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The Macro and Micro-Structure of the Celiac and Cranial Mesenteric Ganglia in a Long-Lived Rodent – Paca (*Cuniculus paca*, Linnaeus 1766)

La Macro y Micro Estructura de los Ganglios Mesentéricos Celíacos y Craneales en un Roedor Longevo – Paca (C*uniculus paca*, linnaeus 1766)

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SUMMARY: The celiac, cranial mesenteric and celiacomesenteric ganglia of the paca (*Cuniculus paca*) were found between the celiac and cranial mesenteric arteries. Two predominant patterns were found: isolated celiac and cranial mesenteric ganglion and the celiacomesenteric ganglion. At the microscopic level, the ganglia are constituted by an agglomeration of neurons surrounded by capsule of connective tissue. Most of these neurons had a single eccentric nucleus. Satellite cells and mast cells were found around the soma. The mast cells were also found ar ound blood vessels and in the capsule of the ganglia.

KEYWORDS: Anatomy, Celiac plexus, Histology, Sympathetic ganglia.

INTRODUCTION

The paca (*Cuniculus paca*, Linnaeus 1766) is a large rodent, belonging to the Hystricomorpha suborder. It feeds on fruit and in some cases also vegetables and insects (Matamoros, 1981; Dubost & Henry, 2006). It has the average lifespan around 16 years. This rodent is found in Brazil and also in Latin America (Redford & Eisenberg, 1999; Lange & Schmidt, 2007; Queirolo *et al*., 2008).

The autonomic nervous system (ANS), belonging, in part, to the peripheral nervous system, is an extensive array of nerves and ganglia connected to the central nervous system (Gabella, 1995). The abdominal plexus can be organized in different arrangements; celiac ganglia and cranial mesenteric ganglia or fused as celiacomesenteric ganglia (Ribeiro *et al*., 2000a,b; Sasahara *et al*., 2003).

The celiac and cranial mesenteric ganglia provide the main innervation of the stomach, intestines, liver, pancreas and also contributes to innervation of the spleen. This innervation is essential to the control of gastrointestinal motility (Ribeiro *et al*., 2000b).

Due to the importance of these ganglia to the innervation and function of the digestive organs and to support comparative studies of the nervous system this study aimed to describe the morphology of the celiac, cranial mesenteric and celiacomesenteric ganglia of the paca (*Cuniculus paca*).

MATERIAL AND METHOD

Eight adult male and female pacas (*Cuniculus paca*) weighing between 5 to 10 kg were used. The animals were obtained from the Wild Animals Sector of the University of the State of São Paulo, Jaboticabal-SP, Brazil which is registered with the Brazilian Institute of Environment and Natural Resources Renewables - IBAMA, as a breeding for specimens of the Brazilian fauna for scientific purposes (registration register - 482508). The experiment was approved by the Animal Use Ethics Committee of the University of the State of São Paulo (FCAV- UNESP) under number: 5898/16.

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For euthanasia, the animals were first sedated with meperidine (3 mg/kg) associated with midazolam (1mg/kg) intramuscularly and then anesthetized with ketamine (25 mg/kg) and xylazine (0.5 mg/kg) followed by intracardiac injection of potassium chloride 19.1 %, dose-effect, until the cardiorespiratory arrest. The animals were fixed with paraformaldehyde 10 % in sodium phosphate buffer (PBS) by ascending aorta. Red stained latex was injected via the common carotid artery in one animal. This animal was kept in a freezer for one day for complete polymerization of the latex.

Following the fixation, the abdominal cavity was opened by umbilical pre-retro incision to exposure the celiac and cranial mesenteric ganglia. The ganglia were dissected, photographed and removed for the histology. The samples were included in paraplast and five micrometer sections were collected on slides and stained with toluidine blue and hematoxylin-eosin. The images of the sections were acquired in microscope Leica DM 5000B.

RESULTS

The celiac, mesenteric and the occasionally fused celiacomesenteric ganglia of the paca were found in the abdominal cavity, in right and left antimeres and between the celiac and the cranial mesenteric arteries, which are branches of the abdominal aorta. The celiac ganglion was the one closest to the celiac artery and the cranial mesenteric ganglion, the one closest to the cranial mesenteric artery. The ganglion was called celiacomesenteric when there was an observed fusion of the two ganglia. Two formations were observed (i) isolated celiac and cranial mesenteric ganglia and (ii) a fusion of the two, called the celiacomesenteric ganglia. This fusion was found in the right antimere in only one animal. In the celiac ganglion as in the celiac mesenteric ganglion a cranial portion was observed on the celiac artery. This portion was visible in both antimeres. The ganglion surrounded the celiac artery and emitted branches that connected to the right and left cranial mesenteric ganglia. The cranial mesenteric ganglia, of both antimeres, presented an elongated, rectangular shape and emitted fiber ventrally and under the cranial mesenteric artery. The celiac-mesenteric ganglion presented an elongated shape and located on the celiac artery, projecting under the cranial mesenteric artery (Fig. 1). In the histology, the celiac and mesenteric cranial ganglia were formed by a cluster of neurons surrounded by a connective tissue capsule. Most of these neurons had a single eccentric nucleus. Binucleate neurons were also observed. Around the soma were seen satellite cells (Fig. 2). In the sections stained with toluidine blue mast cells were found in the capsule and inside the celiac and cranial mesenteric ganglia. Mast cells were also found around blood vessels (Fig. 3).

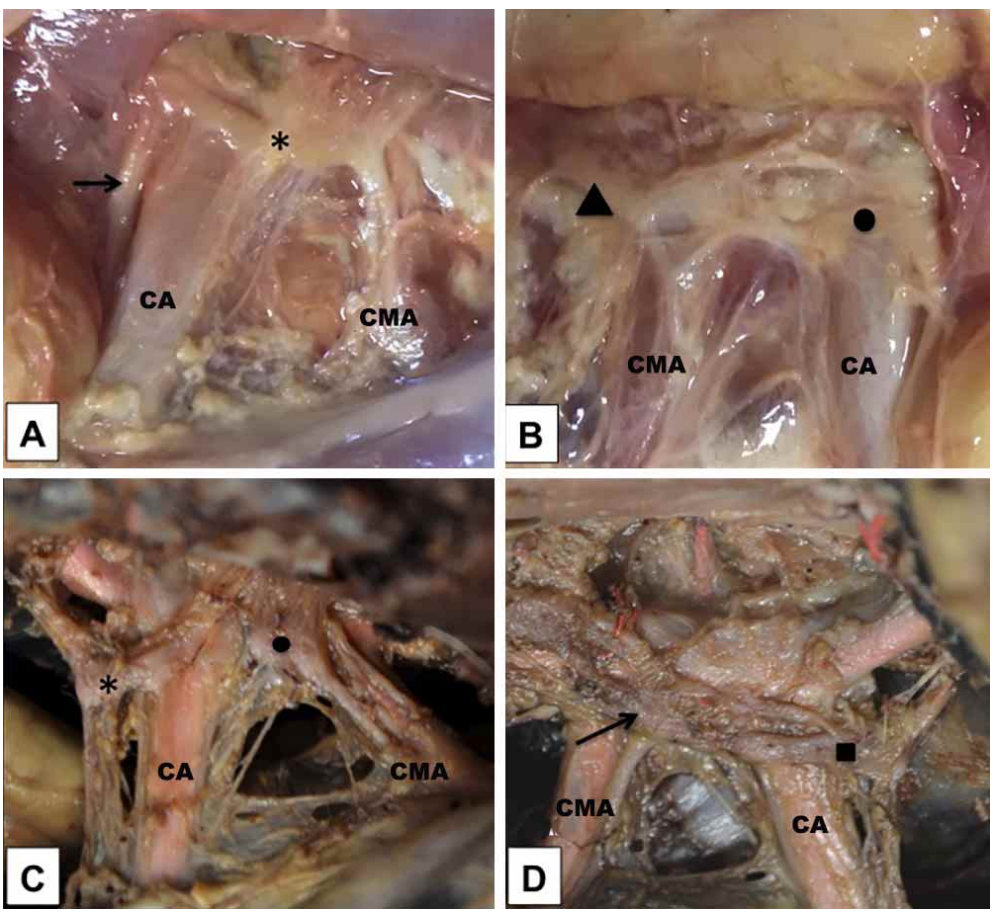

Fig. 1. The celiac, cranial mesenteric and celiacomesenteric ganglia of the paca. Right antimere of paca (A), with cranial portion of the left celiac ganglion (à) and celiacomesenteric ganglion (*). Left antimere of paca (B), with cranial mesenteric ganglion (s) and celiac ganglion (l). Right antimere of paca (C), with celiac ganglion (*) and cranial mesenteric ganglion (l). The left antimere of paca (D), with cranial mesenteric ganglion (à) and celiac ganglion (n). CA: Celiac artery and CMA: Cranial mesenteric artery.

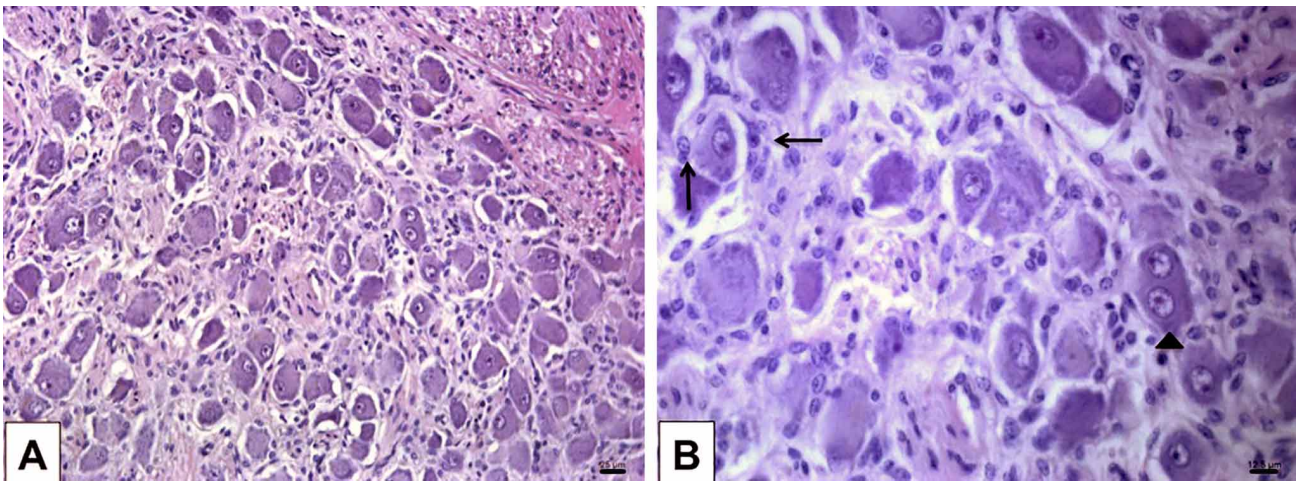

Fig. 2. The celiac and cranial mesenteric ganglia of the paca. Cluster of neuron bodies; single and eccentric nucleus (A). Neuron body with satellite cells (arrows). Binucleated neuron (s) (B). Scale bar: 25mm (A), 125mm (B). H&E.

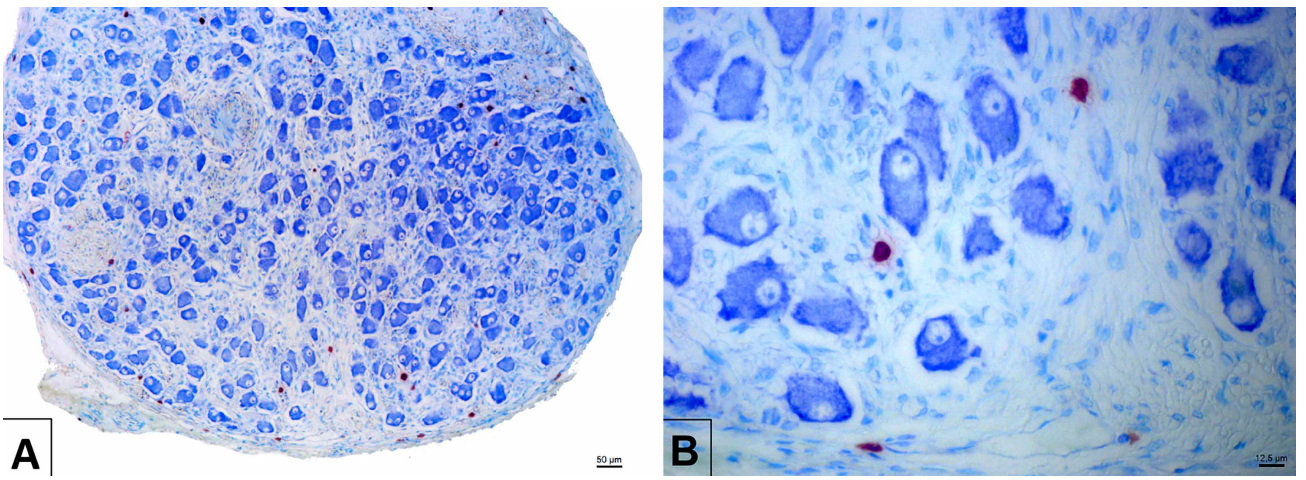

Fig. 3. The celiac and cranial mesenteric ganglia of the paca. Agglomerate of neuron bodies with single and eccentric nucleus. Mast cells distributed in the celiacomesenteric ganglion (A). Mast cells (purple) (B). Bar scale: 25mm (A), 12.5mm (B). Toluidine blue.

DISCUSSION

Two predominant patterns were seen in pacas: celiac and cranial mesenteric ganglion and the celiacomesenteric ganglion, as observed in cats and in rabbits (Ribeiro *et al*., 2000b; Sasahara *et al*.). The paca celiac ganglion presented elongated shape as observed in Sauim (Saguinus niger), a neotropical primate (Pinto *et al*., 2013).In humans, several shapes were observed as laminar, nodular and sickle. In cats the shape also varies between rectangular, elliptic, irregular and piriformis and in rats the format is pear shape (Hamer & Santer, 1981; Ribeiro *et al*., 2000b). The cranial mesenteric ganglia presented the elongated and rectangular shape similar to cats (Ribeiro *et al*., 2000b), however, they also presented the elliptical and piriform shape in some animals, whereas in the rat the shape is spindle (Pastelín *et al*., 2017). In rabbits, the rectangular shape was also reported, but the triangular shape was more frequent (Sasahara *et al*.). Related to the celiacomesenteric ganglion, the shape was elongated in pacas and semilunar in cats (Ribeiro *et al*., 2000b). These neurons had, majority, eccentric nucleus, as it was described in the cats and in dogs. The paca and the rabbit, we found binucleated neurons (Ribeiro *et al*., 2000b, 2002; Sasahara *et al*.).

Mast cells were also found in paca as well described in dog ganglia (Ribeiro *et al*., 2002).The mast cells in paca were present around the neurons, vasculature and in the capsule of the ganglion. The same was reported in pigs by Vodenicharov (2008). This same author suggests that mast cells in the autonomic nervous system are involved in the

secretion of biologically active substances such as histamine, dopamine and intestinal vasoactive polypeptide.

Mast cell secretion of substances has also been described by Leon *et al*., (1994). These authors hypothesize that mast cells are able to synthesize nerve growth factor when there is post-injury mast cell activation or inflammation.

In conclusion, paca presented two arrangements; celiac and mesenteric cranial ganglia isolated and the fusion of these two, the celiacomesenteric ganglion, as in the cat and the rabbit. At the microscopic level, it is formed by agglomeration of bodies of neurons surrounded by connective tissue capsule. It presents binucleate nuclei as rabbits and mast cells as in swine and dogs.

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RESUMEN: Los ganglios celíacos, mesentérico-craneales y celíaco mesentéricos de la paca (*Cuniculus paca*) se encontraron entre las arterias celíaca y mesentérica craneal. Se visalizaron dos patrones predominantes: celiaca aislada y ganglio mesentérico craneal y ganglio celiaco mesentérico. A nivel microscópico, los ganglios están constituidos por una aglomeración de neuronas rodeadas por una cápsula de tejido conectivo. La mayoría de estas neuronas tenían un solo núcleo excéntrico. Se encontraron células satélites y mastocitos alrededor del soma. Los mastocitos también se encontraron alrededor de los vasos sanguíneos y en la cápsula de los ganglios.

PALABRAS CLAVE: Anatomía; Plexo celíaco; Histología; Ganglios simpáticos.

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