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CLINIC AND SURGERY

Anatomy and surgical approach to the humerus, radius and ulna of common sloth (*Bradypus variegatus*)

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ABSTRACT: *The surgical clinic of wild animals has increased in routine veterinary, where fractures by traumas are of frequent occurrence. This study determined the surgical accesses for osteosynthesis of the diaphyses of the humerus, radius and ulna of common sloth (Bradypus variegatus). Seven cadavers of B. variegatus were used for determination of the muscles of the thoracic limb, as well as the most important vessels and nerves, and better bone area for fixation of internal implants. The structural conformation of the radius and ulna in Bradypus variegatus were like those described in the literature for domestic animals but the humerus presented differences in the distal extremity because it was flattened. The musculature of Bradypus variegatus showed similarities with domestic animals. Due the different conformation of the humerus the surgical access to this bone can be performed by lateral approach, from the incision of M. triceps brachii lateral head, for fixation of the implant on the lateral side of the bone. Surgical access to the radius shaft can be performed by craniolateral approach, by incising the muscular fascia and separation of the cranially M. common digital extensor, and lateral digital extensor caudally. In ulna, a caudal access to the bone can be performed followed by release of the insertion m. flexor carpoulnar for placement of the internal implant on the lateral bone face.*
Key words: *osteology, myology, surgery, fractures, radius, ulna, humerus.*

Anatomia e acesso cirúrgico ao úmero, rádio e ulna de preguiça-comum (*Bradypus variegatus*)

RESUMO: *A clínica cirúrgica de animais silvestres tem se intensificado na rotina veterinária, onde fraturas por traumas são frequentes. O objetivo deste estudo foi a determinação de acessos cirúrgicos para osteossíntese das diáfises do úmero, rádio e ulna de preguiça-comum (Bradypus variegatus). Sete cadáveres de B. variegatus foram utilizados para determinação dos músculos do membro torácico, bem como dos vasos e nervos mais importantes, e melhor área óssea para fixação de implantes internos. A conformação estrutural do rádio e da ulna em B. variegatus eram similares às descritas na literatura para animais domésticos, o úmero apresentou diferenças na extremidade distal pois apresentou-se achatado. A musculatura de B. variegatus mostrou semelhanças com os animais domésticos. Devido à diferente conformação do úmero o acesso cirúrgico a este osso pode ser realizado por abordagem lateral, a partir da incisão do M. tríceps braquial cabeça lateral, para fixação do implante na face lateral do osso. O acesso cirúrgico à diáfise do rádio pode ser realizado por abordagem craniolateral, por incisão da fáscia muscular e separação cranialmente do M. extensor digital comum e extensor digital lateral caudalmente. Na ulna, pode-se realizar um acesso caudal ao osso seguido de liberação da inserção do M. flexor carpoulnar para colocação do implante interno na face lateral do osso.*
Palavras-chave: *osteologia, miologia, cirurgia, fraturas, rádio, ulna, úmeroo.*

INTRODUCTION

The species of sloths of the family Bradypodidae belonging to the genus *Bradypus,* where the three-toed sloths (*B. torquatus*, *B.variegatus*, *B. tridactylus* e *Bradypus pygmaeus*) (ANDERSON & HANDLEY, 2001). They are mammals of the order Xenarthra, as well as armadillos and anteaters, which besides presenting peculiar anatomical and physiological characteristics, such as low metabolism and low body temperature, have morphological adaptations to the most diverse types of niches (MIRANDA & COSTA, 2007). The *Bradypus variegatus* (SCHINZ, 1825), popularly known as common sloth, has strictly arboreal habits and essentially folivorous feeding (MESSIAS-COSTA et al., 2001). It is widely distributed by the neotropical forest region of South America and it is estimated that the most abundant among species of sloths (CHIARELLO et al., 2004).

B. variegatus commonly falls from the top of the trees and with falls can suffer injuries with serious consequences and in some cases lethal (MESSIAS-COSTA et al., 2001). Traumatic fractures occur frequently in wild animals, both in free-living, as those bred in captivity (CARISSIMI

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et al., 2005). In this sense, the clinical-surgical care of wild animals has increased in the routine of zoos and specialized veterinary hospitals; however, there is a shortage of studies in the literature on surgical interventions in these animals (MIRANDA & COSTA, 2007). Considering the need for the detailed anatomical knowledge of this species, which has aspects adapted for tree life, the objective was to describe the musculoskeletal anatomy of the forelimb sloth (*Bradypus variegatus*) and to establish the best surgical access for osteosynthesis in the diaphysis of the humerus, radius and ulna, as well as the best bone area for fixation of internal implants.

MATERIALS AND METHODS

Seven common sloth (*Bradypus variegatus*) from the Jardim Botânico Bosque Rodrigues Alves, located in Belém, Pará, were donated after natural death to the Animal Morphological Research Laboratory (LaPMA) of the Federal Rural University of Amazonia (UFRA) under the authorization SISBIO N° 23401-7.

The dissection for the study of the musculature that composes the thoracic limb of *B. variegatus* was performed in three cadavers, after injection of latex Neoprene added of red dye aiming the visualization of the arteries, followed by fixation with aqueous solution of formaldehyde a 10%, and another three shortly after thawing. To do this, with the aid of surgical material, the skin was folded, and the muscles of the arm and forearm were identified through their insertion and function in limbs, in addition to the vessels and nerves most important to the vital function of the limb.

To determine the best bone area for fixation of internal implants, the long bones of interest (humerus, radius and ulna) were obtained by macerating in water for approximately 7 days, being dried outdoors after cleaning the periosteum and remaining soft tissues. These were analyzed with digital radiographs (CR 30-X AGFA 500 MA) of the thoracic limbs in the craniocaudal and mediolateral projections performed before the dissection procedures.

A cadaver was used to demonstrate surgical access to the humerus, radius and ulna diaphysis immediately after thawing. After tricotomy of the thoracic limbs and dorso-ventral positioning of the animal, the skin was incised, followed by musculature bending, for exposure of the bone and placement of plaque and bolts 2.0 (Focus®), with the aid of orthopedic instruments. For the placement of the screws the drilling was performed with a 1.5 mm drill bit, using an orthopedic depth gauge to choose the appropriate screws, placed after lapping. For illustration of the implants placed, radiographs of the thoracic member of *B. variegatus* were made in mediolateral and craniocaudal projections. For the adequacy of the description of the surgical accesses, books related to the subject were used (JOHNSON, 2013; LATORRE, 2012; PIERMATTEIET al., 2009).

All nomenclature adopted was based on the Veterinary Anatomical Nomenclature (INTERNATIONAL COMMITTEE ON VETERINARY GROSS ANATOMICAL NOMENCLATURE, 2017).

RESULTS

Osteology

With the use of maceration technique, we can analyze the bone anatomy of the arm of the common sloth that contains the humerus as sole bone, and the forearm consisting of two bones, the radius and the ulna. The humerus differs in three segments, two epiphysis (proximal and distal) and a diaphysis. The proximal epiphysis presents caudally a smooth head with articular surface in half sphere shape, a neck separating the head from the diaphysis and two tuberculum, being in relation to the head, the greater a craniolateral prominence and the smaller a craniomedial prominence, separated by a sulcus intertubercularis. The humeral diaphysis is elongated and cylindrical, with the distal portion wider and flat. The distal epiphysis is flattened craniocaudally, composed of the condylus humeri divided into the trochlea (medial) and the capitulum (lateral). Laterally to the condylus are the medialis and lateralis epicondylus, the lateral one being more prominent. Cranially we have the fossa radialis and caudally a discrete fossa olecrani that receives part of the proximal epiphysis of the ulna (Figure 1A and B).

The ulna occupies a caudolateral position in relation to the radius. In its proximal epiphysis the olecranon protrudes to the caudal part of the distal end of the humerus, presents an incisura trochlearis for articulation with the humerus, and cranially the processus anconeus as a projection to fit into the fossa olecrani. The diaphysis presents a slight curvature in the proximal third, being evidenced a spatium interosseum antebrachii between this and the diaphysis of the radius. The distal epiphysis is narrow, and its extremity consists of a prominent processus styloideus (Figure 1C).

Figure 1 - (A) Cranial and (B) caudal view of the right humerus of *Bradypus variegatus*. 1. Proximal epiphysis; 2. Diaphysis; 3. Distal epiphysis; 4. Major tuberculum; 5. Lateral epicondylus; 6. Capitulum; 7. Trochlea; 8. Medial epicondylus; 9. Radial fossa; 10. Humerus head; 11. Fossa olecrani. C and D- Cranial view of the right ulna and lateral view of the right radius 1. Proximal epiphysis; 2. Diaphysis; 3. Distal epiphysis; 4. Incisura troclearis; 5. Processus anconeus; 6. Tuberositas radii; 7. Process Styloideus of the radius; 8. Process Styloideus of the ulna.

The radius presents in the proximal epiphysis a circular caput and fovea capitis radii for articulation with the distal end of the humerus. The diaphysis is slightly curved in its extension. The distal epiphysis is flattened craniocaudally, where it meets the trochlea to articulate with the carpi, and the processus styloideus is evidenced as a rounded projection (Figure 1D).

Miology

The thoracic limb of the common sloth, in general, presents small muscle volume. In the arm, the muscles in evidence, in lateral view, were M. latissimus dorsi, M. coracobrachialis, M. triceps brachii Caput longum and Caput laterale, M. tensor fasciae antebrachii and M. brachioradialis (Figure 2 A and B). In medial view, were M. biceps brachii and M. tensor fasciae antebrachii (Figure 2 C and D).

The M. latissimus dorsi, triangular in shape, is located caudally to the scapula covering part of the thoracic dorsal wall, presenting insertion in the tuberositas teres major. The M. coracobrachialis originates in the processus coracoideus of the scapula and is inserted in the crista tuberculi minoris of the humerus. The M. triceps brachii consists of two caputs, laterale and longum, which originated at the caudal end of the scapula (caput longum) or at the proximal end of the humerus (caput laterale) with insertion into the tuber olecrani. The M. tensor fasciae antebrachii extends as a continuation of M. latissimus dorsi inserting into the olecranon. The M. brachioradialis presents origin in the distal third of the lateral margin of the humerus and insertion in the processus styloideus of the radius. The M. biceps brachii has two heads, long and short, consisting of a long, fusiform muscle that extends throughout the humerus (Figure 2).

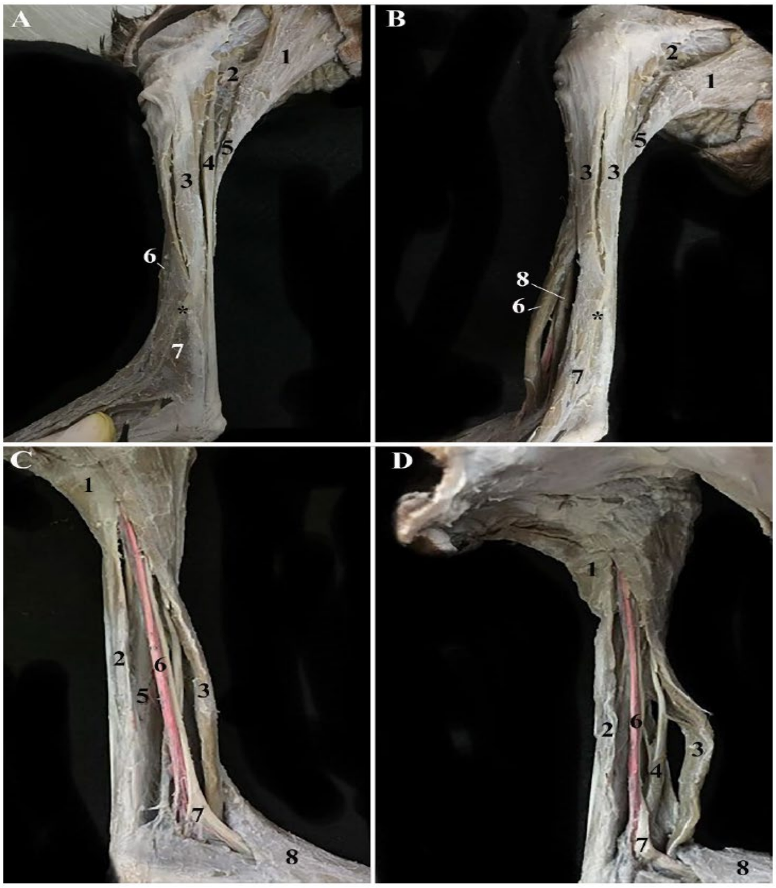

Figure 2 - (A and B) Lateral view of *Bradypus variegatus* arm. 1. M. latissimus dorsi; 2. M. coracobrachialis; 3. M. triceps brachii Caput laterale; 4. M. triceps brachii Caput longum; 5. M. tensor fasciae antebrachii; 6. M. biceps brachii short head; 7. M. brachioradialis; 8.M. biceps brachii long head. * Radial nerve. (C and D) Medial view of *Bradypus variegatus* arm. 1. M. latissimus dorsi; 2. M. tensor fasciae antebrachii; 3. M. biceps brachii short head; 4. M. biceps brachii long head; 5. Humerus; 6. Brachial artery; 7. Median nerve; 8. M. brachioradialis.

In the medial view of the arm, the median nerve can be observed, following the medial face of the forearm, and as the main vessel, the brachialis artery traversing the entire medial aspect of the humerus and emitting several bundles of arteries composing the *rete mirabile* (Figure 2).

In the forearm, the muscles in evidence, in lateral view, were: M. brachioradialis, M. extensor carpi radialis, M. extensor digitorum communis, M. extensor digitorum lateralis, M. abductor digiti I longus, M. extensor carpi ulnaris and M. flexor carpi ulnaris (Figure 3 A and B). In medial view, were the M. brachioradialis, M. pronator teres, M. flexor carpi radialis, M. flexor digitorum superficialis, M. flexor digitorum profundus and M. flexor carpi ulnaris (Figure 3 C and D).

The M. brachioradialis emerged from the lateral of the crista epicondylus descending along the cranial portion of the M. extensor carpi radialis to insert into the periosteum of the radius. The M. extensor carpi radialis, M. extensor digitorum communis, M. extensor digitorum lateralis and M. extensor carpi ulnaris originated in the lateral epicondyle of the humerus presenting distally one muscular belly each. The M. abductor digiti I longus originated in the lateral middle third of the

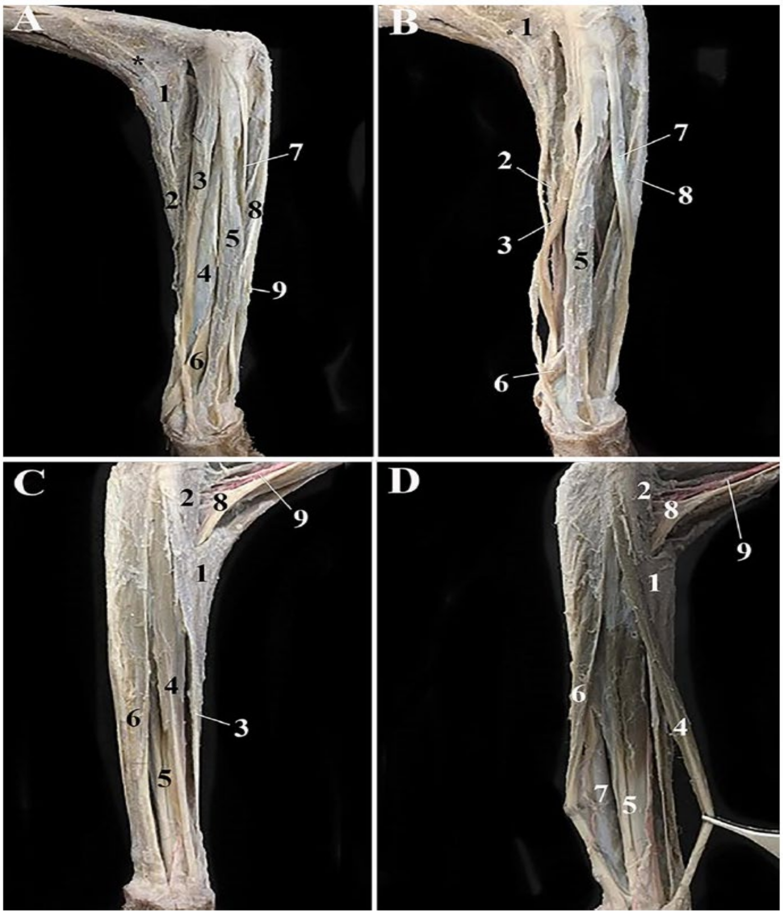

Figure 3 - (A and B) Lateral view of *Bradypus variegatus* forearm. 1.M. brachioradialis; 2. M. extensor carpi radialis; 3. M. extensor digitorum communis; 4. Radius; 5. M. extensor digitorum lateralis; 6. M. abductor digiti I longus; 7. M. extensor carpi ulnaris; 8. M. flexor carpi ulnaris; 9. Ulna; * Radial nerve. (C and D) Medial view of *Bradypus variegatus* forearm. 1.M. brachioradialis; 2. M. pronator teres; 3. M. flexor carpi radialis; 4. M. flexor digitorum superficialis; 5. M. flexor digitorum profundus; 6. M. flexor carpi ulnaris; 7. Ulna; 8. Median nerve; 9. Brachialis artery.

forearm directing obliquely under the extensor muscles to the carpal region. The M. pronator teres originated in the epicondylus medialis of the humerus inserting medially to the radius. The M. flexor carpi ulnaris, M. flexor carpi radialis, M. flexor digitorum superficialis, M. flexor digitorum profundus originate in the medial epicondyle of the humerus, distally presenting a muscular belly each, inserting in the carpal bones (M. flexor carpi ulnaris, M. flexor carpi radialis) or in digits (M. flexor digitorum superficialis, M. flexor digitorum profundus) (Figure 3).

Comparing to the anatomical structures, from the radiographs made in the craniocaudal and mediolateral incidences, it is possible to evaluate the best bone area for fixation of implants in the thoracic member of *Bradypus variegatus* (Figure 4A).

Surgical access

For surgical access of the humeral diaphysis of *B. variegatus* the best access is through the lateral side of the bone, since the medial face is the brachialis artery composing the *rete mirabile* and the median nerve. The morphology of the humeral

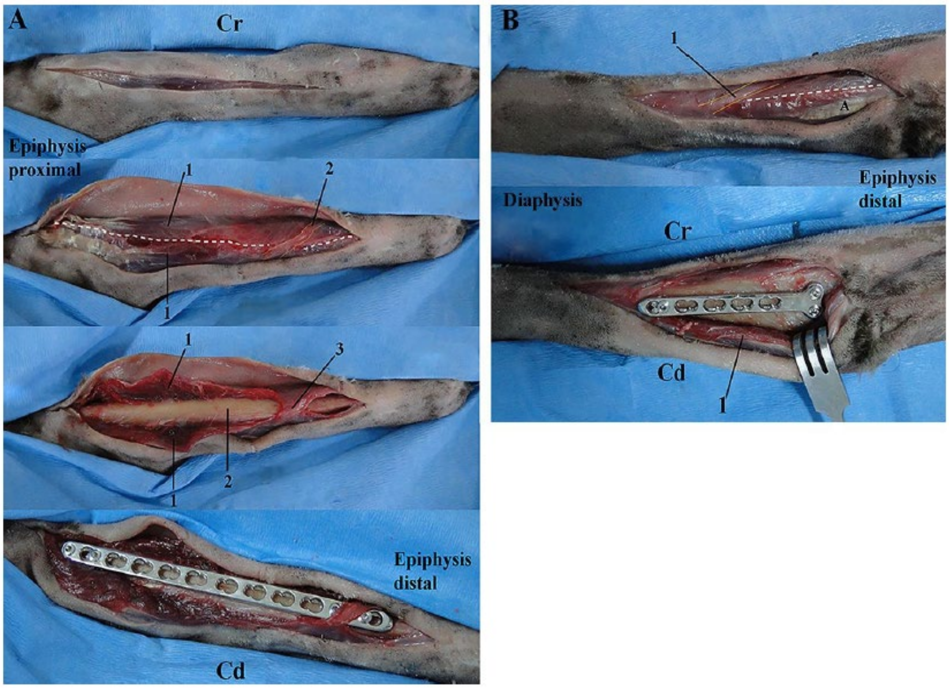

Figure 4 - (A) Cutaneous incision in lateral approach of left thoracic limb. Musculature present in the lateral approach to the left humerus: 1. M. triceps brachii Caput laterale, 2. Radial nerve. Incision site (--). Incision and divulsion of the M. triceps brachii Caput laterale (1) to visualize the humeral diaphysis (2). Radial nerve (3). Demonstration of the position of the blocked bone plate to reduce possible fractures in the humeral diaphysis. (B) Musculature present in the caudolateral approach to the caudal region of the right humerus: 1. Radial nerve, A - M. brachioradialis. Incision site (--). Demonstration of positioning of the blocked bone plate to reduce possible fractures in the distal humerus: 1. M. brachioradialis.

diaphysis of *B. variegatus* because it is long and cylindrical facilitates the placement of implants in this region.

To approach the animal is placed in lateral decubitus position, the lateral cutaneous incision should extend from the proximal epiphysis to the distal third of the lateral side of the limb. After divulsion and folding of the skin, superficially in the middle distal region, it is necessary to identify and avoid the radial nerve, and then to perform an incision of the M. triceps brachii Caput laterale. After bone exposure, the implant can be fixed to the lateral fascia of the bone, preserving the radial nerve (Figure 5A).

Fractures in the epiphysis distal of the humerus of *B. variegatus* have a better approach to caudolateral access due to craniocaudal flattening of this region, which prevents intramedullary pin placement and makes it difficult to use plaque on lateral or medial face. To expose the distal region of the humerus, the skin incision extends from the mid-distal third to the distal epiphysis, the M. brachioradialis is identified and releasing it for bone exposure and placement of the implant in the caudal region of the bone (Figure 5B).

To access the radial diaphysis of *B. variegatus*, the cutaneous incision line should extend from the proximal epiphysis to the distal middle third through the craniolateral side of the limb. After divulsion and folding of the skin, the muscular fascia of M. extensor digitorum communis and M. extensor digitorum lateralis are located, the fascia is incised to separate the muscles cranially and caudally, respectively. For distal approaches, separate and preserve cranially the M. abductor digiti I longus. The implant can be placed on the cranial face of the bone (Figure 6).

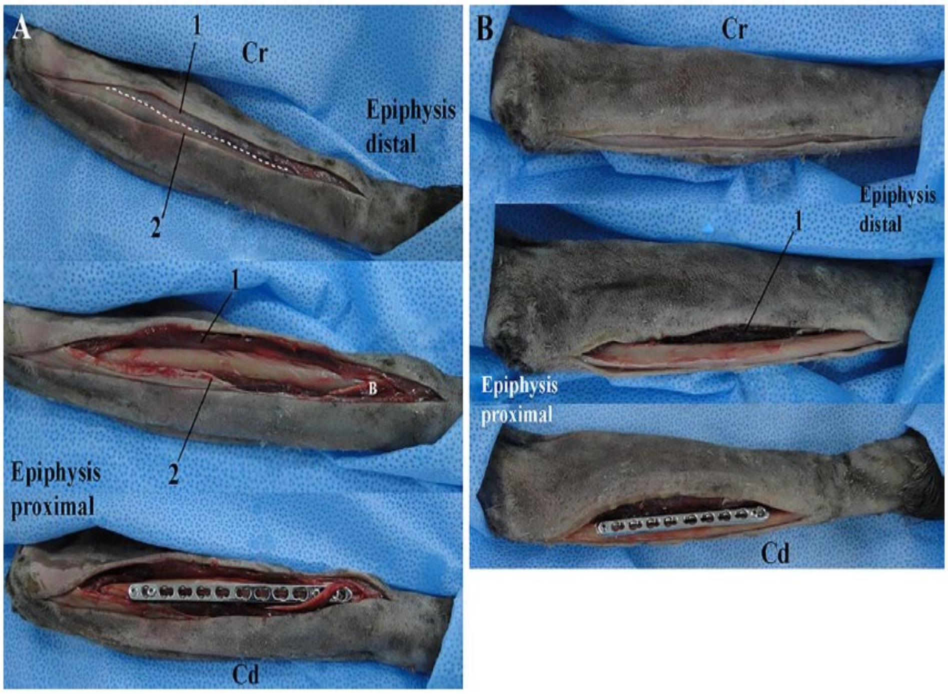

Figure 5 - (A)- Cutaneous incision in a craniolateral approach of the right forearm: 1. M. extensor digitorum communis, 2. M. extensor digitorum lateralis. Incision site (--). Musculature present in the craniolateral approach for radial diaphysis: 1. M. extensor digitorum communis, 2. M. extensor digitorum lateralis, B - M. abductor digiti I longus. Demonstration of positioning of the blocked bone plate in the cranial face of the radius diaphysis. (B) Cutaneous incision by caudal approach to the right ulna. Release of the M. flexor carpi ulnaris (1). Demonstration of the position of the blocked bone plate on the lateral bone of the ulna.

For access to the diaphysis of the ulna, the incision is made by caudal approach to the bone and the release of the fixation of the M. flexor carpi ulnaris for placement of the internal implant on the lateral bone face (Figure 6).

The radiographic images after placement of the implants in the thoracic member of *B. variegatus*, in mediolateral and craniocaudal projections, is illustrated in figure 4B.

DISCUSSION

The anatomical study of wild animals not only allows the understanding of their physiological aspects and life habits, but also provides knowledge for captive management and rehabilitation processes, allowing an adequate return of the animals to their natural habitat (MONTILLA-RODRÍGUEZ et al., 2016). In 1935, the anatomist Ruth Miller wrote, "of all mammals sloths probably have the strangest mode of locomotion," because of their suspensive posture "upside down", these animals represent interesting models for studying the functional implications of reverse orientation of the body in relation to the force of gravity (NYAKATURA & FISCHER, 2011).

The characteristics of the humerus, radius and ulna of *B. variegatus*, and of the adjacent soft tissues were observed through the anatomical and radiographic study in order to identify the best surgical access for these bones. The bone plate was used as an option for orthopedic implants, since in addition to supporting all the forces existing in a fracture, they present great applicability in the different types of appendicular skeleton fractures (JOHNSON, 2013).

The common sloth humerus is a bone that has a long cylindrical diaphysis which in the distal region becomes broad and flat, being in agreement with the one described by MONTILLA-

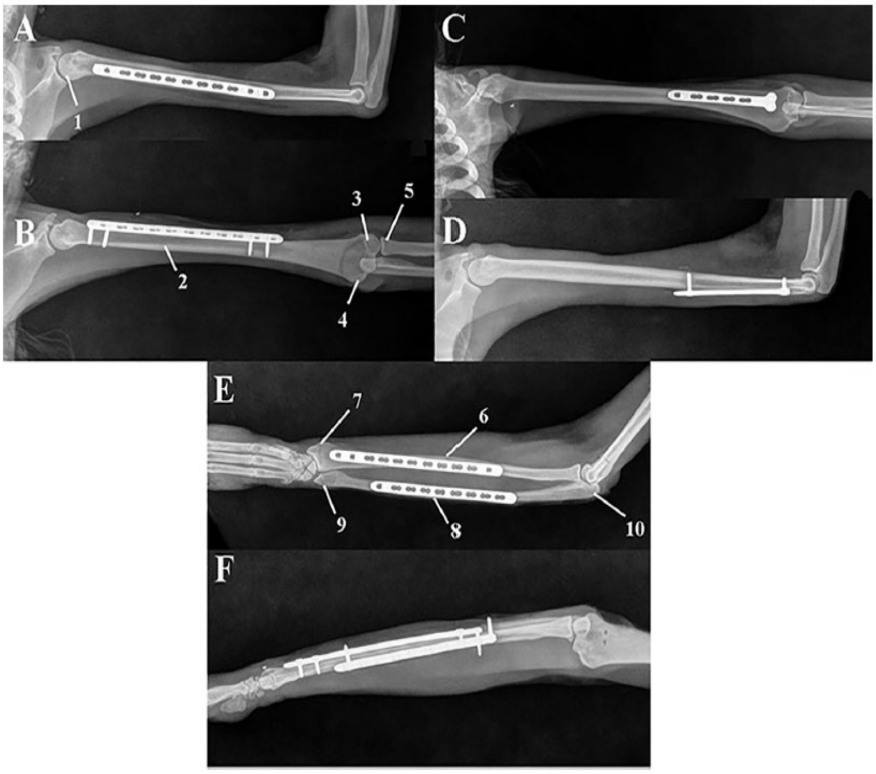

Figure 6 - Radiography after placement of the implant on the left humeral diaphysis. Mediolateral projection (A); Craniocaudal projection (B). Radiography after placement of the implant on the distal diaphysis of the right humerus. Craniocaudal projection (C); Mediolateral projection (D). Radiography of the right forearm after placement of the implant on the radius and ulna diaphysis. Mediolateral projection (E); Craniocaudal projection (F). 1. Tuberculum minus; 2. Diaphysis of the humerus; 3. Epicondylus lateralis; 4. Epicondylus medialis; 5. Tuberositas radii; 6. Diaphysis of the radius; 7. Epiphysis of radius; 8. Diaphysis of the ulna; 9. Epiphysis of ulna; 10. Olecranon.

RODRÍGUEZ et al. (2016). It's almost straight structure differs from domestic animals, in which the humerus has a spiral shape due to the sulcus m. brachialis (KÖNIG & LIEBICH, 2021). The distal extremity of the humerus is flattened craniocauldally, as observed in the anteater, presenting developed epicondylus that offer great area for fixation of the powerful flexor and extensor muscles of the carpus and the fingers (SESOKO et al., 2016).

The *B. variegatus* forearm formed by radius and ulna, as in the dog and the cat, come into contact only at the proximal and distal extremities, leaving a long interosseous space between its diaphyses (DYCE et al., 2019). In domestic animals the radius is a rod-shaped bone, which is more developed and has more resistance in ungulates than in carnivores (KÖNIG & LIEBICH, 2021). In ungulates the humeral support in ulnar joint occurs only through the radius, whereas in the carnivorous one also occurs with the participation of ulna (DYCE et al., 2019; KÖNIG & LIEBICH, 2021), same way observed in *B. variegatus*. The body of the radius in *B. variegatus*, as well as in the dog and cat is also slightly arched along its entire length, having the cranial and caudal smooth faces, the medial margin being mostly subcutaneous (KÖNIG & LIEBICH, 2021). At the distal end, in all domestic animals is evidenced medially the processus styloideus for the insertion of the medial collateral ligament of the carpus, also identified in the distal epiphysis in *B. variegatus*.

The *B. variegatus* ulna occupies a caudolateral position in relation to the radius. It presents in its proximal epiphysis the olecranon protruding to the caudal part of the distal end of the humerus, has an Incisura trochlearis for articulation with the humerus, and cranially the processus anconeus, as well as in domestic animals (KÖNIG & LIEBICH, 2021).

Many features of muscle sloth topography appear to be related to the inverse orientation of the body to the force of gravity in adopting the suspensory stance during locomotion (NYAKATURA & FISCHER, 2011). As for the musculature of the arm of *B. variegatus*, M. latissimus dorsi origin had its origin from the posterior half of the spinal processes of the thoracic vertebrae inserting medially in the proximal portion of the humerus, as described by NYAKATURA & FISCHER (2011) for the sloths *Choloepus didactylus* and *Bradypus variegatus*. Some fibers of the M. latissimus dorsi extend as a continuation to M. tensor fasciae antebrachii, which is inserted into the olecranon, similar to the giant anteater (SESOKO et al., 2016), bovine and equine (KÖNIG & LIEBICH, 2021). However, NYAKATURA & FISCHER (2011) and MILLER (1935) named M. tensor fasciae antebrachii in *B. variegatus* as M. dorsoepitroclear.

The M. coracobrachialis originated in the Processus coracoideus of the scapula and is inserted in the Crista tuberculi minoris of the humerus, as in the domestic animals (KÖNIG & LIEBICH, 2021), and corroborating with the descriptions of NYAKATURA & FISCHER (2011). The M. biceps brachii of *B. variegatus* consisted of a long, fusiform muscle that extends over the entire length of the humerus, dividing into two caputs, longu and short. NYAKATURA & FISCHER (2011) described M. biceps brachii in *C. didactylus* arising from the Processus coracoideus of the scapula and *B. variegatus* originating from the humerus, dividing into what they called the anterior and posterior belly. In domestic animals, this muscle has only one head (KÖNIG & LIEBICH, 2021).

The M. triceps brachii consisted of two heads, lateral and longum, which originated at the caudal end of the scapula (caput longum) or at the proximal end of the humerus (caput laterale) and were inserted into the Tuber olecrani. MILLER (1935) described three caputs for the genus *Bradypus* (laterale, longum and mediale), as well as for equine, bovine and swine (KÖNIG & LIEBICH, 2021). The dog has the caput accessorium, which originates from the caudal part of the Collum humeri and merges with the caputs longum and laterale (DYCE et al., 2019; KÖNIG & LIEBICH, 2021). The M. brachioradialis in *B. variegatus* originates in the distal third of the lateral margin of the humerus and extends to the distal medial part of the forearm, as in the dogs (DYCE et al., 2019).

In general, the origin of each muscle that makes up the forearm of *B. variegatus* is the same as observed in the domestic species (DYCE et al., 2019; KÖNIG & LIEBICH, 2021), but some muscles are different. The M. extensor carpi radialis in domestic animals is the most important and strong extensor muscle of the carpus articulation (KÖNIG & LIEBICH, 2021). In man it is divided into two muscles called M. extensor carpi radialis longus and M. extensor carpi radialis brevis (DI DIO, 1999). According to Miller (1935), in the genus *Bradypus*, the longus and brevis portions are fused into a single muscle that inserts with the M. brachioradialis on the carpi bones, as observed in our study.

In domestic animals M. flexor digitorum superficialis is in the caudomedial part of the forearm, appears in the medial epicondyle of the humerus and radiates differently among the species in several branches, already the M. flexor digitorum profundi lies deep in the caudal aspect of the forearm bones (DYCE et al., 2019; KÖNIG & LIEBICH, 2021). In the genus *Bradypus*, according to MILLER (1935), Mm. flexor digitorum superficialis and profundi are fused into a single muscle, but we found these two muscles separated.

For surgical access of the humeral diaphysis of *B. variegatus* the best approach is the lateral aspect, since the medial face is the brachialis artery composing the *rete mirabile* and the median nerve. In dogs, depending on the type and site of the fracture, both the craniolateral and medial sides of the humerus can be used for the placement of bone plaques (JOHNSON, 2013). The dog's humerus has a complex shape that makes it difficult to attach internal implants; the twisted appearance of the diaphysis is conferred by a sulcus that follow in spirals shape over the side (DYCE et al., 2019). According to SESOKO et al. (2016), the humerus of the giant anteater has well pronounced ridges on the craniolateral face that difficult the surgical access through this approach, being indicated the craniomedial approach where the humerus has a straight end, allowing the placement of bone plates. The morphology of the humeral diaphysis of the common sloth is long and cylindrical, facilitating the placement of implants in this region.

In *B. variegatus* the distal humerus is flattened craniocaudally, as in the anteater (SESOKO et al., 2016), preventing the placement of an intramedullary pinus and making it difficult to use the lateral or medial plaque. Due to this anatomical conformation, in the present study a caudal approach was used for fractures in distal regions, for adequate fixation of the implants (plate and screws).

To access the radial diaphysis of *B. variegatus*, a craniolateral approach of the limb was performed, placing the implant on the cranial bone face. In dogs, the cranial placement of the plaque on the radius diaphysis has been the most widely used method because it is an easily accessible bone face that provides a wide surface; however, according to PIERMATTEI et al. (2009), the craniomedial approach for skin incision provides good exposure, since the radius is subcutaneous in this area.

For the craniolateral approach of radius diaphysis in *B. variegatus* the M. abductor digiti I longus was preserved during plaque placement. According to JOHNSON (2013), this muscle can be sectioned for greater exposure of the distal end of the radius, although, simply, the displacement of this allows radius exposure to be obtained.

To access the diaphysis of the ulna in *B. variegatus* the best approach was for the caudal aspect of the forearm with placement of the internal implant on the lateral bone face after the release of M. flexor carpi ulnaris. In dogs, caudal access to the diaphysis of the ulna is a little more laborious, where after dissecting the Fascia brachii Lamina profunda, M. anconeus, M. flexor carpi ulnaris and M. extensor carpi ulnaris should be separated from their fixation in the ulna for Corpus ulnae exposure (LATORRE, 2012).

CONCLUSION

Sloths present anatomical aspects adapted for tree life, and thus, the bone and muscular anatomy of the thoracic member of *Bradypus variegatus* differs from domestic animals and other Xenarthras. The anatomical accidents and structural conformation of the radius and ulna in *Bradypus variegatus* were like those described in the literature for domestic animals, the humerus in turn presented differences in the distal extremity because it was flattened. The musculature of *Bradypus variegatus* showed similarities with domestic animals but some forearm muscles presented different characteristics. The humerus has a long and cylindrical diaphysis facilitating the placement of orthopedic implants in this region, with a better approach from the lateral aspect, since the medial face is the *rete mirabile* and the median nerve. For distal region, it is suggested that the access is caudolateral, because the humerus becomes craniocaudally flattened. Already for the access to the diaphysis of the radius, it is suggested a craniolateral approach, placing the implant in the cranial face of the bone, and for the access to ulnar diaphysis, caudal approach, placing the implant in the lateral face of the bone.

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BIOETHICS AND BIOSSECURITY COMMITTEE APPROVAL

We, authors of the article entitled Anatomy and surgical approach to the humerus, radius and ulna of common sloth (*Bradypus variegatus*), declare that the data from this study were not submitted for evaluation to the Ethics and Biosafety Committee of Universidade Federal Rural da Amazônia (UFRA) in Belém, Para State, because are animal that death for natural causes in Jardim Botânico Bosque Rodrigues Alves. We have authorization from Chico Mendes Institute for Biodiversity Conservation (ICMBio) SISBIO N° 23401-7 for use of this animals. Thus, the authors assume full responsibility for the data and are available for possible questions.

DECLARATION OF CONFLICT OF INTEREST

The authors declare no conflict of interest. The founding sponsors had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, and in the decision to publish the results.

AUTHORS' CONTRIBUTIONS

All authors contributed equally for the conception and writing of the manuscript. All authors critically revised the manuscript and approved of the final version.

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