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Bone and muscular anatomy of the forearm and hand in *Tapirus terrestris* (Perissodactyla, Tapiridae)

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Resumo

Anatomia óssea e muscular do antebraço e mão de *Tapirus terrestris* (Perissodactyla, Tapiridae). Existem duas espécies de anta brasileira, os maiores mamíferos terrestres do Brasil, as quais pertencem à ordem dos Perissodactyla, assim como os equinos. Objetivou-se descrever a anatomia óssea e muscular do antebraço e mão de *Tapirus terrestris* e fazer considerações adaptativas. Foram utilizadas cinco peças anatômicas doadas por um criadouro ao Laboratório de Ensino e Pesquisa em Animais Silvestres da Universidade Federal de Uberlândia (LAPAS-UFU), após óbito sem traumas. Os ossos foram analisados, os músculos dissecados, e ambos descritos. Os ossos que constituem o esqueleto do antebraço e mão da anta são a ulna, rádio, metacarpos, carpos, falanges e *sesamoides*. Os músculos são: M. extensor carpo radial, M. ulnar lateral, M. flexor carpo radial, M. extensor radial comum, M. extensor longo dos dedos II, III, IV e V, M. extensor digital lateral, M. abdutor longo, M. flexor digital superficial, M. flexor digital profundo, M. flexor carpo ulnar, M. flexor oblíquo do carpo, M. interósseos e M. lumbricais. Os acidentes ósseos e a estrutura muscular estão adaptados para o desenvolvimento do nicho do animal.

Palavras-chave: Anta; Morfologia; Músculos; Osteologia

Abstract

In Brazil, there are two species of tapirs, the largest land mammals in Brazil, which belong to the order Perissodactyla, as do horses. Our aim was to describe the bone and muscular anatomy of the forearm and hand in *T. terrestris* and to propose adaptive functions. We used five anatomical specimens donated from a breeder to the Laboratory for Teaching and Research on Wild Animals of the Federal University of Uberlandia after death with no trauma. The bones were analyzed, the muscles dissected, and both described. The bones of the forearm and hand of the tapir are the ulna, radius, Os. metacarpalia, Os. carpi, phalanx and Os. sesamoideum.

The muscles are M. extensor carpi radialis, M. ulnaris lateralis; M. flexor carpi radialis; M. extensor radialis communis; M. extensor digitorum longus II, III, IV and V, M. extensor digitorum lateralis; M. extensor digitorum; M. abductor longus; M. flexor digiti superficialis; M. flexor digitalis; M. flexor carpi ulnaris; M. flexor carpi obliquus; and M. interossei and M. lumbricales. Characteristics of bone and muscle structure are adapted to the development of the animal's niche.

Key words: Morphology; Muscles; Osteology; Tapir

Introduction

Tapirus terrestris (tapir) (Linnaeus, 1758) is an animal belonging to the order Perissodactyla and family Tapiridae. Tapirs date back to the Pleistocene (HOLANDA, 2007). The genus *Tapirus* includes five species nowadays, *T. terrestris*, *T. pinchaque*, *T. bairdii*, *T. indicus* and *T. kabomaini* (COZZUOL et al., 2013).

The tapirs are ungulate animals, which are characterized by having an odd number of fingers, and they stand on the ends of their fingers (EISENBERG; REDEFORD, 1999). *Tapirus terrestris*, in contrast, has four fingers on the hand and three fingers on the foot. These animals have a wide geographical distribution in South America, and specifically in Brazil, it is distributed in all biomes, except in the extreme south of the Pampas (PADILLA; DOWLER, 1994; BROOKS et al., 1997). It is extinct in the Caatinga (MEDICI et al., 2012) and its relative density is considered low in the state of Paraná (VIDOLINI et al., 2011).

The anatomy and physiology of the tapir are similar to that of the domestic horse and other Perissodactyla (HERNÁNDEZ-DIVERS, et al., 2007; RINCÓN, 2008). *Tapirus terrestris* is of great importance in the environment as a seed disperser, and it has tight integration in food webs (VIDOLINI et al., 2011). However, this species is exposed to different threats (MEDICI et al., 2012).

According to Heleno et al. (2011) and Rosa et al. (2012), the morphological description of wild species helps in interventions at the surgical and clinical-surgical levels and in conservation policies, and also helps the enhancement of applications in the veterinary and therapy clinic.

Tapirus terrestris has a wide distribution and importance for the environment, and it is considered a species vulnerable to extinction. Therefore, besides evaluating the importance of information on the anatomy of wild animals, we aimed to describe the bone and muscle anatomy of the forearm and hand of *T. terrestris* and to propose adaptive functions.

Material and Methods

We used five anatomical specimens of adult animals donated by a breeder to LAPAS-UFU after natural death without trauma. The specimens were fixed in aqueous 10% formalin in opaque vats. The study was approved by the Ethics Committee for Use of Animals of the UFU (CEUA) under nº 069/12, and was in accordance with Normative Ruling nº 03, September 1, 2014 of ICMbio.

For the description of bones, four anatomical specimens were macerated in boiling water and subsequently placed in hydrogen peroxide solution for 12 h for bleaching. For the muscle study, two of the five anatomical specimens were carefully dissected, according to the usual techniques in gross anatomy, preserving the attachment points and features of the muscles. The nomenclature adopted was according to the International Committee on Veterinary Gross Anatomical Nomenclature (2012).

For the complementation of the description, radiological images were taken to check the position of the bones after the maceration process and to help in the assembly of the skeleton. The images were recorded with a digital camera (Nikon Coolpix L820 16 Mpx Zoom 30x) and by the radiographic imaging apparatus of the Veterinary Hospital of UFU (Siemens RZ9), and the photographs were handled using Adobe Photoshop software CC 14.

Results and Discussion

The bones that constitute the forearm skeleton of *T. terrestris* are the ulna and radius, since the bones of the hand, os. metacarpalia, os. carpi, phalanx and os. sesamoideum. The ulna of *T. terrestris* articulates proximally with the humerus and fits into the fossa olecrani, and it is fused to the radius, like in *Ozotoceros bezoarticus* (pampas deer) (VARELA, 2010). Differently from horses, the radius and ulna have their distal part at the same height for the articulation with the carpi. They are long bones, which help in moving over long distances and supporting the body weight upright (BARBIERI et al., 2011).

The radius (Figure 1) is a long bone and it is located cranially to the ulna, the articular carpal surface, the distal part of the radius, is smooth, and it articulates with the carpal bones, all these features are quite similar to those described by Dyce et al. (2010) for cattle. The carpal bones in *T. terrestris* (Figures 2 and 3) are a set of seven short bones divided into two rows, proximal and distal, the same as in cattle and horses (DYCE et al., 2010).

FIGURE 1: Photography of the radius and ulna bones of *Tapirus terrestris*. I medial view: (1) Tuber olecrani; (2) Incisura trochlearis; (3) Fovea capitis radii; (4) Tuberositas radii; (5) Corpus radii; (6) Facies articularis carpea; (7) Corpus ulnae; (8) Interosseous space. II Side view: Radius and ulna – (1) Tuber olecrani; (2) Processus anconeus [anconaeus]; (3) Incisura trochlearis ; (4 and 6) Interosseous space; (5) Tuberositas radii; (7) Corpus do radii; (8) Sulcus tendii extensorius digitalis comum.

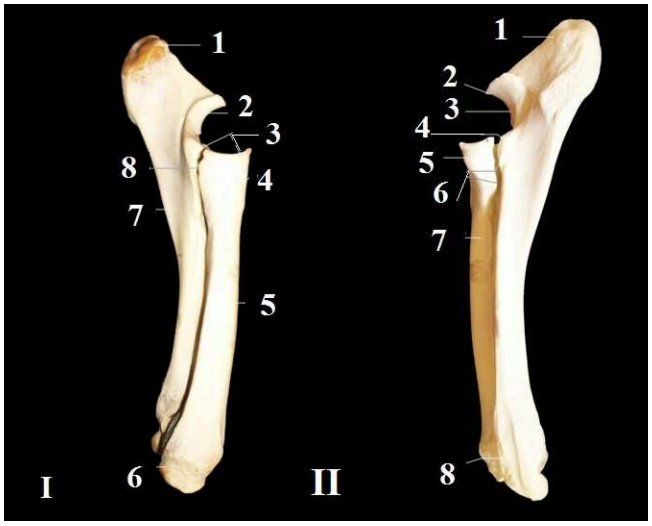


FIGURE 2: Photography of the carpi and metacarpalia bones of *Tapirus terrestris*, dorsal view Radius and ulna. (1) Carpi radialis; (2) Carpi intermedium; (3) Carpi ulnare; (4) Carpale II; (5) Carpale III; (6) Carpale IV; (McII) Metacarpale II; (McIII) Metacarpale III; (McIV) Metacarpale IV; (McV) Metacarpale V.

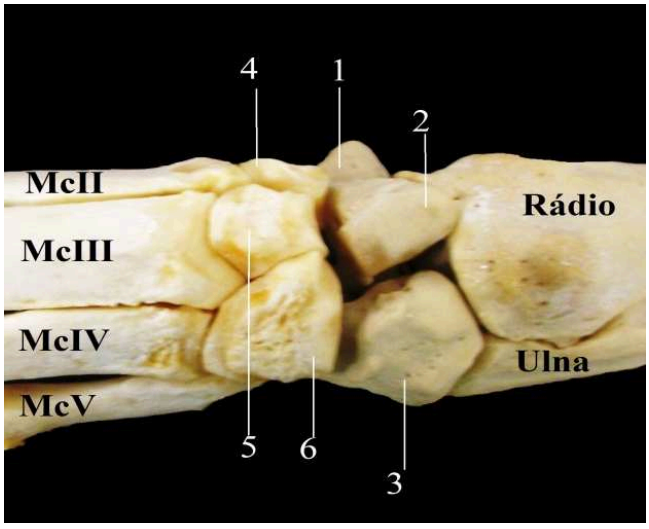
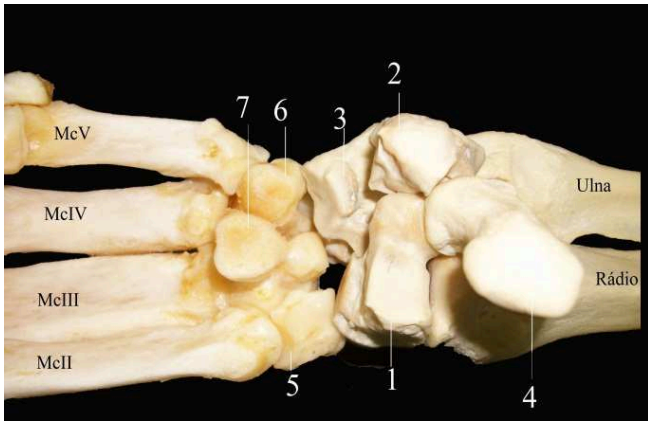


FIGURE 3: Photography of the carpi and metacarpalia bones of *Tapirus terrestris*, palmar view. (1) Carpi radialis; (2) Carpi intermediale; (3) Carpi ulnare; (4) Carpi accessorium; (5) Carpale II; (6) Carpale IV; (7) Carpale III; (McII) Metacarpale II; (McIII) Metacarpale III; (McIV) Metacarpale IV; (McV) Metacarpale V.

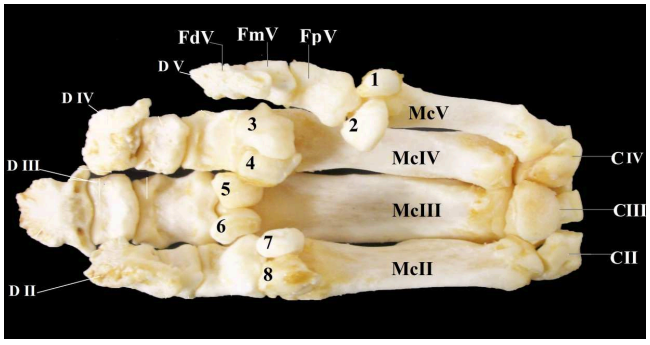


The presence of four fingers is what makes this type of Perissodactyla different from the others, which have an odd number, but phylogenetically, they are included in this order (CAMPBELL, 1936). Fingers II, III and IV touch the ground more frequently during walking (KÖNIG; LIEBICH, 2002). According to Campbell (1936), the fourth finger of *T. terrestris* is important in the resting position, while having other

functions. According to Fragoso and Huffman (2000), the morphological interactions of cursorial legs with the environment reinforce the notion that there may be a mutualistic maintenance to maintain ecological patterns and processes between the disperser and seeds, especially in megaflora, due to the habit of *T. terrestris* covering large areas.

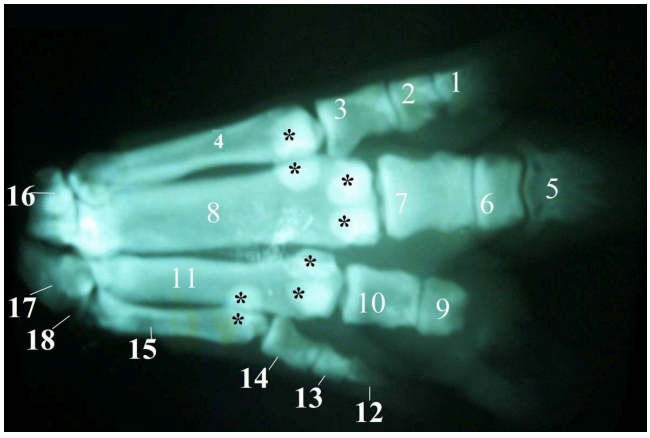
Tapirus terrestris has the phalanges articulating with the metacarpal bones in the metacarpal sequence II, III, IV and V (Figures 4 and 5). There are eight sesamoid bones, two for each phalanx, and they have articular function and help change the direction of the tendons or increase lever strength for the muscles and tendons of the hand (GETTY et al., 1986). According to Hildebrand (1995), the longer the leg, the longer the step is, and the forelegs of *T. terrestris* are elongated, and its four fingers also help in its moving (CAMPBELL, 1936). *Tapirus terrestris* has bone and muscle characteristics of an animal adapted to moving or running and any eventual swimming with protuberant bones (PEREIRA et al., 2015).

FIGURE 4: Photography of the hand bones of *Tapirus terrestris*, facies palmaris. (CII) Carpale II; (CIII) Carpale III; (CIV) Carpale; (McII) Metacarpale II; (McIII) Metacarpale III; (McIV) Metacarpale IV; (McV) Metacarpale V; (1) and (2) Sesamoideum digiti V; (3) and (4) Sesamoideum digiti IV; (5) and (6) Sesamoideum digiti III; (7) and (8) Sesamoideum digiti II; (FpV) Phalanx proximalis digiti V; (FmV) Phalanx medialis digiti V; (FdV) Phalanx distele digiti V; (D II) Digiti 2; (D III) Digiti 3; (DIV) Digiti 4; (DV) Digiti 5.



The forearm and hand muscles are divided into two groups, the extensors and flexors (Figures 6 and 7). The M. extensor carpi radialis (Figures 6 and 7) is the largest muscle of the extensor group in *T. terrestris*. The M. ulnar lateralis (M. extensor carpi ulnaris) (Figure 7 and 8) in *T. terrestris* it is elongated. The M. flexor carpi radialis is a muscle that is located on the medial side of the forearm. The M. flexor carpi ulnaris (Figure 6) is long and slender. The M. extensor digitorum communis located laterally to the M. extensor carpi radialis (Figure 7 and 8) the same as in ruminants according to König and Liebich (2002).

FIGURE 5: Radiological image of the hand of *Tapirus terrestris*, dorsal view. (1) Phalanx distalis the digiti II; (2) Phalanx medialis the digiti II; (3) Phalanx proximalis the digiti II; (4) Metacarpi II; (5) Phalanx distalis the digiti III; (6) Phalanx medialis the digiti III; (7) Phalanx proximalis the digiti III; (8) Metacarpi III; (9) Phalanx medialis the digiti IV; (10) Phalanx proximalis the digiti IV; (11) Metacarpi IV; (12) Phalanx distalis the digiti V; (13) Phalanx médialis the digiti V; (14) Phalanx proximalis the digiti V; (15) Metacarpo V; (16) Carpi II; (17) Carpi III; (18) Carpi IV; * Sesamoidea



The M. extensor longus of the II, III, IV and V is attached to this muscle, the same as in horses, cattle and pigs (KÖNIG; LIEBICH, 2002). The M. extensor digitorum lateralis (Figure 7) is located caudally to the M. extensor digitorum communis and cranially to M. ulnar lateralis. The M. abductor longus of the digiti, is located at the lateral portion of the radius, it is an elongated muscle. The M. flexor digitorum superficialis in *T. terrestris* (Figure 7) is divided into two parts (shallow and deep), and it is situated in the forearm. This muscle has two tendons in the palmar aspect of the carpus. The M. flexor digitorum profundus in *T. terrestris* (Figure 6) is divided into three parts; radial, humeral and ulnar.

FIGURE 6: Photography of the muscles of the forearm *Tapirus terrestris*, medial view. (I) M. extensor carpi radialis; (II) Fibrous lacertus collateral ligament; (III) M. flexor carpi radialis; (IV) M. flexor digiti profundus; (V) M. flexor digitorum brevis (two heads); (VI) M. flexor carpi ulnaris; (VII) M. flexor digiti profundus heads radiallis; (VIII) Radius; (IX) Common tendon of the digitis.

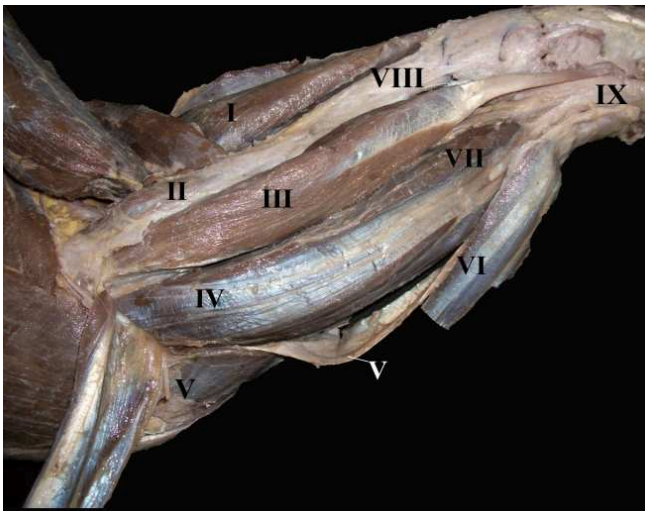


FIGURE 7: Photography of the forearm musculature of *Tapirus terrestris*, side view. (I) M. extensor carpi radialis; (II) M. extensor digitorum communis; (III) M. extensor digitalis lateralis; (IV) M. ulnar lateralis; (V) M. flexor digitalis superficialis;(VI) M. extensoris carpi obliqui.

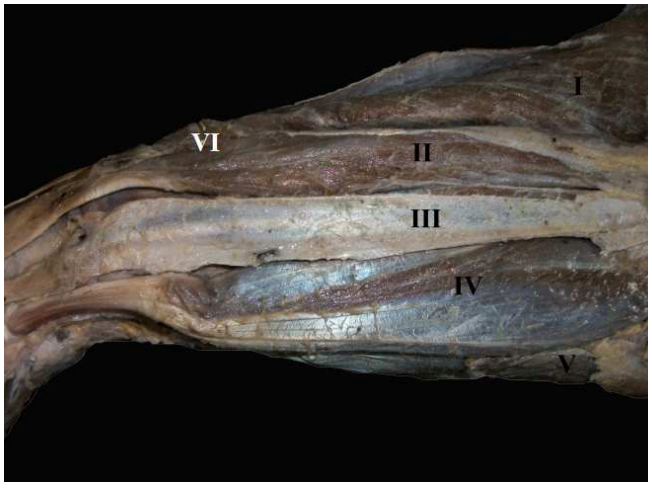


FIGURE 8: Photograph of the hand muscles of *Tapirus terrestris*, dorsolateral view. (I) M. extensor digitorum long the digiti II and III; (II) M. extensor digitorum common the digiti IV and V; (III) Tendo incertion the M. ulnar lateralis; (IV) Fascia insertion the M. digitalis lateralis.

The M. extensor carpi oblique located on the cranial surface (Figure 7) is a small muscle that is obliquely connected to the radius. The Mm. interossei of *T. terrestris* are mostly composed of fibrous tissue (Figure 9). They are situated on the palmar side, between the metacarpal bones II, III, IV and V, and they are made up of superficial and deep parts. The Mm. lumbricales are divided into lateral and medial and are little evident (Figure 9). The protuberant muscles reinforce their function in strength and resistance for running and eventual swimming (HILDEBRAND, 1995).

FIGURE 9: Photograph of the hand muscles of *Tapirus terrestris* medialis palmar view. (I) Mm. interossei; (I') Mm. lumbricales; (II) Tendo digitalis comum.

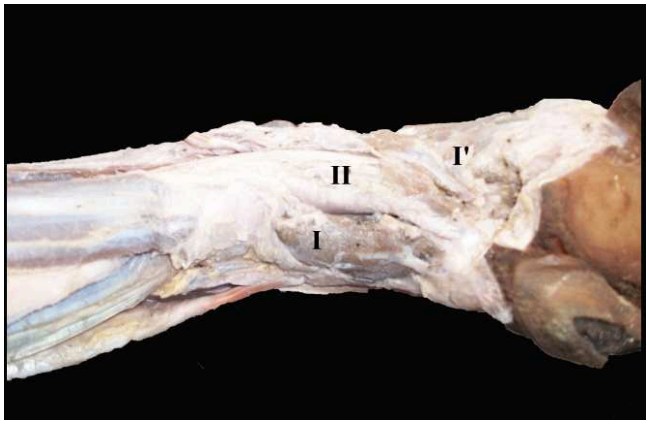


Table 1 presents the origin, insertion and inference of action of the described muscles.

TABLE 1: Origin, insertion and inference of action of the forearm and hand muscles of *Tapirus terrestris*.

Muscle	Origin	Insertion	Action Inference
M. extensor carpi radialis	Epicondyle humeral side	Metacarpal tuberosity by a strong tendon	Extend the carpal joint and flex the elbow joint
M. ulnar lateralis	Epicondyle humeral side	Bone Carpal accessory in its proximal edge	Flex the joint carpus and extend the elbow
M. flexor carpi radialis	Epicondyle humeral side	Palmar surface, in the metacarpal bone III	Flex the joint carpus and extend the elbow
M. extensor digitorum communis	Epicondyle humeral side, by a strong aponeurosis	Distal phalanx of fingers III and IV	Extend the articulation of the carpus
M. extensor digitorum long the digiti II and III	Epicondyle humeral side	Distal phalanx of the fingers II and III	Extend the articulation of the carpus
M. extensor digitorum communis the digiti IV and V	Epicondyle humeral side	Distal phalanx of fingers IV and V	Extend the articulation of the carpus
M. digitalis lateralis	Epicondyle humeral side	Phalanx middle fingers III and V	Extend the metacarpophalangeal joint of the fingers
M. abductor longus	Of the radi side	Metacarpal III	Abductor carpal
M. flexor digitalis superficialis	Epicondyle humeral medial	Superficially: common tendon of the fingers. Deep: fascia m. carpal ulnar	Flexing the carpometacarpal joint
M. flexor digiti profundus	Medial part: face flow in the proximal radial third	Common tendon of the fingers	Flexing the phalanges and the carpus
	Humeral part: distal end of the humerus	Common tendon of the fingers	
	Ulnar part: medial, in caudodistal margin the olecranon	Common tendon of the fingers	
M. flexor carpi ulnaris	Humeral part: medial epicondyle of the humerus	Accessory carpal bone	Flex the joint carpus and extend the elbow
	Ulnar part: olecrany	Accessory carpal bone	
M. extensor carpi oblique	Middle third of the radius, the M deep. common digital extensor	Metacarpal III	Extend the articulation of the carpus
Mm. interossei	Proximal metacarpal bones following the	Sesamoid bones of the metacarpophalangeal joint	Flexing the carpometacarpal joint
Mm. lumbricales	Tendon deep digital flexor	Fibrous tissue in the palmar region	Posture maintenance

On the basis of the results, we conclude that the bones of the forearm and hand of *T. terrestris* have specific characteristics that give this mammal the capacity of moving over long distances and weight bearing. As mentioned above, even with an even number of fingers (four) on the hand, it is assigned to the order Perissodactyla, and it is believed that finger V helps in moving and the resting position. They have the same number and arrangement as in horses, also showing similarities with other wild animals. *Tapirus terrestris* has bone and muscle characteristics suitable for moving at a fast pace and eventual swimming with obvious bone features and protuberant muscles.

References

BARBIERI, G.; MAZZER, N.; MORO, C. A.; MONTE-RASO, V. V.; OKUBO, R.; BARBIERI, C. H. Desenvolvimento e desempenho de um fixador flexível na consolidação de fraturas diafisárias transversais provocadas iatrogênicamente na tíbia de carneiros. **Ciência Rural**, Santa Maria, v. 41, n. 6, p. 1036-1042, 2011.

BROOKS, D. M.; BODMER, R. E.; MATOLA, S. **Tapirs –** Status survey and conservation action plan. IUCN/SSC Tapir Specialist Group. Gland and Cambridge: IUCN, 1997. 164 p.

CAMPBELL, B. Comparative myology of the forelimb of the hippopotamus, pig and tapir. **The American Journal of Anatomy**, New York, v. 59, n. 2, p. 201-247, 1936.

COZZUOL, M. A.; CLOZATO, C. L.; HOLANDA, E. C.; RODRIGUES, F. H. G.; NIENOW, S.; THOISY. B.; REDONDO, R. A. F.; SANTOS, F. R. A new species of tapir from the Amazon. **Journal of Mammalogy**, Lawrence, v. 94, n. 6, p. 1331-1345, 2013.

DYCE, K. M.; SACK, W. O.; WENSING, C. J. G. **Tratado de anatomia veterinária.** Rio de Janeiro: Elsevier, 2010. 834 p.

EISENBERG, J. F.; REDEFORD, K. H. **Mammals of the Neotropical –** The central neotropics: Ecuador, Peru, Bolívia, Brazil. Vol. 3. Chicago: The University of Chicago Press, 1999. 609 p.

FRAGOSO, J. M. V.; HUFFMAN, J. Seed-dispersal and seedling recruitment patterns by the last Neotropical megafaunal element in Amazonia, the tapir. **Journal of Tropical Ecology**, Winchelsea, v. 16, p. 369-385, 2000.

GETTY, R.; SISSON, S.; GROSSMAN, J. D. **Anatomia dos animais domésticos.** Vol. 1. 5. ed. Rio de Janeiro: Guanabara Koogan, 1986. 1134 p.

HELENO, A. R.; SANTOS, L. M.; MIGLINO, M. A.; PERES, J. A.; GUERRA, R. R. Biometria, histologia e morfometria do sistema digestório do cachorro-do-mato (*Cerdocyon thous*) de vida livre. **Biotemas**, Florianópolis, v. 24, n. 4, p. 111-119, 2011.

HERNÁNDEZ-DIVERS, S.; QUSE, V.; MAY, J. A.; THOISY, B. DE; VANSTREELS, R. E. T.; MARQUEZ, P. A. B.; TORRES, I. L. **Manual de medicina veterinária de antas em campo.** IUCN/SSC Tapir Specialist Group (TSG), Comitê de Veterinária, 2007. 60 p.

HILDEBRAND, M. **Análise da estrutura dos vertebrados.** São Paulo: Atheneu, 1995. 700 p.

HOLANDA, E. C. **Os Tapiridae (Mammalia, Perissodactyla) do pleistoceno superior do estado de Rondônia, Brasil.** 2007. 80 f. Dissertação (Mestrado em Geociências) – Universidade Federal do Rio Grande do Sul, Porto Alegre. 2007.

INTERNATIONAL COMMITTEE ON VETERINARY GROSS ANATOMICAL NOMENCLATURE. **Nomina anatômica veterinária.** 5. ed. Knoxville: World Association on Veterinary Anatomist, 2012. 160 p.

KÖNIG, H. E.; LIEBICH, H. G. **Anatomia dos animais domésticos –** Aparelho locomotor. Vol. 1. Porto Alegre, Artmed, 2002. 269 p.

MEDICI, E. P.; FLESCHER, K.; BEISIEGEL, B. de M.; KEUROGHLIAN, A.; DESBIEZ, A. L. J.; GATTI, A.; PONTES, A. R. M.; CAMPOS, C. B. de; TÓFOLI, C. F. de; MORAES JÚNIOR, E. A.; AZEVEDO, F. C. de; PINHO, G. M. de; CORDEIRO, J. L. P.; SANTOS JÚNIOR, T. S.; MORAIS, A. A. de; MANGINI, P. R.; RODRIGUES, L. F; ALMEIDA, L. B. de. Avaliação do risco de extinção da anta brasileira *Tapirus terrestris* Linnaeus, 1758, no Brasil. **Biodiversidade Brasileira**, Brasília, v. 2, n. 3, p. 103-116, 2012.

PADILLA, M.; DOWLER, R. C. *Tapirus terrestris*. **Mammalian Species,** New York, v. 2, n. 481, p. 1-8, 1994.

PEREIRA, S. G.; SANTOS, A. L. Q.; BORGES, D. C. S.; RIBEIRO, P. R. Q.; SOUZA, R. R. Anatomia óssea e muscular do cíngulo escapular e braço de *Tapirus terrestris* (Perissodactyla: Tapiridae). **Ciência Animal Brasileira**, Goiânia, v. 16, n. 2, p. 268-278, 2015.

RINCÓN, G. **Restricción química, hematologia y hallazgos parasitários del Proyecto Ecología y Conservación de la Danta de Montaña em los Andes Centrales de Colombia.** 2008. 172 f. Trabalho de Conclusão de Curso (Graduação em Medicina Veterinária) - Universidad de Ciencias Aplicadas y Ambientales, Bogotá. 2008.

ROSA, L. A.; SILVA, F. O. C.; SANTOS, A. L. Q.; SILVA, D. C de O.; SANTOS, L. A. dos S.; LIZARDO, F. B. Origem e distribuição do nervo axilar em tamanduá-bandeira (*Myrmecophaga* tridactyla). **Biotemas**, Florianópolis, v. 25, n. 3, p. 249-255, 2012.

VARELA, G. **Osteología y miología de lós miembros anterior e posterior del venado de campo (*Ozotoceros bezoarticus*).** 2010. 51 f. Tesina (Licenciatura en Ciências Biológicas) - Universidad de La República Uruguay, Montevidéu. 2010.

VIDOLINI, G. P.; BIODINI, D.; WANDEMBRUCK. A. A anta (*Tapirus terrestris*) em Fragmentos de Floresta com Araucária, Paraná, Brasil. **Floresta**, Curitiba, v. 41, n. 4, p. 685-694, 2011.