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## Impact of Dietary Immunostimulants on Morphometric and Haematological Responses of *Catla catla* (Hamilton, 1822) Challenged with *Aeromonas hydrophila*

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**Abstract** Aquaculture is a rapidly expanding sector that contributes significantly to global food production by cultivating aquatic organisms under controlled conditions. However, a major obstacle to aquaculture is the widespread use of antibiotics since the emergence of antibiotic-resistant bacteria. Thus, the immunostimulants are replacing chemotherapeutic therapies for aquaculture disease control. In such a scenario, morphometric and haematological evaluations are necessary to check the impact of immunostimulants on the health of both healthy and pathogen-infected fish. Because of its high nutritional value and other beneficial effects on human health, *Catla catla* has been a popular cultured freshwater fish in India, limited information is available regarding the effects of dietary immunostimulants on *Aeromonas hydrophila*-challenged *C. catla*. Therefore, the study examined the effects of immunostimulants on *C. catla* morphometric and haematological parameters under normal and *Aeromonas*-infected conditions. This study found that oral administration of immunostimulants such as vitamin C, vitamin E, chitin, chitosan, and levamisole significantly increased body weight, feed intake, feed conversion, and biomass. Morphometric investigations demonstrated that immunostimulant-supplemented feed considerably affected body length, width, and weight. Among all the tested feeds, vitamin C showed the strongest growth-promoting effect under *Aeromonas hydrophila* infection. The haematological analysis demonstrated that immunostimulants substantially increased haemoglobin content, RBC, WBC, neutrophil, lymphocyte, monocyte counts, and ESR as well as decreased eosinophil count and do not exhibit any effect on basophil count. Among all the immunostimulants Vitamin E has shown more effect in improving the haematological parameters. In conclusion, immunostimulants promote *C. catla* growth, immunity, and survival under *Aeromonas* infection. Thus, among the above selected immunostimulants, Vitamin C and Vitamin E are more potent and can be used in developing alternative dietary strategies for improving fish health management and reducing dependence on antibiotics in aquaculture.

**Keywords** *Aeromonas hydrophila*; *Catla catla*; Haematology; Immunostimulants; Morphometry

## 1 Introduction

Aquaculture is a rapidly expanding food production sector involving the cultivation of aquatic organisms under controlled (Ahmed and Thompson, 2019). The worldwide fish production in 2018 accounted for around 179 million tonnes, according to the Food and Agriculture Organization (FAO, 2020). Cultivated fish serve as a primary food supply for impoverished individuals, offering a cost-effective source of animal protein (Nolle et al., 2020). The global fishery stock is extensively depleted as a result of overfishing. Due to the growing human population, there is a need to enhance the productivity of aquaculture, which has become the main way of satisfying the growing demand for fish (Gephart et al., 2020).

Furthermore, the rise of antibiotic-resistant microbes poses a significant barrier to the widespread use of antibiotics. The administration of costly chemotherapeutic agents and antibiotics for managing diseases has faced major challenges due to their adverse effects, such as the accumulation of residues in tissues, the emergence of drug resistance, and immunosuppression. As a result, the market demand for antibiotic-treated food fish has decreased (Anderson and Jeney, 1992). Preventing disease is more preferable to intervening to suppress or stop the disease progression after it has commenced. Therefore, rather than using chemotherapeutic treatments, there is a growing focus on utilising immunostimulants as a means of controlling disease in aquaculture. The growing trend of