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Environmental aspects of fisheries resources
Biodiversity conservation
Openwater management
Policy or status paper on national interest

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Bangladesh Journal of Fisheries Research

Special Issue

Extended Abstracts of the Development of Sustainable Aquaculture Project (DSAP)/WorldFish Center Funded Research Projects

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Preface

The potential to expand aquaculture production in Bangladesh is immense. There is an estimated area of 228,500 ha with perennial waters and 76,200 ha with seasonal waters, many of which are un- or underutilized in respect to fish production through aquaculture. Although levels of management and yields vary, the fish yields have been more than tripled in numerous demonstrations, by simply following basic low-cost management practices. A WorldFish Center (previously known as ICLARM) study in Tangail District in 1999 revealed that farmers were producing fish at only 292 kg/ha/yr of fish through traditional culture practices in their homestead ponds. Production among demonstration farmers using recommended practices resulted in an increase by 880% estimating 2,574 kg/ha/yr, which clearly shows the immense scope of boosting fish production through aquaculture in Bangladesh including improvement of livelihood of the rural poor people.

Since its inception in 2000, the USAID-funded Development of Sustainable Aquaculture Project (DSAP) of the WorldFish Center has its major thrust of implementing aquaculture demonstrations and to bring unused and/or underused seasonal and perennial ponds and rice fields under improved production practices feasible for resource poor farmers. The objectives are to improve the farmer's incomes and life circumstances.

Probably the greatest constraint forwarded the improvement of aquaculture worldwide is an understanding of how people can learn to accept and sustain change. The WorldFish Center is continuing its efforts to develop appropriate technologies and to identify effective ways of disseminating technologies among the target people. The Development of Sustainable Aquaculture Project supported some applied research for National Research Institutions and individuals in the following areas:

- Research on technology development and refinement,
- Research on technology dissemination, and
- Impact studies.

With the aforementioned objectives the project has funded a total of 42 research studies through small grants of which 10 were awarded through competitive process. Among the 42 studies, 14 were carried out by the Bangladesh Fisheries Research Institute (BFRI) under a Technical Assistance Project, and 28 were implemented by different universities of the country along with several other organizations and NGOs.

This special issue of the Bangladesh Journal of Fisheries Research is a compilation of extended abstracts of all the DSAP-funded research projects mentioned above. Each extended abstract consists of a traditional abstract, followed by major research findings, and a brief on livelihood and policy implications. The objective of this format is to present the research findings and their implications in a concise and precise format to a wide audience of interested people, such as scientists, extension workers, development workers and decision makers and administrators. For any information and/or clarification, or for a copy of the final reports of a particular study request may be made either to the WorldFish Center, South Asia and Bangladesh Office, Dhaka or the principal investigator.

We believe that the results and technologies generated from these studies will contribute to increase aquaculture production and help planning for further research.

We would like to take the opportunity to sincerely thank the editorial team of this special issue, in particular, Dr. Md. Aminul Islam for leading and guiding the editorial team and all the editors for their dedication to complete this difficult task in such a short period.

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Cryopreservation of sperm of common carp, *Cyprinus carpio* and silver barb, *Barbonymus gonionotus* for genetically improved seed production

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Abstract
Experiments were conducted to develop and standardize the protocols for cryopreservation of sperm of common carp, *Cyprinus carpio* and also for using the cryopreserved sperm for fertilization of eggs. Nine extender solutions as Alsever's solution, kurokura-1, kurokura-2, urea egg-yolk, egg-yolk citrate, 0.6% glucose, 0.9% NaCl, M^a and M^b , and five cryoprotectants namely ethanol, methanol, dimethylsulfoxide (DMSO), dimethylamine (DMA) and glycerol were tested. The cryoprotectants were mixed at 10% concentration of the extenders (v/v) to make the cryodiluents. Milt and cryodiluents were mixed at a ratio of 1:9 for Alsever's solution, kurokura-1, kurokura-2, 0.6% glucose and 0.9% NaCl, 1:4 for urea egg-yolk, egg-yolk citrate, M^a and M^b. Among the cryodiluents Alsever's solution mixed with either ethanol or methanol was found to be suitable and it produced more than 90% and 80% spermatozoan motility at equilibrium and post-thaw periods, respectively. Kurokura-1 and kurokura-2 when mixed with the same cryoprotectants showed good spermatozoan motility at equilibrium period (80-90%) but the motility was reduced (30-55%) at post-thaw state. Other extenders did not produce acceptable sperm-motility and in some cases the frozen milt became clotted. Different dilution ratios (1:1, 1:2, 1:4, 1:5, 1:7, 1:9, 1:12, 1:15, 1:20) were formulated for obtaining a suitable milt dilution, the dilution ratio of 1: 9 (milt : cryodiluent) demonstrated the highest post-thaw spermatozoan motility (80%) in Alserver's solution. The optimum concentration of cryoprotectants in the cryodiluents was determined, 10% concentration level was found to be effective to produce the highest number of spermatozoan motility in comparison to the other concentrations (5%, 15%, 20% 30%). Sperm preserved with the cryodiluent Alsever's solution along with either methanol or ethanol was found to be effective to fertilize eggs and produce hatchlings. The hatching rates ranged between 1.48% and 14.76%, compare to control. The fish produced through use of cryopreserved sperm and normal sperm were found to grow well and no significant ($P<0.05$) growth difference was observed between them. In case of silver barb, *Barbonymus gonionotus*, sperm tested against six extenders such as egg-yolk citrate, urea-egg-yolk, kurokura-1, kurokura-2, 0.9% NaCl and modified fish ringer (MFR) solution. Cryoprotectants used were the same as those of *C. carpio*. Milt was diluted with the cryodiluent at a ratio of 1:4 for egg-yolk citrate and urea-egg-yolk, 1:5 for kurokura-1 and 1:9 for 0.9% NaCl, MFR and kurokura-2. The cryoprotectant

concentration was maintained at 10% of the extender (v/v) in all the cases. Among the extenders, egg-yolk citrate and urea-egg-yolk mixed with 10% DMSO, methanol and ethanol produced 50% post-thaw spermatozoan motility, whereas DMA and glycerol provided only 10% motility. Trials on milt dilution ratio and cryoprotectant concentration are being conducted. Fertilization trials are also underway.

Key words: Cryopreservation, Sperm banking, Common carp, Silver barb

Research findings

- Preliminary optimization of the protocols for cryopreservation of sperms of common carp and silver barb was done.
- Alsever's solution mixed with either 10% methanol or ethanol was found to be the best for common carp sperm preservation and produced 80% post-thaw active spermatozoa. However, the presence of 10% DMA and DMSO in Alsever's solution produced only 40% and 25% spermatozoan motility, respectively. The milt samples having glycerol became clotted in most cases.
- The fertilization of eggs with the cryopreserved sperm was successful and the hatching rate of 1.48% to 14.76% was obtained.
- The fish produced by cryopreserved sperm performed well and there was no significant deviation from the growth rate that was obtain4ed from the fish produced by using normal sperm.
- Egg-yolk citrate and urea-egg-yolk mixed with 10% DMSO, methanol and ethanol exhibited 50% post-thaw motility of silver barb spermatozoa, whereas DMA and glycerol provided only 10% motility (Fig. 1).

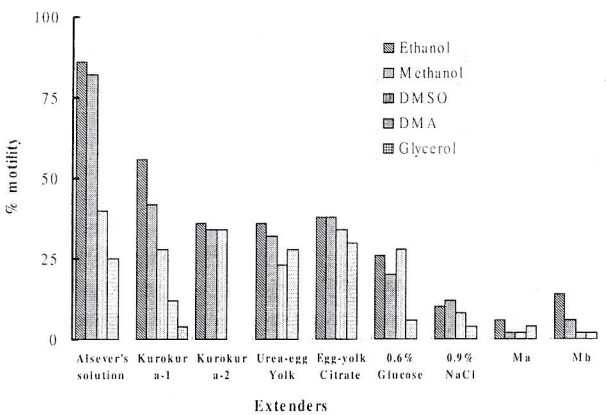

Fig. 1. Post-thaw motility of sperm preserved with different combinations of extenders and cryoprotectants.

Policy implications

- The cryopreservation techniques should be optimized and adopted by the government as well as by the private entrepreneurs. Department of Fisheries (DoF) can take a pioneer role to disseminate the optimized techniques.
- Unwanted inter-specific hybridization mostly resulted from asynchronous breeding times or shortage of breeding partners and inbreeding can be effectively reduced through cryopreservation technique.
- As quality seed production entirely depends on good genetic materials (sperm and ovum), cryopreservation technique can potentially help to preserve and supply of quality sperms from outbred and genetically improved brood stock.
- To maintain a sustainable supply of quality sperm, regional cryogenic gene banks need to be established. Government and private entrepreneurs can take initiative to set up such gene banks at convenient places in the country.

Livelihood implications

The unexpected growth performance of fish mostly resulted from negative selection, inbreeding and inter-specific hybridization in the hatcheries have become a serious constraint to quality seed production in Bangladesh. Cryopreservation of sperm can potentially resolve the problem as it will facilitate to use good sperm and its timely supply to the users. Establishment of cryogenic gene bank and practice of cryopreservation techniques in the selected hatcheries will obviously improve the livelihood of the farmers and the hatchery operators in a number of ways. Fish farmers can get their desired fish seeds produced by cryopreserved sperm in the hatcheries. The hatchery operators, on the other hand will be economically benefited by producing more female brood stocks instead of investing their valuable resources and time for male brood stock production.

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Allozyme variation in four hatchery populations of Thai pangas, *Pangasius hypophthalmus* in Bogra, Bangladesh

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Abstract
Genetic variation of four hatchery stocks of Thai pangas, *Pangasius hypophthalmu* of Bogra region, Bangladesh was studied from 1 January 2002 to 31 December 2003. Muscle samples were collected for allozyme analysis from four (Bhai-Bhai, Jahangir, Belal and Bhai-Bon) different hatchery populations. For allozyme electrophoresis, eight enzymes were used and 11 loci viz. *Adh-1*, Est-1*, G3pdh-1*, Gpi-1*, Gpi-2*, Idhp-1*, Ldh-1*, Ldh-2*, Mdh-1*, Mdh-2** and *Pgm** were identified , of which three loci (*Est-1*, Gpi-2*, G3pdh-1*and *Pgm**) were polymorphic in all the four populations. The mean proportion of polymorphic loci per population and the mean proportion of heterozygous loci per individual was 36.36% and 13.33, respectively for all the population studied. The highest variability measured by the mean number of alleles per locus was 1.545 in Bhai-Bon hatchery population. Based on Nei's (1972) genetic distance, the dendrogram (UPGMA) shows that four populations have made two clusters by *D*-value (*D*=0.043). Bhai-Bhai and Jahangir hatchery populations have made cluster-I, and Belal Uddin and Bhai-Bon hatchery populations formed cluster-II. Among the four populations, Bhai-Bhai and Jahangir hatchery populations were differentiated from each other by *the D*-value of 0.013, and Belal Uddin and Bhai-Bon populations were differentiated from each other by the *D*-value of 0.002, which suggests that the four populations may be fallen into the local population or race.

Key words: Allozyme variation, Hatchery population *Pangasius hypophthalmus*

Research findings

- Out of eleven loci, four *(Est-1*, Gpi-2* G3pdh-1* and *Pgm*)* were polymorphic ($p>0.95$) in all the populations studied.
- The mean proportion of polymorphic loci per population and the mean proportion of heterozygous loci per individual were 36.36% and 13.33, respectively for all the populations studied.
- The mean number of allele per locus was the highest (1.545) in Bhai-Bhai population.

- The plotted dendrogram (UPGMA) shows that four populations have made two clusters by *D*-value (D=0.043). Bhai-Bhai and Jahangir hatchery populations have made cluster-I, and Belal Uddin and Bhai-Bon populations formed cluster-II.
- The *D*-value between Bhai-Bhai and Jahangir hatchery populations is 0.013, which suggests that their broods might be from the same sources. And the *D*-value between Belal Uddin and Bhai Bon hatchery populations also indicates that the broods might be from similar sources.

Policy implications

- Genetic marking technique through allozyme analysis can be applied in identification of the status of the Thai pangas populations.
- The identified individuals with higher genetic variabilities can further be used as outbred broodstock for mass seed production program by the public and private hatcheries.
- Proper identification of the genetic status of the hatchery stocks can foster greater scope for their dissemination through satellite stations of DoF among commercial hatcheries.

Livelihood implications

Being a potential species in the pond aquaculture systems of the country, genetic status of the Thai pangas needs to be known. By knowing the genetic status of the species, outbred seeds can be produced in the hatchery. Therefore, it has greater livelihood implications for pangas seed producers and growers.

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Use of allozyme markers to determine the genetic structure of hatchery population of Thai pangas, *Pangasius hypophthalmus* of Jessore, Bangladesh

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Abstract
Genetic structure of hatchery population of Thai pangas (*Pangasius hypophthalmus*) of Jessore region, Bangladesh has been investigated from 1 January 2004 to 31 December 2004. Samples for this study were collected from five fish hatcheries viz. Asrom, Banchte Shekha, Chowdhury, Maola and Rezaul Haque. The enzymes were encoded by 15 gene loci: *Adh-1*, Est-1*, G3pdh-2*, Gpi-1*, Gpi-2*, Idhp-1*, Idhp-2*, Ldh-1*, Ldh-2*, Mdh-1*, Mdh-2*, Pgm*, Sdh-1*, Sdh-2**and *Sod**. Among them four (*Est-1*, G3pdh-2*, Gpi-2**and *Pgm**) were found to be polymorphic in different populations but only *Gpi-2** was polymorphic in all the sampled populations. The mean proportion of polymorphic loci per population was the highest (26.7%) in Banchte Shekha hatchery while the mean proportion of heterozygous loci was 13.33% per individual in Banchte Shekha and Maola hatcheries. The UPGMA dendrogram of Nei's (1972) genetic distances indicated a relationship between the genetic distance and geographical difference. High genetic variability in stocks of Thai pangas was observed in the Banchte Shekha and Maola hatcheries and less variability was found in the other three hatcheries.

Keywords: Genetic structure, Allozyme markers, Hatchery stocks

Research findings

- Among 15 loci only *Gpi-2**showed heterozygosity in all the populations studied.
- The mean proportion of polymorphic loci per population was the highest (26.7%) in Banchte Shekha population and the mean proportion of heterozygous loci per individual was found to be higher (13.33) in both Bachte Shekha and Maola population.
- Based on Nei's (1972) genetic distance, the UPGMA showed that five populations belong to three clusters, each separated from the other by genetic distance value D = 0.152 (Fig. 1). Cluster-I consisted of Asrom, Chowdhury and Rezaul Haque populations, cluster-II of Banchte Shekha population and cluster-II of Maola population.

- The results suggest that the Banchte Shekha hatchery stock has the higher genetic variability than the other hatcheries.

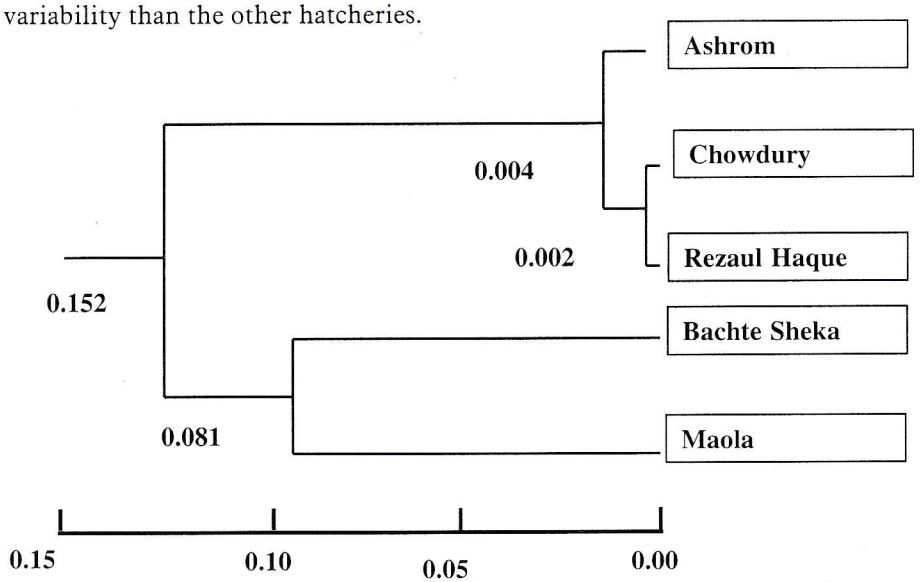

Fig. 1. UPGMA dendogram derived from Nei's genetic distance among five populations of Thai pangas.

- Genetic marking technique through allozyme analysis can be applied in identification of the status of the Thai pangas populations.
- For breeding and quality seed production, Thai pangas broodstock with high genetic variability will be useful and identified improved stocks should be distributed to different hatchery owners.
- True identification of the genetic status of the hatchery stocks can foster greater scope for their dissemination through satellite stations of DoF among commercial hatcheries.
- New pangas trait from original sources could be collected and supplied to the hatchery owner to maintain wider genetic diversity.

Livelihood implications

Pangas culture has tremendous livelihood implications for seed producers and growers Livelihoods of a considerable number of people are dependant on pangas culture in small and large water bodies in Bangladesh. The growth and taste were the main concern in pricing. True breeding broodstock with high genetic variation will certainly ensure the quality seed production of Thai pangas in the existing hatcheries of the country.

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Allozyme and morphological variation in four hatchery stocks of Thai pangas, *Pangasius hypophthalmus* in Mymensingh, Bangladesh

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Abstract
Genetic and morphological characters of four hatchery population (Shambhuganj, Brahmaputra, Anudan and Bhai-Bhai) of Thai pangas, *Pangasius hypophthalmus* in Mymensingh region of Bangladesh was studied using morphological characters and allozyme markers from 29 November 2001 to 29 November 2002. A total of 14 morphometric and 6 meristic characters were verified, among which 3 morphometric (BDA, PELFL and HW) and 2 meristic characters (AFR, CFR) of Anudan hatchery population were found to be significantly higher ($p>0.001$) than those of the other three hatchery populations. Brahmaputra hatchery population was also significantly higher in two meristic characters (PCFR and CFR). For allozyme electrophoresis nine enzyme markers were used viz.: *Est-1**, *G3pdh-2**, *Gpi-1**, *Gpi-2**, *Ldh-1**, *Ldh-2**, *Mdh-1**, *Mdh-2* and Pgm** where three loci (*Est-1**, *Gpi-2** and *Pgm**) were polymorphic ($p>0.95$) in Anudan and Brahmaputra hatchery populations. The mean proportion of polymorphic loci per population was higher (33.3%) in Brahmaputra and Anudan hatchery populations. Also the expected heterozygosity levels were 0.149 and 0.177 in Brahmaputra and Anudan hatchery populations, respectively. Based on Nei's (1972) genetic distances, the UPGMA dendrogram grouped the populations into two clusters. The Brahmaputra and Anudan populations are in one group; Shambhuganj, and Bhai-Bhai populations are in the second group. High genetic variation in Thai pangas was observed in the Brahmaputra and Anudan hatchery populations and less variation in the other two hatchery populations.

Key words: Allozyme variation, Morphological variation, Hatchery stocks, Thai pangas

Research findings

- Three morphometric characters (BDA, PELFL and HW) and two meristic characters (AFR and CFR) of Anudan hatchery populations were found to be significantly different ($p>0.001$) from those of the other three populations. Two

meristic characters (PCFR and CFR) of Brahmaputra population were also significantly different from those of the other three populations.

- *Est-1**, *Gpi-2** and *Pgm** were polymorphic ($p>0.95$) in Anudan and Brahmaputra populations.
- The mean proportion of polymorphic loci per population was higher (33.3%) in Brahmaputra and Anudan populations than in the other two hatchery populations. The expected heterozygosity levels in Brahmaputra and Anudan hatchery populations was 0.149 and 0.177, respectively.
- Shambhuganj and Bhai-Bhai population showed less allozyme variation and no genetic distance in the plotted dendogram.

Policy implications

- Genetic characterization through using allozyme markers can be used as one of the useful techniques for identification of genetic status of the existing hatchery populations of Thai pangas in Bangladesh.
- For breeding and quality seed production, Thai pangas brood stock with high genetic variability should be used.
- Identification of genetic status of the hatchery population can foster greater scope for their dissemination through satellite stations ofDoF.

Livelihood implications

Broodstock with high genetic variation will certainly ensure the production of quality seed of Thai pangas in the existing hatcheries of Bangladesh. Therefore, it has tremendous livelihood implications for seed producers and catfish growers.

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Development of artificial breeding techniques for long-whiskered catfish, *Sperata aor* and giant river catfish, *Sperata seenghala* of Bangladesh

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Abstract
Sperata aor and *S. seenghala* are the two important native catfishes of Bangladesh but commercial farming of these species is not possible due to lack of naturally collected or artificially produced seeds for stocking. Attempts were made to develop techniques for seed production by artificial breeding and nursery-rearing of fries of these catfishes. A total of 60 *S. seenghala* (750-1,500 g) and 10 *S. aor* (600-1,000 g) broods were collected from the Brahmaputra river-basin and floodplains in Mymensingh region four months prior to their breeding season. The collected brood fishes were reared in separate earthen ponds with supplementary feeds comprising of rice bran (40%), mustard oil cake (29%), fish meal (30%) and vitamin-premix (1%). Three experiments were cond8ucted to optimize the hormone dose. A total of nine *S. seenghala* females weighing from 750 to 1,500 g were given an initial and resolving dose of 12-20 and 16-24 mg PG/kg body weight, respectively. The males weighing from 650-950 g were administered a single dose of 18-26 mg PG/kg body weight at the time of the time of administering the resolving dose to the females. The females ovulated partially and the eggs were examined under a compound microscope, but most of them were found to be less ripe or damaged. Collection of milt by stripping the males was not successful. The testes were taken out and sperm were observed to be non-motile and less developed. In view of stimulating natural propagation of *S. seenghala*, artificial holes (nests) were constructed in the pond bottom. Each hole was 0.7 m in diameter and 0.3 m in depth. A total of 10 holes were made and then 10 pairs of *S. seenghala* breeders (800-1,200 g) were stocked in the pond. In mid February, 3,000 fry of *S. seenghala* with a mean length of 4.60 cm and weight of 0.36 g were collected by repeated netting followed by drying of the pond. The fry were then stocked in a nursery pond and fed with commercial feed (SABINCO starter-1). The average length and weight of the fingerlings were 9.01 cm and 3.95 g, respectively and the estimated survival was 60% after two months of rearing. *S. aor* did not respond to natural spawning. Further study is essential to develop techniques for their successful artificial and natural breeding.

Key words: Artificial and natural breeding, Catfish, *Sperata aor, Sperata seenghala*

Research findings

- Induced breeding of *S. seenghala* was not successful due to lack of knowledge and skill to identify the brood fishes with proper gonadal maturity.
- Natural breeding appeared to be successful in case of *S. seenghala* but not in case of *S. aor*.
- *S. seenghala* fry were produced through natural breeding. Fingerlings attained an average mean length of 9.01 cm and weight of 3.95 g after two months of rearing.
- Survival rate of *S. seenghala* was 60%.

Policy implications

- Steps should be taken to develop induced and controlled natural breeding technique for small and medium scale seed production of *S. seenghala* and *S. aor*.
- Biology of *S. aor* and *S. seenghala* should be investigated thoroughly to understand their gonadal development and natural breeding phenomena.
- Government should take initiative for conservation of gene pools of *S. aor* and *S. seenghala* and their natural habitats e.g. floodplains, rivers, reservoirs, lakes etc.
- Induced breeding and mass seed production techniques of *S. aor* and *S. seenghala* should be developed to supply the seeds for commercial farming as well as to save the gene pools of these valuable species.

Livelihood implications

Until now *S. seenghala* and *S. aor* are produced in the natural water bodies by natural recruitment. As the fishes are tasty and have high market value, development of artificial propagation and mass seed production techniques might create excellent livelihood opportunities for hatchery/nursery operators, fish farmers and traders.

Bangladesh J. Fish. Res., 9(1): 13-14

Reproductive biology, artificial propagation and larval rearing of two freshwater eels, *Monopterus cuchia* and *Mastacembelus armatus*

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Abstract
Studies on reproductive biology and artificial propagation including larval rearing of freshwater mud eel, *Monopterus cuchia* and spiny eel, *Mastacembelus armatus* were attempted. The gonadosomatic index (GSI) of mud eel ranged from 0.41 (August) to 5.52 (June) in males and 0.53 (August) to 7.61(June) in females. In both cases the GSI showed a peak in June. Fecundity ranged from 228 (TL - 396 mm; W - 78g) to 5510 (TL - 865 mm; W - 630 g). In case of spiny eel, the GSI varied from 0.65 (August) to 8.30 (July) in males and 0.70 (August) to 10.46 (July) in females. GSI showed single peak in July. Fecundity ranged from 570 (TL - 240 mm, W - 30 g) to 10870 (TL - 601; W - 350g). Histology of the testes and ovaries of the eels were carried out to investigate the gonadal development stages during the reproductive months (August to November 2003). In case of male *M. cuchia*, the secondary primordial germ cells, primary spermatogonium, some spermatogonia A and clone of spermatogonium B in testis were observed in September. In October-males different sized lobules having spermatogonia, spermatocytes and spermatids were observed. In the ovary of *M. cuchia*, polygonal shaped oocytes were seen during September. The oogonia were reduced with dense and irregular shaped during October. Numerous pycnotic cells were visible during November. In male *M. armatus* numerous broken lobule walls were found in testes during September. In October, abundant primary germ cells, pycnotic nests of degenerating cells, spermatogonia and spermatids were observed. In females, ovaries had distinct yolk vesicles stage and yolk granules stages in August. In September, the follicular cells of the oogonia were ruptured, shrunk forming irregular shaped in October. Oogonia were also shrunk with thin, irregular shaped structure but broken parts of the ruptured follicular cells were scattered in case of *M. armatus*. Experimental attempts on artificial propagation indicated that both freshwater eels were difficult to breed using inducing agents like pituitary glands (PG) of 10, 20, 50, 100 and 150 mg per kg of body weight. Same doses were used for both sexes with equal sex-ratio. In both cases, brood fish died at higher doses of injection given at 100 and 150 mg PG/kg bodyweight. However, *M. cuchia* breed naturally in cisterns when provided with water hyacinths and tunnel in muddy bottom. *M. cuchia* fed with chopped cooked fish attained a mean weight of 18.75 ± 2.3 g and cent percent survival. While in case of *M. armatus* best growth by weight (12.0 ± 2.48 g) and cent percent survival were achieved using chopped raw fish. Car tyre was observed as best shelter for attaining the mean weight gain 22.53 ± 2.24 g and cent percent survival of *M.*

cuchia. While PVC pipe was found to be the best shelter for *M. armatus*, where it attained the mean weight of 12.73 ± 1.88 g and cent percent survival.

Key words: Reproductive biology, Artificial propagation, Larval rearing, Freshwater eel

Research findings

- Fecundity of *M. cuchia* and *M. armatus* were ranged from 228 to 5,510 and 570 to 10,870, respectively.
- Spent stages of *M. cuchia* and *M. armatus* were identified through gonadal histology and GSI.
- The present attempt on artificial propagation of *M. cuchia* and *M. armatus* was not successful but research need to be continued. *M. cuchia* responded to natural breeding in cisterns under environmental manipulation system.
- Car tyre and PVC pipe were observed to be the best shelters for *M. cuchia* and *M. armatus*, respectively.

Policy implications

- More research is needed to develop the artificial breeding and rearing techniques for *M. cuchia* and *M. armatus*.
- Fishing of *M. cuchia* and *M. armatus* should be banned by Government during breeding period to save biodiversity of these species.
- After the success of mass seed production technique of freshwater eels, commercial breeding and farming can be encouraged at entrepreneur's level.

Livelihood implications

The livelihood of small-scale hatchery operators and rural farmers can be improved by developing the breeding and rearing technology of freshwater eels. Large entrepreneurs can involve unemployed men and women as worker in their farms.

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Status of fish broodstock management and seed production in Bangladesh

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Abstract
The study was conducted with the broad objectives to assess the existing situation of broodstock management and fish seed production in private fish seed farms in Bangladesh. The data were collected from 100 private hatcheries and 40 nurseries in seven upazilas under four districts. There was no shed in forty hatcheries and the owners faced many problems. Brood fish ponds were found suitable for rearing brood fish. About 66% of the hatchery owners collected brood fish from their own ponds and ponds of neighboring areas. Activities like pond preparation; manuring and supplementary feeding were done properly but stocking density of brood fish in 76% of the hatcheries was 3,000-7,000 kg ha^{-1}. Infection of argulosis was found in brood fish of 87% of the hatcheries. About 67% of the hatchery owners practiced inter-species crossing. Major problems faced by the hatchery owners were argulosis of brood fish, unavailability of pure brood stock, inadequate brood fish pond. The hatchery owners were found interested to find out the preventive measures of argulosis, develop pure brood stock of indigenous carp and import pure strain of exotic carp. According to the nursery operators, they cultivated hybrid fry because of high demand, rapid growth and good taste. Problems of using hatchery spawn as mentioned by the nursery operators were inbreeding, under sized and aged brood stock, stunted growth, physical deformities and high mortality of spawn due to unknown causes.

Key words: Broodstock management, Seed production, Hatchery and nursery problems

Research findings

- The majority of hatchery owners (69%) were within the age range of 31-50 years. Most of them (78%) had education from SSC to graduation level. Hatchery management was the main occupation for most of the hatchery owners.
- Two types of pump - electric and diesel were in use in the hatcheries. Number of pumps used in a hatchery varied from one to eight. Leaves of trees and other dirty things used to fall on water as there was no cover in most (94%) of the surveyed hatcheries that allowed algae to grow and water temperature to rise due to open access of sunlight.

- Forty hatcheries had no shed. Total area of brood fish pond in each hatchery ranged from 0.20 to 8.25 ha and the physical conditions were suitable for rearing brood fish.
- The hatchery owners applied supplementary feed such as mustard oil cake, rice bran, fish meal, wheat bran, maize bran, bone dust, broken rice and pulses. The brood fish of 87% hatcheries were found infected by argulosis.
- The experienced hatchery operators had adequate knowledge about hatchery management and induced breeding compared to the new operators.

Policy implications

- Emphasis should be given to find out the preventive measures of argulosis.
- Availability of pure brood fish should be ensured. In addition, brood stock farm may be established in some selected areas of Bangladesh where private entrepreneurs should be encouraged. These multiplier entrepreneur hatcheries will produce and maintain pure broodstock and initiate spawn production from such stocks for distribution among the hatchery/nursery operators.
- The pure strain of exotic carps should be imported by the Government from China and distributed to the hatcheries from time to time.
- Posters, leaflets, booklets etc. should be published and distributed to the hatchery and nursery owners and program in television and radios indicating negative effect of inbreeding and hybridization need to telecast.
- Research program should be undertaken on the use of cryopreserved sperm for quality seed production.
- Fish certification scheme to be adopted and regulated by the Government.

Livelihood implications

Stocking of quality fish seeds in ponds and other suitable confined water bodies will increase fish production in the country and enhance family income of a large number of rural farmers. With these activities, respective sections of the society will be benefited and improve their livelihood conditions.

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Seed production and culture techniques of Genetically Improved Farmed Tilapia (GIFT) in brackishwater environment

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Abstract
Effects of different levels of salinity on survival, growth and gonadal development of Genetically Improved Farmed Tilapia (GIFT) were studied under laboratory conditions in glass aquarium, for a period of ten weeks. The initial individual size of the GIFT was 20.23±4.45 and the salinity levels tested were 0, 5, 10, 15 and 20 ppt. The highest survival of 87.5% was found in 0 ppt and the lowest 60.5% in 20 ppt. Though the survival decreased progressively with increased salinity, there were no significant differences ($P>0.05$) among 0, 5, and 10 ppt (Table 1). Similar to what has been observed in survival, the specific growth rate (SGR %/day) also decreased as of 1.30, 1.24, 1.08, 0.90 and 0.71, respectively, with the increased salinity of 0, 5, 10, 15 and 20 ppt. The gonadal development was highest in 0 ppt with a GSI value of 3.75 and lowest of 2.01 in 20 ppt. In the second experiment, gonadal development and seed production performance of GIFT in brackishwater condition were investigated for a period of three months. Each of the three fine meshed hapas of 20 m^2 made from nylon net was placed in a freshwater (0 ppt) and in a brackish water (10-15 ppt) pond of the Brackishwater Station (BS). GIFT of 65 g average weight from a single cohort were stocked into three hapas at a rate of 2 m^{-2}. The male vs female ratio was 1:3. The development of gonad was faster with the higher gonadosomatic index (GSI %) of 3.85 % in freshwater condition than that of 2.73 % in brackish water. Within three months of the study period, a total of 70,510 and 44,250 GIFT fry were produced respectively, in freshwater and brackishwater conditions. Finally under third experiment, a participatory on-farm trial was carried out to evaluate the production performance of GIFT in monoculture and in polyculture with silver barb in coastal freshwater pond conditions. Nine ponds were selected for three treatment combinations of GIFT monoculture (T_1), GIFT and silver barb polyculture (T_2), and silver barb monoculture (T_3). The ponds have been stocked in April, 05 at a density of 25,000 fry ha^{-1}. Fishes were fed with rice bran at the rate of 6% bw day^{-1}. In one month culture period, GIFT attained an average weight of 16.27 g in monoculture and 17.23 g in polyculture, against an average stocking weight of 0.37 g. Silver barb reached an average weight of 16.62 g in polyculture with GIFT and 10.01 g in monoculture, against an average stocking weight of 3.79 g.

Key words: GIFT, Brackishwater, Survival, Growth, Gonadal development

Table 1. Mean weight gain, survival and GSI of GIFT under different salinity levels

Treatments/ salinity (ppt)	Initial weight (g)	Final weight (g)	Survival (%)	SGR (% day^{-1})	GSI (%)
0		50.0 ± 8.5	87.5	1.30	3.75
5		48.0 ± 1.4	75.0	1.24	3.62
10	20.23 ± 4.45	43.0 ± 6.1	62.5	1.08	3.25
15		38.8 ± 7.9	61.0	0.90	2.51
20		33.3 ± 6.8	60.5	0.71	2.01

Research findings

- GIFT can tolerate salinity level of 20 ppt with a survival rate of 61%.
- The specific growth rate of GIFT in a salinity of 15 ppt is similar to that of it in freshwater (0 ppt) condition.
- The GSI values of GIFT also do not vary significantly within the salinity levels of 0 to 15 ppt.
- GIFT can survive, grow, mature and breed well in brackishwater environment with a salinity level up to15 ppt.
- About 0.11 million GIFT fingerlings have been distributed among the fish farmers in Paikgacha region for stocking in household rain-fed ponds and shrimpghers.

Policy implications

- As GIFT can survive, grow, mature and breed in 15 ppt salinity as it does in freshwater (0 ppt) and has a shorter culture period (4-5 months), it could be one of the potential aquaculture candidate in coastal region.
- If GIFT could be introduced in shrimp ghers, either concurrently or alternately, it may not only compensate the severe and sudden loss of shrimp due to disease but also act as a biological mean of disease prevention through its role in minimizing soil and water quality degradation.
- Mass awareness is needed for introducing GIFT in coastal areas as a single aquaculture species or as a co-species in crop diversification in shrimp culture.
- Further research and development activities should be undertaken towards maintaining the pure strain and improvement of stock and in assessing the role of GIFT in shrimp culture.

Livelihood implications

Fisheries are the main livelihood option for the majority of the coastal poor people. Coastal aquaculture, mainly shrimp farming, has emerged as an industry playing a vital role in employment generation and poverty alleviation in coastal region. However, the present state of less abundance of fishes in coastal waters and out-break of disease in shrimp ghers is pushing the coastal people below the poverty level. This situation could be minimized to some extent through species diversification and bringing a huge number of household brackishwater ponds/ditches in coastal region under aquaculture. The results of the present study indicates that GIFT could not only be introduced in brackishwater aquaculture, but also be cultured in household ponds/ditches with economic significance from the point of aquaculture concept. If GIFT seed supply and technological back up are ensured with a mass awareness, rural farmers in the coastal region would be immensely benefited with nutritional upliftment and sustainable livelihood.

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Development of low cost feed using local ingredients for culture of freshwater prawn, *Macrobrachium rosenbergii* in ponds

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Abstract
Two experiments were conducted to formulate and evaluate test diets using locally available ingredients to find out suitable diets for mono and polyculture of *Macrobrachium rosenbergii* in ponds. The first experiment was conducted from 1 July 2003 to 29 September 2003 in 12 experimental ponds each measuring 30 m^2 behind the Fisheries Faculty Building, BAU campus, Mymensingh. Three experimental diets containing 30% protein were formulated using fish meal, meat and bone meal, mustard oilcake, sesame meal and rice bran and assigned to treatments 1, 2 and 3, respectively. A special shrimp feed (Starter-II) from Saudi-Bangla Fish Feed Ltd. was assigned to treatment 4 (Control). Each treatment had three replications. Juveniles of *M. rosenbergii* (2.90±0.81g) were stocked at the rate of 4/m^2. Prawns were fed three times daily at the rate of 15% of their body weight at the beginning, which was gradually reduced to 10% and 5% for the last two months. There was no significant ($P>0.05$) difference between the weight gains of prawns fed diets 1 and 4 (control), but they were significantly ($P<0.05$) higher than those of diets 2 and 3. The FCR values of diets ranged between 2.61 to 3.36 with diets 1 and 4 showing significantly ($P<0.05$) lower FCR values. The survival rate of prawns ranged between 68 to 78% with prawns fed diets 1 and 4 showing significantly higher survival rate. The production of prawn ranged from 921 to 1,428 kg/ha/90 days and diet 1 gave the highest production. Treatment 1 gave the highest net profit of Tk. 161,980/ha/90 days. The second experiment was conducted from December, 2003 to April, 2004 to see the growth of over wintered *M. rosenbergii* juveniles in polyculture with indigenous major carps (catla and rohu) in ponds using formulated diets. Three isoenergetic experimental diets formulated using fish meal, meat and bone meal, mustard oil cake, rice bran, wheat bran and molasses, and a shrimp feed 'Golda special feed' from Saudi-Bangla Fish Feed Ltd. were assigned to treatments 1, 2, 3 and 4 (control), respectively, each treatment had two replications. Eight experimental ponds each measuring 80 m^2 in the Field Laboratory Complex of the Faculty of Fisheries, BAU campus, Mymensingh were used. The mean initial weights of *M. rosenbergii,* catla and rohu were 1.60±0.01, 30.0±0.09 and 25.0±0.08 g, respectively. A total of 160 fish and prawn (20,000/ha) were stocked in each pond at the ratio of 2:1:1 (prawn: catla: rohu). Fish were fed at the rate of 3-5% of their body weight. Prawns fed diet 1, 2 and 4 showed higher weight gains compared to diet 3. The weight gain of catla was significantly higher in T_1 while in case of rohu was higher in T_1 and T_4, respectively. There were no

significant differences (P>0.05) in the survival rate of fish as obtained from different treatments. The overall total fish production ranged from 2196 to 2679 kg/ha/5 months. The highest production and the highest profit (Tk. 56,531/ha/5 months) was obtained from T_1 and the lowest (Tk. 24,932/ha/5 months) from T_4.

Key words: *Macrobrachium rosenbergii*, Low-cost feed, Local ingredients, Culture

Research findings

- There was no significant (P>0.05) difference between the weight gains of prawn fed test diet 1 and special shrimp feed (Starter-II) of Saudi-Bangla Fish Feed Ltd.
- The maximum net profit as obtained from diet 1 was Tk 161,980/ha/90 days while that of Saudi-Bangla special shrimp feed (Starter-II) was Tk. 39,683/ha/90 days only.
- The diet containing 20% fish meal, 10% meat and bone meal, 15% mustard oilcake, 15% sesame meal, 35% rice bran, 4% molasses and 1% vitamin premix (diet 1) was found to be the best for monoculture of *M. rosenbergii* in ponds.
- It is possible to culture *M. rosenbergii* with Indian major carps, the highest profit of Tk. 56,531/ha/5 month was obtained from treatment 1 while the lowest (Tk. 24,932/ha/5 months) from treatment 4.
- Supplemental feed consisting of 25% fish meal, 10% meat and bone meal, 15% mustard oilcake, 20% rice bran, 20% wheat bran and 5% binder was the best for polyculture of *M. rosenbergii* with Indian major carps.

Policy implications

- Culture of golda, *M. rosenbergii* in freshwater ponds should be encouraged and availability of the golda PL/Juveniles should be ensured through government initiatives.
- Cheaper feed using local feed ingredients as developed through the present study should be made available to the rural farmers who can not afford to buy costly commercial feeds.
- For profitable golda farming, farmers can also use over-wintered *M. rosenbergii* juveniles for polyculture of golda with indigenous major carps in ponds.
- The government and non-government agencies involved in the fisheries development should take initiatives to motivate the rural farmers to incorporate golda in the carp polyculture system.

Livelihood implications

The present study has great implication on poverty reduction and livelihood improvement of the rural farmers by introducing golda farming in ponds. The use of locally available feed ingredients for formulating diets for the monoculture of *M. rosenbergii* in pond farmers can maximize their profit margin because such feeds are much cheaper than the commercial feeds. The other positive approach is the incorporation of over-wintered golda juveniles in the carp polyculture system in ponds. As the hatchery operators in Bangladesh do not get proper price for the PLs they produce in the later stage of the production cycle and some times they can not even sell them, so they are compelled to rear them at high stocking densities during the winter months. So, introduction of over wintered golda juveniles in the carp polyculture in ponds can utilize the lately produced PLs, which have a positive livelihood implication for the hatchery operators as well as for the rural farmers.

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Culture potentials of bata, *Labeo bata* under semi-intensive management system

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Abstract
Small indigenous fish species (SIS) provide food, nutrition, subsistence and supplemental income to a great majority of the people particularly the poor and disadvantaged people of Bangladesh. To date nobody explored the possibilities of culturing these species in combination with the indigenous major carps viz. catla, *Catla catla*; rohu, *Labeo rohita*, and mrigal *Cirrhinus cirrhosus* and grass carp, *Ctenopharyngodon idellus*. An experiment on the polyculture of carps with a popular SIS, bata (*Labeo bata*) was carried out to evaluate the production performance of carp-SIS culture in on-farm condition during 15 March to 15 September 2003. Three treatments each having three replications with different stocking densities of bata were tested keeping the carp species combination and stocking density similar in all the treatments viz. treatment 1 (T_1), bata (5,000/ha) + catla, rohu and mrigal (5,000/ha at the ratio of 1:1:1) + grass carp (250/ha); treatment 2 (T_2), bata (7,500/ha) + catla, rohu and mrigal (5,000/ha at the ratio of 1:1:1) + grass carp (250/ha); and treatment 3 (T_3), bata (10,000/ha) + catla, rohu and mrigal (5,000/ha at the ratio of 1:1:1) + grass carp (250/ha). After six months rearing, the production obtained were 2,466±77, 2,395±85 and 2,074±72 kg/ha from T_1, T_2 and T_3, respectively. The highest production was obtained from T_1, where the stocking density of bata was the minimum (5,000/ha) while the lowest production was obtained from T_1, where the stocking density of bata was maximum (10,000/ha). Significant difference ($P<0.05$) exists in the production levels as obtained from different treatments. The contribution of bata to total production was 10.31%, 13.96% and 14.38% in case of T_1, T_2 and T_3, respectively.

Key words: Culture potentials, *Labeo bata*, carp polyculture, semi-intensive management

Research findings

- Bata attained an average weight of 62±3.83 g, 54±3.88 g and 42±3.0 g in T_1, T_2 and T_3, respectively. There is a significant difference ($p<0.05$) in weight gain as obtained from different treatments.