SEVEN
publicações acadêmicas

SYSTEMATIZATION, DISTRIBUTION, AND TERRITORIES OF THE MIDDLE CEREBRAL ARTERY ON THE SURFACE OF THE BRAIN IN NUTRIA (MYOCASTOR COYPUS)

SISTEMATIZAÇÃO, DISTRIBUIÇÃO E TERRITÓRIOS DA ARTÉRIA CEREBRAL MÉDIA NA SUPERFÍCIE DO CÉREBRO EM NUTRIA (MYOCASTOR COYPUS)

SISTEMATIZACIÓN, DISTRIBUCIÓN Y TERRITORIOS DE LA ARTERIA CEREBRAL MEDIA EN LA SUPERFICIE DEL CEREBRO DEL COYOTE (MYOCASTOR COYPUS)

https://doi.org/10.56238/sevened2025.037-050

Laura Ver Goltz[1], Guilherme Pereira Chiarello[2], Juliana Voll[3], Ana Cristina Pacheco de Araújo[4], Rui Campos[5]

ABSTRACT

The nutria (*Myocastor coypus*) is a semi-aquatic rodent, valued in the fur and meat industry. The aim of this study is to describe and systematize the middle cerebral artery on the surface of the brain in nutria, establishing a standard model and its main variations and territories in this species. The 30 animals were euthanized, the arterial system was washed and filled with colored latex and fixed in formaldehyde. Schematic drawings were made to elaborate the results. The brain was vascularized exclusively by the vertebrobasilar system. The terminal branches of the basilar artery gave rise to the rostral cerebellar, caudal cerebral, rostral choroidal, and middle cerebral arteries, and its terminal branch, the rostral cerebral artery. The middle cerebral artery was the last collateral branch emitted by the basilar artery, projecting laterally through the lateral fossa of the brain, giving off branches to the paleopallium of the region. Upon crossing the lateral rhinal sulcus, it formed one or two main axes that ascended to the convex surface of the cerebral hemisphere, giving off caudal and rostral convex hemispheric branches. In its initial course, within the lateral fossa of the brain, the middle cerebral artery emitted caudal and rostral central branches. The middle cerebral artery emitted convex hemispherical branches caudal and rostral to the convex surface of the cerebral hemisphere. The middle cerebral artery was the last collateral branch of the basilar artery as it passed through the optic tract, as in capybaras, ground squirrels, and chinchillas. The projection of the middle cerebral artery differed among rodent species, but its branching and territory were similar between nutria and chinchillas.

Keywords: Arterial Vascularization. Anatomy. Rodents. Encephalon. Brain.

[1] Professor. Universidade Federal do Rio Grande do Sul (UFRGS). E-mail: laura.goltz@ufrgs.br
Orcid: https://orcid.org/0000-0001-5972-1417 Lattes: http://lattes.cnpq.br/3639378385545865
[2] Professor. Universidade Federal do Rio Grande do Sul (UFRGS). E-mail: guilherme.chiarello@ufrgs.br
Orcid: https://orcid.org/0000-0002-1828-1272 Lattes: http://lattes.cnpq.br/9517968025126533
[3] Professor. Universidade Federal do Rio Grande do Sul (UFRGS). E-mail: juliana.voll@hotmail.com
Lattes: http://lattes.cnpq.br/9805216216377960
[4] Professor. Universidade Federal do Rio Grande do Sul (UFRGS). E-mail: ana.cristina.araujo@ufrgs.br
Orcid: https://orcid.org/0000-0001-8940-0294 Lattes: http://lattes.cnpq.br/2599270947966957
[5] Professor. Universidade Federal do Rio Grande do Sul (UFRGS).
Lattes: http://lattes.cnpq.br/5142750759783852

RESUMO
A nutria (*Myocastor coypus*) é um roedor semi-aquático, apreciado na indústria de peles e carne. O objetivo deste trabalho é descrever e sistematizar a artéria cerebral média na superfície do cérebro em nutria, estabelecendo um modelo padrão e suas principais variações e territórios nesta espécie. Os 30 animais foram eutanasiados, o sistema arterial foi lavado e preenchido com látex colorido e fixados em formaldeído. Desenhos esquemáticos foram realizados para a elaboração dos resultados. O cérebro foi vascularizado exclusivamente pelo sistema vértebro-basilar. Os ramos terminais da artéria basilar originaram as artérias cerebelar rostral, cerebral caudal, corióidea rostral, cerebral média e seu ramo terminal, a artéria cerebral rostral. A artéria cerebral média foi o ultimo ramo colateral emitido pela artéria basilar e ela projetou-se lateralmente pelo interior da fossa lateral do cérebro, lançando ramos para o páleo-palio da região. Ao ultrapassar o sulco rinal lateral, formou um a dois eixos principais que ascendiam à face convexa do hemisfério cerebral, lançando ramos hemisféricos convexos caudais e rostrais. Em seu percurso inicial, no interior da fossa lateral do cérebro, a artéria cerebral média emitiu ramos centrais caudais e rostrais. A artéria cerebral média emitiu ramos hemisféricos convexos caudais e rostrais à face convexa do hemisfério cerebral. A artéria cerebral média foi o último ramo colateral da artéria basilar ao transpor o trato óptico, como em capivara, esquilo terrestre e chinchila. A projeção da artéria cerebral média foi diferente entre as espécies de roedores, porém sua ramificação e território foram semelhantes entre nutria e chinchila.

Palavras-chave: Vascularização Arterial. Anatomia. Roedores. Encéfalo. Cérebro.

RESUMEN
La nutria (*Myocastor coypus*) es un roedor semiacuático, apreciado en la industria peletera y cárnica. El objetivo de este trabajo es describir y sistematizar la arteria cerebral media en la superficie del cerebro de la nutria, estableciendo un modelo estándar y sus principales variaciones y territorios en esta especie. Los 30 animales fueron sacrificados, se lavó el sistema arterial, se rellenó con látex coloreado y se fijó en formaldehído. Se realizaron dibujos esquemáticos para la elaboración de los resultados. El cerebro estaba vascularizado exclusivamente por el sistema vertebrobasilar. Las ramas terminales de la arteria basilar dieron origen a las arterias cerebelosa rostral, cerebral caudal, coroidea rostral, cerebral media y su rama terminal, la arteria cerebral rostral. La arteria cerebral media fue la última rama colateral emitida por la arteria basilar y se proyectó lateralmente por el interior de la fosa lateral del cerebro, lanzando ramas hacia el paleopalium de la región. Al superar el surco lateral, formaba uno o dos ejes principales que ascendían a la cara convexa del hemisferio cerebral, lanzando ramas hemisféricas convexas caudales y rostrales. En su recorrido inicial, en el interior de la fosa lateral del cerebro, la arteria cerebral media emitía ramas centrales caudales y rostrales. En su recorrido inicial, dentro de la fosa lateral del cerebro, la arteria cerebral media emitió ramas centrales caudales y rostrales. La arteria cerebral media emitió ramas hemisféricas convexas caudales y rostrales a la cara convexa del hemisferio cerebral. La arteria cerebral media fue la última rama colateral de la arteria basilar al atravesar el tracto óptico, como en el capibara, la ardilla terrestre y la chinchilla. La proyección de la arteria cerebral media fue diferente entre las especies de roedores, pero su ramificación y territorio fueron similares entre la nutria y la chinchilla.

Palabras clave: Vascularización Arterial. Anatomía. Roedores. Encéfalo. Cerebro.

1 INTRODUCTION

The rodents belong to the order Rodentia and represent the most numerous group within the class Mammalia. The order Rodentia is subdivided into three suborders, the hystriomorphs, the myomorphs and the sciuromorphs. The suborder of the scyuromorphs is composed of seven families, among them the family Capromyidae, represented by a single genus, *Myocastor sp*. (Lacerca, 1990).

The nutria (*Myocastor coypus*) is a semi-aquatic rodent, known as the swamp rat (SILVA, 1994). It feeds on grass, roots and aquatic plants. Its skin is covered by long hairs of dark brown dorsally and light yellow ventrally, much appreciated by the fur industry (Baroffio; De Paoli; Fiordelisi, 1979).

According to Machado, Cal and Birck (2009), in southern Brazil, nutrias have been hunted by fish farmers, who argue that they have caused losses in their production caused by the habit of these rodents digging underground galleries on the banks of rivers, lakes and dams. These underground burrows serve as refuge and nest (Silva, 1994).

The first classic works on brain irrigation were carried out by Tandler (1898) and De Vriese (1905), bringing important considerations about the phylogenesis and ontogenesis of brain arterial models. De Vriese (1905) classified several animal groups according to the formation of the cerebral arterial circle into three distinct types. However, the classical treatises describe little or nothing about the brain irrigation of nutria.

To study the development of the rodents' brains, several authors who studied rodents were researched in the literature consulted. Jablonski and Brudnicki (1984) studied musk rats (*Ondatra zibethica*) and chinchillas (*Chinchilla lanigera*). Scremin (1995) described the cerebral vascular system of rats (*Mus rattus*). Majewska-Michalska (1995), Majewska-Michalska (1997) and Librizzi *et al*. (1999) studied guinea pigs. The capybara (*Hydrochoerus hydrochaeris*) was systematized by Reckziegel, Lindemann and Campos (2001), Reckziegel *et al*. (2002), Reckziegel *et al*. (2004a) and Reckziegel *et al*. (2004b). The arterial vascularization of the nutria brain was studied by Azambuja, Goltz and Campos (2018), Goltz (2017) and Goltz, Azambuja and Campos (2020). Araújo and Campos (2005), Araújo and Campos (2007), Araújo and Campos (2009), Araújo and Campos (2011) and Araújo and Campos (2020) described the arterial vascularization of the brain of chinchillas (*Chinchilla lanígera*). Esteves *et al*. (2013) investigated the arrangement and anatomical distribution of the cerebral arterial circle of rats (*Rattus norvegicus*). Silva *et al*. (2016) researched arterial vascularization at the base of the brain of agoutis (*Dasyprocta aguti*). The arterial vascularization of the artery at the base of the prey brain (*Galea spixii*) was studied by Costa *et al*. (2017). Szczurkowski *et al*. (2007) studied the cairo spiny rat (*Acomys cahirinus*). The cerebral arteries of the European beaver (*Castor fiber*, Linnaeus, 1758) were described by Frackowiak and Smielowski (1998). The cerebral arterial circle of the rooked rat (*Spalax leucodon*) (Aydin *et al*., 2008), the hedgehog (*Hystrix cristata*) (Aydin *et al*., 2005), the red squirrel (*Sciurus vulgaris*) (Aydin, 2008) and the ground squirrel (*Spermophilus citellus*) (Aydin *et al*., 2009) was reported.

Research on the functioning of the central nervous system has been intensified in recent years, but despite the growing economic interest (meat and skin), there are few reports on the anatomy and especially on the cerebral vascularization of the nutria, and based on this finding, this research was carried out. The hypothesis of this work is that the middle cerebral artery of nutria presents and distributes itself according to that of other rodents, and for this 30 nutria brains were analyzed, injected with colored latex and due to the lack of information about this species, both in the classical literature and in specialized articles, our results will be compared with those of other authors who have studied in rodents.

This study aims to expand the information in the area of morphological sciences, as well as to serve as a basis for future scientific studies in *Myocastor coypus*, to gather knowledge and discuss about the systematization, distribution and territories of the middle cerebral artery on the surface of the cerebral hemisphere in nutria, with the purpose of expanding the information in the area of comparative anatomy, providing resources for investigations pertinent to brain vascularization in rodents, establishing a standard model and determining its main variations in this species.

2 METHODOLOGY

For this study, 30 nutria brains (*Myocastor coypus*) were used. Of the total of these brains, 24 were already in the laboratory, as they were used for a master's thesis developed in 2006 at the Animal Anatomy Laboratory of the Veterinary School of the Federal University of Rio Grande do Sul (Azambuja, 2006). And it was necessary to acquire six more animals to replace the brains that presented problems with the technique used.

All 30 nutrias came from a commercial breeding facility authorized by IBAMA (Brazilian Institute of Environment and Renewable Natural Resources) located in the municipality of Caxias do Sul (environmental license n° 114/2014 SEMMA Caxias do Sul), in the state of Rio Grande do Sul. This project was approved by CEUA/UFRGS under number 29415.

Of the 24 brains used, there were 12 males and 12 females, adults and had weights ranging from 1.02 to 4.75 kilograms. These specimens provided for the experiment were considered by the breeder to be discarded animals because they presented dermatological problems, poor coat quality, abscesses (which made it impossible to use the skin), low efficiency or other reproductive problems. The six animals that were missing to complete the "n" of 30 were two males and four females, adults, weighing from 3.40 to 5.60 kilograms and were also animals considered discarded by the breeder.

During the transport of the nutrias, each one was placed separately in a transport box for domestic animals and went directly from the breeder's property in Caxias do Sul to the Animal Anatomy Laboratory of the Veterinary School of the Federal University of Rio Grande do Sul (Ministry of Science, Technology and Innovation, 2013).

The six new animals acquired, immediately upon arrival at the laboratory they were euthanized, without the need to perform previous food and water fasting. To perform euthanasia, first the animals were physically restrained, heparin was applied (Hepamax-s – Blausiegel Indústia e Comércio Ltda, Cotia, SP) 10000 U.I per animal, intraperitoneally, they were placed again in the transport boxes and after 30 minutes they were sedated with the association of the pre-anesthetic medications acepromazine (Acepran 1% – Vetnil Indústria e Comércio de Produtos Veterinários Ltda, Louveira, SP) 0.5 mg/kg and meperidine (Meperidine Hydrochloride – União Química, São Paulo, SP) 20 mg/kg, intramuscularly. After sedation, they were euthanized by overdose of sodium thiopental (Thiopentax – Cristália Produtos Químicos Farmacêuticos Ltda, Itapira, SP) at a dose of 120 mg/kg, intraperitoneally, which is three times higher than the normal dose of the medication. Sodium thiopental at 2.5% was mixed with lidocaine (Dorfin – Hertape Calier – Saúde Animal S.A, Juatuba, MG), at a concentration of 10 mg/ml to minimize pain during the application of the medication.

After confirmation of death (due to the absence of eyelid movements and heartbeat, perceived with the use of a stethoscope), the thoracic cavity was opened ventrally, the internal thoracic artery was then clamped near the xiphoid cartilage, as well as the aortic arch. The cardiac apex was sectioned and the aorta was cannulated via the left ventricle. The artery system was flushed with 150 ml, per animal, of 0.9% cooled saline solution (0.9% Sodium Chloride; Fresenius Kabi Brasil, Barueri / SP, Brazil), and filled with latex 603 (Latex Cola 603 – Bertoncini Ltda, São Paulo, SP) stained red with the specific dye (Suvinil Corante – BASF S.A, São Bernardo do Campo, SP). The animals remained submerged in running water for one hour to polymerize the latex. The skin was folded and a bony window was opened in the cranial vault. The specimens were then fixed in 20% formaldehyde for at least seven days and after this period, the brains, with a follow-up of the cervical spinal cord, were removed for subsequent dissection and observation of the arteries at the base of the brain. The brains had their dura mater removed and the arteries studied in the convex and medial surfaces of the cerebral hemispheres and the brainstem.

To record the results, schematic drawings of the ventral views, dorsal views, right lateral, left lateral, right medial and left medial views of the cerebral arteries of all preparations were performed. The schematic drawings were made with the aid of a magnifying glass (Magnifying glass with LTS lamp – 5X magnification and Stemi SV8 Zeiss microscope, Göetting, Germany) and some pieces were photographed for documentary record. To perform the statistical analysis of the results, a percentage calculation was applied, using a rule of three, considering that a total population of 30 nutrias is equivalent to 100 percent of the samples. The description of the cerebral arteries and their branches were named according to the Nomina Anatomica Veterinaria (2017).

3 RESULTS

The right and left internal carotid artery in nutria (*Myocastor coypus*) was atrophied in all cases, in both antimeres, and its terminal branch was found at the base of the skull before penetrating the foramen laceraus, not cooperating in the arterial vascularization of the brain.

The brain was supplied exclusively by the vertebrobasilar system. The vertebral artery was a collateral branch of the subclavian artery, ascended the neck through the transverse canal of the cervical vertebrae and when it reached the atlantal fossa it crossed the alar and lateral vertebral foramina of the Atlas, reaching the interior of the vertebral canal. Its terminal branch anastomosed with its contralateral counterpart, on the ventral surface of the medulla oblongata, forming a large-caliber basilar artery, when it penetrated through the foramen magnum.

The basilar artery, a rectilinear vessel of large caliber, when it traveled ventrally through the base of the hindbrain, launched pairs of caudal, middle and trigeminal cerebellar arteries, dividing into their terminal branches, which diverged latero-rostralally, at an angle of approximately 90°.

The terminal branches of the basilar artery gave rise to the caudal cerebellar, caudal cerebral, rostral chorioid, middle cerebral arteries and its terminal branch, the rostral cerebral artery (Figure 1).

The middle cerebral artery, a large-caliber vessel, was emitted from the right and left terminal branch of the basilar artery, which, upon crossing the optic tract, launched it laterally as its last collateral branch. The middle cerebral artery projected laterally through the interior of the lateral fossa of the brain, launching caudal and rostral central branches to the paleopallium of the region. And when it passed the lateral renal sulcus, it formed one to two main axes that ascended to the convex surface of the cerebral hemisphere, launching caudal and rostral convex hemispherical branches.

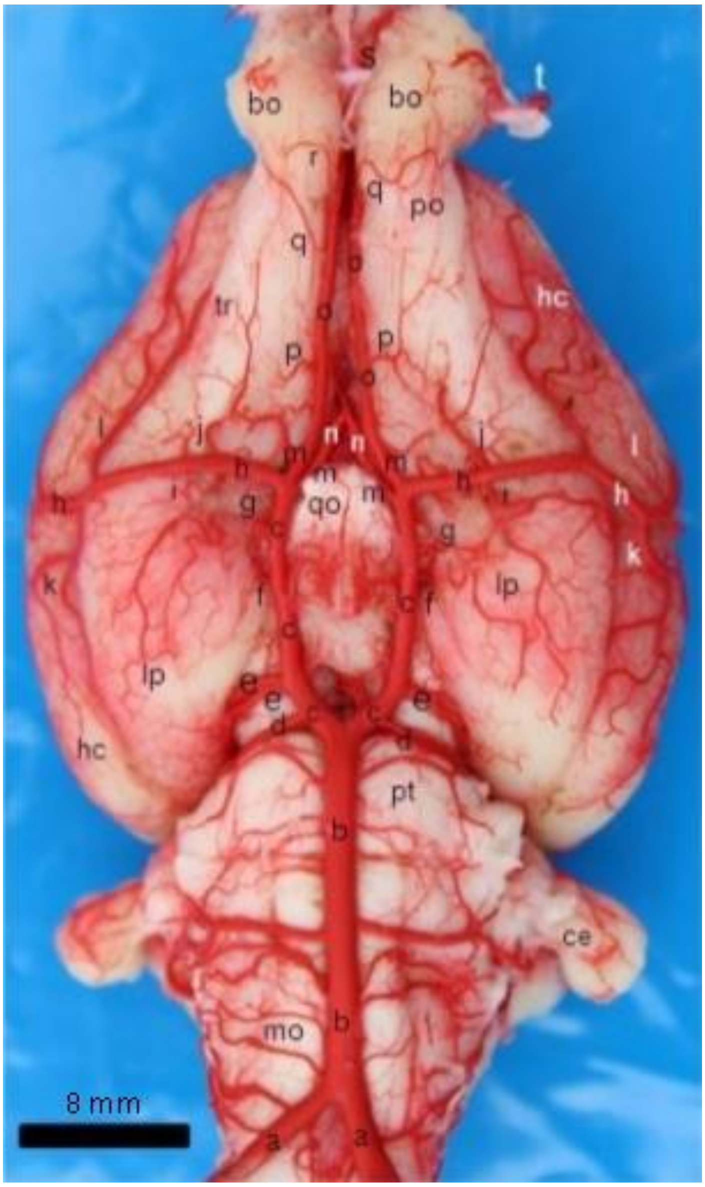
The main axis of the middle cerebral artery was normally directed to the convex aspect of the cerebral hemisphere, and its terminal branches reached the parietal lobe, anastomosing "in osculum" with the terminal branches of the rostral medial hemispheric arteries, branches of the rostral cerebral artery. The right and left middle cerebral artery, in 86.7% of the samples, had a single axis with cortical, hemispherical, convex, caudal and rostral branches, and in 13.3% it had a double axis. In only one observation, on the left side, the main axis of the middle cerebral artery presented an "island" formation at the level of the lateral renal sulcus.

In its initial course, inside the lateral fossa of the brain, the middle cerebral artery emitted two caudal central branches to the ventral surface of the piriform lobe, vascularizing its paleopallium only in a small rostrumolateral area (Figure 1). The right middle cerebral artery emitted two central caudal branches to the piriform lobe in 60% of the cases, in 26.7% three branches and in 13.3% one branch. While the left middle cerebral artery originated two caudal central branches in 56.7%, one branch in 26.7% and three branches in 16.7%. In an observation that the caudal central branch of the left middle cerebral artery was unique, the caudal central branch was launched from the first caudal convex hemispheric branch, very well developed, which originated very close to the origin of the middle cerebral artery, going to the caudal neopallium of the cerebral hemisphere.

Also in its initial course within the lateral fossa of the brain, before passing through the lateral rhinal sulcus, the middle cerebral artery (Figure 1) emitted central rostral branches to the paleopallium of the lateral fossa of the brain and part of the olfactory trigone and the lateral olfactory tract. Some of these vessels emitted perforating branches into the striatum.

Figure 1

Detailed photograph (Obs.18) of the ventral view of the nutria brain without pituitary gland, highlighting the origin and distribution of the middle cerebral artery



The image shows: a – vertebral artery; b – basilar artery; C – terminal branch of B; d – caudal cerebellar artery; e – caudal cerebral artery; f – rostal chorioid artery; g – central branch of c; h – middle cerebral artery; I – central caudal branch of h; j – rostral central branch of h; k – caudal hemispherical convex branch of h; L – Rostral convex hemispheric branch of H; M – Rostral cerebral artery; n – medial branch of m; o – main axis of m; P – Central Branch of M; q – lateral artery of the olfactory bulb; r – medial artery of the olfactory bulb; s – internal ethmoid artery; t – external ethmoid artery; BO – olfactory bulb; PO – olfactory peduncle; TR – lateral olfactory tract; QO – Optic Chiasm; HC – cerebral hemisphere; LP – Piriform Wolf; PT – Bridge; ce – cerebellum; mo – medulla oblongata. [Bar=8mm]
Source: the authors (2025**)**.

The right middle cerebral artery launched two central rostral branches in 46.7%, and in one of the observations the most lateral branch overlapped the paleopallium reaching the neopallium of the cerebral hemisphere, rostrally in 36.7%, the right middle cerebral artery emitted three central rostral branches, and in four of these observations, one of the central branches was more developed, reaching the rostral neopallium of the cerebral hemisphere; in 13.3% of the cases, four central rostral branches were created for the paleo-pallium, and in one of these observations, one of the branches was directed to the rostral neopallium of the cerebral hemisphere; and, finally, in 3.3% a single well-developed rostral central branch was emitted, but without reaching the neopallium of the cerebral hemisphere, rostrally

In 46.7% of the preparations, the left middle cerebral artery emitted two central rostral branches to the paleopallium, and in one of the observations, one of the branches went beyond the lateral renal sulcus to supply the rostral neopallium cerebral hemisphere; while in 40% of the specimens it launched three central rostral branches, in which in four preparations one of the branches was very developed and vascularized the rostral neopallium of the cerebral hemisphere; in 10% it emitted four central rostral branches, and in two of these specimens a central branch was highly developed, also vascularizing the rostral neopallium of the cerebral hemisphere; in 3.3% it originated a single central rostral branch, very developed, which reached the neopallium of the cerebral hemisphere rostrally

By passing the lateral rhinal sulcus, the middle cerebral artery ascended to the convex surface of the cerebral hemisphere, emitting three to four branches on the right, and three to five caudal convex hemispheric branches on the left, which projected to the occipital lobe of the cerebral hemisphere, and their terminal branches anastomosed "in osculum" with the terminations of the occipital hemispheric arteries. near the transverse fissure of the brain (Figures 2 and 3).

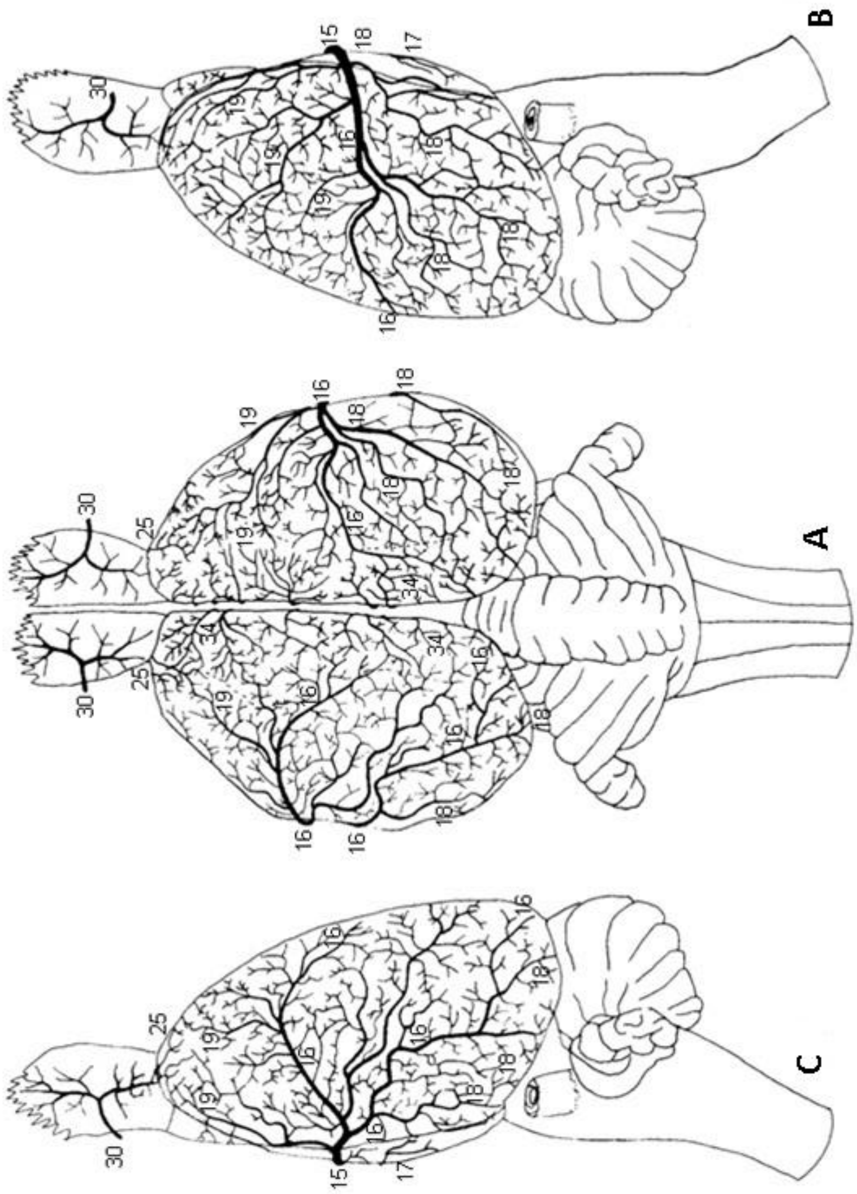
Figure 2

Photograph (Obs. 18) in dorsal (A) and right lateral (B) views of the cerebral hemisphere of nutria, highlighting the middle cerebral artery, its ramifications and distributions

The following can be seen in the image: a – middle cerebral artery main axis; b – caudal convex hemispheric branches; c – rostral convex hemispheric branches; d – terminal branches of the rostral medial hemispheric branches of the rostral cerebral artery; and – terminal branches of the occipital hemispheric artery, branch of the caudal cerebral artery; * - Boundary of the territory of the middle cerebral artery with the rostral and caudal cerebral arteries; SR – lateral renal sulcus; ft – transverse fissure of the brain; fl – longitudinal fissure of the brain; PR – Rostral pole of the cerebral hemisphere; CP – caudal pole of the cerebral hemisphere. [Bar = 8 mm]
Source: the authors (2025).

Figure 3

Schematic drawing (Obs. 18) of the dorsal (A), right lateral (B) and left lateral (C) views, highlighting the distribution of the middle cerebral artery on the surface of the nutria brain (Myocastor coypus)



The following can be seen in the image: 15 – middle cerebral artery; 16 – main axis of the middle cerebral artery; 17 – central branch of the middle cerebral artery; 18 – caudal convex hemispheric branch of the middle cerebral artery; 19 - Rostral convex hemispheric branch of the middle cerebral artery; 30 – external ethmoid artery; 34 – terminal branches of the rostral medial hemispheric branches.
Source: the authors (2025).

In 46.7% of the preparations, the right middle cerebral artery launched four caudal convex hemispheric branches, and in two of these observations, in which the axis of the right middle cerebral artery was double, the rostral vessel caudally emitted three caudal convex hemispheric branches to the central part (parietal lobe) of the cerebral hemisphere; in 33.3% of the cases, it launched three caudal convex hemispheric branches, where in one of the samples where the axis of the right middle cerebral artery was doubled, the rostral vessel caudally launched two caudal convex hemispheric branches to the central part (parietal lobe) of the cerebral hemisphere; in 10% it originated two caudal convex hemispherical branches and in 10% it emitted six caudal convex hemispherical branches

In 33.3% of the findings, the left middle cerebral artery gave rise to four caudal convex hemispheric branches, and in 33.3% of the findings, it emitted three branches, and in one observation in each case described above, in which the left middle cerebral artery was doubled, the rostral vessel caudally emitted three caudal convex hemispheric branches to the parietal lobe of the cerebral hemisphere. In 26.7% of the cases, the left middle cerebral artery launched five caudal convex hemispheric branches, where in an observation, in which the left middle cerebral artery was double, the rostral vessel caudally originated two caudal convex hemispheric branches to the parietal lobe of the cerebral hemisphere. In 3.3% of the preparations, two caudal convex hemispherical branches were emitted and in 3.3% six branches were launched.

Also when it passed the lateral renal sulcus, the middle cerebral artery emitted, to the right and left, three to five rostral convex hemispheric branches to the frontal pole of the cerebral hemisphere (Figures 2 and 3).

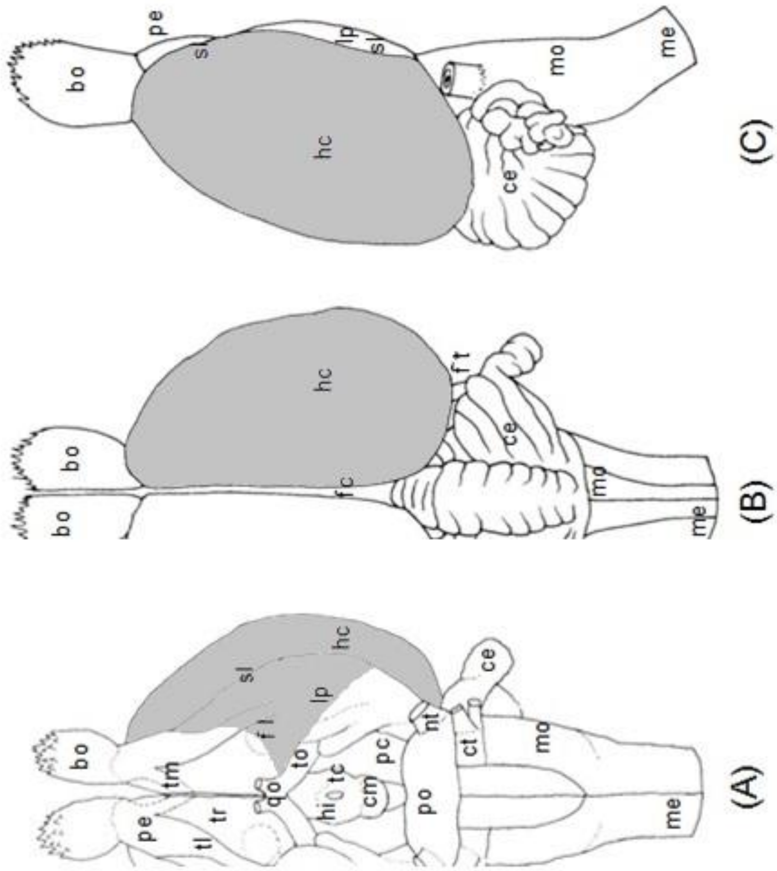
In 40% of the cases, the right middle cerebral artery emitted four rostral convex hemispheric branches, and in one of the observations, in which the axis of the right middle cerebral artery was double, the caudal vessel rostrally launched two rostral convex hemispheric branches to the parietal lobe of the cerebral hemisphere; In 23.3% of the findings, the right middle cerebral artery launched five rostral convex hemispheric branches, in 23.3% it originated three branches, and in 13.3% it emitted two branches.

The left middle cerebral artery originated in 43.3% of the cases five rostral convex hemispheric branches, in 30% it emitted three branches, where in one observation, in which there was duplicity of the left middle cerebral artery, the caudal axis emitted rostrally to the parietal lobe four rostral convex hemispheric branches, in 23.3% it launched four branches and in 3.3% two branches.

The vascular territory of the middle cerebral artery (Figure 4), in nutria, comprised the lateral fossa of the brain, the caudolateral part of the olfactory trigone, and a small rostral part of the piriform lobe, in addition to a caudal part of the lateral olfactory tract. On the convex surface of the cerebral hemisphere, its distribution extended from the rostral pole to near the limit of the caudal pole, except in a wider medial band rostrally bordering the longitudinal fissure of the brain.

Figure 4

Schematic drawing of the nutria brain, highlighting the territorial areas in ventral (A), dorsal (B) and right lateral (C) views of the cerebral hemisphere, highlighting the territory of the middle cerebral artery, in gray



The image shows: me – spinal; mo – medulla oblongata; CT – trapezoid body; ce – cerebellum; PO – Bridge; NT – trigeminal nerve; CP – cerebral peduncle; cm – nipple body; TC – Tuber Cinereo; hi – pituitary gland (dotted); LP – Piriform Wolf; to – optic tract; QO – Optic Chiasm; fl – lateral fossa of the brain; tr – olfactory trine; tl – lateral olfactory tract; TM – medial olfactory tract; PE – olfactory peduncle; BO – olfactory bulb; HC – cerebral hemisphere; SL – lateral renal sulcus; CF – longitudinal fissure of the brain; FT – transverse fissure of the brain.
Source: the authors (2025).

Regarding the distribution of the middle cerebral artery, its main axis extended from the convex surface towards the parietal lobe, its caudal convex hemispheric branches anastomosed with the terminations of the occipital arteries, a branch of the caudal interhemispheric artery, at the level of the transverse fissure of the brain. Its rostral convex hemispheric branches anastomosed at the rostral pole with the terminal branches of the rostral interhemispheric artery. Along the entire length of the convex surface, in a band near the longitudinal fissure of the brain, the terminal branches of the middle cerebral artery anastomosed with the terminations of the rostral medial hemispheric branches, branches of the rostral interhemispheric artery, which was a branch of the rostral cerebral artery, which advanced to the convex surface.

4 DISCUSSION

The discussion of brain irrigation in nutria (*Myocastor coypus*) was based on the work developed in nutria and was compared with irrigation in other rodents such as capybara (*Hydrochoerus hydrochaeris*), chinchilla (*Chinchilla lanigera*), agoutis (*Dasyprocta aguti*), guinea pig (*Guinea pig*), black rat (*Mus rattus*), brown rat (*Rattus norvegicus*), musk rats (*Ondatra zibethica*), preá (*Galea spixii*), European beaver (*Castor fiber*, Linnaeus, 1758), topeira rat (*Spalax leucodon*), hedgehog (*Hystrix cristata*), red squirrel (*Sciurus vulgaris*) and ground squirrel (*Spermophilus citellus*), to understand whether the brain irrigation of nutria is similar to that of other rodents. There are still few studies describing in detail the middle cerebral artery of different species of rodents.

In nutria, the middle cerebral artery was the last collateral branch of the right and left terminal branch of the basilar artery when transposing the optic tract. This same finding was found in capybara (Reckziegel; Lindemann; Campos, 2001), in nutria (Azambuja, 2006; Goltz, 2017; Azambuja; Goltz; Campos, 2018), in preá (Costa *et al*., 2017), in ground squirrel (Aydin *Et al*., 2009) and in Chinchilla (Araújo E Campos, 2005; Araújo; Campos, 2009; Araújo; Campos, 2020). Jablonski and Brudnicki (1984) described in chinchilla that the middle cerebral artery was emitted by the rostral cerebral artery, this information does not match, since it was observed that the middle cerebral artery was a collateral branch of the terminal branch of the basilar artery (Araújo; Campos, 2005; Araújo; Campos, 2009; Araújo; Campos, 2020). In black rats (Scremin, 1995), brown rats (Esteves *et al*., 2013), topcock rats (Aydin *et al*., 2008) and European beaver (Frackowiak and Smielowski, 1998) the middle cerebral artery was one of the terminal branches of the internal carotid artery. In the hedgehog (Aydin *et al*., 2005) and the red squirrel (Aydin, 2008) the middle cerebral artery is described as a branch of the rostral cerebral artery. This difference in the origin of the middle cerebral artery occurs due to the great variability of the cerebral arterial circle, due to the degrees of atrophy of the internal carotid artery.

The middle cerebral artery in nutria protruded laterally through the interior of the lateral fossa of the brain, just as in musk rats, but in this species it launched branches to the neopallium (Jablonski; Brudnicki, 1984), while in the nurtured (Azambuja, 2006; Goltz, 2017; Azambuja; Goltz; Campos, 2018) issued branches to the paleo-palio of the region. In nutria, capybara (Reckziegel *et al*., 2002), chinchilla (Araújo; Campos, 2005; Araújo; Campos, 2009) and in brown rats (Esteves *et al*., 2013), the middle cerebral artery, after crossing the lateral fossa of the brain, reached the lateral renal sulcus and was distributed on the convex surface of the cerebral hemisphere (Reckziegel; Lindemann; Campos, 2001). Majewska-Michalska (1995) described that the middle cerebral artery in guinea pigs supplied the convex surface of the cerebral hemisphere in the frontal, temporal, and parietal lobes. Librizzi *et al*. (1999) showed that in guinea pigs, the amygdala, the peritonsilloid cortex and the piriformis cortex were supplied by the middle cerebral artery and perforating branches, while the perirhinal, postrenal and entorinal cortexes were supplied by the middle cerebral and caudal arteries. The middle cerebellar artery in black rats originated from the cerebral arterial circle at the rostral border of the optic tract, running laterally and rostrally over the paleopalium, originating branches to the piriform cortex (Scremin, 1995).

The middle cerebral artery in nutria, in the description of Azambuja (2006), Goltz (2017) and Azambuja, Goltz and Campos (2018) presented a description similar to that found in this work, where it ascends to the convex surface of the cerebral hemisphere and is distributed in arborescence, as well as in chinchilla (Araújo; Campos, 2009). For Silva *et al*. (2016), in his work on agoutis, the middle cerebral artery followed laterally, emitted vessels to the piriform lobe and the mid-lateral area of the brain, reached the dorsal surface and distributed itself there.

In this study and in that of Azambuja (2006), Goltz (2017) and Azambuja, Goltz and Campos (2018) on nutrias, the middle cerebral artery was unique in 100% of the findings on the right and left. Silva *et al*. (2016) observed that in 10% of the agoutis, the middle cerebral artery was a double vessel, originating near the optic tract region, and in 90% of the samples it was a single vessel. Costa *et al*. (2017) described the middle cerebral artery of the preá as a single vessel in 75% of the animals in both antimeres, double in 20% and was found as a triple vessel in 5% of the samples.

The main axis of the middle cerebral artery in nutria was single in 86.7% of the cases and presented with cortical, hemispherical, convex, caudal and rostral branches, and in 13.3% of the specimens, on the right and left. In capybara, the middle cerebral artery was odd, on the right and left, in 96.7% of the preparations, but in 3.3% it had a double origin (Reckziegel; Lindemann; Campos, 2001).

The middle cerebral artery in nutria and chinchilla (Araújo; Campos, 2009) vascularized the paleopallium in only a small rostrolateral area through the caudal central branches emitted to the base and rostral lateral surface of the piriform lobe, with two branches in 60% of the right brains and two branches in 56.7% of the left samples, while in chinchilla three branches were emitted on the right in 50% of the cases and three branches on the left in 43.3% (Araújo; Campos, 2009).

In chinchilla, the central rostral branch was emitted from the middle cerebral artery at the base of the brain and was directed to the caudal third of the olfactory trigone, to the lateral olfactory tract, and to the lateral portion of the olfactory peduncle, supplying the paleopallium of these regions. The central striatum (perforating) branch was also emitted to the lateral fossa of the brain, and it was submerged in the rostral perforated substance, supplying the structures adjacent to the striatum (Araújo; Campos, 2009). In nutria, the description of the central rostral branches was very similar, and perforating branches for the striatum were also found. In nutria, one of the central rostral branches on the left was highly developed, going to supply the neopallium of the cerebral hemisphere. In black rats, the middle cerebral artery, at the level of the lateral olfactory tract, originated the corticostriate artery, then it curved to the side of the cerebral hemisphere and branched into a varied pattern of vessels (Scremin, 1995).

In nutria and chinchilla (Araújo; Campos, 2009), the middle cerebral artery, when it passed the lateral renal sulcus, ascended to the convex surface of the cerebral hemisphere, emitting caudal convex hemispheric branches, which projected to the occipital lobe of the cerebral hemisphere, close to the transverse fissure of the brain. In chinchilla, the caudal convex hemispherical branches also directed towards the temporal lobe, and the first caudal convex hemispheric branch branched to a small area of the piriform lobe (Araújo; Campos, 2009).

The middle cerebral artery emitted rostral convex hemispheric branches in nutria and chinchilla (Araújo; Campos, 2009) irrigating the frontal pole of the cerebral hemisphere. In chinchilla, the number of these branches varied greatly, and the first branch launched vessels that also supplied the area of the paleo-palium (lateral olfactory tract) (Araújo; Campos, 2009).

The vascular territory of the middle cerebral artery, in nutria and chinchilla (Araújo;

Campos, 2009) are quite similar, but have small differences, in both the territory comprised the lateral fossa of the brain. In nutria it also irrigated the caudolateral part of the olfactory trigone and in chinchilla the most caudal third of the olfactory trigone. A caudal part of the lateral olfactory tract was irrigated by the middle cerebral artery in nutria, while in chinchilla it is described as the entire lateral olfactory tract. In nutria a small rostral part of the piriform lobe was the territory of the middle cerebral artery and its branches, while in chinchilla it included the piriform lobe except for a small medial and caudal area. In capybara, the middle cerebral artery emitted two or three collateral branches that were distributed in the piriform lobe and to the ventral rostruolateral and ventral caudolateral parts of the cerebral hemisphere (Reckziegel *et al*., 2002). The surface of the cerebral hemisphere was almost entirely vascularized by the middle cerebral artery in nutria and chinchilla (Araújo; Campos, 2009), but in nutria its distribution extended from the rostral pole to near the limit of the caudal pole, except in a wider medial band rostrally bordering the longitudinal fissure of the brain, while in chinchilla it did not include a small section, medial to the vallecula and extending from the rostral pole to the caudal, bypassing the transverse fissure of the brain. These differences occur due to the different anatomical conformation of the brain between the two species. As in nutria and chinchilla, in preá the middle cerebral artery irrigated the interior of the lateral fossa and irrigated the cerebral hemispheres, the piriform lobes, and the olfactory trine (Costa *et al*., 2017). In capybara, the branches of the middle cerebral artery were distributed in the cerebral hemisphere, up to the marginal sulcus (Reckziegel *et al*., 2002).

The distribution of the middle cerebral artery in nutria and chinchilla (Araújo; Campos, 2009) are also similar. In nutria, its main axis extended on the convex surface towards the parietal lobe, and in this species and in chinchilla its terminal branches, the caudal and rostral convex hemispheric branches, reached the occipital and rostral poles of the brain. The caudal convex hemispheric branches at the level of the transverse fissure of the brain in the nutria anastomosed with the terminations of the occipital hemispheric arteries, branches of the caudal interhemispheric artery, while in the chinchilla they anastomosed in osculum with caudal middle hemispheric branches, terminal branches of the caudal cerebral artery. The rostral convex hemispheric branches anastomosed at the rostral pole, at the nutria with the terminal branches of the rostral interhemispheric artery and at the chinchilla with the terminal branches of the rostral cerebral artery (frontal and middle hemispheric branches). Near the longitudinal fissure of the brain, the rostral convex hemispheric branches of the chinchilla ran parallel to the fissure, limited caudally by the vallecula to the caudal pole, while in the nutria they anastomosed with the terminations of the rostral medial hemispheric branches, a branch of the rostral interhemispheric artery (branch of the rostral cerebral artery), which advanced to the convex surface. In the capybara, the terminal branches were distributed in the cerebral hemisphere, up to the marginal sulcus and anastomosed with the cortical branches of the cerebral, rostral and caudal arteries (Reckziegel *et al*., 2002).

5 CONCLUSION

This study concludes, based on the observations of the cerebral arteries of the nutria brains (*Myocastor coypus*) and the territorial distribution of the middle cerebral arteries and their vascularizations, that the middle cerebral artery was the last collateral branch of the terminal branch of the basilar artery, and the latter usually presented a single axis that directed to the parietal lobe and vascularized with its branches, in an arboriform distribution, the neopallium of the convex face of the cerebral hemisphere. The middle cerebral artery, with its central branches to the paleopalian, advanced very little in the rostrolateral part of the piriform lobe, due to the presence of the central branches of the terminal branch of the basilar artery, also supplying the lateral fossa of the brain and part of the lateral olfactory tract. The middle cerebral artery with its terminal branches showed extensive anastomoses with the terminal branches of the rostral and caudal cerebral artery. This study shows that the brain vascularization of nutria was similar to that of other rodents found in the literature, but there are some differences between animals of this species mainly due to the anatomical difference between the brains and the origin of the middle cerebral artery. There are still few studies detailing the cerebral vascularization of rodents.

ACKNOWLEDGMENTS

The authors would like to thank CAPES for the financial resources to carry out the research.

REFERENCES

Araújo, A. C. P., & Campos, R. (2005). A systematic study of the brain base arteries and their blood supply sources in the chinchilla (Chinchilla lanigera - Molina 1782). Brazilian Journal of Morphological Sciences, 22(4), 221–232.

Araújo, A. C. P., & Campos, R. (2007). Sistematization, distribution and territory of the caudal cerebral artery on the surface of the brain in chinchilla (Chinchilla lanígera). Brazilian Journal of Morphological Sciences, 24(3), 180–186.

Araújo, A. C. P., & Campos, R. (2009). Sistematization, distribution and territory of middle cerebral artery on the brain surface in chinchilla (Chinchilla lanígera). Anatomia, Histologia, Embryologia, 38, 12–17.

Araújo, A. C. P., & Campos, R. (2011). Sistematization, distribution and territory of rostral cerebral artery on the brain surface in chinchilla (Chinchilla lanígera). Brazilian Journal of Morphological Sciences, 28(2), 98–103.

Araújo, A. C. P., & Campos, R. (2020). Sistematização e descrição da vascularização arterial da área páleo-palial na superfície do cérebro de chinchila (Chinchilla lanigera). Acta Scientiae Veterinariae, 48, Article 1721.

Aydın, A., et al. (2005). The morphology of circulus arteriosus cerebri in the porcupine (Hystrix cristata). Veterinarni Medicina, 50(3), 131–135.

Aydın, A., et al. (2008a). Morphological investigations on the circulus arteriosus cerebri in mole-rats (Spalax leucodon). Anatomia, Histologia, Embryologia, 37(3), 219–222.

Aydın, A. (2008b). The morphology of circulus arteriosus cerebri in the red squirrel (Sciurus vulgaris). Veterinarni Medicina, 53(5), 272–276.

Aydın, A., et al. (2009). The morphology of the circulus arteriosus cerebri in the ground squirrel (Spermophilus citellus). Veterinarni Medicina, 54(11), 537–542.

Azambuja, R. C. (2006). Sistematização das artérias da base do encéfalo e suas fontes de suprimento sanguíneo em nutria (Myocastor coypus) [Master's dissertation, Universidade Federal do Rio Grande do Sul].

Azambuja, R., Goltz, L. V., & Campos, R. (2018). Sistematização das artérias da base do encéfalo em nutria (Myocastor coypus). Acta Scientiae Veterinariae, 46, Article 1580.

Baroffio, R., De Paoli, J., & Fiordelisi, A. (1979). Clasificacion zoológica de la nutria. In Nuestra nutria (Myocastor coypus) (pp. 2–5). Hemisferio Sur.

Costa, H. S., et al. (2017). Vascularização arterial da base do encéfalo de preá (Galea spixii). Acta Scientiae Veterinariae, 45, Article 1456.

De Vriese, B. (1905). Sur la signification morphologique des artères cérébrales. Archives de Biologie, 21, 357–457.

Esteves, A., et al. (2013). Anatomical arrangement and distribution of the cerebral arterial circle in rats. Journal of Morphological Sciences, 30(2), 132–139.

Frackowiak, H., & Smiełowski, J. (1998). Cephalic arteries in the European beaver Castor fiber. Acta Theriologica, 43(2), 219–224.

Goltz, L. V. (2017). Sistematização, distribuição e territórios das artérias cerebrais rostral, média e caudal na superfície do encéfalo em nutria (Myocastor coypus) [Master's dissertation, Universidade Federal do Rio Grande do Sul].

Goltz, L. V., Azambuja, R. C., & Campos, R. (2020). Systematization, distribution and territories of the caudal cerebral artery on the surface of the brain in nutria (Myocastor coypus). Pesquisa Veterinária Brasileira, 40(6), 484–492.

International Committee on Veterinary Gross Anatomical Nomenclature. (2017). Nomina anatomica veterinaria (5th ed.). Editorial Committee.

Jablonski, R., & Brudnicki, W. (1984). The effect of blood distribution to the brain on the structure and variability of the cerebral arterial circle in musk-rat and in chinchilla. Folia Morphologica, 43(2), 109–114.

Lacerca, A. M. (1990). Cria de nutrias. Ed. Albatros.

Librizzi, L., et al. (1999). Arterial supply of limbic structures in the guinea pig. Journal of Comparative Neurology, 411, 674–682.

Machado, G. V., Cal, J. A., & Birck, A. J. (2009). Topografia do cone medular no ratão-do-banhado (Myocastor coypus Molina – 1782 – Rodentia: Mammalia). Biotemas, 22(2), 117–120.

Majewska-Michalska, E. (1995). Vascularization of the brain in guinea pig II. Regions of vascular supply and spatial topography of the arteries in particular parts of the brain. Folia Morphologica, 54(1), 33–40.

Majewska-Michalska, E. (1997). Vascularization of the brain in guinea pig V. Angioarchitectonics of the thalamus, telencephalon and internal capsule. Folia Morphologica, 56(1), 55–62.

Ministério da Ciência, Tecnologia e Inovação. Conselho Nacional de Controle de Experimentação Animal. (2013). Diretriz brasileira para o cuidado e a utilização de animais para fins científicos e didáticos. http://www.ufrgs.br/ceua/normas/diretrizes-concea-maio-2013

Reckziegel, S. H., Lindemann, T., & Campos, R. (2001). A systematic study of the brain base arteries in capybara (Hydrochoerus hydrochaeris). Brazilian Journal of Morphological Sciences, 18(2), 103–110.

Reckziegel, S. H., et al. (2002). Distribuição e territórios da artéria cerebral média na superfície do encéfalo em Hydrochoerus hydrochaeris (capivara) [Conference session]. XXIX Congresso Brasileiro de Medicina Veterinária, Gramado, Brazil.

Reckziegel, S. H., et al. (2004a). Anatomy of the caudal cerebral artery on the surface of the capybara (Hydrochoerus hydrochaeris). Brazilian Journal of Morphological Sciences, 21(3), 131–134.

Reckziegel, S. H., et al. (2004b). Vascularização arterial do hipocampo em Hydrochoerus hydrochaeris (capivara). Revista Portuguesa de Ciências Veterinárias, 99(551), 145–148.

Scremin, O. U. (1995). Cerebral vascular system. In The rat nervous system (2nd ed., pp. 3–18). Sydney Academy Press.

Silva, F. (1994). Mamíferos silvestres do Rio Grande do Sul (2ª ed.). Fundação Zoobotânica do Rio Grande do Sul.

Silva, R. S. B. S., et al. (2016). Arterial vascularization of the brain of the agouti (Dasyprocta agouti Linnaeus, 1766). Semina: Ciências Agrárias, 37(2), 773–784.

Szczurkowski, A., et al. (2007). Topography of arterial circle of the brain in Egyptian spiny mouse (Acomys cahirinus, Desmarest). Anatomia, Histologia, Embryologia, 36, 147–150.

Tandler, J. (1898). Zur vergleichenden anatomie der Kopfarterien bei den Mammalia. Denkschriften der Akademie der Wissenschaften, 67, 677–784.