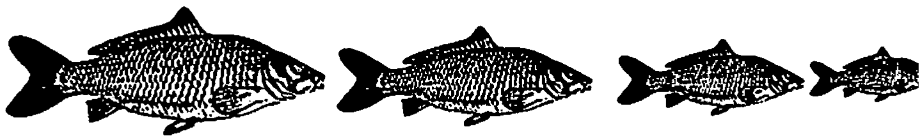
# Simple Broodstock Management to Control Indirect Selection and Inbreeding: Indian Carp Example



*Far from being sources of improved fish seed for farmers, some tropical hatcheries may actually be doing the reverse – inadvertently causing negative selection, producing, for example, slower growing fish.*

AMBEKAR E. EKNATH
*ICLARM*

Whether or not conscious genetic manipulation to improve the stocks of fish in a hatchery is practised, there will always be indirect selection pressures exerted by farm management practices such as choice of the founder stock, the number of breeders maintained, the type of mating system followed, the method of replenishing the broodstock, stocking density and feeding regime. Such accumulation of genetic changes from generation to generation will eventually lead to permanent changes in the cultured stocks.

The indirect selection imposed by various management decisions can be of the same magnitude as direct, artificial selection, and can either augment or diminish the effectiveness of organized selection programs.

Since the advent of the hypophysation technique (injection of crude extracts of pituitary glands) of induced spawning in the mid-1950s, Indian carp hatcheries have been virtually closed to genetic exchange with the wild stock. They have one major function: to produce and distribute fish seed until a predetermined annual production target is met. The breeding procedure begins with selection of potential breeders and their segregation by sex about two months prior to the breeding season. Large hatcheries maintain separate broodstock ponds, while smaller hatcheries isolate breeders temporarily into separate ponds during the breeding season. Replenishment of broodstock occurs as and when necessary. Individuals for replenishment invariably come from within the hatchery.

## Indirect Selection

An essential prerequisite for selection analysis is data on comparative performance of individuals in a population. Specifically, "longitudinal" data on traits such as growth rates, age at first maturity and general growth characteristics throughout the life of an individual are necessary. Such data are usually unavailable but can be estimated indirectly by statistical manipulation of information from important fish scale features, namely, number and radial measurements of growth checks, circuli counts and circulus spacing. Using this approach, the mean superiority (for a given trait) of the breeders selected for fish seed production relative to mean values of selected and unselected individuals in hatcheries can be estimated. In genetic parlance, this is called intensity of selection.

The intensity of selection on important traits in some southern Indian hatcheries has been surveyed, and a representative example is presented in the Table. The broodstock selection there was size selective, exerting strong, negative selection on prematuration growth rate and positive selection on age at first maturation. In other words, there was a tendency in this hatchery to breed inadvertently slower growing and later maturing individuals.

**Intensity of indirect selection on important traits during selection of breeders for fish seed production (values are in standard deviation units) in a representative carp hatchery in south India. The traits were estimated indirectly by using fish scales. Fish hatcheries choose mainly larger breeders which turn out to be older. The indirect selection on prematuration growth rate is strongly negative.**

| | Selected breeders |
|---|---|
| Estimated age | 0.765 |
| Estimated prematuration growth rate | -0.306 |
| Estimated age at first maturation | 0.388 |
| Estimated size at first maturation | 0.275 |

## Approaches to Avoid Negative Selection

Data on sizes of individuals chosen for fish seed production and their reproductive performance are routinely recorded in Indian carp hatcheries. To complement these data, records of size when fish are transferred from nursery to rearing ponds, and from rearing ponds to the broodstock pool, are essential. One of the easiest ways of avoiding negative selection on prematuration growth is to select broodstock when they are young and when only fast growing individuals have matured.

A hatchery manager may also consider marking (e.g., using injected dyes) of individuals of different year classes. This way, relatively larger breeders of a given year class can be chosen for seed production and broodstock replenishment.

### Inbreeding

Inbreeding can be broadly defined as the mating together of individuals that are related to each other by common ancestry. The degree of relationship between mating pairs is measured as the coefficient of inbreeding (F). F is essentially a comparison between the population at a given time and the ancestral or 'founder' population in which F is defined to be zero. The number of individuals comprising the founding population sets the upper limit on the number of genes in the founding population. This founding sample of genes may represent a high or a low level of genetic variability.

Inbreeding is a cumulative phenomenon. The rate of accumulation of inbreeding per generation is denoted by $\Delta F$. In finite genetically closed hatchery populations, inbreeding can occur when individuals for replenishment of broodstock come from within the hatchery. The genetic relationships among the individuals will continue to increase with each generation of inbreeding.

The key parameter for estimating rate of inbreeding is the effective population size ($N_e$). $\Delta F$ is inversely related to $N_e$. $N_e$ is the actual number of individuals that contribute progeny to the next generation. $N_e$ is determined not by the total number of breeders used for seed production but by the number of individuals that eventually contribute progeny for the replenishment of the broodstock. Specifically, it is the family size and replacement success which determine $N_e$. Family size refers to the number of progeny of a parent that eventually become breeding individuals in the next generation. Depending on the mating scheme followed, the family size of male and female breeders will vary. $N_e$ will also be determined by the number of males and females contributing progeny. Unequal sex ratios reduce $N_e$ with the less numerous sex having the greatest effect.

In Indian carp hatcheries, the base populations are not well defined. Moreover, conventional techniques for estimating inbreeding rates based on pedigrees and direct census data cannot be applied because such data are unavailable. However, estimates of $N_e$ for a given production cycle can be obtained by using farm records, from which variance of family size can be estimated routinely using certain statistical procedures. $\Delta F$ is estimated as a reciprocal of $2N_e$.

Results from the survey of carp hatcheries in southern India indicated that the $N_e$ ranged from as low as 3 to a maximum of only 30, and the rate of accumulation of inbreeding ranged from 2% to 17%. Higher inbreeding rates occurred in small hatcheries (water area less than 1 ha).

***The indirect selection imposed by various management decisions can be of the same magnitude as direct, artificial selection, and can either augment or diminish the effectiveness of organized selection programs.***

### Approaches to Minimize Inbreeding

The rate of accumulation of inbreeding can be reduced in several ways: increasing the number of breeding individuals as much as possible; maintaining pedigree records; deliberate equalization of family sizes; exchange of stocks between hatcheries; and special breeding systems such as rotational line-crossing schemes.

There are limitations: for example, available facilities and resources for procurement, maintenance and breeding limits for increasing the number of breeders. Maintaining full pedigree records of broodstock can reduce inbreeding by avoiding mating between close relatives. This procedure delays the first increment of inbreeding but achieves very little further. Pedigree records can be useful only in making F more uniform among individuals within a generation.

Broodstock can be arbitrarily divided into several groups (lines) and marked. Mating can then be performed between individuals from different lines on a rotational basis. Broodstock can also be maintained as separate year classes by suitable marking. Crossing between year classes at regular intervals will restore genetic variability to a certain extent.

One of the most practical approaches is to reduce the variance of family size and thereby increase $N_e$. This can be done by keeping a few individuals from all families (or breeding sets) for eventual replenishment of broodstock.

The limited information available indicates poor growth performance of stocks in other carp hatcheries in India also. Given the growing importance of the carp culture industry for the national economy, an organized genetic improvement program should start immediately.

A promising beginning has already been made in this direction. The Central Institute of Freshwater Aquaculture of the Indian Council of Agricultural Research has started comparing the growth performance of hatchery stocks with several "wild" riverine stocks, as was done for tilapias in the GIFT project (see article, p. 3). Preliminary results indicate that the growth performance of riverine stocks is superior to that of the established hatchery stocks. Extensive screening of riverine stocks to build a new base population and initiate a selection program is in progress.

### Further Reading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