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On

Applied Zoology, Profitable Animal Production, and Health: Current Status and Future  
Progress (NSAZ-2022) 23<sup>rd</sup> & 24<sup>th</sup> September- 2022

# Recent Trends in Applied Zoology

Dr.D.S.Rathod  
Editor

Associate Editors  
Dr. K.S.Raut  
Mr.Datta Nalle

National Edited Book

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Recent Trends in Applied Zoology

**Edited by:** Dr.D.S.Rathod

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**Editor**

**Dr.D.S.Rathod**

Head

Department of Zoology and Fishery Science,  
Rajarshi Shahu Mahavidyalaya (Autonomous),

Latur- 413531, Maharashtra

**Associate Editors**

**Dr. K.S.Raut**

**Mr.Datta Nalle**

Department of Zoology and Fishery Science, Rajarshi Shahu Mahavidyalaya (Autonomous),  
Latur- 413531, Maharashtra

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## Chapter 2

# Review on Important role of *Danio rerio* in Animal and human vaccination research

Datta Ashok Nalle and Dnyaneshwar S. Rathod

Department of Zoology and Fishery Science, Rajarshi Shahu Mahavidyalaya,  
(Autonomous) Latur-413512 (MS)

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### Abstract

Animal models are used extensively in medical research to better understand the origins of both human and animal diseases as well as to facilitate the creation of novel treatments. Though rodents are still the most popular study model used globally, zebrafish (*Danio rerio*) models have rapidly gained popularity among scientists in recent years. This is due to the fact that a little tropical freshwater teleost fish shares significant physiological, anatomical, and genetic similarities with mammals. Zebrafish are a great experimental model for behavioural, genetic, and toxicological research that helps to understand the causes of numerous human disorders. Testing novel therapeutics, including the security of novel vaccinations, is also beneficial. This review's objective was to offer a systematic literature analysis of the most recent studies conducted on the subject. It highlights increases in time and cost savings of research and analyses by outlining a number of benefits of using this kind of animal model in studies of the safety and efficacy of both animal and human vaccines.

**Keywords:** health; Immunity; Vaccine safety, *Danio rerio*

### Introduction

The function of the immune system is to defend the body from invasions by bacteria, viruses, or other foreign antigens. Vaccination is used to increase immunity against diseases brought on by microorganisms in order to improve protection. It often contains a less dangerous substance that causes a reaction and prompts the immune system to identify it as foreign. Every time an invasion is recognised, a body's defence mechanism gains the ability to identify and eliminate a bacterium, its poisons, or its surface proteins [1].

The use of vaccinations is crucial because it encourages the body's defence mechanisms to be stimulated and the growth of both individual and group immunity. In contrast to immunostimulants, which solely affect innate immunity, vaccinations can affect both nonspecific (innate) and specific (adaptive) immune responses. It is important to remember the function vaccines play in disease control both as prophylactic and non-therapeutic strategies. As a result, the body can create antibodies that recognise, alert, and neutralise infections or specialised cellular responses that recognise the antigens in concern. with high efficiency and affinity.

Despite the fact that research on fish immunology is more recent than that on humans and other animals, the concepts and methods employed are comparable [3]. The research of vaccine usage in fish

is a rapidly expanding field. Commercial vaccination of various fish types is already a reality in many nations as aquaculture develops and the need to control infections becomes more urgent. It assists in preventing illnesses that could endanger the shoal's health as well as in preventing financial losses brought on by infection-related mortality. It lessens the quality of finished fish products and the overuse of antibiotics that might contaminate water sources [4, 5, 6, 7, 8,9, 10].

The Zebrafish model has been extensively employed in studies on the health of both humans and animals as well as, more recently, in aquaculture. Despite rodents being the most popular study model in the world, zebrafish (*Danio rerio*) models have become increasingly popular among scientists in recent years. It adheres to the 3Rs (replacement, reduction, and refinement) philosophy as demanded by numerous national and international regulatory agencies. In addition, compared to the models made from those more well-known animals, using the zebrafish model saves time and resources. When compared to in vitro outcomes, it also offers a larger capacity for information and prediction [11].

Challenge trials for vaccine development measure the vaccine's effectiveness and safety against various infections when designing immunisation tests. These are typically evaluated using animal models, primarily mammalian ones, which are typically inaccurate in simulating human diseases [12], not to mention time-consuming and requiring a lot of animals. Additionally, laboratory testing, clinical symptoms, and mortality are typically examined to determine if an immune system response was innate (non-specific) or adaptive (specific). T and B lymphocytes, which emerge from the thymus and kidneys, respectively, are the components of Zebrafish's adaptive immune system, which is similarly well-maintained to that of mammals. Fish appear to contain memory cells of the type B and T, albeit, when it comes to the maturation of memory lymphocytes [13,14,15,16,17 ].

There isn't enough evidence to support that in zebrafish. The enzyme system involved in the genetic rearrangement process that gives rise to the B (BCR) and T (TCR) lymphocyte receptors is also seen in zebrafish. The rearrangement of gene segments V, D, and J in Zebrafish, like in humans, is governed by recombination activator genes, which create the variety of antibodies and lymphocyte receptors. Additionally, the immune system of the zebrafish is five orders of magnitude less complex than that of humans and three orders of magnitude less than that of mice since it only has about 300,000 antibody-producing B cells [18,19 20.21,22].

Due to the antibodies' greater affinity, the humoral reaction is more effective. In comparison to mammals, affinity maturation of antibody responses is less effective in cold-blooded animals. Despite this, zebrafish data showed that directed mutations were occurring in areas of the BCR receptor that targeted particular nucleotides. Therefore, it was hypothesised that affinity maturation and activation-induced deaminase both contributed to the diversification of antibodies in fish [23,24,25,26,27]. When teleost fish were immunised with the TNP-KLH antigen (linked to trinitrophenyl to keyhole limpet hemocyanin), for instance, the production of specific, low affinity antibodies was stimulated. These antibodies were replaced in 5 weeks by intermediate affinity antibodies, and in 15 weeks by antibodies with higher affinity for the antigen [28,29 ]

The most common immunological tests include erythrocyte count, thrombocyte and leukocyte counts, differential white cell counts, hematocrit measurements, glucose readings, organ histology, and immunological essays like serology, specific antibody titration, and agglutination [30,31,32] toxicity tests can also be carried out on zebrafish, including those for embryotoxicity, hepatotoxicity, neurotoxicity, endocrine toxicity, and genotoxicity. Until recently, these tests were carried out on rats, but in recent years, the Zebrafish model has emerged as a crucial resource for the investigation of infections and immune reactions. This approach has the benefit of OECD-specific rules for acute toxicity testing of chemical compounds, which is completed in 96 hours [33,34]. Real-time observations can also be obtained on the effects of vaccines on the cardiovascular, hepatic, neurological, and endocrine systems as well as the monitoring of embryogenesis

To prevent harm, including death, to animals, especially to immunosuppressed organisms, young children, and the elderly, vaccinations should be evaluated using animal models before being used on humans, cattle, or pets [35]. Zebrafish have additional biological benefits over other vertebrates, such as high fecundity, external fertilisation, optical transparency, and quick development. A highly developed immune system that is strikingly similar to the human immune system is also present in zebrafish. It follows that it would be reasonable to assume that the majority of the signalling pathways and molecules involved in the immune response in humans exist in fish and operate similarly [36].

Fish include components of innate and adaptive immunity, which makes them susceptible to infections from gram-positive and gram-negative bacteria, protozoa, viruses, fungi, and mycobacteria. As a result, this makes it possible to study infectious processes. A sizable number of mutants were identified thanks to the development of specialised cloning, mutagenesis, and transgenesis procedures. The ability to produce knockout zebrafish for whole organism gene studies is made possible by commercial mutant zebrafish lines and the recently created CRISPR/Cas9 genome modification system [37]. Additionally, Casper zebrafish and other non-pigmenting mutants have enhanced the visibility of interior organs [38,39]

Fish Mucosal tissues were examined for a Th17-like immune response following the injection of live, attenuated *V. anguillarum* via several vaccination methods. Immersion vaccination induced robust Th17-like immune responses in the gastrointestinal tissue of zebrafish when compared to injection vaccination. During a study on zebrafish responses to vaccine, *Vibrio vulnificus*, an aquatic bacterium that can cause primary sepsis and soft tissue infection, was also examined. A sort of crucial immunomodulator known as CpG oligodeoxynucleotides was found to protect zebrafish.[40,41,42]

Up to 165 million cases of shigellosis occur each year due to *Shigella*, which is a leading cause of dysentery globally [43]. Although a vaccine is not currently available, observational studies in *Shigella*-endemic areas as well as human and animal challenge-rechallenge experiments with virulent *Shigella* are encouraging. Following *Shigella* infection, the disease's incidence dropped, indicating the biological viability of a vaccination [44]. Using adult zebrafish to explore the immune response to *Shigella* was suggested by [45] and Mani et al. [46]. Understanding the interplay between *Shigella* and T-lymphocytes [47] is essential for the development of vaccination methods.



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