TAILORING DIETS FOR THE EARLY STAGES OF FLATFISH: REVIEWING LATEST FINDINGS ON SOLE AND TURBOT LARVAE NUTRITION

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Introduction

Flatfish species such as Senegalese sole (*Solea senegalensis*) and turbot (*Scophthalmus maximus*) have emerged as valuable niche species in Southern-European aquaculture, primarily due to their high-quality white flesh and elevated market value. Nonetheless, these species have some significant behavioural, anatomical and physiological variations. Namely, both present differences in feeding behaviour and digestive tract anatomy, already noticeable from the post-larval stage, with sole being more passive, feeding on the bottom of the tanks and displaying an elongated digestive tract typical of an omnivorous species. Contrarily, turbot actively feeds on water surface and exhibits a well-developed stomach and a shorter intestine, typical traits of a carnivorous species. Moreover, considerable research and development efforts over the past two decades have led to notable advancements in sole larval rearing techniques, including the refinement of weaning protocols, improvements in microdiet quality, and optimization of zootechnical procedures (Pinto et al., 2018). In contrast, the literature on nutritional strategies and feeding protocols during the early developmental stages of turbot remains relatively scarce. The present study aims at reviewing the latest efforts conducted on the road to create specific microdiets for sole and turbot larvae. To this end, this study aims at demonstrating how tailored microdiets can help tackling the nutritional challenges faced by each species during the early developmental stages.

Materials and methods

Experimental trials were conducted during the first weeks of development of sole and turbot, ranging from 25 to 70 days after hatching (DAH). In these trials, larvae were reared in triplicate tanks under standard zootechnical conditions and fed *ad libitum* on experimental diets comprising of each trial. Trials focusing on macronutrients evaluated sources (marine vs plant-based) and levels of protein (55-61%) and lipids (12-17%). In terms of micronutrients, dietary calcium to phosphorous (Ca:P) ratio was investigated to understand its effect on skeletal malformations and body conformation of sole (e.g. slender vs round phenotype). In addition, the adequacy of feed additives (e.g. binder levels) and functional ingredients (e.g. curcumin) were also evaluated for both species. At the end of experimental trials fish were analysed for growth parameters (weight, length and relative growth rate), survival, and feed conversion ratio, to evaluate the biological efficacy of dietary treatments. The physical properties of microdiets (e.g. floatability) and leaching of water-soluble nutrients were also monitored on the different experimental trials to ensure their adequacy for the feeding behaviour of each species.

Results

Results from the experimental trials showed different scenarios for sole and turbot, not only in terms of preferential ingredients to be included in microdiets, but also on sources and levels of macro/micronutrient to be adopted. Sole showed no preference between dietary protein sources (fish, squid, krill and plant-based diets), increasing growth performance when high levels of protein and medium levels of lipids were included in

the diet. In addition, graded levels of dietary Ca:P ratios did not affect sole development in terms of growth performance, skeletal malformations or body conformation. The inclusion of high binder levels also increased sole growth performance, with these being negatively correlated to leaching of dietary water-soluble nutrients. In terms of functional ingredients, it was observed that dietary curcumin supplementation boosted sole growth performance. Diet physical properties were also shown to be extremely relevant for sole, as depressed growth and low survival was found when fish were fed a commercial diet with high floatability and residence properties at water surface.
On the other hand, turbot did not tolerate high levels (>30 %; feed basis) of squid meal in the diet, exhibiting good growth performances when the main protein sources were fishmeal, krill meal or a mixture of marine and plant-based proteins. Contrarily to sole, turbot growth was not affected by diets with protein levels equal or above 55 %, or when dietary lipids were at medium or high levels. Opposed to sole, diet binder levels did not play a key role in turbot growth, with fish showing similar performances at low and high levels. Dietary curcumin supplementation did not play a significant role in boosting turbot growth but had a positive effect on larval total antioxidant capacity.

Discussion

Senegalese sole and turbot showed a different response to the nutritional composition of microdiets during the early developmental stages. As an omnivorous species, sole is apparently more eclectic in its dietary preference, showing a good response to several sources of dietary protein. However, continuous research showed by this study on the effects of different dietary nutritional compositions indicates the species tends to prefer high-protein diets and moderate lipid levels, benefiting from diets with a high binder inclusion level that retains water-soluble nutrients for a prolonged period. This feature is particularly important due to its passive feeding behaviour, with a positive effect on water quality. These clear nutritional preferences justify the considerable amount of research conducted during the past two decades to optimise the nutritional composition of sole diets (e.g. Pinto et al., 2016; Canada et al. 2017; Pinto et al., 2018). On the other hand, turbot seems to require a diet with a lower degree of specialization during the early developmental stages, as it is more tolerant to nutritional changes without a significant loss of performance. Combined with its voracity and active feeding behaviour, it is also perceptible why a lower research effort has been conducted on nutritional preferences and weaning of the species. Nonetheless, it is clear that a unique diet will not be optimised for both species, as nutritional composition and diet physical properties such as floatability have a preponderant role on the performance of sole and turbot during the early developmental stages. To this end, this work supports that tailoring the nutritional composition and physical properties of diets for marine fish larvae will contribute to produce high quality juveniles in aquaculture.

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