AGRIALLIS
Science for Agriculture and Allied Sector: A Monthly Magazine
Volume 6, Issue 4
www.agriallis.com

Article Id
AL04331

FISH ALSO HAVE TONSILS

[1]Ravikumar M. Chovatia, [1]Parmar Bindiya Kirtikumar, [2]Chandana Dinakaran and [2]Arpit Acharya*

Email
acharya.arpit18@gmail.com

[1]Kerala University of Fisheries and Ocean Studies, Kochi, Kerala, India

[2]ICAR- Central Institute of Fisheries Education, Mumbai, Maharashtra, India

Protection mechanisms against pathogens at barrier tissues, which serve as the boundary between the environment and the host, are crucial for the survival of pluricellular organisms. The advent of adaptive immunity, which occurred some 500 million years ago, was a significant milestone in the field of pathogen defence. Adaptive immunity relies on the process of clonal selection, where cells that express genes generating antigen (Ag) receptors are chosen. Naïve B or T cells are generated and undergo differentiation in primary lymphoid organs. Subsequently, these naïve lymphocytes migrate to secondary lymphoid organs, where they begin adaptive immune responses. Both main and secondary lymphoid organs are in a state of constant development and form at specific places (Hofmann et al., 2010).

Secondary lymphoid organs have played a crucial role in promoting adaptive immune responses throughout evolution. They provide an organisational structure that promotes the colocalization of antigens (Ags) and Ag-specific cells, which are necessary for efficiently inducing antibody-mediated responses. Extensive research has been conducted on the evolutionary development of lymphoid tissues and adaptive immunity in vertebrates (Zapata and Amemiya, 2000; Boehm et al., 2012; Neely and Flajnik, 2016; Flajnik, 2018; Zapata, 2020). There are several parallels between the key elements of the immune system in teleost fish and humans (Renshaw and Trede, 2012; Carmona et al., 2017). Teleost fish possess a majority of the cells found in the innate and adaptive immune systems of mammals, including granulocytes, innate lymphoid cells, T cells, B cells, and Ag-presenting cells like macrophages. Jawed vertebrates also possess common molecular processes that are involved in the detection of infections and the modulation of immune responses (van der Vaart et al., 2012). Teleost fish possess two types of major lymphoid organs: (i) the thymus, which serves as the location for the development and maturation of T lymphocytes, and (ii) the kidney, which is responsible for haematopoiesis and the development of B cell precursors. The pronephros, often known as the "head-kidney," is a significant location of immunological activity in teleost fish. It is closely linked to the functioning of secondary lymphoid organs (Bjørgen and Koppang, 2022). Nevertheless, within the fish species, the spleen is often recognised as the primary systemic secondary lymphoid organ. Teleost fish have not been found to possess lymph nodes or tonsil counterparts.

Mucosal tissues in both fish and humans serve as a large surface that links the organism to the external environment. This connection enables important processes like food absorption and gas exchange. However, it also increases the organism's vulnerability to diseases. Fish mucosae, like those in humans, have protection by many "mucosa-associated lymphoid tissues" (MALTs) that play a role in the immunological monitoring of the mucosal barrier. Fish MALTs are mostly found in the gastrointestinal tract (GALT), the integumentary system (SALT), the nasal cavity (NALT), and the gills (GIALT). Recent research has also shown the presence of a malignant adenocarcinoma (MALT) linked to the oral cavity and the pharynx. Mammalian MALTs are organised into distinct zones where immune cells are dispersed, resulting in a diffuse mucosal immune system. Additionally, they create organised lymphoid aggregates, such as Peyer's patches in the gut and Waldeyer's ring of tonsils in the nasal area. On the other hand, the fish mucosal immune system is normally viewed as a collection of dispersed immune cells distributed over mucosal regions (Salinas et al., 2011; Salinas, 2015).

Recent Findings

The fish MALTs exhibit a greater level of organisation. This phenomenon is indeed applicable to the branchial cavity, which is referred as gill chambers or pharyngeal cavities. The branchial cavity is comprised of two chambers, flanking the head, which are connected by the pharynx in the centre and may be accessed externally by the operculum slits. The sub-pharyngeal isthmus refers to the area located underneath the pharynx that serves as a barrier between the gill chambers. The entire branchial cavity is covered with a nonkeratinized squamous epithelium known as the "cavo-branchial epithelium," which is derived from the pharyngeal tissue. The gill chamber of zebrafish exhibits a series of four gill arches, with each arch consisting of two ALTs and one ILT. Finally, a thymus lobe is situated on the upper surface of each gill chamber.

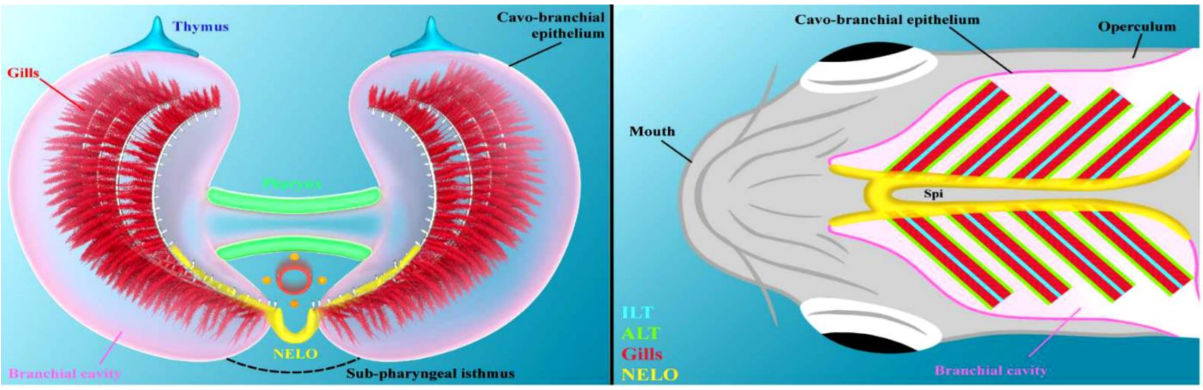

Figure 1 Diagrams of NELO's localization. Image is taken from Resseguier et al., 2023.

Nemausean lymphoid organ (NELO)

The Nemausean lymphoid organ (NELO) is derived from the Gallic-Roman mythology of "Nemausus - Nemausicae" and is linked to the concepts of protection, water, and healing. The recent studies differentiate it from the histologically unique epithelium that envelops the pharynx. In the sub-pharyngeal area of the branchial cavity, there is a conspicuous lymphoid organ that has not been previously characterised; it is called the "Nemausean lymphoid organ" (NELO).

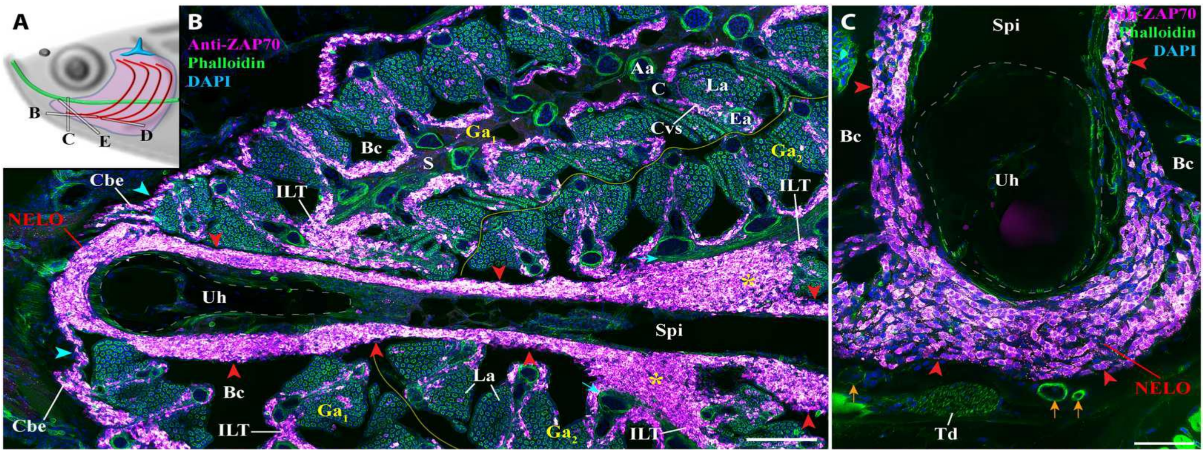

Figure 2 General organization and localization of NELO in zebrafish (A) The different orientations of the NELO images and the position of the thymus (blue), pharynx (green), and gills (red). (B and C) NELO (red arrowheads) wraps around the urohyal bone. Image is taken from Resseguier et al., 2023.

NELO is a substantial anatomical assemblage characterised by a high concentration of ZAP70-positive cells situated in the squamous mucosal epithelium that lines the sub-pharyngeal isthmus, a region situated under the pharynx and serving as a partition between the two gill chambers. NELO encircles the urohyal bone at the front of the branchial cavity and then extends along both sides of the sub-pharyngeal isthmus until it reaches the back of the branchial cavity. NELO is linked to all 24 gill lymphoid aggregates, namely the 8 ILTs and the 16 ALTs, over its whole length. There is a lack of distinct demarcation between ILT/ALT and NELO at these linkage points, indicating that the lymphoid tissues inside the branchial cavity may operate as an integrated unit (Resseguier et al., 2023).

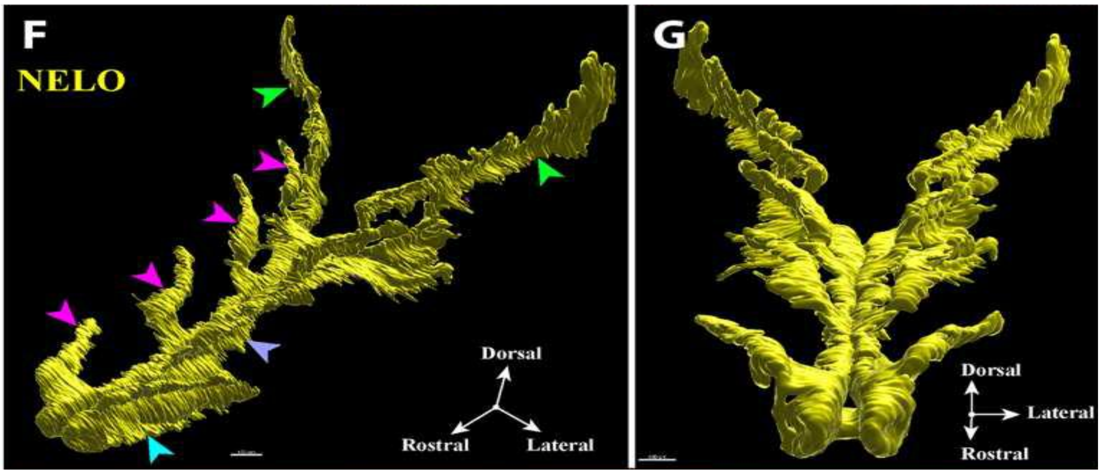

Figure 3 (F and G) NELO 3D reconstruction and its segmentation into four anatomic regions: the anterior area wrapped around the urohyal bone (cyan arrowhead), antler-like protrusions (magenta arrowheads), the core (blue arrow), and the posterior end (green arrowheads). Image is taken from Resseguier et al., 2023.

Conclusion

The NELO is a mucosal secondary lymphoid organ found in fish, which has several characteristics that bear resemblance to the tonsils seen in mammals. NELO, which is closely linked to gill lymphoid aggregates, emerges as a promising lymphoid centre that plays a crucial role in coordinating lymphocyte movement and defence mechanisms inside the respiratory mucosa of fish. This enhances comprehension of the evolutionary development of the immune system in vertebrates and provide novel perspectives on fish immunology. The concept of graft immunity is becoming significant in the context of future aquaculture vaccines and the advancement of zebrafish disease models.

References

Bjørgen, H. and Koppang, E.O., 2022. Anatomy of teleost fish immune structures and organs. *Principles of Fish Immunology: From Cells and Molecules to Host Protection*, pp.1-30.

Boehm, T., Hess, I. and Swann, J.B., 2012. Evolution of lymphoid tissues. *Trends in immunology*, 33(6), pp.315-321.

Carmona, S.J., Teichmann, S.A., Ferreira, L., Macaulay, I.C., Stubbington, M.J., Cvejic, A. and Gfeller, D., 2017. Single-cell transcriptome analysis of fish immune cells provides insight into the evolution of vertebrate immune cell types. *Genome research*, *27*(3), pp.451-461.

Flajnik, M.F., 2018. A cold-blooded view of adaptive immunity. *Nature Reviews Immunology*, 18(7), pp.438-453.

Hofmann, J., Greter, M., Du Pasquier, L. and Becher, B., 2010. B-cells need a proper house, whereas T-cells are happy in a cave: the dependence of lymphocytes on secondary lymphoid tissues during evolution. *Trends in immunology*, *31*(4), pp.144-153.

Neely, H.R. and Flajnik, M.F., 2016. Emergence and evolution of secondary lymphoid organs. *Annual review of cell and developmental biology*, *32*, pp.693-711.

Renshaw, S.A. and Trede, N.S., 2012. A model 450 million years in the making: zebrafish and vertebrate immunity. *Disease models & mechanisms*, *5*(1), pp.38-47.

Resseguier, J., Nguyen-Chi, M., Wohlmann, J., Rigaudeau, D., Salinas, I., Oehlers, S.H., Wiegertjes, G.F., Johansen, F.E., Qiao, S.W., Koppang, E.O. and Verrier, B., 2023. Identification of a pharyngeal mucosal lymphoid organ in zebrafish and other teleosts: Tonsils in fish?. *Science Advances*, *9*(44), p.eadj0101.

Salinas, I., 2015. The mucosal immune system of teleost fish. *Biology*, *4*(3), pp.525-539.

Salinas, I., Zhang, Y.A. and Sunyer, J.O., 2011. Mucosal immunoglobulins and B cells of teleost fish. *Developmental & Comparative Immunology*, *35*(12), pp.1346-1365.

van der Vaart, M., Spaink, H.P. and Meijer, A.H., 2012. Pathogen recognition and activation of the innate immune response in zebrafish. *Advances in hematology*, 2012.

Zapata, A. and Amemiya, C.T., 2000. Phylogeny of lower vertebrates and their immunological structures. *Origin and evolution of the vertebrate immune system*, pp.67-107.

Zapata, A.G., 2022. Lympho-hematopoietic microenvironments and fish immune system. *Biology*, *11*(5), p.747.