ECONOMIC AND ENVIRONMENTAL EFFECTS OF GENETIC IMPROVEMENT OF GROWTH RATE AND FEED CONVERSION RATIO IN SEA CAGE FARMING WITH PRODUCTION AND FEED QUOTA

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Introduction

In sea cage farming, as in most open aquaculture systems, production quotas apply. They limit the production capacity with the underlying objective to limit environmental impacts of fish farming (IUCN, 2009). We showed previously that selective breeding was an efficient tool to increase profit at farm level and at the same time, reduce environmental impact per unit of product by increasing production and productivity when fish are reared in (closed) RAS systems (Besson et al., 2014). However, in sea cage system the interactions between changes in fish performance and production quota is not known. In the present study, therefore, we investigated the effects of improving only growth rate or only feed conversion ratio (FCR) by selective breeding in three situations: without quota, with quota on production and with quota on feed consumption. The objective is to estimate the economic and environmental potential of improving growth rate and FCR.

Material and Method

At farm level, genetic improvement of a trait affects feeding strategy and/or management practices according to the limiting factor. Evaluating the impact of a genetic improvement requires therefore, (1) to model the whole farm operations via a bioeconomic model and (2) to calculate the environmental impacts along the production chain using Life Cycle Assessment. The bioeconomic model developed in this study is based on the model presented by Besson et al. (2014). The model describe a typical sea cage farm producing 1,000 tonnes of sea bass per year and estimates the purchase of feed and the sale of fish to calculate profit at farm level. The life cycle assessment includes two main stages: the production of feed purchased and the farm operations. The environmental contribution of the inputs and the outputs for each stage was evaluated to calculate the environmental impact of the production of one kg of fish.

The environmental and economic values (ENV and EV) of growth rate and FCR were calculated using the difference in profit and in environmental impacts per kg of fish produced between the current population mean for both traits (μt) and the next generation of selective breeding ($\mu t + \Delta t$).

EV and ENV were calculated in three different scenarios: no quota applied, production restrited by production quota and production restrited by feed quota.

Results

Without quota, improving growth rate can have a positive effect on economic profit and environmental impacts by increasing production. Improving FCR would improve both, profit and environmental impacts by increasing production and productivity. In this case, however, the environmental impacts at farm level would increase.

With quota on production, improving growth rate would increase stocking density but not production nor productivity. Consequently, profit and environmental impacts per ton of fish would not increase as well. Improving FCR would decrease individual feed intake leading to better productivity, higher economic profit and lower environmental impacts per tonne of fish.

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With quota on feed consumption, improving growth rate would not increase economic profit nor environmental impacts per tonne of fish. Improving FCR, however, would decrease individual feed requirement and therefore, increase production, which increases profit and decreases environmental impacts per ton of fish.

Moreover, when quotas apply, the environmental impacts at farm level remain stable.

Discussion and conclusion

First, production and feed quotas are efficient tools to limit the environmental impacts at farm level. Moreover, the results show that selective breeding could be an efficient tool to decrease the environmental impacts per ton of fish produced when quotas are applied. For instance, improving FCR would have considerable economic and environmental impacts by increasing production and productivity. However, the economic and environmental impacts of improving growth rate are very limited. This results confirm that FCR would be a major trait to breed for in order to improve economic and environmental efficiency of fish farming. These results also show the importance of evaluating the impacts of improving traits in order the better define the breeding objectives according to the farm constrains.

References

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