Branching pattern of aortic arch in the white-eared opossum (*Didelphis albiventris*)

Ramescência do arco aortico no gambá-de-orelha-branca (Didelphis albiventris)

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Abstract

Knowledge of the aortic arch main and collateral branches is important because these arteries supply vital organs found in the head, neck, thoracic cavity and forelimbs of domestic and wild animals. This study aimed to contribute to the anatomical knowledge in opossums and collaborate with veterinary medical and surgical clinics. Thus, the anatomy of aortic arch was described in eighteen opossums. The results indicated that the aortic arch gives off the brachiocephalic trunk and the left subclavian artery in all animals studied. The branching pattern of the aortic arch is similar to that reported in the guinea pig, chinchilla, paca, raccoon, nutria, red squirrel, and ocelot. The brachiocephalic trunk showed as collateral branches, the right subclavian artery and the bicarotid trunk, that originated in the right and left common carotid arteries (77.7%). Bicarotid trunk was absent in four animals (22.2%). The right and left subclavian arteries originated in the vertebral artery, costocervical trunk, internal thoracic artery, and superficial cervical artery. Collateral branches of the subclavian artery showed similarities to that observed in other wild animals such as paca, ocelot and rock cavy.

Keywords: Marsupial. Aorta Artery. Heart. Wildlife. Opossum.

Resumo

O conhecimento do comportamento das artérias que emergem do arco aórtico é importante, pois estas artérias irrigam órgãos vitais encontrados na cabeça, pescoço, cavidade torácica e membros torácicos de animais domésticos e selvagens. Com o objetivo de contribuir com o conhecimento anatômico em gambás e colaborar com a clínica médica e cirúrgica de animais selvagens, descreveu-se neste estudo, a ramescência do arco aórtico em dezoito gambás. Os resultados indicaram que o tronco braquiocefálico e a artéria subclávia esquerda se originaram do arco aórtico em todos os animais estudados. Este padrão de ramescência do arco aórtico é similar ao descrito para a cobaia, chinchila, paca, mão-pelada, nutria, esquilo-vermelho e jaguatirica. O tronco braquiocefálico apresentou como ramos colaterais, a artéria subclávia direita e o tronco bicarotídeo, o qual se bifurcou nas artérias carótidas comuns direita e esquerda (77,7%). O tronco bicarotídeo não apareceu em quatro animais (22,2%). As artérias subclávias direita e esquerda originaram a artéria vertebral, o tronco costocervical e, as artérias torácica interna e cervical superficial. A ramescência encontrada nas artérias subclávias do gambá mostrou similaridades quando comparada com a descrita para outros animais selvagens como a paca, jaguatirica e o mocó.

Palavras-chave: Marsupial. Artéria aorta. Coração. Animais selvagens. Gambá.

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Introduction

The opossum is an animal belonging to the Marsupialia order and Didelphidae family (ZELLER, 1999). Two species appear in the neotropics, the black-eared opossum (*Didelphis aurita*), and white-eared opossum *(Didelphis albiventris*) (EMMONS; FEER, 1990). Marsupials are characterized by having well-developed pouches, where females carry newborns. The presence of the pouch is very important for these mammals, since the postnatal development of neonates

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is completed in the pouch (LIMA et al., 2013). These animals have solitary nocturnal habits and have numerous offspring. They are omnivores and eat small vertebrates like rodents and amphibians, birds, eggs, fruits and vegetables (CULAU et al., 2010).

Many species of opossum have been created and used in laboratories, opening a wide field for the study and knowledge of habits, diseases, diet and reproduction of these animals (BERTASSOLI et al., 2013). Moreover, the opossum, an animal that inhabits the Cerrado, has aroused the interest of several researchers and has been the target of several morphological reports, such as the sacral branching of the abdominal aorta (PINTO E SILVA; BOARO MARTINS, 2004), the anatomy of celiac artery (CULAU et al., 2010), the morphology of the pineal gland (MANÇANARES et al., 2007), the anatomy and histology of the penis (MATHEUS et al., 2011), the anatomy and histology of the stomach, featuring its endocrine cells (SANTOS, 2012), and the morphology of the larynx and trachea (BERTASSOLI et al., 2013).

The blood supply to the head, neck, thoracic cavity and forelimbs of domestic and wild animals comes from the aorta through the branches of the aortic arch. The aortic arch, in turn, gives rise to the subclavian arteries and common carotid arteries. In large animals, these vessels join to form a short brachiocephalic trunk, directed cranially; whereas in canine and porcine species, the left subclavian artery remains distinct and has a separate and more distal origin. The right and left common carotid arteries supply the structures of the head, whereas the right and left subclavian arteries supply mainly forelimbs and structures of the neck and the cervicothoracic junction (DYCE et al., 2010).

The arterial patterns of arteries originating from the aortic arch have been studied in several mammals. There are descriptions of the aortic arch in domestic and wild animals such as armadillo (SOUZA et al., 1998; DOMENICONI et al., 2004), water buffaloes (CORTELLINI et al., 2000), carnivores (FERRIGNO et al., 2001; KIM et al., 2006), small rodents and lagomorphs (KABAK; HAZIROGLU, 2003; ÖZTÜRK et al., 2003; ARAÚJO et al., 2004; ÖZDEMIR et al., 2008; AYDIN, 2011), paca (OLIVEIRA et al., 2001), porcupine (ATALAR et al., 2003), raccoon (SANTOS et al., 2004), capybara (CULAU et al., 2007), ocelot (MARTINS et al., 2010), nutria (CAMPOS et al., 2010), and deer (FUKUTA et al., 2003; AHN et al., 2008; SCHIMMING et al. 2012; PÉREZ; ERDOGAN, 2014).

The first study of the aortic arch in opossums was reported by Souza et al. (1982), where the authors cited that the bicarotid trunk and right subclavian artery branched off from the brachiocephalic trunk. Later, the branching pattern was reported in another study of the aortic arch in the same animal (RECKZIEGEL et al., 2003). However, these authors reported only the branches of aortic arch. There was no information on branches of subclavian artery in the opossum. Thus, the aim of this study was to describe the collateral branches of the aortic arch and, for the first time, the branching of subclavian artery in *Didelphis albiventris*.

Material and Methods

This study followed the guidelines for the care and use of laboratory animals and was approved by the Animal Use and Ethics Committee (CEUA 626/2014) and by the National Environmental and Wildlife Bureau (SISBIO 44768-2).

Eighteen (ten females and eight males) adult opossums (*Didelphis albiventris*) were used in this study. The animals came from the Center for Medicine and Research Wildlife (CEMPAS), Faculty of Veterinary Medicine and Animal Science, UNESP, Botucatu. All died in CEMPAS, for reasons inherent in this study. After death, the animals were sent to the Veterinary Anatomy Laboratory, Department of Anatomy, Institute of Biosciences of Botucatu, UNESP. The thoracic cavity was opened in the left antimere, in the fourth intercostal space, and then the thoracic portion of the aorta artery was dissected and cannulated. The vessel was injected with Neoprene Latex 650® solution (Du Pont of Brazil S.A.), stained with red pigment (Suvinil - BASF S.A.). The animals were then fixed in 10% formaldehyde. After fixation,

the dissection of the arterial system was performed, proceeding to the opening of the ribcage to expose the heart and the aortic arch. The branches of the aortic arch and branching of the right and left subclavian arteries were dissected. The results were outlined, photodocumented and named, according to Nomina Anatomica Veterinaria (ICVGAN, 2012).

Results

Two arteries branched off from aortic arch in white-eared opossums, the brachiocephalic trunk and the left subclavian artery. In this study, we found two patterns of branching of the brachiocephalic trunk. This trunk gives off the right subclavian artery and the bicarotid trunk in 14 animals (77.7%). The bicarotid trunk branched to the right and left common carotid artery (Figures 1A and 2A). The bicarotid trunk was absent in four animals (22.2%). In these possums, the brachiocephalic trunk branches off the right subclavian artery and right and left common carotid arteries (Figures 1B and 2B).

The right subclavian artery arose from the brachiocephalic trunk, while the left subclavian artery originated directly from the aortic arch in all animals studied. The right and left subclavian arteries give off branches in its intrathoracic course, from the cranial to the lateral way: vertebral artery, costocervical trunk, and internal thoracic and superficial cervical arteries. The internal thoracic artery originated ventrally from the right and left subclavian arteries. In seven cadavers (38.8%), the vertebral artery and costocervical trunk emerged from a common root that branched off from the subclavian artery (Figures 3B and 4A). This common root was not observed in eight animals (44.4%) (Figures 3A and 4B). The superficial cervical artery was the last branch of the subclavian artery in 15 animals (83,2%). The internal thoracic artery emerged as the last branch of the subclavian artery in three animals (16.6%) (Figures 3C and 4C). The right and left axillary arteries seemed to be a continuation of subclavian arteries (Figures 3 and 4). There were no differences between the right and left antimeres of the white-eared opossums analyzed in this study. Therefore, there were no differences in branching pattern with respect to the sex of animals.

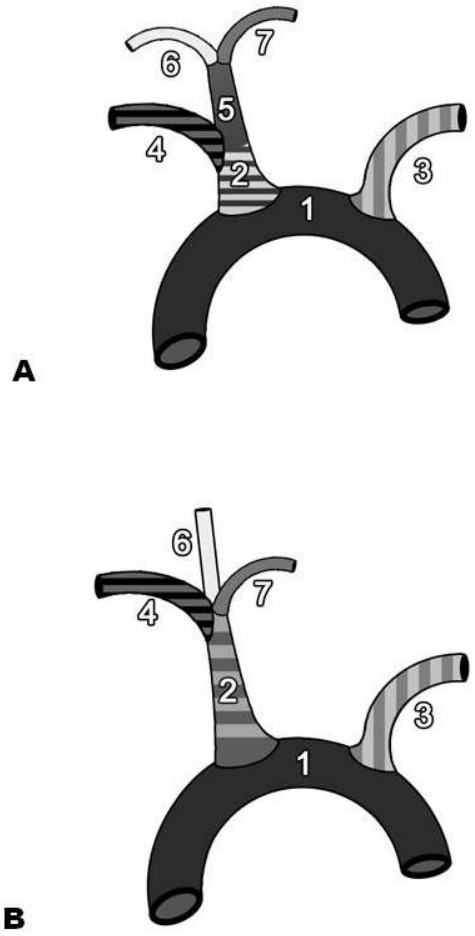

Figure 1 – Schematic representation of aortic arch in the *Didelphis albiventris*. Aortic arch (1), brachiocephalic trunk (2), left subclavian artery (3), right subclavian artery (4), bicarotid trunk (5), right common carotid artery (6), and left common carotid artery (7)

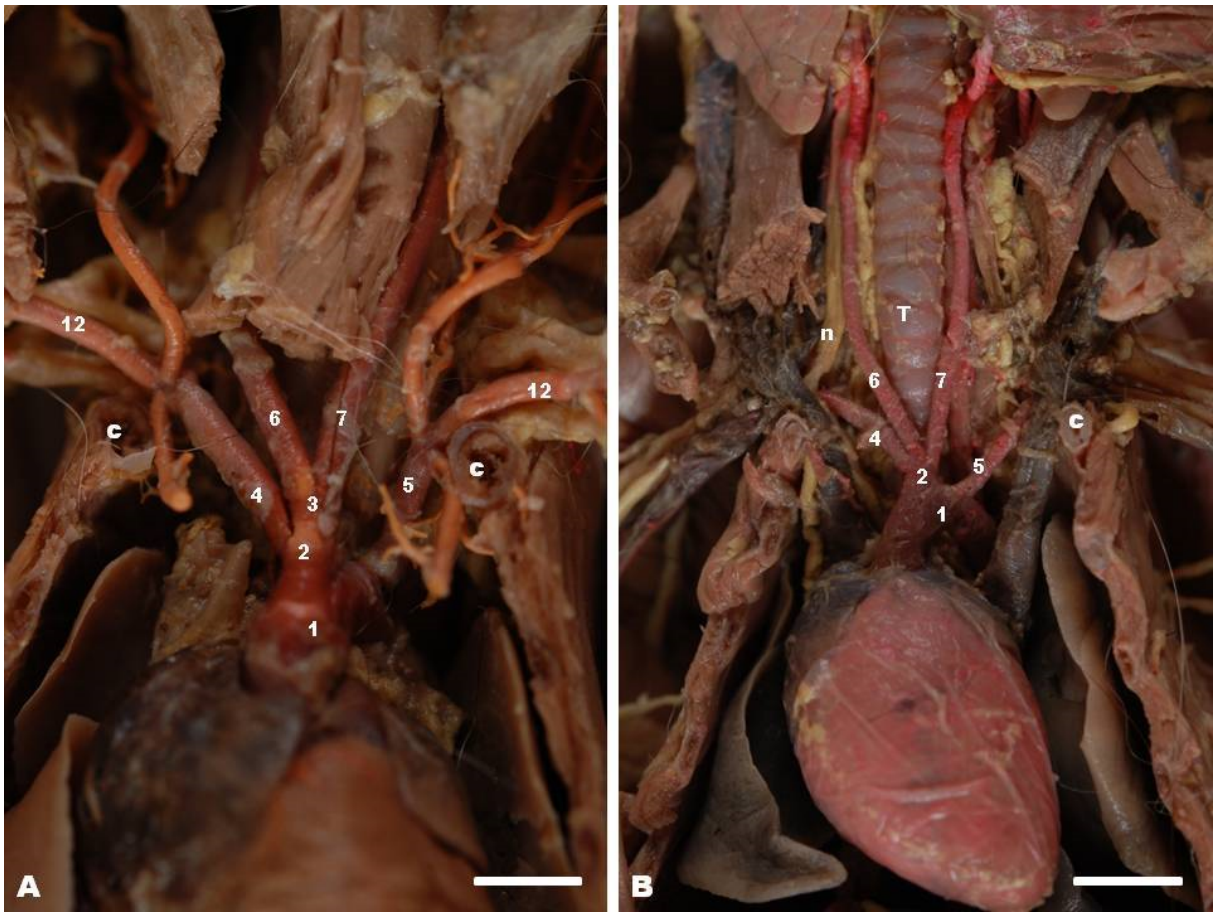

Figure 2 – Aortic arch in *Didelphis albiventris*. Aortic arch (1), brachiocephalic trunk (2), bicarotid trunk (3), right subclavian artery (4), left subclavian artery (5), right common carotid artery (6), left common carotid artery (7), axillary artery (12), trachea (T), first rib (C), and vagus nerve (n). Bar = 1,5 cm

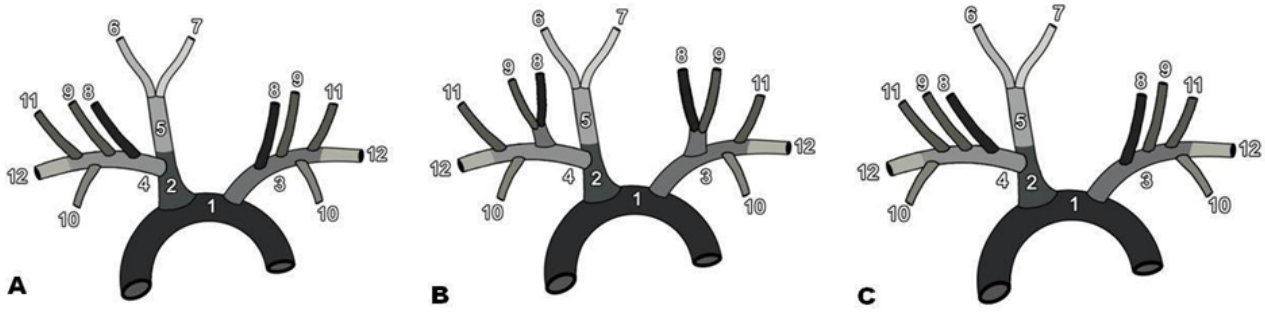

Figure 3 – Schematic representation of branching pattern of right and left subclavian arteries in the *Didelphis albiventris*. Aortic arch (1), brachiocephalic trunk (2), left subclavian artery (3), right subclavian artery (4), bicarotid trunk (5), right common carotid artery (6), left common carotid artery (7), vertebral artery (8), costocervical trunk (9), internal thoracic artery (10), superficial cervical artery (11), and axillary artery (12)

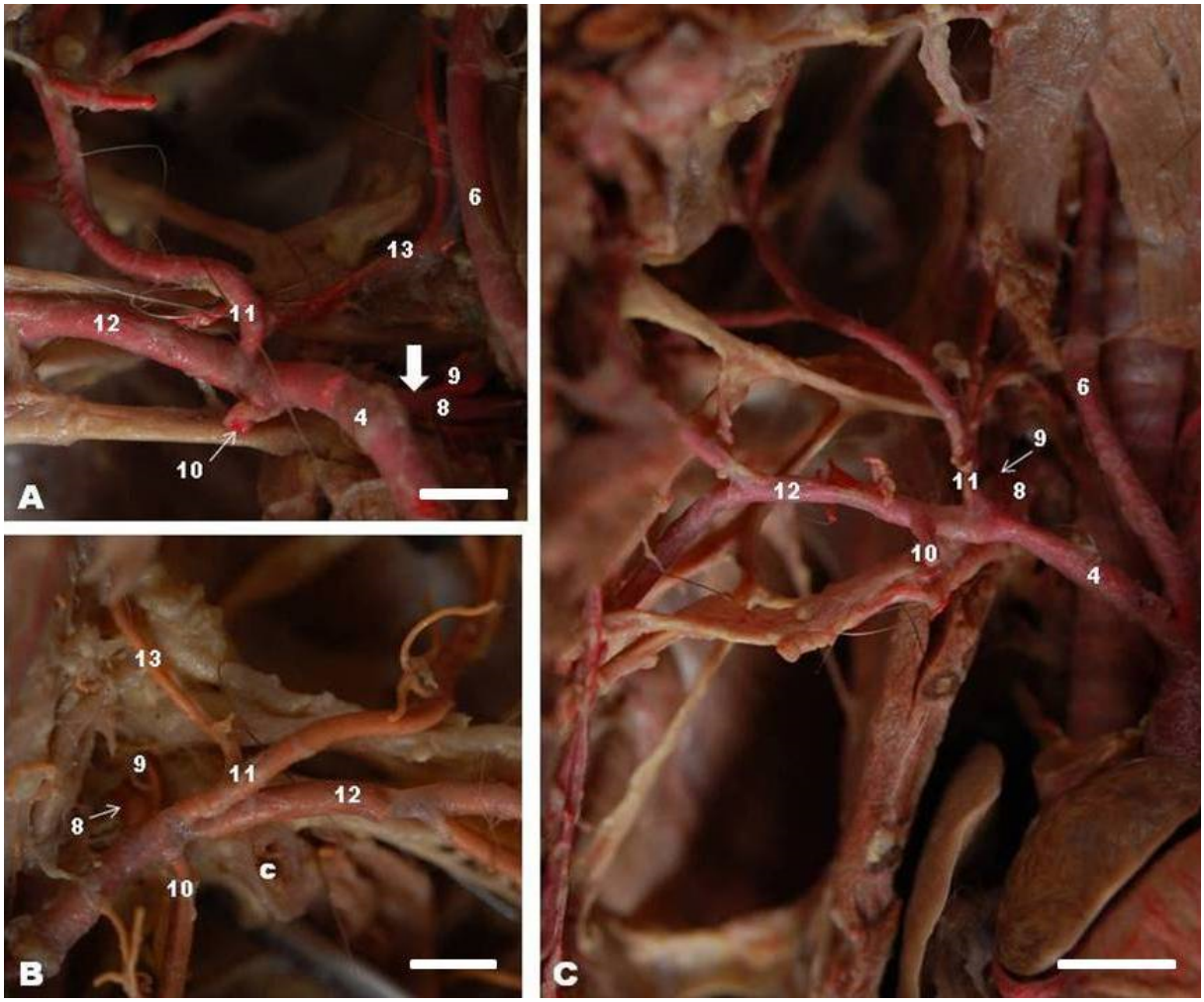

Figure 4 – Branching pattern of subclavian artery in the *Didelphis albiventris*. Right subclavian artery (4), right common carotid artery (6), vertebral artery (8), costocervical trunk (9), common roof of origin of the vertebral artery and costocervical trunk (thick arrow), internal thoracic artery (10), superficial cervical artery (11), axillary artery (12), ascending branch of the superficial cervical artery (13), and first rib (c). Bar = 1,5 cm

Discussion

Anatomical knowledge of the arteries that originate from the aortic arch is important because these arteries supply vital organs found in the head, neck, thoracic cavity and forelimbs of domestic and wild animals. According to Özdemir et al. (2008), the vessels arising from the aortic arch may be different in number or origin according to the species studied and even in the same species.

In the white-eared opossums analyzed in this study, the aortic arch gives off brachiocephalic trunk and the left subclavian artery. This branching pattern of the aortic arch of the opossum is similar to domestic mammals such as dogs and pigs (DYCE et al., 2010). This same branching pattern of the aortic arch was confirmed in another preliminary study with *Didelphis* (RECKZIEGEL et al., 2003), and with other animals as well as paca (OLIVEIRA et al., 2001), rabbits (ÖZTÜRK et al., 2003), chinchilla (ARAÚJO et al., 2004, ÖZDEMIR et al., 2008), guinea pig (KABAK; HAZIROGLU, 2003), raccoon (SANTOS et al., 2004), rock cavy (MAGALHÃES et al., 2007), nutria (CAMPOS et al., 2010), ocelot (MARTINS et al., 2010), and in red squirrels (AYDIN, 2011). However, in other

animals such as buffalo (CORTELLINI et al., 2000), capybara (CULAU et al., 2007), Korean water deer (AHN et al., 2008), horse and cow (DYCE et al., 2010), brown brocket and pampas deer (SCHIMMING et al., 2012; PÉREZ; ERDOGAN, 2014), the brachiocephalic trunk was the only branch of the aortic arch of the aorta. In the porcupine, the collateral branches of the aortic arch were the brachiocephalic trunk, and the left common carotid and left subclavian arteries (ATALAR et al., 2003). Reckziegel et al. (2003) described in four *Didelphis*, the aortic arch giving rise to right and left subclavian arteries and bicarotid trunk. However, we did not observe this pattern in the white-eared opossums studied.

In our study, two branching patterns of the brachiocephalic trunk were found. The brachiocephalic trunk gives off the right subclavian artery and bicarotid trunk in 14 animals. The brachiocephalic trunk originated right subclavian artery, and right and left common carotid artery in the four animals. In the preliminary study with opossums, Reckziegel et al. (2003) reported that the brachiocephalic trunk gives off right subclavian artery and bicarotid trunk in 82.15% of the animals. However, these authors found other branching patterns of the brachiocephalic trunk, which were not observed in this study. Therefore, in our study, the bicarotid trunk was found in 77.7% of the animals. In another study of opossums, this trunk was present in 96.15% of the cadavers (SOUZA et al., 1982). The bicarotid trunk commonly appears in large animals such as horses and domestic ruminants (DYCE et al., 2010), in rock cavy (MAGALHÃES et al., 2007), and in pampas deer (PÉREZ; ERDOGAN, 2014), but was not observed in the armadillo (SOUZA et al., 1998), buffalo (CORTELLINI et al., 2000), paca (OLIVEIRA et al., 2001), porcupine (ATALAR et al., 2003), ocelot (MARTINS et al., 2010), and in the brown brocket and axis deer (SCHIMMING et al., 2012; PÉREZ; ERDOGAN, 2014).

In small rodents such as guinea pig (KABAK; HAZIROGLU, 2003) and chinchilla (ÖZDEMIR et al., 2008), the subclavian artery gives off the following collateral branches: costocervical trunk, and internal thoracic, vertebral, dorsal scapular and superficial cervical arteries. In the white-eared opossums, the right and left subclavian arteries originated costocervical trunk, and vertebral, internal thoracic and superficial cervical arteries. The dorsal scapular artery was not observed as a collateral branch of the subclavian artery. This same artery was also not observed in other wild animals such as paca (OLIVEIRA et al., 2001) and porcupine (ATALAR et al., 2003). The present results are in agreement with the reports on paca (OLIVEIRA et al., 2001), rock cavy (MAGALHÃES et al., 2007), ocelot (MARTINS et al., 2010), and red squirrels (AYDIN, 2011). In dogs, the dorsal scapular artery has been considered a collateral branch of the costocervical trunk, which supply the serratus ventralis muscle and not a collateral branch of the subclavian artery (EVANS; DE LAHUNTA, 2013). Different from this study, where the vertebral artery was a separate branch of the subclavian artery, the vertebral artery was a branch of the costocervical trunk in the raccoon (SANTOS et al., 2004), water deer (AHN et al., 2008), and pampas and brown brocket deer (PÉREZ; ERDOGAN, 2014). In addition, in the white-eared opossum, the costocervical trunk and vertebral artery originated from a common root in the seven animals, similar to that reported in branching of the right subclavian artery in porcupine (ATALAR et al., 2003).

Conclusion

This study examined the branching pattern of the aortic arch and subclavian artery in white-eared opossums. The aortic arch branches off to two major vessels: the brachiocephalic trunk and the left subclavian artery, as reported in other animals such as guinea pig, paca, raccoon, nutria, red squirrel, ocelot, and chinchilla. The branching pattern of the subclavian artery was examined for the first time in these animals. The vessels originating from the right and left subclavian artery showed similarities when compared with other wild animals such as paca, ocelot, and rock

cavy. Variations in number and in distribution of the vessels analyzed in this study were independent of gender and antimeres. The results of this study can contribute to the basic anatomical knowledge about opossums and collaborate with wildlife medical and surgical clinics.

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