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Comparison of the Histological Structure of Gill Tissue in Local Common Carp and Catfish and Their Relationship to Oxygen Requirements

Ahmed I. Mohammed[1], Muayad N. Kareem[2], Noor A. Azawi[3], Oday A. Al-Juhaishi[3]*
[1]Department of Anatomy, College of Medicine, Tikrit University, Iraq.
[2]Department of Biology, College of Science, Kerbala University, Iraq.
[3]Department of Anatomy and Histology, College of Veterinary Medicine, Tikrit University, Iraq.
***Corresponding Author: ahmed.i.hamood@tu.edu.iq**

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ABSTRACT
Fish are considered one of the aquatic species that have a high diversity in nature, due to their ability to adapt to various environments. These adaptations assist in the reduction of the consumption of energy, depending on the required of water body. Consequently, the gills serve as the sites for adaptation between the internal and external environments because of their main role in respiration. Twenty samples were taken from two different species of Iraqi fish, including ten from common carp and another ten from catfish. Specimens were collected from gills for histological analyses, and a hematoxylin and eosin stain were used for general description of the structures. In both investigated species in the current study, their gills were found to be composed of cartilaginous arches that contained rows of plates organized by bundles of connective tissue and lined with a layer of simple squamous or cuboidal epithelium, as well as goblet cells. The main difference was that the gills of the catfish have larger surface area comparative to those of common carp. Also, it was noted that the gill structure in catfish may be modified to assist in getting a large amount of oxygen while use less energy. The finding indicated active fish's, such as catfish, contain a wide surface area that increases the ability of an adequate amount of oxygen absorption during various environmental circumstances.

INTRODUCTION

Fish in nature are the largest group of vertebrates that live in aquatic environments, and are considered the main source of food from the important aquatics ecosystems **(Dallingr *et al.*, 1987**; **Essa *et al.*, 2020; Kim *et al.*, 2021)**. Depending on the histological organization of the gills, they play a main role in breathing processes through their secondary gill plates, which contain respiratory cells and blood vessels. Thus, they are the active sites of respiration for gas exchange between the internal environment of blood and the external environment of water through their secondary plates **(Pathan *et al.*, 2010; Alsafy *et al.*, 2025; Bashar *et al.*, 2025)**.

The various structures of gills could be related to the way of fish life within different aquatic environments, depending on the requirements of metabolic fish **(Wilson & Laurent, 2002; Jalloob *et al*., 2022; Sabah *et al*., 2024)**. Therefore, previous studies have mentioned that fish characterized by high motor activity and a large respiratory surface in their gills presented a high metabolic average compared to those in the fish having low mobility **(Evans *et al*., 2005; Suzuki *et al*., 2008; Alhtheal *et al*., 2024)**. The oxygen levels in fish are indicative of their activity levels. For instance, the Scomber, known for its energetic nature, carries oxygen capacity of approximately 19.6 percentage, whereas the Opsanus Tau, recognized as a less active species, holds an oxygen capacity of just 5.3% **(Mcfarland *et al*., 1979; Jasim *et al*., 2021; Alsudani *et al*., 2024)**. Therefore, by knowing the respiratory area of the gills, the amounts of oxygen consumptions to respiration, growth, and metabolism can be estimated, as previous studies have indicated that amounts of oxygen consumptions was high in fish such as Chorhynchus, which amounted to 800 mg, and *Carassius auratus* 170 mg / H. This suggests of fish with higher speed and higher motor efficacy rate needed large amounts of oxygen to meet their requirement comparative to fish with a low efficacy rate no need to move a great distance as they had everything from foods and nutrient in near by environmental **(Marsden, 1991; Smith *et al*., 2012; Shakir *et al*., 2024)**.

MATERIALS AND METHODS

Twenty healthy fish **(**ten common carp and ten catfish**)** were brought to the Veterinary Anatomy Laboratory at the Faculty of Veterinary Medicine, Tikrit University, to study the histological structure of the gills. The samples were then wash and fix with 10% formalin for 24 hrs. The samples were then prepared histological for histological cutting. The histologically process was accorded to **(Bancroft & Steven, 1982; Ammar *et al*., 2019)**. In short, the sample was dried with 35, 50, 70, 80, 90 and 100 percentage ethanol for an hour per concentrations. After that, the samples were clean with xylene. Then sample was filter and combin use paraffin wax. After all the above step, the sample were kept at room temperature for cool. The sample was then cut and dyed use routine dyes (eosin and hematoxylin).

RESULTS AND DISCUSSION

Histologically section of the gill in domestic carp and catfish showed that the gill arch is the cartilaginous structures for supporting the gills filament, which are feathery thin structures, and the thin lamina, plate-like structures that form the gills filament (Fig. 1). Histologically section of the gill arch in common carp and catfish show structure similarity in appearances, with difference in fine details. The gills arch is cartilaginous structures of support the gills filament (Fig. 2). The gills arch was present in both species for the supports of gills filament, which are thick and long filament, with a larges surface area to gas exchanges at Common carp comparative to Catfish. This appears as a smooth surface, which refers to a good ability for absorption of oxygen (Fig. 3). A clear difference was found in the gill structure between the two investigated species through histological analyses. The gill filaments ﻩin the catfish were wide and short, while the common carp had long gill filaments (Fig. 3). Also, both the primary and secondary plates contained primary and secondary lamellae, but they were arranged tightly in the common carp compared to those in catfish (Fig. 3).

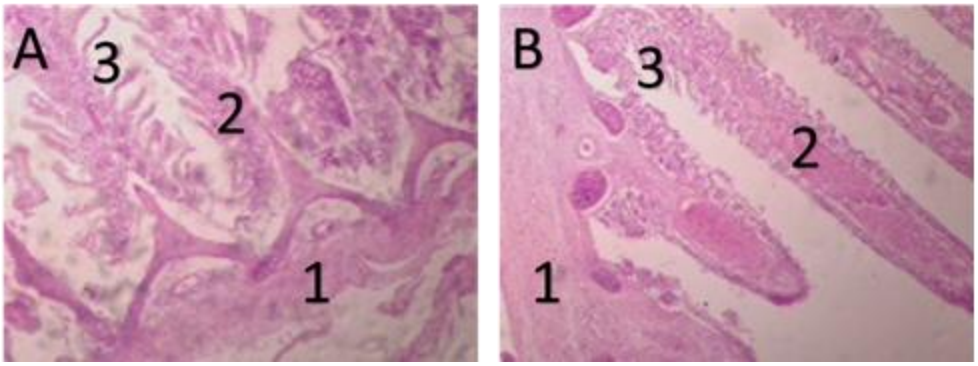

Fig. 1. Histological section of the gills in common carp (A) and catfish (B). Gill arch (1), gill filaments (2), lamina (3), (H & E, 10X)

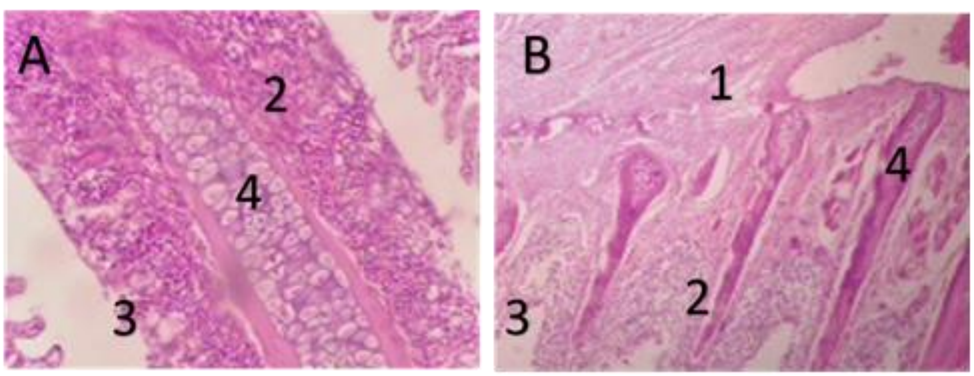

Fig. 2. Histological section of the gills in common carp (A) and catfish (B) shows the Gill arch (1), gill filaments (2), lamina (3), cartilage (4). (H & E, 10X)

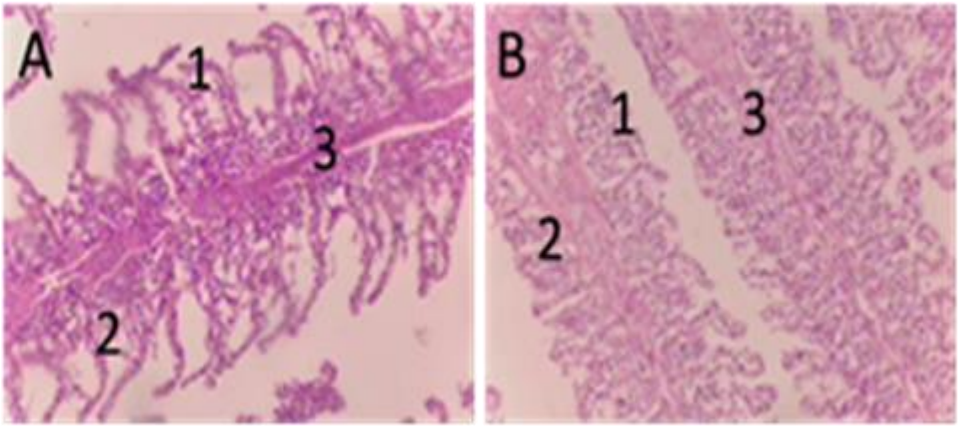

Fig. 3 Histological section of the gills in common carp (A) and catfish (B) shows secondary lamina (1), epithelium of filament (2), sinus of venous (3) (H & E, 10X)

This histological study investigated the gill structure of two common fish species that live in Iraqi waters. The result analysis show that gill of the catfish revealed significantly greater surface area comparative to those of the common carp. This indicates that the gills in the catfish may be adapted to extract a large amount of oxygen with minimum cost of energy. Thus, the catfish, like other active fish, contains gills with a large surface area to get a high concentration of oxygen, which enables them are adapt to different external environments. This concept has been shown previously in the study **(Habeeb *et al*., 2024; Abd *et al*., 2025)**, which indicated that the gills of WA. Ocellatus and C. auratus contain different histological features. Both species exhibited different efficiencies in oxygen uptake, despite having similar mechanisms of gas exchange. This occurs through the work of gill arch, gill plates, and gill filaments to provide an active exchange system. This histological study indicated that the gill tissue was different, by notoiced the gill filaments in the C.auratus are longer than those in the A. Ocellatus type **(Jumma, 2024)**. They confirmed that the variation in the length of gills filament can increase the surface area that is essential for respiration. Their results were also supported by another study. It was confirmed of size the gills surface area is relate to length of gill filament, which influence the amounts of ions and gases exchanged. It also acts on the osmotic pressure between the fish's body and the externally environments **(Chen *et al*., 2022; Hou *et al*., 2023**; **Oday *et al*, 2024)**. In general, gill arches are important structures in biological development, as they perform important respiratory, supportive, and developmental functions. They are also responsible for the exchange of gases **(**oxygen and carbon dioxide**)**. Therefore, it serves as a supporting structure that holds the gill filaments and spines, as well as connects the gills to the pharynx. As mentioned earlier by **Evans *et al*. (2005)** the gill of bony fish consist of four gill, each dividing to two halve **(**half-gills**)** separate by a septum. The rear and front are connected. Furthermore, the gills arch, were play roles of managing the pressures inside gills and serves to regulate the movement of water inside the gills, has Gill clamps that prevent micro nutrients from pass through gills and act as filter **(Wilson and Laurent, 2002; Al-Bayati *et al*., 2024)**. They investigation of filament contain two type of lamellae, including primary lamellae and secondary lamellae consisting of a single layer of epithelial cells to act as a gas exchange site. While the gill filaments hold the secondary plates, increasing the gas exchange surface between water and blood. Secondary platelets are described as the actual gas exchange sites, where oxygen enters the blood and carbon dioxide is excreted. This is done through a fine network of capillaries that transport blood near the gas exchange surface, working with a counterflow system to maximize the efficiency of oxygen absorption. The gill surface is protected by epithelium that allows the passage of gases, contains mucous and chlorotic cells.

CONCLUSIONS

Histologically section of the gill of common carp and catfish showed somewhat similarity phenotypic structure, which suggests that two types have adaption to extract oxygen from water use similarity mechanism. Some difference found at size and abundances of some structure, which indicated species-specific adaptation relate to their environment, lifestyle, and behavior.

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