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09.30-12.30 Parallel Sessions

Session 1.2 Facing the challenges of climate change: Adaptation in the livestock and fishery sectors

1.2.1 Selective breeding in aquaculture for future environments under climate change

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SUMMARY

Aquaculture is the fastest growing food production sector that contributes significantly to global food security. Based on FAO reports, aquaculture production has to increase by 42.9% to meet the future global demand for aquatic foods in 2020. According to the reports by IPCC and FAO, climate change may result in global warming, sea level rise, changes of ocean productivity, freshwater shortage, and more frequent extreme climate events. Consequently, climate change may affect aquaculture to various extents depending on climatic zones, geographical areas (inland or coastal), type of aquaculture systems, and species farmed.
Climate change may introduce opportunities as well as several challenges:

Opportunities may arise at certain locations and geographical areas; for instance, a rise of temperature may prolong growth period, increase fish growth rate, allow new and more efficient farming systems, and new-farmed species. Spatial planning will enable the identification of locations with optimal conditions for farming.

Challenges; There are two major challenges caused by climate change.
Firstly, the current fish material, adapted to the prevailing environmental conditions, may be suboptimal under future conditions. Similarly, breeding programmes selecting for genotypes with current superior performance, may not be the optimal genotypes in the future. Genotype-by- environment interaction (GxE) is a phenomenon by which animals respond differently to changes in environment. The presence of GxE indicates that there is genetic variation in environmental sensitivity and it is possible to select for fish that can adapt to the changing environments. For instance, rainbow trout (*Oncorhynchus mykiss*), a very popular farmed salmonid worldwide, has a narrow optimal temperature range. Strong GxE in growth performance of rainbow trout in different temperatures has been reported; hence, utilisation of selective breeding can be advantageous for breeding rainbow trout that are best adapted to the temperature changes induced by climate change.

Secondly, climate change may facilitate outbreaks of existing pathogens or parasites. Moreover, change in water temperature may promote dispersal of new diseases. Disease prevalence increases with physical stress, e.g., that associated with a change in temperature, due to reduction in host resistance and increasing growth of pathogens. Many diseases of farmed fish can potentially become a greater problem at higher temperatures. Thus, mortality rates will increase and production from aquaculture will reduce. In Australia, farmed abalone (*Haliotis laevigata*) has experienced 25% summer mortality due to elevated water temperature, leading to AU$1.75 million loss of profit.

To cope with the challenges above, adaptive measures must be addressed through both a reduction of environmental impacts from greenhouse gas (GHG) emissions and selective breeding strategies.

Adaptive strategies. Three major adaptive strategies are identified:

1. Fish species are often poikilothermic, and may therefore be particularly vulnerable to temperature changes. This will make low sensitivity to temperature more important for fish than for livestock and other terrestrial species. Hence, general "robustness" will become a key trait in aquaculture, whereby fish will be less vulnerable to current and new diseases and parasites while at the same time thriving in a wider range of temperatures. Breeding goals may change toward prioritising robustness. Nevertheless, knowledge of, and implementation of genetic adaptation to fish breeding is limited and has not received much attention.

2. The limited adoption of breeding programmes in aquaculture (<10%) is a major concern. Aquaculture based on wild stocks that are not adapted to the farm environment, or farmed animals from breeding programmes without proper selection and/or control of inbreeding, will lead to poor performance and survival compared to genetically improved or well-managed stocks. This implies low aquaculture production and inefficient use of resources for feed and land. Consequently, a higher carbon footprint with a negative impact on climate change per kg fish produced is expected. Aquaculture should use genetically improved and robust species not suffering from inbreeding depression. This will imply using fish materials from well-managed selective breeding programmes with proper breeding goals and a controlled rate of inbreeding. Policy makers should provide incentives and public support to boost selective breeding programmes in aquaculture for more robust fish tolerating climatic changes.

3. Although aquatic organisms do not emit GHGs as ruminants do, aquaculture activities, such as input power, transport, and feed production contribute to GHG emissions. Life cycle analysis (LCA) is a method to quantify the use of resources and emission of pollutants of the entire production chain for a product. Selective breeding for increased production is expected to enhance efficiency of resource utilisation (feed, energy and land) of a production system, through correlated changes in feed efficiency or shorter production period. Applications of LCA to define breeding goals that maximise production while minimising environmental impacts can be one solution, as already demonstrated in African catfish.

Conclusions.

Climate change poses opportunities and challenges to aquaculture production. Selective breeding is a long-term, cost-effective strategy that can best minimise the detrimental effects of climate change on aquaculture. Empirical studies are required to estimate the potential of increasing robustness of fish by selection methods. Applying selective breeding to develop robust animals will become more important under climate change, and dissemination of genetically improved stocks will in-turn efficiently increase aquaculture production and reduce environmental load, including GHG-emissions. Established selective breeding programmes are a prerequisite to apply genomic information for further genetic improvement of aquaculture production. Hence, stakeholders should support the adoption and development of selective breeding by disseminating genetically improved materials and knowledge of selective breeding at all levels of the aquaculture sector worldwide, to ensure food security for the growing human population under climate change.

Keywords: aquaculture, climate change, environmental sensitivity, genotype-by-environment interaction, selective breeding

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