



## Review

## Microbial manipulations to improve fish health and production – A Mediterranean perspective

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## ARTICLE INFO

## Article history:

Received 19 April 2010

Received in revised form

26 July 2010

Accepted 15 August 2010

Available online 27 August 2010

## Keywords:

Sea bream

Sea bass

Probiotic

Prebiotic

Immunity

## ABSTRACT

The interactions between the endogenous gut microbiota and the fish host are integral in mediating the development, maintenance and effective functionality of the intestinal mucosa and gut associated lymphoid tissues (GALTs). These microbial populations also provide a level of protection against pathogenic visitors to the gastrointestinal (GI) tract and aid host digestive function via the production of exogenous digestive enzymes and vitamins. Manipulation of these endogenous populations may provide an alternative method to antibiotics to control disease and promote health management. Applications of probiotics for Mediterranean teleosts can stimulate immune responses, enhance growth performance, feed utilisation, digestive enzyme activities, antioxidant enzyme activities, gene expression, disease resistance, larval survival, gut morphology, modulate GI microbiota and mediate stress responses. Although considerably less information is available regarding prebiotic applications for Mediterranean teleosts, prebiotics also offer benefits with regards to improving immune status and fish production.

Despite the promising potential benefits demonstrated in current literature, obtaining consistent and reliable results is often difficult due to our incomplete understanding of indigenous fish GI microbiota and their subsequent host interactions which mediate and drive both localised and systemic host immunological responses. Additionally, the probiotic and prebiotic (biotics) mechanisms which mediate host benefits at the mucosal interface are poorly understood. Future studies focused on these interactions utilising gnotobiotic techniques should provide a better understanding of how to extract the full potential of biotic applications to promote immune function of Mediterranean teleosts.

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### 1. Introduction

Since the EU moratorium on the banning of antibiotic growth promoters in animal feeds [1], including fish, research for alternative nutraceutical products has been a major objective for both Mediterranean and global fish culture practices. Alternative methods of disease prevention have been sought where

manipulation of microbial populations in the rearing environment, and associated with the fish host, have been used as a means of reducing the presence of opportunistic pathogens and simultaneously stimulating the host immunological responses. In this respect, microbial manipulation of the microbiota within the gastrointestinal tract (GI) of the fish host and live feed microbial assemblages have received great attention due to recent studies which have given us a more broad understanding of the importance of the endogenous microbiota of fish in mediating immunological development and functionality, particularly at the mucosal interface within the GI tract.

The present review is focused on Mediterranean fish species, which have been extensively studied over the past 10 years, and continue to constitute a key source of quality seafood in southern Europe, Northern Africa and several Middle Eastern countries [2,3]. Despite the progress in hatchery and culture techniques, intensive

*Abbreviations:* CFU, colony forming units; DGGE, denaturing gradient gel electrophoresis; dph, days post-hatching; EM, electron microscopy; FISH, fluorescent *in situ* hybridisation; GALT, gut associated lymphoid tissue; GI, gastrointestinal; HK, head–kidney; HSP, heat shock protein; MOS, mannan oligosaccharides; SEM, scanning electron microscopy; TEM, transmission electron microscopy.

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