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LATERAL LINE OF THE NURSE SHARK (*Ginglymostoma cirratum*): BRIEF REVISION

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Abstract. The nurse shark (*Ginglymostoma cirratum*), also known in Portuguese as "tubarão lixa" or "lambaru", is found mostly in groups of variable size. Specimens inhabit the bottom of the sea, in warm, littoral waters. The nervous system of these sharks arises embryologically from the medullary plate, in which the cephalon develops. The cephalon is divided into three parts, prosencephalon, mesencephalon, and rhombencephalon. These sharks have very sensitive sensors, both mechanoreceptors and electroreceptors, that contribute to the exploration of their surrounding aquatic world and enhance their survival,

Keywords: Chondrychthyes; Neuromasts; Ampullae of Lorenzini.

LINHA LATERAL DO TUBARÃO LIXA (*Ginglymostoma cirratum*): BREVE REVISÃO

Resumo. O tubarão lixa (*Ginglymostoma cirratum*) também conhecido como tubarão-enfermeiro ou lambaru, e são encontrados, na maior parte do tempo, reunidos em grupos de tamanhos diversos. Habitam o fundo do mar em águas litorâneas e mornas. O sistema nervoso destes tubarões surge embriológicamente a partir da placa medular, e nesta se apresenta a estrutura chamada de encéfalo, que está dividido em três partes, denominados de prosencéfalo, mesencéflo e rombencéfalo. Estes tubarões possuem sensores de precisão muito sensíveis, que são os mecanoreceptores e eletroreceptores, que lhes conferem grande capacidade de sobrevivência contribuindo para registrar e reconhecer o mundo subaquático ao seu redor, contribuindo para sua sobrevivência.

Palavras-chave: Condrictes; Neuromastos; Ampolas de Lorenzini.

TIBURÓN LIJA (*Ginglymostoma cirratum*) LÍNEA LATERAL: BREVE REVISÓN

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Resumen. El tiburón lija (*Ginglymostoma cirratum*) también conocido como tiburón nodriza o lambaru, y se encuentra la mayoría de las veces, reunidos en grupos de diferentes tamaños. Habitan el fondo marino en aguas costeras y cálidas. El sistema nervioso de estos tiburones surge embriológicamente de la placa medular, y en esto está la estructura llamada cerebro, que se divide en tres partes, llamadas cerebro anterior, cerebro medio y rombencéfalo. Estos tiburones tienen sensores de precisión muy sensibles, que son los mecanorreceptores y electrorreceptores, que les dan una gran capacidad de supervivencia que contribuye a registrar y reconocer el mundo submarino que los rodea, lo que contribuye a su supervivencia.

Palabras clave: Condrictes; Neuromastas; Ampollas Lorenzini.

INTRODUCTION

The nurse shark *Ginglymostoma cirratum* (Bonnaterre, 1788) is also known as “tubarão lixa” or “lambaru” in Portuguese language. It belongs to the chordate subclass Elasmobranchii, order Orectolobiformes, family Ginglymostomatidae (FIGUEIREDO, 1977).

This animal may attain a length of 4 m and weight up to 500 kg. It is an oviparous species, in which the female may lay up to 30 eggs. Saville et al. (2002), using DNA methods, studied cases of multiple paternity in juveniles of this species, indicating that this reproductive tactic represents a way to guarantee genetic variability of the nurse shark, when one considers that their migratory movements are relatively restricted. Sexual dimorphism is observed, females ataining the largest sizes (1-3 m), relative to males (2.2-2,57 m) (FURTADO et al., 2018).

The mouth contains small and sharp teeth, similar on both dental arcades. Matott, Motta, and Hueter (2005) found that, although there is some specialization of the buccal apparatus, the nurse shark does not have a specialized diet. The snout is short and flat, with branchial folds on the posterior surface of the pectoral fins. Fins are rounded, the posterior dorsal fin being larger than the second fin. During the daytime the animals are less active and remain stationed on the sand bottom or within available caves. They become very active at night. They present the curious habit of piling themselves one over the other, forming clusters of up to 30 individuals. Their mean life span is estimated at round 25 years (FURTADO et al., 2018; MOTTA et al., 2002).

Nurse sharks are found mostly reunited into groups. Although they are not eminently dangerous for humans, a safety distance should be observed when approaching them. They remain immobile for hours during the day (CARVALHO, 1992; FERREIRA, 2015). Their feeding items include bottom fishes, shrimp, squids, octopuses, crabs, and lobsters, among

others. They have a structure popularly called a goatee, that helps locating prey mostly during the night (FURTADO et al., 2018).

Nurse sharks live in warm littoral waters, in depths of up to 60 m. They range from Brazil to North America and to Africa. They are also found along the West coast of the Americas, from Ecuador to the Gulf of California (CASTRO, 2000; COMPAGNO, 1984). Nurse sharks have sense organs that make them well adapted to prey species sharing the habitats in which they live. This special character instigates research directed to understand their structure and function (FURTADO et al., 2018).

CENTRAL NERVOUS SYSTEM

The nervous system of sharks appears embryologically from the medullary plate, which is formed from the neural tube. Here is located the cephalon, that is divided into three parts, the prosencephalon, mesencephalon, and rhombencephalon. All three belong to and help to conserve the central nervous system (YOPAK et al., 2007).

The prosencephalon concentrates olfactive and visual functions. The mesencephalon coordinates the nervous system in general, and the rhombencephalon coordinates the muscles and the control centers for respiration, cardiac action and metabolism. Leaving the cephalon are two cranial nerves that connect to the sensory organs. Chondrichthyans (cartilaginous fishes, such as sharks) have well developed sensory organs (YOPAK et al., 2007).

The sensory organs provide sharks with a great ability to locate their prey. The nerves also connect to the muscles, especially those that attach to the head of the animal, the cephalon is connected to the spinal cord, from which several nerves (the spinal nerves) project to reach all body parts. The cephalon and the spinal cord form the Central Nervous System (CNS), while the nerves and ganglia form the Peripheric Nervous System (PNS). The system becomes highly specialized, representing an important evolutionary trait of sharks (BROWN, 2003; LISNEY, 2010).

Chondrichthyes also present a lateral line, which is a set of channels filled with water that have sensory cells, which function to detect variations in water pressure, water vibrations, and the movement of other fishes. These mechanoreceptors of the lateral line are able to perceive pressure and touch (TRICAS; CARLSON, 2012).

The system is formed by neuromasts (specialized receptor organs) (Fig. 1), that are located within the tubes connected by pores, that rum from the head to the lateral sides of the shark (FIELDS; FIELDS; FIELDS, 2007; TRICAS; CARLSON, 2012).

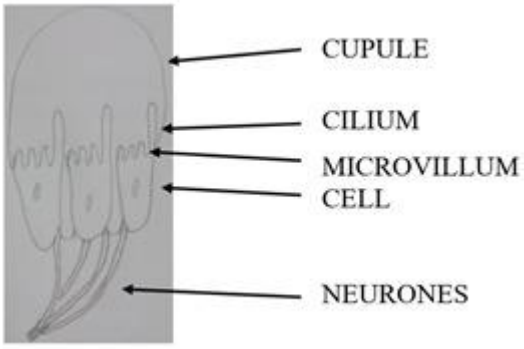


Figure 1. Scheme of a neuromast. Source: By authors.

The ampullae of Lorenzini are observed in the snout of the shark (Fig. 2). These are located in canals filled with water, having sensitive cells (that are electro-receptive). These cells are capable of detecting electrical currents in other living beings. The ampullae of Lorenzini, located in the head of the shark, are used to find prey that is buried in the sand (by way of the perception of very slight electrical currents) (FIELDS; FIELDS; FIELDS , 2007; TRICAS; CARLSON, 2012).

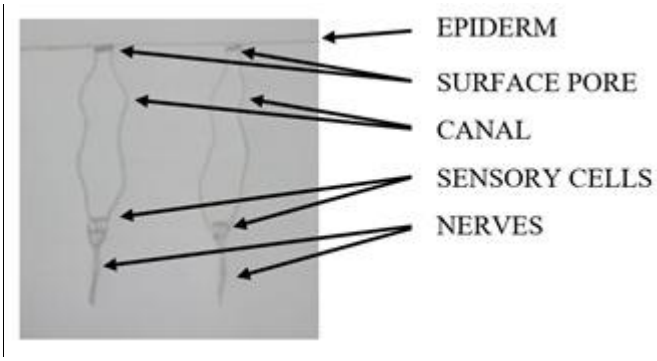


Figure 2. Scheme of an ampulla of Lorenzini. Source: By the authors.

The mechanoreceptor (lateral line) is a sensory organ that detects vibrations of the prey or of any other organisms present in the range of perception of the shark. This sensory system is located on both sides of the shark, aiding in the detection of vibratory movements of the surrounding water. It thus helps the shark to avoid bumping into obstacles, aids in its orientation regarding marine currents, and represents a means for the shark to locate its prey (MEYER; HOLLAND; PAPASTAMATIOU, 2005).

Each neuromast is formed by a group of ciliated cells that are surrounded by a prominent cupule. The ciliated cells and the cupules of the neuromasts are usually visibly located below

the surface orifice of the lateral line. Additional neuromasts may appear on several other places along the surface of the body of the shark (TRICAS; CARLSON, 2012).

Sharks have well developed sensory organs that are fundamental for an oceanic predator. They permit the finding of prey placed at considerable distance or in hiding. Along the millennia the shark has been able to perfect this sensory system of great biological significance, resulting in the efficient shark that has survived up to our days (TRICAS; CARLSON, 2012).

CONCLUSIONS

The nurse shark *Ginglymostoma cirratum* has sensory organs of great precision. Its mechanoreceptors and electroreceptors are formed by specialized ampullae located in lateral water channels located along the sides of the animal. They are filled by a gelatinous substance and end in surface pores on the epidermis that communicate with the surrounding water. The several functions of this system have been described in the literature (FIELDS; FIELDS; FIELDS, 2007. In this review we emphasize the pressure sensors (MURRAY, 1957) and those specialized in detecting electrical fields (KALMIJN, 1982). The shark uses its senses to record and to explore the surrounding subaquatic environment, resulting in a highly efficient predator, and contributing to its long-term survival.

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