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Luiz Ricardo de Oliveira Roberto
Universidade Federal Rural do Rio de Janeiro, luiz_ricardoroberto@yahoo.com.br

Marcelo Soares Antunes
Universidade Federal Rural do Rio de Janeiro, antunesms@yahoo.com.br

Andressa Kagohara
Médica Veterinária, de.kagohara@gmail.com

Marcelo Abidu-Figueiredo
Universidade Federal Rural do Rio de Janeiro, marceloabidu@gmail.com

Orlando Marques da Costa
Universidade Federal Rural do Rio de Janeiro, orlandomacosta@gmail.com

See next page for additional authors

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Autor

Luiz Ricardo de Oliveira Roberto, Marcelo Soares Antunes, Andressa Kagohara, Marcelo Abidu-Figueiredo, Orlando Marques da Costa, Paulo Roberto Bernardes Lopes, and Luciano Da Silva Alonso

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Anatomical Description of the Gracilis Muscle in Lesser Anteater (*Tamandua tetradactyla*)*

Luiz Ricardo de Oliveira Roberto[1] / Marcelo Soares Antunes[2] / Andressa Kagohara[3] / Marcelo AbiduFigueiredo[4] / Orlando Marques da Costa[5] / Paulo Roberto Bernardes Lopes[6] / Luciano Da Silva Alonso[7]

Abstract

The lesser anteater (*Tamandua tetradactyla*) is a mammal of the family *Myrmecophagidae*, which is part of the *Superordem Xenarthra*. It is found in South America and is distributed in all the Brazilian biomes. The ecologic aspects of the morphology of the lesser anteater are still little known. This study used 12 specimens of *Tamandua tetradactyla* with unknown gender; a specimen of dog (*Canis lupus familiaris*) male; a specimen of cat (*Felis catus*) female; a specimen of sheep (*Ovis aries*) with unknown gender. The gracilis muscle was dissected, evidencing its origin and insertion. This paper describes the origin and insertion of the gracilis muscle in *Tamandua tetradactyla*. Knowledge about biomechanical aspects of terrestrial and arboreal species is essential in ecomorphological studies. The lesser anteater is a climber who actively uses its hind limbs in adduction when climbing trunks and trees.

Keywords: *Xenarthra,* collared anteater*,* ecomorphology*,* adaptation, locomotion.

Descripción anatómica del músculo Gracilis en el oso hormiguero menor (*Tamandua tetradactyla*)

Resumen

El hormiguero menor (*Tamandua tetradactyla*) es un mamífero de la familia *Myrmecophagidae*, que forma parte del superorden *Xenarthra*. Se encuentra en América del Sur y se distribuye en todos los biomas brasileños. Los aspectos ecológicos de la morfología del hormiguero menor *aún son poco conocidos. Este estudio utilizó* doce especímenes de *Tamandua tetradactyla* de género no identificado; un espécimen de perro macho (*Canis lupus familiaris*); un espécimen de gata (*Felis catus*); y un espécimen de oveja (*Ovis aries*), los cuales fueron disecados para evidenciar el origen e inserción del músculo gracilis. El objetivo de este trabajo es describir el origen y la inserción del músculo gracilis en el hormiguero menor. El conocimiento sobre los aspectos biomecánicos de las especies terrestres y arbóreas es importante en los estudios ecomorfológicos. En ese contexto, el *Tamandua tetradactyla* es trepador y utiliza activamente sus extremidades posteriores en aducción cuando trepa por troncos y árboles.

Palabras clave: *Xenarthra*, tamanduá de colete, ecomorfología, adaptação, locomoción.

* Artigo de investigação.

1 Aluno de Graduação em Medicina Veterinária, UFRRJ.
✉ luiz_ricardoroberto@yahoo.com.br
http://orcid.org/0000-0003-2458-7670

2 Doutorando em Biologia Animal, UFRRJ.
✉ antunesms@yahoo.com.br
https://orcid.org/0000-0002-3557-7163

3 Médica Veterinária.
✉ de.kagohara@gmail.com
http://orcid.org/0000-0001-9897-7298

4 Professor do Departamento de Anatomia Animal e Humana, UFRRJ.
✉ marceloabidu@gmail.com
https://orcid.org/0000-0003-2251-171X

5 Professor do Departamento de Anatomia Animal e Humana, UFRRJ.
✉ orlandomacosta@gmail.com
https://orcid.org/0000-0002-8849-971X

6 Professor do Departamento de Anatomia Animal e Humana, UFRRJ.
✉ prbl@ufrrj.br
https://orcid.org/0000-0002-0052-8468

7 Professor do Departamento de Anatomia Animal e Humana, UFRRJ.
✉ alonso.rural@gmail.com
https://orcid.org/0000-0001-8130-7810

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Descrição anatômica do músculo grácil em tamanduá mirim (*Tamandua tetradactyla*)

Resumo

O tamanduá mirim (*Tamandua tetradactyla*) é um mamífero da família Myrmecophagidae, que faz parte da Superordem Xenarthra. É encontrado na América do Sul e estão distribuídos em todos os biomas brasileiros. Os aspectos ecológicos da morfologia do tamanduá mirim ainda são pouco conhecidos. Este estudo utilizou 12 espécimes de *Tamandua tetradactyla* de gênero não identificado; um espécime de cão (*Canis lupus familiaris*) macho; um espécime de gato (*Felis catus*) fêmea; um espécime fêmea de ovelha (*Ovis aries*), os quais foram dissecados para evidenciar a origem e inserção do músculo grácil. O objetivo deste trabalho é descrever a origem e inserção do músculo grácil em tamanduá mirim. O conhecimento sobre aspectos biomecânicos de espécies terrestres e arbóreas é importante em estudos ecomorfológicos e o *Tamandua tetradactyla* é escalador e usa seus membros posteriores em posição de adução, ativamente ao escalar troncos e árvores.

Palavras chave: *Xenarthra*, tamanduá de colete, ecomorfologia, adaptação, locomoção.

Introduction

The lesser anteater (*Tamandua tetradactyla*) is a mammal of the Myrmecophagidae family, which is part of the Xenarthra Superorder, as well as the Armadillos and the Sloths. The anteaters are found in South America and are distributed in all Brazilian biomes (1). These animals have as characteristic the golden coat with black bands that gives a vest aspect, being able to vary of color according to its geographical distribution (2). They are insectivores, feeding mainly on termites and ants (3, 4).

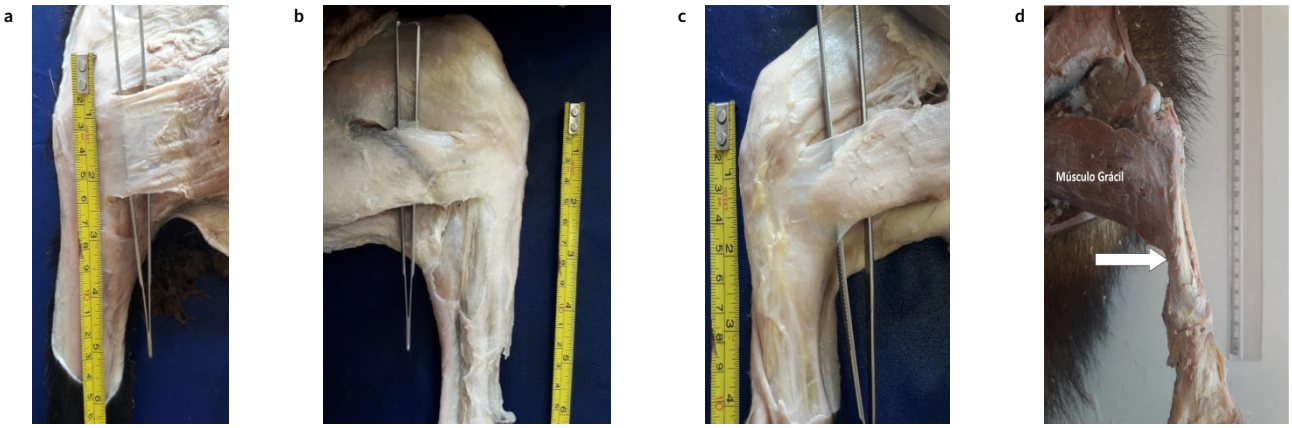
The ecological aspects of the morphology of the lesser anteater are still little known. Morphological ecology is an area of knowledge that relates the performance of the organism as a whole and not only the segmented study of its parts. In arboreal species, the ecomorphological study makes it possible to understand biomechanical aspects of this type of locomotion (5). In previous dissections, our research group observed that the gracilis muscle in *Tamandua tetradactyla* is distinct compared to domestic mammals. The objective of this work is to describe the anatomical points of origin and insertion of the gracilis muscle in lesser anteater, contributing to the understanding of the biomechanical aspects involved in the locomotion of arboreal and terrestrial, typical of this species.

Materials and methods

In this study, 12 specimens of *Tamandua tetradactyla*, youths and adults of unidentified genus were used. The animals were killed by being run over on roads in the state of Rio de Janeiro and donated to the Anatomy Laboratory of the Rural Federal University of Rio de Janeiro. The license for receiving biological material from vertebrates is SISBIO 65486. A male specimen (*Canis lupus familiaris*); a specimen of a female cat (*Felis catus*); a sheep specimen (*Ovis aries*) of hembra, donated by the Veterinary Hospital, after natural death, with free and informed consent, were also used in this study. The anatomical description was based on the Nomina Anatomica Veterinaria. The project is registered with the

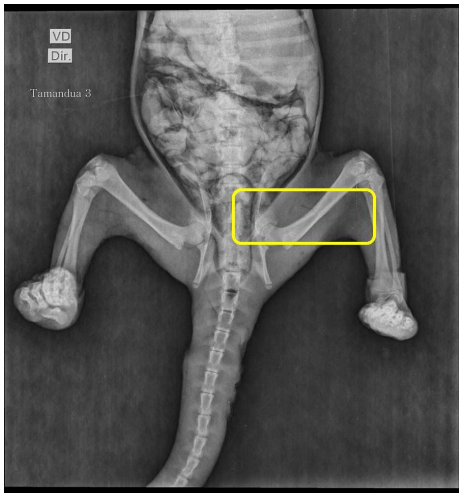
Committee on Ethics in the Use of Animals (CEUA) under number 018/2017, at the Institute of Biological Sciences and Health, Federal Rural University of Rio de Janeiro. The specimens, after thawing, were prepared by injecting a 10 % formaldehyde solution into the common carotid artery of the dog, cat and sheep specimens; and by muscle infiltration in *T. tetradactyla*. After fixation and immersion in 10% formaldehyde solution for 72 hours, all were dissected with a scalpel, forceps and scissors. The gracilis muscle was dissected, evidencing its origin and insertion (Figure 1). An x-ray of the pelvic limb was performed in one specimen to visualize the related bone structures, with the equipment FCR Prima Series, Fuji Film. (Figure 2).

Figure 1. The medial region of the thigh and leg dissected from cat (A), dog (B) and goat (C), highlighting the gracilis muscle with the metal clamp, with broad Aponeurosis inserted onto the medial surface of the proximal portion of the tibia. In lesser *Tamandua* (D), the insertion occurs in the middle third of the tibia, with white arrow indicating the distal limit of the muscle fibers directly inserted onto the periosteum.



Source: own work

Figure 2. Lesser anteater youth radiograph showing in the yellow area of the gracilis muscle, between the pelvic symphysis and the body of the tibia. Ventro-dorsal position. Equipment: FCR Prima Series Fuji Film



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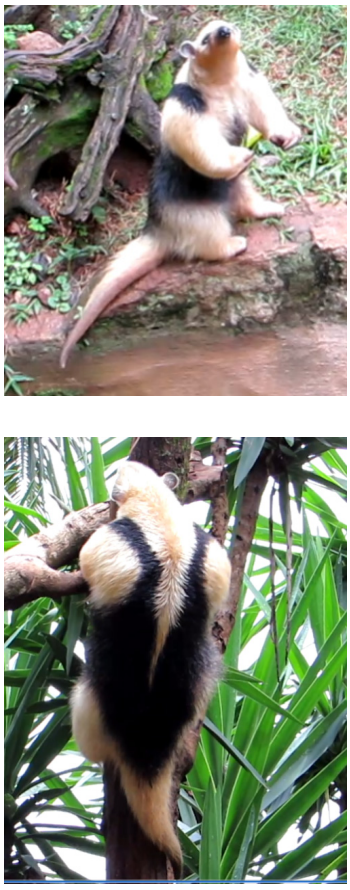
Results and discussion

The gracilis muscle is a broad, flat muscle located on the medial aspect of the thigh. It is an adductor muscle of the pelvic limb, contributing secondarily to the movements of the knee and tarsal joints (6). In general, the gracilis muscle is described by several authors in anatomy texts of domestic animals as having aponeurotic origin in the ventral surface of the pubis and the ischial symphysis and as insertion point the medial face of the knee and the crural fascia (7). In our observations of specimens of *Tamandua tetradactyla*, the gracilis muscle, in all observations and in both right and left pelvic limbs, presented origins from the pelvic symphysis, as described for domestic animals. The insertion point for the gracilis muscle, however, showed along the medial surface of the tibia, with strong muscle fibers inserting into the periosteum directly (figure 1), and not as the flat tendon and connective tissue characteristic of domestic species. This finding differs from that described for domestic animals whose insertion for this muscle is invariably in the proximal third of the tibia as described above. This type of insertion in domestic animals occurs through wide tendon of the gracilis muscle as compared in anatomical parts of our anteater specimens dissected in this study (Figure 1A, B, C). In lesser anteater, the muscle fibers are inserted directly into the bone (Figure 1D).

The insertion of the gracilis muscle onto along the medial surface of the middle third of the tibia in *Tamandua tetradactyla* is similar to that described for the giant anteater (*Mymercophaga tridactyla*) by Ribeiro et al. (8). Although the giant anteater is not recognized as an arboreal species, the species has the ability to climb, as that observed by Cubas (1), who reported on an individual of giant anteater seen eight meters high in a tree. In addition, in terrestrial locomotion, the anteater also stands on the ground with bipedal support, lifting the body vertically (figure 3A). The anteater also uses the tail support, which stands firmly on the ground in the biped position (2). Considering the similar arrangement for the insertion of the gracilis muscle between these two species of anteater, this may be a contributing factor for the moment of force necessary in the action of the pelvic limbs, which suggests an evolutionary adaptation that favors the escalating locomotion, increasing the vector of force for the adduction of limbs (9) at the moment of climbing (figure 3B), characterizing a bio-lever capable of producing force, with low amplitude and speed of action. It also makes the muscle potent, in the movement of the knee and hock, for digging the ground at moments of ant hill and termite openings. The site of insertion of the muscles in the tibia and its correlation with bone pathologies in *T. tetradactyla* was performed by Cott et al. (10), which suggests an insertion of the m. gracilis proximomedially in the tibia, contrasting with our results that point to a more extensive medial insertion of the muscle fibers, going up to the middle of the body of the tibia in *T. tetradactyla.*

Figure 3. Lesser anteater in support of the ground (A) biped and climbing tree (B)



Source: own work

Conclusions

In the lesser anteater the insertion of the gracilis muscle on to along middle third of the tibia is similar to that described for giant anteater, suggesting that this is a common feature of the Vermilingua. This condition may be an adaptation to an arboreal locomotion, able to increase strength to support the pelvic limb, on the occasion of the climbing. In lesser anteater, the insertion of the gracilis muscle is performed by muscular fibers along the middle third of the body of the tibia, while in domestic mammals the insertion is made by a wide aponeurosis into the proximal third of the tibia. Other studies for evaluation of muscle groups of the pelvic limbs, since the bone pelvis until the distal elements, at the end of the limbs, should also be considered in ecomorphological perspective.

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