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Status of selective breeding programs in fishes in india

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Selection involves favouring certain individuals to reproduce more than others, which in turn alters the frequency of existing genes in a population. Although it does not introduce new genes, the process increases the prevalence of alleles that improve targeted traits while reducing those that are less advantageous.

Selective breeding is the process by which humans breed other animals and plants for particular traits. The offspring of two purebred animals of different breeds is called a crossbreed; crossbred animals are also referred to as hybrids.

Approaches for Selective Breeding

There are two approaches for selective breeding. One method involves intentionally selecting animals that display the highest expression of a specific trait. Another method relies on natural selective pressures applied within a controlled environment.

Basis of Selective Breeding

The basis of selective breeding is to identify traits which are influenced by genetic factors and to choose individuals possessing a majority of desirable genes responsible for that trait. These individuals will be the parents in the next generation so that their progeny, as a group, have the highest possible additive genetic merit for the trait.

Before initiating a breeding program, the lifecycle of the species in captivity must be closed, and the commercially valuable traits must be identified. Then it is essential to establish that these traits have both genetic variability and moderate to high levels of heritability (Mair, 2007).

According to Kirpichnikov (1966), the main aims of fish selection are as follows:

- To increase the growth rate by better utilization of artificial and natural food in the pond
- To increase resistance to environmental variations
- To increase resistance to infectious and parasitic diseases
- To increase the nutritive properties of fish

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Selective Breeding Programmes in India

Jayanti Rohu by ICAR-CIFA, Bhubaneswar

The Jayanti Rohu programme, initiated by ICAR-Central Institute of Freshwater Aquaculture (ICAR-CIFA) in collaboration with the Institute of Aquaculture Research (AKVAFORSK), Norway in 1992, aimed to improve growth traits using a combined selection method. Improved Jayanti Rohu™ is the first genetically improved fish in India.

The base population consisted of rohu stocks from the Ganga, Yamuna, Brahmaputra, Sutlej and Gomati rivers. The local farm stock at ICAR-CIFA was also included in the base population as the sixth stock.

Over multiple generations, this initiative reported substantial gains in harvest weight, averaging over 18.3% genetic improvement per generation after 8 generations of selection (Mahapatra et al., 2021).

The improved rohu variety produced had substantial additive genetic variance for growth, with negligible heterosis for growth. It takes 2 months or less to attain marketable size, and 50% economic gain has been reported in farmers' ponds. The fish has an attractive colour to fetch a better price in the market.

Although improving the growth rate was the primary objective of this selective breeding programme, a disease-resistant trait against Aeromonas was added as a second trait to the breeding programme (Mahapatra et al., 2016).

Amrit Catla by ICAR-CIFA, Bhubaneswar

The primary objective of the selective breeding program behind the Amrit catla (a genetically improved variety of Catla (Labeo catla)) was to enhance the body weight of Catla at harvest.

ICAR-CIFA, Bhubaneswar, commenced this selective breeding program in 2010 by collecting 9 different strains of Catla from West Bengal, Bihar, Odisha, Andhra Pradesh, and Uttar Pradesh, which were used as the base population.

They followed the Combined Family Selection method and reported a 15% genetic gain per generation after four generations of breeding, leading to a cumulative gain of 35% by the third generation.

Based on the results obtained through field trials, they have reported that Amrit catla reached an average weight of 1.8 kg in polyculture systems, compared to 1.2 kg for local strains in one year.

GI Scampi by ICAR-CIFA, Bhubaneswar

The genetically improved variety of the freshwater prawn Macrobrachium rosenbergii, named "CIFA-GI SCAMPI®" was developed by the ICAR-CIFA in collaboration with WorldFish, Malaysia.

The program commenced in 2007 and the base population included scampi stocks from Gujarat, Kerala, and Odisha. After 14 generations, the genetically improved scampi was registered in 2020.

In carp polyculture systems, CIFA-GI SCAMPI® has been reported to perform well with the production of 950 kg/ha of scampi in 7 months.

Common Carp by ICAR-CIFE, Mumbai

The ICAR-Central Institute of Fisheries Education, Mumbai, is presently developing a strain of Cyprinus carpio for inland saline aquaculture in India through a selective breeding programme.

This selective breeding programme aims to develop a common carp strain which grows faster in low-saline waters. The base population from Madhya Pradesh, Haryana, Tripura, Andhra Pradesh, Manipur, and Maharashtra is being used for the programme (Lalramnansunga et al., 2024).

Mahamagur by ICAR-CIFE, Mumbai

A genetic selection programme to improve the body weight of Clarias magur was implemented at ICAR-CIFE in 2014.

In order to produce the "Mahamagur", 3 stocks of magur from Andhra Pradesh, Assam and West Bengal were used as base population, and the genetic improvement was done by complete diallel crossing using a single paired mating design (Haldar et al., 2019).

Until 2024, four successful generations of selection, including the base generation, have been carried out.

Penaeus indicus by ICAR-CIBA, Chennai

The ICAR-Central Institute of Brackishwater Aquaculture, Chennai, is operating a project on "Genetic Improvement Programme for Penaeus indicus (GIPPI)" under the Pradhan Mantri Matsya Sampada Yojana (PMMSY).

The Indian shrimp culture mainly relies on P. vannamei, an exotic species. In order to reduce the dependence on the exotic species, this programme aimed to develop domesticated, genetically improved broodstock of P. indicus, which will have a fast growth rate.

To support the programme, CIBA has completed the whole-genome sequencing of P. indicus (≈ 1.93 Gb size, 28,720 protein-coding genes) (Katneni et al., 2022).

They have also demonstrated that P. indicus shows 90% survival and a growth rate of 18.5 g in 93 days in their on-farm trials.

Conclusion

Selective breeding remains one of the most effective methods for enhancing commercially important traits in aquaculture species. By consistently selecting individuals with desirable genetics, producers can achieve long-term improvements in growth rate, resilience, and overall productivity.

Although it does not create new genetic material, it effectively reshapes the genetic structure of populations, enabling improvements in growth, disease resistance, environmental tolerance, and overall productivity.

The success of such programmes relies on identifying heritable traits, maintaining a genetically diverse base population, and applying consistent selection pressure using approaches such as breeders' selection and controlled natural selection.

India's advancements in selective breeding—exemplified by genetically improved varieties like Jayanti Rohu, Amrit Catla, GI Scampi, Mahamagur, and improved strains of common carp and Penaeus indicus—demonstrate the transformative impact of long-term, scientifically managed breeding programmes.

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