International Symposium on Genetics in Aquaculture XII

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Conclusions from the Technology Transfer Round Table held within the framework of the International Symposium on Genetics in Aquaculture – ISGA XII

(Santiago de Compostela (Spain), June 24th 2015)

Scheduled within the framework of the International Symposium on Genetics in Aquaculture – ISGA XII (2015 Santiago de Compostela, Spain), a round table session on "Technology transfer" was held with the objective of providing an insight on how best to improve both technology uptake and market impact of genetic research applied to aquaculture, considering the available capacities and knowledge progress in this field.

The global aquaculture production in 2012 amounted to 90.4 million tonnes -live weight equivalent- (US$144.4 billion)[1], from which 66.6 million tonnes correspond to food fish (including finfishes, crustaceans, molluscs, amphibians, and other aquatic animals) and 23.8 million tonnes to aquatic algae. The main production areas are Asia, which has reached 54 percent of total production, and Europe, with 18 percent. According to FAO estimates world food fish aquaculture production rose by 5.8 percent to 70.5 million tonnes in 2013, from which China alone produced 43.5 million tonnes. Over recent years, world aquaculture production has undergone an uninterrupted growth trend; however, some major producers such as the United States, the European Union or Japan, among others, have experienced stagnation due to a combination of market, technical and administrative factors. Obtaining growth and development remains in a central position with regard to strategic planning for the aquaculture industry in these areas, and three key performance indicators need to be addressed in order to overcome this situation, namely growth performance, mortality and feed efficiency.

Within this context, genetic and genomic tools offer a huge potential for contributing to sustainable growth and to the improvement of industrial competitiveness.

The session, which was organised as an open debate with the symposium participants, was moderated by Mrs. Rosa Fernández (CETMAR). The panel was made up of Mr. Courtney Hough, general secretary of the Federation of European Aquaculture Producers (FEAP) and of the European Aquaculture Technology and Innovation Platform (EATIP); Mrs. Ana Riaza, director of R&D and Health at Stolt Sea Farm – Prodemar; Dr. Anna Kristina Sonesson, senior scientist at the Department of Breeding & Genetics of Nofima; and Mr. Pierrick Haffray, head of the Aquaculture Unit of the French Genetic Centre for Poultry and Aquaculture Breeding (SYSAAF).

Considering the audience profile and acknowledging that the round table's target was not a completely new issue under discussion for the aquaculture stakeholders, the starting point for the debate were the conclusions arisen from the EAS & EATIP workshop on the performance of the sea bass and sea bream sector in the Mediterranean. The latter was held within Aquaculture Europe 2014, on 16th October at San Sebastián (Spain)[2], and Mr. Courtney Hough outlined the outcomes briefly:

- relevance of improving knowledge on nutritional requirements of the different species, at different life stages, and feeds formulation as a key aspect for industrial improvement;
- the availability of high quality and genetically improved broodstock for increased survival and performance rates;
- spatial planning issues were also pointed out as critical;
- company size, collaboration strategies and funding/ investment capacity were also pointed out as relevant drivers for underpinning the sectors' uptake of new technologies.

There is a general acceptance that relevant research progress has been attained in the field of aquaculture

[1] Source: The State of World Fisheries and Aquaculture 2014. FAO.
[2] http://www.eatip.eu/shortcut.asp?FILE=1222

genetics and genomics during the last decades and that this can provide an important window of opportunity for the sector but what is restricting the uptake of results by the industry? Why is this aspect far from realising its potential impact?

Key points discussed

Technical issues

There has been some support for fundamental research in genomics for aquaculture during the last years. High density SNP chips and well annotated reference genomes are therefore now commercially available in Atlantic salmon and rainbow trout, but they are missing for the other important species reared in Europe (e.g. turbot, sea bass, sea bream, oysters,…). These genomic resources are essential both for improving accuracy of selection and understanding important biological processes.

One of the main kinds of traits with greater potential for improvement by applying genetic and genomic tools is disease resistance, as disease mortality constitutes a major threat for aquaculture industry. Preventive or therapeutic treatments can only be applied when the activity is carried out within controlled facilities, but they are useless in most molluscs rearing stages and in cages in the sea. Nutrition and feed performance is another critical target, since it has a direct influence in other key parameters related to health, growth, fertility, etc.

Through the application of selective breeding programmes, best growers, disease resistant or tolerant and, in general, individuals with certain characteristics of interest can be obtained, as some successful experiences demonstrate. In Norway, the selection programmes of Atlantic salmon started in 1970's. In Spain, Stolt Sea Farm – Prodemar started in early 90's a selective breeding programme for turbot, which the company is currently rearing the fifth generation, and they are now carrying out a similar strategy for the production of sole. In France in 1991, fish farming companies interested by genetic selection joined the SYSAAF poultry advising organisation to develop and share a collective advising service to initiate their own selection programs on rainbow trout (Aqualande, Les Fils de Charles Murgat, Pisciculture de Ménaouen, Salmona, …) and later on a similar approach has been implemented for turbot (France Turbot), sea bass (EMG), sea bream (FMD), sturgeon (Ecloserie de Guyenne), meagre (Les Poissons du Soleil) and now for oysters. These examples show that it is possible to keep this kind of strategies ongoing; however, as Mrs. Riaza and Mr. Haffray pointed out, they require the availability of highly qualified staff and technical advice to deal with and to keep carefully the selected stocks and constant and confident interaction with research organisations.

Moreover, progress in this field will need collaborative research investments with the industry owning stocks to develop and promote new breeding practices adapted to the biological specificities of aquaculture breeding.

Bearing in mind that improving production performance also needs to take into account economic and market issues, it is necessary to get further insight on how and how much the implementation of genetic and genomics can benefit companies. Bio-economic modelling and cost-benefit analysis should always be taken in by research projects on aquaculture genetics. There is a general perception that large investments in facilities are required to initiate breeding programs with several hundreds of tanks, but SYSAAF experience in using DNA-based parentage assignment since 1995 has demonstrated the possibility to limit such investments in adapting breeding programs to their investment capacities. Whatever the method of selection used, potential benefit is high if the industry is able to make genetic make-up expressed. This last aspect was considered as determinant by the panel and more interaction between breeding and feed companies was highlighted as a key condition to speed up integration of genetic innovation and to provide to the growers and processors the best combinations of seeds and feed and feeding practices.

A frequent topic that arises when the objective of putting knowledge into action is addressed refers to intellectual property rights (IPR). However, since animal strains cannot be protected by means of a patent with current regulations, it is likely to see concurrent use of the genetic progress created by breeding companies. Different strategies could be established to limit this risk but the most relevant protection strategy in this field is industrial secrecy and investment in R&D so as to be at the front of innovations.

Technology readiness level in aquaculture

It is widely agreed that moving to genomics is a key issue for the aquaculture industry, but the integration of genomic tools in a cost-effective way strongly depends on the Technology Readiness Level and, therefore, the time to market of such tools. Technology Readiness Levels (TRL)[3] are a type of measurement system used

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[3] https://www.nasa.gov/directorates/heo/scan/engineering/technology/txt_accordion1.html

to assess the maturity level of a particular technology, originally developed by NASA, which application is recently becoming widespread in Europe. The lower TRL value for a certain technology, the higher investment is required for getting it ready to market. Usually, agricultural crops and livestock farming are seen as reference sectors, while the aquaculture sector faces different issues, principally derived from the aquatic environments in which it is done. Plant breeding companies are currently investing around 10% of their annual revenue in R&D while, in an aquaculture company, this rate can be expected around 2,5%, in best cases, and includes other research than genetics.

The TRL of genomic tools applied to aquaculture should be considered on a case-by-case basis, since the capacity for technology uptake differs significantly between species due to market size and turnover and companies' particular characteristics (size, investment capacity, technology intensity, etc.). As seen in other economic activities, bigger companies are in a better position for knowledge uptake, so they might be able to adopt technologies and knowledge outputs at lower TRLs (from 4-5) and usually have better access to the financial and human resources necessary for a successful exploitation. Some of these have adopted the strategy of integrating all the components of the production cycle, so they have better control of the overall process. However, although there is consolidation going on in European fin-fish aquaculture companies and sub-sectors, there are still many SMEs operating in EU aquaculture. In many cases, SMEs need higher TRLs, normally 8 or 9 for being able to integrate new knowledge and technology, and they normally lack the capacity to integrate all production cycle stages. Therefore, there is a need of scaling up and adopting solutions that allow results to reach higher TRLs, which smaller companies are able to deal with. Intermediate organizations that would be able to uptake knowledge in an earlier stage, such as technology and research centres linked to clusters and industrial associations, are approaches that have proven to be successful in terrestrial agriculture and in some areas with certain species in aquaculture.

However, in general, in the case of rearing molluscs, or pond fishes as common carp, additional measures need to be undertaken for a more successful investment and adoption of genetics technologies by these productions. These subsectors are highly fragmented with mostly family based companies and most of the production, at least for molluscs, relies on natural recruitment, and common carp on out-breed domesticated and non-selected seeds. However, and after more than a decade of developing hatchery production, already 40% of the oyster Crassostrea gigas grown in France (the major producer) comes from selected seeds produced in hatcheries, but an intense effort is still needed to overcome the specific sociologic or economic barriers, other than technology maturity and investment needs, affecting these species.

Scope for collective planning and collaboration

Considering that production in different areas (not only geographically but also marine vs. fresh water) focus on diverse species and face different problems, and taking into account that funding is a major issue to initiate the implementation of new genetic and genomic tools, the decision on the geographical scope for addressing the identified challenges is of paramount importance for a successful result.

At EU level, technology platforms constitute a good channel both for boosting cooperation among different stakeholders and provide industry-led joint communication channels towards the European Commission. The Farm Animal Breeding & Reproduction Technology Platform (FABRE) and The European Aquaculture Technology and Innovation Platform (EATIP) have already set their visions and priorities after the EU AQUABREEDING concerted action "Towards enhanced and sustainable use of genetics and breeding in the European aquaculture industry"[4] (6th Framework Programme), in which they were partners. Collaborative research projects involving genetic improvement in aquaculture have been founded in the last 7th Framework Programme calls, such as FISHBOOST[5] and DIVERSIFY[6], and Horizon 2020, like ResisGal[7] (MSCA-ITN), and they provide significant steps but a new action plan needs to be developed. Advantage should be taken from the collaboration networks created within these projects' consortia that include breeding companies, following similar collaboration models to the ones adopted in the livestock or poultry farming sectors. Results arising from on-going and new R&D initiatives are expected to be available in the short term and within the next 5 to 10 years, if current challenges get sufficient support.

It is worthy to keep in mind that Horizon 2020 is open to third countries participation under certain conditions, so a cooperation strategy beyond European borders could be considered under this framework, and mutual learning between different areas of the planet can yield opportunities and help introduction to new markets.

[4] http://cordis.europa.eu/publication/rcn/11790_en.html
[5] http://www.fishboost.eu/
[6] http://www.diversifyfish.eu/
[7] http://cordis.europa.eu/project/rcn/195715_en.html

The European Maritime and Fisheries Fund (EMFF) is also expected to be source of funding opportunities for additional aquaculture research, but these will be conditioned by strategic multiannual plans set up by Member States.

It should also be mentioned that the European Investment Bank could be interested in funding the aquaculture sector, but complementary important private funding is required.

All the above means that there are clear chances for raising funds for aquaculture investment on R&D and Innovation but having a common European strategy is the base for being able to present the activity in a cohesive way in front of the regulatory and funding bodies. Acting at Member State level through national and regional technology platforms, associations, support structures and bodies, etc., would help to orient national policies and funding instruments; but also at European level, as the message to the Commission can be supported by the National Representatives in different European committees (European Parliament, funding programmes' committees, etc.).

General understanding of genetics, capacity building and other relevant enabling conditions

Improving the general understanding of genetics by society and governing bodies was pointed out, as a necessary condition in order to increase acceptance and create an enabling environment for the industrial uptake of genetics and genomics knowledge. The implementation of breeding programmes can contribute to improve production efficiency around 7-10% per generation, but it is essential to encompass such technical improvements with other legislative and administrative aspects that actually hinder further development of the available knowledge to prepare it ready for industrial exploitation. The more that aquaculture productivity increases, the higher will be the need for infrastructures for different purposes; obtaining licences and access to suitable space has been a big issue in many cases, especially with regard to specific needs on water quality, accessibility and/or communication infrastructures. For example, new areas may be required for certain stages of the production cycle such as the conditioning and maintenance of broodstock, so progress on the effective implementation of Marine Spatial Planning regulations - integrating

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all aquaculture activities - is a clear need for the sector, for planning and negotiating the activity futures with some more certainty. Another example of existing constraints, in addition to the ethical considerations it may have, has to do with limitations that do not legally allow to the fulfilment of controlled challenge of sibs by breeding companies to pathogens to identify more resistant families and associated genomic markers. This kind of challenge causes a mortality impact on a limited number of individuals in the breeding programs but shall also provide relevant knowledge and genetic progress for fighting against such disease that will save life of billions of siblings produced at commercial level. Adaption of regulation is then also needed to allow research works to be applied by the production sectors.

Raising collective awareness on the relevance and implications of the application of genetic tools to aquaculture practices, would also contribute to a better understanding and potentially increase acceptance of aquaculture activities, facilitating the necessary changes involving shared use of natural areas, in inland as well as coastal or marine facilities.

On the other hand, particular attention should be paid to new training needs arisen from the access to new genomic tools, in order to guarantee the availability of the aforementioned highly qualified staff that is required for a successful implementation of such tools.

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