Stock evaluation and development of a breeding program for common carp (*Cyprinus carpio*) in Karnataka, India: progress of a research project

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Abstract

Common carp (*Cyprinus carpio*) is the single most important species for aquaculture in the state of Karnataka, India, where it is generally grown in polyculture with Indian major carps. Precocious maturation and unwanted reproduction in the species have been identified as constraints to increase production in aquaculture and culture-based fisheries in Karnataka state. Stocks of *C. carpio* obtained from Hungary (Amur and P3), Indonesia (Rajdanu) and Vietnam (SV) are being assessed alongside two local stocks (L-BRP and L-FRS) in a series of culture performance trials with the objective of setting up a base population for selective breeding. The paper presents progress of research being undertaken at the Fisheries Research Station, University of Agricultural Sciences, Bangalore, India.

Background

Carps are the mainstay of aquaculture in Asia and make a substantial contribution to the livelihoods of poor people through production, consumption and associated activities. Carps feed low down in the food chain, making them suitable for low input aquaculture and for many species the market prices are fairly low, making them affordable as a source of protein for poor people.

While the genetic management and improvement of stocks of all species in aquaculture is important to sustain and improve production, particular problems are presented in the case of non–indigenous species. The founder stocks may have been of poor, or unknown quality, e.g., the stocks of Chinese carps originally introduced into several Asian countries were secondary transfers from countries other than China. Small numbers of parent fish contributing to these or other introductions, or the low survival/breeding rate among the introduced fish, may lead to poor performance associated with low levels of genetic variation (bottlenecking) or a genetic makeup, which is unrepresentative of the parent population (founder effect). For indigenous species, it is often possible to go back to local wild populations to supplement or even replace hatchery stocks that have suffered genetic "degradation". For non-indigenous species, logistical and political factors may make this difficult, along with associated risks of introducing pathogens or other undesirable species. As a result, the introduction of effective genetic management protocols has a particular urgency for introduced species.

Genetic improvement of common carp through stock evaluation and breeding program development

The common carp (*Cyprinus carpio*) has steadily increased in importance, both in terms of seed supply and stocking of fishery and aquaculture systems in

Table 1. Cyprinus carpio *stocks used in the project and the coded abbreviations used*

Strain	Code	Origin	Year obtained
Local-FRSH	L-FRSH *	Indian stocks from a mix of two introductions from Sri Lanka in 1939 (German strain) and Thailand in 1957 (Bangkok strain)	Already present
Local-BRP	L-BRP		Already present
Selected Vietnamese	SV	Base population of stocks from Hungary, Indonesia and Vietnam	1998
Hungary-Amur carp	Amur	River Amur, E-Asia	2000
Hungary P-3	P-3	European	2000
Indonesian-Rajdhanu	RJ	Probably derived from European stock(s)	2001

** Two discrete populations of the local common carp were initially evaluated. The stock at the UASB Fisheries Research Station was discarded after initial evaluation due to significantly inferior culture performance compared to the other local stock from a major state hatchery*

a: *Local stock from Bhadra Reservoir Project, DOF hatchery*

b: *Selected line stock from Vietnam*

c: *Stock from Hungary*

d: *Stock from Indonesia*

e: *Selected line stock from Hungary*

Fig. 1. C. carpio *stocks used in project*

Karnataka, India. *C. carpio* presently grown in Karnataka originated from two introductions to India in 1939 ("German" strain) and in 1957 ("Bangkok" strain) (Jhingran 1991). These have become mixed over many generations to give the current stock. *C. carpio* is grown either alone or in polyculture, most commonly with catla (*Catla catla*) and rohu (*Labeo rohita*).

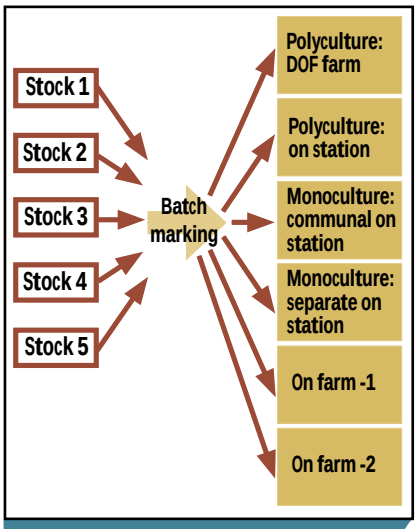

Fig. 2. Design for evaluating different stocks and crossbreds of Cyprinus carpio

According to the available statistics, *C. carpio* now contributes approximately 43 per cent of seed stocked by the Department of Fisheries (Basavaraju et al. 2000) and contributes about 35 per cent to the total inland aquaculture production. Precocious maturation and unwanted reproduction in the species have been identified as constraints to increased production in aquaculture and culture-based fisheries in Karnataka state (Basavaraju et al. 2002). Both males and females can attain sexual maturation well before reaching a marketable size of about 500 g. Even if fish do not spawn and produce fry, the gonadosomal index (GSI) can exceed 20 per cent of the harvested weight of an individual fish. This early maturation poses a potential problem for culture as energy is diverted from somatic growth into gonad development and reproduction. Fry and fingerlings produced as a result of breeding may compete with stocked fish for resources within the culture system.

Various approaches have been assessed for improving the performance of the *C. carpio* including hormonal sterilization, triploidy and monosex production. The most promising and practical approach is to evaluate different stocks of *C. carpio*, set up a base population from the most promising stock(s) and develop a breeding program to improve traits of importance to farmers. The article presents progress of a project implemented at the Fisheries Research Station, University of Agricultural Sciences, Bangalore, India, with funding support from the DFID Aquaculture and Fish Genetics Research Program (AFGRP).

Identification and collection of different stocks of *Cyprinus carpio*

In addition to the locally available stocks, a number of stocks of *C. carpio* from different geographical locations were identified, based on expected properties of rapid growth and delayed maturity. These stocks were introduced to Karnataka, having been obtained through the International Network on Genetics in Aquaculture (INGA), following recommendations on germplasm transfers, quarantine, etc. The number and details of stocks currently held for evaluation after initial screening are presented in Table1.

Performance evaluation of different stocks

The project is currently evaluating several stocks of *C. carpio* (Figure 1) in different culture systems and environments. Some of these evaluations are taking place in farmers' ponds in areas involved in the micro-watershed management research program of the University. Six trials are being conducted over the duration of the project (2001 to 2004) to accommodate different combinations of stocks and crossbreds. The typical design for such trials is shown in Fig. 2.

The fish were batch marked using the fin cauterization technique developed under the project and proven to be a cheap and robust method for batch marking of carps. The trials are conducted over approximately six months of grow-out with intermediate sampling to assess their growth, health and, where appropriate, to reschedule feeding rates. Traits assessed at harvest included weight gain, length, body shape, survival, yield, GSI, dress out weight, and seinability. The data collected are analysed using the SAS statistical package. Three trials i.e., *purelines*, *some crosses* and *their parents* have been completed to date and three more are under progress and will be completed this year. The results from the completed trials involving pure lines indicated that the P3 stock from Hungary and the Rajdhanu (RJ) stock from Indonesia appear to be the most promising in terms of weight at harvest, survival and

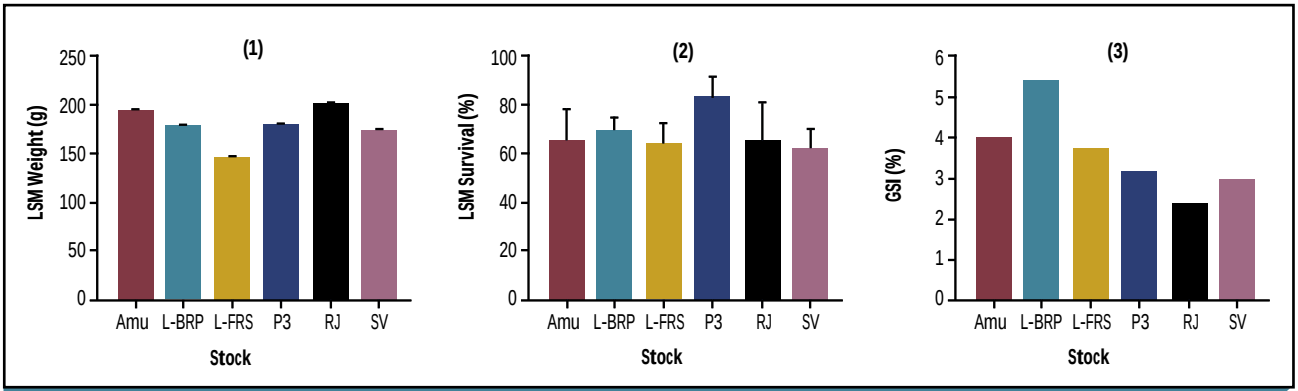

Fig. 3. Graphs showing least square means (LSM) for harvest weight (1), survival (2) and and GSI (3) based on comparisons of the six pure stocks over three successive performance evaluation trials. Results indicate the desirable culture properties of P-3 and Rajdhanu stocks

Table 2. Options for developing a breeding program

Differences between pure stocks	Degree of heterosis in crossbreds	
	Negligible or low	High
Low	Use pure stock parents, chosen at random, to find two selected lines.	Use pure stock parents giving the two best crosses to find a line (selected or just managed with high N_e) based on each parental stock.
High	Use parents from best stocks (more from most highly ranked, less from lower ranked stocks) to find two selected lines.	Use pure stock parents giving the best cross to find one (selected or just high N_e) line based on each parental stock.

GSI. The P3 and RJ stocks were superior to other stocks with a higher mean weight at harvest, low GSI and better survival (Figure 3). However, as the RJ and P3 stocks have undergone evaluation in only a single trial, it is too early to reach a conclusion at this stage (further data from the trials currently underway will be available later).

Prioritization of traits

A preliminary participatory study was undertaken in which 31 farmers/consumers were shown harvested fish which had phenotypic differences in color, scale pattern, and body shape. They were asked to rank these, giving also the main reasons for their ranking. Analysis of the mean ranks for each stock or cross in this survey indicated a very close relationship between the rank and the mean weight at harvest, indicating that size was the influencing preference. Further evidence supporting harvest size as the most important trait comes from a socio-economic survey of fish farmers in Karnataka State, also undertaken by the project.

Breeding program: Options

The approach to genetic improvement of *C. carpio* will be decided after completion of the current trials and data analyses. The approach chosen will depend on the relative differences between the performance of the pure stocks, the degree of heterosis seen in the crossbreds, and the magnitude of genotype-environment interaction. Table 2 illustrates how stock differences and heterosis may influence decisions.

If there is little evidence for significant positive heterosis in crossbreds (evidence available to date is insufficient to evaluate this), selective breeding is likely to be the most effective approach to improvement. Given the limited physical, human and economic resources available for a long-term breeding program, it is likely that a form of adapted mass selection, using two separate lines to minimize the effects of inbreeding, will be the preferred approach to selection.

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