

exploring various synergistic approaches for minimising fish infections has led to the accelerating use of immunostimulants as an appealing and potential substitute for chemotherapeutants in aquaculture practices.

An immunostimulant is a substance that enhances the innate or non-specific immune response through direct interaction with immune system cells, leading to their activation. Immunostimulants can be categorised into various agents according to their source including bacterial preparations, polysaccharides, extracts from animals or plants, nutritional components, and cytokines (Sakai, 1999). Immunostimulants enhance the immune system, decrease vulnerability to disease, and protect fish against stress and diseases. This minimizes adverse environmental effects and lessens reliance on chemicals or pharmaceuticals. New developments indicate that probiotics and immunostimulants, which are environmentally friendly methods, can greatly improve fish cultivation and health management (Sakai, 1999).

Several recent studies of peer researchers such as Rodriguez et al. (2003), Sahoo and Mukherjee (2001), and Smith et al. (2003) recommend incorporating the use of immunostimulants into the overall health management strategy. Immunostimulant elicit a strong and effective immune response against pathogenic organisms, including viruses, bacteria, fungi, and parasites, while exhibiting no risk of toxicity, carcinogenicity, or tissue residues (Bairwa et al., 2012). However, the effect of adding immunostimulants to fish is reliant on a number of factors such as the species, stage of development, kind of immunostimulant, and the dosage, which may vary depending on the animal's growth (Ringo et al., 2010).

In addition, studying an organism's response to a stressful event involves two types of responses: direct which affect biochemical and metabolic function, and indirect which affect the food chain, habitat accessibility, and behavioural changes (Adams, 2005). Finding and analysing biomarkers, especially in fish, has been recognised as a useful way to learn more about the state of stressed ecosystems and how they interact with aquatic life (Viarengo et al., 2007). Research studies indicate that immunostimulants can have beneficial impacts on the haematological parameters of fish. For instance, Hoseinifar et al. (2017) examined the impact of immunostimulants on the haematological parameters of rainbow trout, and they discovered that adding β -glucan, a widely used immunostimulant to fish's food resulted in higher levels of white blood cells and haemoglobin concentration.

In this context, fish morphometric and haematological measurements have become useful diagnostic tools and promising stress indicators. These measurements are crucial for evaluating the overall health of fish and the intensity of stress-induced reactions. Thus, a morphometric and haematological assessment is required to screen for the effects of immunostimulants on the health of fish that are both normal and infected with pathogen. In India, there is a scarcity of information on the effect of immunostimulants on the *Aeromonas*-infected *C. catla*. *C. catla* exemplifies a successful cultivated freshwater species for consumption, attributed to its notable nutritional and health benefits (Ismail, 2005). Therefore, this study aimed to evaluate the effects of different dietary immunostimulants on growth performance, morphometric characteristics, and haematological responses of *Catla catla* particularly under *Aeromonas hydrophila* challenge conditions, compared with previous studies on other cultured fish species.

2 Materials and Methods

2.1 Collection and acclimatisation of fish samples

Live healthy and young *C. catla* fish samples, with an initial body weight of 142 ± 10 g, were collected at a private farm (Longitude: $83^{\circ}10' 14.88''$ to $83^{\circ}11' 6.72''$ E; Latitude: $17^{\circ}40' 23.52''$ to $17^{\circ}45' 57.6''$ N) in K. Kotapadu village, Visakhapatnam, Andhra Pradesh, India, from December 2023 to January 2024. The live samples were carried to the lab in sterile zip pouches with pond water and maintained under regulated conditions. All fish were kept for two weeks to acclimatise to the laboratory environment. Fish were maintained in $50 \times 30 \times 40$ cm plastic containers with aerated, dechlorinated tap water.