Conclusions and summary of the discussions

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The major *issues* and *needs* (relating to Genetics and Breeding in Mediterranean Aquaculture Species) raised by the participants during the discussions held in the seminar and workshop are summarized below and are therefore recognized as being crucial to the application of genetic technologies to aquaculture in the Mediterranean.

Summary of Issues

The application of genetic techniques to aquaculture in the Mediterranean Region is complicated by economic, social, organizational, environmental and technical issues. Genetic techniques involve both breeding technologies, such as induced spawning, and manipulation of the genome by selective breeding, chromosome-set manipulation, hybridization, production of mono-sex stocks, and genetic engineering, e.g., gene-transfer.

The development of improved breeds (level of domestication) in aquaculture is far behind the achievements obtained in other domestic plant and animal species. Although methods of selection, statistical analysis, and experimental design used in agriculture can, in theory, be applied to aquaculture, a basic understanding of the biology and ecology of many aquatic organisms is still lacking. An understanding of the genetic basis for many characters of use to aquaculture is also lacking in many aquatic species. Basic research utilizing modern molecular methods of genetic engineering, e.g., gene transfer, and cell culture, have provided and will continue to provide information that may be applied to genetic improvement in aquaculture. Thus, improved information on basic genetics will be necessary for the utilization of genetic techniques to improve production in aquaculture.

In many areas the infrastructure for breeding programmes, i.e. breeding centres and co-ordination between farmers and scientists, is lacking as are educational programmes informing farmers of the advantage of genetic techniques to improve production.

In agriculture, the application of genetic techniques and genetic resource management constitute a large portion of the improvement strategy and this has greatly benefited the sector, whereas in aquaculture, much less effort is put into the field of genetics. The history of agriculture and the relative importance of technology, husbandry and genetics to increased production needs to be examined to determine the cause of this difference. This discrepancy between land and aquatic farming is even more surprising considering that many aquatic species have some unique features such as the ease of manipulating the gametes of many aquatic species, often external fertilization and their extremely high fecundity that allows for high selection intensity and flexibility in designing selection experiments and programmes.

Improved production in the Mediterranean region has resulted from genetic improvement strategies such as mass selection, including incorporation of molecular techniques, chromosome-set manipulation in sea bass and seabream, sex reversal and mono-sex production in seabass and interspecific hybridization of Sparid fishes. However, systematic, long-term breeding programmes for marine species have not been established in most Mediterranean countries. Information was presented that the cost:benefit ratio of applying selective breeding in aquaculture was extremely favourable. However, there still seems to be resistance on the part of aquaculturists to undertake genetic improvement programmes. This reluctance may be due to ignorance of the benefits of applying such programmes, the current success with the performance of the presently farmed stock, the fear of losing ownership or intellectual property rights to improved breeds, or the fact that other constraints to production have more immediate importance than genetic constraints.

There are a variety of genetic improvement techniques that can be utilized in aquaculture to improve a variety of important traits. Although growth rate is the trait of most importance in most cases, other traits such as age to sexual maturity, resistance to environmental stress, disease resistance, flesh quality and body confirmation can also be improved. Full utilization of aquatic genetic diversity will come from long-term selective breeding programmes that take advantage of additive genetic variance. Short-term improvements, such as hybridization, mono-sex production, and chromosome-set manipulation, provide immediate gains and may be utilized in association with (added to) long-term selective breeding programmes.

Concerns for the protection of the aquatic environment and conservation of natural aquatic genetic diversity will influence the widespread use of genetic technologies. Although technologies such as domestication and directed selection programmes have provided gains in agriculture and will likewise be useful in aquaculture, there has been a loss of many of the wild relatives to current domesticated agriculture species because the genetic status of these wild relatives was often ignored. This represents a loss of valuable genetic diversity.

The aquaculture sector can learn from this experience and take advantage of current technologies and adopt responsible practices that will prevent such loss of genetic resources from wild aquatic populations. To manage better natural and farmed aquatic populations it is necessary to understand fully the genetic structure of the populations. In this regard strain and subpopulation identification can be greatly facilitated by the use of modern genetic technologies, such as microsatellite and mDNA analysis which can be used complementary with older technologies such as morphometrics, meristics and isozyme analyses. Genetic technologies can be utilized to reduce the chance of adverse environmental effects resulting from the breeding of farmed strains with wild populations by producing non-reproducing animals (e.g., sterile all female triploids) that reduce the chance of hatchery stocks interbreeding with wild populations. However, the Seminar noted that the sterility of many triploid animals is not 100% and the reproductive potential of many hybrids, e.g., Sparidae, is not known.

The majority of aquatic diversity, especially for marine species, resides in wild populations that will provide the raw genetic material for genetic improvement programmes. Technologies such as gene-transfer, may be perceived to represent a risk to the natural gene pool and the environment and may meet with both consumer and industry resistance. However, the risk of a genetic manipulation should be based on what change the manipulation imparts on the phenotype of an organism and not on what technique was used. Thus, the products of selective breeding, polyploid organisms, as well as transgenics should be assessed on how the phenotype performs and how any genetic change may be transmitted to other animals or species. If uncertainty exists as to the effects on the phenotype, then more caution, monitoring, and research would be warranted.

Recommended actions

Following the Seminar, a small group, including the Seminar's invited speakers, participated in a workshop to discuss priorities and important topics and to propose specific actions to be taken to help apply genetic technologies to aquaculture.

The workshop identified the establishment of selective breeding programmes utilizing additive genetic variance for sea bass and sea bream as a priority area for future action in the Mediterranean. Such breeding programmes should identify explicit goals and selection objectives, prioritize traits to be improved, establish selection criteria, establish acceptable levels of inbreeding, and establish a monitoring system to evaluate progress of the genetic improvement.

General activities that the Workshop determined to be important for breeding improvement programmes utilizing additive genetic variance included:

The characterization and evaluation of wild populations and farmed stocks both at the phenotypic, e.g., commercial performance in captivity, and genetic level. This characterization and evaluation should include performance and descriptive data, should sample as many groups as possible, should involve groups reared under farm conditions, should include economically important traits, and should include variance quantification in the data collection.

Methods of identification for the above characterization should emphasise neutral genetic markers and should strive to maximize the number of loci analysed. Evidence has shown that production traits are generally not correlated with presently known genetic markers. Therefore, performance evaluation under farm conditions is critical to assess culture value.

Evaluation of a breeding programme is essential to document gains and make further progress in efficient production. Several approaches can be followed in the development of a breeding evaluation programme. For example a reference strain can distributed to various farms and to various environments to compare performance between the reference strain and the strain being developed.. The workshop noted that time is crucial for strain comparison/evaluation.

The Workshop noted that many countries will need improved facilities before selective breeding programmes can be established effectively. Furthermore, the evolution of breed improvement programmes is uncertain at present and will be influenced by numerous factors, such as industry perspectives, intellectual property protection, establishment of local consortiums/co-operatives or large breeding centres, and the ability to control spread of pathogens along with the exchange of genetic material. The workshop recommended modelling different development scenarios to determine an optimum strategy.

International co-operation may be necessary to facilitate exchange of information and animals, establishing user groups, and promoting further co-operation among stakeholders.

The Workshop proposed several specific follow-up actions and activities that may be sponsored in part by TECAM with other interested organisations. These included:

- Establish a working group (under TECAM) on genetics and breeding in Mediterranean aquaculture. This would be a loosely structured network consisting primarily of the participants, but eventually extending to industry and other interested parties. There is a need to define better the goals of this network and to identify a core group of leaders.

- Conduct a survey of industry needs in regards to genetics and breeding with TECAM taking the lead with the collaboration of FAO . Specialists will be required to prepare a broad-based survey to be sent to commercial hatcheries in Mediterranean region (early 1998).

- Convene additional workshops (under TECAM and co-sponsors). Representatives from industry, academia, research and government institutions collaborating with industry, and hatchery managers to be included as participants. Topics would include:

    - Establishment of selective breeding programmes (utilizing additive genetic variance) for seabass and seabream (1998).

    - Applications of biotechnology on the improvement in marine aquaculture in the Mediterranean region (1999).

    - Shellfish production in the Mediterranean region (time not determined).

- Convene an International Symposium on aquaculture genetics in Mediterranean Aquaculture species (1999).