewhat emaciated, the stock should be thinned out or the quantity of supplementary feed is to be increased. In no situation, the fish under rearing exhibit surfacing activities.

Broodstock nutrition and feeding

Natural food production in the rearing pond may not fulfill the requirement of maturing parent fish. Therefore, it is essential to feed them with adequate amount of nutritionally balanced supplementary diet. For the brood raising from young fishes, conventional supplementary feed such as groundnut cake and rice bran (1:1) may be provided at 2% body weight level (Gupta and Rath, 2006). Depending on the availability, mustard cake can be used instead of groundnut cake. Whereas, for rearing of prospective broods with catla as principal brood, the fishes are fed on a formulated diet containing crude protein 33%, crude lipid 10%, gross energy 4000 kcal/kg at 1-2% body weight and this formulated feed showed better result than the traditional ones which contains low protein (15-20%) consisting of groundnut cake and rice bran (1:1) (Gupta *et al.*, 1995a). Grass carp is fed with suitable water weeds like *Hydrilla, Ceratophyllum* and *Nechamandra* or fodder grass at 20-30% body weight daily. However, grass carp can be provided with non-fodder or non-foliage formulated diet comprising of 50% soybean cake, 25% groundnut oil cake, 20% rice bran, and 5% fishmeal (Rath *et al.*, 1999 and Gupta, 2002). Using this non-foliage diet non-stripping induced spawning of grass carp was achieved. Grass carp brood reared in ponds and fed with two different diets, natural aquatic weed, *Hydrilla* and farm made formulated feed, showed higher spawning fecundity of hand stripping than spontaneous spawning in both the diet groups, but spawn recovery rate was more in spontaneously bred fish groups reared separately with *Hydrilla* and formulated diet than the hand stripping method irrespective of their high fecundity (Rath *et al.*, 2008). This indicates that feeding grass carp with natural aquatic weeds is advantageous. For common carp brood raising, sometimes formulated feed at 35% protein level made up from rice bran, groundnut cake and fishmeal gives better breeding performance than the traditional feed mixture of groundnut cake and rice bran (1:1) (Manissery *et al.*, 2001). Along with this formulated diet, regular pond fertilization is required to maintain sustained natural pond productivity.

Lipid and fatty acid composition of broodstock diet have been identified as major dietary factors that determine successful reproduction and survival of offspring. Some fish

species readily incorporate dietary unsaturated fatty acids into eggs, even during the course of the spawning season. Highly unsaturated fatty acids (HUFA) with 20 or more carbon atoms affect, directly or through their metabolites, fish maturation and steroidogenesis and in some species, HUFA in broodstock diets increases fecundity, fertilization and egg quality (Izquierdo *et al.*, 2001). Broodfish diet enriched with lipid consisting of n-3 and n-6 poly unsaturated fatty acids (PUFA) proved to improve gonadal maturation, breeding performance and spawn recovery and hence it is mandatory to ensure incorporation of PUFA by supplementing fish oil and vegetable oil in Indian major carp broodstock feeds (Nandi *et al.*, 2001 and 2007).

Excess feeding should be avoided as it may lead to the deposition of fat in the body, which can finally affect maturity adversely. The composition of protein-rich formulated feed is as follows: groundnut oil cake (48%), soybean cake (40%), rice bran (5%), fish meal (5%), calcium dibasic phosphate (1.5%), sodium chloride (0.3%), multivitamin mixture (0.1%), trace elements (0.1%), and vitamin C and E (30 and 200 mg/ kg of feed, respectively) (Gupta *et al.*, 1990). This feed can be used as a common supplementary diet for all the 3 Indian major carps and is provided at 1% body weight daily. Feed disposal system is different and it varies from pond to pond based on species combination. In catla dominated pond, the powdered feed is broadcast, semi-soaked feed is suspended in the column water for rohu, while soaked feed ball is preferred for the mrigal pond. So the feed distribution system is more or less similar to that of composite carp culture, where feed is placed in the form of dough ball in bamboo basket/ tray fixed in the 3 layers of pond water- upper, middle and bottom for easy access by the different species in the three zones (Mukhopadhyay and Mitra, 2007). However, in principal brood rearing system (described earlier in this article), feed is given for the main 60% species only and the rest of the population thrives on the natural productivity of the pond and left-over feed of the main species. Thus, in this system feed cost is reduced to 40% (Gupta and Rath, 2006).

Water quality management

Periodical checking of water quality is carried out to ensure the pond environment suitable for fish under culture. Liming according to the water pH and fertilization for pond productivity are done at regular interval. Desirable water quality parameters for brood pond should be as follows: temperature 20-35^{0}C, colour greenish, turbidity 8-20 cm visibility, pH 7.5-8.5, dissolved oxygen 4.0-8.0 ppm, total alkalinity 80-150 ppm as $CaCO_3$, ammoniacal nitrogen NH_4 0.2-0.5 ppm, nitrite nitrogen NO_2 < 0.014 ppm and phosphorus P_2O_5 0.01-0.5 ppm (Routray *et al.*, 2007).

Monitoring of health status

Periodical checking of health is mandatory for any infection, emaciated condition of the stock. Over crowding and intensive farming operation may confer upon stress and disease incidence to the fishes under culture and hence should not be practised. It is advisable

not to treat the infected fish with therapeutics in pond itself, instead the diseased fish should be isolated and treated separately in confinement. Routine prophylactic ($KMnO_4$) treatment eliminates the chance of secondary infection during rearing. Overaged, diseased and unproductive brood, if noticed should be replaced by new stock.

Management of brooders for multiple spawning

Carp is known to breed once in a year during monsoon. With proper scientific brood management, they have been domesticated to breed during pre-monsoon, monsoon and post-monsoon months. This has opened a new avenue towards meeting of high seed demand during the months of March and April. Multiple spawning is the timely harvesting of the mature gametes repeatedly two or more times in a season (Gupta *et al.*, 1995b). The fishes are induced bred by adopting hypophysation technique. The brood fishes used for such multiple spawning is termed as professional brood. Indian major carps have been bred as many as four times in a year (Gupta *et al.*, 1995a). Pre-monsoon spawning of captive rohu often exhibits reduced spawning performances and devaluation of final product due to the oocytes' unresponsiveness to hormonal induction, which could be ameliorated through purified carp gonadotropin priming and thereby, the rohu fry production could be initiated successfully as early as May, allowing public and private hatcheries to produce larger age-0 rohu fingerlings ensuring reliable steady source of stocking materials for grow-out system earlier in the season (Dasgupta *et al.*, 2009).

Proper broodstock management is followed for getting early maturity of fish in pre-monsoon days. It is possible to get advance maturity in Asiatic carps during April and May through broodstock management (Gupta *et al.*, 1990). For this purpose prospective broods are preferred as the initial stock. The age of fish, stocking density, formulated diet, pond management with water replenishment should be similar as described earlier in this article. Such managed broods show precocious gonadal maturity at least 3 months prior to the monsoon depending on the locality. Advancing maturity of catla by two months could be achieved using a precooked diet formulated using black gram, horse gram, sunflower cake, rice bran, ground nut oil cake, broken rice and fish meal and monthly injection of the fish with HCG at 6 mg/kg body weight (Somashekarappa *et al.*, 1990). Such fish could be bred once in April and again in July through hypophysation.

Proper care is important for multiple spawners immediately after breeding. Close monitoring is necessary for better survival and early recovery of spent broods. Brood transportation from the farm to the hatchery should be done in canvas bags (hammock) along with water. Hormone administration to brood fish should preferably be intraperitoneally. Stress to brooders in the spawning pool should be minimized by providing the required flow and duration of water supply. Spent brooder is to be removed from the spawning pool immediately as soon as the spawning operation is over. Spent brooders are to be treated at regular intervals with potassium permanganate solution (5 ppm). This keeps a check on secondary infections and also quickens recovery from spawning stress.

Multiple spawning is advantageous over single spawning as it enhances the cumulative spawn yield/ kg body weight by 3-4 times, cost of seed production is also reduced and it gives opportunity for multiple cropping in carp aquaculture.

SOME ISSUES NEED ATTENTION

In many hatcheries, some important aspects in regard to broodstock are not paid attention. In long run, this gives rise to many unwanted hatchery outcomes.

Genetic degradation of domesticated stock

On achieving success in induced breeding technique of carps, many hatcheries have been established all over the country with their prime aim to supply fish seeds as per target paying no attention to quality. Now, there are many complaints often raised by farmers with regard to seed performances in culture ponds. Some of them are slow growth, less disease resistance, low survival, slow maturity, poor spawning output etc. One of the most important reasons for this declining farming performance is genetic degradation. Until very recently, little or no consideration has been given to genetic factors in the management of carp stocks in India (Basavaraju *et al.*, 2007). Without appropriate broodfish management, the long-term decline of genetic quality is almost inevitable. The danger of genetic degradation is extended to the wild stocks too. Although natural hybridisation accidentally occurs among Indian carps (Desai and Rao, 1970 and Khan and Kowtal, 1989), these are usually eliminated through natural selection. The various causes of genetic degradation occurring during seed production through induced breeding are as follows:

Improper selection

Selection is the efficient method in animal breeding programs because it can lead to the long term goals of genetic improvements. Proper selection method is not followed in many hatcheries which use the larger selected broods from mixed population and keep the smaller ones to grow and mature. Sometimes negative selection is also happened while breeding smaller size fishes. Though this kinds of selection, occurring in many hatcheries, seem to be unintentional and beyond the knowledge of breeders. As a result, deleterious effects for growth rate, sexual maturation, disease resistance etc. are observed.

Inbreeding and inbreeding depression

The mating between individuals which are more closely related than random mating is defined as inbreeding (Uraiwan, 2007). In populations under selection, inbreeding produces negative effects such as increased homozygosity, which leads to increased chance of expression of lethal recessive genes, inbreeding depression and reduction of genetic variance (Falconer and Mackay, 1996). Closely related stocks have been repeatedly used over many generations. Inbreeding depression is expressed in many ways which include loss of fitness, lower growth

rates, poor survival, increased incidence of deformities, low fecundity etc. However, farmer should prefer low inbreeding depression since he looks for immediate marketing of seeds. To avoid carp inbreeding in hatcheries a simple cross breeding technique can be followed by mating two unrelated strains/ stocks of the same species either collected from two different river systems or from two different locations (Eknath and Doyle, 1990 and Sarder *et al.*, 2002). Cross breeding can be combined with selection in this program to produce fish with no inbreeding generation after generation (Tave, 1999).

Hazardous hybridization

A communal or mixed spawning system for major carps in West Bengal is being practiced and is known to produce approximately 10% hybrids (Padhi and Mandal, 1997). This technique may lead to loss of genetic purity of important major carps. The main purpose of hybridization is to produce superior offspring which have better genotype than their parents. However, the superior performance could be due to non-additive genetic variance (Uraiwan, 2007). Only particular crosses will achieve this goal. This is termed "hit-or-miss" production of superior hybrids (Tave, 1986). This can be practised with proper scientific planning. In hatcheries, some hybridization always occur unknowingly between species which leads to production of unwanted non-viable, poor performing sterile individuals. This kind of hazardous hybridization also results in genetic introgression of several species. Genetic introgression is the mixing of genes between species or strains and thus poses difficulty in differentiation between parent species or strains. This, in carp, is more likely to have negative consequences of loss of the distinct feeding strategies of the pure species as observed in the case of silver carp in Bangladesh (Rajts *et al.*, 2002).

Hatcheries with no broodstock ponds

Many small-scale hatcheries do not keep broodstock ponds and they have to totally rely for getting broods from farmers undertaking grow-out culture. So, to meet their pre-targeted seed demand they procure early matured, undersized spawners on the day of reproduction. The spent broods are sold dead immediately after operation. This practice also leads to poor performances of offspring.

Lack of proper scientific knowledge

There are insufficiency of wisdom regarding proper broodstock management keeping genetic issues in mind and also overall hatchery operation among breeders. Proper knowledge and skill on rearing environment management, monitoring of health, feeding etc. should be gained.

Improper transport of broodfish

As many hatcheries do not have broodstock ponds and fish seed producers indulge in competition among themselves to meet demand, they depend on external broodfish

transported from distant places. As a result fish are held to confined environment with higher density, higher metabolic load, stress, strain and exhaustion. It ultimately leads to poor breeding performances in terms of spawning rate and hatchability. The broodfish can be transported in well aerated carrier with load ratio of fish to water of about 1 kg fish per 4.5 litre water (Mammen, 1962). As anaesthetics would reduce the metabolic activity, oxygen consumption, the excretion of ammonia, carbon dioxide and other toxic wastes, these may be used with utmost care in selecting and also its dosage.

Use of genetically improved carps

Genetically improved Indian major carp, rohu named *Jayanti* has been achieved through selective breeding with impressive 17% genetic gain after fifth and sixth generation (Das Mahapatra *et al.*, 2007 and Eknath and Jena, 2008). Field testing experiments in different agro-climatic areas, such as Punjab, West Bengal and Andhra Pradesh also showed a similar trend of genetic gain. The commercial production of *Jayanti* seed is to be attempted for popularisation among farmers.

CONCLUSION

Mass scale seed production through induced breeding has started since three decades. Improper broodstock management practices have been followed since then by many seed producers. Although researchers already reported the deleterious effects of poor management in terms of genetic aspects during 1990s (Eknath and Doyle, 1990; Basavaraju *et al.*, 1997 and Maheshwari and Biradar, 1998), farmers are now experiencing the same in their farms. The reason behind this is that the most fish hatcheries are concerned more about the quantity rather than the quality of fish seed and produce them without following any brood selection norms. Consequently, seeds suffer from high rates of mortality, poor growth and high susceptibility to diseases and parasites. Obviously it has become the need of the hour to carry out breeding activities with proper management strategies. As broodstock is one of the major investments in hatchery operation and hatchery's repute depends on the quality of seeds produced by them, due considerations should be given for their selection, replacement and overall management. In this regard, fish hatchery operators should be trained on better broodfish management, hatchery management and nursery management to produce quality fish seed. More emphasis should be laid on management of broodstock for multiple spawning so as to ensure the availability of seed over a longer duration in a year, whereas mixed spawning should be prevented to protect the genetic purity of our precious carp gene pools. Also, broodstock management of carps should be one among first genetics research priorities.

REFERENCES

Alikunhi, K.H., Sukumaran, K.K., 1962. Preliminary observations on Chinese carps in India. *Proc. Ind. Sci. Congr.*, 49 (3): 387.

Basavaraja, N., 2007. Freshwater fish seed resources in India. In: Assessment of freshwater fish seed resources for sustainable aquaculture, Bondad-Reantaso, M.G. (Ed.). FAO Fisheries Technical Paper No. 501. Rome, Italy, pp. 267-327.

Basavaraju, Y., Penman, D.J., Mair, G.C., 1997. A genetic improvement programme on *Catla catla* in Karnataka State, India- Preliminary findings. Paper presented at workshop on "Genetic improvement of carps in Asia" held at CIFA, Kausalyaganga during 26-29 July, 1997 by ICLARM/ADB. Philippines.

Basavaraju, Y., Penman, D.J., Mair, G.C., 2007. Genetic management of carps in hatcheries- Theory and practice. Fishing Chimes, 27 (1): 47-56.

Bhattacharya, S.K., 2008. Status of Fisheries Development in West Bengal. Fishing Chimes, 28 (1): 80-82.

Chattopadhyay, N.R., 2003. Fish breeding in captivity- some innovative adaptations of technology by Bengal farmers. *Aquaculture Asia*, 8 (2): 13-16.

Chaudhuri, H., Alikunhi, K. H., 1957. Observations on the spawning in Indian major carps by hormone injection. *Current Science*, 26 (12): 381-382.

Chaudhuri, H., 1997. Environmental regulation of gonadal maturation and spawning in fishes. In: Frontiers in environmental and metabolic endocrinology, Maitra, S. K. (ed), University of Burdwan Publications, Burdwan, India, pp 91-100.

Das Mahapatra, K., Sahoo, P. K., Saha, J.N., Barat, A., Rye, M., Salte, R., Mohanty, B.R., Sahoo, M., Mohapatra, M. P., 2007. Selective breeding of rohu for innate resistance to aeromoniasis: a model for an alternative disease control. In: Proc. Final Workshop Selective Breeding of Rohu for Innate Resistance to Aeromoniasis, March, 2007, Bhubaneswar, India.

Dasgupta, S., Sarkar, S. K., Sarangi, N., Bhattacharya, S., 2009. Variation in spawning responses, egg and larvae productions from induced rohu (*Labeo rohita*) during pre-monsoon and monsoon seasons: Relationship with hormonal changes and oocyte responsiveness during final maturation. *Aquaculture,* 290 (3-4): 320-326.

Desai, V.R., Rao, K.J., 1970. On the occurrence of natural hybrid catla-rohu in Madhya Pradesh. *J. Zol. Soc. India*, 22 (1-2): 35-40.

Dubey, G.P., 1969. Induced breeding of Indian carp in dry bundhs. FAO/UNDP Regional Seminar on Induced Breeding of Cultivable Fishes, Calcutta, Fri/IBCF/21: 10 p.

Eknath, A.E., Doyle, R.W., 1990. Effective population size and rate of inbreeding in aquaculture of Indian major carps. *Aquaculture*, 85: 293-305.

Eknath, E.A., Jena, J.K., 2008. Freshwater Aquaculture Development in India- Perspective Plan & Vision of CIFA. In: Souvenir of Eighth Indian Fisheries Forum, 22-26th November 2008, Kolkata, pp. 105-111.

Falconer, D.S., Mackay, T.F.C., 1996. Introduction to quantitative genetics (4th Edn). Longman Group Ltd., London, UK, pp 247.

Gupta, S.D., Rath, S.C., 2006. Carp breeding and seed production. In: Handbook of Fisheries and Aquaculture. Indian Council of Agricultural Research, New Delhi, India, pp 248-264.

Gupta, S.D., 2002. Studies on some eco-carp hatchery system and their improvement for augmentation of carp seed production. PhD Thesis, VBS Purvanchal University, Jaunpur, India.

Gupta, S.D., Rath S.C., Dasgupta, S., 1995b. Fertilization efficiency of cryopreserved carp spermatozoa over four years at different time intervals after thawing. *Geobios*, 22: 208-211.

Gupta, S.D., Rath, S.C., Dasgupta, S., Tripathi, S.D., 1995a. A first report on quadruple spawning of *Catla catla* (Ham.). *Veterinarski Arhiv*, 65: 143-148.

Gupta, S.D., Reddy, P.V.G.K., Pani, K.C., 1990. Advancing maturity and spawning in Asiatic carps through brood stock management. In: Carp seed production technology, Keshavanath, P. and Radhakrishnan, K.V. (Eds.), Proceedings of the workshop on carp seed production technology, 2-4 Septemeber, 1998, Special Publication 2. Asian Fisheries Society Indian Branch, Mangalore, India, pp 34-37.

Izquierdo, M.S., Fernández-Palacios, H., Tacon, A.G.J., 2001. Effect of broodstock nutrition on reproductive performance of fish. *Aquaculture,* 197 (1-4): 25-42.

Janaki Ram, K., Rao, G.R.M., Ayyappan, S., Purushothaman, C.S., Saha, P.K., Pani, K.C., Muduli, H.K., 1988. A combination of commercial bleaching powder and urea as a potential piscicide. *Aquaculture,* 72 (3-4): 287-293.

Jhingran, V.G., Pullin, R. S. V., 1985. A Hatchery Manual for the Common, Chinese and Indian Major Carps. ICLARM Studies and Reviews 11. ADB and ICLARM, Manilla, Philippines, 191 p.

Jhingran, V.G., 1991. Fish and Fisheries of India. Hindustan Publishing Corporation (India), Delhi, India, 463 p.

Khan, H.A., Kowtal, G.V., 1989. An account of naturally occurring and artificially produced cyprinid hybrids in India. In: Fish Genetics in India, Das, P. and Jhingran, A.G. (Eds.). Today & Tomorrow's Printers & Publishers, pp 155-162.

Maheshwari, U.K., Biradar, R. S., 1998. Decline in fertility of hatchery bred *Labeo rohita* due to inbreeding. Proc. Fish Gen., Biodiversity Conserv., Natcon Pub. 05: 412-416.

Mammen, T.A., 1962. Live fish transport using modified splashless carrier with compressed in aeration. In: Training Course on Live Fish Transport, November 19-21, Hyderabad. Fisheries Extension Unit, Government of India, 5 p.

Manissery, J.K., Krishnamurthy, D., Gangadhara, B., Nandeesha, M.C., 2001. Effect of varied levels of dietary protein on the breeding performance of Common Carp *Cyprinus carpio*. *Asian Fisheries Science*, 14: 317-322.

Mookerjee, H.K., Mazumdar, S.R., Das Gupta, B., 1944. Observations on the breeding grounds and spawning habits of certain Indian carps in the Midnapore district, Bengal, with suggestions for their breeding, collection of eggs and rearing of fry. *J. Dep. Sci*. Calcutta Univ., 1: 81-89.

Mukhopadhyay, P.K., Mitra, Gopa., 2007. Plant derived feedstuff for freshwater aquaculture in India. Aquaculture Asia Pacific Magazine, Nov./Dec., pp 19-21.

Nandeesha, M.C., 2007. Asian experience on farmer's innovation in freshwater fish seed production and nursing and the role of women. In: Assessment of freshwater fish seed resources for sustainable aquaculture, Bondad-Reantaso, M.G. (Ed.). FAO Fisheries Technical Paper No. 501. Rome, Italy, pp. 581-602.

Nandi, S., Chattopadhyay, D.N., Verma, J.P., Sarkar, S.K., Mukhopadhyay, P.K., 2001. Effect of dietary supplementation of fatty acids and vitamins on the breeding performance of the carp *Catla catla*. *Reprod. Nutr. Dev.*, 41: 365-375.

Nandi, S., Routray, P., Gupta, S.D., Rath, S.C., Dasgupta, S., Meher, P.K., Mukhopadhyay, P.K., 2007. Reproductive performance of carp, *Catla catla* (Ham.), reared on a formulated diet with PUFA supplementation. *J. Applied Ichthyology*, 23 (6): 684-691.

Padhi, B.K., Mandal, R.K., 1997. Inadvertent hyridization in a carp hatchery as detected by nuclear DNA RFLP. *Journal of Fish Biology*, 50: 906-909.

Payne, A.I., Sinha, R., Singh, H.R., Huq, S., 2004. A review of the Ganges basin: Its fish and fisheries. In: Proceedings of the 2nd International Symposium on the management of large rivers for fisheries, volume I, Welcomme, R.L. and Petr, T. (Eds.), FAO Regional Office for Asia and the Pacific, Bangkok, Thailand, RAP Publication 2004/16, pp 229-250.

Rajts, F., Huntingdon, T., Hussain, M.G., 2002. Carp brood stock management and genetic improvement programme under Fourth Fisheries Project. In: Proceedings of a workshop on Genetic Management and Improvement Strategies for Exotic Carps in Asia, Penman, D. J., Hussain, M.G., McAndrew, B.J. and Mazid, M.A. (Eds.), 12-14 February, 2002, Dhaka, Bangladesh. Bangladesh Fisheries Research Institute, Mymensingh, Bangladesh. pp 95-106.

Rath, S.C., Gupta, S.D., Dasgupta, S., 1999. Non-stripping induced spawning and double spawning of grass carp in a hatchery system with foliage-free brood diet. *Veterinarski Arhiv*, 69: 7-15.

Rath, S.C., Sarkar, S.K., Mohanty, S.N., Gupta, S.D., 2008. Spawning performance of *Ctenopharyngodon idella* brood, reared on two different diets. In: Book of Abstracts of Eighth Indian Fisheries Forum, 22-26th November 2008, Kolkata, pp 85.

Reddy, P.V.G.K., 1999. Genetic resources of Indian major carps. FAO Fisheries Technical Paper No. 387, Rome, Italy, 76 p.

Routray, P., Verma, D.K., Sarkar, S.K., Sarangi, N., 2007. Recent advances in carp seed production and milt cryopreservation. *Fish Physiol. Biochem.*, 33: 413-427.

Sarder, A.S., Azam, M.R., Hossain, M.A., 2002. Private hatchery owners' perspectives on hatchery management in Bangladesh. In: Proceedings of a workshop on Genetic Management and Improvement Strategies for Exotic Carps in Asia, Penman, D. J., Hussain, M. G., McAndrew, B. J. and Mazid, M. A. (Eds.), 12-14 February, 2002, Dhaka, Bangladesh. Bangladesh Fisheries Research Institute, Mymensingh, Bangladesh. pp 77-81.

Shetty, H.P.C., Nandeesha, M.C., Jhingran, A.G., 1989. Impact of exotic aquatic species in Indian waters. Exotic aquatic organisms in Asia. pp. 45-55. Proc. Workshop Introduction Aquat. Organ., Asia.

Sinha, V.R.P., 1972. Composite fish culture in India. Indian Farming, 22: 118-119.

Somashekarappa, B., Chandrashekaraiah, H.N., Nandeesha, M.C., 1990. Advancement of maturity in an Indian major carp, *Catla catla* through improved diet and human chorionic gonadotropin administration. In: Carp seed production technology, Keshavanath, P. and Radhakrishnan, K.V. (Eds.). Asian Fisheries Society, Indian Branch. Mangalore, India, pp 29-33.

Tave, D., 1986. Genetics for fish hatchery managers. AVI Publishing Company Inc., Westport, Connecticut, 299 pp.

Tave, D., 1999. Inbreeding and brood stock management. FAO Fisheries Technical Paper No. 392. FAO, Rome, Italy.

Uraiwan, S., 2007. Selective breeding and broodstock management in aquaculture. In: The Third Country Training Programme on Advanced Freshwater Aquaculture, 3rd June to 21st July, 2007, Inland Aquaculture Research Institute, Department of Fisheries, Ayutthaya Province 13290, Thailand, pp 195-207.