Structural features and lamellar mechanoreceptors of the collared peccary's tongue (*Pecari tajacu, Linnaeus 1758*)

[*Aspectos estruturais e mecanorreceptores lamelares da língua do cateto (Pecari tajacu, Linnaeus 1758)*]

"Artigo Científico/Scientific Article"

Tiago da Silva **Teófilo**[1]*, Mychel Raony Paiva Teixeira de **Morais**[2], Maurina Lima **Porto**[1], Diogo Manoel Lopes de Paiva **Cavalcanti**[1], Anaemília das Neves **Diniz**[3], José Domingues **Fontenele-Neto**[1]

[1]Centro de Ciências Biológicas e da Saúde, Universidade Federal Rural do Semi-Árido (UFERSA), Mossoró-RN, Brazil.
[2]Instituto de Ciências Biomédicas, Universidade de São Paulo (USP), São Paulo-SP, Brazil.
[3]Universidade Federal de Alagoas (UFAL), Viçosa-AL, Brazil.
*Autor para correspondência/Corresponding author: E-mail: tiagoteo@hotmail.com

Abstract
Collared peccaries are omnivorous mammalians well known for presenting a prominent skin gland, known as scent gland. We've previously described the histological organization of the palate and lip of this peccary and found several small and large lamellar corpuscles (Vater-Pacini corpuscle) mostly grouped in small aggregates distributed along its lamina propria-submucosa. Here, we described the anatomic structure and histological organization of the tongue of the collared peccary by means of light microscopy. The main features were the presence of a prominent rostral anterior salivary gland and the widespread presence of lamellar corpuscles that could contribute to the tactile function of the tongue.

Keywords: Vater-Pacini corpuscle; oral cavity; suids.

Resumo
Os catetos são mamíferos onívoros bem conhecidos por apresentarem uma glândula proeminente da pele, conhecida como glândula odorífera. Anteriormente, descrevemos a organização histológica do palato e lábio desse pecari e encontramos vários mecanorreceptores lamelares pequenos e grandes (corpúsculo de Vater-Pacini), principalmente agrupados em pequenos agregados distribuídos ao longo de sua lâmina própria-submucosa. Aqui, descrevemos a estrutura anatômica e a organização histológica da língua do cateto por meio da microscopia óptica. As principais características foram a presença de uma proeminente glândula salivar rostral e a presença generalizada de corpúsculos lamelares que poderiam contribuir para a função tátil da língua.

Palavras-chave: corpúsculo de Vater-Pacini; cavidade oral; suídeos.

Introduction

The feeding strategies are vital for adaptation success of a species to an environment and the tongue is essential to this (Iwasaki, 2002). The tongue is the largest structure in the oral cavity and it is important during food apprehension, chew and deglutition. In mammals and several terrestrial vertebrates it is a bulk mass of intertwined skeletal muscle covered by a mucosa. In mammals its dorsal part shows variable degree of keratinization and bears numerous macroscopic lingual papillae. Those papillae are different in shape and are named according to their morphological characteristics they serve either as mechanical or as gustatory function (Dellmann and Eurell, 1998).

Studies based on comparative morphology of the vertebrate's tongues have shown that variations in the morphology and function of the organ might be related to evolutionary events that represent adaptation to the current environment or to texture of the food (Iwasaki, 2002). In the oral cavity is common the presence of mechanoreceptors in the mucosa. The lamellate

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corpuscles are surrounded by several layers of superimposed flattened capsular cell processes. They are elongated or globular in shape, being located in the connective tissue papillae. The capsule is composed of several layers of cytoplasmic extensions of perineural cells. Numerous bundles of collagen fibers are noted at the periphery of the corpuscle. The terminal axon contains an abundance of mitochondria and small clear vesicles. There are neurofilaments in the center of the axon terminal. The free nerve endings are found in the subepithelial regions, very close to the basal laminae of mucosal epithelium. They are surrounded by a thin cytoplasm of Schwann cells (Watanabe, 2004).

Peccaries are New-World artiodactyls mammals represented by three extant species: the collared (*Pecari tajacu*, Linnaeus 1758), the white-lipped (*Tayassu pecari*, Link 1795), and the Chacoan peccary (*Catagonus wagneri*, Rusconi 1930) (Sowls, 1984; Groves and Grub, 1993). Collared peccary also known as cateto or caititu, in Brazil, can be found from Argentina to the southwest of the United States, they are capable to survive a wide great variety of environments from wet tropical forests to semi-arid areas (Hellgren et al., 1995; Gongora et al., 2011). The collared peccary is an omnivorous animal and its diet includes fibrous material, vegetables, fruits, small vertebrates and insects (Robinson and Redford, 1991). Peccaries have an elaborate forestomach that ferments their diet such as fruits, leaves, stems, roots and flowers, and they differ from the other suids in the digestive anatomy (Schwarm et al., 2010).

Previous studies conducted by Teófilo et al. (2007) on the histological organization of the lip of these species showed that it is lined by skin on the outer surface with appendages such as hair follicles (simple and tactile) sweat glands and lined by a mucosa on the inner surface. Lamellar corpuscles are frequently found deep in the connective tissue. The collared peccary's lip, therefore, is not only used for food apprehension, but also functions as sensitive structure providing a tactile input to the central nervous system. In another study, Teófilo et al. (2014) also verified the presence of these receptors on the palate of this species therefore prompted us to study the morphology of the tongue and to compare it with that observed in other mammals, aiming of providing a description of tongue and their sensory receptors.

Materials and Methods

Collared peccaries were kept in semi-intensive system in the Wild Animal's Multiplication Center (CEMAS) from Semi-Arid Federal University (UFERSA), Mossoró city, RN, Brazil, authorized by Brazilian Institute of Environment and Renewable Natural Resources (IBAMA, protocol #1478912). Collared peccaries were euthanized according to ethical principles in animal investigation (protocol #26/2013).

For the present study, the tongues of six adult (2.5 years old) males, weighing 17-20kg, were dissected. They were photographed, the fungiform papilla were accounted (± SD). A sagittal section was made, then the halves were further divided in three parts and fixed by immersion in 3.7% buffered formaldehyde in a pH 7.4, 0.1M sodium phosphate, for 18h at 4ºC. The fragments were then dehydrated through graded ethanol series defatted in xylene and embedded in paraffin. Paraffin chucks were trimmed and sectioned in a rotating microtome (5-8 μm thick). The sections were placed on a Meyer's albumin coated glass slides and finally, we performed hematoxylin-eosin staining. The analysis was made using a photomicroscope (Olympus CX51, Olympus Optical Co., Japan).

Results

The collared peccary's tongue is a muscular organ of approximately 13 ± 0.5cm of length (Figure 1A) it presents a round apex (rostral area), a body (medium area) and a root (caudal area). In the dorsal surface the observed papillae are of three types: filiform, fungiform, and vallate (Figure 1A).

In the rostral portion of the tongue together with the striated musculature there is an accumulation of a brown glandular tissue with approximately 4.0 ± 0.3cm of length and 2.2± 0.1cm of width was found. This structure is characterized as rostral lingual gland (Figure 1B).

The tongue is covered by a parakeratinized stratified squamous epithelium that rests on a lamina propria formed by a loose connective tissue (Figure 2 A and B). Several filiform papillae project from epithelium and give the tongue rough sensation to the touch the ventral surface lacks those projections and is therefore is smooth (Figure 2A).The filiform papillae are found throughout the dorsal part, the fungiform papillae were also found in different regions, however they were found abundant in the rostral portion, there were in average 574 ± 11 papillae per tongue, two vallate

papillae were found at the base of the tongue (Figure 1A).

The muscular layer is formed by intertwined skeletal muscle fibers and distributed in three different axes (Figure 2A and C). Small serous salivary glands can be found among the muscular fibers (Figure 2C) and also accumulations of adipose tissue.

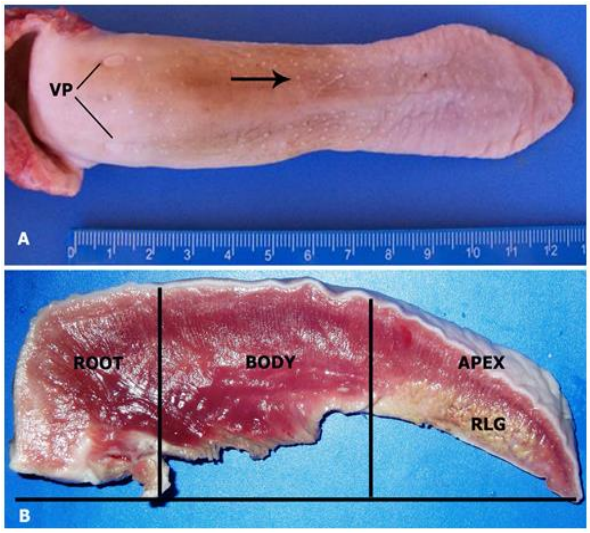

Figure 1. Photography of collared peccary tongue. On **A**, a dorsal view of the tongue, note two vallate papillae (VP) and several fungiform papillae (arrow). On **B**, a sagittal section of the tongue. Observe at the apex a prominent rostral lingual gland (RLG).

Both myelinated and unmyelinated nerves were found as well as parasympathetic ganglia (Figure 2C) and mechanoreceptors. In some regions, the sensory nerves fibers formed a dense and complex network of fine fibrils.

The mechanoreceptors found in the tongue of the collared peccary are lamellar corpuscles (Figure 3). The lamellar corpuscles are large layered onion-like form with a central nerve ending.

Lamellar corpuscles were found throughout the tongue. They were located either buried deep among the muscle or salivary glands or more superficial closer to the epithelium. The corpuscles found in the rostral portion are usually found among muscular cells and are small (75-90 μm in diameter in average) having around 10-13 lamellae surrounding the axon terminal whereas those found at the body and root of the tongue are large (260-280μm in diameter in average). Interestingly lamellate corpuscles were found isolated of arranged in groups (up to four per group).

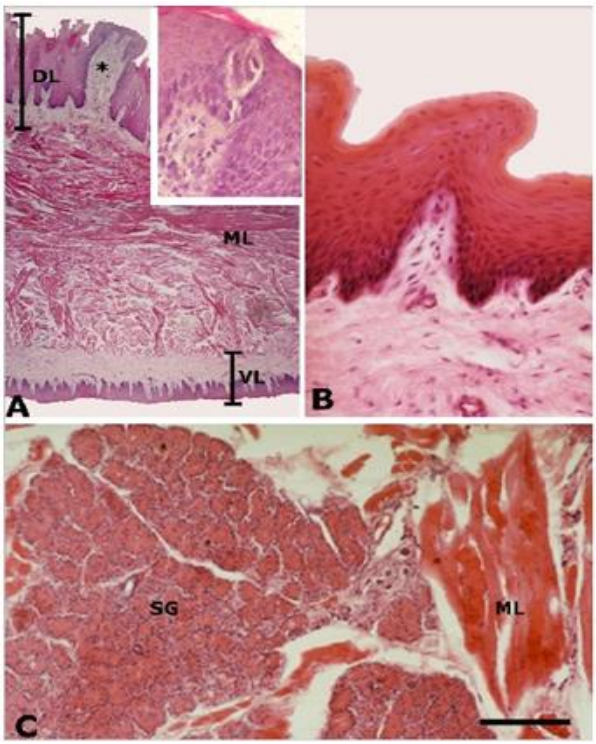

Figure 2. On A, photomicrograph of cross section of the apex of the tongue. The dorsal layer (DL) it is covered by a thick stratified squamous epithelium that rests on a layer of dense connective tissue. The DL shows filiform and fungiform papillae (*). The epithelial layer of the apical portion of the fungiform papillae reveal taste buds (inset). The muscular layer (ML), that is the axis of the tongue, is formed by bundles of skeletal muscle in several directions. The ventral layer (VL) is also lined by a stratified squamous epithelium and is devoid of papillae that renders a smooth appearance. On B note the parakeratinized epithelium that lies on its the lamina propria. On C, rostral lingual gland, which is characterized as a serous gland (SG), and the ML. Scale bar: A 200μm, inset 20μm, B 20μm, C 80μm.

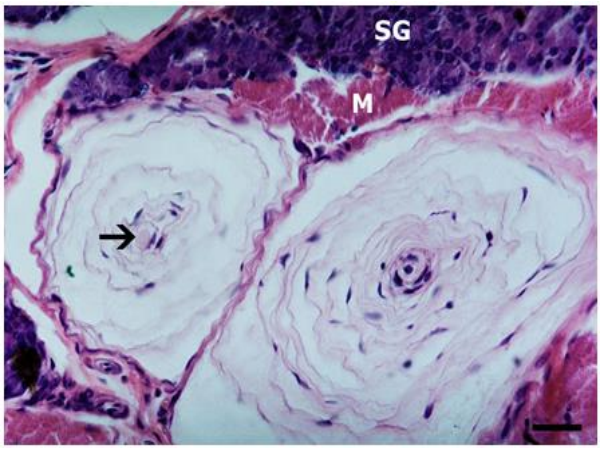

Figure 3. Photomicrograph of lamellar corpuscles at the root of the tongue. It is common to find receptors among muscle bundles (M) and small salivary glands (SG). Observe layers of connective tissue surrounding the axon (arrow). Those receptors located deeper in the tongue are usually larger than those located more superficially. Scale bar: 20μm.

Discussion

The collared peccary's tongue has a morphology similar to other mammals. However, some peculiarities are noted. The absence of foliate papillae in the collared peccary's tongue differs from what is found in wild boars and pigs (Chamorro et al., 1994). In the most species a caudal lingual gland rather than rostral gland is found.

The distribution of the filiform and fungiform papillae is like to describe in the tongue of the black rhinoceros (Emura et al., 2000) and of the white-lipped peccary (Watanabe et al., 2009).

The skeletal muscle fibers of muscular layer distributed in different axes allowing a higher degree of movements (Fawcett, 1994).

Watanabe et al. (2011), studying the presence of lingual papillae and the nerve endings in the middle region of the tongue mucosa of collared peccary, observed that the sensory nerve endings, were usually non-encapsulated and extended into the connective tissue of the filiform and fungiform papillae very close to the epithelial cells. According to these authors, the presence of these nerve fibrils may characterize the mechanisms of transmission of sensitive impulses to the tongue mucosa.

Organized corpuscles such as the lamellate nerve endings are observed in the subepithelial spaces very close to the epithelial cells in the tongue of white-lipped peccary (Watanabe et al., 2009). The connective layers of lamellar corpuscles work as a series of mechanical filters to protect the receptor that is extremely sensitive (Johnson, 2001).

Lamellate corpuscles appear in all classes of vertebrates, except fish. The architecture of these receptors differs between the animal classes, but its general lamellar structure is maintained. The layers of lamellas of connective tissue are either apposed or separated as we can found in snakes (Nishida et al., 2000). Several lamellate mechanoreceptors can be found in the lip, gingiva, cheek, tongue, soft and hard palate mucosa in mammals (Halata et al., 1999; Watanabe, 2004; Teófilo et al., 2007; Teófilo et al., 2014). The tongue of the *Cynamolgus* monkey exhibits several proprioceptors including tendon ending, corpuscles of Ruffini, corpuscle of Vater-Pacini, pacciniforms (Fitzgerald and Sachithanandan, 1979) interestingly lamellar corpuscle are absent in human tongue (Trulsson and Essick, 1997). Lamellar corpuscle close to salivary glands may influence the discharge of saliva acting as pressure receptors as being proposed for the control of the scent gland in collared peccary (Epling, 1956); another possible role for those receptors is to allow the tongue probing the food texture (Teófilo et al., 2007).

These data suggest that the tongue has an important and essential tactile function and the food intake may consider not only the flavor but also the texture of it, the information gathered by mechanoreceptors is fundamental also for correct orofacial and chewing behavior.

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Conflict of interests

Authors declare no conflict of interests.

Ethics Committee

The research project was approved by the Ethics Committee of the Federal Rural Semi-Arid the number 26/2013 (CEUA-UFERSA).

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