Broodstock Management Status and Some Suggestions to Control Negative Selection and Inbreeding in Hatchery Stocks in Bangladesh

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Abstract

The freshwater river systems and floodplains of Bangladesh are the breeding grounds for 13 endemic species of carps and barbs and a large number of other fish species, including a number of exotic carps and other species that have been introduced for aquaculture. Since 1967, breeding of endemic and exotic aquaculture species for seed production through hypophysation techniques has become a common practice. Over 700 hatcheries established in the private and public sectors have been breeding 13 endemic and 13 exotic fish species and contributing more than 98% (about 117 000 kg) of the total spawn (hatchery) production. Stock deterioration in hatchery populations due to poor broodstock management and inbreeding depression has been observed. Retarded growth, poor reproductive performance, morphological deformities, increased incidence of disease and mortality of hatchery-produced seeds have been reported. The widespread stocking of such genetically poor quality fish seed in closed and open waterbodies is causing concern. In this situation, there is an obvious need to adopt proper broodstock management strategies and breeding plans for commercially important fish species.

The paper describes the present status of broodstock management, identifies problems, and suggests some guidelines to control negative selection and inbreeding in hatchery stocks in Bangladesh.

Introduction

Breeding of endemic and exotic aquaculture species for seed production through hypophysation has been a common practice in Bangladesh since 1967 (Ali 1997). Over 631 hatcheries have been established in the public and private sectors (Ali 1998). These hatcheries contribute 98% of the total spawn[1] (hatchlings) production, the rest coming from natural sources mainly from rivers and their tributaries (Banik and Humayun 1998).

Most hatcheries rear their own broodstock and usually do not recruit broodstock from natural sources (rivers) or exchange breeders between farms. Each hatchery, therefore, can be considered as an isolated, self-sustaining and genetically closed unit (Eknath and Doyle 1990). It is now established that in genetically closed hatchery systems, potential selective pressures exerted on finite and often small culture populations by various farm management practices such as the selection of founder stock, number of breeders maintained, method of replenishing broodstock, stocking density, feeding regime etc., can result in 'indirect' or 'negative' selection, inbreeding and genetic drift (Doyle 1983).

Data collected from finfish hatcheries located in Jessore, Comilla and Mymensingh in Bangladesh revealed that most of the hatchery operators lack knowledge of simple broodstock management practices and do not follow any principles or guidelines in selecting adequate sized breeders, injecting hypophysation dosage and mating unrelated male and female spawners (Hussain and Mazid 1997). Ignorance of appropriate hatchery procedures leads to negative selection due to the use of fish of undesirable size and leftover broodstock, and mating breeders generation after generation from closely related or finite populations. Stock deterioration in hatchery populations due to poor broodstock management and inbreeding depression has been observed. Retarded growth, reduction in reproductive performance, morphological deformities, increased incidence of disease and mortality of hatchery produced seeds of carps and silver barb have been reported in recent years.

Presumably, a large quantity of such poor seed is being used in aquaculture and also stocked in floodplains and open waterbodies in Bangladesh. There is widespread

[1]In the Indian subcontinent, the term spawn is used for hatchlings.

concern that mass stocking of such genetically poor quality stocks in the floodplains and related open waterbodies might cause serious feral gene introgression in wild stocks which would ultimately adversely affect aquaculture and inland openwater fish production in the country. To avoid loss of genetic diversity and inbreeding depression problems in hatchery populations, proper broodstock management strategies and effective breeding plans for commercially important fish species need to be designed and implemented.

This paper highlights the present status of broodstock management in Bangladesh, identifies the problems and suggests some guidelines to control 'indirect' or 'negative' selection and inbreeding in hatchery stocks of cultured fish species.

Table 1. List of endemic and exotic fish species used for artificial seed production in hatcheries in Bangladesh.

Family	Species	Local name
Cyprinidae	*Labeo rohita*	Rohu
	Catla catla	Catla
	Cirrhinus mrigala	Mrigal
	Labeo calbasu	Calbashu
	L. bata	Bata
	L. gonious	Gonious
	Puntius sarana	Barb
	Tor putitora	Tor mahseer
	Ctenopharyngodon idella	Grass carp
	Mylopharyngodon piceus	Black carp
	Hypophthalmichthys molitrix	Silver carp
	Aristichthys nobilis	Bighead carp
	Cyprinus carpio var. communis	Common carp
	Cyprinus carpio var. specularis	Mirror carp
	Barbodes gonionotus	Silver barb
Claridae	*Clarias batrachus*	Asian catfish
Siluridae	*Ompok pabda*	Pabda
Bagridae	*Mystus cavasius*	Gulsha
Anabantidae	*Anabas testudineus*	Climbing perch
Heteropneustidae	*Heteropneustes fossilis*	Asian catfish
Schilbedae	*Pangasius sutchi*	Thai pangas
Claridae	*Clarias gariepinus*	African catfish
Chichlidae	*Oreochromis niloticus*	Nile tilapia
	O. mossambicus x O. niloticus	Red tilapia
	O. niloticus	GIFT strain

Breeding Practices in Hatcheries

Fish Species Used

Most of the freshwater river systems and floodplains of Bangladesh are breeding grounds for endemic carps and other species. There are at least 13 species of carps and barbs under six genera in the waters of Bangladesh. Presently, eight species of carps and barbs and five other species *(Clarias batrachus, Ompok pabda, Mystus cavasius, Anabas testudineus* and *Heteropneustes fossilis)*, are being bred and their seed produced in hatcheries. In addition, seeds of 13 exotic species are also being produced in hatcheries (Table 1).

Production

With the successful development of induced breeding practices, a number of hatcheries were established in the public sector during the 1970s. Subsequent training provided by government institutions resulted in the establishment of hatcheries in the private sector. During 1988, a total of 77 hatcheries were operating in the public sector and 162 in the private sector. By 1997, there were 102 public and 631 private hatcheries producing 117.2 t[2] of spawn, respectively (Table 2).

Problems

In view of the concern about genetic deterioration in hatchery stocks, a team of scientists from the Bangladesh Fisheries Research Institute and ICLARM conducted a survey of hatcheries in Jessore and Comilla in 1994 to assess practices followed by the hatcheries for broodstock handling and management. Immediately after the survey, a two-day workshop on Broodstock Management and Opportunities for Genetic Improvement of Cultured Fish Species was organized. It was attended by scientists, policymakers and a large number of managers of government and private hatcheries. The surveys and

Table 2. Number of fish hatcheries and spawn production in Bangladesh.

Year	No. of hatcheries		Spawn production (kg)	
	Public sector	Private sector	Natural sources	Hatcheries
1985			19 362	4 962
1986			13 222	6 287
1987			22 008	8 339
1988	77	162	12 533	6 849
1989	84	185	12 236	5 663
1990	89	204	5 128	14 773
1991	89	218	6 855	24 683
1992	89	222	9 342	35 851
1993	102	256	4 913	48 964
1994	102	297	5 000	52 500
1995	102	390	5 000	78 000
1996	102	498	3 900	95 000
1997	102	631	2 399	117 212

[2]1 kg contains 400 000 spawn or hatchlings.

discussions during the workshop revealed that the recent stock deterioration in hatchery populations is due to poor broodstock management, inbreeding depression (possibly due to sib or parent vs. offspring mating) and hatchery managers' lack of knowledge of good overall hatchery maintenance and operation techniques.

Broodstock Replacement and Handling Methods

The common practice in the majority of fish hatcheries in Bangladesh is to replenish broodstock from: (i) internal sources (from the hatchery itself or from nurseries that received hatchlings from that particular hatchery); or (ii) external sources (collecting fingerlings/breeders from growout ponds which have received fingerlings from other hatcheries or from riverine sources). There has been unconscious 'negative' selection in some hatcheries as relatively bigger (and hence fast-growing) individuals from growout ponds are sold and the remaining smaller (and hence slow-growing) fish are used for broodstock replacement. This practice is also followed by nurseries in selling fast-growing hence 'good' fingerlings and keeping the smaller unsold fingerlings to raise as broodstock. In a given spawning season, it is generally the bigger breeders that are induced to spawn during the early part of the spawning season while the relatively smaller individuals are spawned during the later part of the season. If the fish seed produced early in the spawning season from bigger broodfish (probably fast-growing) are sold and seed produced in the later part of the season from smaller broodfish (probably slow-growing) are retained to build up broodstock by the hatchery operator, it will ultimately result in 'indirect' or 'negative' selection. Negative selection is one of the major reasons for poor growth and survival performance of farmed fish in Bangladesh.

The survey revealed that some hatchery operators use carp broodfish of a very small size, even less than 500 g each in weight, and this affects the quality of seed produced. Later, this was documented through a survey and interview of hatcheries (Table 3).

Inbreeding Depression in Hatchery Stocks

With the rapid expansion of fish culture operations in recent times, farmers solely depend on hatcheries for their seed requirements, whereas in the past a major portion of the seed was collected from rivers. There is every possibility of inbreeding in these hatcheries, where female and male breeders are chosen from a finite (small) population for mating, with a greater chance of crossing sib (brother-sister) or closely related fish. Moav and Wohlfarth (1976) stated that a single full sib mating of a particular fish might result in 10-20% depression in growth and a considerable proportion of individuals might show physiological abnormalities. Because of generations of inbreeding and accumulation of unfavorable alleles from close mating, genetic deterioration of the existing cultured farmed stocks might make them less suitable for culture. An inbred or homozygous population normally loses its general vigor.

This results from a lack of knowledge of broodstock management practices, especially about the need for recruitment of new breeders into the stock at regular intervals, maintenance of proper stocking density of broodfish and their balanced feeding, selecting broodfish of a desirable size, injecting adequate hypophysation dosage, mating unrelated female and male breeders, basic disease control, water quality maintenance, and record keeping of broodstock and spawning.

Table 3. Size of broodfish used in hatcheries in Bangladesh.

Group	Scientific name	Weight of brood fish (kg)	Remarks
Carp	*Labeo rohita*	0.5 - 0.8	•••
	Cirrhinus mrigala	0.5 - 0.8	•••
	Catla catla	1.5 - 2.0	••
	Hypophthalmichthys molitrix	0.8 - 1.0	••
	Aristichthys nobilis	0.8 - 1.5	••
	Ctenopharyngodon idella	1.0 - 1.5	••
	Cyprinus carpio var. *specularis*	0.6 - 1.0	•
	Cyprinus carpio var. *communis*	0.5 - 0.8	•
Barb	*Barbodes gonionotus*	0.1 - 0.15	••
Catfish	*Pangasius sutchi*	1.0 - 1.5	••
	Clarias gariepinus	0.4 - 0.7	•
	Clarias batrachus	0.1 - 0.15	•

Note: ••• Extremely undesirable •• Moderately undesirable • Fairly undesirable

Suggestions

A hatchery should have short-term and long-term plans to avoid the risk of negative selection and inbreeding and build genetically improved stocks. The following practices are suggested to minimize 'indirect' or 'negative' selection in hatcheries:

- the base population should be collected from natural waters (river, floodplain, etc.) or from a known source. Records of location of collection, date of collection/transfer, species, size and weight of the stock, number of individuals at the time of stocking in nursery/rearing ponds, etc., should be kept;
- the fast-growing and best-looking individuals from nursery/growout ponds should be selected for raising as broodstock and few individuals from as many stocks as possible for each species should be selected;

- the broodfish should be marked (e.g., Alcian blue) or tagged (e.g., numbered plastic tags or more sophisticated AVID tags) for record keeping; and
- hatchery-produced seed of different selected stocks should be stocked separately or in a pool. All necessary records, like number of breeders used in each slot with their tag numbers, date of spawning, date of hatching, date of stocking and number of individuals stocked in each nursery/rearing pond, should be maintained.

Stock deterioration due to accumulation of inbreeding can be avoided by:

- keeping an adequate number of broodfish (a medium-sized hatchery needs to keep at least 3 000 to 5 000 breeders per species) in order to select the best performers in terms of size, maturation and breeding efficiency;
- maintaining pedigree records to reduce or avoid the chance of mating between closely related breeders;
- exchanging broodstock among hatcheries to minimize inbreeding;
- maintaining effective population size in a hatchery; and
- adopting a well-planned selective breeding and line-crossing program to improve desirable traits in founder stocks.

It has been suggested that the government should impose restrictions on the minimum size and age of fish to be used for breeding in order to control indiscriminate use of inferior quality broodstock for seed production by the hatcheries. The desirable size, particularly for female breeders, should be as follows: *L. rohita* >1 kg, age 2 years; *C. mrigala* >1 kg, age 2 years; *C. catla* >3 kg, age 3 years; *H. molitrix* >1.5 kg, age 2 years; *A. nobilis* >2.0 kg, age 2 years; *C. idella* >2.0 kg, age 2 years; *C. carpio* >1 kg, age 1 year; *B. gonionotus* >0.2 kg, age 1 year; *P. sutchi* >2 kg, age 2 years; *C. gariepinus* >0.8 kg, age 1 year; *C. batrachus* >0.2 kg, age 1 year.

The government should establish 'brood banks' where wild germplasm can be preserved and maintained and genetically improved broodstock developed. Periodic assessment of hatchery conditions should be made throughout the country by a team of experienced fish breeding scientists/specialists. Finally, hatchery staff/managers should be trained in simple broodstock management practices.

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