Validation of a new biological indicator to quantify the osmoregulatory capacity of salmonid species

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Smoltification is one of the most critical and important stages of the salmon production process. It consists of a series of biochemical, physiological, morphological and behavioral changes that allow a juvenile salmon to continue its productive cycle in seawater. It is an irreversible process, so there is a limited period of time for fish to be ready for ocean entry (smolt window).

Currently, smolt producers measure Na+/K+ ATPase pump activity as a routine indicator to determine if the smolts are ready to be transferred to the sea. However, this indicator shows a low time variability and a low predictive value.

The objective of this study was to validate Smoltmeter® as a laboratory service to predict the optimal osmoregulatory capacity of Atlantic salmon smolts (*Salmo salar*) and minimize losses. Smoltmeter® is based on multiple RT-qPCR that evaluates the relative expression of three genes that show a high predictive level of the optimal transfer time of animals to the sea, specifically, a freshwater subunit gene (SAD), a seawater subunit gene (SAM) and a cotransporter gene (COT), in addition to the respective associations between the expression of each of them.

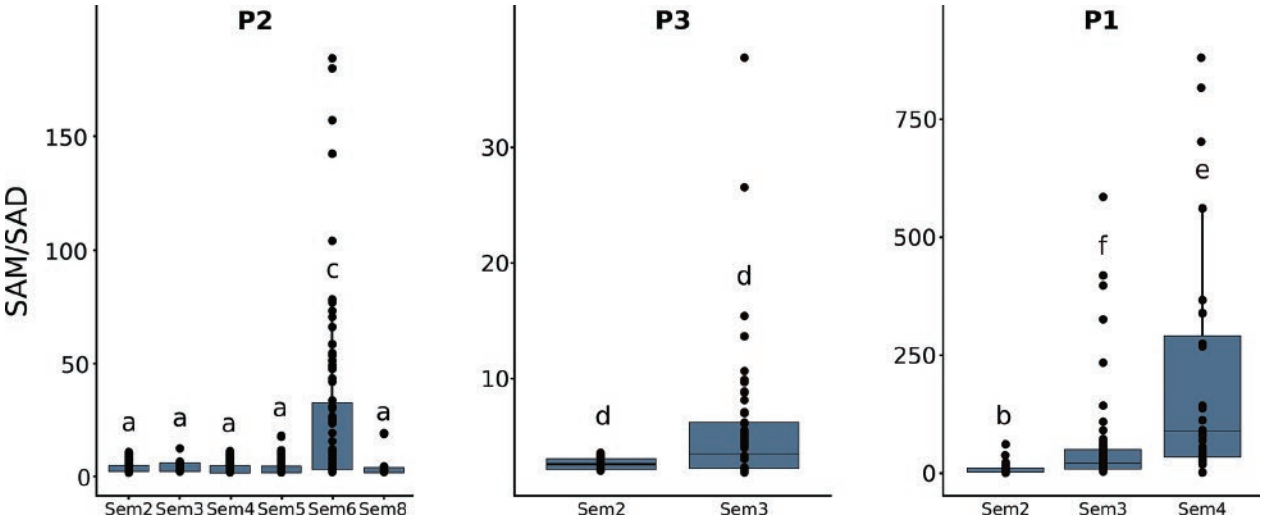

Figure 1. SAM/SAD ratio during smolt photoperiod weeks in each farm (P1, P2, P3).[abcdef] show significant differences between the group, p<0.05.

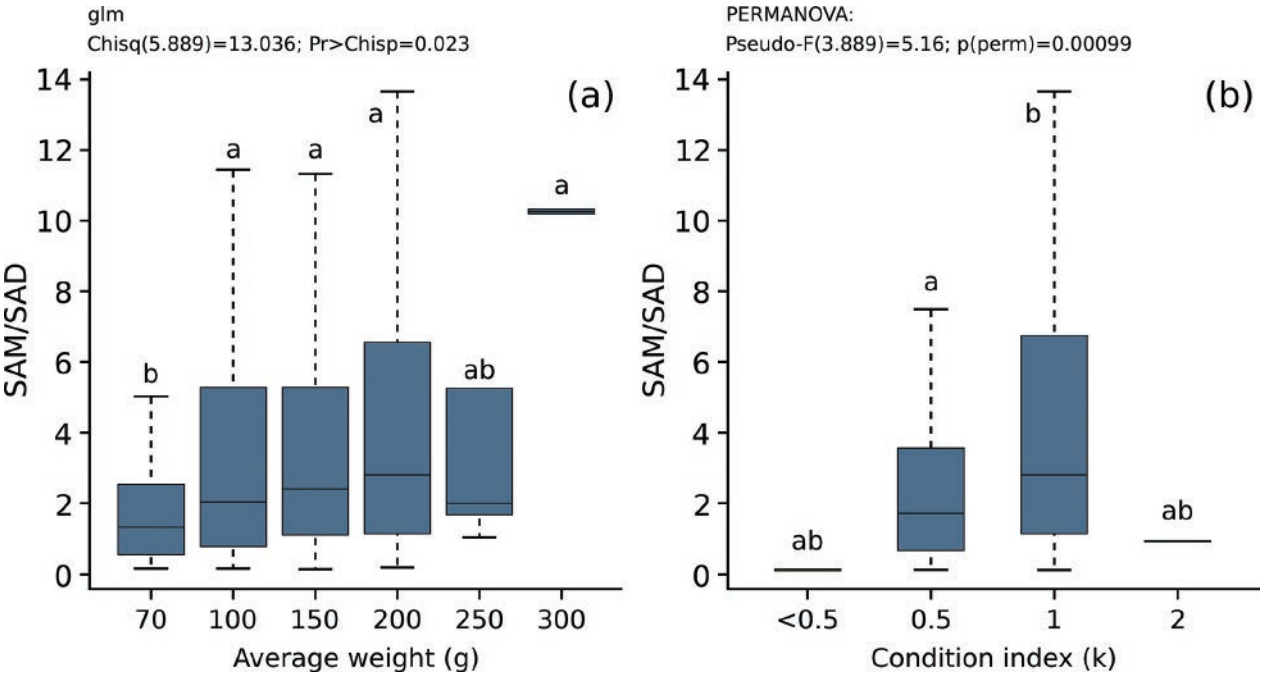

Figure 2. SAM/SAD ratio between the average weight (a) and the condition index (b).

Methods

Fish from three farms (P1, P2, P3) were transferred to a cage farm (CM1). Duplicate samples were collected from the second gill arch of each fish for RT-qPCR analysis (Smoltmeter®) and to measure the activity of the enzyme Na+/K+ ATPase. Data on weight, length, condition factor, body color and fins on each stage were recorded.

The density function for the SAM/SAD ratio was estimated during the summer photoperiod weeks and changes between farms. Weight and condition factors were evaluated. The relationship between the SAM/SAD ratio and the activity of the Na+/K+ ATPase enzyme in failed smolts was also analyzed.

Summer photoperiod weeks

The SAM/SAD ratio showed significant changes during smolt photoperiod. The first change took place on weeks two and three, followed by a significant increase on week five and a reduction on week eight. All SAM/

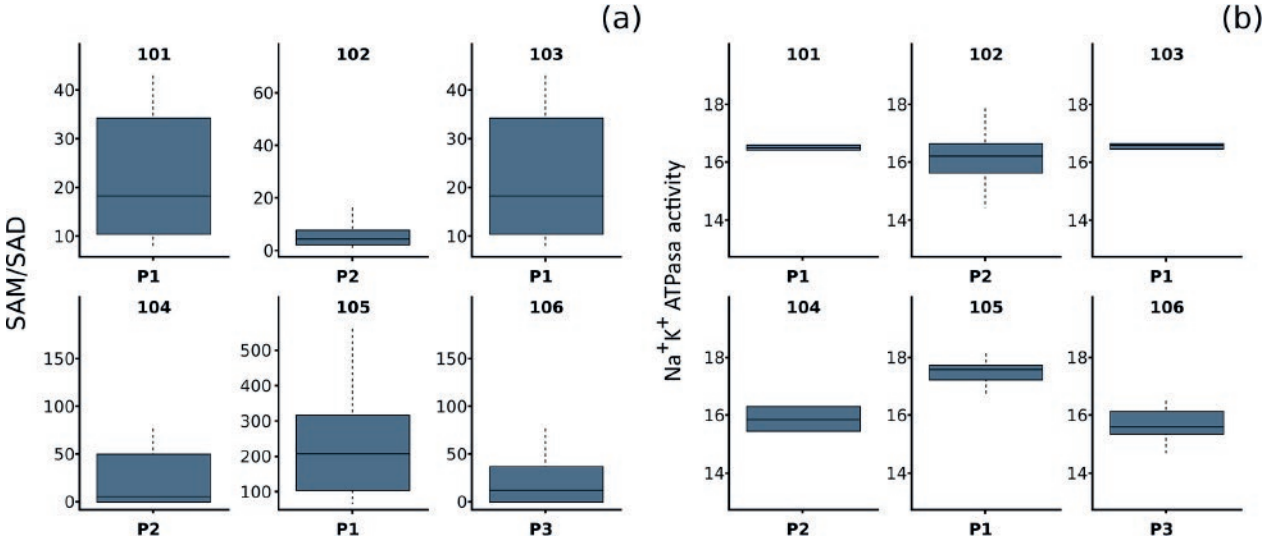

Figure 3. Differences in SAM/SAD ratio (a) and Na+/K+ ATPasa activity (b) in fish depending on its farm origin and cage destiny.

SAD levels were greater than 1.8 (Fig. 1). Different levels of SAM/SAD ratio between fish farms were observed, but P1 had the highest values (Fig. 1).

Additionally, significant differences were observed between the average weight and the condition index depending on the SAM/SAD ratio (Fig. 2). A significant increase in SAM/SAD was observed in fish bigger than 100 g (Fig. 2a) and with a higher condition index (Fig. 2b).

Marine center

One hundred percent of the smolts from P1 were smoltified while the rate of the fish from P2 and P3 was about 60%. Na+/K+ ATPase enzyme activity showed low variability and a value close to 16 in all fish farms (Fig. 3b). However, the proportion of failed smolts in CM1 was higher in fish from P2 and P3, a situation that could not have been predicted by the enzyme. The SAM/SAD ratio was lower in the center P2 and P3 fish (Fig. 3a), which correlated with higher mortality due to mismatches in CM1.

A negative correlation between SAM/SAD and failed smolts at 90 days was observed. Therefore, SAM/SAD can be a good predictor of failed smolts mortality. Mortality began after the sixth week after admission. Cage 104 had the highest mortality rate and cages 101 and 103 with fish from P1 farm cages of P1 has the lowest.

Failed smolts mortality is negatively related when the SAM/SAD ratio is higher than 1.8. The cages with a smaller proportion of fish with a SAM/SAD ratio higher than 1.8 had higher mortality rates. This indicates that there is a significant relationship between failed smolts mortality and a high proportion of SAM/SAD fish> 1.8.

Conclusions

According to the present field study, it is concluded that the higher the proportion of smolts, the lower the failed smolts mortality. The higher the proportion of fish with SAM/SAD ratio> 1.8 in each cage, the lower the risk of failed smolts mortality.

Failed smolts mortality depends on the amount of non-failed smolts (SAM/SAD ratio> 1.8), rather than on farms of origin. To minimize mortality, a homogeneous population is required, where 100% of the cage fish population has SAM/SAD> 1.8.

SAM/SAD> 1.8 shows a better predictive value of failed smolts mortality at the destination center than the activity of the enzyme Na+/K+ ATPase.

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