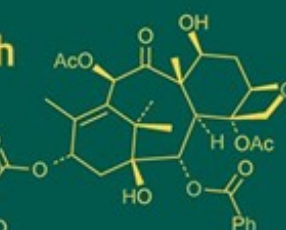


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## Inclusion of indigenous minor carps in polyculture of exotic carps under mid hill condition of the Uttarakhand state

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**ABSTRACT**

A field study was conducted for polyculture of minor carp (*L. dyocheilus* and *Bangana dero*) with exotic carps (*Hypophthalmichthys molitrix*, *Ctenopharyngodon idella*, *Cyprinus carpio*) at the farmer's fields in mid-altitudinal area of Uttarakhand. Four treatments with four replicates viz. polyculture of exotic carp ( $T_1$ - $S_C:G_C:C_C$ ; 30:40:30), polyculture of exotic carp and Minor carp ( $M_C$ ) ( $T_2$ - $S_C:G_C:C_C:M_C$ ; 20:40:20:20), polyculture of exotic carp and Minor carp ( $T_3$ - $S_C:G_C:C_C:M_C$ ; 20:30:20:30) and polyculture of only Minor carp ( $T_4$ - $L. dyocheilus$ : *B. dero*; 50:50) were cultured for one year (Sept. to August). Fingerlings of all the species having size of 20-30 g were stocked @ 3.0 and 4.0 number/ $m^3$  and fed with carp feed @ 3% of their body weight daily basis. During the experiment, water quality parameters were observed as water temperature; 9-20 °C, pH-7.2-7.8, dissolved oxygen- 5.6-6.4 mg/L-1, free  $Co^{2-}$  2-5 mg/L-1, ammonia <0.4 mg/L-1, alkalinity 82-124 mg/L-1. Maximum individual growth was observed for grass carp ( $700 \pm 32$ g) followed by silver carp ( $658 \pm 24$ g). Size of the minor carp at the harvesting was observed as  $482 \pm 38$  g for *L. dyocheilus* and  $446 \pm 24$  g for *B. dero*. Maximum yield was observed in  $T_2$ , 0.58 kg/  $m^3$  with non- significant difference from  $T_1$  and  $T_3$ . However, lower yield was observed with polyculture of minor carp ( $T_4$ ), 0.37 kg/  $m^3$ . Optimum stocking density was observed as 3 number/ $m^3$ . Though, the growth of exotic carp was comparatively higher but minor carp showed better survival and satisfactory growth. Minor carp is also helpful to keep the pond clean due to its browsing feeding habit mainly feed on periphyton. Minor carp has 20-30% higher market price over the exotic carp. The Benefit-Cost ratio (BCR) was calculated as 1.67-2.1. Study reveals that polyculture of exotic carp and minor carp in mid- hills is more economic, sustainable and useful for diversification of hill aquaculture.

**Keywords:** Minor carp, Polyculture, Exotic carp, Stocking density, Fingerlings, Periphyton

**Introduction**

Major occupation in the mountain region of the country is agriculture based activities. The agriculture in the hills is having limitations with a number of factors such as small land holdings, short period of cultivation, and temperate climate. These factors force the human resource to divert their occupation for meeting livelihood. The farmers in the hill region have integrated type of farming pattern. Fish farming is an additional source of income to the farmers with the water conservation and crop production. Locally farm produced fish is suggested to be the best substitute of the animal protein to the hill dwellers. Moreover, fish culture in hills encourage conserving the water as well as indigenous biodiversity. In India, fish farming is mainly based on the polyculture of three Indian Major carp (Rohu, *Catla* and Mrigal) and three exotic carps (silver carp, grass carp and common carp). These carp species contribute about 80% of the annual aquaculture production and a production level as high as 17.5 ton ha<sup>-1</sup> has been reported from polyculture of these species (Tripathi *et al.*, 2000) [1]. Inclusion of other potent indigenous species in this polyculture system is very limited, however, some indigenous fish species in composite culture have been resulted in yield enhancement (Kohinoor *et al.*, 2005 [2]; Hossain and Islam 2006; Jana *et al.*, 2007 [3]; Jasmine *et al.*, 2011; Das and Mishra, 2016)

Due to the low thermal regime, Indian Major Carp is not suitable to culture in mid altitudinal area of the hills and only polyculture of exotic carp (*Hypophthalmichthys molitrix*, *Ctenopharyngodon idella*, *Cyprinus carpio*) is a common aquaculture practice at mid-altitudinal areas. Polyculture is a traditional aquaculture practice in several Asian countries (Ren *et al.*, 2018) [4]. Over time, this technology has promoted to the fish farmers for the productivity and production enhancement (Quyen *et al.*, 2017) [5]. This technology not only supports the farmers for food security but also provide household livelihood. There are so many minor carp species in the natural rivers and streams of the foot hill area and have the potential for culture in ponds. These species have regional importance and high consumer preference having 30-40% higher market price

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in the local markets. Minor carps such as kalbasu (*Labeo calbasu* Hamilton), fringe-lipped carp (*Labeo fimbriatus* Bloch), kuria labeo (*Labeo gonius* Hamilton), bata (*Labeo bata* Hamilton), reba (*Cirrhinus reba* Hamilton), silver barb (*Puntius gonionotus* Bleeker) and olive barb (*Puntius sarana* Hamilton) have been included in polyculture with cultivable carp species and shown promising results in terms of compatibility with major carps and possibility of increasing the biomass yield (Haque *et al.*, 1998; Sahu *et al.*, 2007; Jena *et al.*, 2007, 2008; Jena and Das, 2011) [6]. In earthen ponds of mid-hills (1000-2000 msl) the growth of fish remains slow due to the low thermal regime. In this context, plastics film lined ponds have been found very suitable for fish farming resulting better growth, enhanced production and water retention in the pond (Kumar *et al.*, 2007). An attempt was made in the present study to include minor carp in the polyculture system of the hill aquaculture.

## Materials and Methods

The field study was conducted at village Dadim, district Almora in Uttarakhand (29.475° N and 79.605° E, Altitude 1940 msl) for the 12 months (September to August). The fingerlings of the all tested species (*Hypophthalmichthys molitrix*, *Ctenopharyngodon idella*, *Cyprinus carpio*, *Labeo dyocheilus*, *Bangana dero*) were reared at fish farm, ICAR-CICFR Bhimtal. 16 fish farmers (pond size-100 m<sup>2</sup>) were selected for the field trials. Culture in low density poly ethylene (LDPE) film lined (200 GSM) ponds was adopted for polyculture of exotic carps and algaephagus, eurythermal minor carp (*L. dyocheilus* and *Bangana dero*). All the uniformed Poly tanks (poly ethylene film lined ponds) were filled with the water and treated for crowding and lime. Fingerlings of all the species having size of 20-30 g were stocked @ 3-4 fingerlings/m<sup>3</sup> and fed with carp feed @ 3% of their body weight daily basis. Four treatments with four replicates viz. polyculture of exotic carp ( $T_1$ - $S_C$ : $G_C$ : $C_C$ ; 30:40:30), polyculture of exotic carp and Minor carp ( $M_C$ ) ( $T_2$ - $S_C$ : $G_C$ : $C_C$ : $M_C$ ; 20:40:20:20), polyculture of exotic carp and Minor carp ( $T_3$ - $S_C$ : $G_C$ : $C_C$ : $M_C$ ; 20:30:20:30) and polyculture of only Minor carp ( $T_4$ -*L. dyocheilus*: *B. dero*; 50:50) were tested in field conditions (Fig 1). Fish were har-

vested after 12 months of the stocking and observed for the growth, survival and yield. During the experiment, water quality parameters were observed on monthly basis for water temperature, pH, dissolved oxygen, free CO<sub>2</sub>, ammonia and alkalinity following standard methods (APHA *et al.*, 1998) [7]. The Benefit-Cost ratio (BCR) was calculated by dividing gross return or total income by the total cost of cultivation. The data on water quality parameters and fish yield parameters such as growth, survival and biomass production were statistically analyzed using PC-SAS program.

## Results

The average weight of the individual fish at the time of stocking was noted in the range of 20-28 g. The average biomass of the stocked fish was 7.48 kg, 7.62 kg, 7.64 kg and 7.24 kg in  $T_1$ ,  $T_2$ ,  $T_3$  and  $T_4$ , respectively. The growth of all tested five species was slow during the period of September to March. Maximum individual growth was observed for grass carp (700 ± 32g) in  $T_2$  followed by silver carp (658 ± 24g) in  $T_1$ . Maximum size of the common carp was 558 g in the  $T_2$ , while size of the minor carp at the harvesting was observed as 482 ± 38 g for *L. dyocheilus* and 446 ± 24 g for *B. dero*. Maximum net yield was observed in  $T_2$ , 0.58 kg/m<sup>3</sup> with non-significant difference from  $T_1$  (0.52 kg/m<sup>3</sup>) and  $T_3$  (0.52 kg/m<sup>3</sup>). However, lower yield was observed with polyculture of minor carp ( $T_4$ ), 0.37 kg/m<sup>3</sup>. Optimum stocking density was observed as 3 number/m<sup>3</sup>. The minimum survival was observed for silver carp (58%), while minor carp showed better survival (88-96%). Maximum mortality was observed during the winter months (December and January). The Benefit-Cost ratio (BCR) was calculated as 1.67-2.1 with the higher value in  $T_2$ . The sale price for exotic carp in the local market for this fish size was observed as Rs. 180/kg, while it was Rs. 210-220/kg for minor carp with more consumer's demand (Table 1). During the experiment, water quality parameters were observed as water temperature; 9-20 °C, pH-7.2-7.8, dissolved oxygen- 5.6-7.2 mgL<sup>-1</sup>, free CO<sub>2</sub>- 2-5 mgL<sup>-1</sup>, ammonia <0.4 mgL<sup>-1</sup>, alkalinity 82-124 mgL<sup>-1</sup> (Table 2). During the period of September to March, water temperature was in lower side (9-16 °C) with higher dissolved oxygen (6.4 to 7.2 mg/L).

**Table 1.** Growth performance and yield of fish in different field experiments

| Species                     | Average weight of the fish (g) |                |                |                |                |                |                |                | Survival% |
|-----------------------------|--------------------------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|-----------|
|                             | Initial                        |                |                |                | Final          |                |                |                |           |
|                             | T <sub>1</sub>                 | T <sub>2</sub> | T <sub>3</sub> | T <sub>4</sub> | T <sub>1</sub> | T <sub>2</sub> | T <sub>3</sub> | T <sub>4</sub> |           |
| S <sub>C</sub>              | 23 ± 1.8                       | 22 ± 3.2       | 24 ± 1.2       | -              | 658 ± 24       | 652 ± 22       | 650 ± 21       | -              | 58        |
| G <sub>C</sub>              | 28 ± 1.2                       | 26 ± 2.4       | 28 ± 1.4       | -              | 698 ± 22       | 700 ± 32       | 696 ± 28       | -              | 79        |
| C <sub>C</sub>              | 23 ± 1.2                       | 24 ± 2.2       | 24 ± 1.8       | -              | 552 ± 23       | 558 ± 24       | 556 ± 26       | -              | 87        |
| M <sub>CD</sub>             | -                              | 21 ± 2.2       | 20 ± 2.4       | 21 ± 2.4       | -              | 481 ± 34       | 472 ± 23       | 482 ± 38       | 88        |
| M <sub>CB</sub>             | -                              | 20 ± 1.0       | 20 ± 1.4       | 21 ± 1.8       | -              | 445 ± 28       | 436 ± 22       | 446 ± 24       | 96        |
| Biomass (kg)                | 7.48                           | 7.62           | 7.64           | 7.24           | 59.48          | 65.62          | 63.64          | 44.24          | 74        |
| NetYield kg/ m <sup>3</sup> | -                              | -              | -              | -              | 0.52           | 0.58           | 0.56           | 0.37           |           |
| BCR                         |                                |                |                |                | 1.9            | 2.1            | 2.0            | 1.67           |           |

$S_C$ ; Silver carp,  $G_C$ ; Grass carp,  $C_C$ ; Common carp,  $M_{CD}$ ; Minor carp-dyocheilus,  $M_{CB}$ ; Minor carp-dero; BCR; Benefit cost ratio.

**Table 2.** Physico-chemical parameters in experimental fish rearing ponds

| Parameters                  | Sept. to March | April to August |
|-----------------------------|----------------|-----------------|
| Air temperature (°C)        | 7-14           | 16-22           |
| Water temperature (°C)      | 9-16           | 14-20           |
| pH                          | 7.4-7.8        | 7.2-7.7         |
| Dissolved oxygen (mg/L)     | 6.4-7.2        | 5.6-6.2         |
| Free CO <sub>2</sub> (mg/L) | 2.0-2.2        | 2.4-5.0         |

(continued on next page)

| Parameters             | Sept. to March | April to August |
|------------------------|----------------|-----------------|
| Total alkalinity(mg/L) | 82-98          | 88-124          |
| Ammonia(mg/L)          | 0.0-0.23       | 0.1-0.38        |

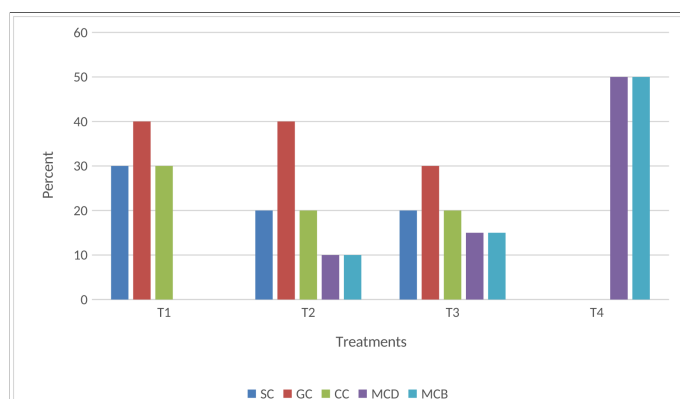


**Figure 1.** Species composition of cultivable fish species in different field trials.

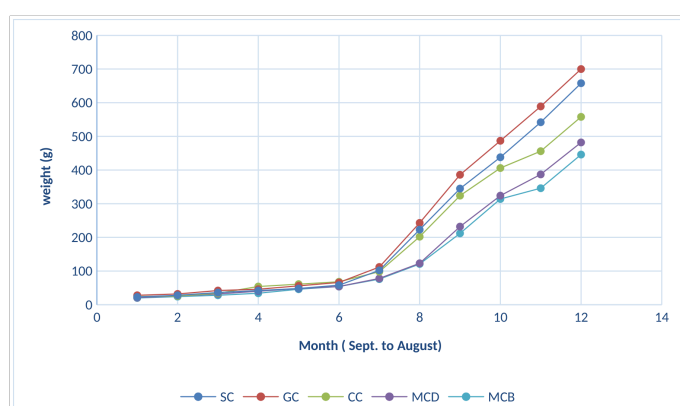


**Figure 2.** Growth trend of different species in different species composition trials.

## Discussion

Carp are the main stay of aquaculture in India. But being a low valued fish in the domestic and international market, carp farming yields low benefit cost ratio compared to culture of other species elsewhere in the globe and therefore, attracts poor entrepreneurial acceptability. Further, the consumers today with their increased purchasing power looking forward for wide spectrum of fish protein. In this context, diversification of the system and species spectrum forms one of the important strategies for aquaculture development in the coming years. There is a need to bring more and more high valued fish species either under monoculture or polyculture with carps to make aquaculture more remunerative to encourage the fish farmers. In previous studies, small indigenous fish species resulted in enhance fish yield and aquaculture sustainability (Kohinoor *et al.*, 2005 [2]; Hossain and Islam 2006; Jana *et al.*, 2007 [3]; Jasmine *et al.*, 2011; Das and Mishra, 2016). Some species have given promising results in terms of compatibility with major carps and possibility of increasing the biomass yield (Haque *et al.*, 1998; Sahu *et al.*, 2007; Jena *et al.*, 2007, 2008; Jena and Das, 2011) [6]. In recent years, minor carp culture has attracted growing interest due to its hardy nature, well adoptability, high nutrient profile and high market demand with consumer's preference (Debnath *et al.*, 2016) [8]. In hills, agriculture and horticulture is primary occupation, while there is an increasing trend for adopting fish farming as secondary source of farming income, similar findings have been reported by the Kumar (2020) [9]. In Minor carps, *Labeo dyocheilus* and *Bangana dero* are promising species having aquaculture potential and can be bed in captivity for the seed availability (Pandey *et al.*, 2012, 2017) [10]. Polyculture is a common practice for semi-intensive aquaculture and a positive impact of this practice on aquaculture was reported by Nsouvi *et al.* (2021) [11] and Babu *et al.*

(2021) [12]. Growth, survival and water quality parameters in the present study are in the permissible limits. In present study, inclusion of minor carp with polyculture of exotic carp in mid-altitudinal hilly area reflects the profitability, sustainability and compatibility of the culture system with BCR near to 2.0, which was reported the index of profitable polyculture by Hossain *et al.* (2022) [13]. Obiero *et al.* (2019) [14] reported that aquaculture technology adoption is strongly and positively associated with increased household income, hence, the present study indicates the greater possibility of the adoption of this technology and positive socio-economic impact.

## Conclusion

Though, the growth of exotic carp in polyculture is comparatively higher but minor carp showed better survival and satisfactory growth. Minor carp is also helpful to keep the pond clean due to its browsing feeding habit mainly feed on periphyton. Minor carp has 30-40% higher market price over the exotic carp. Study reveals that polyculture of exotic carp and minor carp in mid hills using polytanks is is more economic, sustainable and useful for diversification of hill aquaculture.

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