DESIGNING WEANING DIETS BASED ON THE ONTOGENY OF DIGESTIVE TRACT ENZYME ACTIVITY DURING THE CARNIVOROUS-OMNIVOROUS TRANSITION IN GREY MULLET (*Mugil Cephalus*) JUVENILES

W. Koven[1*], E. Gisbert[2], O. Nixon[1], I. Meiri-Ashkenazi[1], A. Gaon[1], M.M. Solovyev[3,4], A. Tandler[1], H. Rosenfeld[1]

[1]Israel Oceanographic and Limnological Research (IOLR), the National Center for Mariculture (NCM), P.O.B. 1212, Eilat 88112, Israel. bmkoven@gmail.com
[2] IRTA, Centre de Sant Carles de la Ràpita (IRTA-SCR), Unitat de Cultius Experimentals, Crta. del Poble Nou Km 5.5, 43540 Sant Carles de la Rápita, Spain
[3] Institute of Systematics and Ecology of Animals, Siberian Branch of Russian Academy of Sciences, 11 Frunze St., Novosibirsk 630091, Russia
[4] Tomsk State University, Tomsk 634050, Russia

Introduction

Grey mullet larvae, as in all marine teleost larvae, are strict carnivores feeding on zooplankton such as rotifers and *Artemia* in commercial hatcheries. However, after metamorphosis into juveniles they begin to change their mode of feeding from a carnivorous to an herbivorous/omnivorous diet as they search out less saline estuaries with higher primary productivity. Our group demonstrated that the digestive tract reaches full maturation around 61dph with considerable pancreatic amylase production at 79dph (an increase of 5.3x from 40dph), while maintaining alkaline protease activity as the mullet adapt to a high carbohydrate, low protein diet. From 24-38dph, mullet juveniles can be weaned off live *Artemia* to a dry, prepared diet. However, the weaning period appears to overlap the trophic shift from carnivory to a more carbohydrate rich diet. Consequently, the aim of the present study was to evaluate the efficacy, in terms of growth, survival and population weight distribution, of weaning on to and feeding a carnivorous, herbivorous or omnivorous diet to juvenile mullet together with the ontogeny of pancreatic and brush border enzyme activity.

Methods and Materials

Fifteen 17 l aquaria in a flow through system with 40 ‰, UV treated, temperature (24.5 ^{0} C) controlled seawater were stocked with eighty five 23dph larvae.aquarium^{-1}. This allowed the testing of three weaning dietary treatments, differing in their protein and carbohydrate content, in replicates of 5 aquaria.treatment^{-1}. Diet 1 was comprised of only dried *Ulva lactuca* produced at the IOLR in Eilat, Israel (34% plant protein, 56% carbohydrate), diet 2 was the commercial starter diet “caviar”(Bernaqua, Belgium; 55% animal protein, 8% carbohydrate) where the protein fraction is comprised of krill, fish and squid. Diet 3 was a 1:1 w/w mixture of the plant diet 1 and the animal diet 2.

Results

The results showed that fish grew significantly ($P<0.05$) less, in terms of dry weight (Fig. 1a), when fed only an *Ulva* based herbivorous diet (Ulva) compared to the carnivorous feed (Caviar), while fish fed the 1:1 omnivorous mix of Ulva and Caviar exhibited markedly

(P<0.05) superior growth than all the other treatments. A wide weight distribution with significantly (P<0.05) higher numbers of smaller, slower growing fish (<100 mg), was demonstrated particularly in fish fed the herbivorous diet compared to the carnivorous and omnivorous diet fish (Fig. 1b). Conversely, 200-300 mg carnivorous and omnivorous treatment fish represented a significantly (P<0.05) higher percentage of the population then the herbivorous diet fed fish (Fig. 1b).

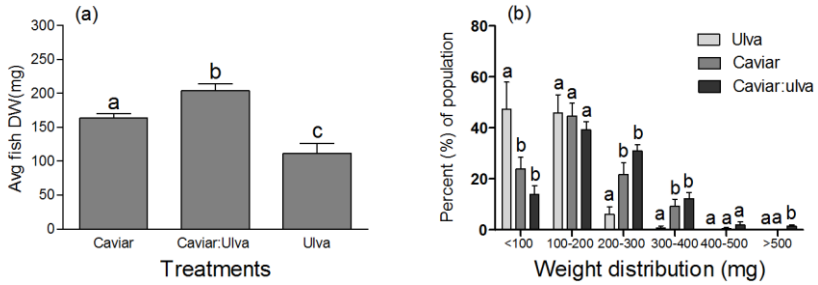

Figure 1. The effect of the commercial starter diet Caviar, dried macroalgae *Ulva lactaca* and the 1:1 mix Caviar: Ulva on (a) fish dry weight (DW) and (b) on weight distribution (mg) at the end of the experiment. DW values and percentages having different letters within a weight class were significantly (P<0.05) different.

Discussion

Animal protein has generally a more balanced amino acid profile including free taurine compared to plant based proteins (Pereira and Oliva-Teles, 2003), which can be deficient in methionine and lysine amino acids as well as containing anti-nutritional factors. On the other hand, the increasing amylase with considerable alkaline protease activities would typify fish moving to estuaries that have the capacity to digest both protein and starch (Gisbert et al. 2016). Omnivory allows for the exploitation of the relatively starch rich microalgae and macroalgae as well as benthic protein rich organisms characterizing these lower salinity estuarine waters. Moreover, an increasing ability to digest *Ulva* carbohydrate would potentially expose more macroalgae protein for protease digestion as well as supplying glucose as an energy source and possibly sparing protein breakdown. Taken together, the results suggest that weaning feeds should be designed for omnivorous feeding fish and include higher levels of starch or other low cost amylolytic energetic compounds.

References

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