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Dietary galactooligosaccharide affects intestinal microbiota, stress resistance, and performance of Caspian roach (*Rutilus rutilus*) frySeyed Hossein Hoseinifar^{a,*}, Mohsen Khalili^b, Hosseinali Khoshbavar Rostami^c, M. Ángeles Esteban^d^a Department of Fisheries, Faculty of Fisheries and Environmental Sciences, Gorgan University of Agricultural Sciences and Natural Resources, Gorgan, Iran^b Young Researchers and Elite Club, Bandargaz Branch, Islamic Azad University, Bandargaz, Iran^c Iranian Fisheries Research Organization (IFRO), Research Center of Inland Waters, Gorgan, Iran^d Fish Innate Immune System Group, Department of Cell Biology and Histology, Faculty of Biology, University of Murcia, 30100 Murcia, Spain

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ABSTRACT

The aim of this study was to assess the effects of galactooligosaccharide (GOS), on the growth performance, stress resistance and intestinal microbiota of Caspian roach (*Rutilus rutilus*) fry. Specimens (1.36 ± 0.03 g) were fed either a basal control diet (0% GOS, non-supplemented) or the basal diet supplemented with 1% and 2% of GOS. After 7 weeks of the feeding trials, growth factors (final weight, weight gain, specific growth rate, condition factor and food conversion ratio) as well as body composition, resistance to salinity stress and autochthonous intestinal microbiota were assessed. Results demonstrated that at the end of the trial growth factors (final weight, weight gain, SGR, FCR) were significantly higher in 2% GOS fed fish ($P < 0.05$). In addition, supplementation of GOS significantly increased both survival rate ($P < 0.05$), and resistance to a salinity stress challenge of prebiotic fed groups ($P < 0.05$). However, body composition and the total autochthonous intestinal heterotrophic bacteria counts remained unaffected in different treatments ($P > 0.05$). Nevertheless, autochthonous lactic acid bacteria levels were significantly elevated in fish fed 2% dietary GOS ($P < 0.05$). These results confirm that GOS improves growth performance, stress resistance and modulates intestinal microbiota by increasing lactic acid bacteria of Caspian roach fry, a very important fish species in the Caspian Sea.

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1. Introduction

The Caspian roach is a commercially valuable species in the Caspian Sea and important prey item for sturgeons [1]. However, over fishing and deterioration of spawning grounds resulted in depletion of natural population and Caspian roach is now considered as a threatened species [2]. Restocking and artificial culture up to marketable size have been developed by Iranian Shilat organization to reduce pressure on natural Caspian Sea populations [3]. Although the production remained to achieve the amount that provide the needs, elevation of fish resistance and performance through dietary supplements is of great importance in commercial aquaculture of Caspian roach, especially in sensitive periods (i.e. larvae and fry culture).

World aquaculture has grown tremendously during the last years becoming the fastest growing food-producing sector in the world [4]. Beside this growth, demand for environment friendly aquaculture, and the use of dietary supplements like pro, pre and symbiotic as an alternatives of antibiotic increased [5]. Prebiotics, non-digestible food ingredients that beneficially affect the host by selectively stimulating the growth of and/or activity of health-promoting bacteria in the intestinal tract [20], and other microbial dietary supplements include probiotics and symbiotic have been demonstrated to show beneficial effects on growth performance, survival and disease resistance of fish and shellfish species [5,6]. Galactooligosaccharide (GOS) is a prebiotic, produced through the enzymatic conversion of lactose and mainly consists of galactose and glucose molecules [7]. Although several studies investigated the effects of GOS on endothermic animals [8–10], very limited information is available on prebiotic properties of GOS in aquatic animals [11–13]. It has been observed that growth parameters remained unaffected with GOS applications in hybrid striped bass (*Morone chrysops* × *Morone saxatilis*) [11] and Atlantic salmon (*Salmo salar*) [12]. However, dietary GOS has shown promising

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