



## Characterization of coronary arteries in Giant Anteater (*Myrmecophaga tridactyla*: Myrmecophagidae)

[*Caracterização da artéria coronária em tamanduá-bandeira (Myrmecophaga tridactyla*:  
Myrmecophagidae)]

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### ABSTRACT

Were used twelve (12) adult anteaters (*Myrmecophaga tridactyla*), adults, 6 (six) males and 6 (six) females, weighing from 20 to 27.32kg from free life. The thoracic cavity was opened until visualization of the whole heart and lungs and later injection of the coronary vessels. The right coronary artery emerged through a single coronary ostium of the aorta, 50%, emitting the *intermediate* branch and the subsinuous interventricular branch, had a path directed to the subsurface interventricular groove. In the other 50%, the right coronary artery was not present, showing only its branches, intermediate branch and subsurface interventricular branch with emergence of the aorta. Left coronary artery presented, in 83.33%, origin from the aorta in single ostium, issuing the circumflex and interventricular paraconal branches. In 16.66%, the left coronary artery was not evidenced originating from the aorta, but its branches, circumflex and interventricular paraconal.

Keywords: heart, coronary artery, wild animals, giant anteaters

### RESUMO

Foram utilizados 12 tamanduás-bandeira (*Myrmecophaga tridactyla*), adultos, sendo seis machos e seis fêmeas, pesando de 20 a 27,32kg, provenientes de vida livre. Foi realizada abertura da cavidade torácica até a visualização do conjunto coração e pulmões e, posteriormente, injeção dos vasos coronários. A artéria coronária direita emergia, 50% dela, por um único óstio coronário da aorta, emitindo o ramo intermédio e o ramo interventricular subsinuoso; tinha trajeto direcionado ao sulco interventricular subsinuoso. Nos outros 50%, a artéria coronária direita não estava presente, exibindo somente seus ramos, ramo intermédio e ramo interventricular subsinuoso com emergência da aorta. A artéria coronária esquerda apresentou, em 83,33%, origem a partir da aorta em óstio único, emitindo os ramos circunflexo e interventricular paraconal. Em 16,66%, a artéria coronária esquerda não foi evidenciada originando-se da aorta, mas, sim, de seus ramos, circunflexo e interventricular paraconal.

Palavras-chave: coração, artéria coronária, tamanduá-bandeira

### INTRODUCTION

The heart is an organ with great functional importance, considering that a great amount of the human population suffers from functional problems which might require a transplant or

even new experimental and remodeling techniques (Taylor *et al.*, 2007; Copeland *et al.*, 2004; Morgan *et al.*, 2004; Hanes *et al.*, 2015). The organ has a specialized arterial supply, the right and left coronary arteries, which originate from the aorta (Schummer *et al.*, 1981; Ghoshal and Getty, 1986; Ghoshal, 1986, Oliveira, 2013).

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These arteries can vary as to their origin, path and number (Schlesinger *et al.*, 1949; Cervený and Kaman, 1963; Schummer *et al.*, 1981; Ghoshal and Getty, 1986; Vicentini *et al.*, 1991; Valentina *et al.*, 2003; Olabu *et al.*, 2007; Yuan *et al.*, 2009; Agustin *et al.*, 2010; Srour, 2011; Kareem *et al.*, 2014)) and they can be presented completely intramyocardial (Sans Coma *et al.*, 1993) or partially (Bezerra *et al.*, 1985 and Machado *et al.*, 2002). In instances where part of the artery is covered by the myocardium, structures called myocardial bridges can be observed and their functions are widely discussed (Berg, 1964 and Corban *et al.*, 2014).

The right and left coronary arteries emerge from the aorta, each one presenting a single coronary ostium (Schummer *et al.*, 1981; Ghoshal and Getty, 1986; Ghoshal, 1986, Valentina *et al.* 2003 and Oliveira *et al.*, 2013). There are cases in calves and humans with only one coronary artery being responsible for the whole heart's irrigation, presenting only one ostium from the aorta (Cervený and Kaman, 1963 and Koizumi *et al.*, 2000) and in the Syrian Hamster and man, where the left coronary artery is absent, presenting only the branches originating from the aorta (Durán *et al.*, 2006 and Ajayi *et al.*, 2015).

The left coronary artery is divided into paraconal interventricular branch and circumflex branch in donkeys (Ozgel *et al.*, 2004), North American beavers ((Bisaillon, 1981), rabbits (Dursun *et al.*, 1996), crab-eating macaques (Buss *et al.*, 1982; Mandarin and Hureau, 1986; Teofilovski-Parapid *et al.*, 1993; Shimada *et al.*, 1994; Teofilovski-Parapid and Kreclovi, 1998), ruminants (Schummer *et al.*, 1981; Ghoshal and Getty, 1986; Oliveira *et al.*, 2013), spotted pacas (Ávila *et al.*, 2009), porcupines (Atalar *et al.*, 2003) and pigs (Moura-Junior *et al.*, 2008), or it can trifurcate into another branch in rodents in a frequency up to 45% (Aikawa and Kawano, 1985; Sans Coma *et al.*, 1993) and green monkey (Valentina *et al.*, 2003). This branch can be named diagonal (Baptista *et al.*, 1991; Moura-Junior *et al.*, 2008; Sahni *et al.*, 2008; Oliveira *et al.*, 2010; Oliveira *et al.*, 2013), *ramus marginalis sinister* (Valentina *et al.*, 2003), obtuse marginal artery (Durán *et al.*, 2006) or *ramus marginis concavi* (Yuan *et al.*, 2009).

The right coronary artery is presented with different patterns among species, which can have

the subsinuosal interventricular branch in pigs and horses and in dogs and ruminants, the circumflex branch (Schummer *et al.*, 1981; Ghoshal and Getty, 1986; Ozgel *et al.*, 2004). In camels there can be the *ramus cone arteriosi*, which is directed to the arterial cone towards the cardiac apex (Yan *et al.*, 2009).

Apart from the heart's importance to the organism function, *Myrmecophaga tridactyla* is included in the "vulnerable" category on the List of Brazilian Fauna Threatened Species (MMA 2003 and Medri and Mourão, 2008), being listed on the "Appendix II" of CITES (Brasil, 2009). Nowadays this species is included in the "vulnerable" category of The IUNC Red List of Threatened Species (Red..., 2012).

Given the great importance of this species and the need for comparative studies, this research describes the vascular architecture of the coronary arteries, aiming to establish a coronary pattern of the species.

## MATERIALS AND METHODS

This study analyzed 12 adult Giant anteaters (*Myrmecophaga tridactyla*), 6 them were males and 6 females, weighing from 20 to 27,32kg. All animals were free-living and were donated by the Department of Wildlife Clinical and Surgical Care (SACCAS) of the Veterinary Hospital "Dr. Halim Atique" and properly sent to the Veterinary Anatomy Laboratory from the University Center of Rio Preto (UNIRP). The research had authorization of the Ethics Committee on Animal Use from the Faculty of Veterinary Medicine and Animal Science, University of Sao Paulo nº 2583/2012.

The thoracic cavity was opened by a scalpel incision of the skin and muscles and removal of the sternum by rupturing the costochondral joints. Subsequently, the heart and lungs were identified. The set of lungs and heart was removed and after isolating the heart it was performed the injection of a latex substance<sup>1</sup> colored with a specific pigment<sup>2</sup> at the origin of both coronary arteries, then fixated in a 10% Formaldehyde solution for 72 hours. After this time, the coronary arteries were dissected, and the results found in each specimen were registered. The Nomina Anatomica Veterinária

(2017) for the description of the anatomical structures.

## RESULTS

In 50.0% of the animals studied the right coronary artery emerged through a single coronary ostium of the aorta emitting the intermediate branch, which continues under the arterial cone towards the cardiac apex, and the subsinuous interventricular branch, which had a path directed to the subsurface interventricular groove (Figure 1). In the other 50.0% the right coronary artery was absent, showing only its branches, the intermediate branch and subsinuous interventricular branch emerging from the aorta (Figure 2A e 2B), taking the same trajectory. It always presented its trajectory superficial to the epicardium.

The left coronary artery has its trajectory upon the epicardium and presented, in 83.33% of the cases, its origin from the aorta in a single ostium, emitting the circumflex and paraconal interventricular branches (Figure 3). The circumflex branch ran through the coronary sulcus in cranial direction, when in the cranial border of the organ, emitted the left marginal artery. The paraconal interventricular branch coursed the paraconal interventricular sulcus ending at the cardiac apical incisure. This branch emitted during its trajectory the intermediate branch, which is more evident and several septal branches (Figure 4). In 16.66%, the left coronary artery was not detected originating from the

aorta, but from its circumflex and paraconal branches, presenting ostio emerging directly from the aorta (Figure 2).

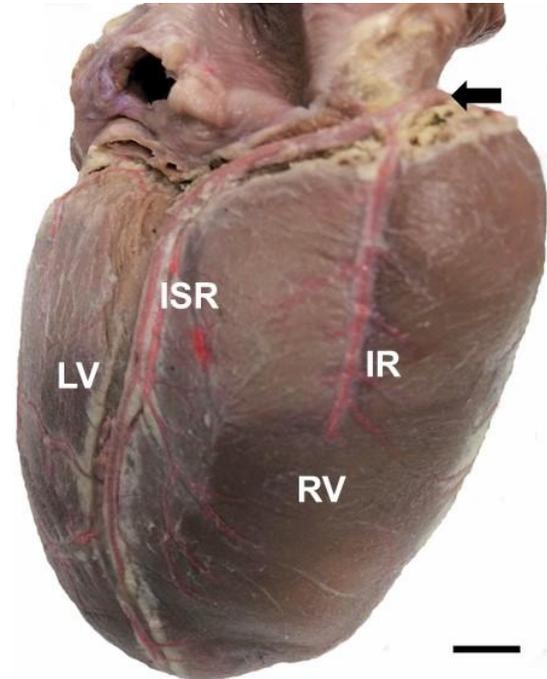


Figure 1. Photograph of the atrial face of the giant anteater heart (*Myrmecophaga tridactyla*). Observe the right coronary artery (arrow) by issuing the interventricular subsinuous branch (ISR) and the intermediate branch (IR), right ventricle (RV) and Left ventricle (LV).

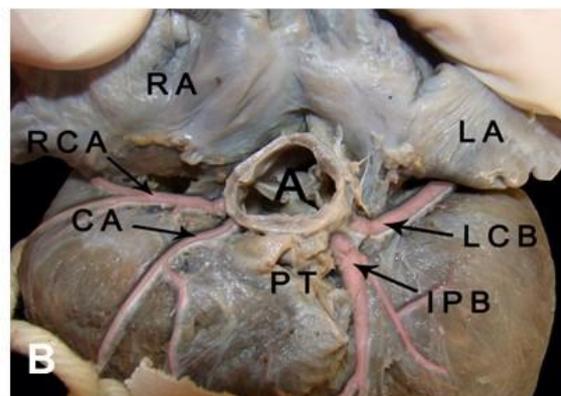
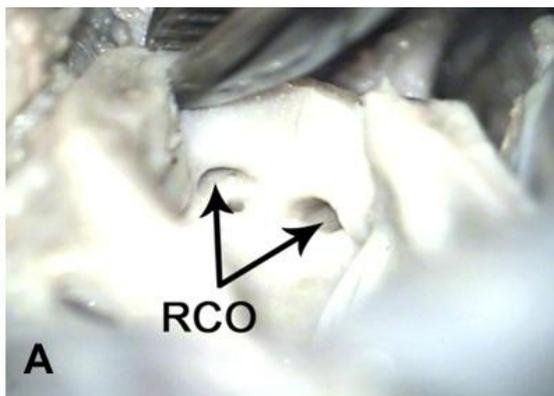


Figure 2. A) Photograph of the right coronary ostio (RCO) of the Giant Anteater, resulting in the right circumflex branch and the conal artery. (20X magnification). B) Photograph of the heart base of the giant anteater (*Myrmecophaga tridactyla*). We observe the right auricle (RA), left auricle (LA), aorta (A), pulmonary trunk (PT), right coronary artery (RCA), conal artery (CA), interventricular paraconal branch (IPB) and left circumflex branch (LCB).

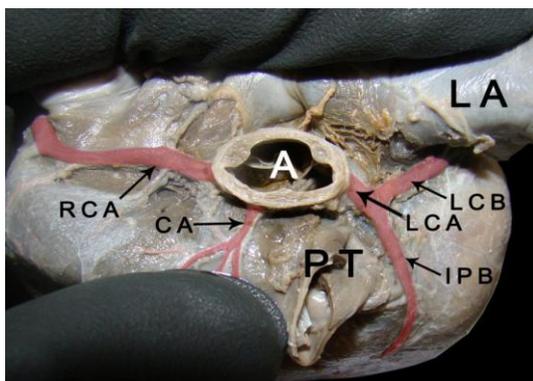


Figure 3. Photograph of the heart base of the Giant Anteater. We observe the left auricle (LA), aorta (A), pulmonary trunk (PT), right coronary artery (RCA), conal artery (CA), left coronary artery (LCA), interventricular paraconal branch (IPB) and left circumflex branch (LCB).

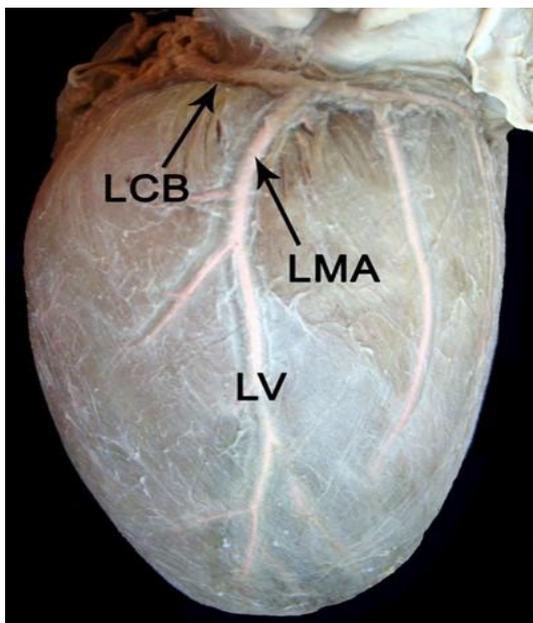


Figure 4. Photograph of the cranial face of the heart of the Giant Anteater. We observe the left circumflex branch (LCB) starting the left marginal artery (LMA), which goes towards the cardiac apex (LV).

### DISCUSSION

The right and left coronary arteries were present superficially to the epicardium and it was not observed deepening vessels in any of the animals as related in other species Sans Coma *et al.* (1993), Bezerra *et al.* (1985), Machado *et al.* (2002). They are the heart suppliers, beginning in

the right and left aortic sinuses, therefore, occupying the atrioventricular and interventricular coronary sulcus (Schummer *et al.*, 1981; Ghoshal and Getty, 1986; Valentina *et al.*, 2003; Oliveira *et al.*, 2013) including in giant anteaters.

The right coronary artery was observed with its emission from the aorta as reported by Banchi (1904), Abramson and Eisenberg (1935), Schlesinger *et al.* (1949), Ghoshal and Getty, (1986), Vicentini *et al.* (1991), Machado *et al.* (2002), Pérez and Lima (2006), Rade *et al.* (2006), Olabu *et al.* (2007), Moura-Junior *et al.* (2008), Yuan *et al.* (2009), Agustín *et al.* (2010), Tenani *et al.* (2010), Srour (2011) and Oliveira *et al.* (2013). It is worth mentioning this statement was evidenced in 50% of the animals studied. In 16.66% of the cases, in Giant Anteaters, the left coronary artery was absent, presenting only its paraconal interventricular and circumflex branches, a fact also observed by Vicentini (1991), who evidenced in guinea pigs four branches originating from the aorta, and by Tenani *et al.* (2010) in capybaras, where in 3.3% of the cases the paraconal interventricular and circumflex branches of the left coronary artery have their origin directly from the aorta. In 50% of the Giant Anteaters, the right coronary artery presented only its branches emerging from the aorta, this variation was also reported in other mammal species, like the Syrian hamster (Durán *et al.*, 2006) and even in humans (Ajayi *et al.*, 2014). This variation, as to the presence, was evidenced in Syrian hamster with a lot of consanguinity (Durán *et al.*, 2006), which could also happen in Giant Anteaters, considering they are found in the “vulnerable” list of animals. The subsinuosal interventricular branch, which is one of the branches of the right coronary artery, is similar to those of swines and equines (Schummer *et al.*, 1981 and Ghoshal and Getty, 1986) donkeys (Ozgel *et al.*, 2004) and Angora rabbits (Bahar *et al.*, 2007).

The other branch was named intermediate branch due to the fact of the *Nomina Anatomica Veterinária* (2017) report the presence of the branch in the left coronary artery, and, in Giant Anteaters, this branch presents itself basically at the same position of this branch of the left coronary artery. This vessel was reported in Angora rabbits (Bahar *et al.*, 2007), also belonging to the right coronary artery as the *r.*

*intermedius atrii dextri*, in donkeys (Ozgel *et al.*, 2004) as the *ramus marginalis convexi* and in camels Yuan *et al.* (2009) as the *ramus cone arteriosi*. In carnivores, sometimes an accessory right coronary artery emerged from the aorta, close to the origin of the right coronary artery, and that normally ended around the arterial cone (Ghoshal and Getty, 1986). The same observation was found in humans (Schlesinger *et al.* 1949), however, describing the existence of a third coronary artery, the conal artery, with direct origin from the aorta or with its origin in the right coronary artery. As reported above, in 50% of the Giant Anteaters, it was evidenced the intermediate branch emerging directly from the aorta. This artery has the function of nurturing the arterial cone region, besides being an alternative route of blood supply (Schlesinger *et al.* 1949; Vicentini *et al.*, 1991; Olabu *et al.*, 2007; Yuan *et al.*, 2009; Agustín *et al.*, 2010 and Srour, 2011). In the present study, it was observed in 100% of the hearts from the Giant Anteaters the presence of the intermediate branch, where 50% presented its own coronary ostium from the aorta and in the other 50% with its origin from a common ostium with the right coronary artery.

The left coronary artery was present in 83,66% of the cases in Giant Anteaters, dividing itself in circumflex and paraconal interventricular branches as well as in donkeys (Ozgel *et al.*, 2004), guinea pigs (Vicentini *et al.*, 1991), capybaras (Tenani *et al.*, 2010), North American beavers (Bisaillon, 1981), camels (Yuan *et al.*, 2009), rabbits (Dursun *et al.*, 1996); dolphins (Pérez and Lima 2006), monkeys (Abramson and Eisenberg 1935; Buss *et al.*, 1982; Mandarim and Hureau, 1986; Teofilovski-Parapid *et al.*, 1993; Shimada *et al.*, 1994; Teofilovski-Parapid and Kreclovi 1998; Rade *et al.*, 2006), spotted pacas (Ávila *et al.*, 2009), porcupines (Atalar *et al.*, 2003 and Srour, 2011), ruminants (Schummer *et al.*, 1981; Ghoshal and Getty, 1986; Machado *et al.*, 2002; Oliveira, *et al.*, 2013) and swines (Moura-Junior *et al.*, 2008). In 16,66% of the cases, this vessel did not present its origin from the aorta, but only its branches, a fact that has not been reported in literature. It was not observed absence of the left coronary artery, as reported in Syrian hamsters (Durán *et al.*, 2006) and humans (Ajayi *et al.*, 2015), or even the artery presenting itself duplicated (Kareem *et al.*, 2014).

As for the fact of the heart presenting a single vessel responsible for its supply such as in calves (Cervený and Kaman, 1963), Syrian hamsters (Durán *et al.*, 2006) or even in humans Koizumi *et al.* (2000), this aspect was not observed.

Regarding the coronary pattern, considering the classification proposed by Banchi (1904), for the present research, 91.66% of the Giant Anteaters presented the normal or balanced coronary pattern, where the right coronary artery provides the subsinuosal interventricular branch, and the left coronary artery provides the paraconal interventricular branch, a feature also observed in spotted pacas (Ávila *et al.*, 2009), in hearts of equines, swines and also, in 50.0% of the cats (Marques, 1962). In swines, the balanced pattern was the dominant (Pinto *et al.*, 2016). In 8.33% of the Giant Anteaters, the left coronary artery provides both the paraconal interventricular and the subsinuosal interventricular branches, therefore characterizing the type A coronary pattern or left, also evidenced in most ruminants, dogs, in 50% of the cats (Marques, 1962), in capybaras (Tenani *et al.*, 2010) and in the dolphin (Pérez and Lima, 2006).

There is a notable need of more profound studies in animals, since some of them could be presented as coronary model for studies, as already demonstrated in monkeys (Valentina *et al.*, 2003) and in bovines (Oliveira *et al.*, 2013).

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