GENETIC VARIATION IN GROWTH IN ATLANTIC SALMON WHEN FED CONVENTIONAL AND INNOVATIVE DIETS

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Introduction

Genotype-by-environment interaction (GxE) is a measure of the magnitude of re-ranking of genotypes across environments. Significant GxE creates discrepancy between the expected and realized performance when the selected genetic material from the breeding nucleus is reared in divergent environmental conditions in commercial aquaculture. Estimates of GxE are lacking for many economically important traits (Sae-Lim *et al.*, 2015) and need to be assessed to enable optimization of breeding programs towards development of robust genetic material for future conditions. Use of alternative raw materials in fish feed formulation is prompted by many regulatory, climatic and societal factors to guarantee future sustainable European aquaculture (Skiba *et al.*, 2015). This brings upon a need to assess whether there is significant genotype-by-feed interaction; breeding companies are dependent on the assessment whether their current genetic material can express the production potential when alternative feed sources are utilized. The objective of this study was to estimate genetic parameters of growth in Atlantic salmon when fed with conventional and innovative diets.

Material and methods

Individually tagged Atlantic salmon from 75 full-sib families (Benchmark Genetics Norway) were randomly assigned in four parallel 5m x 5m cages at Gildeskål Research station (Inndyr, Norway), where two of the cages were fed with conventional marine-based diet (N=1993) and two with innovative diet (N=1960). Both feed types were formulated and produced at Aquafeed Technology Center (Nofima AS, Bergen, Norway) and were isoenergetic. In the innovative diet, 50% of the marine oil was replaced by algae and 75% of the fishmeal by insect meal. Additionally, innovative diet had no soya. In addition to body weight (EWT), $TGC = \frac{\sqrt[3]{EWT} - \sqrt[3]{TAGWT}}{day\ degrees} * 1000$ (thermal growth coefficient) and $ADG = \frac{EWT - TAGWT}{duration\ of\ experiment}$ (average daily gain) were calculated and used as phenotypes. Multivariate model treating phenotypes among diets as different traits was fitted to estimate the genetic parameters using restricted maximum likelihood in BLUPF90 (Misztal *et al.*, 2018). Genomic relationship matrix was used in the estimation.

Results and discussion

The fish from the conventional diet were at the end of the trial significantly larger (1581 g) than those fed with innovative diet (1372 g). The mortality rate in groups fed with the innovative diet was 32.2% whereas in cages fed with conventional diet it was 19.4% (overall 25.8%). The frequency of deformities (6%) and wounding (0.6%) were low, and only three individuals were registered as sexually mature. During the summer 2020 high mortalities were registered and the disease heart and skeletal muscle inflammation (HSMI) was verified causing 6% mortality independent on the diet.

Families expressed large phenotypic variation in EWT in both diets (CV=0.28) (Figure 1). Only two families had higher average growth with the innovative diet than with conventional diet. The difference in EWT family average varied from -5.8 to 32.8%.

Phenotypic rank correlation for growth phenotype family means varied between 0.81 and 0.85, indicating only low re-ranking of families between the diets.

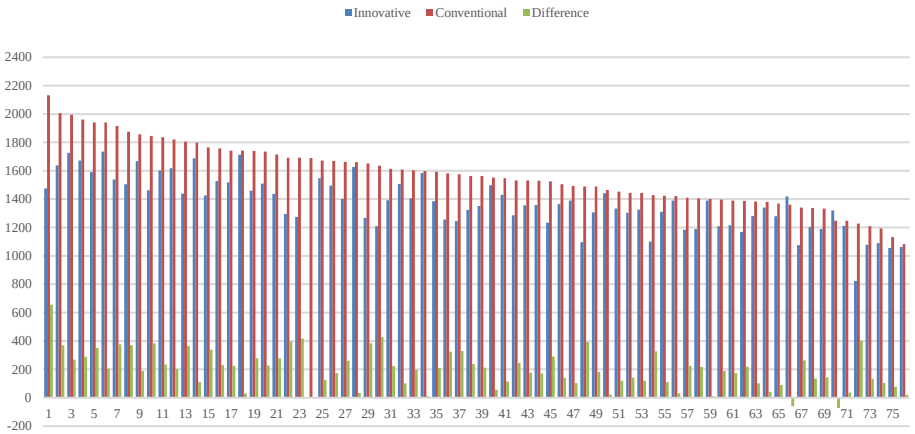

Figure 1. Phenotypic family means (and their difference) for EWT for innovative and conventional diets.

Estimates of heritability for growth traits were high: 0.41-0.45, and genetic correlations between growth traits among diets were very high (0.96-1.00), indicating no re-ranking of genotypes across diets (Table 1). Heritability for survival was low very low for both innovative (0.03) and conventional diet (0.11). Genetic correlation for survival indicated moderate re-ranking of genotypes across diets: r_g=0.68.

	EWT_fut	**EWT_conv**
EWT_fut	**0.44 ± 0.00**	
EWT_conv	1.00	**0.45 ± 0.00**
	TGC_fut	**TGC_conv**
TGC_fut	**0.41 ± 0.03**	
TGC_conf	0.96 ±0.01	**0.44 ± 0.03**
	ADG_fut	**ADG_conv**
ADG_fut	**0.44 ± 0.03**	
ADG_conv	1.0 ±0.01	**0.45 ± 0.03**

Table 1. Estimates of heritability and genetic correlations for growth traits across the diets. Estimates of heritability in sub-diagonals (**bold**).

Our study showed that growth in Atlantic salmon is impaired when fed with innovative feed where large proportions of marine ingredients are replaced by algae and insect meal. We did not detect genotype-by-feed interaction in growth in Atlantic salmon during this limited growth period from average body weight of 135 g until ~1.5 kg, whereas moderate genotype-by-feed interaction was detected for general survival.

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Acknowledgements

FutureEUAqua is funded by the H2020 program Sustainable European aquaculture 4.0: nutrition and breeding (GA nr. 817737).

We wish to acknowledge Gildeskål Research Station for running the experiment for FutureEUAqua WP1 Task 1.1.