Key Nutritional Factors in Larval Development

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ABSTRACT

Fish larvae are fascinating tiny free living forms of vertebrates. They are unique from their parents not only in the physical appearance but also in the nutritional requirement and feeding patterns. The larval phase are the most sensitive period in the rearing of fishes and mortality will be more intensive during this period because of the poor understanding of their nutritional needs and the physiology of the larval forms. This paper reviews the key nutritional factors which contributes in the growth and morphological changes in the larval forms and also the defects cause in larvae due to the lack of these key nutritional factors.

INTRODUCTION

Nutrition is very critical in fish development throughout their early life stages. Understanding the specific dietary requirements of larval fish can help to enhance the efficiency and quality of fish grown in a culture environment. In general, there are three types, a larvae can transform into juvenile stage (Pavlov 1999): indirect development (also known as altricial development), intermediate development, and direct growth (also called precocial). The transition period between endo and exotrophic feeding in fish larvae is crucial because it is frequently associated by poor enzymatic activity, increased mortality, and decreased growth. Before growing larvae to juveniles, the nutrients that play a vital role in larval nutrition must be identified.

TAURINE AND FAA POOL:

FAA (free amino acids) is the single amino acids that are already in the predigested form and are absorbed directly through the blood stream. They are found in all cells of the body and in extracellular fluid. Transportation of these free amino acids is between the tissues in the plasma and cells by variety of transport mechanisms. Free amino acids found in relatively high amounts in fish are glycine, taurine, alanine and lysine. Free amino acids makeup only approximately 2% of the total amino acid content of the body, the rest being present as protein. The most abundant amino acid in the FAA pool from animal blood and tissues is taurine, a b-sulfonic-amino acid that only exists in free form. Taurine has long been thought to be a necessary nutrient for the normal growth of marine fish (NRC 2011). Taurine is not incorporated into proteins, but rather exists in the free amino acid pool where it is employed for cell volume regulation and bile salt production, among other things. It improves growth performance by increasing protein synthesis efficiency and also helps in the protein translation towards digestive enzyme in the first two weeks after hatching. It also affects larval metabolism by increasing methionine availability for a variety of important physiological purposes and has positive effect on larval metabolism. There was also a positive effect of taurine on larval morphological development. The FAA pool is created during the last stage of oocyte development and appears to result from the hydrolysis of a yolk protein. The FAA pool is depleted during yolk resorption and reaches small amounts at first feeding. The FAA are primarily used as metabolic fuel, but they are also used for protein synthesis in the body. After the onset of first feeding, amino acids are also important catabolic substrates, accounting for 60% or more of energy dissipation. Because growth is primarily defined as an increase in body muscle mass through protein synthesis and accretion, and fish larvae grow at a rapid rate, they have an elevated dietary requirement for amino acids. Fish larvae with late stomach development have low proteolytic and absorptive capacities at first feeding.

In the early stages of marine fish larvae, FAA was found to be more absorbable than peptides and protein bound amino acids from the larval gut. Marine fish larvae in the ocean obtain a large supply of FAA by consuming plankton after first feeding. The FAA composition of live feed used in aquaculture can be manipulated to some extent depending on rearing conditions, species and strain selection. Although microdiets are a promising source of nutrition for fish larvae, no satisfactory delivery methods for high FAA content have yet been discovered.

Only liposomes, lipid-walled particles, showed promise for delivering FAA and other water-soluble molecules to first-feeding larvae. These findings are promising, but because liposomes are typically in the nm or mm range, they are unlikely to form the direct food particle of first-feeding fish larvae. Two solutions to this problem have been reported Artemia fed liposomes was a practical way to enrich the live food with phospholipids and FAA. The second technique has been to incorporate phospholipid-rich liposomes into a micro diet, which is then fed to fish larvae.

PHOSPHOLIPID

Phospholipids are structural elements of bio-membranes and thus its of high need in quickly growing larvae. Phospholipids also play a role in lipid digestion, absorption, and transport from the colon to the rest of the body. There are various evidence that fish larvae are unable to synthesis PL efficiently enough to meet their high demand, and so PL must be provided in the diet (Izquierdo & Koven 2011). Fish larvae depend on the quality of the dietary phospholipid (PL), and their docosahexaenoic acid (DHA) content is particularly crucial for normal growth and functional development. Fish larvae require not only a specific quantitative amount of dietary PL in their feed, but they also depend on the quality of the dietary PL. The favourable benefits discovered were primarily connected with growth, survival rates, digestive functions, the presence of abnormalities, and stress resistance in diverse species of fish larval and juvenile stages.

PL are a diverse set of compounds generated by various bases and kinds of fatty acids, their effect in larvae may vary depending on the specific components of the dietary PL source employed. For example, being the major product of PL synthesis in fish enterocytes, phosphatidylcholine (PC) promotes apolipoprotein B production to a greater extent than other PL types (Field & Mathur, 1995). By boosting energy transfer from the intestinal mucosa into the blood, increased lipoprotein synthesis may be responsible for PC's growth promotion impact. Phosphatidylinositol (PI) a structural component of bio-membranes has a wide range of forms and activities within the cell. Thus, PI functions as a precursor of second messengers (inositol 3 phosphate, IP3), controlling the entrance of calcium ions from the endoplasmic reticulum into the cell. It also serves as a membrane anchor for a wide range of cell surface proteins. As a result, PI is implicated in a signaling system that regulates biological activities throughout early vertebrate development.

ARA, EPA, DHA, and total HUFA optimal dietary levels in live prey and larval inert meals, as well as DHA: EPA and EPA: ARA ratios, have not yet been quantified in most European fish larvae, despite the significance of essential fatty acids for fish larvae growth and the wealth of research surrounding these nutrients. Furthermore, in dose-response experiments involving at least five nutrient levels, biotic and abiotic parameters such as salinity, temperature, green water addition, intensiveness of the culture system, and interrelationships with other nutrients such as antioxidants and other vitamins should be examined. And given the variety of physiological effects of the various fatty acids needs should be calculated not simply in terms of development and survival, but also considering development of biological functions and processes, such as pigmentation, muscle skeleton and neural system development.

VITAMINS

Fat soluble vitamins are key morphogenetic nutrients in fish larvae development. The substances known as vitamin A (VA), vitamin D (VD), vitamin E (VE), and vitamin K (VK) are included in the generic category of fat-soluble vitamins. These are critical micronutrients for fish growth and homeostasis that must be delivered in a certain amount and chemical form in the diet because fish cannot build them from scratch. VA is a terpene, while VE and VK contain long terpene chains connected to an aromatic component, whereas VD is an ergosterol steroid derivative. Fat-soluble vitamins are (i) absorbed with dietary fat through the small intestine, (ii) have a more complicated metabolism (including the presence of specialized nuclear receptors), and (iii) may be readily retained in certain organs (primarily the liver and adipose tissue). (iv) are eliminated slowly, therefore they stay in the body longer.

VITAMIN A

Retinoids, also known as VA, are a class of key morphogens that include all compounds with the same biological activity as retinol, serving a variety of important functions in vision, pigmentation, body patterning, epithelial surface maintenance, immune competence, nervous system, reproduction, and embryonic growth and development.

VITAMIN D

The VD endocrine system is well recognized for its function in calcium and phosphate homeostasis, mediating transcellular calcium absorption and promoting cytosolic calcium transport. . It has been demonstrated that VD3 needs are highest during the larval stage and should be assessed for each species since they might vary substantially, with species and developmental stage-specific requirements (Darias *et al*., 2011).

VITAMIN E

VE can play non-oxidant roles such as modulating eicosanoid synthesis and immune responses, inhibiting smooth muscle cell proliferation, and having multiple post-translational signaling functions such as activation of protein phosphatase 2A, among other enzymes. Because marine fish larvae are most likely exposed to high levels of oxidative stress and a high demand for VE in fish species might be predicted, and high lipid content in fish diets can also encourage oxidation. However, because vitamin C is involved in the regeneration of tocopheryl radicals to tocopherol, supplementing of marine fish larval diets with VE and VC is a standard practice.

VITAMIN K

VK may be important for a larger variety of biological processes such as muscular contraction, resistance to osmotic stress, intracellular Ca2+ homeostasis, or energy metabolism using proteome analysis. VK has a key function in the synthesis of sphingolipids, and hence in the development of the central nervous system and cognition capacities. Furthermore, VK may be involved in glucose metabolism by boosting insulin secretion and b-cell proliferation in the pancreas, as well as reproduction by promoting testosterone synthesis.

MINERALS

Minerals such as zinc, manganese, zn+mn, selenium and iodine should be included in the larval diet based on the species-specific requirement of the larvae. It contributes in the larval development, greater survival but the lack of minerals in the diet causes goiter, decreased growth and impacts on the thyroid hormone metabolism in Senegalese sole larvae.

CONCLUSION:

The dietary requirements of larvae have only been partially recognized, and much remains unclear. The nutritional requirements of marine fish larvae can be more readily characterized with the introduction of superior micro diets with increased attractability and digestibility. Minerals, vitamins, particular proteins, and amino acid balance should be considered with estimated and real FCR. This research will lead to better feeding practices and the application of nutritional tools, as in fish nutrition. Finally, more consistency in the design and execution of nutritional experiments will allow for the comparison of results from different systems and trials. Similarly, studies directed towards the modulation of the nutritional composition of novel diets, and existing live food organisms, to match the functional capacity of the larval intestine would seem to be a prerequisite for increased success in larval development

REFERENCES:

Rønnestad, I., Thorsen, A. and Finn, R.N., 1999. Fish larval nutrition: a review of recent advances in the roles of amino acids. *Aquaculture*, *177*(1-4), pp.201-216.

Cahu, C., Infante, J.Z. and Takeuchi, T., 2003. Nutritional components affecting skeletal development in fish larvae. Aquaculture, 227(1-4), pp.245-258.

Infante, J.Z. and Cahu, C.L., 2001. Ontogeny of the gastrointestinal tract of marine fish larvae. Comparative Biochemistry and Physiology Part C: Toxicology & Pharmacology, 130(4), pp.477-487.

Hamre, K., Yúfera, M., Rønnestad, I., Boglione, C., Conceição, L.E. and Izquierdo, M., 2013. Fish larval nutrition and feed formulation: knowledge gaps and bottlenecks for advances in larval rearing. Reviews in Aquaculture, 5, pp. S26-S58.

Conceição, L.E., Aragão, C., Richard, N., Engrola, S., Gavaia, P., Mira, S. and Dias, J., 2010. Novel methodologies in marine fish larval nutrition. Fish physiology and biochemistry, 36(1), pp.1-16.

El Kertaoui, N., Lund, I., Assogba, H., Domínguez, D., Izquierdo, M.S., Baekelandt, S., Cornet, V., Mandiki, S.N., Montero, D. and Kestemont, P., 2019. Key nutritional factors and interactions during larval development of pikeperch (*Sander lucioperca*). Scientific reports, 9(1), pp.1-15.

Watanabe, T. and Kiron, V., 1994. Prospects in larval fish dietetics. Aquaculture, 124(1-4), pp.223-251.

El Kertaoui, N., Lund, I., Assogba, H., Domínguez, D., Izquierdo, M.S., Baekelandt, S., Cornet, V., Mandiki, S.N., Montero, D. and Kestemont, P., 2019. Key nutritional factors and interactions during larval development of pikeperch (Sander lucioperca). Scientific reports, 9(1), pp.1-15.

Hamre, K., Yúfera, M., Rønnestad, I., Boglione, C., Conceição, L.E. and Izquierdo, M., 2013. Fish larval nutrition and feed formulation: knowledge gaps and bottlenecks for advances in larval rearing. Reviews in Aquaculture, 5, pp. S26-S58.

Reitan, K.I., Rainuzzo, J.R., Øie, G. and Olsen, Y., 1997. A review of the nutritional effects of algae in marine fish larvae. Aquaculture, 155(1-4), pp.207-221.

Pavlov, D.A., 1998. Features of transition from larva to juvenile in fishes with different types of early ontogeny. In When do fishes become juveniles? (pp. 41-52). Springer, Dordrecht.

Jobling, M., 2012. National Research Council (NRC): Nutrient requirements of fish and shrimp.

Izquierdo, M.S., Socorro, J., Arantzamendi, L. and Hernández-Cruz, C.M., 2000. Recent advances in lipid nutrition in fish larvae. Fish Physiology and Biochemistry, 22(2), pp.97-107.

Field, F.J. and Mathur, S.N., 1995. Intestinal lipoprotein synthesis and secretion. Progress in lipid research, 34(2), pp.185-198.

Darias, M.J., Mazurais, D., Koumoundouros, G., Cahu, C.L. and Zambonino-Infante, J.L., 2011. Overview of vitamin D and C requirements in fish and their influence on the skeletal system. Aquaculture, 315(1-2), pp.49-60.