

Some Anatomical Studies on the Muscles of the Antebrachium and Manus Regions of Eastern Grey Kangaroo (*Macropus giganteus*)

Shoaib, M.B.

Department of Anatomy, Faculty of Vet. Med., Mansoura University, Egypt

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Abstract

Eastern grey kangaroo is a large herbivorous marsupial animal found in southern and eastern areas of Australia. It belongs to Family Macropodidae. The present investigation was carried out on the carcasses of eight adult eastern grey kangaroos for studying the gross anatomy of the muscles of the antebrachium and manus regions. The antebrachial muscles classified into: *A-dorso-lateral group* which comprise; Mm. extensor carpi radialis, extensor digitorum communis, extensor digitorum lateralis, extensor digiti I and extensor carpi obliquus. Functionally, these muscles represented the extensors for the carpal and digital joints. As well as M. ulnaris lateralis it acts flexion of the carpal. In addition to M. brachioradialis and supinator which located in the flexor angle of the elbow joint and serve to turn the forepaw around the long axis. *B- Palmar group* which comprise; Mm. flexor carpi radialis, flexor carpi ulnaris, palmaris longus, flexor digitorum superficialis and profundus. In addition to Mm. pronator teres and pronator quadratus which rotate the forearm medially. Functionally, these muscles

represented the flexors of the carpal and digital joints. In conclusion, the antebrachium and manus regions in eastern grey kangaroo resemble nearly that of other macropod and carnivores in general, however, some original differences were detected between them in this study.

Key word

anatomy, muscles, antebrachium and manus, eastern grey kangaroo

Introduction

Eastern Grey Kangaroo is a large herbivorous marsupial animal found in southern and eastern areas of Australia. It belongs to Family Macropodidae, Subfamily Macropodinae (Calaby and Richardson, 1988 and Groves, 2005). The Kangaroo moves forward by hopping on their powerful large hind legs. While, their small fore legs and long tail support and balance its body during hopping. In addition, terrestrial kangaroos use their forelimbs for a range of movements, manipulation of their pouch, feeding and fighting among them. The forelimb of the kangaroo has a simple manus with five digits of equal

length radiating from a near circular palm with strongly clawed forepaws.

Anatomical descriptions of the musculature of different body parts of various marsupials are available in the works of (Boardman, 1941, Jones, 1949 and Badooux, 1965). There is lack of information about the anatomy of the muscles of antebrachium and manus regions of the Eastern Grey Kangaroo, for my knowledge only one literature described the intrinsic musculature of the pectoral limb in eastern grey kangaroo (Hopwood, 1974). This study aimed to provide detailed and recent description for the musculature of the antebrachium and manus regions in the Eastern Grey Kangaroo, with photographs and updated nomenclature. Mean while, this study is considered a preliminary work and there will be further studies in the future.

Material and Methods

This investigation was carried out on eight fresh fore limbs of adult eastern grey kangaroo's carcass with body weight ranging from 47 - 60 kg. The specimens were collected from the post mortem room, Melbourne University, Australia, during a Para cytological study. The antebrachium and manus region of each limb were carefully dissected. The gross anatomy of the dissected muscles was described and photographed. With regards to the x- ray investigation, three fresh forelimbs were examined using digital radiology equipments. The radiographic films were performed in order to document the mor-

phology of the bones of the studied regions (Fig. 1/ A).

Results

The antibrachial muscles classified into two groups; dorso-lateral and palmar group. Functionally, these muscles represented the extensors and flexors of the carpal and digits.

A-The dorso-lateral antebrachial Muscles

This group is represented mainly by the extensors of the carpal and digits. They comprised; Mm. extensor carpi radialis, extensor digitorum communis, extensor



Fig.(1): A- Radiograph showing the antebrachium and manus region of an adult eastern grey kangaroo.



B- Photograph showing the antebra-chium and manus region of an adult eastern grey kangaroo.

digitorum lateralis, extensor digiti I and extensor carpi obliques. As well as M. ulnaris lateralis it acts flexion of the carpal. In addition to Mm. brachioradialis and supinator which located in the flexor angle of the elbow joint and serve to turn the forepaw around its long axis.

1- M. brachioradialis

It is a thin, flat muscle located over the flexor side of the elbow joint. It accompanied the proximal part of M. extensor carpi radialis (fig. 2a, b, c, d / **B**). It originated from the lateral supracondylar ridge of the humerus. The muscle gave rise to its tendon of insertion at the proximal part of the antebra-chium. The tendon was long and thin, running along the caudal border of M. extensor carpi radialis and the radius. At the level of the distal part of the antebra-chium, the

tendon of M. brachioradialis passed under the tendon of M. extensor carpi obliques to be inserted on the radial carpal bone. The muscle act as supinator for the forearm in addition, it flex of the elbow joint.

2- M. extensor carpi radialis

It was the first muscle come upon the caudal border of the radius (fig.2 a, b, c, d/**R**) It originated from the lateral supracondylar crest of the humerus adjacent to the m. brachioradialis. It had short muscle belly located medial to M. extensor digitorum communis. At the proximal third of the antebra-chium, the muscle gave rise to its tendon of insertion which was long and broad .The tendon ran along the medial border of the radius in accompany with that of M. brachioradialis, passed under the tendon of M.extensor carpi obliques, and then after divided into two unequal branches; small medial one and large lateral one (fig.3 c, d / R1, R2). Both tendons ran on to the metacarpus by passing under the dorsal annular ligament of the carpus. The medial tendon inserted into the dorsal surface of the metacarpal II, while the lateral one inserted into the dorsal surface of metacarpal III. The muscle was covered superficially by the skin; related deeply by M. supinator and caudo-laterally by M.exten-sor digitorum communis. The action of this muscle is extension to the carpal joint and flexion to the elbow joint.

3- M. extensor digitorum Communis

This muscle is the largest digital extensor, located at the cranio-lateral aspect of the antebrachium between M. extensor carpi radialis medially and M. extensor digitorum lateralis, laterally (fig.2 a, b, c, d, e, f / C). It arose via a single head from the lateral supracondylar crest of the humerus. The muscle gave rise its tendon of insertion at the level of the middle of the radius. The tendon extended distally and joined the tendon of M. extensor digiti I at the level of the distal third of the radius (fig.2.f / TE, TC). Both tendons were enclosed in a common tendon sheath forming the common extensor tendon. The latter, crossed over the tendon of M. Extensor carpi obliquus and ran on to the carpus by passing deeply in the radial groove; between the distal extremity of both radius and ulna; and covered by the dorsal transverse carpal retinaculum. At the metacarpus, the common extensor tendon divided into three extensor braches; medial, lateral and intermediate (fig.3c, d / TC1, TC2, TC3). The medial one bifurcated into two small branches which inserted into the third phalanx of digits II et III. The intermediate branch terminated on the digit IV. While, the lateral one terminated on the third phalanx of digit V, in association with the tendon of M. extensor digitorum lateralis. The action of M. extensor digitorum communis is extension to the metacarpo-phalangeae and inter-phalangeae joints.

4- M. extensor digitorum Lateralis

A small fleshy muscle located in the lateral aspect of the antebrachium be-

tween Mm. extensor digitorum communis and ulnaris lateralis (fig.2, a, e, f / L). It originated from the lateral epicondyle of the humerus in common with M. ulnaris lateralis. At the middle of the antebrachium, the muscle gave rise to a single tendon. The tendon passed obliquely over M. extensor carpi obliquus and M. extensor digiti I. Then after it, continues distally in the ulnar groove of the radius under the transverse carpus retinaculum. At the dorsal surface of the metacarpus, the tendon was divided into two extensor branches; medial and lateral ones (fig.3/d). The medial one is inserted on the extensor process of the third phalanx of the digit IV while, the lateral one is inserted on the dorsal surface of the first phalanx of the digit V in accompany with the lateral extensor branch of M. extensor digitorum communis. The action of this muscle is extension of the digit IV and V.

5- M. ulnaris lateralis

It is a small fleshy muscle, located in the caudo-lateral aspect of the ulna between M. extensor digitorum lateralis, dorsally and M. extensor digiti I, caudally (fig. 2 / e, f). The muscle arose from the lateral epicondyle of the humerus in common with M. extensor digitorum lateralis. In the middle of the antebrachium, it gave rise to its tendon of insertion, which crossed upon M. extensor digiti I to ran on the lateral surface of the distal third of the ulna in accompany with the tendon of M. extensor digitorum lateralis (fig.3 b / TU, TL). The tendon passed laterally under the transverse carpus retinaculum and crossed the dorsal surface of the metacarpus later-

ally to terminate on the proximal end of the metacarpal V. The action of the muscle is flexion of the carpal joint.

6- M. extensor digiti I (pollicis)

It is small, muscle located caudo-lateral to M. ulnaris lateralis (fig.2 a, e, f / E). It originated from the olecranon of the ulna. It ran distally, parallel to the ulna, and gradually passed under Mm. extensor digitorum lateralis and M. ulnaris lateralis. At the level of the middle of the antebrachium, it gave rise to its tendon of insertion. The latter, ran distally deep to the tendon of Mm. extensor digitorum lateralis and M. ulnaris lateralis, superficial to the tendon of M. extensor carpi obliquus. The tendon then crossed the dorsal surface of the distal third of the ulna and radius medially, toward the tendon of M. extensor digitorum communis where the tendons of both muscles were surrounded by a common synovial sheath (.). On the dorso-medial side of the metacarpal III, the tendon directed medially where it inserted on the second phalanx of digiti I (fig.3 c / TE.). The muscle act as, extensor of the first digit.

7- M. abductor digiti I (pollicis) longus (M. extensor carpi obliquus)

This muscle is a well developed flat and oblique muscle, lodged in the lateral groove between the radius and ulna and covered by the digital extensor muscles (figs. 2f / O). It originated from the proximal part of the lateral surface of the ulna and radius. The muscle crossed the dorsal surface of the mid-shaft of the radius in an oblique direc-

tion, and continued as a broad tendon. The latter extended disto-medially, in an oblique direction, deep to the tendon of M. extensor digitorum communis and superficial to the tendons of insertion of M. brachioradialis and M. extensor carpi radialis. The tendon passed deep to the dorsal carpal transverse retinaculum. As the tendon emerges on to the metacarpus, it inserted medially on the proximal surface of metacarpal I (fig.3c / TO). The action of this muscle is abduction of the forepaw and extension of the carpus.

8- M. supinator

This muscle is short, broad and flat. It located laterally on the flexor side of the elbow joint. It is covered by Mm. extensor carpi radialis and extensor digitorum communis and situated caudal to M. extensor carpi obliquus and the radius (fig. 2 c. d / S). It originated from the lateral epicondyle of the humerus and long collateral ligament of the elbow joint. The muscle crossed the radius obliquely in a distomedial direction, covering its proximal part. The supinator muscle is inserted on the proximal fourth of the dorso-medial surface of the radius. It acts as supinator of the fore paw medially.

B-The palmar antebrachial muscles

This group is represented mainly by the flexors of the carpal and digits. They comprised Mm. flexor carpi radialis, flexor carpi ulnaris, palmaris longus, flexor digitorum superficialis and profundus. In addition to Mm. pronator

teres and pronator quadratus which rotate the forearm medially.

1- M. pronator teres

An oblique and relatively short muscle located in the medial side of the elbow joint, covered by M. flexor carpi radialis (fig. 2b & c). It originated from the medial epicondyle of the humerus in common with M. flexor carpi radialis. The muscle belly extended obliquely in a cranio-distal direction and inserted with a short strong tendon on the medial border of the radius, distal to the insertion of M. supinator. The muscle acts as medial rotation of the forearm beside flexion of the elbow joint.

2- M. flexor carpi radialis

It is a relatively thick fusiform muscle located in the medio-palmar side of the antebrachium, between Mm. pronator teres and palmaris longus (fig. 4 a, b). It originated from the medial epicondyle of the humerus and gave rise to its tendon of insertion at the level of the middle of the palmar aspect of the antebrachium. The tendon extended distally, passed under the carpal flexor retinaculum, where it is enclosed in a synovial tendon sheath. The muscle inserted on the palmar aspect of the radial carpal bone and metacarpal I and II. The action of this muscle was flexion of the carpal joint.

3- M. palmaris longus

It is elongated muscle located at the palmar aspect of the ante-brachium between Mm. flexor carpi radialis and flexor carpi ulnaris and related deeply to

M. flexor digitorum profundus (fig. 4 a, b / PL). It originated from the medial epicondyle of the humerus in common with the aforementioned muscles. It gave rise to a single tendon, at the level of the middle of the radius. At the level of the carpus, the tendon of the muscle passed superficially to the flexor carpal retinaculum and broads out to become a flat sheet which inserted on the fascia of the metacarpal pad (fig. 4 c, d / PLT). The main function of this muscle appeared to be an anchor for the skin and fascia of the fore paw.

4- M. flexor carpi ulnaris

This muscle is located on the caudo-medial side of the ante-brachium, superficial to the flexor digital muscles (fig. 4 a, b / FCU). It is formed of one belly and marked by several tendinous intersections. The muscle originated from the olecranon of the ulna. At the level of the proximal half of the antebrachium, the muscle gave its tendon of insertion to end on the accessory carpal bone. The action of this muscle is flexion of the carpus.

5- M. flexor digitorum superficialis

A small thin fleshy muscle originated from the superficial surface of the deep digital flexor tendon at the distal half of the antebrachium. It gave rise to three tendons of insertion which terminated on the middle phalanx of the digits II, III and IV. Proximally, the body of the muscle lay deep to the tendons of insertion of Mm. palmaris longus and flexor carpi ulnaris. The action of this muscle

is flexion to proximal inter-phalan-geal joints of the digits II, III, IV.

6- M. flexor digitorum profundus

It is the largest muscle on the caudo-palmar aspect of the antebrachium. It lay deep to the superficial digital flexor muscle and the flexor muscles of the carpus. It arose by three heads; humeral head (caput humeralis), radial head (caput radiale), and ulnar head (caput ulnare) (fig.5 a / H,R,U). The humeral head is the largest one; it originated from the medial epicondyle of the humerus. The radial head originated from the proximal part of the caudo-medial surface of the radius. The ulnar head is the smallest one; it originated from the caudal border of the ulna. The tendons of the three heads fused into a common deep flexor tendon in the proximal half of the antebrachium. The superficial surface of the tendon gave rise to M. flexor digitorum superficialis in the distal half of the antebrachium. The deep digital flexor tendon passed through the carpal canal covered by the carpal flexor retinaculum. In the carpal canal, the tendon had a marked thickening on its lateral border and concave in its middle. On leaving the carpal canal the deep digital flexor tendon splits into five branches (fig.4 c, d / DDFT 1st and 5th). They descended distally, embraced by the corresponding concave sesamoid bone and enveloped by a tubular sheath. Finally, each branch inserted into the base of the middle phalanx of the corresponding digit I-V. The action of this muscle is flexion to the digits I – V.

7- M. pronator quadratus

It is a thin, delicate muscle occupied the inter-osseous space between the radius and ulna at the distal two-thirds of the antebrachium (fig.5 a). It originated from the disto-medial aspect of the shaft of the ulna and ran obliquely to be inserted into the distal, ventro-medial aspect of the shaft of the radius. This muscle acts as a pronator for the forearm.

8- Palmar interossei muscles

These muscles are four in number, one for each digit, except the third. They placed between the metacarpal bones. They comprised; Mm. adductor digiti I; adductor digiti II; adductor digiti IV; and adductor digiti V. They were bordering each other and occupied the entire palmar surface of the metacarpal bones and concealed by the branches of the deep digital flexor tendon (fig.5). All muscles arose from the proximal end of the metacarpal bones I-V. The muscles adductor digiti I and adductor digiti V were triangular in shape, of almost equal size. They inserted by their apices, the former into the ulnar side of the base of the first phalanx of the first digit (thumb), and the latter inserted into the radial side of the first phalanx of the fifth digit (little finger). The two remaining adductors; adductor indicis and adductor annularis almost concealed by the foregoing ones. Both arose, one opposite the other. They inserted on of the first phalanx of the second (index) and fourth (ring) fingers respectively. The action of these muscles is adduction of the digits towards the line of the middle

finger, as well as flexion to the metacarpopharyngeal joint.

Discussion

The present study on the antebrachium and manus region in the kangaroo resembles nearly that of other macropod and carnivores in general, however, some differences in muscles origin were detected between them in the present study.

According to the current investigation, the muscle extensor carpi radialis has a single belly, although its tendon of insertion is divided into two branches. This result is similar to that described by Jones (1949) in marsupial mouse and Endo et al., (2003) in giant panda. Conversely, Hopwood (1974) in eastern grey kangaroo and Miller et al., (1993) in dog and Liebich et al., (2004) in dog and cat mentioned that, the muscle divided into two parts; *Mm. extensor carpi longior* and *extensor carpi brevior*. Meanwhile, Hopwood (1974) added that this division was difficult to demonstrate in juvenile animals. Furthermore, Liebich et al., (2004) noticed that these muscles were separate in cat and partially fused in dog.

According to the result of this study, *M. extensor digitorum communis* gave rise to its tendon of insertion at the level of the distal third of the radius. It joins the tendon of *M. extensor digiti I* where they enveloped with a common tendon sheath. At the metacarpus, the common extensor tendon divided into three extensor braches; medial, lateral and intermediate ones. This result is different

from that described by Hopwood (1974) in eastern grey kangaroo who stated that the muscle gave rise to three tendons of insertion at the level of the distal half of the antebrachium and he did not refer to the join of the muscle tendon with that of *M. extensor digiti I*. In this concern, Liebich et al., (2004) in dog affirmed that the muscle gave rise to four tendons proximal to the carpus.

In the present work, the tendon of insertion of *M. extensor digitorum lateralis* divided into two extensor branches; medial and lateral ones; the former inserted at digit IV while the latter inserted into digit V. This result is contrary with that described by Hopwood (1974) in eastern grey kangaroo who mentioned that, the tendon of insertion of the muscle gave rise to three extensor branches. The medial one terminated on digit IV while the two lateral ones to digit V.

According to the present study, the *M. extensor carpi obliquus* is a well developed flat and oblique muscle, found between the radius and ulna. Its tendon inserted on the medial aspect of the metacarpal I. So, we suggest that the oblique route of this muscle bundles may acts as a supinator for the fore arm. This result is in agreement with that described by Endo et al., (2003) in giant panda.

The current investigation demonstrated that, the muscle *extensor digit I* exists as a separate muscle. This result is similar to that in carnivores (Miller et al., 1993), while in other domestic animals it is fused to *M. extensor digitorum com-*

munis (Liebich et al., 2004). Moreover, the muscle gave rise to a single tendon of insertion which terminates on the second phalanx of digiti I. This result was converse with that described by Hopwood (1974) in eastern grey kangaroo and Liebich et al., (2004) in cat who stated that the tendon of the muscle was divided into three branches that inserted on the digiti I and II.

The existing work established that, the description of *Mm. brachioradialis*, *ulnaris lateralis*, *supinator*, *pronator quadratus* and *pronator teres* is parallel with that described by (Hopwood, 1974) in eastern grey kangaroo and (Miller et al., 1993 and Liebich et al., 2004) in carnivores and Endo et al., (2003) in giant panda.

According to the present work, the *M. flexor carpi radialis* locates between *M. pronator teres* and *M. palmaris longus*. It is inserted on the palmar aspect of the radial carpal bone and metacarpal I and II. This result is parallel with that described by Hopwood (1974) in kangaroo. On the other had, in dog the muscle is located between *M. pronator teres* and *M. flexor digitorum superficialis* and inserted on metacarpals II and III (Miller et al., 1993).

M. palmaris longus does not listed in the N.A.V. (2005), although it is listed in the N.A. (1986). So there is difficulty to determine the homologues of this muscle .In kangaroo the *M. palmaris longus* do exists and is situated between *M. flexor carpi ulnaris* and *M. flexor carpi radialis*. This result is supported by the findings of Windle and Parsons (1897)

in *Macropus Rufus*, Jones (1949) in marsupial mouse, Hopwood (1974) in kangaroo and (Endo et al., 2003 and Antoń, et al., 2006) in Panda. Moreover, in the present work, the tendon of the muscle was a flat sheet inserted on the fascia of the metacarpal pad. This result was in agreement with that described by Antoń, et al., (2006) in red panda, who added that the muscle sent a branch inserting on the radial sesamoid. Its contraction adducts the latter, or stabilizes it against the pull of the abductors. In this concern, (Oommen and Rajara-jeshwari, 2002 and Williams et al., 1995) in man described the presence of *M. palmaris longus*. Although, the latter author stated that *M. palmaris longus* was one of the most variable muscles in the body. It was often absent about (10 per cent.), and is subject to many variations as it may be digastric.

In the current investigation the muscle *flexor carpi ulnaris* is formed of one belly marked by several tendinous inter-sections. This result was corresponding with that described by Hopwood (1974) in kangaroo. On the other hand, Miller, et al., (1993) in dog, and Endo et al., (2003) in giant panda stated that the muscle is formed of two heads; weak ulnar head and much stronger humeral head. Both converge into a single tendon ending on the accessory carpal bone

The existing study confirmed that, in eastern grey kangaroo, the small muscle originating from the superficial face of the tendon of *M. flexor digitorum profundus* is the muscle *flexor digitorum superficialis*. This result is similar with

that mentioned by Hopwood (1974) in eastern grey kangaroo. On the other hand, this description closely resembled that given by Miller et al. (1993) for *M. interflexorii* in dog. In this concern, Spoor and Badoux (1986) in dog proposed homology of *M. interflexorii* with the human *M. flexor digitorum superficialis*.

According to the current investigation, the muscle *flexor digitorum profundus* has three heads; humeral, radial and ulnar heads. The three heads fused into a common belly in the proximal half of the antebrachium. This finding resembles that described by Hopwood (1974) in eastern grey kangaroo. However, in carnivores, the three heads of the muscle were completely separated. The humeral head consisted of three isolated bellies in cat, whereas in dog the bellies were difficult to separate (Liebich et al., 2004).

The present study established that, the *Mm. palmar interossei* are four in number, one for each digit, except the medium. They comprised *Mm. adductor digiti I*; *adductor digiti II*; *adductor digiti IV*; and *adductor digiti V*. This result was matching with that described in the N.A.V. (2005) and Miller et al., (1993) in dog. Meanwhile, these muscles were corresponding to *Mm. adductor pollicis*; *adductor indicis*; *adductor annularis*; and *adductor minimi digiti*, respectively that described by Young, (1880) in marsupials, Windle and Parsons (1897) in *Macropus Rufus*, and Williams (1995) in human. In this concern, Liebich et al., (2004) mentioned that, in ruminants the interosseous muscles had a single ori-

gin, but divided into five branches at the distal metacarpus. Beside, there were three interosseous muscles in horse. The middle interosseous muscle was also termed the suspensory ligament.

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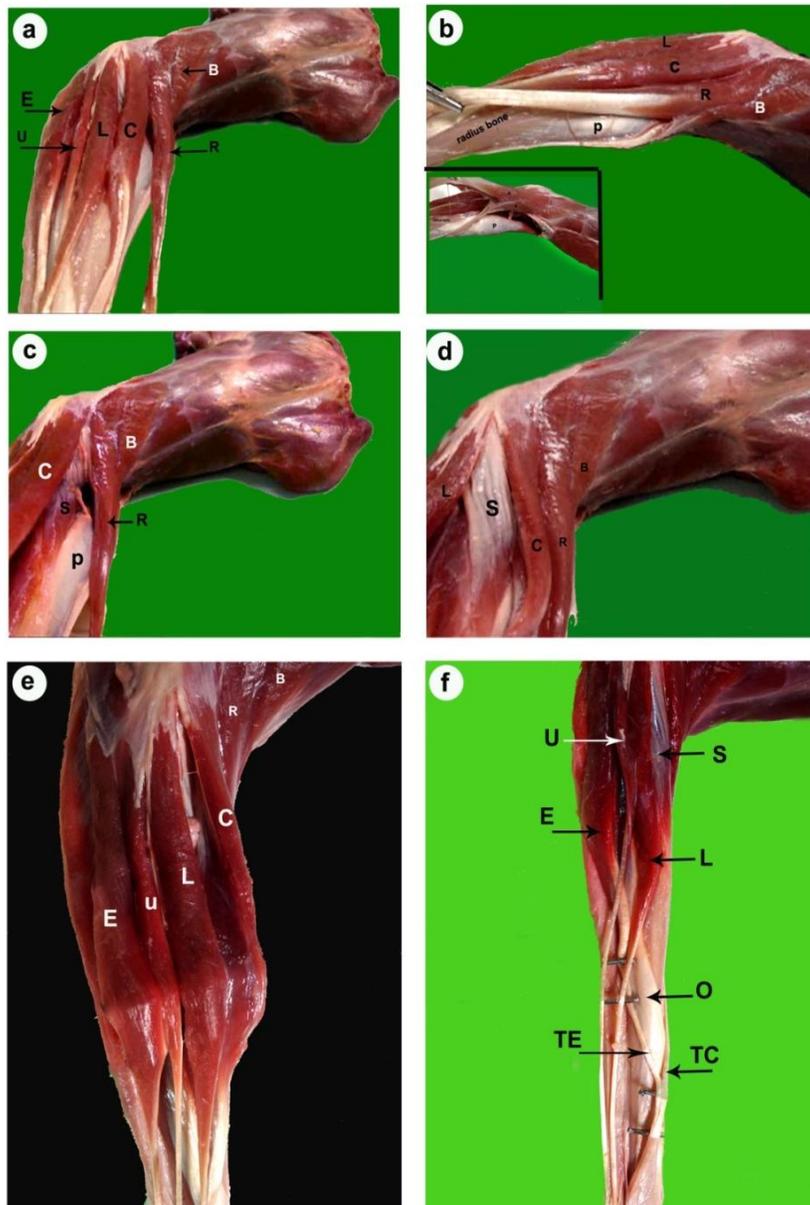


Fig. (2): Lateral view for the muscles of antebrachium region of an adult eastern grey kangaroo: **B**- M. brachioradialis. **R**- M. extensor carpi radialis **O**- M. abductor digiti I longus. **C**- M. extensor digitorum communis. **S**- M. supinator. **U**- M. ulnaris lateralis. **E**- M. extensor digiti I . **L**- M. extensor digitorum lateralis.

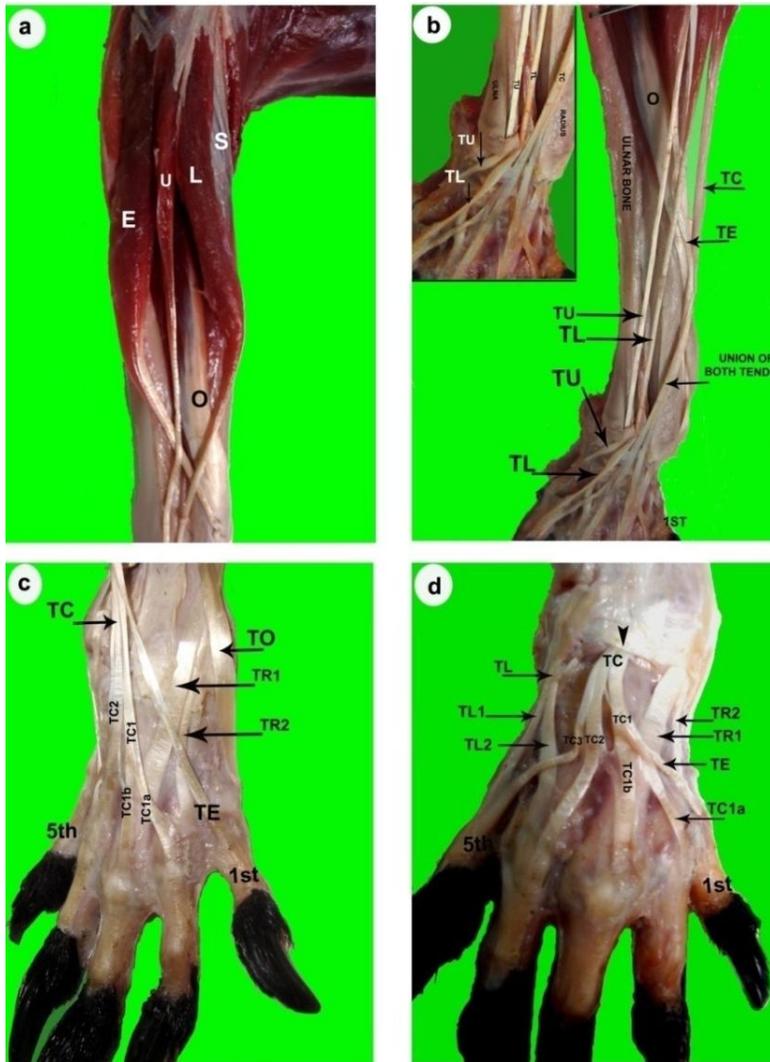


Fig. (3): A- Lateral view for the musculature of antebrachium and manus regions of an adult eastern grey kangaroo. B- Lateral view for the tendon of the left antebrachium and manus regions. C- Dorso-medial view for the tendon of the manus regions.D- Dorso-lateral view for the tendon of the manus regions

TC: tendon of M.extensor digitorum communis which divided into: **TC1:** medial branch, **TC2:** intermediate branch and **TC3:** lateral branch. The **TC1** splits into TC1a & C1b, **TE:** tendon of M.extensor digitorum I , **TU:** tendon of M. ulnaris lateralis, **TL:** tendon of M extensor digitorum lateralis, it divided into TL1 (lat.br. and TL2 (med.br), **TO:** tendon of M. extensor carpi obliques, **TR:** tendon of M.extensor carpi radialis that divided into two branches; TRa &TRb

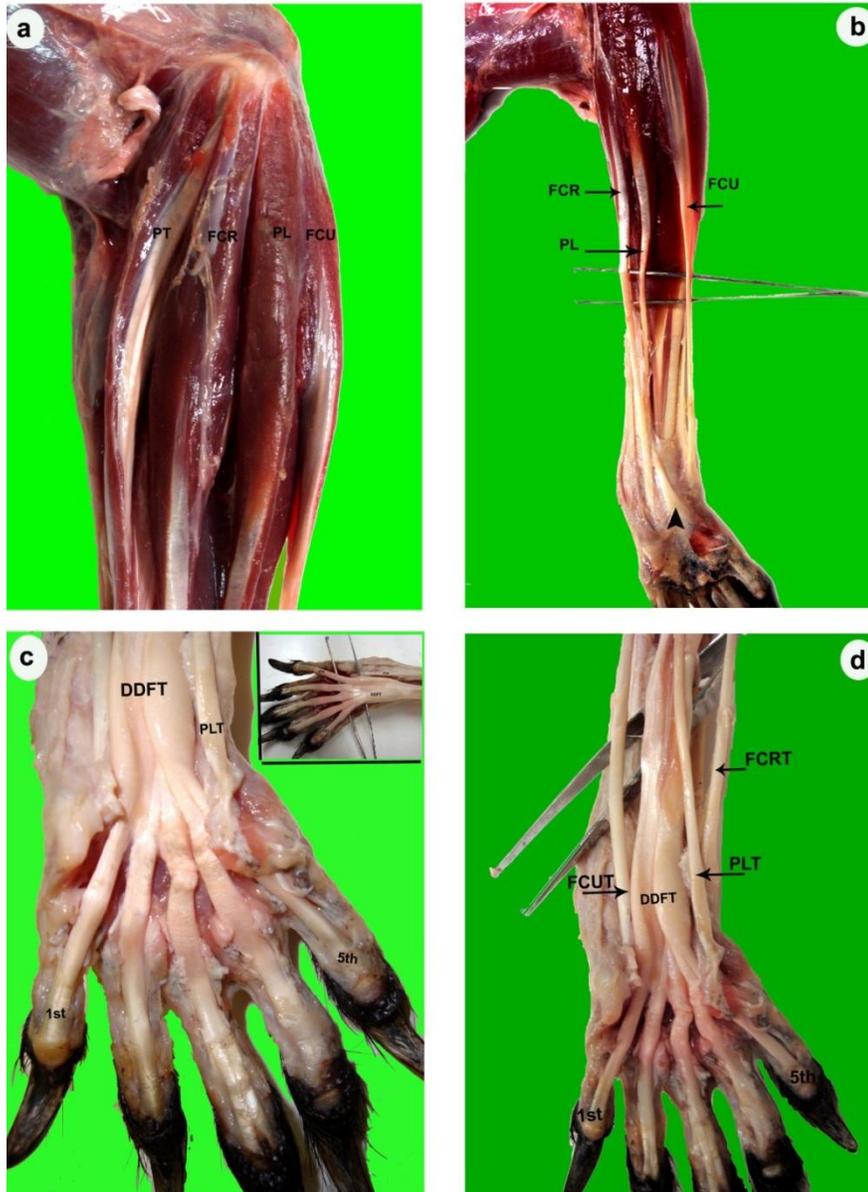


Fig. (4): Palmar view for the muscles and tendons of antebrachium and manus regions of an adult eastern grey kangaroo.

FCR- M. flexor carpi radialis, **FCU-** M. flexor carpi ulnaris, **PL-** M. palmaris longus, **PT-** M. pronator teres, **FCRT:** flexor carpi radialis tendon, **FUT:** flexor carpi ulnaris tendon, **DDFT:** deep digital flexor tendon, **PLT:** palmaris longus tendon

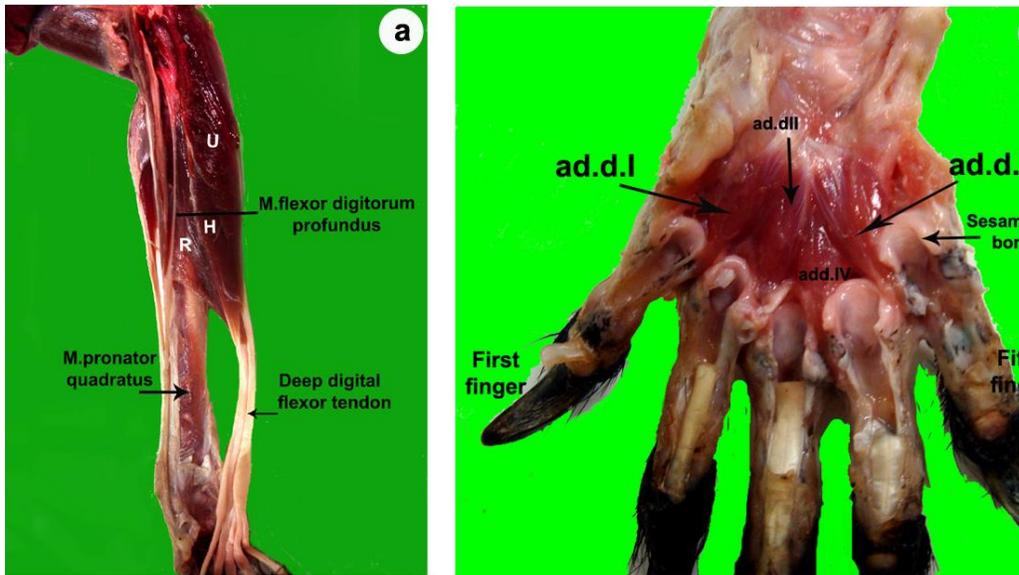


Fig.(5): A- Palmar view for antebrachium region of an adult eastern grey kangaroo showing M. flexor digitorum profundus. **H:** humeral head , **R:** radial head, **U:** ulnar head

B- Palmar view for the manus region showing Mm. palmar interossei. **ad. d. I :** M. adductor digiti I , **ad. d. IV:** M. adductor digiti IV, **ad. d. II:** M. adductor digit II, **ad. d. V:** M. adductor digiti V