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FISH BREEDING AND BROODSTOCK MANAGEMENT

INTRODUCTION

1. This document provides background information on the status of fish breeding and broodstock management in the CACFish area and identifies the main problems and challenges for the application of modern techniques for breeding and broodstock management.

2. Although global aquaculture production has undergone a remarkable increase over the past few decades, the use of modern genetic techniques to increase fish production and improve the quality of cultured fish has not been extensively applied in the CACFish area, mainly because of technical and financial restrictions, but also due to the lack of sound national policies for the exploitation, protection and conservation of aquatic genetic resources.

3. The CACFish area has great potential for the genetic improvement of cultured fish, and classical breeding (genomic selection) programmes should provide the bulk of the future genetic gain. Currently the limited supply of quality seed is a factor restricting the expansion of aquaculture production in Central Asia, a region where classical breeding programmes were partly used for enhanced fisheries practices and the production of carp and trout.

4. Selective breeding is the process of captive breeding of only those fish that possess the desired phenotypic traits, such as disease resistance or rapid growth. To produce such fish requires a well-designed selection and breeding programme that is conducted over many generations. Successful fish breeding programmes depend mainly on the use of high-quality broodstock to produce quality fish seed for aquaculture and stocking into natural waters (e.g. stock enhancement). Creating and maintaining genetically improved broodstock in a controlled environment with no reliance on wild populations of unknown and unpredictable

performance ensures the production of quality progeny in the form of good-quality gametes, feeding larvae and advanced fry in the desired quantities. Maintenance of broodstock is the first step if a fish farm plans to produce feeding larvae; each farm has to establish its own broodstock by selecting and rearing the best-performing females and males with known genetic background.

5. In addition to producing fry and fingerlings for use in aquaculture, hatcheries may also be used for the conservation or restoration of endangered or threatened fish stocks. While broodstock management for aquaculture development typically involves the process of domestication (the selection of desired phenotypic traits) along with the control of inbreeding and genetic drift (the loss of rare alleles in small populations due to random chance), programmes designed for the recovery or enhancement of endangered or threatened wild fish populations must ensure that the genetic integrity of these individual populations is maintained.

6. The stocking of fry and fingerlings derived from captive fish breeding programmes can pose direct and indirect genetic harms to wild populations, leading to the reduction in their genetic variability, decreased fitness and impaired survival. Direct genetic harms result when a cultured stock interbreeds with a reproductively compatible population in the receiving ecosystem and can include impacts on the same species (i.e. loss of adaptation when interbreeding of escaped cultured fish with wild populations displaces allele frequencies at fitness-related genes from selective optima, resulting in loss of fitness in the wild stock) or on another species (i.e. through introgressive hybridization, in which the escape or stocking of an exotic species results in interbreeding with a reproductively compatible species in the receiving environment. If the resulting hybrid is fertile, it poses the risk of introgressive hybridization with the native species, threatening its genetic integrity.) Indirect genetic harms result when an escaped or released cultured stock competes or preys on other populations or species in the receiving ecosystem. They include: (i) loss of genetic variability and ability to adapt in the face of changing selective pressure, and also increased likelihood of subsequent inbreeding and extinction due to reduced population size; and (ii) the loss of reproductive investment if cultured fish interbreed unsuccessfully with a wild population, resulting in a sterile hybrid.

7. Fish typically have high reproductive rates, a single breeding pair often being capable of producing hundreds of thousands of progeny. The frequently observed practice of aquaculturists producing a large number of individuals from only a few breeders can influence the maintenance of allelic diversity, the rate of inbreeding and the effective population size. In addition to the potentially detrimental effects of inbreeding, one of the most important consequences of this at a population level is the effect of genetic drift. This may result in a population having altered gene frequencies that differ from those of earlier generations. This will be accompanied by a loss of alleles at a rate that is inversely proportional to the effective population size. This highlights the vulnerability of cultured populations to a rapid loss of genetic variation, with potential impacts on wild populations as previously mentioned. Therefore it is important to minimize the possible adverse genetic and ecological interactions that hatchery-bred fish may have on wild populations.

8. As in the development of high-yielding strains of plants and domestic animals for use in terrestrial food production, genetically improved strains of fish are essential to aquaculture development. The application of proven quantitative genetic methodology should continue for relevant species such as carp and trout, as there is ample proof of the success that such programmes can achieve. To ensure greater impact of genetically improved stocks at the production level, more emphasis must be placed on their dissemination to farmers. However,

consideration must also be given to the potential impacts of escapees from aquaculture facilities and the need to conserve the genetic resources of wild fish populations. As new strains are developed and aquaculture production further expands, documenting the genetic make up of both cultured and wild fish stocks will become increasingly important for successful aquaculture development and the conservation of wild stocks.

9. The Expert Meeting on Fish Breeding and Broodstock Management, which was held in Istanbul, Turkey from 10 to 12 December 2013, as a scheduled activity of the Technical Advisory Committee (TAC) discussed the status of fish breeding and broodstock management in the CACFish area. The key findings of this meeting were as follows:

- Systematic breeding programmes are not in place in Central Asian region.
- Genetic resources of common carp exist in Europe.
- Methods for breeding programmes and broodstock management are available.
- Maintenance of programmes for breeding and broodstock management is costly, and the market is not always able to "finance" it. This is especially true in case of a "low-market-value" fish like common carp.
- Simple mass selective breeding for growth has not been effective.
- Most often breeding programmes are based on crossbreeding, which brings about quick improvement of growth performance (due to heterosis) in the F1 generation.

  Crossbreeding of species improves survival rate of fry, growth rate, as well as disease and cold resistance. However, improper use of hybrids for further breeding has resulted in contamination of purebred stocks. Due to the easy crossing between silver and bighead carps, the most important issue in their breeding is the conservation of their purity. Inter-species hybrids are losing their most important feature, namely their selective feeding on phyto- and zooplankton. In many countries the pure silver carp stocks have disappeared due to their unintentional crossing with bighead.
- Breeding programmes and broodstock management in Europe are based on costly national breeding programmes and the maintenance of live and cryopreserved gene banks. These gene banks need continuous maintenance, which is an expensive exercise.
- Availability of public funds is essential for sustainable maintenance of activities in the field of breeding programmes and broodstock management of carp.
- The existing genetic resources of common carp could be used for re-habitation of disappeared genetic resources; however, financial restrictions could slow down transfer (exchange) of carps.
- Risk related to the introduction of "very viable exotic (ecologically flexible)" species like common carp should be carefully studied in advance to avoid negative effects of the transfer/introduction.
- Genetic resources of Chinese carps exist in Central and Eastern Europe after their introduction to the former USSR in 1953. Methods for breeding and maintaining their broodstock are also available.

10. The expert meeting identified the following main problems and challenges to the application of modern techniques for breeding and broodstock management in the CACFish area:

- lack of governmental incentives for long-term national breeding programmes;
- lack of specific institutions and research centers for fish breeding;
- lack of quality fish stocks for broodstock use;
- lack of high-quality and disease-free seed;
- lack of investments;
- need for updated information on hatcheries and existing broodstocks;
- insufficient implementation of national policies for aquaculture development;
- slow return on long-term breeding programmes (investment);
- lack of farmer interest in long-term breeding programmes;
- lack of infrastructure for broodstock management and breeding programmes;
- need for renovation of broodstock;
- need for pure strains for all farmed fish species, including common and Chinese carps;
- lack of regular practical training of the staff involved in maintenance of broodstock;
- lack of specialized feed for all cultured species;
- lack of state aid to support fish feed supply;
- poorly developed production basis for broodstock management, which is costly; and
- high production cost of broodstock management.

11. The expert meeting made the following recommendations for the consideration of TAC:

- integration of broodstock management into national fisheries and aquaculture policy;
- promotion of production and trade of high-quality and disease-free seed and healthy fry in the CACFish area;
- development of a "model hatchery" for the production, conservation and research of cultured species;
- establishment of a regional database on genetic resources of important cultured species in the CACFish area;
- establishment of and support to the maintenance of a regional cryobank of sperm for endangered and farmed fish (infrastructure, guidelines and proprietary issues);
- maintenance of genetic identities of fish lines/strains/species and prevention of inbreeding;
- development and implementation of risk-based regulation for the use of exotic species;
- dissemination of technical manuals for broodstock management;
- practical training for the stakeholders (policy-makers, lead fish farmers, etc.) on broodstock management and selective breeding;
- specialized training for hatchery managers and researchers, in cooperation with European Union (EU) initiatives;

- development of technical guidelines for transfer of farmed aquatic genetic resources; and
- promotion/encouragement of renewal of impoverished genetic stocks on the basis of scientific evaluation.

SUGGESTED ACTION FOR TAC

12. TAC is invited to examine the above-mentioned needs, challenges, findings and recommendations of the Expert Meeting on Fish Breeding and Broodstock Management and to formulate technical/scientific advice for the consideration of CACFish. In addition, it is suggested that TAC identify the likely technical/scientific and management actions that might be taken to address the implications of establishing and/or revitalizing programmes for genetic improvement and broodstock management in the CACFish area.