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Histological Comparison of the taste System in Two Species of Carp Related to Dietary Differences

Zainab A. Reheem , Habeeb M. Alsudani

Department of Fisheries and Marine Resources, College of Agriculture, University of Basrah, Iraq.

Email: habeebalsudani@gmail.com

Abstract

Through the images and clips that showed us the shape of the buds, which shows the structural and cellular differences observed in adaptations to nutritional and environmental needs, *Cyprinus Carpio* exhibit more specialized gustatory structures and functions than *Ctenopharyngodon Idella*. These differences underscore the evolutionary diversity of sensory systems among freshwater fish. Morphological and histological studies have revealed that taste buds are denser and more clustered in *C. Carpio* compared to C. *Idella*.

The nerve integration is such that the cranial gustatory nerves have shared connections, while the nerves are isolated in C. *Idella*. The connective tissue is also thicker, providing greater support for the taste buds, as well as a high vascular supply compared to the thinner, less vascularized connective tissue of C. *Idella*.

In addition to the complexity of the basal layer and its high organization in C. *Carpio* compared to its lower organization in C. *Idella*, a detailed examination of these structures sheds light on their roles in enhancing taste perception in both C. *Idella* and C. *Carpio*.

The organization and specialization of these components reflect evolutionary adaptations that allow fish to thrive in their aquatic environment by efficiently detecting and responding to various chemical signals. Understanding these structures not only provides insights into fish biology but also underscores their ecological importance in aquatic ecosystems.

Keywords: histology, fish taste System, Ctenopharyngodon Idella, taste buds.

I. Introduction

Fish feeding behavior is influenced by several sensory systems that play critical roles in the detection of nutrients, starting from vision, olfaction, and hearing, extending to the lateral line organ and electroreception, and culminating in the ingestion phase, which involves taste and mechanoreception. The terms palatability and taste are often used interchangeably and are typically defined based on the chemical properties of food, although physical properties can also affect food acceptance or rejection. Fish are widely used as model organisms in taste research due to their high sensitivity to taste stimuli compared to mammals (Kasumyan & Døving, 2003). Accordingly, some species possess specialized taste organs, such as the appendages in catfish, which contain a high concentration of taste buds associated

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with facial nerves. These characteristics make them ideal models for studying neural taste responses (Yasuoka & Abe, 2009).

Taste buds in fish, as in mammals, are characterized by a bulbous or pear-shaped structure embedded in the sensory epithelium and connected to nerve fibers. These buds are composed of three main cell types: taste receptor cells (TRCs), supporting cells, and basal cells. The TRCs and supporting cells are elongated and run parallel along the longitudinal axis of the taste bud, reaching the epithelial surface through pores that range in diameter from 2 to 20 micrometers, making them directly exposed to the aquatic environment. The number of TRCs per bud varies significantly by species, ranging from 5 to 67, and they overlap with gustatory nerve fibers. Basal cells, usually numbering from 1 to 5, are located at the base of the bud. TRCs terminate in large microvilli that act as receptor structures forming the sensory interface within the taste pore. Supporting cells also possess apical microvilli, surrounding and separating the TRCs, and connect with basal cells via specialized junctions. Between the TRCs and basal cells, tightly packed non-myelinated nerve fibers form a dense plexus that corresponds to the terminal structure of the gustatory nerve (Hara, 1994; Kasumyan & Døving, 2003).

It is well established that fish behavior is heavily influenced by both external environmental factors and internal physiological conditions. Their behavioral responses are often the result of interactions between dominant sensory signals and other concurrent stimuli that may either reinforce or conflict with one another. For instance, feeding behavior can be significantly altered in the presence of a real predator, or when the fish is exposed to its visual, chemical, or olfactory cues (Malyukina *et al*., 1983; Magurran, 1986; Milinski, 1993; Mikheev, 2006).

Taste is a fundamental component of feeding behavior. A notable gap often exists between olfactory and gustatory sensitivity, as taste preferences are closely linked to specific types of food (Goh & Tamura, 1980; Kasumyan & Døving, 2003). Fish living in dark, solute-rich aquatic environments have evolved complex chemical sensory systems, including both olfactory and gustatory pathways, in addition to isolated chemosensory cells (Hara, 1994). In aquatic environments, both olfactory and gustatory receptors are used to detect food from a distance, allowing the animal to assess food attractiveness based on its chemical signals. However, it is the gustatory system that provides the final evaluation of the sensory and nutritional characteristics of the food, influencing the decision to ingest or reject it. Unlike olfactory responses, which are generally less flexible and more conserved across species, gustation may also play essential roles in kin recognition, predator-prey interactions, orientation, and spatial recognition (Goh & Tamura, 1980; Hara, 1994).

Fish exhibit remarkable development in their gustatory systems. In some species, up to 20% of the brain mass is devoted to neural tissue associated with taste processing (Kotrschal & Palzenberger, 1992). In mature fish, taste buds are peripheral sensory structures situated within the epithelial layer, typically pear-shaped or bulbous in form. These buds rest on small dermal papillae and consist of various modified epithelial cells. They have been described using transmission electron microscopy (TEM) based on their electron density characteristics (Reutter, 1978, 1982; Jakubowski & Whitear, 1990).

Taste buds are located either within small dermal protrusions in the epidermis—as seen in barbels and certain areas of the lips—or on elevated ridges such as those found on the gill arches. In some regions, they may be flat and not elevated at all, such as in the skin of the head and lips (Reutter et al., 1974). Generally, the most prominent taste buds

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are located in the most exposed parts of the fish's body, such as the lips, gill arches, and barbels. The first type of taste bud is likely stimulated by food molecules and may also be mechanically sensitive (Reutter, 1978).

The presence of multiple types of taste buds in the oral cavity reflects the highly developed gustatory capacity in fish, enabling them to detect and analyze food quality effectively. For instance, three types of taste bud cells have been identified in fish: Type I, Type II, and Type III. Morphologically, Type I buds are partially embedded within the surrounding epithelium and are often found near the mouth entrance. Type II buds are slightly elevated above the epithelial surface and lack a surrounding channel at the base. Type III buds remain level with the epithelial surface and do not protrude. These types collectively enhance the gustatory ability of fish by facilitating food evaluation and palatability detection while the food remains in the oral cavity (Elsheikh *et al*., 2012). In some cases, taste buds located on the gill arches may provide further insight into the dietary habits of fish (Elsheikh, 2012).

Sample collection:

Fish samples were collected from the natural environment and were alive to preserve the tissue from damage and transferred to the laboratory in containers and cryopreserved. Two types of carp fish were used in this study and the work was on two parts. the first was the weight, length and phenotypic measurements of the body and head of the fish were taken and examined under an anatomical microscope and a magnifying glass to the tissue in this area is solidified by using a solution consisting of (10 ml of formalin and 5 ml of nitric acid and continue to 100 ml with distilled water) for a period of 3-4 hours, which was enough to withdraw calcium and make the fabric in a softer state to facilitate the cutting process

Then the parts prepared for the histological study were treated according to the Humason method (1978)

1. In the laboratory, after removing the parts for both types and removing the hardness from the fabric, this method is considered to stabilize the fabric instead of fixation using formalin at a concentration of 10% and the sample was washed with distilled water for a period of 15-30

A- dehydrogenation: samples are passed by an ascending series of concentrations of ethyl alcohol EthanoI aIcohoI from (35 ، ٪50 ، ٪70 ، ٪80 ، ٪90 ، ٪100٪) for a whole hour for each concentration in a row.

B- CIearing: liking samples with xylene according to gradual steps, through the use of xylene with alcohol in a ratio of 1:1 for a period of 30-45 minutes, then using only 100% xylene for a period of 30-45 minutes

C - Infiltration: the samples are placed with a mixture of paraffin wax melting point of 60 m° with xylene in a ratio of 50:50 for 4-6 hours and then the samples are impregnated with paraffin wax for 24 hours in an electric oven temperature of 60 m°.

D-Embedding samples of the same type of wax used for impregnation are immersed in special molds and a hot-slicing needle is used to expel air bubbles from the mold wax and to determine the direction and position of the model before the wax solidifies.

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E- Sectioning: cutting the models using a rotary Microtome with a thickness of 7 micrometers, then the cut and sequenced tapes are placed on marked glass slides, drops of distilled water are added, And then the slices are transferred to an electric hot plate its temperature (40-45m°) to dry.

F- Staining: the samples are passed with pure xylene for 10 minutes according to the type of fabric, then a mixture of xylene with ethylene alcohol in a ratio of 1:1 for 5 minutes, then the slices are transferred to 100% absolute alcohol for 3 minutes, then the slices are passed with descending concentrations of ethyl alcohols (90% ،80% ،70% ،50% ، 35%) and for 3 minutes for each concentration.

stain the slices with aqueous dye Hematoxyiin for 5 minutes and wash with distilled water, then dye with eosin aqueous stain Eosin for 5 minutes and then pass the slices with an ascending chain of ethyl alcohol (35% ،50% ،70% ،80% ، 90%) for 3 minutes each and then 5 minutes in absolute alcohol and quenched with xylene for 5 minutes.

G- Mounting: loading slides using material D.P.X. The prepared slides are examined using a compound light microscope and under different magnification power and images of tissue sections are taken.

II. Results

The taste buds are found at the front of the head under the mouth and lips and extend over the gill cover right and left and are used to sense small organic matter and bottom sediments on which they feed. The Shape of the taste buds in C. *caripo* is small in size, they appear in the form of round dots, they are slightly elongated, their shape is clear on the fish, they are clearer in the tissues and their external structure is in the form of small open pores, but the color usually appears in a light brown color to suit the muddy environment Where it lives and is visible on the skin especially around the mouth and lips.

Taste buds are located on and under the lips and are extended on the gill cover on the side near the mouth and help to distinguish algae and plants and are less widespread and less prominent compared to C. *caripo.* The form of taste buds in C. *idella* is smaller in size compared to C. *caripo* due to the nature of its plant nutrition and are less dense than common and concentrated under the lips. They appear in a shape similar to that found in Carp and are often less prominent, and they are united with each other by a line of dots connected with each other, either the color tends to gray or white, they are round or spherical, and their appearance is smaller than that found in C. *caripo*.

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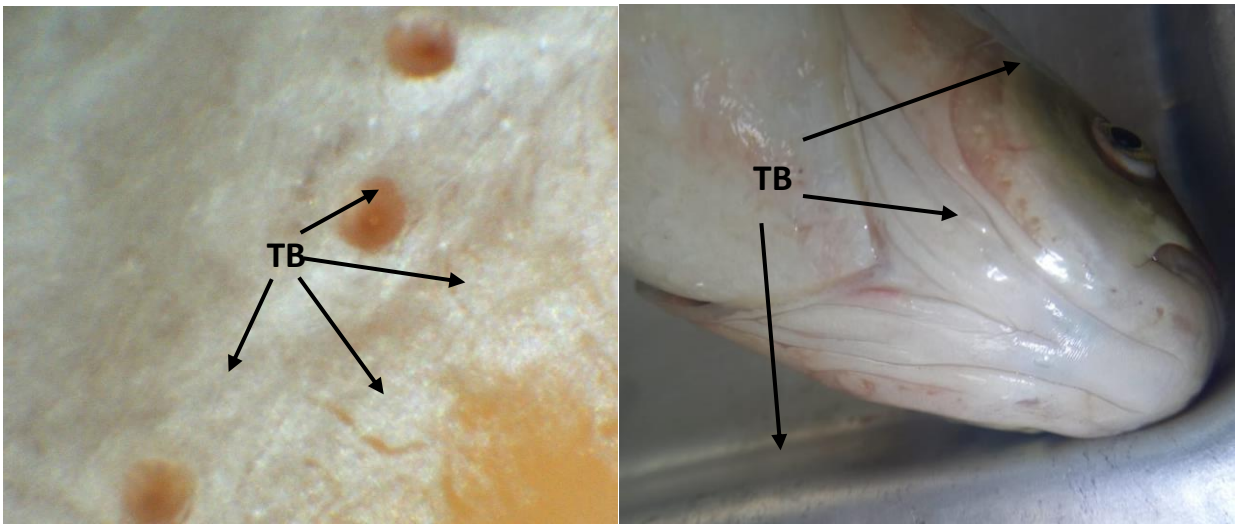

Image (1) shows the phenotypic form of taste buds and their distribution on the gill cover in C. *idella* fish.

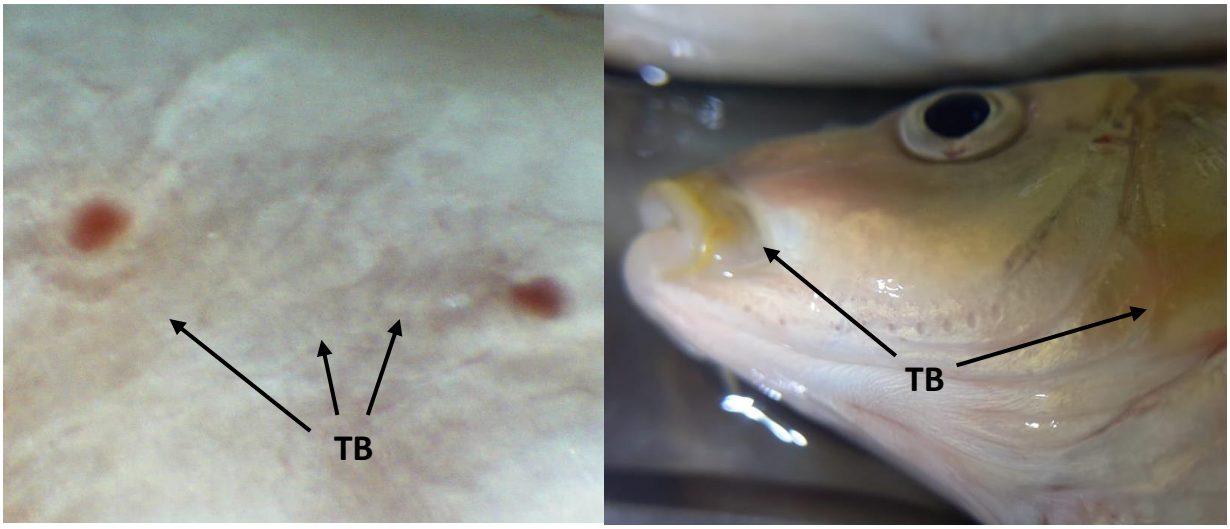

Image (2): shows the phenotypic form of taste buds and their distribution on the gill cover in common carp fish.

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Histological study :

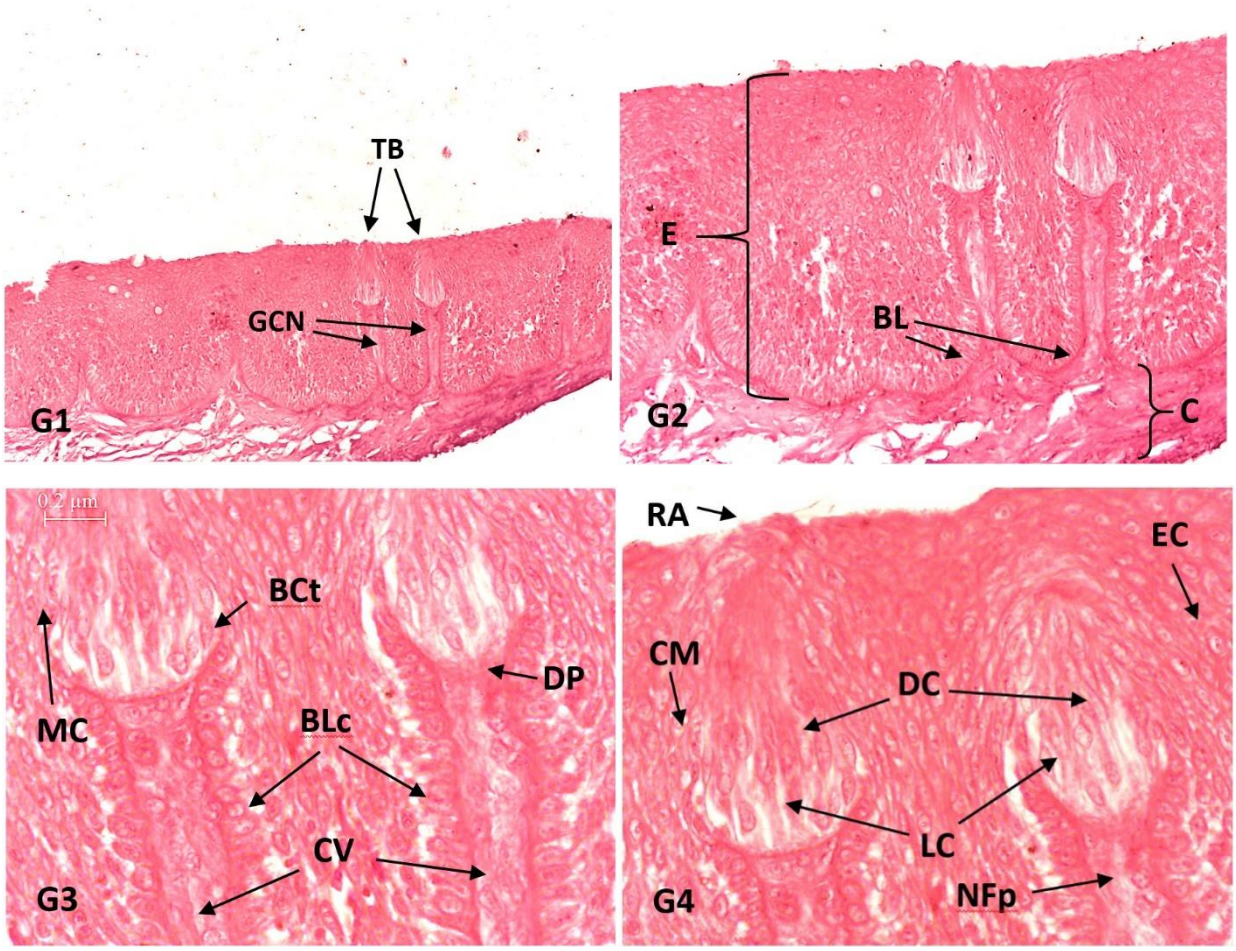

Figure (1): longitudinal sections of taste buds in the area of the gill cover of C. *idella*, (G1) shows five Taste buds (TB) and the Gustatory Cranial Nerve (GCN) , (G2) shows epithelium Tissue (E) Epithelium Tissue and connective tissue (C) Connective tissue and basal layer (BL) as shown in Figure (G3) Basal cell (BCt) and secondary cells (MC) Marginal cells and basal layer cells (BLc) Basal layer cells and capillary vessel (CV) Capillary vessel and (DP) dermal papilla, while figure (G4) shows the (Ra) receptor area, (DC) Dark cells, (LC) light cells, (EC) epithelial cells and taste bud nerve fiber plexus (H&E scale drawing: 0.2 micrometers).

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It has been observed in grass carp that the gill cover area is equipped with specialized structures responsible for the sense of taste, which is necessary in feeding behavior. A longitudinal cross-sectional study provides insights into the organization and function of these structures.

Figure G1: taste buds (TB): each taste bud is a collection of sensory cells that have the ability to detect chemical stimuli. In this clip five taste buds have been identified which indicate a specialized adaptation for sensing food in aquatic environments. Taste buds are embedded within the epithelial layer and are often located close to the surface to maximize contact with water-borne chemicals. Gustatory Cranial Nerve (GCN): this nerve is responsible for transmitting taste information from the taste buds to the brain. It plays a crucial role in processing sensory inputs related to food quality and safety. The presence of the gustatory cranial nerve indicates an active sensory pathway that supports the ability of fish to detect and effectively respond to various tastes.

Figure G2: histological composition epithelium Tissue (E) is observed as the epithelial layer forms the outer perimeter of the taste buds and provides a protective barrier against pathogens and mechanical damage and is characterized by tightly packed cells. Connective tissue (C) surrounds and supports the base of the taste buds, providing structural integrity. It contains components of the extracellular matrix that facilitate the transport of nutrients and cell signals. This tissue may also contain immune cells that protect against infection. Basal layer (BL) consists of stem cells that can differentiate into different types of cells surrounding the taste buds. This regenerative ability is vital for maintaining the function and integrity of the parts around the taste bud over time. It acts as a reservoir for new cells to replace cells lost due to corrosion or damage.

Figure G3: shows the cellular components of the taste bud observing basal bud cells (BCt) these cells are precursors of mature taste receptor cells. They play a crucial role in the ongoing life cycles of taste bud cells. Its presence indicates an active regeneration process, which is necessary to maintain sensory function. Secondary marginal cells (MC) are located on the periphery of the taste bud and help maintain the integrity of the structural structure and may contribute to the secretion of substances that support the function of the taste bud. It also plays a role in modulating the response of taste receptor cells. Basal layer cells (BLc) these cells are part of the basal layer and contribute to supporting the overall structure of the taste buds. Also involved in signaling pathways that affect cell differentiation and maturation. The capillary vessels (CV) inside the connective tissue supply the taste buds with oxygen and nutrients, supporting their metabolic needs. It also removes waste products, which ensures the optimal functioning of sensory cells inside the taste buds. Dermal papillae (DP) are the base on which all the cells of the taste bud rest and promote the connection between the taste buds and the surrounding tissues. This structure also plays a role in mechanical sensing, which helps fish detect physical changes in their environment.

Figure G4: sensory structures includes the sensory receptor area (RA), which contains specialized sensory cells equipped to detect chemical compounds. It is in these receptors that the signaling pathways leading to taste perception begin. This area is vital for distinguishing different tastes, through which it influences feeding behavior. Dark cells (DC) are often associated with secretory functions, they may produce substances that help in chemoreception or protect against pathogens. Its role can also vary depending on environmental conditions and nutritional needs to provide food to meet the body's need. Light cells (LC) are mainly involved in the transmission of sensory signals and the conversion of chemical signals into electrical impulses that are sent to the nervous system. They usually contain more organelles that are related to metabolic activity compared to dark cells. Epithelial cells (EC) these cells make up the majority of the epithelial layer surrounding the taste buds and they provide structural support for the taste buds. Epithelial cells

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also interact with sensory receptors facilitating communication between external stimuli and internal responses. The Nerve fiber plexus (NFp) consists of a network of nerve fibers that interconnect with receptor cells inside the taste buds. This network is necessary for fast signal transmission. They allow efficient communication between taste receptors and central nervous system pathways enabling rapid responses to changes in the chemical composition in water.

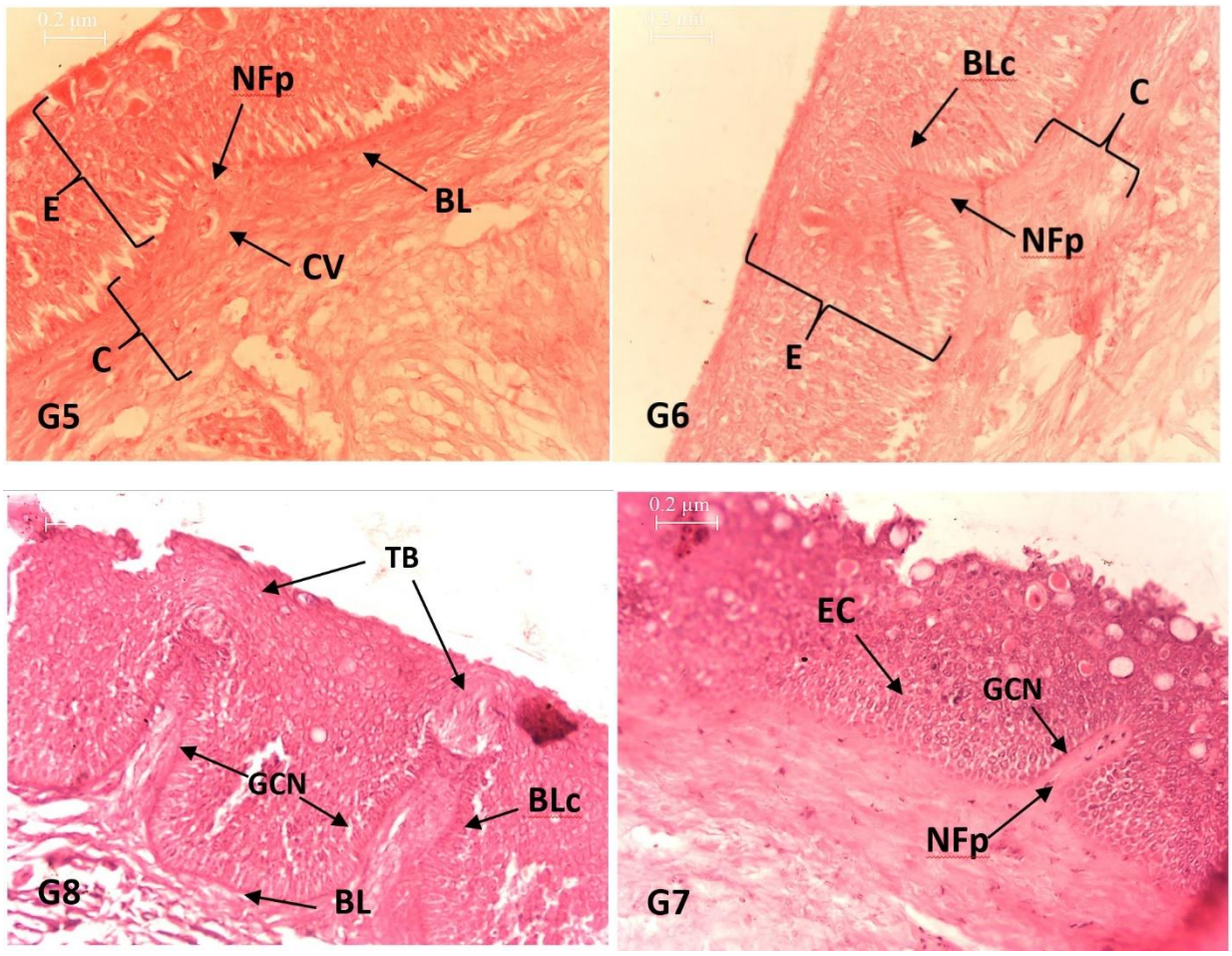

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Figure (2): a longitudinal section of the area of the taste buds in the area of the gill cover of grass carp shows the successive layers of the structure of the taste bud. (G5) notes the edge of the base of the cranial nerve extending from the connective tissue layer. Also in this layer it is possible to distinguish the basal layer (BL) , nerve fiber plexus (NFp) , capillary vessel (CV) , epithelium Tissue (E) and connective tissue (C) , (G6) in this layer, approximately half of the cranial nerve extending from the connective tissue layer is observed. Basal layer cells (BLc) basal layer cells , connective tissue (C) , and the beginning of the nerve fiber plexus of the organ (NFp) and epithelium tissue (E) are clearly shown, while figure (G7) shows larger parts of the gustatory Cranial Nerve nerve (GCN) and nerve fiber plexus for the organ (NFP) and epithelial cells (EC) , (G8) shows all the details of taste buds (TB), gustatory cranial nerve nerve (GCN), basal layer cells (BLC) and basal layer (BL) H&E drawing scale: 0.2 micrometers).

The longitudinal section of the region of the taste buds in the region of the gill cover in (C. *Idella*) provides a detailed presentation of the structural regulation and cellular components involved in taste functions. This analysis is organized into four characteristic layers (G5, G6, G7 and G8), each of which reveals important aspects of the structure of the taste buds.

Layer G5: the base of the cranial nerve and structural components in this layer the edge of the base of the cranial nerve can be seen prominently extending from the surrounding connective tissue layer. The main components identified in this layer include: Basal layer (BL), this basic layer consists of basal cells that play a crucial role in the regeneration and maintenance of taste buds. These cells are responsible for replacing aging or damaged taste receptor cells ensuring that the function of the taste buds continues. The Nerve fiber plexus (NFp) is a network of nerve fibers that interconnect with taste receptor cells. They are necessary for the transfer of sensory information from the taste buds to the central nervous system. The presence of this plexus indicates a well-developed sensory pathway. Capillary vessel (CV) observation of capillary vessels within this layer indicates an active role in the supply of nutrients and oxygen to the taste buds. Such an effective augmentation is vital for maintaining cellular metabolism and the overall health of the structures of the taste buds. Epithelium Tissue (E) the epithelial layer contains specialized taste receptor cells that react to chemical stimuli from the environment. These cells are equipped with microvilli that increase their surface area enhancing their ability to detect solutes. Connective tissue (C) this supporting tissue surrounds and stabilizes the various components of the taste bud area providing structural integrity and facilitating intercellular communication.

Layer G6 provides a more detailed view of the neural structure as it exposes approximately half of the cranial nerve extending from the connective tissue layer. The segment includes basal layer cells (BLc) and these cells are essential for the regeneration process within the taste bud. They can differentiate into different cell types including mature taste receptor cells and thus play an important role in maintaining the function of the taste bud. Connective tissue (C) similar to layer G5 this connective tissue supports the organization of nerve fibers and blood vessels ensuring that all components are properly aligned for optimal function. The beginning of the Nerve fiber plexus (NFp) in this layer an early part of NFp appears indicating its role in the transmission of sensory signals. This suggests that sensory information from taste receptors is transmitted to the central pathways. Epithelium Tissue (E) epithelial cells in this layer are observed more clearly, which indicates an active role in taste perception. These cells are likely to be involved in detecting specific chemical signals from food sources.

Layer G7 illustrates the larger components related to taste function, including the gustatory Cranial Nerve (GCN), this nerve is necessary to transmit taste information from the taste buds to the brain. Its greater representation in this layer

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indicates a strong neural connection necessary for the processing of gustatory stimuli. Nerve fiber plexus (NFp) the NFp is more developed in this layer indicating an extensive network that enhances the efficiency of sensory signal transmission. Epithelial cells (EC) the presence of many epithelial cells indicates a high density of taste receptors which may enhance the ability of fish to detect various chemical signals in their aquatic environment.

Layer G8 represents a comprehensive visualization of the structures of the taste buds, providing a more detailed appearance of many key structures. taste buds (TB) this layer reveals complex details about the taste buds including their shape and cellular composition. Taste buds are essential for discovering different tastes from different food sources. The gustatory Cranial Nerve (GCN), the detailed picture of which confirms its role as the main channel for transmitting gustatory information to the higher brain centers responsible for processing tastes. Basal layer cells (BLc) these cells are clearly defined, which confirms their importance in maintaining and renewing taste buds over time. Basal layer (BL) the overall structure of the basal layer is clear, which highlights its supporting role within the structure of the taste buds.

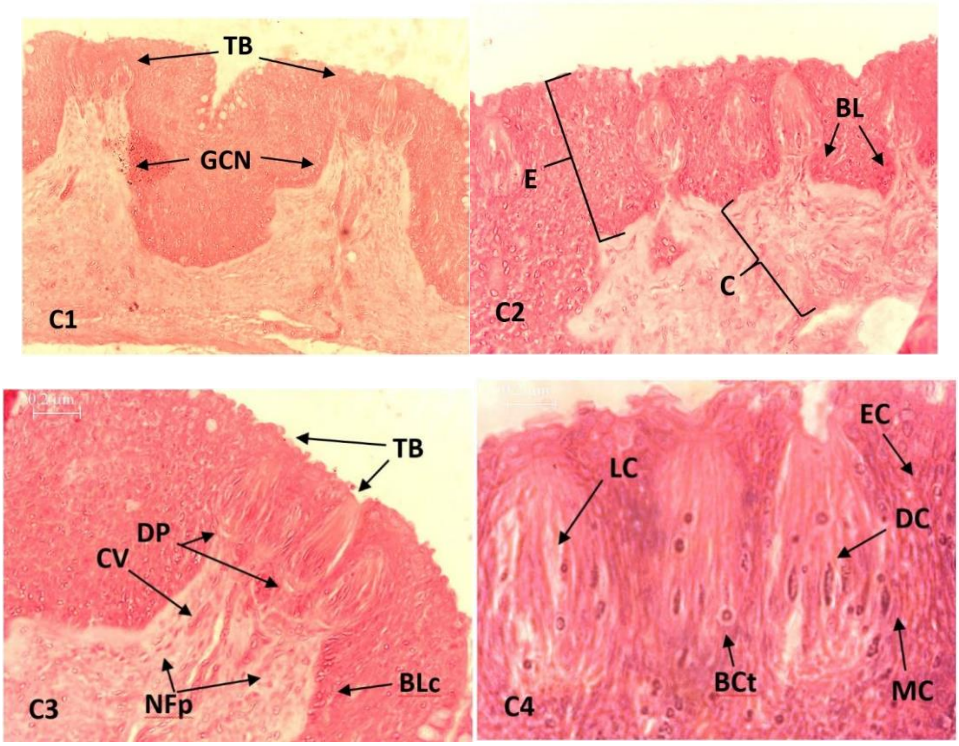

Figure (3): longitudinal sections of the taste buds in the area of the gill cover of ordinary carp, (C1) shows six taste buds (TB) each three share a short gustatory Cranial Nerve (GCN) , (C2) shows a thin layer of epithelium Tissue (E) and a larger layer of connective tissue (C) (C3) basal layer cells (blc) basal layer cells, Capillary vessel (CV) , dermal papilla (DP) , receptor area (ra) and taste bud nerve fiber Plexus (NFP) basal fiber Plexus , While figure (C4) shows

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basal cells (BCt), (MC) Marginal cells, dark cells (DC), light cells (LC) and epithelial cells (EC) (H&E drawing scale: 0.2 micrometers).

Comparative analysis of histological sections of taste buds in Cyprinus caripo and Cetenopharyngodon idella:

The structural differences in taste buds between C. *idella* and C. *caripo* are obvious as shown in Figure 1 and 3, which provide a detailed histological presentation of the taste buds in the area of the gill cover of C. *caripo* and C. *idella*. Including specific cellular, tissue and functional observations.

The distribution of taste buds and the gustatory neural connection of C. *caripo* (section C1) six taste buds (TB) can be seen inside the section. Three of these taste buds share a short gustatory Cranial nerve (GCN) indicating a more complex neural integration. This arrangement suggests a denser clumping of the taste buds and stronger neural connections which may facilitate more precise sensory input. Compared with C. *idella*, fewer taste buds are distributed across the histological sections and there are often isolated nerve connections instead of common cranial nerves. This arrangement reflects a less clumped organization and less complex neural processing of taste stimuli. The higher density and neural connections involved in C. *caripo* indicate an adaptation to detect a wider range of taste stimuli that are related to wider food preferences compared to C. *idella*.

The histological composition of the sectioned C. *caripo* (C2) shows the presence of a thin layer of epithelium Tissue (E) acting as a protective barrier. Below this layer is a much larger layer of connective tissue (C) that provides structural support and harbors capillaries and nerve fibers. With the basal layer (BL) forms the basis with the presence of differentiated cellular structures that help in the function of taste. Compared to grass carp fish in which the epithelial layer is relatively thicker while the connective tissue layer is thinner. With a less differentiated basal layer. The strong connective tissue in C. *caripo* indicates an increase in blood vessel formation and nerve integration, which supports the transmission and processing of taste signals more efficiently.

The structural complexity of the basal layer of C. *caripo* (section C3) shows that the basal layer contains many specialized structures such as basal layer cells (BLc) that serve as a reservoir for the renewal of taste buds. And capillary vessels (CV) that support the supply of nutrients and the removal of waste for active gustatory cells. The dermal papilla (DP) also increases the surface area for interaction between connective tissue and gustatory structures. And the receptor area (RA) specializes in the detection of taste stimuli. The Nerve fiber plexus (NFp) also appears on a dense network of nerve fibers that provide signal transmission to the processing center. Compared to C. *idella* fish in which the basal layer is less complex with fewer specialized structures such as capillaries or dermal papillae. The receptor zone and the plexus of nerve fibers are also less developed. Thus, the functional effect is reflected as the developed basal layer in C. *caripo* indicates a higher regenerative capacity and more efficient sensory signal transmission compared to C. *idella*.

Cellular structure of taste buds in cut C. *caripo* (C4) the taste buds show a wide range of cellular differentiation, including basal cells (BCt), which provide structural integrity and regenerate taste cells. And the Marginal cells (MC) surrounding the taste buds, which play a protective role. While dark cells (DC) are involved in the transmission of ions and sensory signals. In addition to light cells (LC): responsible for taste perception. And epithelial cells (EC) form the outer layer to support taste buds. While the cellular diversity of C. *idella* is less pronounced with basal cells and secondary cells being the dominant species. Specialized cells such as dark cells and light cells are less

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differentiated. Thus, the functional effect due to the greater cellular diversity in C. *caripo* indicates a more specialized and more accurate tasting function, which allows the detection of diverse taste patterns.

III. Discussion

In this study, it was observed that the opercular region in grass carp is equipped with specialized structures responsible for the sense of taste, which is essential in feeding behavior. Each taste bud consists of a cluster of sensory cells capable of detecting chemical stimuli. This finding is consistent with what was reported by Whitear (1971), who stated that gustation in fish often takes place in gustatory organs, and taste sensors—or taste buds (TBs)—are distributed around the mouth, in the oropharyngeal cavity, on the gill arches, the skin, and the barbels. Several studies have shown that the distribution patterns and density of these taste buds are closely linked to the species' lifestyle. Species inhabiting shallow waters with low visibility tend to have higher density and more regionally distributed taste buds compared to species living in clearer waters (McCormick 1993; Lombarte and Aguirre 1997; Aguirre and Lombarte 2000).

The number and distribution patterns of taste buds are closely related to the organism's efficiency in locating food sources (Laverack 1988). Fish taste preferences exhibit unique, species-specific traits. Attractive or stimulating substances differ among species but tend to be similar among individuals of the same species, even when they come from different populations, generations, or have had varying dietary experiences (Kasumyan and Morsi, 1997; Kasumyan and Døving, 2003; Fokina and Kasumyan, 2003; Kasumyan and Sidorov, 2005). These phenomena suggest a strong genetic determination of taste preferences, indicating low flexibility and minimal subjectivity to diverse external factors.

In this context, the gustatory system provides selective feeding capabilities for fish across different habitats. However, the influence of the environment on taste preferences and feeding behavior in fish has not been sufficiently studied. Research suggests that changes in taste spectra are associated with water temperature, which also influences many other physiological processes and feeding motivation in fish (Kasumyan *et al*., 1993).

The study also showed that taste buds are embedded within the epithelial layer and are often located close to the surface to maximize exposure to waterborne chemical stimuli. This agrees with findings indicating that some taste buds are positioned above the epithelial surface to reduce sensitivity to tactile stimuli (Devitsina, 2003). This also aligns with reports describing three types of taste buds in fish, differing in dimensions and degrees of projection above the epithelial surface (Whitear 1971; Grover-Johnson and Farbman 1976; Reutter 1978).

The distribution of taste buds on the barbels of several fish species has been studied (Lombarte and Aguirre 1997; Aguirre and Lombarte 2000), and many studies confirm that taste bud distribution patterns and density are tightly linked to species lifestyle. Species in shallow, low-visibility waters have higher and more regionally concentrated taste bud densities compared to those in clearer water.

Taste buds are sensory end organs embedded within the epithelial layer or epidermis. They occur in the epithelium of the mouth, head, and branchial regions (internal taste buds), and also on the skin of the head and body, especially on body appendages like barbels, fins, and unpaired fin rays (external taste buds). The number and primary locations of taste buds differ among specific fish species (Osse *et al*., 1997).

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In carp, the gustatory system is highly developed and represented by numerous intraoral and external taste buds irregularly distributed over the body surface (Marui and Caprio, 1992). Turbid habitats often coexist with environments where visibility is limited. In such cases, the external taste system gains importance in food detection. External taste can serve as a stepwise search mechanism, as seen in catfish, and often leads to ingestion upon contact (Atema 1971; Bardach & Atema 1971; Wunder 1927). Tactile stimuli also play a role in triggering feeding reflexes, similar to chemical stimulation (Davenport & Caprio 1982). In fact, all gustatory systems studied also respond to touch (Kiyohara et al. 1985; Marui 1977; Marui & Funakoshi 1979; Marui & Caprio 1982; Peters et al. 1987; Peterson 1972).

The study revealed the presence of the Gustatory Cranial Nerve (GCN), which is responsible for transmitting taste information from the taste buds to the brain and plays a critical role in processing sensory input related to food quality and safety. The existence of this nerve suggests an active sensory pathway that supports the fish's ability to detect and effectively respond to various tastes. The larger components associated with taste function include the GCN, whose prominent representation indicates a strong neural connection necessary for processing gustatory stimuli.

This agrees with the findings of Yasuoka and Abe (2009), who noted that the segmental organization of the gustatory system in fish follows an anterior-posterior arrangement with respect to cranial innervation and taste bud location. Three cranial nerves transmit gustatory information directly to the central nervous system:

The facial nerve (VII), which innervates taste buds on external surfaces (lips, spines, fins, body surface) and the mandibular arch, including oral taste buds of the premaxillary palate.The glossopharyngeal nerve (IX), which innervates the branchial arches and the posterior oral cavity. The vagus nerve (X), which innervates the branchial and pharyngeal arches (Hara, 1994; Kasumyan and Døving, 2003).

Mature fish taste buds are terminal sensory organs within the epithelium, pear-shaped or bulbous, situated on small dermal papillae. They are composed of modified epithelial cells of various types, classified based on electron density under transmission electron microscopy (Reutter 1978, 1982; Jakubowski and Whitear, 1990). The sensory epithelium includes vertically aligned cells: dark cells with many short microvilli, and light cells with larger, single apical microvilli. Basal cells extend horizontally between the dark and light cells and the basal lamina. These cells resemble Merkel cells (mechanosensory cells) rather than the "basal cells" seen in mammals (Reutter and Witt, 1993).

Generally, bony fish taste buds contain two cell types: dark cells and light cells (Reutter and Witt, 1993), thought to correspond to supporting and gustatory receptor cells, respectively (Jakubowski and Whitear, 1990). Interestingly, in Zebrafish (Danio rerio), three cell types were identified within taste buds, each with distinct apical endings: dark cells with many small microvilli, light cells with a single large microvillus, and a third type with a brush-like cluster of long microvilli. This third cell type had a different electron density, lower than that of dark cells.

In some instances, other cell types were observed in the TBs of bony fish. There is evidence that dark cells are synaptically connected to nerve fibers of the TB plexus, indicating a sensory role. Given their morphology—particularly their richness in intermediate filaments and processes—it is unlikely that the more rounded light cells are purely supportive. Thus, we prefer the classification: sensory epithelium of taste buds consists of light cells, dark cells (not simply sensory and supportive), basal cells, and the nerve fiber plexus (Reutter 1978, 1982; Reutter and Witt 1993; Witt *et al*., 2003).

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Our study suggests that the arrangement of taste buds indicates denser clustering and stronger neural connectivity, possibly allowing for more refined sensory input. In comparison, grass carp show fewer taste buds per histological section, often with isolated neural connections rather than shared cranial nerves, suggesting a less compact and less complex neural processing structure for gustatory stimuli.

This is consistent with a study on ten carp species that found bottom-dwelling, benthic-feeding species to have more external taste buds than those inhabiting open or surface waters, with taste bud density declining in most studied species (Gomahr et al., 1992). Benthic species tend to have high external taste bud density, whereas midwater or surface species usually have much lower densities. In general, body surfaces in contact with food sources show higher taste bud densities (Schemmell 1967). However, these ecological-functional factors do not fully explain low taste bud density in small benthic organisms in dark habitats. High relative density of taste buds in surface-dwelling fish in dark environments might be linked to occasional benthic feeding excursions (Schiemer 1985).

Although a benthic lifestyle may explain high taste bud densities, it does not fully account for similar densities in midwater fish found in relatively clear streams and lakes. Some species' taste bud densities may relate to highly turbid habitats, where chemical cues serve as important sources of information (Bardach & Atema 1971). Hence, the density and arrangement of external gustatory systems can often be predicted based on a species' habitat.

IV. Reference

Kasumyan,A. and Døving,K.V.(2003). "Taste Preferences in Fish," Fish Fisheries 4 (4), 289–347

Yasuoka, A., and K. Abe,K(2009). Gustation in fish: Search for prototype of taste perception. Results Probl. Cell Differ. 47: 239– 255.

Hara, T. J.(1994). The diversity of chemical stimulation in fish olfaction and gustation. Rev. Fish Biol. Fisher., 4(1): 1–35.

Malyukina,G.A., Marusov,E.A., and Karpov.A.K.(1983). "Some Specific Features of Chemical Signalling in the White Sea Coastal Cod Gadus morhua marisalbi Derju gin (Gadidae)," Vopr. Ikhtiol. 23 (5), 839–844

Magurran,A.E.(1986). "Predator Inspection Behavior in Minnow Shoals: Differences Between Populations and Individuals," Behav. Ecol. Sociobiol. 19, 267–273 .

Milinski,M. "Predation Risk and Feeding Behavior," in Behaviour of Teleost Fishes, Ed. by T.J. Pitcher (Chapman and Hall, London, 1993), pp. 285–305.

Mikheev,V.N.(2006) Environmental Inhomogeneity and Trophic Relations in Fish (Nauka, Moscow, 2006) [in Russian].

Goh, Y., and T. Tamura.(1980a)Olfactory and gustatory responses to amino acids in two marine teleosts—red sea bream and mullet. Comp. Biochem. Physiol., 66C(2): 217–224

Reutter K. (1978). Taste organ in the bullhead (Teleostei). Adv Anat Embryol Cell Biol 55:1–98.

Reutter K. (1982). Taste organ in the barbel of the bullhead. In: Hara TJ, editor. Chemoreception in fishes. Amsterdam: Elsevier. p 77 91.

Jakubowski, M., & Whitear, M. (1990). Comparative morphology and cytology of taste buds in teleosts. Zeitschrift fur *mikroskopish Anatomische Forschung,* 104, 529–560.

ISSN Onlin:2708-9347, ISSN Print: 2708-9339 Volume 14, Issue 2 (2025) PP 250-265

https://iasj.rdd.edu.iq/journals/journal/issue/18682 *https://doi.org/10.54174/utjagr.v13i1.323*

Reutter K, Breipohl W, Bijvank GJ. (1974). Taste bud types in fishes. II. Scanning electron microscopical investigations on Xiphophorus helleri Heckel (Poeciliidae, Cyprinodontiformes, Teleostei). Cell Tissue Res 153:161–165.

Reutter K. (1978). Taste organ in the bullhead (Teleostei). Adv Anat Embryol Cell Biol 55:1–98.

Elsheikh E. H., (2013). Scanning electron microscopic studies of gill arches and rakers in relation to feeding habits of some fresh water fishes, The Journal of Basic and Applied Zoology, 66, 121-130

Elsheikh E. H., Nasr E. S. and Gamal A. M., (2012). Ultrastructure and distribution of the taste buds in the buccal cavity in relation to the food and feeding habit of a herbivorous fish: Oreochromis niloticus, Tissue and Cell, 44, 164-169

Whitear, M. (1971). The free nerve endings if fish epidermis. Journal of Zoology: Proceedings of the Zoological Society of London, 163, 231–236.

McCormick, M.I. (1993). Development and changes at settle ment in the barbell structure of the reef fish, Upeneus tragula (Mullidae). Env. Biol. Fish 37: 269–282.

Lombarte, A. and Aguirre, H. (1997) . Quantitative differences in the chemoreceptor systems in the barbells of two species of Mullidae (Mullus surmuletus and M. barbatus) with different bottom habitats. Mar. Ecol. Prog. Ser. 150: 57–64.

Aguirre, H. and Lombarte, A.(2000). Distribution pattern of taste buds along hyoidal barbells of Mullus barbatus and M. surmuletus. Brain Behav. Evol. 56: 323–329.

Laverack, M.S. (1988). The diversity of chemoreceptors. In: Sensory Biology of Aquatic Animals. pp. 287–312. Edited by J. Atema, R.R. Fay, A.N. Popper and W.N. Tovolga. Springer-Verlag, New York, N.Y.

Kasumyan, A. O., & Morsi, A. M. H. (1997). Taste preference for classic taste substances in juveniles of the grass carp C. Idella (Cyprinidae, Pisces) reared on various diets. Doklady Biological Sciences, 357, 562–564

Kasumyan, A. O., & Marusov, E. A. (2005). The complementarity of chemo sensory systems in mediating the searching behavioral response to food chemical signals in stone loach Barbatula barbatula. Doklady Biological Sciences, 402, 202–204.

Kasumyan, A. O., Sidorov, S. S., & Pashchenko, N. I. (1993). Effect of water temperatures on taste sensitivity of fry of the stellate sturgeon Acipenser stellatus to free amino acids. Doklady Biological Sciences, 331, 265–267.

Lombarte, A. and Aguirre, H. (1997) . Quantitative differences in the chemoreceptor systems in the barbells of two species of Mullidae (Mullus surmuletus and M. barbatus) with different bottom habitats. Mar. Ecol. Prog. Ser. 150: 57–64.

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https://iasj.rdd.edu.iq/journals/journal/issue/18682 *https://doi.org/10.54174/utjagr.v13i1.323*

Marui, T., & Caprio, J. (1992). Teleost gustation. In T. J. Hara (Ed.), Fish che moreception (pp. 171–198). London: Chapman and Hall.

Atema, J.(1971). Structures and functions of the sense of taste in the catfish (Zctulurw natalis). Brain

Bardach, J.E. &J. Atema. (1971). The sense of taste in fishes. pp. 293336. In: L.M. Beidler (ed.) Handbook of sensory physiology, 4 Chemical senses 2. Taste, Springer Verlag, Heidelberg.

Davenport, D.E. &J. Caprio. (1982). Taste and tactile recordings from the ramus recurrents facialis innervating flank taste buds in the catfish. J. Comp. Physiol. (A) 147: 217-229.

Kiyohara,. S., S. Yamashita & J. Kitoh. (1980). Distribution of taste buds on the lips and inside the mouth in the minnow, Pseudorasbora parva Physiol. Behav. 24: 1143-1148.

Marui, T., & Caprio, J. (1992). Teleost gustation. In T. J. Hara (Ed.), Fish che moreception (pp. 171–198). London: Chapman and Hall.

Yasuoka, A., and K. Abe,K(2009). Gustation in fish: Search for prototype of taste perception. Results Probl. Cell Differ. 47: 239– 255.

Reutter K, Witt M. (1993). Morphology of vertebrate taste organs and their nerve supply. In: Simon SA, Roper SD, editors. Mechanisms of taste transduction. Boca Raton: CRC Press. p 29–82.

Gomahr, A., Palzenberg, M., & Kotrschal, K. (1992). Density and distribution of external taste buds in cyprinids. Environmental Biology of Fishes, 33, 125–134

Schemmel, C.(1967). Vergleichende Untersuchungen an den Hautsinnesorganen ober- und unterirdisch lebender Astya- nax-Formen. Z. Morph. Tiere 61: 255-305.

Schiemer, F. (1985). Die Bedeutung der Augewlsser als Schutz- zone fur die Fischfauna. Gsterreichs Wasserwirtschaft 37: 239-245.