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# COMPARATIVE MORPHOLOGICAL STUDY OF THE LOCOMOTOR APPARATUS OF THE THORACIC AND PELVIC LIMBS OF THE BUFFALO *(BUBALUS bubalis,* L*)* AND CATTLE *(BOS taurus,* L*)*

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**ABSTRACT**

The present morphological study compares the structures of the thoracic and pelvic's limbs muscles and bones of the buffalo and cattle. *M. extensor digiti primi longus,* and absence of *os sesamoideum metatarsale* have been observed in the buffalo. The differences in the insertion of *m. peroneus tertius* on the hindlimb and structure of *m. flexor digitorum superficialis* and insertion of *m. extensor carpi oblquus* on the forelimb in the buffalo were noted. The attachments of the muscles with more ending tendons in the buffalo give bigger stability of the limbs than cattle.

**Key words:** buffalo, cattle, muscles, bones, forelimb, hindlimb.

## Introduction

The buffalo is an original species of Africa and Asia, diffused practically in all the continents, probably for the adaptation easiness in any adapts (Fonseca, 1987).

Some differences in the musculoskeletal system between cattle and buffalo are mentioned in anatomy textbooks (Gadzhev, 2000; Gadzhev, 2014). Recently, more and more authors in their research describe differences in the anatomical structures between cattle and buffalo – in the omasum (McSwenney, 1988), in the heart and lungs (Tajima et al, 1989), in the appendicular skeleton (Muchammad & Shahid 2000), in the axial skeleton (Shahid and Muchammad, 2001), in the facial veins (Ardalani and Bagheri, 2002), weight and length of ossicles (Neurinezhad et al., 2021). Independently in the buffalo, some authors use imaging methods for researches of the hindfoot (Abdellatif et al, 2018) other authors made an anatomic measurement of the normal heart (Panhwar et al., 2007; Magiugad & Balagan, 2021) and gross anatomy investigation of muscles and vessels on the tail (Tawfiek, 2007), of segments of the spinal cord (Sharma & Rao, 1971), on systematization of cranial vena cava (Amorm Jr and Amorim, 2002), of cardiac veins (Karrimi et al, 2010) and cardiac skeleton (Daghash and Fargahali, 2017). Limbs of the buffalo were studied by many authors and by different methods. El-Shafey & Sayed-Ahmed (2012) used imaging methods for visualization of the structures in the metacarpal and digital regions, Supriya et al. (2014) perform routine dissections of the hip joint, carpal joint and interosseous muscle (Supriya et al., 2016b), and femorotibial joint, where a new ligament was found (Supriya et al., 2016a). A combination of both types of methods was used for the description of the tendons of *mm. flexor digitorum superficialis et profundus and vagina synoviales tendinum digitorum pedis* on the hind limb of the buffalo (Ali, 2016).

From the literature data we can conclude that the limbs of the buffalo are of great interest compared to other ruminants, especially cattle, but there is no exact description of these differences to which we will direct the present study.

## Materials and methods

Four thoracic and four pelvic limbs on the buffalo with two thoracic and two pelvic limbs of the cattle were compared. Two female buffalos in the age of 1 and 6 years and one female cattle calf were used. The limbs were separated from the carcass and the gross morphology of the structures and their relations were studied by careful dissection and were photographed. Nomina Anatomica Veterinaria (2012) was followed as nomenclature for names of the muscles and bones.

## Results and discussion

The first difference between the muscles of the buffalo and cattle is the insertion of *m. extensor carpi obliquus (m. abductor digiti primi longus)*. It finishes on the medial side of the base on *os metacarpale III+IV* in the cattle (Fig. 1A) but except this part in the buffalo had a second insertion of this muscle that ends proximally of the medial styloid process of the radius (Fig. 1B). Termination of *m. extensor carpi obliquus* in the ruminants was reported by many authors (Gadzhev, 2000; Schaller, 2007; Vodenicharov, 2011) and was clarified in the cattle by Wünsche et al. (2003), Aschdown & Done (2010) and in the present study in the cattle, but the additional part in the buffalo is reported for the first time to our knowledge. A very interesting difference is the formation of the superficial flexor of the digit. All ruminants have superficial and deep parts (belly) which fuse in the level between proximal and middle parts of the metacarpus and continue distally with one common tendon which separates in two - one for each digit, where together with interosseous muscles form *manica flexoria* (Fig. 2A). In the buffalo the deep part is directed toward the third digit, the superficial part is directed toward the fourth digit, and there was no connection between these parts of *m. flexor digitorum superficialis* in the metacarpal region (Fig. 2B). This specific formation was found in the calf (Fig. 2 B) and adult buffalo (Fig. 2C). Formation of the superficial flexor of the digits in the ruminants was described by Gadzhev (2000), Vodenicharov (2011) and was detailed in the cattle by Wünsche et al. (2003) and Aschdown & Done (2010) but the described by us in the buffalo is quite different. It gives the ability for relatively independent flexion and mobility of the third digit in this animal.

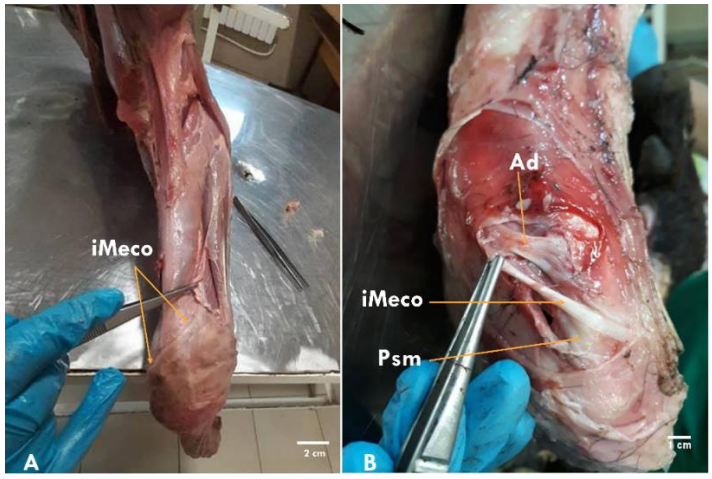


**Figure 1: Dissection appearance of the thoracic limb: A. Left forearm of the cattle, cranial view; B. Right distal forearm of the buffalo, medial view: iMeco – typical insertion of *m. extensor carpi obliquus*; Psm – processus styloideus medialis of the radius. Ad – additional insertion of *m. extensor carpi obliquus*. Bar (A) = 2 cm, Bar (B) = 1 cm.**

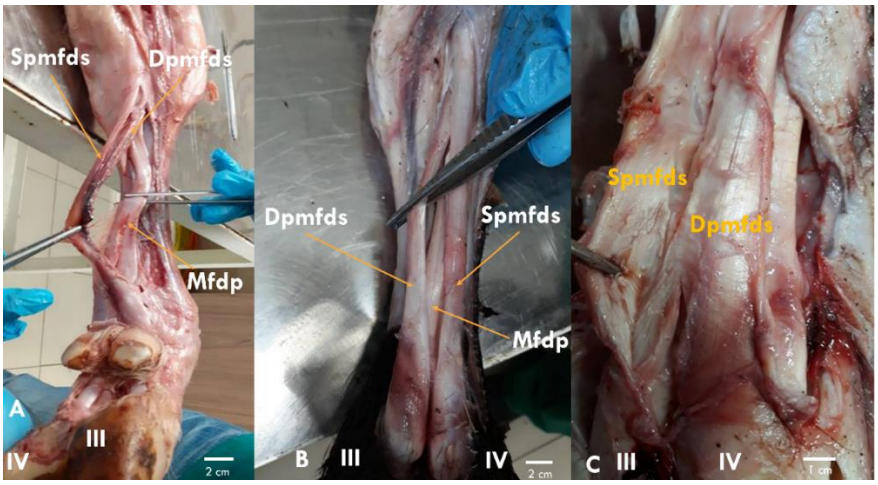


**Figure 2: Dissection appearance of the thoracic limb: A. Left metacarpus of the cattle, mediopalmar view; B. Right metacarpus in the calf buffalo, palmar view; C. Right distal metacarpus in the adult buffalo, lateropalmar view: III – third digit; IV – fourth digit; Spmfds – superficial part of *m. flexor digitorum superficialis*; Dpmfds – deep part of the *m. flexor digitorum superficiclis*; Mfdp – *m. flexor digitorum profundus.* Bar (A) = 2 cm, Bar (B) = 2 cm, Bar (C) = 1 cm.**

In the proximal metacarpus between the deep and the superficial flexor of the digits in the ruminants has red muscles fibers,called by the above authors *mm. interflexorii* or *m. interflexorius distalis* (Vodenicharov, 2011) which is confirmed in the cattle (Fig. 3A) but in the buffalo this muscle is presented by a long tendon with no muscle fibers (Fig. 3B). El-Shafey & Sayed-Ahmed (2012) visualized muscles and bones in the metacarpal and digital regions of the buffalo and camel by computed tomography but in their research absents the exact descriptions of the *m. flexor digitorum superficialis and mm. inteflexorii* in the buffalo given by the present study.

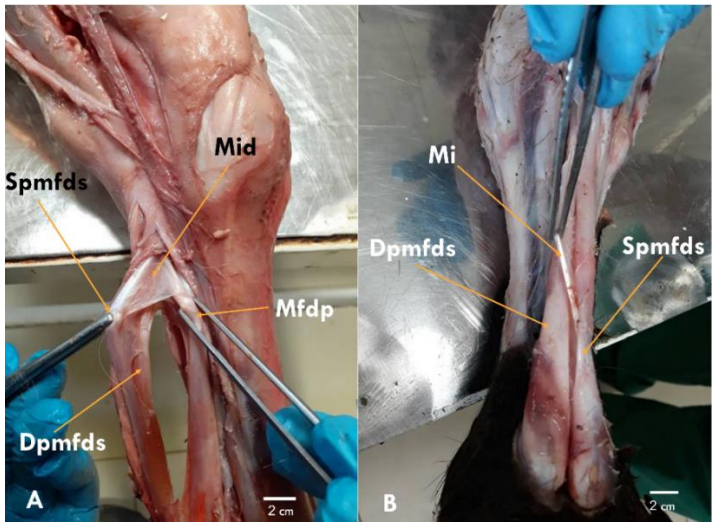


**Figure 3: Dissection appearance of the thoracic limb: A. Left metacarpus of the cattle, medial view; B. Right metacarpus in the buffalo palmar view: Spmfds – superficial part of *m. flexor digitorum superficialis*; Dpmfds – deep part of the *m. flexor digitorum superficialis*; Mfdp – *m. flexor digitorum profundus*; Mid – muscles fibers of *m. interfexorius distalis*; Mi – tendinous *mm. interflexorii*. Bar (A) = 2 cm, Bar (B) = 2 cm.**

Another difference between buffalo and cattle is the insertion of *m. peroneus tertius (m. fibularis tertius)* in the hind limb. Its terminal tendon divides into two parts, medial, which ends on the *os tarsale II+III* and lateral, which ends on *tuberositas ossis metatarsalis III* in the cattle (Fig. 4A). In the buffalo its terminal tendon divides into four parts: lateral - ends centrally on the base of *os matarasale III+ IV*, two middle - end on the *tuberositas ossis metatarsalis III*, and medial - ends on the *os tarsale II+III* (Fig. 4B). Termination of *m. peroneus tertius* in the ruminants was described by many authors (Gadzhev, 2000; Vodenicharov, 2011) and was clarified in the cattle by Wünsche et al. (2003), Aschdown & Done, (2010) and by us in the buffalo. The four-part insertion tendon of *m. peroneus tertius* gives stronger dorsal attachment into the proximal metatarsus of this muscle in the buffalo than cattle.

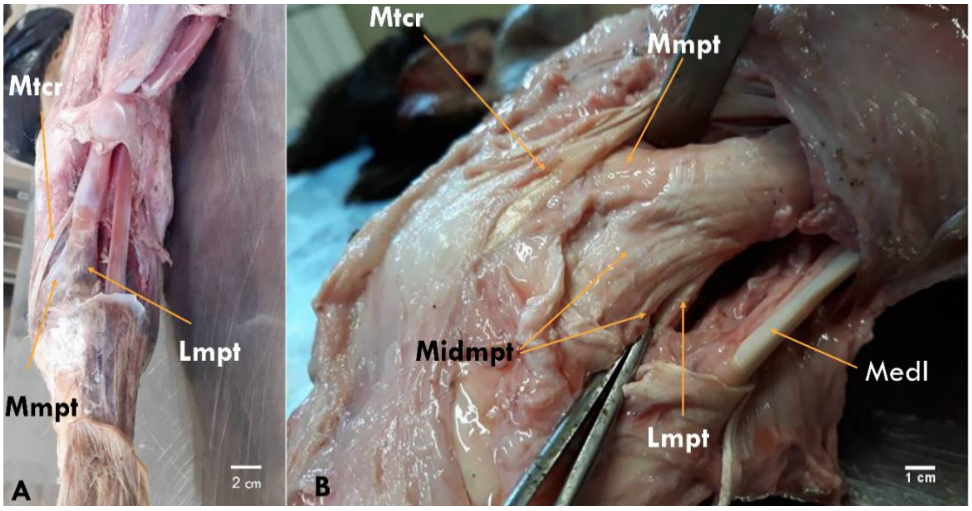


**Figure 4: Dissection appearance of the pelvic limb: A. Left hind limb of the cattle, cranial, dorsal view; B. Left tarsus and metatarsus in the buffalo, dorsomedial view: Mtcr – insertion of *m. tibialis cranialis*; Lmpt– lateral end part of *m. peroneus tertiis*, Midmpt– middle end parts of *m.peroneus tertius*, Mmpt – medial end part of *m. peroneus tertius*; Medl – tendon of *m. extensor digitorum longus*. Bar (A) = 2 cm, Bar (B) = 1 cm.**

The next difference is the presence of vestigial *m. extensor digiti primi longus* which is fully fused with *m. tibialis cranialis* in the cattle (Figs. 5A; 6A) but presented in the buffalo with an origin from the rudimentary fibula and lateral margin of the tibia. The muscle is directed distally in the crus, tarsus, and metatarsus with a clear border from the belly and the insertion of *m. tibialis cranialis* (Figs. 5B; 6B). The ends of these muscles are visible on the proximomedial side of the base of *os matarasale III+ IV* for the lateral part of the insertion of *m. tibialis cranailis* and *m. extensor digiti primi longus*, while the medial part of the insertion of m. *tibialis cranialis* finishes on *os tarsale I* (Fig. 6 B). Vestigial *m. extensor digiti primi longus* is fused with *m. tibialis cranialis* in the cattle and goat and separated from it in the sheep according to Gadzhev (2000), Schaller (2007); Vodenicharov (2011). Sometimes in the cattle terminal tendon of both muscles can separate on the first tarsal and main metatarsal bones (Wünsche et al., 2003). In the buffalo, this muscle is like the sheep which is shown in the present research.

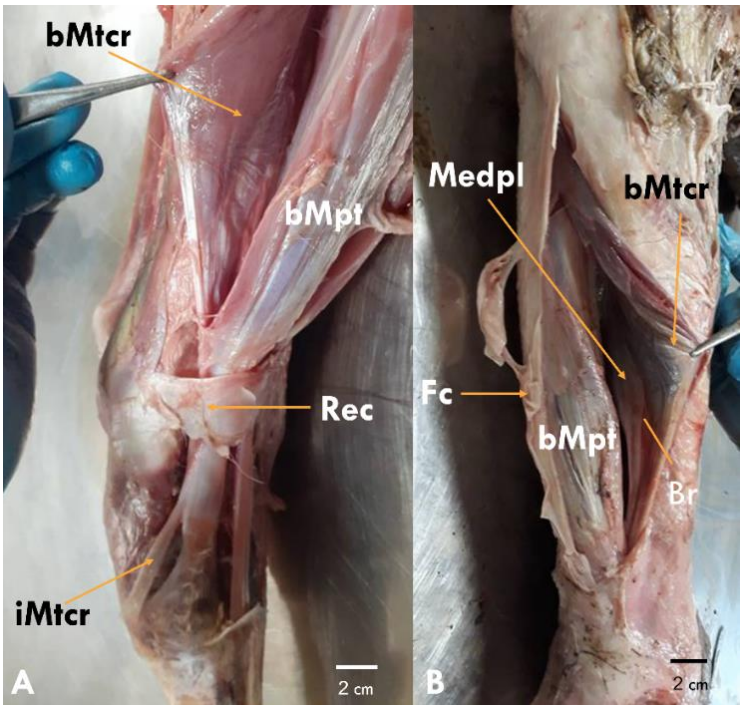


**Figure 5: Dissection appearance of the pelvic limb: A. Left crus and tarsus of the cattle, cranial, dorsal view; B. Right crus region the buffalo, cranial view: bMtcr – belly of *m. tibialis cranialis*; iMtcr – insertion of *m. tibialis cranialis*, Medpl – belly of *m. extensor digiti primi longus*, Br– border between two muscles, bMpt – belly of fleshy *m. peroneus tertius*; Rec – *retinaculum extensorium crurale*; Fc – *fascia cruris*. Bar (A) = 2 cm, Bar (B) = 2 cm.**

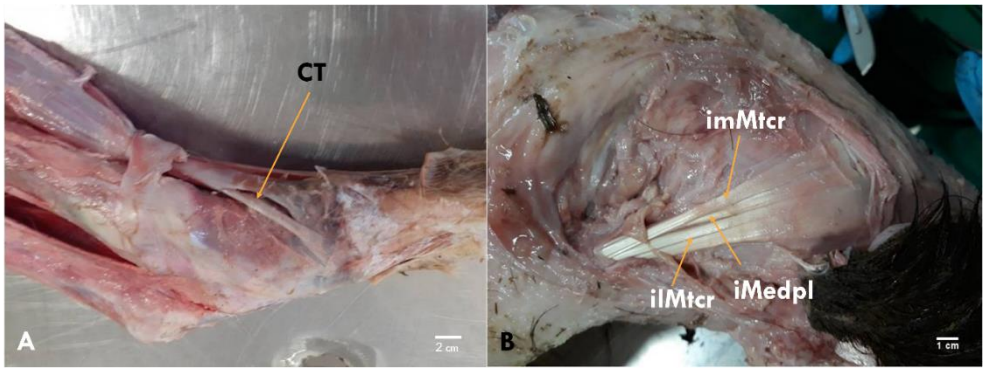


**Figure 6: Dissection appearance of the pelvic limb: A. Left crus, tarsus and metatarsus of the cattle, dorsomedial view, B. Right tarsus and metatarsus of the buffalo, medial view: imMtcr – insertion of medial part of tendon of *m. tibialis cranialis*; ilMtcr – insertion of lateral part of tendon of *m. tibialis cranialis*, CT– common insertion of medial part of *m. tibialis cranialis et m. extensor digiti primi longus*; iMedpl – insertion of *m. extensor digiti primi longus*. Bar (A) = 2 cm, Bar (B) = 1 cm.**

Another difference is the presence of the bones into metatarsus in the buffalo. In the cattle proximoplantomedially on the third metatarsal bone, there is an articular surface for the discoid *os sesamoideum metarasale* (Figs. 7A; 7B). In the buffalo this bone is absent and its articular surface on the plantar surface of the main metatarsal bone too (Fig. 7C) which is proof of its absence. *Os*

*sesamideum metatarsale* is reported as first that is included into the anterior tibial muscle in the human (Dogăroiu et al. 2012), as second metatarsal bone but discoid and sesamoid which fuses with the origin tendons of interosseous muscles in the cattle, sheep, and goat (Schaller, 2007; Wùnsche et al., 2003; Gasse, et al., 2012), as third in the pig (Gadzhev, 2000; Schaller, 2007, Gasse, et al., 2012) as fifth in the bear (Dogăroiu et al. 2012). This bone was not established in the buffalo by us. The sesamoid bones give mobility of the interosseous muscles origin and support the fetlock joint in cattle, sheep, and goat. The absence of this bone gives bigger stability in the origin of these muscles and gives stronger support function on the hindlimb of the buffalo. Rudimentary second and fifth digits or dewclaws in the fore- and hindlimb of the small ruminants consist only soft tissue under the capsule and are called *paraungula* (Gasse, et al., 2012; Gadzhev, 2014). In the cattle and buffalo consist of two rudimentary bones - middle and distal phalanxes and are called *paradigitus* (Fig.8 A; B). This is different from the observed three phalanxes in the buffalo *paradigitus* described by Gadzhev, 2000, 2014.

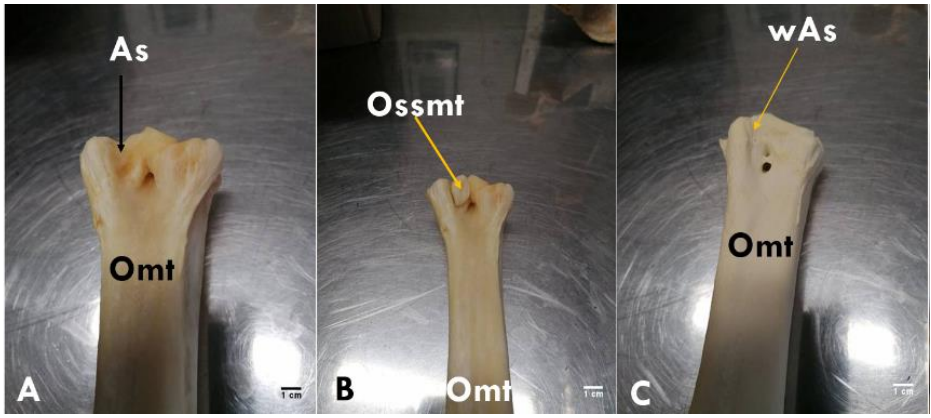


**Figure 7: Bone comparison: A.** ***Left os metatarsale III+IV*** **Of the cattle, proximoplantar view; B. Left** ***os metatarsale III+IV*** **of the cattle, proximoplantar view; C. Left** ***os metatarsale III+IV*** **of the buffalo, proximoplantar view: Omt –** ***os metatarsale III+IV;*** **Ossmt –** ***os sesamoideum metatarsale*** **with discoid shape; As – articular surface for sesamoid bone; wAs – without articular surface. Bar (A, B, C) = 1 cm.**

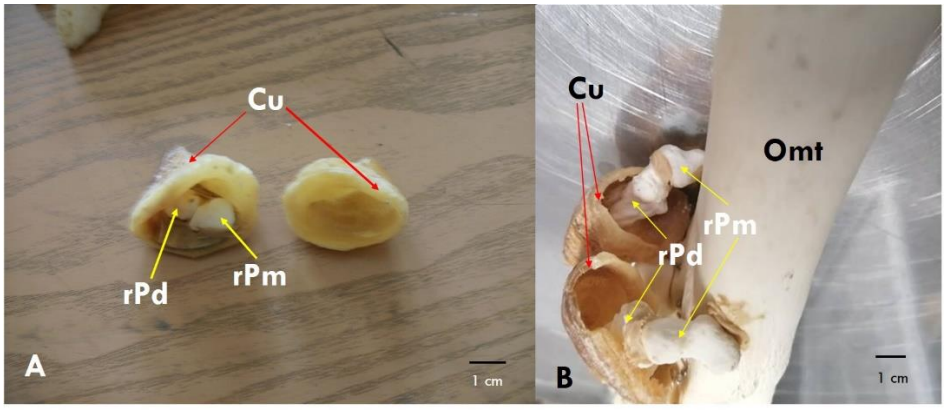


**Figure 8: Bone comparison: A.** ***Paradigitus*** **in the cattle, proximal view; B.** ***Paradigiti*** **in the buffalo, proximoplantar view: Omt –** ***os metatarsale III+IV*****; Cu –** ***capsula ungulae*** **of** ***paradigitus*****; rPm – rudiment** ***phalanx media*****; rPd – rudiment** ***phalanx distalis*****. Bar (A) = 1 cm, Bar (B) = 1 cm.**

## Conclusion

Based on the review and the conducted study, we can conclude that the muscles of the buffalo have more insertions. A relatively more flexible third digit of the thoracic limb is to achieve greater stability of the limbs of the buffalo compared to the cattle because of the constitution and massive appendicular skeleton of the buffalo. To our knowledge this is the first time to describe the absence of the metatarsal sesamoid bone in the buffalo.

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