Immunological Behaviour in Fishes

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Over the last 25 years, aquaculture has grown into a very significant industry. Fish hatcheries and farms are becoming increasingly important as part of the industry in supplementing food production. Fishes are farmed intensively and under such a high population density, infectious diseases remain a constant threat. Even under perfect sanitary conditions certain infection agents get entry and become so virulent that mortalities do occur. A better understanding of the immunology of fish and the prophylactic measures taken thereafter can prevent heavy losses caused due to mass mortalities in the fishes. Unlike human beings and other higher vertebrates, fish immunology is still in its infancy but the basic mechanism of immunity and cells participating therein are more or less same as in other animals.

The major lymphoid organs in teleost fish are the thymus, kidney and spleen. Thymus, as in other vertebrates, is regarded as the main lymphoid organ where the virgin lymphocytes are produced and these emigrate to the main blood circulation and other lymphoid organs. Kidney is the main antibody producing organ which contains haemopoietic tissue rich in lymphocytes and plasma cells (antibody producing cells). It also contains macrophages which ingest and digest (Phagocytosis) the antigens. The spleen comparatively contains less haemopoietic tissue and is composed mainly of blood sinuses. The specialised capillary walls termed ellipsoids are composed of reticulin fibres and macrophage and thus help in phagocytosis and trapping the immune-complexes (antigen-antibody complexes).

Mechanism of Immunity

The knowledge of Antigen and Antibodies is a prerequisite for the understanding of the basic mechanism of Immunity. Antigens are complex molecules recognized as foreign by immunologically competent cells of the body and when introduced into the organism, stimulate the production of antibodies and also lead to the sensitization of cells. Both antibodies and sensitized cells react specifically with the antigen. Antibodies are the proteins produced as a result of introduction of antigen and have the ability to combine with the antigen specifically.

The resistance to infections is based on several defense lines. The first line of defense consists of skin and mucosa which provide natural resistance. Natural resistance refers to the ability of an individual to resist infection through normal body functions. Skin and mucosa are not only physical barriers but produce chemical disinfectants (Chemotoxins) which can kill pathogens at the entry point itself. Pathogens successfully penetrating the skin and mucosa will be confronted with polymorphonuclear (PMN) leucocytes which form the second line of defence and reach the site to fight against the bacterial invasions. The resistance against pathogens by PMN cells is marked by acute inflammation. If the pathogenic invasion is too strong to be coped up by PMN cells, the macrophages, second in line will take over, giving rise to the condition of chronic inflamation.

The third line of defense operates when the first two barriers are crossed by the pathogens. Lymphocytes, the army of the third line of defence are stimulated and activated by "activated and antigen presenting" macrophages. This type of immunity is known as adaptive or specific immunity and is of two types : humoral immunity (antibody production) and cell mediated immunity. Exposure to an antigen results in the stimulation of lymphocytes which constitute a clone. Micro-organisms have many different antigens on their surface and each antigen is capable of being recognized by a different clone of lymphocytes. There are two main populations of lymphocytes (T and B) of which T lymphocytes originate from thymus whereas the origin of B lymphocytes is not definitely known but it is likely to be the kidney. A pictorial representation of development of T and B cells is shown in figure 1. B lymphocytes are mainly responsible to bring about humoral immunity whereas T lymphocytes are responsible for cell mediated immunity. Two additional sets of lymphocytes killer cells and Natural killer cells having the capacity for the lytic activity are also known. The origin of these cells, whether T or B cell, is not known. Killer cells have the receptors for IgG antibodies which mediate the cytotoxic reaction. Natural killer cell mediated cytotoxicity refers to the lytic activity of lymphocytes from healthy individuals (Not immunized deliberately). Interaction between

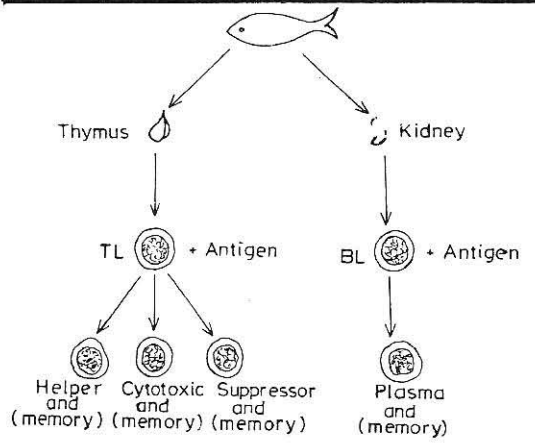

Fig 1. Origin and destiny of T and B lymphocytes
TL - T Lymphocyte, BL - B Lymphocyte

the different immuno-competent cells in the defence mechanism is shown in figure 2 and the sequence of reactions in figure 3.

Humoral Immunity : On primary exposure to an antigen, T and B cells co-operate in the response. B lymphocytes differentiate into plasma cell and memory cells. Plasma cells produce antibodies specific to the stimulating antigen. Memory cells become plasma cells on subsequent exposure to antigen and produce antibodies rapidly and in higher concentration. Similarly T cells act as helper cells and on stimulation by antigens proliferates into long living helper memory cells which co-operate with B memory cells and leads to the rapid and higher concentration of antibodies on subsequent exposure to antigen. This ability of memory cells to effect the rapid and high concentration of antibodies accounts for the increased resistance (i.e. secondary immune response) on exposure to a pathogen or vaccine.

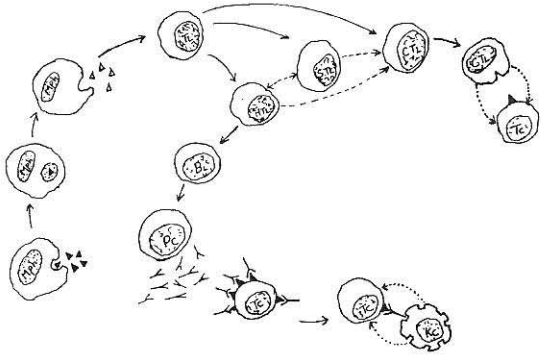

Fig.2 Interaction between different immunocompetent cells leading to the lysis of target cell.

Mphs-Macrophage, TL-T lymphocyte, HTL-Helper T lymphocyte, STL-Suppressor T lymphocyte, CTL-Cytotoxic T lymphocyte, TC-Target cell, KC-Killer cell.

▲ - Antigen, ▲ - Processed antigen, Antibody, Development of differentiation to, Stimulation or suppression, Causing lysis, Receptor for antibody.

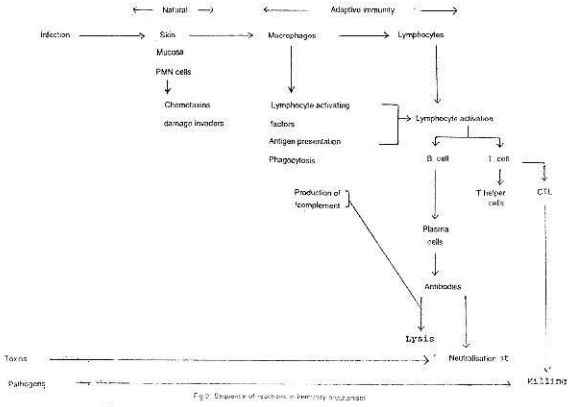

Fig 3 Sequence of reactions in immunity mechanism

Cell mediated Immunity : This type of immune response is wide ranging and engages macrophages also which either phagocytose or process the antigen and present it in such a form that it can eassily be recognised by T Cell and immune response is triggered. On stimulation by the antigen, T lymphocytes in addition to T helper cell, produce cytotoxic T cell and Suppressor T Cells also. Cytotoxic T Cell on further proliferation and maturation leads to the development of large sized cytotoxic T lymphocytes (CTL) and small sized memory cells. When exposed to the same antigen at a later occasion these memory cells will again transform into CTLs giving rise to a large pool of lymphocytes adapted to react with the antigen involved. Cytotoxic T cells kill the foreign cells by direct contact without the help of antibodies. Suppressor T Cell on stimulation gives rise to Suppressor T Cells and memory cells. Suppressor cells regulate the production of antibodies and lymphokines (explained later) by switching off the process and thus stop the excess production. This part of the immune response has a vital importance in vaccination and prevents any imbalance in the positive and negative immunity.

Certain T Cells on stimulation by the antigen release lymphokines (or Interleukins) which enhance the defense capacity of macrophage, polymorphonuclear cells and also regulates the activity of other lymphocytes.

Role of vaccines in the Immunity

Vaccines are the preparation of antigens derived from pathogenic organisms reduced non-patho-

genic by various means (heat or chemical inactivation) which will stimulate the immune system in such a way as to increase the resistance to disease from subsequent infection by a pathogen.

Vaccines are of two types : Dead vaccines, which are composed of inactivated pathogens, and live vaccine, which have attentuated pathogens with no or less virulence. An effective vaccine must be 'safe' (it should not produce clinical illness), immunogenic (it should stimulate the immune response effectively) and protective (it should induce the immune response to only virulence factors of the pathogen).

Various ways of vaccination : The purpose of vaccination is to provide resistance against a disease without undergoing the infection. Vaccine works by inducing the immune response to virulence factors of a pathogen which by virtue of memory cells presist for long period of time. Natural infection acts as a booster to the immunity produced by vaccination. In the absence of natural exposure to the pathogen, the immunity can be induced by a booster dose of vaccination. Varius methods of vaccination of fish have been developed which include injection,, immersion, hyperosmotic immersion, bath, spray and oral. Each method has its own merits and demerits. Intraperitoneal injection is the most effective method and is used for individual vaccination of fish whereas other methods are used for mass vaccination. In addition to this, other vaccine related factors which affect the immune response are Antigen dose, nature of antigen and immuno-stimulants like adjuvants.

Risk in vaccination : Sometimes after an outbreak of certain major disease like furunclulosis, BKD, VHS, survivers become the carriers of pathogen. SImilarly, after vaccination, the vaccinated stock while being resistant to disease may become carriers of the pathogen. This effects the marketing potential of the live stock as the carriers are not permitted to be transferred to non-infected sites. The transfer of healthy fishes which in fact are the carriers of pathogen may spread the disease to susceptible populations and cause a threat to the whole stock. To avoid this the vaccination should be done using a proven vaccine only. Presently, vibriosis and Redmouth vaccine are only proven vaccines for use on commercial scale where vaccines against several other diseases (table 1) are still at experimental stage.

To think over

Progress in science can be compared with the metamorphosis of a butterfly which starts with an ugly, inactive, sluggish caterpillar and changes into an imago which again looks lifeless and static but inside, it is teeming with activity. Then one day suddenly it transforms into a coloured wonderful butterfly showing its crinkled wings and preparing for flight. Immunology in humans and other higher vertebrates, is flowering day by day and entering avenues of research of which no one had dreamed. But fish immunology is still in the caterpillar or the imago stage and is waiting to be transformed into maginificient butterfly. Particularly the fish transplantation biology which is currently in stagnation needs few crucial discoveries which may change the situation drastically. The association between major histo-compatibility antigens and major diseases as found in the human beings and other vertebrates may give a cue to the fish immunologists to act and achieve some break-throughs in fish disease control.

Common fish diseases

There are several common fish diseases. These include bacterial, Viral and parasitic diseases causative organisms for six bacterial diseases, five viral diseases and three parasitic discases are given in Table I.

Suggested readings

1. Otto, G. ier, Wilmar Dias DA Silva, Dietrich Gotze and Ivan Mota (Ed) 1981
Fundamentals of Immunology published by Springer Verlag, New York Inc.

2. Jan Klein (Ed) 1982
Immunology The Scinece of Self -Nonself Discrimination.
Published by John Wiley & Sons., New York.

3. A E Ellis (Ed) 1988
Fish Vaccination published by Academic Press, London.

4. Margaret J. Manning and Marry F. Tatner (Ed.) 1985
Fish immunology Published by Academic Press, London.