

A SYSTEMATIC STUDY OF THE BRAIN BASE ARTERIES IN THE PAMPAS FOX (*Dusicyon gymnocercus*)

Jurema Salerno Depedrini and Rui Campos

Division of Animal Anatomy, Department of Morphological Sciences, Faculty of Veterinary Medicine,
Federal University of Rio Grande do Sul (UFRGS), Porto Alegre, RS, Brazil.

ABSTRACT

Thirty specimens of the pampas fox (*Dusicyon gymnocercus*) were injected with Neoprene latex to study the distribution of the internal carotid and vertebral arteries, and their derived vessels, on the ventral surface of the brain. The internal carotid artery and its rostral and caudal branches were single on both sides in all cases, as was the right middle cerebral artery; the corresponding left artery was single in 96.7% of the cases and double in 3.3%. The right rostral cerebral artery was single in all cases, and single (96.7%) or absent (3.3%) on the left. The rostral communicating artery was present in 96.7% and absent in 3.3%, while the right caudal cerebral artery was single in 86.7% and double in 13.3%, but only single on the left. The basilar artery was single in all cases. The cerebral arterial circle was closed rostrally in 96.7% of the cases and open in 3.3%, but was closed caudally in all animals. The encephalon blood supply was derived principally from the carotid system, but also from the complementary vertebral-basilar system.

Key words: Brain vascularization, blood supply, Canidae, encephalic arteries, wild dog

INTRODUCTION

The encephalic arteries are the main route for blood transport to the brain and therefore have an essential role in the maintenance of normal brain activity. The functional importance of these vessels has led to various morphological studies in many animal species. In this work, we investigated the irrigation of the base of the encephalon in the pampas fox (*Dusicyon gymnocercus*), a South American wild dog that inhabits open areas of southern Brazil.

Since no data on this species were found in a comprehensive literature search, studies in canines were used as a basis for discussion of our findings. Tandler [10] reported an extensive study on the comparative anatomy of the head arteries, including two canine species, *Canis familiaris* and *Canis lupus*. De Vriese [6], in her phylogenetic and ontogenetic study, classified several groups of animals according to the type of encephalic irrigation. Jewell [9], De La Torre *et al.* [4,5], Anderson *et al.* [3], Gillilan [7] and Alcântara and Prada [1,2] studied the domestic dog. Wiland [11] investigated the basilar artery of the red fox, *Vulpes vulpes*, silver fox, and white fox, *Alopex lagopus*. In the present study, we examined the arteries of the base

of the encephalon in *Dusicyon gymnocercus*, with emphasis on the vessels contributing to the formation of the arterial cerebral circle, and its main branches. The general pattern of vessel occurrence and its main variations were also established.

MATERIAL AND METHODS

Thirty encephala with a segment of the spinal cord were collected from *Dusicyon gymnocercus* (13 M, 17 F) under a license granted by the Brazilian Institute of the Environment (IBAMA). The foxes were anesthetized with zolazepam chloride associated with tiletamine chloride (10 mg/kg, i.m.; Zoletil 50-Virbac). The common carotid arteries were cannulated, the external jugular veins were opened and the circulatory system was washed with cold saline solution containing heparin (2,500 IU/kg; Liqueimine-Roche) followed by the injection of red-dyed latex (Neoprene; Artecocola). Subsequently, the neck was sectioned at its insertion to the trunk, the skin was totally removed, and a window was opened in the cranium. The specimens were then fixed in 20% formalin for at least seven days. The encephala were then removed from the cranium and the vertebral channel, the dura mater, was removed and the arteries were dissected. All specimens were observed under a magnifying glass. Schematic drawings of the arteries of the base of the brain were prepared, and some photographs were taken in order to complement the documentation of the results. The designation of the arteries of the base of the encephalon was based on the *Nomina Anatomica Veterinaria* [8]. The occurrence and distribution of the vessels was expressed as a percentage of the total number of specimens examined. Differences in distribution were compared using a two ratios test for a normal distribution. A value of $p < 0.05$ indicated significance.

Correspondence to: Jurema Salerno Depedrini
Setor de Anatomia Animal, Faculdade de Medicina Veterinária,
Universidade Federal do Rio Grande do Sul (UFRGS), Av. Bento
Gonçalves, 9090, CEP 91540-000, Porto Alegre, RS, Brasil. Tel: (55)
(51) 3316-6924, Fax: (55) (51) 3316-6122.
E-mail: jurema.depedrini@ufrgs.br

RESULTS

The blood supply to the brain was derived mainly from the carotid system, but also from the complementary vertebral-basilar system. The carotid system irrigated the entire prosencephalon and the rostral part of the mesencephalon, whereas the vertebral-basilar system supplied the rhombencephalon and the caudal part of the mesencephalon. In all cases the left and right carotid arteries penetrated the foramen lacerus through the carotid canal, and projected rostrally up to the lateral sides of the hypophysis, where they curved dorsally and divided into the terminal rostral and caudal branches (Figs. 1 and 2). In the middle of this course, before dividing, the carotid artery received a thick anastomosis of the maxillary artery through the foramen orbitorotundum. The rostral branch of the internal carotid artery was a natural continuation of this artery. This short vessel gave off a thick collateral artery, the middle cerebral artery, that continued as the rostral cerebral artery, its terminal branch.

The middle cerebral artery projected laterally from the rostral branch of the internal carotid artery, then went around the pyriform lobe and up to the lateral cisure, where it branched and distributed on the dorsal lateral surface of the brain hemisphere. In all specimens, the right middle cerebral artery was single artery, although in one case it had a double origin that formed an "island" anastomosis. The left middle cerebral artery appeared as a single vessel in 96.7% of the specimens, with one case of a double origin, and was double in the remaining 3.3%.

The rostral cerebral artery represented the terminal branch of the rostral branch of the internal carotid artery and proceeded in a rostral medial direction up to the ventral longitudinal brain fissure. The branches of this vessel were distributed on the olfactory bulb and on the medial surface of the brain hemisphere (Fig. 3). On the right, the rostral cerebral artery was present as a single vessel in all cases. The left rostral cerebral artery was a single vessel in 96.7% of the cases, and was absent in the remaining 3.3% (Fig. 4).

The internal ophthalmic artery appeared as a fine vessel that followed the optic nerve towards the eye globe. On the right, this vessel was present as a single collateral branch of the rostral cerebral artery in 96.7% of the cases, and was absent in 3.3% of the specimens. On the left, this vessel was single in all specimens. In 27 brains, the internal ophthalmic artery was a collateral branch of the rostral cerebral artery, in two brains it derived from the rostral branch of the

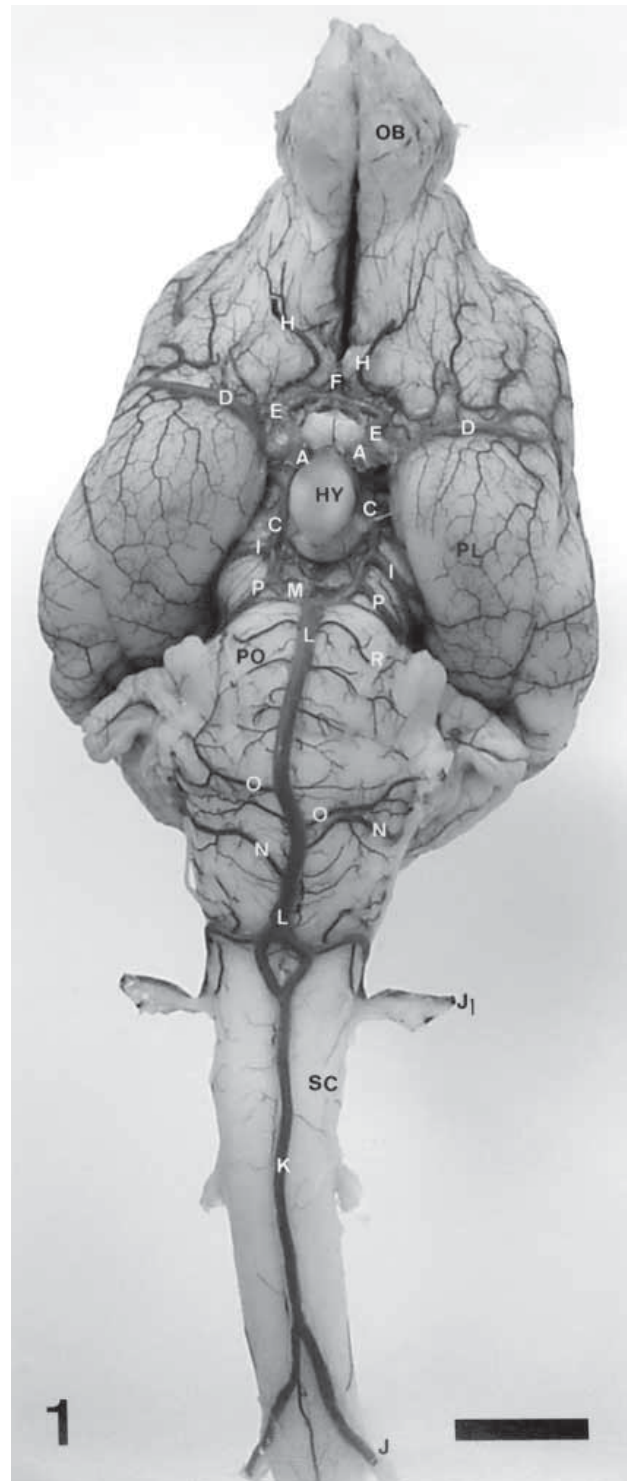
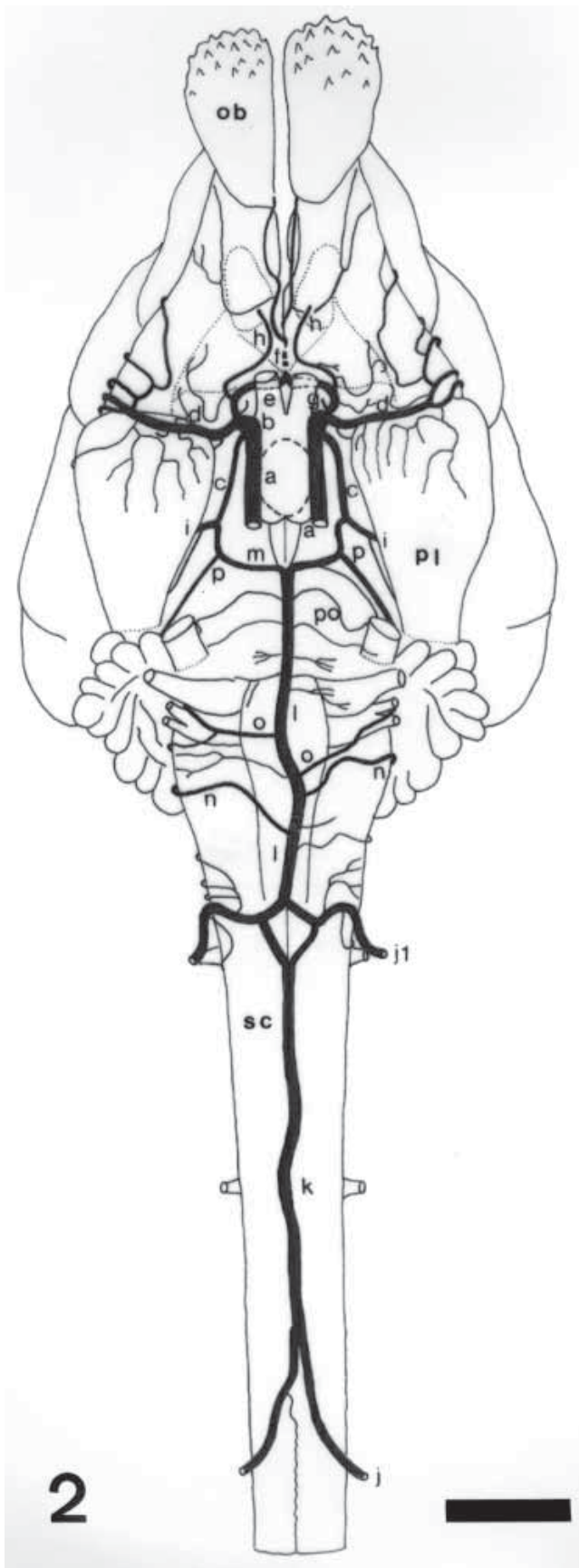


Figure 1. Ventral view of the brain base arteries of *D. gymnocercus*. **A** – internal carotid artery, **C** – caudal branch, **D** – middle cerebral artery, **E** – rostral cerebral artery, **F** – rostral communicating artery, **H** – internal ethmoidal artery, **I** – caudal cerebral artery, **J** – first branch of the vertebral artery, **J1** – second branch of the vertebral artery, **K** – ventral spinal artery, **L** – basilar artery, **M** – terminal branch of the basilar artery, **N** – caudal cerebellar artery, **O** – middle cerebellar artery, **P** – rostral cerebellar artery, **OB** – olfactory bulb, **PL** – pyriform lobe, **HY** – hypophysis, **PO** – pons, **SC** – spinal cord. Bar = 10 mm.



internal carotid artery, and in one case from the internal ethmoidal artery (Fig. 4).

In all specimens, the internal ethmoidal artery was a single vessel of variable thickness that often derived from the rostral cerebral artery and projected rostrally towards the olfactory bulb. This vessel perforated the dura mater ventrally and emitted branches to the rostro-ventral part of the falx brain before reaching the olfactory bulb. On the right, the internal ethmoidal artery corresponded to a collateral branch of the rostral cerebral artery in all cases, while on the left, it was as a collateral branch of the rostral cerebral artery in 96.7% of the cases, and derived from the rostral branch of the internal carotid artery in the remaining 3.3% (Fig. 4).

The communicating rostral artery consisted of an anastomotic bridge that united the left and right rostral cerebral arteries, and was located ventrally to the ventral longitudinal fissure and rostrally to the optic chiasma. The rostral communicating artery was present in 96.7% of the encephala and closed the cerebral arterial circle rostrally (Fig. 3). The communicating rostral artery was absent in 3.3% of the specimens, which left the cerebral arterial circle open rostrally (Fig. 4). This artery consisted of a single median artery in 20 specimens, a single and oblique anastomotic tract in four cases, a single transversal anastomotic vessel in two cases, a double vessel with two sequential transversal anastomoses in one case, a double transversal anastomotic vessel followed by a single median formation in one case, and an oblique anastomotic vessel followed by a single median tract in one case.

The caudal branch of the internal carotid artery, which was thinner than the rostral branch, consisted of a single vessel in all specimens. After leaving its origin, this vessel proceeded caudally, lateral to the hypophysis, and joined the right and left ipsilateral terminal branches of the basilar artery (Figs. 1 and 2). During its course, it emitted several thin collateral branches and a thick collateral branch, the caudal cerebral artery.

Figure 2. Schematic drawing showing the standard distribution of the brain base arteries in a ventral view of *D. gymnocercus*. **a** – internal carotid artery, **b** – rostral branch, **c** – caudal branch, **d** – middle cerebral artery, **e** – rostral cerebral artery, **f** – rostral communicating artery, **g** – internal ophthalmic artery, **h** – internal ethmoidal artery, **i** – caudal cerebral artery, **j** – first branch of the vertebral artery, **j1** – second branch of the vertebral artery, **k** – ventral spinal artery, **l** – basilar artery, **m** – terminal branch of the basilar artery, **n** – caudal cerebellar artery, **o** – middle cerebellar artery, **p** – rostral cerebellar artery, **ob** – olfactory bulb, **pl** – pyramidal lobe, **po** – pons, **sc** – spinal cord. Bar = 10 mm.

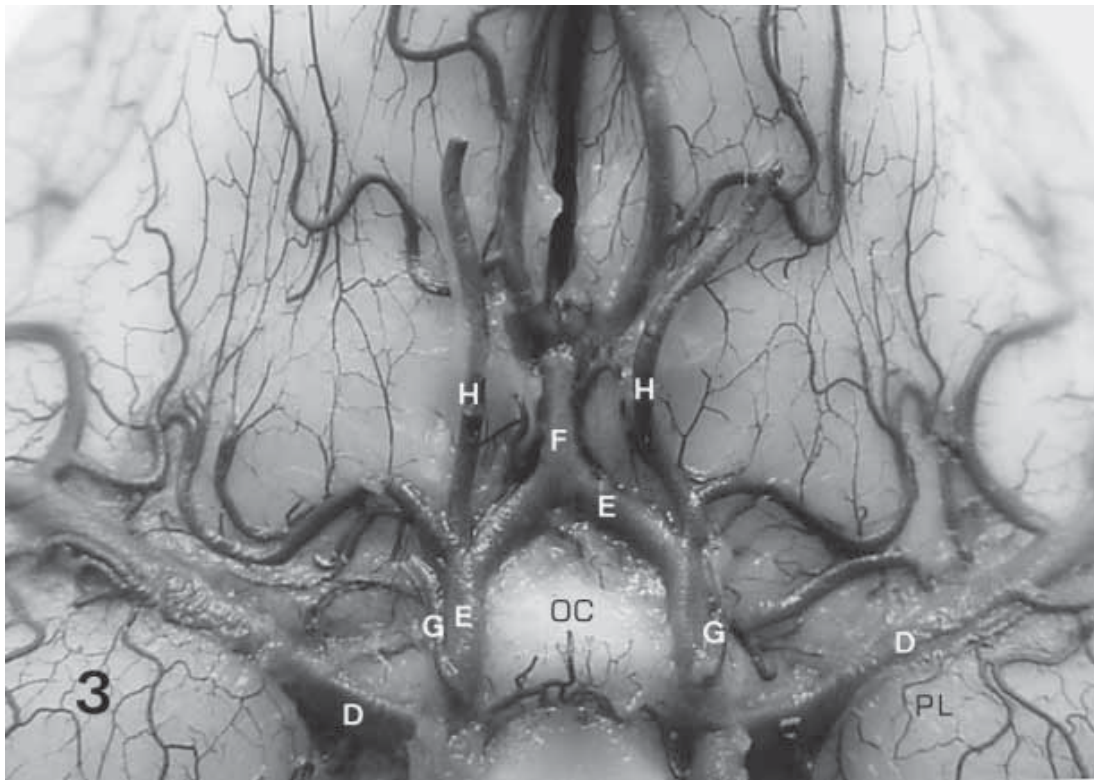


Figure 3. Ventral view of the brain of *D. gymnocercus* showing the rostral communicating artery, represented by a single median vessel. **D** – middle cerebral artery, **E** – rostral cerebral artery, **F** – rostral communicating artery, **G** – internal ophthalmic artery, **H** – internal ethmoidal artery, **OC** – optic chiasma, **PL** – pyriform lobe. Bar = 2 mm.

The caudal cerebral artery derived from the caudal branch of the internal carotid artery and proceeded latero-dorsally to the interior of the transverse fissure, irrigating part of the mesencephalon and the tentorial and medial faces of the brain hemispheres. On the right, this vessel was single in 86.7% of the specimens and double in 13.3%; on the left, it was single in all cases.

The right and left vertebral arteries usually derived from the ipsilateral subclavian artery and projected from the thorax towards the neck, where they penetrated the transversal canal of the transverse foramen of the sixth cervical vertebra. As this vertebral artery ascended through the transversal canal, its first branch penetrated the second inter-vertebral foramen to anastomose with the counter-lateral homolog and form a thick ventral spinal artery. This artery projected rostrally and joined the second branch to form an “island” anastomosis at the level of the foramen magnum. After crossing the atlantal fossae, the second branch went around the alar incisure and penetrated the vertebral canal through the lateral vertebral foramen to anastomose with its counter-lateral homolog and form the basilar artery in an “island” anastomotic junction. The right vertebral artery presented two

branches in 93.3% of the brains. These branches contributed to the formation of the ventral spinal and basilar arteries. In 6.7% of the cases, the right vertebral artery emitted a third accessory branch which penetrated the first inter-vertebral foramen and contributed to the formation of the ventral spinal artery. The left vertebral artery consisted of only the first and second branches in 93.3% of the cases, but had a third accessory branch in 3.3%; the first branch was absent in 3.3% which, however, had the second and third accessory branches.

The ventral spinal artery consisted of a thick vessel that projected onto the ventral surface of the first three segments of the spinal cord. This vessel was derived from the anastomosis of the first branches of the right and left vertebral arteries up to the foramen magnum, where it joined the second branches in an “island” anastomotic formation, from which the basilar artery was derived rostrally (Figs. 1 and 2). The course of the ventral spinal artery varied from rectilinear to sinuous. This vessel was single in 93.3% of the specimens, but double in 6.7%, which generated an “island” anastomosis.

In all specimens, the basilar artery was a single, thick, median vessel that arose from the rostral ex-

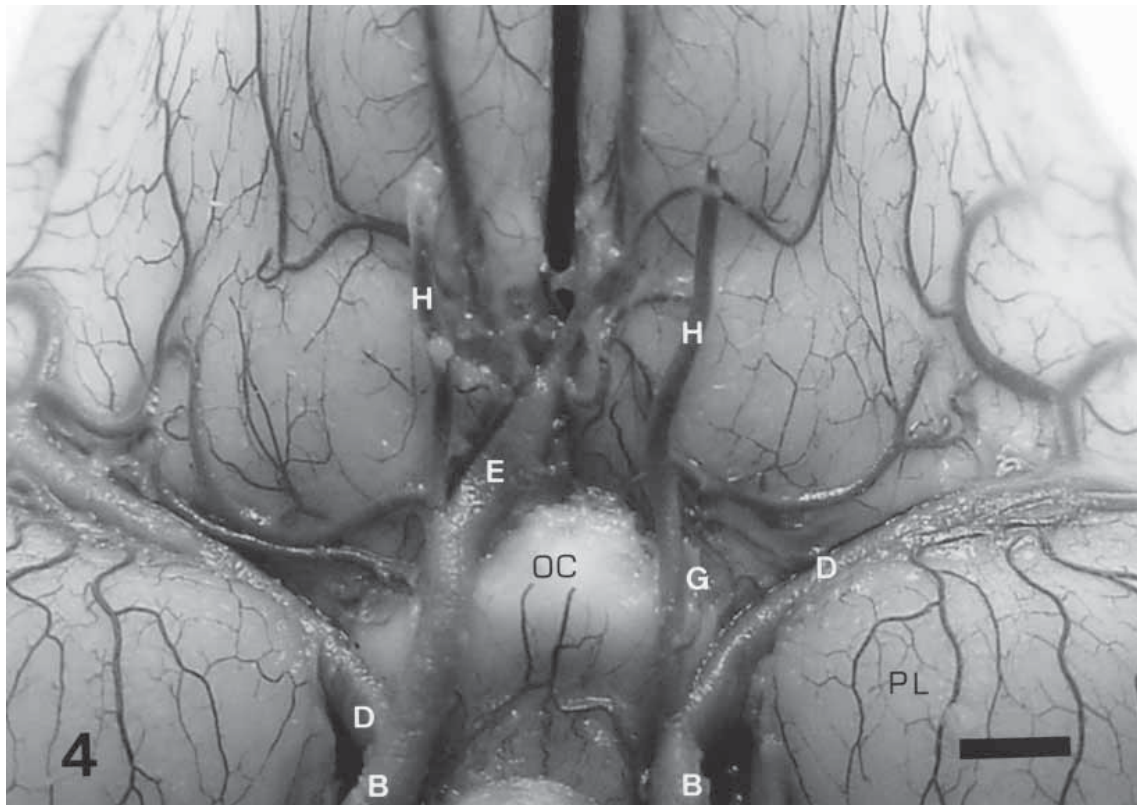


Figure 4 – Ventral view of the brain of *D. gymnocercus* showing the cerebral arterial circle opened rostrally by the absence of the left rostral cerebral artery. **B** – rostral branch of the internal carotid artery, **D** – middle cerebral artery, **E** – right rostral cerebral artery, **G** – internal ophthalmic artery, **H** – internal ethmoidal artery, **OC** – optic chiasma, **PL** – pyriform lobe. Bar = 2 mm.

tremity of an “island” anastomosis formed by the second branch of the right and left vertebral arteries and by the rostral terminal bifurcation of the ventral spinal artery at the foramen magnum (Figs. 1 and 2). The basilar artery extended rostrally on the ventral surface of the medulla oblongata and pons, and divided into right and left terminal branches at the rostral pontine groove. The right terminal branch of the basilar artery was a single vessel in all cases, whereas the left terminal branch was a single vessel in 96.7% and double in 3.3%. In the latter case, the vessel formed an “island” anastomosis before emitting the rostral cerebellar artery. During its course, the basilar artery emitted several extremely thin collateral branches, including the middle and caudal cerebellar arteries, which were thicker than the others.

The right and left caudal cerebellar arteries, usually represented by one vessel, projected rostro-ventrally on the ventral surface of the medulla oblongata, and were distributed in the caudal part of the cerebellum. These vessels derived from different regions of the course of the caudal third of the basilar artery, but also from the second branch of the vertebral artery, including the “island” anastomotic for-

mation. The right caudal cerebellar artery was single in 93.3% of the encephala and double in 6.7%. The left caudal cerebellar artery was single in 76.7% of the specimens, double in 10%, absent in 10%, and triple in 3.3%.

The middle cerebellar artery (right and left) projected laterally from the basilar artery on the ventral surface of the medulla oblongata and followed the trapezoid body up to the cerebellum, where it branched out on the flocculus and paraflocculus. The right middle cerebellar artery was single in 76.7% and double in 23.3% of the cases. The left middle cerebellar artery was single in 90% and double in 10% of the encephala.

The rostral cerebellar artery (right and left) usually consisted of a natural continuation of one of the terminal branches of the basilar artery after its anastomosis with the ipsilateral caudal branch of the internal carotid artery on the caudal third of the ventral surface of the pedunculus cerebri. This vessel projected latero-dorsally to the interior of the transverse fissure, and was distributed in the rostral part of the cerebellum and in the caudal part of the mesencephalic tectum. On the right, this vessel was single in 100%

of the specimens, while on the left it was single in 96.7% and double in 3.3%.

The arterial cerebral circle extended from the rostral pontine groove at the base of the encephalon up to the ventral longitudinal fissure, and included the optic chiasma, the tuber cinerium with the hypophysis, and the mamillary body. The arterial circle was closed rostrally through the union of the rostral cerebral arteries which formed a communicating rostral artery with one or more vessels. The caudal portion of the circle, always closed, was formed by the union of the caudal branch of the internal carotid artery with the ipsilateral branch of the basilar artery in both antimeres. The cerebral arterial circle was closed caudally and rostrally in 96.7% of the specimens. However, it was closed caudally and opened rostrally through the absence of the left rostral cerebral artery in 3.3% of the cases.

Statistical analysis of the results showed that there were no significant differences in the behavior of the arteries at the base of the encephalon between the sexes.

DISCUSSION

In *D. gymnocercus*, the internal carotid artery had a course similar to that described in dogs [5,7,9]. Laterally to the hypophysis, this artery divided into two terminal branches (rostral and caudal) [1], also designated as anterior and posterior [5,10], or cranial and caudal [6,7]. The rostral branch of the internal carotid artery was a short vessel which gave off a thick, middle cerebral artery as collateral branch, that continued as the rostral cerebral artery [1]. In contrast, De Vriese [6] observed that the rostral branch gave rise to a thick, middle cerebral artery, an ethmoidal branch, and a lateral olfactory bulb artery, and ended as the anterior cerebral artery. Alcântara and Prada [1] reported variations in the behavior of the terminal branches of the internal carotid arteries in dogs, where this artery trisected into a caudal branch and middle and rostral cerebral arteries on the left in 10% and on the right in 13.3% of the specimens. Despite its extremely short course in *D. gymnocercus*, the rostral branch was always present.

The middle cerebral artery, designated as the *fossa Silvii* artery [10], represents the continuation of the rostral branch of the internal carotid artery, according to Gillilan [7]. De Vriese [6] mentioned that, in more primitive arrangements, the middle cerebral artery was a collateral branch of the cranial terminal branch of the internal carotid artery, whereas in higher vertebrates it lost the appearance of a collateral ar-

tery since its development was similar to or greater than the anterior cerebral artery. However, this author argued that these changes in vascular morphology were secondary, and that it was incorrect to consider the middle cerebral artery as a terminal branch of the internal carotid artery. Alcântara and Prada [1] observed this artery as a single vessel in 96.6% of the specimens. This frequency was similar to that found in the present study.

The rostral cerebral artery, also designated as the anterior cerebral artery [6] or corpus callosum artery [10], projected rostro-medially and passed the optic nerve dorsally [5] to reach the ventral longitudinal fissure. This vessel's collateral arteries included the internal ophthalmic and internal ethmoidal arteries [5,7]. The internal ophthalmic artery, also known as the ophthalmic artery [6], was a thin vessel [5,7].

The rostral communicating artery, also designated as the anterior communicating artery [5-7,10], was formed by an anastomotic bridge between the left and right rostral cerebral arteries. De La Torre *et al.* [5] described this vessel as thicker than the anterior cerebral artery. De Vriese [6] asserted that in all mammals the anterior cerebral arteries anastomosed among themselves to form either a single median artery, which went around the corpus callosum bifurcation, or was joined by one or more transversal arteries. This author noted that one or more anterior communicating arteries were found in carnivorous animals. Gillilan [7] reported that in 10 of the 11 brains analyzed, both of the anterior cerebral arteries fused and extended to the inter-cerebral fissure before bisecting into two separate vessels; in all specimens there was a small anterior communicating artery. Alcântara and Prada [1] stated that in 83.3% of her observations the rostral cerebral artery proceeded rostro-medially and joined the artery of the opposite side to form a 1-4 mm trunk, which she did not name. In 13.3% of the specimens, the rostral cerebral arteries were joined by transversally arranged anastomotic tract, and in 3.3% of the observations, the arteries proceeded separately. In agreement with the observations by De Vriese [6], on rostral communicating artery, the single median artery formed by the communication between both rostral cerebral arteries, which was present in most cases, irrigated both antimeres with its branches. This vessel was considered a communicating artery because it linked two systems distributed in different antimeres. The variation seen in the number and arrangement of the median rostral communicating arteries may indicate that this vessel system is still evolving.

De Vriese [6] considered that, in the primitive state, the caudal cerebral artery [1] was a collateral of the terminal branch of the internal carotid artery. This vessel may form the limit of the anastomosis between the caudal branch of the internal carotid artery and the dividing branch of the basilar artery, and may represent the termination of the division branch of the latter. More recently, the posterior cerebral artery has been considered a collateral of the dividing branch of the terminal branches of the basilar arteries. Thus, the posterior cerebral artery apparently belongs to the carotid group, although superficially secondary vascular modifications may make it appear to belong to the vertebral domain. According to De La Torre *et al.* [4], the posterior cerebral artery is one of the largest branches derived from the posterior communicating arteries, and Gillilan [7], reported that the posterior cerebral artery was sometimes larger than its contributing vessels. Alcântara and Prada [1] noted that in all specimens the caudal cerebral artery was a bilateral single vessel derived from the joining of the internal carotid artery with the terminal branch of the basilar artery.

According to Alcântara and Prada [1], during its cranial course the vertebral artery emits two branches at the level of each inter-vertebral foramen. At the level of the first cervical vertebra, the vertebral artery penetrates the inter-vertebral foramen to form a lozenge along with the ventral spinal artery, and occasionally an anastomotic “island”. In the present study, we considered only the branches that contributed to the irrigation of the spinal cord and the encephalon. The first branch to be emitted penetrated the second inter-vertebral foramen to form the ventral spinal artery. The second branch penetrated the vertebral canal by the alar incisure and lateral vertebral foramen of the atlas to form an “island” anastomosis and the basilar artery. An accessory branch which appeared sporadically penetrated the vertebral canal in the first inter-vertebral foramen and contributed to the formation of the ventral spinal artery. The anastomotic “island”, located at the level of the *foramen magnum*, is also known as the cerebral-spinal circle [4,5] or spinal arterial circle [3,11]. De La Torre *et al.* [4,5] observed that the vertebral artery anastomosed with the inferior branch of the occipital artery to form the occipital-vertebral artery, which penetrated the inter-vertebral foramen to form the cerebral spinal circle. Wiland [11] designated the first branch of the vertebral artery as the third spinal branch, and described the second branch beyond the anastomosis of the occipital artery as the cerebral spinal artery.

The ventral spinal artery [1,3-5] is also known as the anterior spinal artery [7] or arterial trunk (*truncus spinalis ventralis cranialis*) [11].

According to De Vriese [6] and Tandler [10], the basilar artery derives from the junction of the vertebral arteries beyond the anastomosis of the occipital arteries. Jewell [9] stated that the vertebral artery joined the ventral spinal artery on the ventral surface of the spinal cord after receiving the anastomosis of the occipital artery and that the result of this union proceeded rostrally as the basilar artery. De La Torre *et al.* [5] reported that this artery was formed by the union of the left and right upper branches of the occipital-vertebral branch. According to Wiland [11], the basilar artery derived from the union of the branches of the vertebral and occipital arteries. Gillilan [7] referred to the basilar artery as a vessel of uniform thickness that was formed on the lower border (ventral face) of the spinal cord, next to the roots of the hypoglossus nerve, through the union of the rostral branches of the cerebrospinal artery. In the pampas fox, this artery projected from the rostral portion of the “island” formation, a characteristic also seen in dogs [1,3,4].

The terminal branches of the basilar artery [1] were designated by Gillilan [7] as the basilar trunk.

De La Torre *et al.* [5] and Jewell [9] observed that, rostrally, the basilar artery contributed to the formation of the posterior branches of the circle of Willis.

In our observations, the caudal cerebellar artery [1], also termed the posterior inferior cerebellar artery [3,11] and inferior cerebellar artery, varied in number and origin, in agreement with other studies. According to De La Torre *et al.* [4], the largest branches of the basilar arteries are the cerebellar arteries. These authors noted that 2-4 branches appeared in each antimere, but with some variations. However, since they did not name these cerebellar arteries, we assumed that they were referring to the caudal and middle cerebellar arteries in generic terms. Wiland [11] considered the caudal and middle cerebellar arteries as posterior cerebellar arteries and mentioned that the posterior inferior cerebellar artery derived from the cerebrospinal artery, from the cephalic section of the vascular loop, or from the basilar artery, in one or two branches. This arrangement was similar to that seen here in the pampas fox.

The middle cerebellar artery is also referred to as the anterior inferior cerebellar artery [11] or middle inferior cerebellar artery [3]. According to Wiland [11], this artery is well developed. Anderson and

Kubicek [3] reported that in 50% of the cases they studied the left and right middle inferior cerebellar arteries derived from the basilar artery, rostrally to the origin of the posterior inferior cerebellar artery, and that this vessel was variable in its origin and course. This artery was absent in one third of their specimens or was present as a single vessel. Bilateral absence of this vessel was seen in 16.7% of the cases. According to De La Torre *et al.* [4], the rostral cerebellar artery [1], also known as the superior cerebellar artery [3,4,7] and nasal cerebellar artery [11], is the largest branch derived from each posterior communicating artery. Wiland [11] claimed that the nasal cerebellar artery was a well-developed trunk that proceeded to the cerebellum along the nasal border of the pons. Gillilan [7] mentioned that the superior cerebellar artery, which derived from the basilar trunk, was large, symmetrical and constant.

The cerebral arterial circle is often referred to as the arterial circle [10], the circle of Willis [5,6,9], and the arteriosus circle [7]. De Vriese [6] classified the formation of the circle of Willis into three types. In type I, the encephalon was supplied exclusively by the carotid system, in type II, both the carotid and the vertebral-basilar systems participated in brain irrigation, and in type III, only the vertebral-basilar system supplied blood to the brain. Type II was further subdivided into subtypes α , β and γ . In subtype II α (alpha), the internal carotid artery bisected into cranial and caudal terminal branches, but the latter was not directly linked to the basilar artery. It ended as the posterior cerebral artery and anastomosed with the branch of the basilar artery which resulted from the union of the vertebral arteries. In this case, the anterior, middle and posterior arteries derived from the internal carotid arteries. In subtype II β , the basilar artery was more important, and the posterior cerebral arteries were terminations of its division branches that anastomosed with the caudal terminal branches of the internal carotid arteries; these branches were less developed than in subtype II α . In subtype II β , the anterior and middle cerebral arteries derived from the internal carotid artery, whereas the posterior cerebral artery had a vertebral origin. Finally, in subtype II γ , the internal carotid arteries had no caudal terminal branches, but there was a single cranial terminal branch which originated from the middle and anterior cerebral arteries. The basilar artery was derived from the anastomosis of the vertebral arteries and bisected into two branches which anastomosed with the internal carotid arteries after the latter had crossed the dura mater. The posterior cerebral arteries were

collaterals of the terminal branches of the basilar artery, and thus belonged to the vertebral arterial domain.

According to Alcântara and Prada [1], the formation of the arterial circle in dogs belonged to subtypes II α and II β [6]. When we examined these vessels, which close the arterial circle of the pampas fox caudally, we observed that the caudal cerebral arteries were dependent on the caudal branches of the carotid system. In a few specimens, and not always in both antimeres, the caudal cerebral artery depended on concurrent blood flow from both the caudal branch of the internal carotid artery and the terminal branch of the basilar artery. This predominance of the carotid system allowed us to classify the arterial circle of the *D. gymnocercus* as essentially subtype II α , with a slight tendency to subtype II β .

ACKNOWLEDGMENTS

The authors thank the Brazilian Institute of the Environment (IBAMA) for allowing capture of the specimens. This work is part of a masters dissertation by J.S.D.

REFERENCES

1. Alcântara MA, Prada ILS (1996a) Artérias da base do encéfalo de cães (*Canis familiaris*, L., 1758). I. Estudo anatômico de suas origens e comportamento. *Braz. J. vet. Res. anim. Sci.* **33**, 67-71.
2. Alcântara MA, Prada ILS (1996b) Artérias da base do encéfalo de cães (*Canis familiaris*, L., 1758). II. Formação e comportamento do circuito arterial do encéfalo. *Braz. J. vet. Res. anim. Sci.* **33**, 72-76.
3. Anderson WD, Kubicek W (1971) The vertebral-basilar system of dog in relation to man and other mammals. *Am. J. Anat.* **132**, 179-188.
4. De La Torre E, Mitchell OC, Netsky MG (1962) Anatomic and angiographic study of the vertebral-basilar arterial system in the dog. *Am. J. Anat.* **110**, 187-197.
5. De La Torre E, Netsky MG, Meschan I (1959) Intracranial and extracranial circulations in the dog: anatomic and angiographic studies. *Am. J. Anat.* **105**, 343-381.
6. De Vriese B (1905) Sur la signification morphologique des artères cérébrales. *Arch. Biol.* **21**, 357-457.
7. Gillilan LA (1976) Extra- and intra-cranial blood supply to brains of dog and cat. *Am. J. Anat.* **146**, 237-254.
8. International Committee on Veterinary Gross Anatomical Nomenclature (1994) *Nomina Anatomica Veterinaria*. 4th edn. Publisher: New York.
9. Jewell PA (1952) The anastomoses between internal and external carotid circulations in the dog. *J. Anat.* **86**, 83-94.
10. Tandler J (1898) Zur vergleichenden anatomie der Kopfarterien bei den Mammalia. *Denkschr. Akad. Wiss.* **67**, 677-779.
11. Wiland C (1966) The basilar artery of the brain (*a. basilaris cerebri*) in foxes. *Folia Morphol.* **25**, 603-607.

Received: February 19, 2003

Accepted: July 28, 2003