Genetic Status and Strategies for Improvement of Common Carp (*Cyprinus carpio*) in Karnataka, India - Evaluation of Stocks for the Development of a Breeding Programme

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Abstract

The importance of common carp (*Cyprinus carpio*) to aquaculture and enhanced fisheries in Karnataka state, southern India has steadily increased since its first introduction. According to the most recently available statistics, common carp now contributes 43% of the seed stocked by the Department of Fisheries (Basavaraju *et al*., 2000). Precocious maturation and unwanted reproduction have been identified as potential constraints on yields of common carp in aquaculture and culture-based fisheries in Karnataka (Basavaraju *et al*., 2002). Both males and females can attain sexual maturation well before reaching a marketable size. Even if fish do not spawn and produce fry, the gonadosomal index (GSI) can exceed 20% of the harvested weight of an individual fish. This early maturation poses a potential problem for culture, in that energy is likely to be diverted from somatic growth into gonad development and reproduction, and fry and fingerlings may compete with stocked fish for resources within the culture system. Various options such as induction of triploidy, production of monosex populations and evaluation of different stocks were

investigated under a research project funded by DFID FGRP, UK. The present paper discusses the results of the preliminary trials on evaluation of different stocks of common carp, and future strategies planned for the genetic improvement of common carp stocks.

Introduction

The common carp (*Cyprinus carpio*) is an important species in aquaculture and enhanced fisheries in Karnataka state, southern India. It is grown either alone or in polyculture, most commonly with catla (*Catla catla*) and rohu (*Labeo rohita*). The common carp presently grown in Karnataka originate from two introductions to India, in 1939 ("German" strain) and 1957 ("Bangkok" strain) (Jhingran, 1991). These have become mixed over many generations to give the current stock. This stock of common carp is characterised by early sexual maturation (at an age of approximately six months and sometimes at a weight below 100 g) and multiple spawning in a single year. This early maturation poses a potential problem for culture, in that energy is likely to be diverted from somatic growth into gonad development and reproduction, and fry and fingerlings may compete with stocked fish for resources within the culture system. Several local farmers, fisheries officials and scientists have cited this as a problem in the culture of common carp in the state, although the extent of this problem has not been quantified. The problem is unlikely to be as severe as that seen for tilapia but may nevertheless have significant negative impacts on yields.

The bulk of common carp seed production in Karnataka is by the State sector, with approximately 30 State controlled hatcheries producing seed of this species. Whilst there is a greater degree of gene flow in and out of some of these hatcheries than exists for Indian major carp stocks, most of these hatcheries nevertheless function as reproductively isolated units. Furthermore, hatchery managers are commonly focused on producing sufficient quantity of seed to attain prescribed targets, with little if any consideration for the genetic quality of the stocks. Inbreeding, negative selection and genetic drift are likely to have occurred during the long history of domestication of these stocks in such environments, although this is hard to verify (Basavaraju et al., 2000).

There are a number of potential solutions to problems of early maturation:

- Induce sterility by induction of triploidy or through hormonal treatments
- Produce monosex populations, which will not breed and may mature later (sexual maturation is commonly delayed in fish in the absence of the opposite sex).

- Evaluate other strains of the species in the hope of identifying later maturing strains.

The above options were investigated under research funded by DFID-AFGRP, UK.The present paper describes results of initial growth trials on several stocks of common carp and the development of a breeding programme for this species in Karnataka. Faster growing stocks of common carp may also mature later (at a larger size and/or greater age) and are likely to benefit those involved in producing and consuming common carp as long as genetic improvement is carried out in an appropriate way (e.g. selecting for improved performance in low input environments rather than increased appetite).

Identification and collection of different stocks of common carp

A number of stocks of common carp from different geographical locations outside India were identified as having potential for faster growth and delayed maturation. These were imported into India following appropriate quarantine, etc. Two local stocks of common carp were also included in the collections. These stocks are listed in Table 1.

Table 1. List of common carp stocks held by the project component in India and the abbreviations used for them.

Full Name	Abbreviations	Source
Wild Amur Carp	Amur	Hungary
P-3 (Selected Line)	P-3	Hungary
Selected Vietnamese	SV	Vietnam
Unselected Vietnamese	UV	Vietnam
Rajadanu	RJ	Indonesian
Local stock (FRSH)	L-FRSH	Fisheries Research Station, Hesaraghatta
Local stock (BRP)	L-BRP	BRP state hatchery

Evaluation of different stocks of common carp: trial I

The initial growth trials were conducted with the first two imported stocks (SV and UV) and with one local stock of common carp in mono and polyculture systems. For each pond, fingerlings of each stock were reared to a similar size before being communally stocked. Data is presented here from monoculture experiments conducted on station (at FRSH) and polyculture growth trials conducted in a farmer's pond. The fish were marked using PIT tags. The results of two monoculture trials are summarised in Tables 2 and 3, while those from the farmer's pond are shown in

Tables 4 and 5. It is clear from these results and other trials (not shown here) that the performance of the SV was superior to L-FRSH and UV in that it exhibited faster growth rate and lower GSI (gonadosomatic index).

Table 2. Stocking details and mean weight (g) attained by different stocks of common carp in monoculture at final harvest (after 36 weeks of rearing). Means within a column with different letter superscripts are significantly different from each other ($P<0.05$).

Stock	Pond 1		Pond 2	
	Initial wt	Final wt	Initial wt	Final wt
SV	13.41±0.16[a] (55)	238.79±45.97[a] (29)	13.39±0.12[a] (55)	181.6±9.13[a] (25)
UV	12.47±0.38[a] (55)	155.4±23.44[ab] (25)	13.03±0.46[a] (55)	160.38±8.03[a] (26)
L-FRSH	12.29±0.34[a] (55)	106.55±10.32[b] (29)	12.19±0.30[a] (55)	126.21±5.97[b] (29)

Table 3. GSI of different strains of common carp in monoculture at final harvest (after 36 weeks of rearing). Means within a column with different letter superscripts are significantly different from each other ($P<0.05$).

Stock	GSI - Pond 1		GSI - Pond 2	
	Male	Female	Male	Female
SV	8.50±1.00[a] (7)	22.22± 0.00[a] (1)	13.00±3.83[b] (2)	21.88±1.68[a] (6)
UV	10.01±1.23[a] (5)	22.29±1.51[a] (3)	11.76±1.45[b] (4)	18.69±6.58[a] (4)
L-FRSH	11.23±1.78[a] (4)	21.30±1.69[a] (4)	17.61±1.55[a] (5)	22.58±2.33[a] (3)

Table 4. Stocking details and mean weight (g) attained by SV and L-FRSH stocks of common carp in polyculture at harvest in on farm trial, Amareshwara camp. Means within a column with different letter superscripts are significantly different from each other (P<0.05).

Stocks	Initial No.	Initial Mean Wt. (g)	No. Harvested	Mean Wt. (g)	Survival (%)	Wt. Gain (g)
SV	50	6.78 ±0.10[a]	22	444.54 ±22.75[a]	44	437.76 ±22.72[a]
L-FRSH	50	6.69 ±0.14[a]	21	371.19 ±13.88[b]	42	364.45 ±13.90[b]

Table 5. GSI and Dressout percentage of SV and L-FRSH stocks of common carp in polyculture at harvest in on farm trial, Amareshwara camp. Means within a column with different letter superscripts are significantly different from each other (P<0.05).

Stocks	No.	GSI (%)	Dressout (%)
SV males	15	4.90±0.74[c]	88.33±0.84[a]
SV females	7	5.92±1.75[c]	87.24±1.58[a]
L-FRSH males	14	8.47±1.35[b]	81.97±2.44[b]
L-FRSH females	7	12.87±2.00[a]	82.27±1.37[b]

Evaluation of different stocks of common carp: Trial II

With the addition of more stocks, further trials were conducted during 2000-01 under different environments and farming systems. Table 6 shows the general design for this and subsequent trials. Figure 1 presents results from on-station environments in this trial as histograms, while Table 7 gives the mean rank of each stock across the different environments for a range of traits.

Table 6. Generalised trial design - environments and farming systems.

Location	Culture environment	No. of units
FRS	Pond polyculture – communal	1
	Pond monoculture – communal	1
	Concrete tanks monoculture – separate	5 x 2
BRP	Pond polyculture – communal	1
Farmer 1	Pond polyculture – communal	1
Farmer 2	Pond polyculture – communal	1

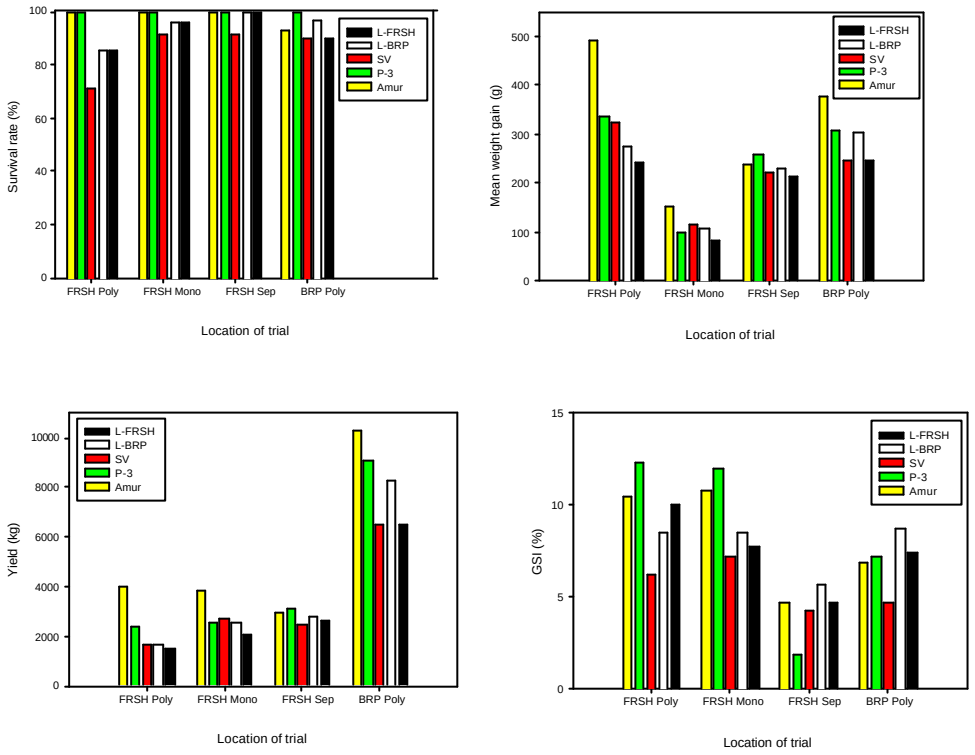

Figure 2. Histograms showing the relative culture performance (survival, mean weight gain, yield and GSI) of five strains of common carp cultured in four different on-station environments. Environments are (from left to right in each histogram) FRSH-Polyculture, FRSH-Monoculture, FRSH-Monoculture (separate stocking) and BRP-Polyculture (see also Table 6).

It is clear from these results that the Amur strain introduced from Hungary is superior for the majority of traits. The other Hungarian strain (P3) showed the highest survival rate during the trial. Interestingly, the SV strain, although performing relatively poorly for most traits, was the best for reproduction-related traits (GSI and dressout).

Table 7. Mean rank of different stocks for a range of traits across four culture systems (highlighted cells indicate highest ranking stock for each trait).

Trait	Amur	P-3	SV	L-BRP	L-FRSH
Survival	2.13	1.63	4.88	2.88	3.50
Weight Gain	1.25	2.25	3.50	3.25	4.75
Harvest Weight	1.25	2.25	3.50	3.25	4.75
Gutted Weight	1.25	2.75	3.00	3.00	5.00
Yield	1.25	2.00	4.00	3.25	4.50
Gutted Yield	1.25	2.25	3.50	3.25	4.75
GSI (%)	2.50	2.50	4.75	2.25	3.00
Dressout (%)	3.00	4.00	1.25	3.25	3.50
Seinability	2.13	2.75	2.75	3.63	3.75

Evaluation of different stocks of common carp and F1 crosses between stocks

The current series of trials focuses on completion of the evaluation of the different stocks and on evaluation of F1 crosses between the better performing stocks to determine if heterosis (superiority of crosses over parental stocks) is found and should be taken into account in future breeding plans. The L-FRSH and UV stocks have been dropped from this series of trials, but the most recent import, the RJ stock, has been added, making a total of five (Amur, P-3, SV, L-BRP and RJ). We are currently running one trial comparing pure stocks and one containing a mixture of F1 and pure parental stocks. Ranking of mean weights from the on-station ponds approximately three months after stocking gives the following overall rank order for the first of these (pure stocks): RJ > Amur > L-BRP > SV. The same analysis for the second trial (pure stocks and crossbreds) gives: Amur > L-BRP*Amur > L-BRP = L-BRP*SV > SV. This data is very preliminary, but does appear to suggest consistency of stock ranking between the two trials (not surprising given that they came from the same breeding sets) and an absence of heterosis in the crossbreds at this stage.

Future activities

The current series of trials will be completed in 2003, allowing us to determine which stocks and/or crosses are best for conditions in Karnataka. Heterosis has been observed in crosses between different stocks of common carp in other situations, and if large may be worth utilising. The exact nature of the breeding plan will be determined by the outcome of the current trials. For example, in the absence of significant heterosis, this may consist of a selective breeding programme based on a synthetic base population developed from the best stocks.

A socioeconomic survey is under progress to study the present status of carp aquaculture in Karnataka and also the perception of farmers and those involved in development of fisheries and aquaculture in the state. The survey will also provide information on the type and socioeconomic status of the farmers. Participatory studies are also expected to help us to prioritise traits for selection.

Cryopreservation will be used to set up a sperm gene bank from the founder stocks: this can be used in the future to replace any unexpected losses and to evaluate progress through selective breeding (eggs from a future generation of carp can be split and fertilised by milt from the future generation and milt from the base stock: comparison of the performance of the two groups should give us a measure of half of the genetic gain). Monosex female production is also being evaluated and may be incorporated into breeding plans.

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