Optimizing microdiets and feeding levels for improved growth and feed conversion in Atlantic halibut post-larvae

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Atlantic halibut is a key species for diversifying European aquaculture, due to its high market value and strong consumer demand. Although significant progress has been made in zootechnical practices, feeding strategies and microdiet quality for other emerging flatfish species such as Senegalese sole (Pinto *et al.*, 2018), research and development efforts aimed at optimizing the feeding and nutrition of Atlantic halibut larvae remain limited.

Transitioning from live feed to inert microdiets

Current feeding protocols for Atlantic halibut larvae are heavily reliant on live feed, particularly Artemia, which has been associated with suboptimal larval and juvenile quality (Puvanendran *et al.*, 2009). Additionally, Atlantic halibut struggles to accept inert microdiets during first feeding (Hamre *et al.*, 2019), which can delay the weaning process and lead to higher mortality and reduced growth rates. To address these challenges, it is essential to develop customized microdiets with enhanced attractiveness, suitable nutritional content and optimized physical properties. Furthermore, investigating the impact of varying feeding levels on halibut performance is crucial to improve feeding efficiency. The ultimate goal is to achieve optimal growth and feed conversion while minimizing any negative impact on water quality.

Testing microdiets and feeding levels on Atlantic halibut post-larvae

SPAROS and Otter Ferry Seafish partnered up to conduct a study (Trial A) evaluating the effects of three different microdiets, fed at two feeding levels, on the growth performance and feed conversion of Atlantic halibut post-larvae (Fig. 1). Two commercial microdiets (CM1 and CM2) and one experimental microdiet (EXP) formulated by SPAROS were tested at two feeding levels (100% and 80%). The study comprised a total of six treatments, combining each microdiet with each feeding level (CM1_100, CM1_80, CM2_100, CM2_80, EXP_100, EXP_80). Atlantic halibut post-larvae were randomly distributed into 18 tanks at 107 days post-hatch (dph) and monitored until 148 dph. Microdiet size ranged from 500 to 1,200 µm and water temperature ranged from 12.2°C to 14.6°C throughout the trial.

Feeding levels were adjusted daily based on visual inspection of the tanks and feeders. The total feed ration and leftovers were also recorded at the tank level. Fish were sampled at the beginning (107 dph) and at the end (148 dph) of the trial in order to measure Wet Weight (WW), Total Length (TL), Relative Growth Rate (RGR, %.day-1), Feed Conversion Ratio (FCR), and survival rate. Additionally, the whole-body composition of halibut post-larvae was analyzed to estimate nutrient retention. All statistical analyses were conducted using R software, considering a p-value <0.05 as significant.

Enhanced performance with a customized microdiet

Both CM2 and EXP groups demonstrated increased Relative Growth Rate (RGR) regardless the feeding level. By the end of the trial, only CM1 group exhibited a significant reduction in RGR between the 100% and 80% feeding levels. In contrast, the EXP group had the lowest Feed Conversion Ratio (FCR) at both feeding levels ($p<0.05$, Fig. 2). Furthermore, Atlantic halibut post-larvae fed on the EXP microdiet tended to have a higher final body weight when compared with fish fed CM1 or CM2 microdiets.

The improved growth performance and excellent feed conversion may be attributed to the higher protein content in the EXP microdiet (66% compared to 56% and 55% for CM1 and CM2, respectively). EXP microdiet also contains a blend of highly digestible ingredients, including a moderate level of pre-digested protein, which has been previously linked to promoting growth and survival in Atlantic halibut larvae (Tonheim *et al.*, 2005). In addition, EXP microdiet's high phospholipid and low neutral lipid content may further reduce the likelihood of excessive lipid accumulation in the liver (Morais *et al.*, 2007), thus allowing good liver health and normal lipid metabolism during early development stages.

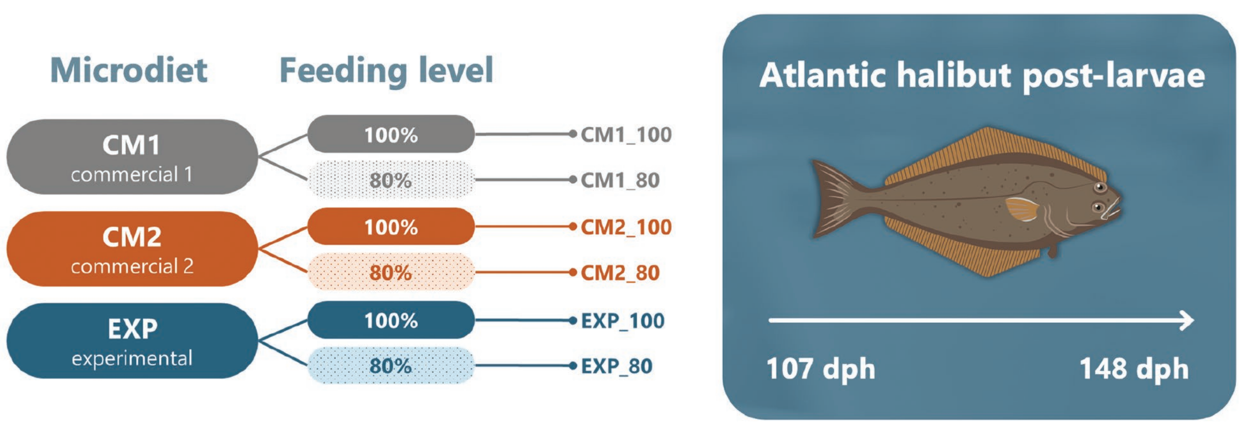

Figure 1. Diagram illustrating the experimental design of Trial A.

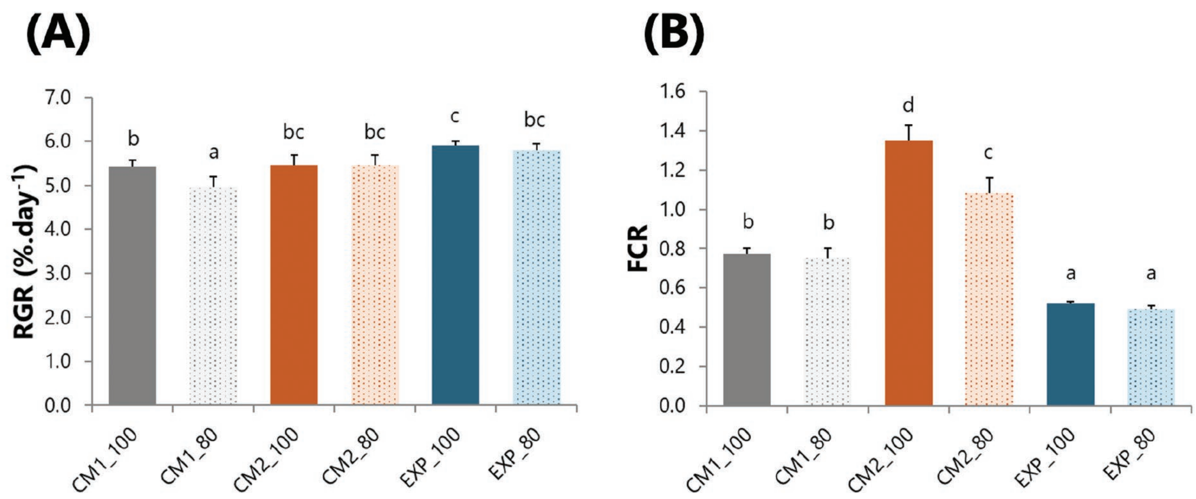

Figure 2. Relative Growth Rate (A) and Feed Conversion Ratio (B) of Atlantic halibut post-larvae at 148 dph, after being fed three different microdiets (CM1, CM2 and EXP) at two feeding levels (100% and 80%). Results are expressed as means ± standard deviation. Different lowercase letters indicate significant differences between dietary treatments (ANOVA, Tukey-HSD, $p<0.05$).

Overall, the results of this trial show that improved feed conversion can be achieved during early developmental stages through customized nutrition, and that higher feeding levels may not result in extra growth for halibut post-larvae.

Customized microdiets can help reduce production costs, starting at weaning

In a subsequent study (Trial B), SPAROS formulated and produced 3 additional customized microdiets (D1, D2 and D3), which were tested with older Atlantic halibut larvae (180-221 dph) and benchmarked against the most widely used commercial diet. Results on growth performance were similar across all fish groups. The main highlight goes to the FCR, with fish fed on experimental diets D2 and D3 tending to have lower feed conversion, similar to what was observed with the EXP diet in the first trial. Such differences in FCR translate into a substantial reduction in feed used to achieve the same growth performance during the early life stages of Atlantic halibut. Overall, the customized microdiets tested in both trials can contribute to a reduction of up to 8% in Economical Conversion Ratio (ECR; Eur spent on feed per kg of fish produced; Fig. 3), ultimately helping halibut hatcheries to maximize profitability, while keeping good water quality and fish welfare standards.

Leveraging data science for future innovations

These studies were carried out as part of the HATCHTOOLS project, a collaborative R&D initiative between SPAROS (Portugal), Otter Ferry Seafish (Scotland), and FLATLANTIC (Portugal). The project's goal is to enhance flatfish larvae nutrition and feeding

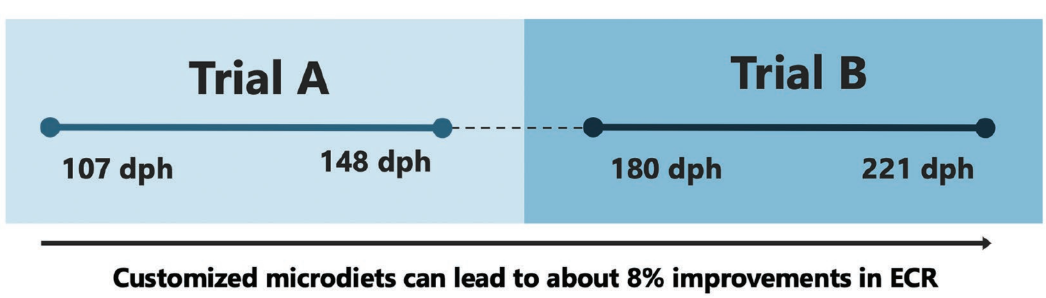

Figure 3. Diagram illustrating the stages of Atlantic halibut post-larvae evaluated in both trials, highlighting potential improvements in economic conversion when using customized microdiets.

management through the development of data science tools in the form of a software system tailored for fish hatcheries. The project includes: (i) research into mathematical models to describe larval growth and feeding, combining historical research data with new data generated through nutrient flow studies and respirometry measurements; (ii) the development of data analytics and predictive tools presented as a user-friendly web application; (iii) industrial-scale demonstration of these tools to validate their potential in improving larval nutrition, feeding strategies, and overall hatchery management practices.

The HATCHTOOLS system will enable the automation of research and production data analysis, streamlining processes and improving decision-making in flatfish larvae nutrition and hatchery management.

By utilizing an integrated data science approach, future innovations can be achieved more efficiently and rapidly.

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