Origin and antimeric distribution of brachial plexus nerves in *Alouatta guariba clamitans* Cabrera, 1940 (Primates: Atelidae)

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Abstract
The Southern brown howler monkey, *Alouatta guariba clamitans*, is one of the largest Neotropical primates. The objective of this study was to describe the origin and antimeric distribution of brachial plexus nerves in *A. g. clamitans* and, thereby, to provide information for comparative anatomy and for anatomy applied to loco-regional anaesthetic blocking in primates. For this purpose, a macrodissection of 10 thoracic limbs of corpses that were collected from highways was performed, and the corpses were stored in 10% formaldehyde solution. The brachial plexus was essentially formed from the ventral spinal branches of segments C5 to T1, although in one specimen the contribution of C4 and in another specimen the contribution of T2 was registered. There was a grouping of ventral branches in cranial, medium and caudal trunks, and branches of C5 and C7 were the ones that mostly contributed to the origin of nerves from the plexus. Comparatively, the brachial plexus from *A. g. clamitans* reflected characteristics that are typical in the primate order, but also of mammal species that require versatility and precision in movements of the thoracic limbs. On the basis of that similarity, it is proposed that anatomic landmarks for anaesthetic block techniques used in other primate species may be successfully applied to *A. g. clamitans*.

Keywords: Anaesthetic block, howler monkey, Neotropical primates, nervous system, thoracic limb

Introduction
The Southern brown howler monkey, *Alouatta guariba clamitans* Cabrera, 1940, is found in the east part of Brazil, along the Atlantic Forest, in the states of Espírito Santo, Rio de Janeiro, Minas Gerais, São Paulo, Paraná, Santa Catarina and Rio Grande do Sul, and also in the forest of Misiones Province, in Argentina (Gregorin 2006).

It belongs to the Atelidae family, is one of the largest Neotropical primates and feeds on a large amount of leaves (Drubbel & Gautier 1993). With an arboreal habitat, it takes to nearly every stratum of the forest, having a tolerance for modifications/disturbances in the environment (Bicca-Marques et al. 2013; Silva & Bicca-Marques 2013). Adult males of *A. g. clamitans* weigh an average of 6.7 kg, with females weighing an average of 4.4 kg (Smith & Jungers 1997).

The high density of human populations in the south and south-east regions of Brazil and the consequential destruction of their habitats have decreased the broad original distribution of *A. g. clamitans* to a few populations, restricted in isolated forestry fragments (Chiarello & Galetti 1994; Crockett 1998). The main threats comprise the expansion of farming activities and urbanisation, yellow fever epidemics, road kills on highways, accidents with power grids and hunting (Printes et al. 2001; Lokschine et al. 2007; Almeida et al. 2012). For these reasons, it is considered a vulnerable species in most Brazilian states (Bicca-Marques et al. 2015).

The brachial plexus is a complex anatomical structure formed by a varied set of connections between the ventral ramus of the last cervical spinal nerves and the first thoracic vertebra (Martini et al. 2009). Although there are hundreds
of Primates species, the anatomical description of the brachial plexus is limited to a few of them, as follows: *Galago senegalensis senegalensis* (Kanagasuntheram & Mahran 1960); *Saimiri sciureus* (Mizuno 1969; Araújo et al. 2012); *Cercopithecus pygerythrus* (Booth 1991); *Papio ursinus* (Booth et al. 1997); *Cebus apella* (Ribeiro et al. 2005); *Lagotrix lagotricha* (Robertson 1944; Cruz & Adami 2010); *Pan paniscus* (Kikuchi et al. 2011); *Cebus apella* (Ribeiro et al. 2005); *Lagothrix lagothricha* (Robertson 1944; Cruz & Adami 2010); *Papio ursinus* (Booth et al. 1997); *Cebus apella* (Ribeiro et al. 2005); *Lagothrix lagothricha* (Robertson 1944; Cruz & Adami 2010); *Pan paniscus* (Kikuchi et al. 2011); *Macaca mulatta* (Lu et al. 2013; Santos-Sousa et al. 2016); and *Callithrix jaccus* and *Callithrix penicillata* (Santos et al. 2016). The comparative study of the formation of brachial plexus among species has aroused interest since the 19th century (Paterson 1887), and understanding it remains one of the most challenging areas in contemporary anatomy (Johnson et al. 2010). Knowledge of the anatomic pattern and potential variations in the development of the brachial plexus is important in specific situations. For example, it can guide local and regional anaesthetic blocking techniques that result in the analgesia of somatic structures in thoracic limbs (Futema et al. 1999; Mencalha et al. 2016; Mistry et al. 2016; Shinn et al. 2016).

Given the importance and applicability of the plexus anatomy, combined with the lack of descriptions of the referred species, the aim of this study is to characterise the origin and distribution of the nerves in the brachial plexus of *A. g. clamitans*.

**Materials and methods**

For the present study, 10 thoracic limbs of five adult males of *A. g. clamitans* were dissected. They were found dead along the highway (IBAMA/SISBIO authorisation no. 33,667). Four specimens were collected from Highway BR 116 between the cities of Guapimirim and Teresópolis in Rio de Janeiro State, Brazil. The fifth was collected on Highway BR 290 in the municipality of Cachoeira do Sul, Rio Grande do Sul State, Brazil. After they were collected, the specimens were identified, fixed with intramuscular and intracavitary injections of 50% formaldehyde solution and subsequently packaged in polyethylene boxes containing the same solution.

After 2 months of fixation, macrodissections of both thoracic limbs were performed. For this, the skin and superficial fascia were removed, and the musculature of the limb was exposed. Afterwards, the latissimus dorsi muscle was reflected from its point of insertion at the medial aspect of the humerus, the pectoral muscles were sagittally sectioned 1 cm from their origin in the sternum and the thoracic portion of the ventral serratus muscle was released from its origin in the ribs. These manoeuvres increased the axillary space and allowed the dissection and individualisation of the nerves of the plexus, as well as the definition of its origins in relation with vascular structures and innervated muscles.

The muscles and nerves were named according to the International Committee on Veterinary Gross Anatomical Nomenclature (2017). Schematic drawings were created and the photo-documentation was made using a Samsung® camera, model PL20, 16 megapixels.

**Results**

The brachial plexus was formed in three specimens by the ventral branches of C5 to T1 (60%), in another specimen by the ventral branches of C4 to T1 (20%) (Figure 1), and in another specimen by those of C5 to T2 (20%). The ventral spinal branches formed the cranial, medium and caudal trunks. The cranial

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Figure 1. Photomacrograph of the axillary region and medial brachial surface of a male adult specimen of *Alouatta guariba clamitans* evidencing the constitution of the brachial plexus and its cranial (C4, C5 and C6), medium (C7) and caudal (C8 and T1) trunks. cb = communicating branch; nax = axillary nerve; ncrap = cranial pectoral nerve; nmu = musculocutaneous nerve; nmcf = medial cutaneous of the forearm nerve; nme = median nerve; nsb = subscapularis nerve; nsc = subclavius nerve; nsp = suprascapularis nerve; nra = radial nerve; nul = ulnar nerve. Scale bar: 10 mm.
trunk was formed, invariably, by C5 and C6 (with the contribution of C4 in one specimen). The medium trunk was formed by C7, and the caudal one was formed, essentially, by C8 and T1 (with the contribution of T2 in a single individual). There was no antimeric variation concerning the origin of the plexus or the nerves in the same specimen.

Overall, 328 ventral branches formed 120 nerves (12 nerves in 10 limbs), which resulted in an average of 2.7 branches per nerve. Of these, 64.7% of the ventral branches originated nerves to intrinsic muscles and 35.3% to extrinsic muscles. The nerves destined to the intrinsic musculature were formed, on average, from 2.7 branches, and the ones destined to the extrinsic musculature were formed from 2.3 branches. The ventral branch of C4 collaborated in the formation of 1.2% of the nerves, the ventral branch of C5 in 23.2% of the nerves, the ventral branch of C6 in 21.3%, the ventral branch of C7 in 22.0%, the ventral branch of C8 in16.5%, the ventral branch of T1 in 14.0%, and the ventral branch of T2 in 1.8% (Figure 2). Thus, the branches of the cranial trunk originated 45.7% of the nerves, the medium trunk 22.0% and the caudal trunk 32.3%.

The origin of the nerves in the brachial plexus of 10 thoracic limbs of A. g. clamitans is detailed in Tables I and II, and the motor innervation is given in Table III.

Concerning the route of the nerves, the subclavian, long thoracic, subscapular, suprascapular, cranial and caudal pectoral, thoracodorsal and axillary nerves were observed to be restricted to the most proximal portion of the limb (scapular region and gleno-humeral joint). The musculocutaneous nerve was visualised until the cubital region, while the radial, median and ulnar nerves were observed until the most distal portions of the limb, being responsible for the innervation of the muscles of the forearms and hands.

The median nerve presented two communicating branches with the musculocutaneous nerve, as follows: a proximal one on the level of cranial and medium trunks, and a distal one on the distal portion of the arm (Figure 3). In both antimeres, the formation of an axillary “ansa” was observed, composed by the communication between the medium and caudal trunks for the formation of the ulnar nerve.

**Discussion**

Among the 10 dissected plexuses, all presented their origin in the ventral branches of C5 to T1, although in one animal there was a delicate contribution of C4, and in another one there was a delicate contribution of T2. The origin of the plexus between C5 and T1 is very nearly a rule for primates, having been reported in G. senegalensis (Kanagasuntheram & Mahran 1960), S. sciuereus (Mizuno 1969), P. ursinus (Booth et al. 1997), L. lagotricha (Cruz & Adami 2010), M. mulatta (Lu et al. 2013; Santos-Sousa et al. 2016) and human beings (Parada et al. 1989; Zhang et al. 2016). However, intraspecific variations concerning the spinal segments of origin are also reported in those studies that used more specimens, as in the case of C. apella (Ribeiro et al. 2005) and M. mulatta (Santos-Sousa et al. 2016). The dissection of 10 plexus of A. g. clamitans allowed detection of intraspecific variations that may have implications for comparative anatomy inferences as well as in loco-regional anaesthesia procedures.

The participation of C4 in the formation of brachial plexus, observed in one specimen of A. g. clamitans, has been reported in human beings (Johnson et al. 2010; Zhang et al. 2016) and in non-human primates such as L. lagotricha (Robertson 1944), C. apella (Ribeiro et al. 2005), S. sciuereus (Araújo et al. 2012) and M. mulatta (Santos-Sousa et al. 2016), which characterises a pre-fixed brachial plexus (Parada et al. 1989).

The contribution of T2, observed in one specimen of this study, was noted in a few specimens of C. apella (Ribeiro et al. 2005) and S. sciuereus (Mizuno 1969), and in human beings (Johnson et al. 2010; Guday et al. 2017). Similarly, the participation of T2 configures a post-fixed type of plexus (Parada et al. 1989). In the existence of post-fixed plexus in humans, the inferior (caudal) trunk may be compressed by the first rib and induce neurovascular disorders in the thoracic limb (Guday et al. 2017).
is reasonable to assume that the morphofunctional complexity of the primates’ thoracic limbs is associated with the occurrence of pre- and post-fixed plexus (Ribeiro et al. 2005).

In fact, the origin of the brachial plexus in primates concentrates, mandatorily, between C5 and T1. Indeed, intraspecific variations in the origin and ramifications of each nerve of the plexus are more a rule than an exception (Johnson et al. 2010). Studies showed that more than half of the brachial plexus of human foetuses may present variations to the expected pattern (Uysal et al. 2003). In humans, the high incidence of variations may include the absence of nerves and antimeric asymmetries (Malukar & Rathva 2011). Such variations can be explained by changes in the signalling between the mesenchymal cells and the growing of neuronal cones, which can lead to considerable variations that persist to the postnatal period (Dent et al. 2003).

Antimeric variations in the origin of the plexus in the same individual were not found in the present study, although their occurrence has been reported in 1 in 10 specimens of *M. mulatta* (Santos-Sousa

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### Table I. Origin and frequency of the nerves of the brachial plexus that supply the intrinsic muscles of the thoracic limb of *Alouatta guariba clamitans.*

| Nerve         | Origin                | Trunk(s)          |
|---------------|-----------------------|-------------------|
| Suprascapularis | C5 (n = 10)          | Cranial (n = 10)  |
|               | C4-C5 (n = 2)        | Cranial (n = 10)  |
|               | C5-C6 (n = 2)        | Cranial (n = 6)   |
| Subscapularis  | C4-C5 (n = 2)        | Cranial (n = 6)   |
|               | C5-C6-C7 (n = 4)     | Cranial and medium (n = 4) |
| Axillary      | C5-C6 (n = 2)        | Cranial (n = 6)   |
|               | C5-C6-C7 (n = 4)     | Cranial and medium (n = 4) |
|               | C6 (n = 2)           | Cranial (n = 6)   |
|               | C6-C7 (n = 2)        | Cranial (n = 6)   |
| Musculocutaneous | C5-C6 (n = 6)       | Cranial (n = 6)   |
|               | C5-C6-C7 (n = 4)     | Cranial and medium (n = 4) |
| Median        | C5-C6-C7 (n = 6)     | Cranial and medium (n = 6) |
|               | C6-C7-C8-T1 (n = 2)  | Cranial, medium and caudal (n = 4) |
| Radial        | C5-C6-C7-C8-T1 (n = 6)| Cranial, medium and caudal (n = 10) |
|               | C4-C5-C6-C7-C8-T1 (n = 2) | Cranial, medium and caudal (n = 10) |
| Ulnar         | C8-T1 (n = 8)        | Caudal (n = 10)   |
|               | C8-T1-T2 (n = 2)     | Caudal (n = 10)   |
| Medial cutaneous of the forearm | C8-T1 (n = 8) | Caudal (n = 10)   |
|               | C8-T1-T2 (n = 2)     | Caudal (n = 10)   |

### Table II. Origin and frequency of the nerves of the brachial plexus that supply the extrinsic muscles of the thoracic limb of *Alouatta guariba clamitans.*

| Nerve         | Origin                | Trunk(s)          |
|---------------|-----------------------|-------------------|
| Subclavius    | C5 (n = 10)           | Cranial (n = 10)  |
| Long thoracic | C5-C6-C7 (n = 4)      | Cranial and medium (n = 6) |
|               | C6-C7 (n = 2)         | Medium (n = 2)    |
|               | C7 (n = 2)            | Medium and caudal (n = 2) |
|                | C7-C8 (n = 2)        | Cranial and medium (n = 2) |
| Thoracodorsal | C5-C6-C7 (n = 2)      | Cranial and medium (n = 2) |
|               | C6-C7-C8 (n = 2)     | Cranial, medium and caudal (n = 2) |
|               | C7-C8 (n = 2)        | Cranial and medium (n = 2) |
| Cranial pectoral | C5-C6-C7 (n = 8)  | Cranial and medium (n = 10) |
|               | C6-C7 (n = 2)        | Cranial and medium (n = 2) |
| Caudal pectoral | C7-C8-T1 (n = 8)   | Medium and caudal (n = 8) |
|               | C8-T1 (n = 2)        | Caudal (n = 2)    |
|               | C8-T1-T2 (n = 2)     | Caudal (n = 2)    |
The dissection of a higher number of specimens of *A. g. clamitans* would probably reveal some antimeric variation.

The brachial plexus constitutes of ventral branches of at least five segments, as in *A. g. clamitans* and other primates. This is typical of species whose thoracic limbs are versatile and act in, for example, climbing, excavation, running, swimming, handling food and/or prey capture. This also occurs in mammals of other orders whose demands of the thoracic limbs are not limited to terrestrial locomotion, such as the monotremes (Koizumi & Sakai 1997), *Bradytus variatus* (Amorim Júnior et al. 2003), *Hydrochaeris hydrochaeris* (Fioretto et al. 2003), *Agouti paca* (Scavone et al. 2008), *Tamandua tetradactyla* (Cruz et al. 2012), *Myrmecophaga tridactyla* (Souza et al. 2014) and *Myocastor coypus* (Taketani 2017).

The formation of three trunks observed in *A. g. clamitans* is frequently reported in humans (Johnson et al. 2010) and also in non-human primates (Cruz & Adami 2010; Kikuchi et al. 2011; Santos-Sousa et al. 2016). In *S. sciureus*, four trunks were recognised (Araújo et al. 2012). Non-primate mammals, such as monotremes (Koizumi & Sakai 1997), *Hystricristata* (Aydin 2003), *Sciurus vulgaris* (Aydin 2011), *Hippopotamus amphibius* (Yoshitomi et al. 2012), *T. tetradactyla* (Cruz et al. 2012) and *Bradytus torquatus* (Cruz et al. 2013), also form trunks in the plexus distribution. However, trunks are not identified in several other mammal species; their absence was noted in the domestic mammals (Getty 1986).

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The ventral branch of C5 most individually contributed to the formation of the nerves of the brachial plexus in *A. g. clamitans*, the cranial trunk being the one from which most nerves originated. This type of counting is not usual between brachial plexus descriptions to allow comparisons, but it differs from the observations in *M. mulatta*, where the

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**Table III. Muscle innervation of the brachial plexus of *Alouatta guariba clamitans*.**

| Nerves            | Muscle innervation                                                                 |
|-------------------|------------------------------------------------------------------------------------|
| Subclavius        | m. subclavius                                                                      |
| Long thoracic     | m. serratus ventralis thoracis                                                     |
| Suprascapularis   | m. supraspinatus and m. infraspinatus                                              |
| Subscapularis     | m. subscapularis and m. teres major                                                |
| Pectorales        | Superficial and deep pectorales muscles                                             |
| Toracodorsal      | m. latissimus dorsi                                                                |
| Axillary          | m. deltoideus and m. teres minor                                                   |
| Musculocutaneous  | m. biceps brachii, m. brachialis and m. coracobrachialis                           |
| Median            | m. pronator teres, m. palmaris longus, m. flexor carpi radialis, m. flexor carpi ulnaris (distal half), m. flexor digitorum superficialis, m. flexor digitii II, m. flexor digitorum profundus and m. pronator quadratus |
| Ulnar             | m. flexor carpi ulnaris (proximal half), m. flexor digitii V, and m. flexor pollicis longus |
| Radial            | m. tensor fasciae antebrachii, m. triceps brachii, m. brachioradialis, m. extensor carpi radialis longus, m. extensor carpi radialis brevis, m. extensor digitorum, m. extensor digitii minimi, m. extensor carpi ulnaris, m. abductor pollicis longus, m. extensor indicis, and m. extensor digitii III. |

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**Figure 3. Photomicrograph of the medial surface of the right arm of an adult male specimen of *Alouatta guariba clamitans*, evidencing the relations between nerves and blood vessels.**

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ax = axillary artery; abr = brachialis artery; nmcf = medial cutaneous of the forearm nerve; nme = median nerve; nm = musculocutaneous nerve; nra = radial nerve; nsb = subscapularis nerve; nsc = subclavius nerve; nsp = suprascapularis nerve; nul = ulnaris nerve; vax = axillary vein; vbr = brachialis vein. Scale bar: 10 mm.
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majority of the nerves received the contribution of C6 and C7 (Santos-Sousa et al. 2016). In the Neotropical canids Cerdocyon thous and Lycalopex gymnogercus, the ventral branches C7 and C8 preponderated (Souza-Junior et al. 2014, 2017), yet C5 does not take part in the plexus of these species.

The suprascapular nerve of other primate species exhibited the participation of C6 almost as a rule, as described in Pongo sp. (Hepburn 1891), P. paniscus (Kikuchi et al. 2011), G. senegalensis (Kanagasuntheram & Mahran 1960), P. ursinus (Booth et al. 1997), L. lagotricha (Cruz & Adami 2010), S. sciureus (Araújo et al. 2012) and M. mulatta (Santos-Sousa et al. 2016). In L. lagotricha, the suprascapular nerve also innervated the deltoid muscle (Cruz & Adami 2010), which was not observed in A. g. clamitans or in the other primates.

The participation of C6 in the formation of subscapular nerve in every individual was expected, since the cranial trunk is always present in the formation of this nerve in primates (Booth et al. 1997; Cruz & Adami 2010; Santos et al. 2016; Santos-Sousa et al. 2016). The participation of C7 in forming this nerve has also been described in M. mulatta (Santos-Sousa et al. 2016).

The axillary nerve presented the most intraspecific variations in the samples of this study, although it always had the involvement of C6 and, therefore, of the cranial trunk. The contribution of C6 in the formation of the axillary nerve was observed in every species of primates for whose plexus a description was found (Paterson 1887; El-Assy 1966; Champneys 1975; Booth et al. 1997; Ribeiro et al. 2005; Cruz & Adami 2010; Araújo et al. 2012; Santos et al. 2016; Santos-Sousa et al. 2016). The innervation of the shoulder flexors muscles was similar to the descriptions of L. lagotricha (Cruz & Adami 2010), S. sciureus (Araújo et al. 2012) and M. mulatta (Santos-Sousa et al. 2016).

The formation of the musculocutaneous nerve of A. g. clamitans, essentially by the cranial trunk, was described in L. lagotricha (Cruz & Adami 2010), C. jacchus and C. penicillata (Santos et al. 2016), while the origin from both trunks, cranial and medium, was reported in P. ursinus (Booth et al. 1997), S. sciureus (Araújo et al. 2012), M. mulatta (Santos-Sousa et al. 2016) and humans (Nascimento et al. 2016). This nerve supplied the coracobrachialis, biceps brachii and brachialis muscles, similar to what was observed in L. lagotricha (Cruz & Adami 2010) and M. mulatta (Santos-Sousa et al. 2016), though in S. sciureus the brachialis muscle is not innervated by the musculocutaneous nerve (Araújo et al. 2012).

The origin of the median nerve primarily from cranial and medium trunks and eventually also from the caudal trunk was normal, since this nerve is inevitably formed by several ventral branches, including all the trunks (Natsis et al. 2016). This was the case for P. ursinus (Booth et al. 1997), L. lagotricha (Cruz & Adami 2010), P. paniscus (Kikuchi et al. 2011), C. jacchus and C. penicillata (Santos et al. 2016). Its motor innervation was directed to the pronators and flexors of the carpus and of the digit muscles as described for S. sciureus (Araújo et al. 2012). In L. lagotricha, it also innervated portions of the biceps brachii and triceps brachii muscle (Cruz & Adami 2010), which did not happen in A. g. clamitans.

The proximal communication between the musculocutaneous and median nerves formed the axillary ansa and the distal communication is associated with the brachial artery, according to reports concerning other primates (Booth et al. 1997; Cruz & Adami 2010; Araújo et al. 2012; Santos-Sousa et al. 2016). These communicating branches have a clinical importance in humans because they may compress the arteries and compromise blood supply to the limbs (Fazan et al. 2003; Deshmukh & Devershi 2006; El-Faloughy et al. 2013).

The radial nerve originated, invariably, from the three trunks, which indicates its high functional complexity. Its formation from all trunks is described in primates P. ursinus (Booth et al. 1997), C. apella (Ribeiro et al. 2005), L. lagotricha (Cruz & Adami 2010), P. paniscus (Kikuchi et al. 2011), S. sciureus (Araújo et al. 2012), C. jacchus and C. penicillata (Santos et al. 2016), but not M. mulatta in which the contribution of the cranial trunk was not observed (Santos-Sousa et al. 2016). The radial nerve was responsible for stimulating the extensor muscles of the elbow, carpus and fingers, as well as the supinator ones, which coincided with the description for L. lagotricha (Cruz & Adami 2010), S. sciureus (Araújo et al. 2012), and M. mulatta (Santos-Sousa et al. 2016). At the level of the elbow, it bifurcated in superficial and deep branches, which is usually observed in the extant placental species (Arlamowska-Palider 1970).

The same origin of the ulnar nerve of A. g. clamitans was also observed in every primate whose plexus was described, reinforcing that C7 or T2 participation is occasional, as in S. sciureus (Araújo et al. 2012). Like the median nerve, the ulnar nerve supplied the flexor muscles of the carpus and fingers, as described in S. sciureus (Araújo et al. 2012) and M. mulatta (Santos-Sousa et al. 2016).

In the species of the present study, the medial cutaneous nerve of the forearm was formed invariably in the caudal trunk, just as described in humans (Martini et al. 2009), P. ursinus (Booth et al. 1997), P. paniscus (Kikuchi et al. 2011), L. lagotricha (Cruz & Adami 2010) and S. sciureus (Araújo et al. 2012).
The presence of C5 in the formation of the subclavian nerve is referred to also in every specimen of *M. mulatta*, although the concomitant contributions of C4 or C6 were documented variations (Santos-Sousa et al. 2016). In *S. sciureus*, the subclavian nerve originated more cranially by the ventral branches of C4 (Araújo et al. 2012).

The findings on the origins of the thoracodorsal nerve in *A. g. clamitans* matched the description for *P. ursinus* (Booth et al. 1997) and *L. lagotricha* (Cruz & Adami 2010), where every trunk formed the nerve. In fact, the formation of this nerve widely varied among the different species of primates: C6 to C8 in *C. apella* (Ribeiro et al. 2005); C6 and C7 in *P. paniscus* (Kikuchi et al. 2011); and C7 and C8 in *S. sciureus* (Araújo et al. 2012) and *M. mulatta* (Santos-Sousa et al. 2016). Despite the variation in the formation of this nerve, its innervation for the latissimus dorsi muscle is invariable (Cruz & Adami 2010).

The nomenclature of the pectoral nerves in non-human primates differs in the literature, which is what makes it challenging to compare them. They may be named “anterior thoracic nerves” (El-Assy 1966), “major and minor pectoral nerves” (Ribeiro et al. 2005), “medial and lateral pectoral nerves” (Kikuchi et al. 2011), or there may be no distinctiation made between them (Cruz & Adami 2010; Santos et al. 2016). In the present study, the Nomina Anatomica Veterinaria (ICVGAN 2017) was followed that determines the “cranial pectoral nerve” as being the one directed to the superficial pectoral muscle and the “caudal pectoral nerve” as the one directed to the deep pectoral muscle.

The formation of the cranial pectoral nerve included the cranial and median trunk (from C5 to C7), varying in just one specimen in which the contribution of C5 did not happen. The participation of the cranial and median trunks is in agreement with the description for *Pan* sp., *Pongo* sp., *Hylobates* sp. and *Gorilla* sp. (Hepburn 1891; Champneys 1975), and *P. paniscus* (Kikuchi et al. 2011). In *M. mulatta* the most frequent formation was by the cranial and median trunks, although in some cases caudal trunk participation occurred, with or without the contribution of the cranial one (Santos-Sousa et al. 2016). The caudal pectoral nerve originated, invariably, from the median and caudal trunks in 80% of the plexus of this study, as in *M. mulata* (Santos-Sousa et al. 2016). In *P. paniscus* there was no contribution from the median trunk (Kikuchi et al. 2011).

The constitution of the long thoracic nerve of *A. g. clamitans*, primarily by the cranial and median trunks, was the same as reported in chimpanzees (Champneys 1975) and *C. apella* (Ribeiro et al. 2005). In *L. lagotrichia* it is described as being formed only by C7 (Cruz & Adami 2010), which was observed in one specimen of *A. g. clamitans*. In *M. mulatta* the long thoracic nerve originated from C6 and C7 in the majority of the individuals, although C8 contributed in some individuals (Santos-Sousa et al. 2016). It innervated the thoracic portion of the serratus ventralis muscle, as described in other primates (Hepburn 1891; Hill 1972; Booth et al. 1997; Ribeiro et al. 2005; Cruz & Adami 2010; Santos-Sousa et al. 2016).

The anatomical similarity in the origin and distribution of the brachial plexus between *A. g. clamitans* and primates (humans and non-humans) suggests that the anaesthetic blocking techniques developed for humans may succeed when applied to howler monkeys. This was confirmed by Santos et al. (2017) who used the anatomical landmarks recommended for humans (Muñoz et al. 2010) in one male specimen of *A. g. clamitans*, and obtained analgesia and muscular relaxation in the distal region to the gleno-humeral joint. Another report describes the use of the subscapular technique with palpation of the axillary pulse to create an anaesthetic block of the brachial plexus in an *A. g. clamitans* specimen (Ido 2016). In this case, the same landmarks proposed in the anaesthetic technique developed for domestic carnivores were adopted (Klaumann et al. 2013). Certainly, there is a gap in the anatomical basis of anaesthetic techniques not only for *A. g. clamitans* but also for wildlife species in general (Ido 2016; Santos et al. 2017).

Lastly, it may be concluded there was an antimeric symmetry associated with the origin and the resulting nerves in every animal of the present study. The brachial plexus of *A. g. clamitans* was largely formed by the contributions of the ventral spinal branches of C5 to T1, with eventual participation of C4 and T2. The branches of C5 and C7 were the ones that most contributed to the formation of the nerves of the brachial plexus.

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