

An Introduction to Comparative Biochemistry

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Abstract

UNTIL recently, the criteria of zoological and botanical relationships were, in the main, qualities of external or internal structure, or of functional behaviour. The possibly more intimate and certainly less obvious resemblances and differences between different animal types, in the chemical make-up of their tissues and body fluids and in their metabolic habits, have only recently begun to come within the sphere of established knowledge. It is as a direct result of the new methods which have been developed in biochemistry, particularly as an outcome of increased accuracy in dealing analytically with very small quantities of material, that information has accumulated in the last few years regarding these matters, throwing a flood of light on the ways in which the physical and chemical problems presented to different types of living organisms at various stages in their evolutionary history have been overcome.

Introduction

Baldwin has written the first textbook on the evolution of animals from a chemical point of view. It is a lucid work. Perhaps the part of most interest to physiologists and physicians is that on water balance and kidney action. By tracing the entire evolution of the kidneys, the subject is a great deal more intelligible than it would be if taken up merely from the standpoint of the mammalian kidney [1]. The simplest kidney action is merely the pumping out from the body of water containing waste products, and this water is then replaced by osmosis. The first difficulty arises in adaptation to fresh water in which there is not enough salt in the incoming water, and work has to be performed by the kidney in pumping out a hypotonic urine. After the filtrate of the blood passes out of the glomerulus or a similar organ, a salt-absorbing segment

Diet quality is crucial for the development of offspring. Here, we examined how the nutritional quality of prey affects somatic growth and the lipid, carbohydrate, protein, amino acid, and polyunsaturated fatty acid content of rainbow trout (*Oncorhynchus mykiss*) fry using a three-trophic-level experimental setup [2]. Diets differed especially in their content of eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA), which are physiologically essential polyunsaturated fatty acids for a fish fry. Trout were fed with an artificial diet (fish feed, DHA-rich), marine zooplankton diet (krill/Mysis, DHA-rich), or freshwater zooplankton diet (*Daphnia*, Cladocera, DHA-deficient) [3]. The *Daphnia* were grown either on a poor, intermediate or high-quality algal/microbial diet simulating potential changes in the nutritional prey quality (EPA-content). Trout fed with the fish feed or marine zooplankton entirely replaced their muscle tissue composition with compounds of dietary origin. In contrast, fish tissue renewal was only partial in fish fed any *Daphnia* diet. Furthermore, fish grew five times faster on marine zooplankton than on any of the *Daphnia* diets [4]. This was mainly explained by the higher dietary contents of arachidonic acid (ARA), EPA, and DHA, but also by the higher content of some amino acids in the marine zooplankton than in the *Daphnia* diets. Moreover, fatty acid-specific carbon isotopes revealed that trout fry could not biosynthesize ARA, EPA, or DHA efficiently from their precursors. Our results suggest that changes in the zooplankton and macroinvertebrate communities' structure in freshwater habitats from DHA-rich to DHA-poor species may reduce the somatic growth of fish fry (Figure 1).

Zooplankton culturing

Daphnia magna, clone DK-35-9, was maintained in the laboratory

on *Acutodesmus. Daphnia* were cultured in ADaM in glass beakers (1 L) and fed every second day (for 7–14 days) with three separately designated diets consisting of algae or algae and bacteria. Due to the high biomass required for fish feeding, *Daphnia* were cultured in separate batches over a period of two months. *Daphnia* were stored at -20°C prior to the feeding experiments [5].

Fish culturing

Rainbow trout fry originated from a fish farm located in Central Finland and were transported to the laboratory facilities at the Department of Biological and Environmental Science (University of Jyväskylä). The fish were maintained for 12 weeks prior to the feeding experiment in two 20 L aquaria in borehole water with a flow-

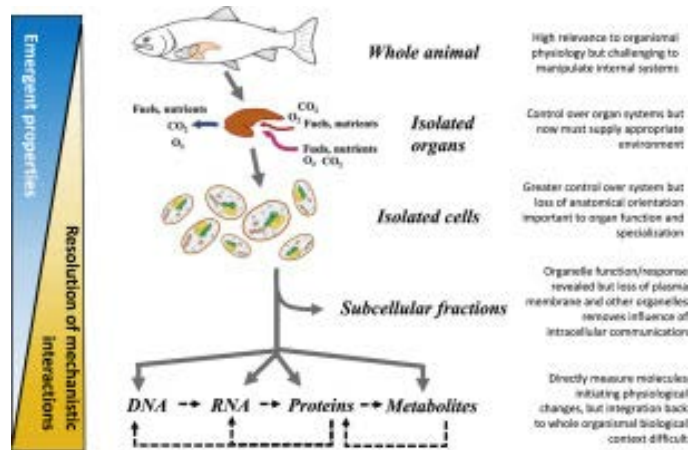


Figure 1: Reduce the somatic growth of fish.

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through (9.4 L h⁻¹) at 10–12 °C to keep their growth slow and fed with commercial feed (Biomar Inicio Plus, 0.5 mm) [6].

Experimental design

Our aim was to explore how the change in the nutritional quality of prey impacts the somatic growth of fish fry and its biomolecule content. Our special interest was to compare fish fry growth with DHA-rich diet to DHA-poor diets and when EPA content is also altered. This simulated zooplankton community change from copepod-dominated to Cladocera-dominated zooplankton and green algae and cyanobacteria dominance in lakes (lack of DHA and EPA; diets 35) or change in the macroinvertebrate community from DHA-rich to DHA-poor species and when benthic cyanobacteria have increased. Rainbow trout fry growth and biomolecule content were additionally compared to an artificial diet that represented possibility for the maximal growth [7].

More specifically, the following five fish diets were used 1. Artificial diet (Fish feed, Biomar Inicio Plus; 1.0% and 0.5% of ω -3 PUFA and DHA) was used as an optimal diet to achieve maximum growth rate for rainbow trout, 2. Marine zooplankton diet of krill and Mysis (Krill Pacifica and Mysis, Ocean Nutrition; feeding ratio of krill and Mysis: 50% and 50%; Krill/Mysis; 1.5% and 0.6% of ω -3 PUFA and DHA) to simulate DHA-rich diets in lakes and streams, [8]. *Daphnia* fed on poor nutritional quality methylotrophic bacteria (grown on methane) and intermediate quality green algae (*Daphnia* 1; bacteria + green algae; 0.5% of ω -3 PUFA of DW), 4. *Daphnia* fed on the intermediate quality diet (*Daphnia* 2; green algae; *Acutodesmus* sp.; 1% of ω -3 PUFA of DW), 5. *Daphnia* fed on a mixture of high quality (*Cryptomonas*, *Mallomonas*, *Synura*, *Peridinium*, *Diatoma*, *Stephanodiscus*, and *Nitzschia*) and intermediate quality algae (*Daphnia* 3: feeding ratio 80% high quality and 20% of green algae; 2% of ω -3 PUFA of DW and 0.2% of EPA of DW). Diets 3–5 represented DHA-deficient diets (cladoceran and most macroinvertebrates in freshwaters). Moreover, *Daphnia*-dominated diets differed in their EPA-content and thus presented poor, intermediate, and high (rich in EPA) nutritional quality. This simulated situation when the dietary availability of EPA for daphnids and macroinvertebrates is limited [9-10].

Conclusion

We compared how DHA-rich and DHA-deficient prey impact the

development and biochemical content of rainbow trout (*O. mykiss*) fry by altering the dietary availability of macromolecules (lipids, carbohydrates, proteins) and essential amino acids and fatty acids. The fast somatic growth of trout fry when feeding on a DHA-rich diet compared to DHA-poor diets demonstrates that change in zooplankton or macro invertebrate communities to DHA-deficient species may reduce the growth of salmonid fish fry. This is especially likely when fish fry cannot efficiently biosynthesize EPA, DHA, or ARA from their precursors and thus cannot overcome suppressed availability of these physiologically essential biomolecules by endogenous biosynthesis.

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