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Ashtari Mota Piancastelli

DESCRIPTION OF THE FORELIMB MUSCULATURE OF *HERPAILURUS YAGOUAROUNDI* AND *PUMA CONCOLOR* (FELIDAE, CARNIVORA) AND MYOLOGICAL COMPARISON OF THE ACINONYCHINI TRIBE

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Orientador: Fernando Araújo Perini

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Description of the forelimb musculature of *Herpailurus yagouaroundi* and *Puma concolor* (Felidae, Carnivora) and myological comparision in the tribe Acinonychini

ASHTARI MOTA PIANCASTELLI

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RESUMO

O membro anterior dos felinos tem um papel importante na captura, subjugação e despacho de presas, bem como na locomoção. Por esse motivo, estudos comparativos do membro anterior podem refletir variáveis ecológicas, como preferência por tamanho de presa, habitat e modo de locomoção. No entanto, ainda são poucos os estudos que correlacionam a anatomia muscular com a função e ecologia em felinos. A musculatura do jaguarundi (*Herpailurus yagouaroundi*) nunca foi descrita antes e não há comparação publicada com outros membros da tribo Acinonychini, o puma (*Puma concolor*) e o guepardo (*Acinonyx jubatus*). O objetivo deste estudo é descrever a musculatura do membro anterior do jaguarundi e compará-la com os demais membros do Acinonychini. Ambos os membros anteriores de dois espécimes de jaguarundi e dois puma foram dissecados e documentados com fotos digitais. As inserções musculares foram documentadas com lápis aquarelável diretamente nos ossos. O peso muscular foi registrado usando uma balança de precisão BEL engineering 720g (e:0,01g) e os dados da musculatura foram comparados com o puma, guepardo e outros felinos descritos na literatura. Nossos resultados mostram que o m. *triceps brachii* do jaguarundi e do puma tem cinco cabeças, embora apenas quatro tenham sido descritas no guepardo. O *m.palmaris longus* da onça parda e do jaguarundi serve aos cinco dedos, enquanto na jaguatirica serve aos dedos II a V. Algumas fibras carnosas do *m. latissimus dorsi* insere-se na região ventral do *m. pectoralis profundus* no jaguarundi e jaguatirica, o que não foi documentado para o guepardo e onça parda. O *extensor digitorum communis* do puma possui mais um tendão que serve ao digito I, que não foi encontrado no jaguarundi. No entanto, o *m. pectoralis profundis* do puma tem uma inserção distinta no tubérculo supraglenoide da escápula, o que contribui para sua estabilização. A presença de cinco cabeças do *m. triceps brachii* tem um papel na estabilização e extensão do cotovelo, que é congruente com a locomoção terrestre. Essas características sugerem que o jaguarundi é mais adaptado para a locomoção terrestre, embora apresente proporções semelhantes de músculos flexores e extensores, característica típica da locomoção scansorial. A presença de cinco tendões no *m. palmaris longus* contribui para o fechamento completo da mão, o que ajuda a manipular a presa, já a inserção atípica do peitoral e o tendão extra do *m. extensor digitorum communis* do puma podem ajudar na sua locomoção em paisagens rochosas.

Palavras chave: musculatura; anatomia; gato-mourisco; onça-parda.

ABSTRACT

The forelimb of felids has an important role in capturing, subjugating and dispatching prey, as well as in locomotion. For this reason, comparative studies of the forelimb could reflect ecological variables such as prey size preference, habitat, and locomotor mode. However, there are still few studies correlating muscular anatomy with function and ecology in felids. The musculature of the jaguarundi (*Herpailurus yagouaroundi*) was never described before and there is no published comparison with other members of the tribe Acinonychini, the puma (*Puma concolor*) and the cheetah (*Acinonyx jubatus*). The objective of this study is to describe the musculature of the forelimb of the jaguarundi and compare it with the other members of Acinonychini. Both forelimbs of two specimens of jaguarundi and two puma were dissected and documented with digital photos. Muscle attachments were documented with pencil paint directly in the bones. Muscle weight was recorded using a BEL engineering 720g (e:0,01g) precision balance and the musculature data was compared with the puma, the cheetah and other felids as described in the literature. Our results show the *m. triceps brachii* of the jaguarundi and puma shows five heads, although only four have been described in cheetah. *The m. palmaris longus* of puma and jaguarundi serves all five digits, while in the ocelot it serves digits II to V. Some fleshy fibers of *m. latissimus dorsi* insert onto the caudal belly of the *m. pectoralis profundus* in the jaguarundi and ocelot, which was not documented for the cheetah and puma. The *extensor digitorum communis* of puma has one more tendon that serves digit I, which was not found in the jaguarundi. However, the *pectoralis profundus* of puma has a distinct insertion onto supraglenoid tubercle of scapula, which contributes to its stabilization. The presence of five heads of the *m. triceps brachii* has a role in stabilizing and extending the elbow, which is congruent with terrestrial locomotion. These characteristics suggest that the jaguarundi is more adapted for terrestrial locomotion, although it shows similar proportions of flexor and extensor muscles, a characteristic typical of scansorial locomotion. The presence of five tendons in the m. palmaris longus contributes to the complete closing of the manus, which helps to manipulate prey, and the atypical insertion pectoralis and the extra tendon of extensor digitorum communis of the puma might help its locomotion in rock landscapes.

Key words: musculature; jaguarundi; anatomy; cougar;

LISTA DE ILUSTRAÇÕES

Figure 1 - Scapula lateral aspect (left) and medial aspect (righ). 1) Acromion; 2) Tuberculum supragleinodale; 3) Processur hamatus; 4) Processur suprahamatus; 5) Spina scapulae; 6) Margo caudalis; 7) Angulus caudalis; 8) Fossa infraspinata; 9) Fossa supaspinata; 10) Margo cranialis; 11) Angulus cranialis; 12) Margo dorsalis; 13) Incisura scapulae; 14) Processus coracoideus; 15) Cavitas glenoidalis; 16) Fossa subscapularis; 17) Facies serrata; 18) Collum scapulae. 25

Figure 2 - Humerus cranial aspect (left) and caudal aspect (righ). 1) Tuberculum majus; 2) Tuberculum minus; 3) Sulcus intertubecularis; 4) Condylus humeri; 5) Corpus humeri; 6) Crista supracondylaris lateralis; 7) Capitulum humeri; 8) Trochlea humeri; 9) Fossa coronoidea; 10) Epicondylus lateralis; 11) Epicondylus medialis; 12) Tuberculum epicondylus medialis; 13) Crista pectoralis profundus; 14) Crista pectoralis superficialis; 16) Facies lateralis; 17) Facies medialis; 18) Caput humeri; 19) Collum humeri; 20) Facies caudalis; 21) Fossa olecrani; 22) Sulcus brachialis; 23) Crista tuberculi minoris. 25

Figure 3 - Radius anterior aspect (left) and caudal aspect (righ). 1) Caput radii; 2) Fovea capitis radii; 3) Circunferentia articularis; 4) Corpus radii facies cranialis; 5) Margo lateralis; 6) Margo medialis; 7) Corpus radii; 8) Processus styloideus; 9) Trochlea radii; 10) Incisura ulnaris; 11) Tuberositas radii; 12) Collum radii; 13) Corpus radii fascies caudalis. 26

Figure 4 - Ulna lateral aspect (left) and medial aspect (righ). 1) Olecranon; 2) Incisura trochlearis; 3) Processus coronoideus medialis; 4) Processus coronoideus lateralis; 5) Corpus ulnae facies cranialis; 6) Corpus ulnae margo lateralis; 7) Corpus ulnae facies cranialis; 8) Corpus ulnae; 9) Caput ulnae; 10) Processus styloideus; 11) Circumferentia articularis; 12) Corpus ulnae facies medialis. 26

Figure 5- Superficial muscles of shoulder (Lateral View – Specimen UFMG 7045). Bce – Brachiocephalicus; DS – Deltoideus par scapularis; LD – Latissimus dorsi; O – Omotransversarius; TC – Trapezius cervicalis; TT – trapezius thoracis; TBLo – Triceps brachii caput longum; TBLa – Triceps brachii caput laterale; PP – Pectoralis profundus. 33

Figure 7- Extrinsic muscles of shoulder in situ (Lateral view – Specimen UFMG 7045). BCe – Brachiocephalicus; Cma – Cleidomastoideus; O – Omotransversarius; Ssp – Supraspinatus; TC – Trapezius pars cervicalis. 34

Figure 8- Mm. rhomboideus (Dorsal view – Specimen UFMG 7045). Rca - Rhomboieus capitis; Rce - Rhomboideus cervicis; RT - Rhomboideus thoracis.......... 35

Figure 10 - Intrinsic muscles of shoulder (Medial View – Specimen UFMG 7045). BB - Biceps brachii; LD - Latissimus dorsi; Ssca - Subscapularis; Ssp - Supraspinatus; TMa - Teres major. 38

Figure 11- Medial scapula muscles of specimen UFMG 7045 with m. biceps brachii (BB) pushed back to show the insertion of mm. articularis humeri (*) and teres major (TMa). 38

Figure 12- Medial view of proximal part of UFMG 7045' arm showing: BB - Biceps brachii; Bch - Brachialis; TBLo - Triceps brachii caput longum; Tmi - Teres minor.. 39

Figure 13 - Lateral aspect of UFMG 7045 arm showing: TBLa - Triceps brachii caput laterale; TBLo - Triceps brachii caput longum.. 40

Figure 14- Caudo-medial view of UFMG 7045 arm. Triceps brachii. TBA - Triceps brachii caput accessorum; TBLa - Triceps brachii caput laterale; TBLo - Triceps brachii caput longum; TBM - Triceps brachii caput mediale; * Triceps brachii caput mediale accessorum.. 41

Figure 15 – Lateral view of antebrachum of UFMG 7045. Bch - Brachialis; Bcr - Brachioradialis; ECRL - Extensor carpi radialis longus; ECU - Extensor carpi ulnaris; EDC - Extensor digitorum communis; EDL - Extensor digitorum lateralis. 43

Figure 16- Lateral view of antebrachium of UFMG 7045. EDC - Extensor digitorum communis; EDL - Extensor digitorum lateralis; ECR - Extensor carpi radialis. 43

Figure 17- Cranial aspect of m. exensor digitorum communis insertion (specimen UFMG 7045). 44

Figure 18- Lateral view of m. extensor digitorum lateralis (EDL)(specimen UFMG 7045). 44

Figure 19- Lateral view of EDI-II - Extensor digiti I et II (UFMG 7045)......... 45

Figure 20- Cranio-lateral aspecto of ECU - Extensor carpi ulnaris. Arrow signs the insertion by a tendon (specimen UFMG 7045). 46

Figure 21- Lateral view of UFMG 7045' forearm. ECRB - Extensor carpi radialis brevis; ECRL - Extensor carpi radialis longus. 47

Figure 22- Dorsal aspect of UFMG 7045 manus showing the insertion (arrow) of ECRB - Extensor carpi radialis brevis and ECRL - Extensor carpi radialis longus....... 47

Figure 23 - Medial view of UFMG 7045' antebrachium. An - Anconeus; Bcr - Brachioradialis; FCR - Flexor carpi radialis; FDP HM - Flexor digitorum profundus caput humerale mediale; PL - Palmaris lonus; PT - Ponator teres.. 49

Figure 24 – Lateral aspect of UFMG 7045'manus showing the ADV - Abductor digit V in green.. 50

Figure 25 – Ventral aspecto f UFMG 7045' forearm. PL - Palmaris longus; FBM - Flexor brevis manus (Caudal view). 50

Figure 26 – Ventral aspet of UFMG 7045' forearm. FCH- Flexor carpi ulnare caput humerale (purple); FCU - Flexor carpi ulnare caput ulnare (yellow). 50

Figure 27 – Caudal aspect of UFMG 7045' antebrachium showing the FCR - Flexor carpi radialis (cian).. 51

Figure 28 – Caudo-lateral aspect of UFMG 7045' antebrachium showing the m. flexor digitorum profundus. HL - caput humerale laterale; HM - caput humerale mediale; HP - caput humerale profundus; RU - caput radiale et ulnare; U - caput ulnare (Lateral view).. 51

Figure 29 – Caudal aspect of antebrachium of UFMG 7045 showing the two bellies of m.flexor digitorum superficialis (FDS). 52

Figure 30 – Caudal aspect of UFMG 7045' antebrachium showing the m. pronator quadratus (PQ – light yellow).. 52

Figure 31- Caudal aspect of UFMG 7045'manus showing the m.lumbricales (Lum/cyan color). 53

Figure 32 – Caudal view of UFMG 7045' manus showing the mm. adductores digitorum (AD I, II and V). 54

Figure 33 - Caudal view of UFMG 7045' manus showing the mm.flexores breves profundi (FBP).. 54

Figure 34- Lateral view of forelimb muscle attachments. ADIL – Adductor digiti I longus; An – Anconeus; Bcr – Brachioradialis; DA – Deltoideus pars acromialis; ECRB – Extensor carpi radialis brevis; ECRL – Extensor carpi radialis longus; ECU – Extensor carpi ulnaris; EDI-II – Extensor digiti I et II; EDC – Extensor digitorum communis; EDL – Extensor digitorum laterales; FDP U – Flexor digitorum profundus caput ulnare; Isp –

Infraspinatus; O – Omotransversarius; PP – Pectoralis profundus PT – Pronator teres; RCe – Rhomboideus cervicis; RCp – Rhomboideus capitis; RT – Rhomboideus thoracis; Ssp – Supraspinatus; TB – Triceps brachii; TBA – Triceps brachii caput accessorum; TBLo – Triceps brachii caput longum. 55

Figure 35 - Medial view of forelimb muscle attachments. ADIL - M. aductor digiti I longus; AH - M. articularis humeri; An - M. anconeus; BB - M. biceps brachii; Bch - M. brachialis; Bcr - M. brachioradialis; DA - M. deltoideus pars acromialis; DS - M. deltoideus pars scapularis; ; FCR - M. flexor carpi radialis; FCU H - M. flexor carpi ulnaris caput humerale; FCU U - M. flexor carpi ulnaris caput ulnare; FDP HM - M. flexor digitorum profundus caput humerale mediale; FPD HL - M. flexor digitorum profundus caput humerale laterale; FDP HP - M. flexor digitorum profundus caput humerale profundus; FDP U - M. flexor digitorum profundus caput ulnare; FDP RU - M. flexor digitorum profundus caput radiale et ulnare; PP – M. pectoralis profundus;; PQ - M. pronator quadratus; Ssca - M. subscapularis; Ssp - M. supraspinatus; SV - M. serratus ventralis; TBA - M. triceps brachii caput accessorium; TBLa - M. triceps brachii caput laterale TBLo - M. triceps brachii caput longum;; TBM - M. triceps brachii caput mediale; TBMA - M. triceps brachii caput mediale accessorium; TMa - M. teres major; TMi - M. teres minor; 56

Figure 36 - Dorsad aspect of extrinsic muscles of shoulder (specimen LOM 952). Cce - Cleidocephalicus; DA - Deltoideus pars scapularis; DS - Deltoideus pars scapularis; LD - Latissimus dorsi; O - Omotransversarius; TC - Trapezius pars cervicalis; TT - Trapezius pars thoracis. 59

Figure 37 – Entire extension of m. omotransversarius (at light blue) in situ (specimen LOM 952). 59

Figure 38- Dorsad aspecto of R – Rhomboideus in situ (Specimen LOM 952). 60

.... 60

Figure 39 – Dorsal aspect of shoulder muscles of LEM 003. RCe - Rhomboideus cervicis; RCp - Rhomboideus capitis; RT - Rhomboideus thoracis; SV - Serratus ventralis. 60

Figure 40 -Ventral aspect of mm. pectoralis of LOM 952**.** PS - Pectoralis superficialis; PP - Pectoralis profundus. 60

Figure 41 – Cranial aspect of the insertion of mm. pectoralis of LEM 003. PP - Pectoralis profundus; PS - Pectoralis superficialis; * Insertion. 61

Figure 42 – Lateral aspect of extrinsecs muscles of puma arm (specimen LOM 952). Ssp - Supraspinatus; Isp - Infraspinatus; DA - Deltoideus acromialis; DS-Deltoideus spinatus; PS - Pectoralis superficialis; PP - Pectoralis profundus; Cma - Cleidomastoideus; Cce - Cleidocephalicus; Cbra – Cleidobrachialis. 64

Figure 43 – Medial aspect of LOM 952 arm. LD - Latissimus dorsi; PP - Pectoralis profundus; PS - Pectoralis superficialis; Ssca - Subscapularis; Ssp - Supraspinatus; TMa - Teres major (Medial View)... 65

Figure 44 - Medial aspect of brachium of LOM 952. Ssca - Subscapularis; TMa - Teres major 65

Figura 45 – Medial aspect of Lom 952 brachium showing the connection between the TFA - Tensor fascia antebrachii and TMa - Teres major. 66

Figura 46 – Medial aspect of shoulder of LOM 952 showing the huge articularis humeri. AH - Articularis humeri; BB - Biceps brachii; Ssca - Suscapularis (Medial aspect of shoulder).. 67

Figure 47 - Triceps brachii of LOM 942 at medial view. TBA - caput accessorum; TBLa - caput laterale; TBLo - caput longum; TBM - caput mediale; TBMA - caput mediale accessorum.. 67

Figure 48 – Caudal aspect of LOM 952 arm. An - Anconeus; Bch – Brachialis. 68

Figure 49 - Lateral aspect of antebrachium (specimen LOM 952). An - Anconeus; ADIL - Aductor digiti I longus; Bch - Brachialis; Bcr - Brachioradialis; ECRB - Extensor carpi radialis brevis; ECRL - Extensor carpi radialis longus; ECU - Extensor carpi ulnaris; EDC - Extensor digitorum communis; EDL – Extensor digitorum lateralis................. 71

Figure 50 - Lateral aspect of extensores of antebrachium (specimen LEM 003). ECU – Extensor carpi ulnaris; EDC – Extensor digitorum communis; EDL LM – Extensor digitorum lateralis lateral belly; EDL MB – Extensor digitorum lateralis medial belly; ECRL – Extensor carpi radialis longus. 71

Figure 51 – Lateral aspect of antebrachium (specimen LOM 952). ADIL - Aductor digiti I longus; ECRB - Extensor carpi radialis brevis; ECRL - Extensor carpi radialis longus; EDI - II - Extensor digiti I et II. 72

Figura 52 – Cranial aspect of distal portion of antebrachium and proximal part of manus showing the insertion of ECRB - Extensor carpi radialis breves; ECRL - Extensor carpi radialis longus (specimen LOM 952). 72

.... 73

Figure 53 – Lateral aspect of deep muscles of forearm (specimen LOM 952). ADIL - Aductor digiti I longus; ECU - Extensor carpi ulnaris; Sup – Supinator. 73

Figure 54 – Cranial aspect of manus sowing the insertion of EDC - Extensor digitorum communis and EDL - Extensor digitorum lateralis (specimen LOM 952). .. 73

Figure 55 – Cranial aspect of manus of LOM 952 showing the 5 tendons of EDC - Extensor digitorum communis tendons. 74

Figure 56 – Cranial aspect of manus of LOM 952. The numbers indicate the tendons of 1. Extensor carpi radialis longus; 2. Extensor carpi radialis brevis; 3. Extensor digiti I et II. 75

Figura 57 - Lateral aspect of LOM 952 antebrachium showing the PT - Pronator teres. 75

Figura 58 - Cranial aspect of LOM 952 antebrachium showing the PT - Pronator teres; Sup – Supinator. 76

Figure 59 – Caudal aspect of antebrachium (specimen LOM 952)**.** FCU H - Flexor carpi ulnaris caput humerale; FCU U - Flexor carpi ulnaris caput ulnare; FDS - Flexor digitorum superficialis (Caudal aspect). 78

Figure 60 – Caudal aspect of antebrachium and manus (specimen LOM 952). FDP HL - Flexor digitorum profundus caput humerale laterale; FDP HM - Flexor digitorum profundus caput humerale mediale; FDP U – Flexor digitorum profundus caput ulnare; FDS – Flexor digitorum superficialis; LUM – Lumbricalis. 78

Figure 61 – Caudo-medial aspect of antebrachium and manus (specimen LOM 952). FCU - Flexor carpi ulnaris; FDP HL - Flexor digitorum profundus caput humerale laterale; FDP HP - Flexorigitorum profundus caput humerale profundus; FDP RU - Flexor dgitorum profundus caput radiale et ulnare; PT - Pronator teres. * Insertion of flexor digitorum profundus. 79

Figure 62 – Caudal aspect of antebrachium (specimen LOM 952). FBM - Flexor breves manus; PL - Palmaris longus. 79

Figura 63 - FBM - Flexor breves manus and PL - Palmaris longus isolated (specimen LOM 952). 80

Figura 64 – Ventral aspect of manus showing the PL - Palmaris longus. Number I-V indicates palmaris longus' tendons (specimen LOM 952). 80

Figure 65 – Caudal aspect of antebrachium showing the FCR - Flexor carpi radialis and PQ - Pronator quadratus (specimen LOM 952). 81

Figura 66 – Lateral aspect of ADV - Abductor digiti V (specimen LOM 952). 82

Figura 67 - Abductor digiti V isolated (specimen LOM 952). 83

Figura 68 – Caudal aspect of manus showing the mm. adductores digitorum. ADI – Adductor digiti I; ADII – Adductor digit II. ADV – Adductor digiti V...................... 83

Figura 69 – Ventral aspect of manus (specimen LOM 952). FBP - Flexores breves profundi (I-V); PB - Palmaris breves. 84

Figure 70 - Left limb of jaguarundi UFMG 7045 showing the two bellies of m. pectoralis superficialis juxtaposed and fused with m. cleidoephalicus. 86

Figure 71 - Insertion of mm. pectoralis profundus (PP) and superficialis (PS) indicated by "*". 86

Figure 72 - Muscle mass distribution on Acinonychiini................................... 90

Figure 73 - Comparative muscle mass distribution for felids. 90

Figure 74 - Comparative forelimb muscle mass for scansorial felids. 91

Figure 75 - Distribution of muscle mass in small felids. 91

Figure 76 - Distribution of forelimb muscle mass for terrestrial felids. 92

LISTA DE TABELAS

Table 1 - Correspondence of nomenclature of scapula. 27

Table 2 - Correspondence of nomenclature of humerus 27

Table 3 - Correspondence nomenclature of radius. 28

Table 4 - Correspondence nomenclature of ulnae 28

Table 5 - Muscles nomenclature used in other articles. 29

Table 6 - Percentual body mass for each muscle group. [1.] The righ pectoralis of male jaguarundi was damaged, so it was not weighed. 89

ABREVIAÇÕES

AD	Mm. adductores digitorum
AD I	digit I
AD II	digit II
AD VL	digit V lateral belly
AD VM	digit V medial belly
ADIL	M. aductor digiti I longus
ADV	M. abductor digiti V
AH	M. articularis humeri
An	M. anconeus
BB	M. biceps brachii
Bce	M. brachiocephalicus
Bch	M. brachialis
Bcr	M. brachioradialis
Cbra	m. cleidobrachialis
Cce	m. cleidocephalicus
Cma	m. cleidomastoideus
D	M. deltoideus
DA	pars acromialis
DS	pars scapularis
ECRB	M. extensor carpi radialis brevis
ECRL	M. extensor carpi radialis longus
ECU	M. extensor carpi ulnaris
EDC	M. extensor digitorum communis
EDI-II	M. extensor digiti I et II
EDL	M. extensor digitorum lateralis
FBP	Mm. flexores breves profundi
FCR	M. flexor carpi radialis
FCU	M. flexor carpi ulnaris
FCU H	caput humerale
FCU U	caput ulnare
FDBM	M. flexor digitorum brevis manus
FDP	M. flexor digitorum profundus
FDP HM	caput humerale mediale
FDP HP	caput humerale profundus
FDP RU	caput radiale et ulnare
FDP U	caput ulnare
FDS	M. flexor digitorum superficialis
FPD HL	caput humerale laterale
Isp	M. infraspinatus
LD	M. latissimus dorsi

Lig.	Ligamentum
Lum	Mm. lumbricales
M	Musculus
O	M. omotranversarius
Os	Ossus
PB	M. palmaris brevis
PL	M. palmaris longus
PP	M. pectoralis profundus
PQ	M. pronator quadratus
PS	M. pectoralis superficialis
PS	M. pectoralis superficialis
PT	M. pronator teres
RCe	M. rhomboideus cervicis
RCp	M. rhomboideus capitis
RT	M. rhomboideus thoracis
Ssca	M. subscapularis
Ssp	M. supraspinatus
Sup	M. supinator
SV	M. serratus ventralis
T	M. trapezius
TB	M. triceps brachii
TBA	caput accessorium
TBLa	caput laterale
TBLo	caput longum
TBM	caput mediale
TBMA	caput mediale accessorium
TC	pars cervicalis
TFA	M. tensor fascia antebrachii
TMa	M. teres major
TMi	M. teres minor
TT	par thoracis

SUMÁRIO

1. INTRODUCTION 22

2. MATERIAL AND METHODS **24**

3. DESCRIPTION OF THE FORELIMB MUSCULATURE OF *HERPAILURUS YAGOUAROUNDI* (FELIDAE, CARNIVORA) **31**

3.1. EXTRINSIC MUSCLES 31

3.2. INTRINSIC MUSCLES OF SHOULDER 35

3.3. CRANIAL ASPECT OF ANTEBRACHIUM 41

3.4. CAUDAL ASPECT OF ANTEBRACHIUM 48

3.5. MANUS 52

4. DESCRIPTION OF THE FORELIMB MUSCULATURE OF *PUMA CONCOLOR* (FELIDAE, CARNIVORA) **57**

4.1. EXTRINSIC MUSCLES OF SHOULDER 57

4.2. INTRINSIC MUSCLES OF SHOULDER 61

4.3. CRANIAL ASPECT OF ANTEBRACHIUM 68

4.4. CAUDAL ASPECT OF ANTEBRACHIUM 76

4.5. MANUS 81

5. COMPARATIVE ANALYSES AND DISCUSSION **85**

5.1. MYOLOGICAL DIFFERENCES 85

5.2. Quantitave comparation *88*

CONCLUSION **94**

REFERENCES **96**

INTRODUCTION

The family Felidae is one of the more recognizable among modern carnivoran families. They were irradiated during the late Miocene, in Asia, and today include about 41 extant species in 8 different lineages (Johnson et al., 2006; Kitchener et al., 2017). All felids are hyper-carnivorous and adapted to hunt prey of distinct sizes, from tiny insects to large mammals (Kitchener et al., 2017). To be able to hunt such a great diversity of animals, felids evolved flexible forelimbs that are used to capture and subjugate prey. On the other hand, locomotion on the ground needs stable limbs to support the weight of the animal. Therefore, to fulfill both conditions, the forelimb of felids usually blends flexibility and stability to different degrees (Meachen-Samuels & van Valkenburgh, 2009).

Forelimbs with elbow joints and paws more flexible are commonly found in arboreal felids since they need to change direction on the trees with agility. Arboreal felids also have more developed flexors than extensor muscles, which allows bringing the body closer to the tree while climbing (Böhmer et al 2019; Gambaryan 1974). In contrast, terrestrial felids have elbow joints more stable and show more developed extensors than flexor muscles, which maintain the forelimb farther from the ground and closer to the thorax, which helps sustain the entire body during walk (Gambaryan, 1974; Julik et al., 2012; Miriam Mariana Morales & Giannini, 2021). Many characteristics related to both locomotion and capture of prey are predominantly related to the muscular structure of the animal, such as the number of muscles used to execute a movement, the type of the muscle, and its attachments. Therefore, musculature description, together with osteological morphology, is crucial to understand locomotion and prey capture adaptations . Despite that, data on forelimb muscles are poorly documented to the Felidae family and most studies focus on quantitative data such as physiological cross-sectional area (PCSA) (Cuff et al., 2016; Hudson et al., 2011)

The lack of adequate knowledge about muscle anatomy is particularly noticeable for Neotropical felids, for which many species lack any kind of morphological description, such is the case of the jaguarundi (*Herpailurus yagouaroundi*). The jaguarundi is a distinct member of the tribe Acinonychini being closely related to the puma (*Puma concolor*) and to the cheetah (*Acinonyx jubatus*), species whose musculature was previously described by Concha et al (2004) and Ross (1876), respectively.

Compared with the other members of this tribe, the jaguarundi is the smallest and most divergent species, since it is relatively long-bodied and short legged, and feeds mainly on small vertebrates, unlike the puma and the cheetah, which prefer middle-size prey (Oliveira T.G., 1998; Meachen-Samuels and Valkenburgh, 2009).

Meachen-Samuels and Van Valkenburgh (2009) classified the jaguarundi as scansorial, based on osteological measurements, but recently Morales and Giannini (2021) expanded the locomotor morphotypes for Felidae, classifying them in nine groups. In their analyses, the jaguarundi was placed in category II composed by "small species, small-prey hunters with various locomotor modes but no specific adaptations for climbing". This category also includes two arboreal species and four species considered as terrestrial by Meachen-Samuels and Van Valkenburgh (2009), which shows that this form of locomotion classification is of little help to understand the locomotor habit of felids. Their analyses also showed a significant difference in the morphotypes present in the tribe Acinonychini. According to them, the cheetah is the only sprinter felid while the puma is classified as rock-dwelling. They also suggest that the puma and snow-leopard have similar morphotypes. However, only osteological data were analyzed, and possible myological similarities and differences remain poorly understood.

It seems clear that there is a lack of understanding of the patterns of locomotion in felids, and that may be directly correlated to the lack of information about basic limb anatomy, especially about musculature. The jaguarundi may be crucial to understand how forelimbs evolved in the tribe Acinonychini and how the disparate species of this group are differently adapted for locomotion. Therefore, the objective of this study is to provide a complete muscle description of the forelimb of the jaguarundi, and compare it with other members of Acinonychini, including new dissections of the puma, and other felids previous described in literature.

MATERIAL AND METHODS

The dissections were conducted on the left and right forelimb of two jaguarundis (H. yagouaroundi), one adult male (UFMG 7046) and one adult female (UFMG 7045), and two specimens of puma (Puma concolor), one adult female (LOM 952) and one adult of indeterminate sex, lacking genitals (LEM 003). All specimens were roadkilled, so many of them had fractures throughout the body, and, therefore, some of the muscles there were too damaged and were not available for inclusion in this study. To preserve the carcasses during dissection, they were previously frozen, fixed by formaldehyde 10%, and stored in alcohol 70%. The dissection was made following Allen and Harper (2003), and each removed muscle was stored in an individual bag with alcohol 70% to later weighting. To document the process, each step of dissection was photographed by a Samsung A31 smartphone. Muscle weight was recorded using a BEL engineering 720g (e:0,01g) precision balance, including the tendons. Each muscle had the excess fluid removed dried by a paper towel previously to the weighing. Each muscle was weighted three times, with the mean of the three measurements being recorded.

Muscle attachments were mapped painting the origins and insertions with watercolor direct onto the bone, immediately after removing the muscle. Simultaneously, we painted the attachment onto a corresponding bone of another specimen. All the attachments were transfered to a drawing of the bones (e.g., Figure 34). The muscles were named according to Nomina Anatomica Veterinaria 6th edition (N.A.V, 2017) and the bone structures also follow the NAV, except for three structures of humerus, that were named in this study to facilitate the muscles description, *crista pectoralis superficialis* (Figure 2, n. 13), *crista pectoralis profundus* (Figure 2, n. 14) and *tuberculum epicondylus medialis* (Figure 2, n. 12). All bones structures used are illustrated in Figures 1 to 4. Data from dissections were compared with published musculature descriptions of other felids, such as the cheetah (Acinonyx jubatus), ocelot (Leopardus pardalis), snow leopard (Panthera uncia) and lion (Panthera leo). To analyze weight distribution the muscles of the forelimb were grouped by function and plotted on a radar graphic and subsequently compared with other felids.

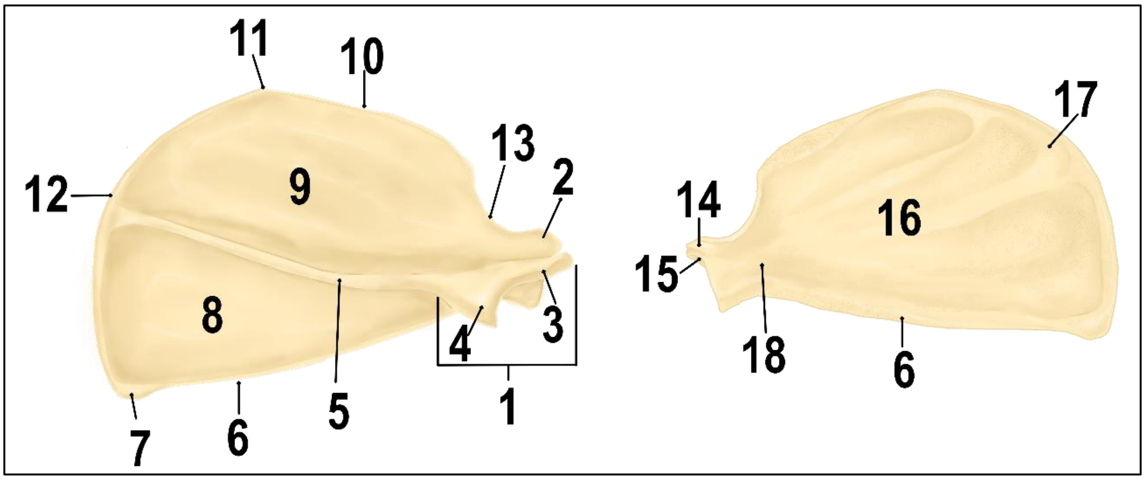

Figure 1 - Scapula lateral aspect (left) and medial aspect (righ). 1) Acromion; 2) Tuberculum supragleinodale; 3) Processur hamatus; 4) Processur suprahamatus; 5) Spina scapulae; 6) Margo caudalis; 7) Angulus caudalis; 8) Fossa infraspinata; 9) Fossa supaspinata; 10) Margo cranialis; 11) Angulus cranialis; 12) Margo dorsalis; 13) Incisura scapulae; 14) Processus coracoideus; 15) Cavitas glenoidalis; 16) Fossa subscapularis; 17) Facies serrata; 18) Collum scapulae.

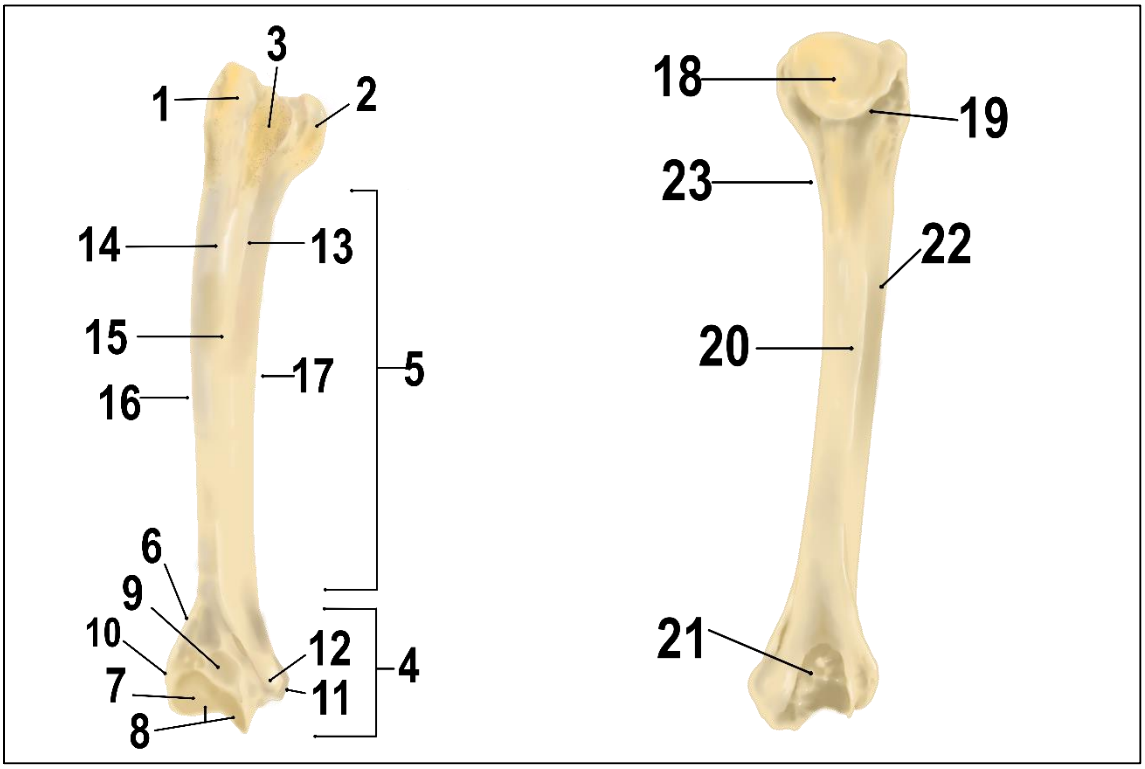

Figure 2 - Humerus cranial aspect (left) and caudal aspect (righ). 1) Tuberculum majus; 2) Tuberculum minus; 3) Sulcus intertubecularis; 4) Condylus humeri; 5) Corpus humeri; 6) Crista supracondylaris lateralis; 7) Capitulum humeri; 8) Trochlea humeri; 9) Fossa coronoidea; 10) Epicondylus lateralis; 11) Epicondylus medialis; 12) Tuberculum epicondylus medialis; 13) Crista pectoralis profundus; 14) Crista pectoralis superficialis; 16) Facies lateralis; 17) Facies medialis; 18) Caput humeri; 19) Collum humeri; 20) Facies caudalis; 21) Fossa olecrani; 22) Sulcus brachialis; 23) Crista tuberculi minoris.

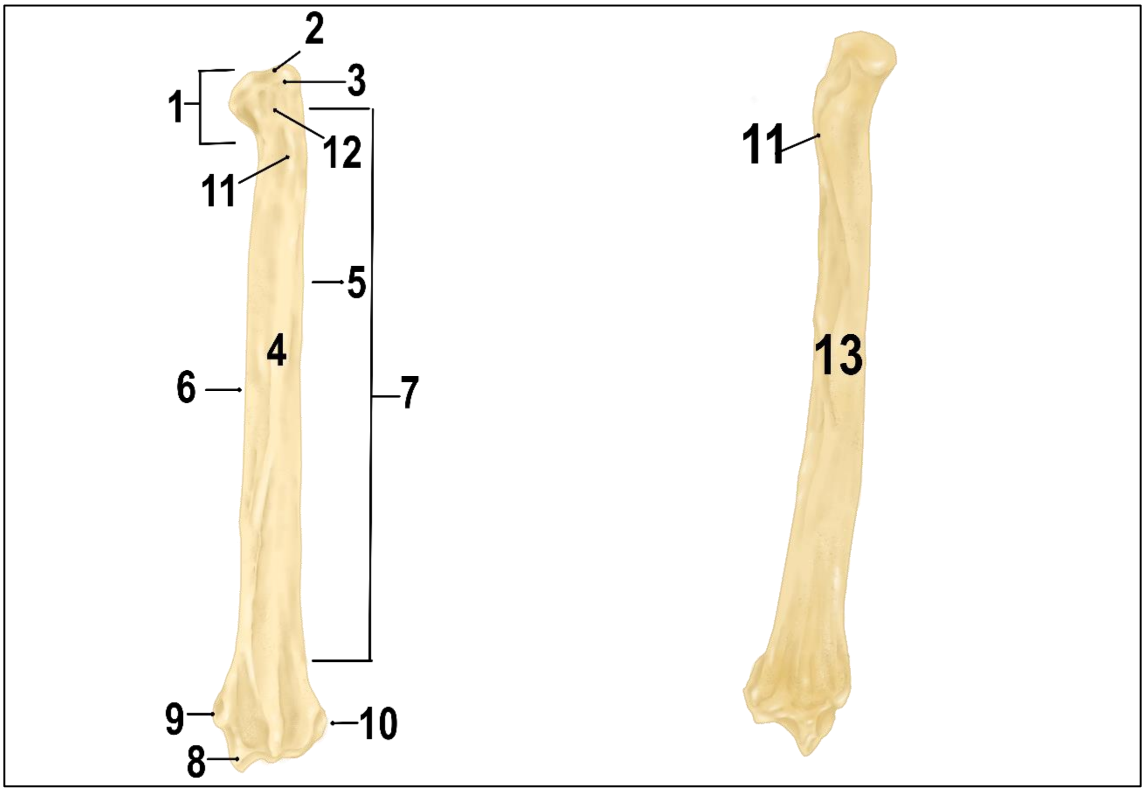

Figure 3 - Radius anterior aspect (left) and caudal aspect (righ). 1) Caput radii; 2) Fovea capitis radii; 3) Circunferentia articularis; 4) Corpus radii facies cranialis; 5) Margo lateralis; 6) Margo medialis; 7) Corpus radii; 8) Processus styloideus; 9) Trochlea radii; 10) Incisura ulnaris; 11) Tuberositas radii; 12) Collum radii; 13) Corpus radii fascies caudalis.

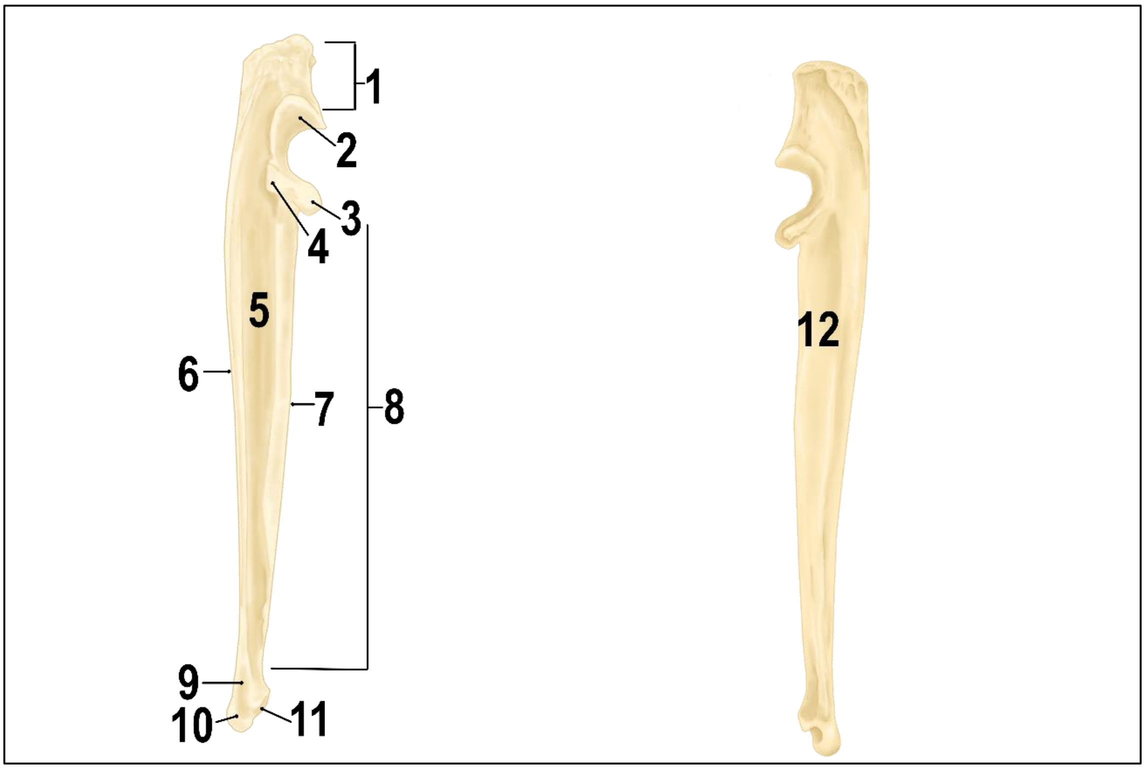

Figure 4 - Ulna lateral aspect (left) and medial aspect (righ). 1) Olecranon; 2) Incisura trochlearis; 3) Processus coronoideus medialis; 4) Processus coronoideus lateralis; 5) Corpus ulnae facies cranialis; 6)

Corpus ulnae margo lateralis; 7) Corpus ulnae facies cranialis; 8) Corpus ulnae; 9) Caput ulnae; 10) Processus styloideus; 11) Circumferentia articularis; 12) Corpus ulnae facies medialis.

Table 1 - Correspondence of nomenclature of scapula.

N.	Constantinescu & Schaller 2012	De Iulis & Pulera 2007
1	Acromion	Acromion
2	Tuberculum supragleinodale	-
3	Processus hamatos	Acromion
4	Processus suprahamatus	Metacromion
5	Spina scapulae	Scapular spine
6	Margo caudalis	Posterior border
7	Angulus ventralis	-
8	Fossa infraspinata	Infraspinous fossa
9	Fossa supraspinata	Supraspinous fossa
10	Margo cranialis	Anterior border
11	Angulus cranialis	-
12	Margo dorsalis	Dorsal border
13	Incisura gleinodalis	-
14	Processus coracoideus	Coracoid process
15	Cavitas gleinodalis	Glenoid fossa
16	Fossa subscapularis	Subscapular fossa
17	Facies serrata	-
18	Collum scapulae	-

Table 2 - Correspondence of nomenclature of humerus

N.	**Constantinescu & Schaller 2012**	**De Iulis & Pulera 2007**
1	Tuberculum majus	Greater tuberosity
2	Tuberculum minus	Lesser tuerosity
3	Sulcus intertubercularis	Bicipal groove
4	Condylus humeri	-
5	Corpus humeri	Shaft
6	Margo caudalis	Posterior border
7	Caitulum humeri	Capitulm
8	Trochlea humeri	Trochlea
9	Fossa coronoidea	Coronoid fossa
10	Epicondylus lateralis	Lateral epicondyle
11	Epicondylus medialis	Medial epicondyle

12	Tuberculum epicondylus medialis	-
13	Crista pectoralis superficialis	Pectoral ridge
14	Crista pectoralis profundus	-
15	Facies cranialis	
16	Facies lateralis	
17	Facies medialis	-
18	Caputi humeri	-
19	Collum humeri	Neck
20	Facies caudalis	
21	Fossa olecrani	Olecranon fossa
22	Sulcus m. brachialis	-

Table 3 - Correspondence nomenclature of radius.

N.	Constantinescu & Schaller 2012	De Iulis & Pulera 2007
1	Caput radii	Head
2	Fovea capitis radii	Fovea
3	Circuferentia articularis	Articular circumference
4	Corpus radii facies cranialis	-
5	Margo lateralis	-
6	Margo medialis	-
7	Corpus radii	Shaft
8	Processus styloideus	Stylid process
9	Trochlea radii	Bicipal tuberosity
10	Incisura ulnaris	-
11	Tuberositas radii	Bicipal tuberosity
12	Collum radii	Neck
13	Corpus radii facies caudalis	-

Table 4 - Correspondence nomenclature of ulnae

N.	**Constantinescu & Schaller 2012**	**De Iulis & Pulera 2007**
1	Olecranon	Olecranon
2	Incisura trochlearis	Trochlear notch
3	Processus coronoideus lateralis	Coronoid process
4	Processus coronoideus medialis	Radial notch
5	Corpus ulnae facies lateralis	-
6	Corpus ulnae margo caudalis	-
7	Corpus ulnae margo cranialis	-

8	Corpus ulnae	Shaft
9	Caput ulnae	-
10	Processus styloideus	Styloid process
11	Circumferentia articularis	-
12	Corpus ulnae facies medialis	-

Table 5 - Muscles nomenclature used in other articles.

Julick et al 2012	Reighard and Jennings, 1901	Ross 1883
M. trapezius		M. trapezius
pars cervicalis	M. acromiotrapezius	par clavicularis
par thoracis	M. spinotrapezius	par scapulares superior
		par scapulares inferior
		M. rhomboideus
M. rhomboideus capitis	M. occipitoscapularis	occipital
M. rhomboideus cervicis	M. rhomboideus	major
M. rhomboideus thoracis	M. levator scapulae ventralis	minor
M. omotranversarius	M. serratus anterior/levator scapulae	trachelo-acromialis
M. serratus ventralis	M. pectoantibrachialis	M. serratus magnus
M. pectoralis superficialis	M. pectoralis major	M. pectoralis major
		superficial layer
		deep layer
M. pectoralis profundus	M. pectoralis minor	M. pectoralis minor
M. latissimus dorsi	M. latissimus dorsi	M. latissimus dorsi
M. brachiocephalicus		
m. cleidocephalicus	M. clavotrapezius	
m. cleidomastoideus	M. cleidomastoideus	cleido-mastoid
m. cleidobrachialis	M. clavobrachialis	
M. deltoideus		M. deltoid
pars scapularis	M. spinodeltoideus	scapularis
pars acromialis	M. acromiodeltoideus	acromialis
		clavicularis
M. supraspinatus	M. supraspinatus	
M. infraspinatus	M. infraspinatus	
M. teres minor	M. teres minor	M. teres minor
M. teres major	M. teres major	M. teres major
M. subscapularis	M. subscapularis	M. subscapularis
M. triceps brachii	M. triceps brachii	M. triceps brachii
caput longum	caput longum	longus
caput laterale	caput laterale	externus
caput mediale	caput mediale	internus

caput accessorium		M. triceps accessorius
caput mediale accessorium		Anconeus-internus
M. anconeus	M. anconeus	Anconeus-externus
M. tensor fascia antebrachii	M. epitrochlearis	
M. articularis humeri	M. coracobrachialis	M. coraco-brachialis minor
M. biceps brachii	M. biceps brachii	M. biceps humeri
M. brachialis	M. brachialis	M. brachiaeus
M. brachioradialis	M. brachioradialis	
M. extensor carpi radialis longus	M. extensor carpi radialis longus	M. Extensor carpi radialis longior
M. extensor carpi radialis brevis	M. extensor carpi radialis brevis	M. extensor carpi radialis brevior
M. extensor digitorum communis	M. extensor digitorum communis	M. Extensor longus digitorum
M. extensor digitorum lateralis	M. extensor digitorum lateralis	
M. extensor carpi ulnaris	M. extensor carpi ulnaris	M. extensor carpi ulnaris
M. supinator	M. supinator	M. Supinator radii brevis
M. aductor digiti I longus	M. extensor brevis pollicis	
M. extensor digiti I et II	M. extensor indicis	
M. pronator teres	M. pronator teres	M.pronator radii teres
M. flexor carpi radialis	M. flexor carpi radialis	
M. palmaris longus	M. palmaris longus	
M. flexor carpi ulnaris	M. flexor carpi ulnaris	M. flexor carpi ulnaris
caput humerale	humeral head	
caput ulnare	ulnar head	
M. flexor digitorum superficialis	M. flexor sublimis digitorum (radial part)	
M. flexor digitorum profundus	M. flexor profundus digitorum	M. flexor digitorum profundus
M. pronator quadratus	M. pronator quadratus	M. pronator quadratus
M. palmaris brevis		
M. flexor digitorum brevis manus	M. flexor sublimis digitorum (ulnar part)	M. flexor sublimis
M. abductor digiti V	M. abductor digiti quinti	
Mm. lumbricales	Mm. lumbricales	
Mm. adductores digitorum		
digit I	M. adductor pollicis	
digit II	M. adductor digiti secundi	
digit V medial belly	M. opponens digiti quinti	
digit V lateral belly		
Mm. flexores breves profundi	Mm. interossei/flexor brevis pollicis	

1. DESCRIPTION OF THE FORELIMB MUSCULATURE OF *HERPAILURUS YAGOUAROUNDI* (FELIDAE, CARNIVORA)

1.1.1. Extrinsic Muscles

The ***m. trapezius*** originates by aponeurosis from the middorsal line of the neural process of the cervical and thoracic vertebrae. This muscle could be divided in two parts: par cervicalis and par thoracica. The *par cervicalis* originates from the C7 - T4 vertebrae and inserts onto the caudal border of *processus suprahamatus*. The *par thoracica* originates from the T5 - T10 vertebrae and inserts onto the first two-thirds of the *spina scapulae* and a small part of the *m. infraspinatus*. The *par thoracica* is partially fused with *m. latissimus dorsi* in the UFMG 7045.

The ***M. rhomboideus*** is divided into three parts: *m.rhomboideus capitis*, *m. rhomboideus cervicis*, *m. rhomboideus thoracis*. The *m. rhomboideus capitis* originates from the *linea nuchae* (superior nuchal line), caudally from the origin of *m. cleidocephalicus*, at level of axis vertebrae. This muscle lies onto the *m. splenius capitis*, covering the neck dorsally and inserts onto the dorsal border of the scapula from the beginning of this border until the end of the *fosssa supraspinata*. It is fused with the *m. serratus ventralis* next to its insertion. The *m. rhomboideus cervicis* originates from the anterior part of the *lig. nuchae*, at level of C5-T3 and inserts onto the dorsal border of the scapula from the line of the scapular spine to the half of infraspinous fossa. The *m. rhomboideus thoracis* is the smallest of all *mm. rhomboideus*, it originates from the *lig. supraspinales* between T4-T5 vertebrae and inserts onto the dorsal border of the scapula from the half to the end of infraspinous fossa.

The three *mm. rhomboideus* stabilize the scapula and fix the forelimb in the thorax.

The ***m. omotransversarius*** is a slender muscle originated from *processus transversus* of atlas, via fleshy fibers. This muscle pass over shoulder and inserts onto proximal part of scapular spine. It helps to stabilize the scapula and it is fused with the *m. longissimus capitis* next to the vertebrae.

The ***m.serratus ventralis*** is a multifascicle muscle that is composed of a *par cervicalis* and a *par thoracis*. The *par cervicalis* oiriginates from the transverse process of vertebrae C3-T1 while the *par thoracis* from the lateral aspect of ribs 1-8. Both parts converge and insert together onto the medial aspect of *margo caudalis* of scapulae, via fleshy fibers.

Mm. pectoralis superficialis is composed of two bellies, one most cranial, and another caudal. They originate together and juxtaposed from manubrium of sternum, via fleshy and inserts, via mixed fibers (part with tendinous fibers and part with fleshy fiber) onto *crista pectoralis superficialis*.

The ***m. pectoralis profundus*** originates from the first to the last sternebrae of the sternum by fleshy fibers. This muscle converges to the limb and inserts onto *crista pectoralis profundus*, a small ridge situated medially at the greater tuberosity of the humerus until the "pectoral ridge". This muscle is partially fused with the *m. latissimus dorsi* at the distal portion.

M. latissimus dorsi originates from the thoracolumbar fascia by an aponeurosis, at level of T5-L6 vertebrae, it lies down laterally through the thoracic chamber and inserts onto the forelimb. Its insertion is divided into two: part inserts onto the surface of m. teres major and part onto the anterior portion of the medial surface of the *m. tensor fascia antebrachi*i (m. eptroclearis). This muscle also attaches onto the medial surface of the *m. pectoralis profundus* by two points, one next to the thoracic limb and other next to thoracic chamber and it shows a caput that inserts onto the border surface of *m.trapezius*.

The ***m. brachiocephalicus*** seems like a great band composed for three muscles: *m. cleidocephalicus*, *m. cleidomastoideus* and the *m. cleidobrachialis*. The *m. cleidocephalicus* originates from the superior nuchal line and the proximal portion of the nuchal ligament at level of C2 - C5, it lies down through the forelimb and inserts onto the clavicle and part of the *m. cleidobrachialis*.This muscle is partially fused with the *m. trapezius par thoracica* at the cranial lateral aspect of the limb. The *cleidomastoideus* originates from the lateral part of the mastoid bone, it lies down together with the *m. cleidocephalicus* through the forelimb and inserts onto entire extensions of the clavicle and the intersection clavicularis. The *m. cleidobrachialis* originates from the ventral aspect of the clavicle and the distal surface of the *m. cleidocephalicus*. It is partially fused with the *m. pectoralis superficialis* cranialmedially and with the tendon of *m. brachialis* next to the insertion. This muscle inserts with *m. brachialis* onto the lateral aspect of the ulna shaft, and in the left forelimb of UFMG 7045 it inserted onto *tuberositas radii* with *m. biceps brachii*.

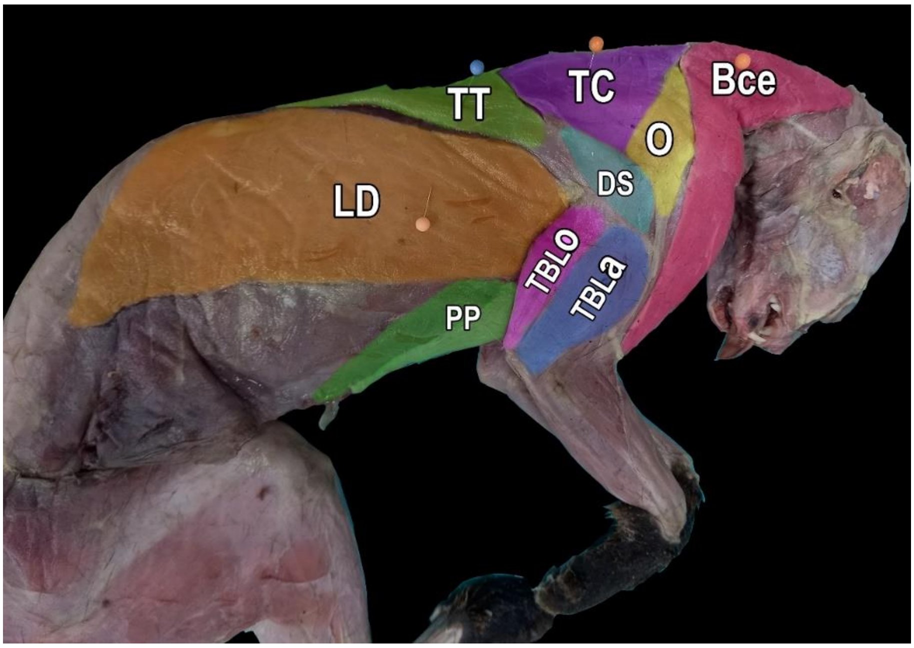

Figure 5- Superficial muscles of shoulder (Lateral View – Specimen UFMG 7045). Bce – Brachiocephalicus; DS – Deltoideus par scapularis; LD – Latissimus dorsi; O – Omotransversarius; TC – Trapezius cervicalis; TT – trapezius thoracis; TBLo – Triceps brachii caput longum; TBLa – Triceps brachii caput laterale; PP – Pectoralis profundus.

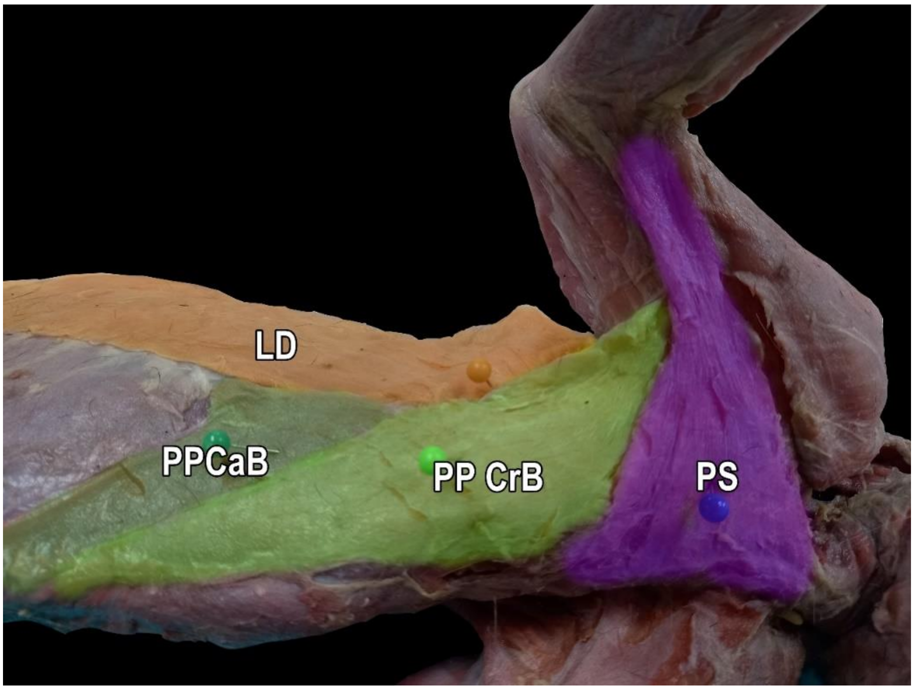

Figure 6- Mm. pectoralis (Ventral view – Specimen UFMG 7045). PS - Pectoralis superficialis; PP CrB - Pectoralis profundus cranial belly; PPCaB - Pectoralis profundus caudal belly.

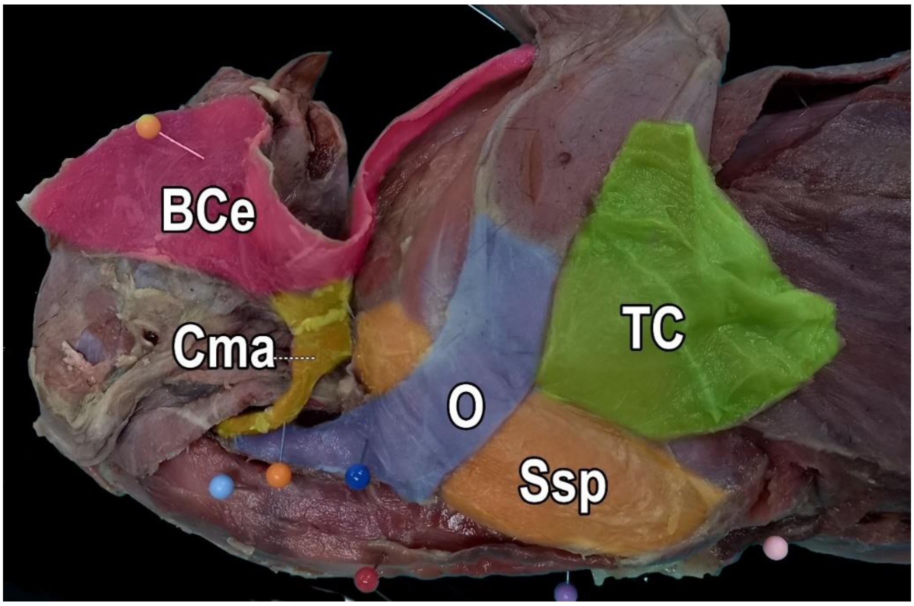

Figure 7- Extrinsic muscles of shoulder *in situ* (Lateral view – Specimen UFMG 7045). BCe – Brachiocephalicus; Cma – Cleidomastoideus; O – Omotransversarius; Ssp – Supraspinatus; TC – Trapezius pars cervicalis.

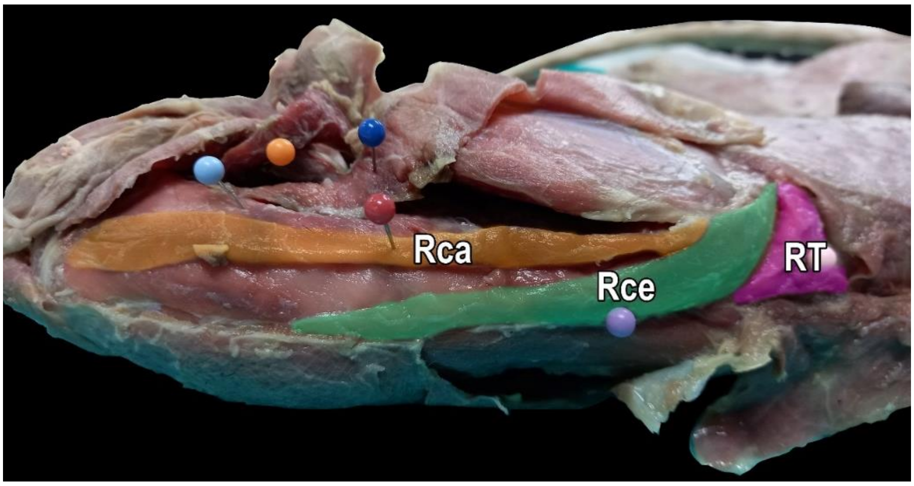

Figure 8- Mm. rhomboideus (Dorsal view – Specimen UFMG 7045). Rca - Rhomboieus capitis; Rce - Rhomboideus cervicis; RT - Rhomboideus thoracis.

1.1.1. Intrinsic Muscles of Shoulder

The ***m. deltoideus pars acromialis*** originates from the border of the acromion (from the processus suprahamatus to processus hamatus) and the lateral part from the *m.supraspinatus*, via fleshy. It inserts onto the humeral shaft, next to the deltoid ridge via fleshy fibers and just cranially to the insertion of the *m. pectoralis superficialis*.

M. deltoideus pars scapularis originates from the spina scapulae and from the surface of m.infraspinatus. It inserts onto the surface of the *m. triceps brachii caput laterale et longum* in UFMG 7046 and onto *m. deltoideus pars acromialis* in UFMG 7045.

M. supraspinatus originates via fleshy fibers from the entire supraspinous fossa of the scapula, the anterior border, part of the scapular spine, and onto a flat triangle shape area at the cranial portion of the acromion. It inserts via tendinous fibers onto an anterior portion of the greater tubercle of the humerus, laterally to the insertion of the *m. pectoralis profundus*.

The ***m. infraspinatus*** originates via fleshy fiber from the entire infraspinous fossa (*fossa spinata*) and the ventral aspect of the metacromion of the scapula and inserts via tendinous fibers onto the lateral aspect of the greater tubercle, next to the insertion of the *m. supraspinatus*.

M. teres major originates from the *angulus caudalis* of scapulae, via flehy fiber, and inserts via a flat tendon onto the first proximal quarter of *corpus humeri facies* *medialis*, next to the pectoral ridge. In the left limb of the specimen UFMG 7046, this muscle was damaged, so it was not included. This muscle is fused with the surface of the *m. triceps brachii caput laterale* by the lateral aspect and dorsocaudally with the *m. teres minor*.

The ***m.teres minor*** originates, via fleshy, from the entire extention of *margo caudalis* of scapula and inserts onto *caput humeri*, at a small area next to *tubercullum minus*.

M. subscapularis in the right limb have eight bipennate muscle bundles that originate from the subscapular fossa (*fossa subscapularis*), and the lateral aspect of the caudal border of the scapula. It inserts onto caput humeri, at a cranial-medial area next to *tuberculum minus*, just above to insertion of *m. teres minor*.

M. articularis humeri (***Coracobrachialis)*** originates via tendon from the *processus coracoideus* and part from the medial aspect of the lesser tubercle of the humerus, next to the lesser tuberosity and inserts via fleshy fibers onto the humerus shaft.

The ***m. biceps brachii*** is a fusiform muscle that originates, via a long tendon, from the *tuberculum supraglenoideale*. In the specimen UFMG 7046, the origin of this muscle was from the cranial aspect of *caput humeri* and *sulcus intertubercularis* (bicipal groove), in both limbs, however this condition might be a muscle laceration, caused by the crash. This muscle crosses the capsule joint and inserts onto the *tuberositas radii* (bicipal tuberosity of radius).

The ***m. brachialis*** originates via fleshy fibers from the entire *sulcus brachialis*, an area from the caudal aspect of humerus, next to *collum humeri* to the proximal part of the *copus humeri facies cranialis*. This muscle crosses the humerus and inserts with the *m. cleidobrachialis* onto the lateral aspect of the ulna shaft, just below to coronoid process, but in the left limb of UFMG 7045 it insers onto *tuberositas radii* with *m. biceps brachii*.

The ***m. tensor fascia antebrachii (epitrochlearis)*** originates via aponeurosis from the surface of the *m. triceps brachii caput longum* and inserts also via aponeurosis onto the elbow joint. This muscle is partially fused with *m. latissimus dorsi* at the medial aspect of the limb.

The **m. *triceps brachii*** in jaguarundi is usually composed of five caputs in both limbs: *caputs longum, laterale, mediale, acessorium* and *mediale acessorium*. The ***caput longum*** is the largest caput *m.triceps brachii*, it originates via mixed fibers from *margo caudalis* and a small part of *collum scapulae*. The ***caput laterale*** originates from the lateral aspect of *collum humeri*, via fleshy fibers. The ***caput mediale*** originates from dorsal and medial part of *collum humeri*. It is partially fused with the *caput acessorium* at the distal portion. The ***caput acessorium*** originates from distal part of *crista tuberculi minoris*, next to the insertion of the *m. articulari humeri*. It is partially fused with *caput accessorium* distally. The *caput acessorium* and *caput mediale* was almost complete fused in the right limb of the specimen UFMG 7046, because of that, the *caput acessorium* could be originated from the *caput mediale*. ***M. triceps brachii caput mediale acessorium*** originates from the medial supracondylar crest and inserts onto medial epicondyle. All heads insert together onto the caudal aspect of the olecranon, via mixed fibers.

The ***m. brachioradialis*** seems like a slender band that originates at the humerus and crosses the antebrachium until the base of the carpus. It originates via fleshy fibers from the lateral surface of *m. brachialis* and the *crista supracondylaris laterais*, just above the insertion of the *m. anconeus* and inserts via tendinous fibers onto *processus styloideus* of ulna, just below the retinaculum of the carpus.

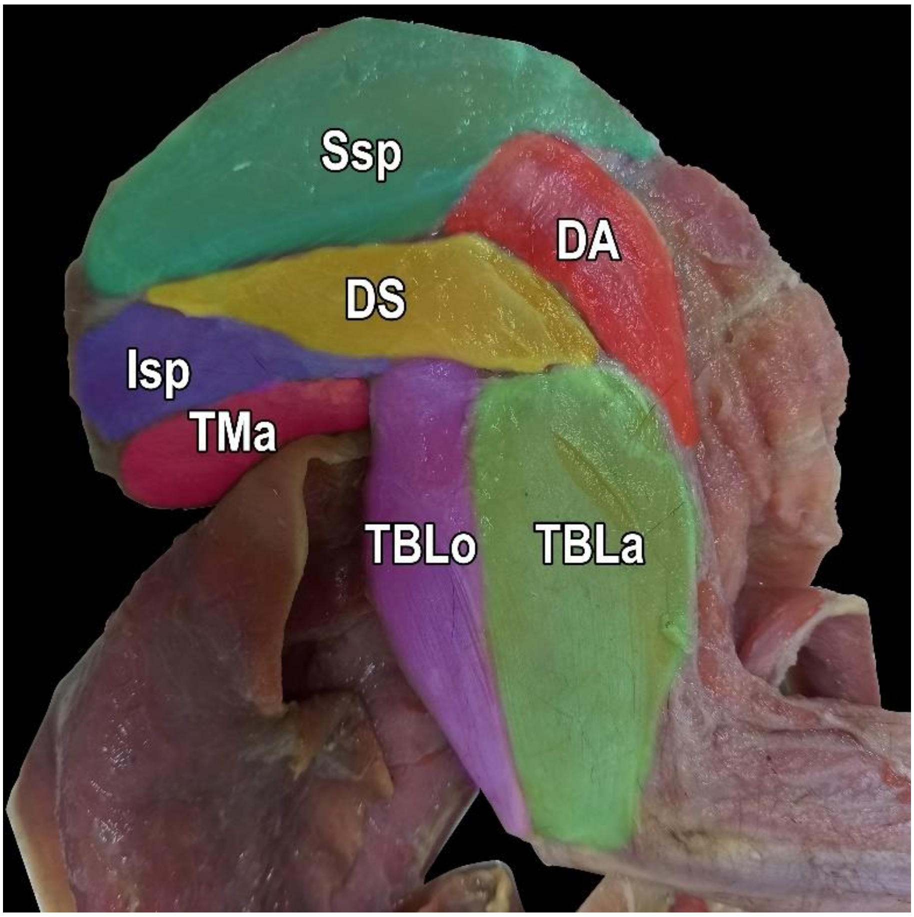

Figure 9- Intrinsic muscles of shoulder (Lateral view – Specimen UFMG 7045). DA – Deltoideus pars acromialis; DS – Deltoideus pars scapularis; Isp – Infraspinatus; Ssp – Supraspinatus; TBLa – Triceps brachii caput lateralis; TBLo – Triceps brachii caput longum; TMa – Teres major.

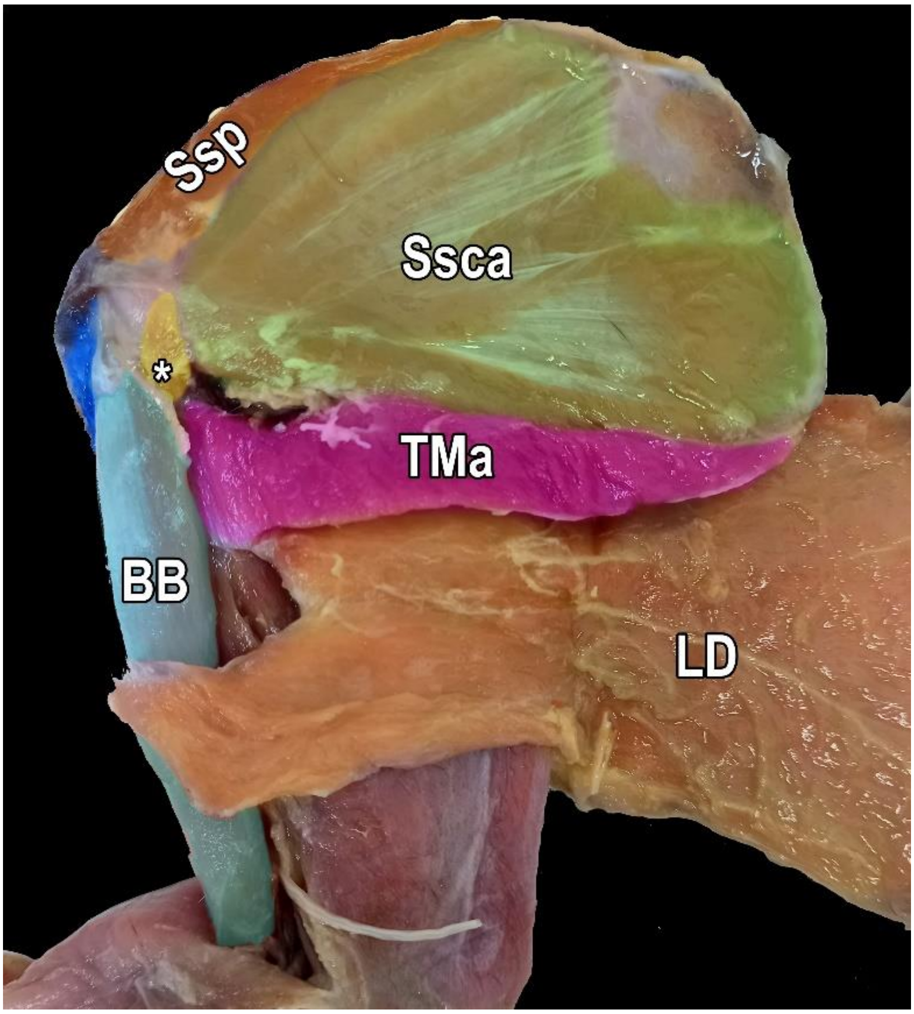

Figure 10 - Intrinsic muscles of shoulder (Medial View – Specimen UFMG 7045). BB - Biceps brachii; LD - Latissimus dorsi; Ssca - Subscapularis; Ssp - Supraspinatus; TMa - Teres major.

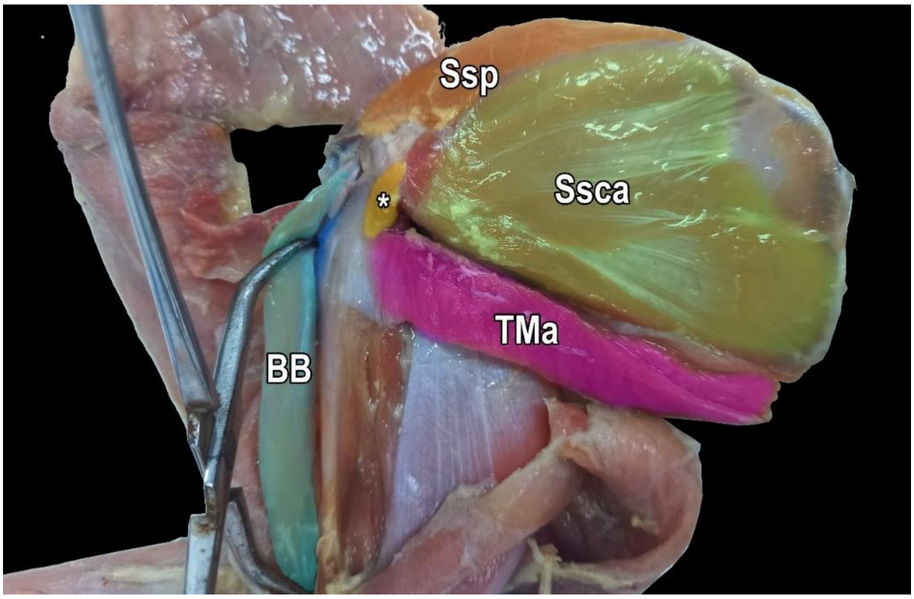

Figure 11- Medial scapula muscles of specimen UFMG 7045 with *m. biceps brachii* (BB) pushed back to show the insertion of mm. articularis humeri (*) and teres major (TMa).

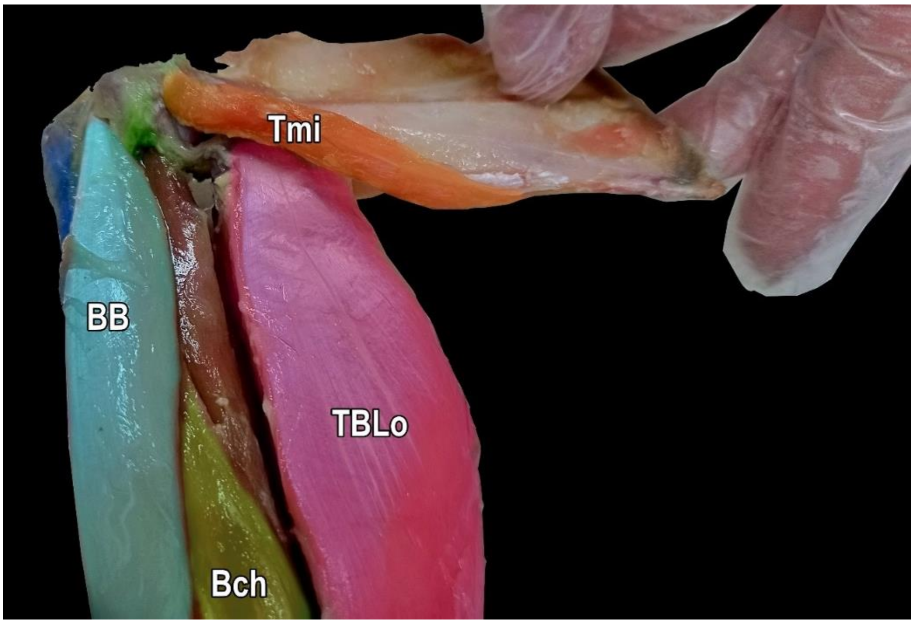

Figure 12- Medial view of proximal part of UFMG 7045' arm showing: BB - Biceps brachii; Bch - Brachialis; TBLo - Triceps brachii caput longum; Tmi - Teres minor.

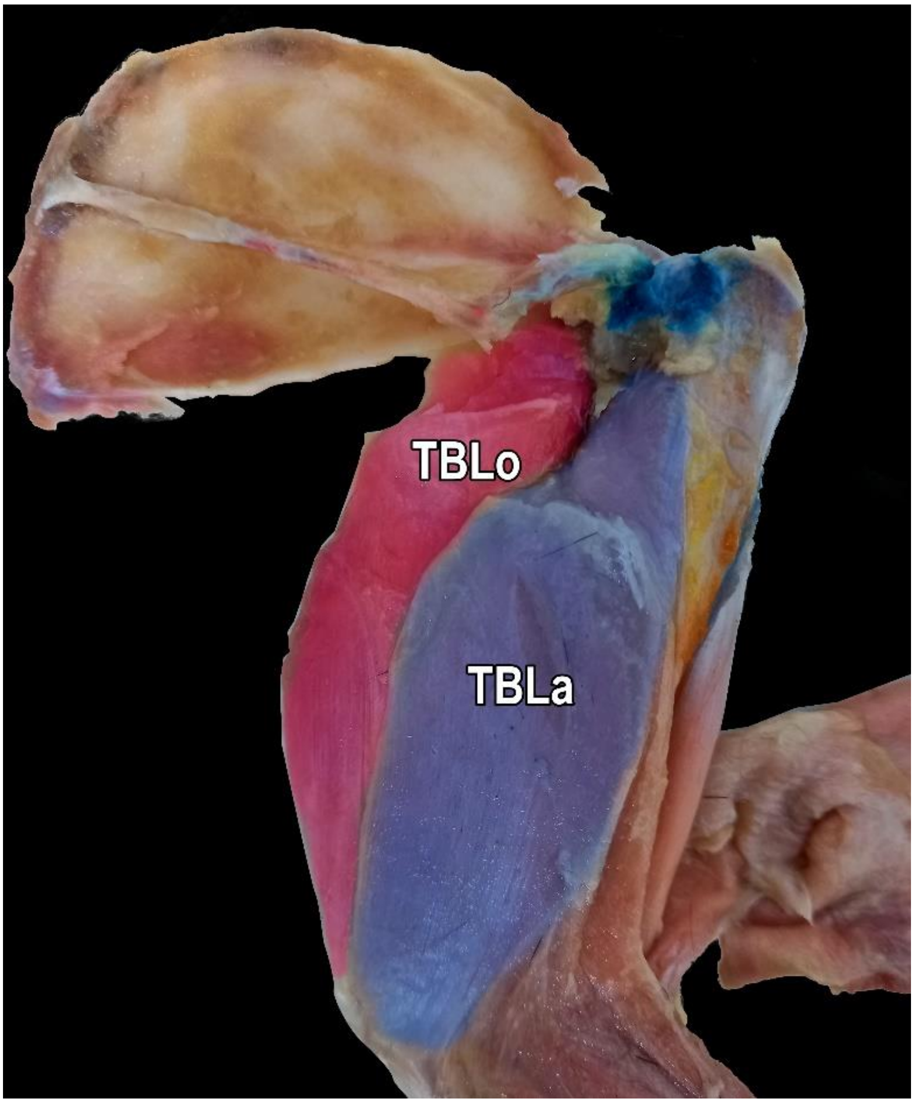

Figure 13 - Lateral aspect of UFMG 7045 arm showing: TBLa - Triceps brachii caput laterale; TBLo - Triceps brachii caput longum.

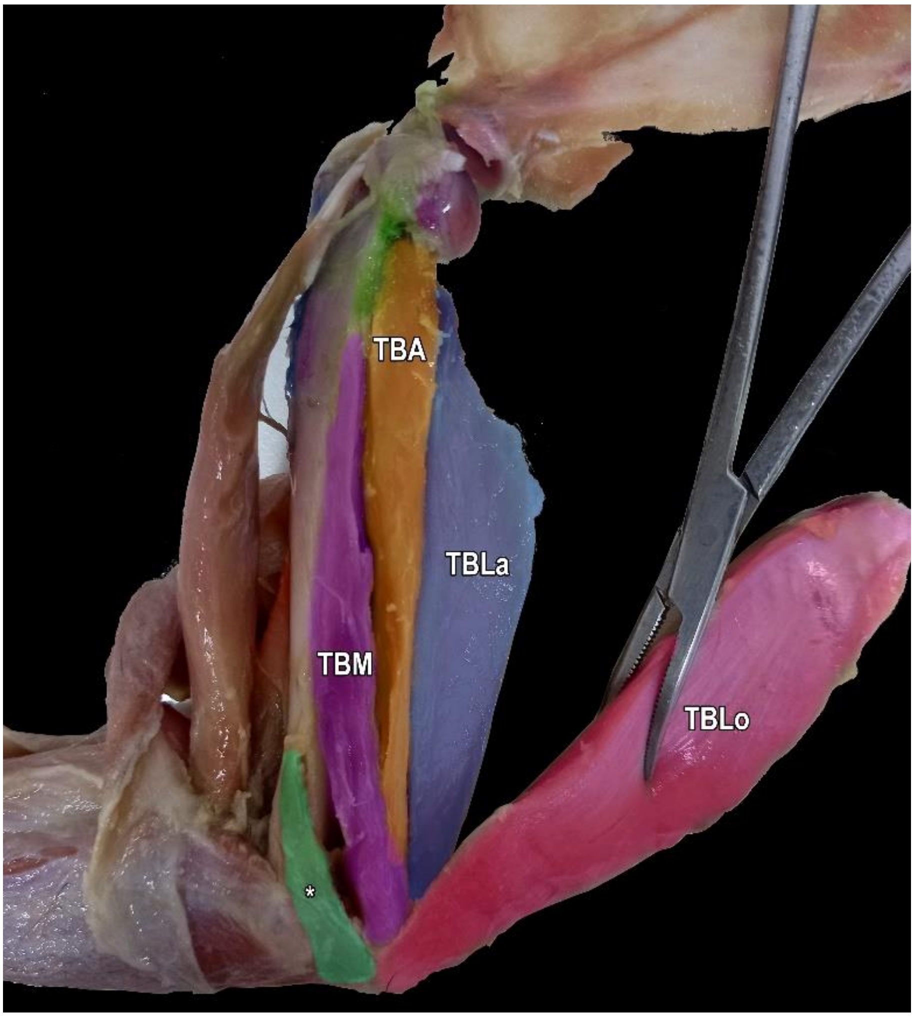

Figure 14- Caudo-medial view of UFMG 7045 arm. Triceps brachii. TBA - Triceps brachii caput accessorum; TBLa - Triceps brachii caput laterale; TBLo - Triceps brachii caput longum; TBM - Triceps brachii caput mediale; * Triceps brachii caput mediale accessorum.

1.1.2. Cranial aspect of antebrachium

The ***m. extensor digitorum communis*** originates from the *crista supracondylaris laterales* (supracondylar ridge of humerus), proximally to the lateral epicondyle and up to the origin of the *m. extensor digitorum lateralis*. It is proximally fused with the *m. extensor carpi radialis brevis* by a fleshy attachment in the right limb and with the *m.extensor digitorum lateralis* in the left forelimb. *M. extensor digitorum communis* could be separated into four bundle at its distal portion, each one extends by fibrous and slender tendons that cross the metacarpal retinaculum that serve the proximal phalanges of the digits II to V. The UFMG 7046 had five tendons, the tendons III and IV serves the digit

IV, while the tendons I, II and V serves the digits II, III and V, respectively. The tendon I encounter the tendon of *m. extensor digit I et II* at proximal-middle phalanx joint and the tendons II, III and V encounter the tendons of *m. extensor carpi lateralis* in their respective digits. In the UFMG 7045 the *m. extensor digitorum communis* had four tendons that inserts onto extensor expansion of digits II-V.

M. extensor digitorum lateralis originates via tendon from the *crista supracondylaris lateralis* of humerus, just down to the insertion of *m. extensor digitorum communis*. It crosses the *extensor retinaculum* and split into three tendons that inserts onto proximal phalanx III, IV and V. In left limb of UFMG 7045 it had two caputs, the medial with two tendons, that serves the digits III and IV, and the caput lateral with the tendon that serve digit V.

The **m. *extensor carpi ulnaris*** originates from a small flat area of *epicondylus lateralis* of humerus and via flesh fibers from the surface of *m. anconeus*. It is possible to distinguish six bundles that originates and inserts together. This muscle inserts via a flat tendon onto *basis* of the metacarpal V.

The ***m. supinator*** of jaguarundi originates from the *epicondylys lateralis*, via a long tendon that cross the elbow joint capsule. The belly arises between the bicipal tuberosity and the neck of the radius and lies down through the first half portion of the shaft of the radius where it inserts, via fleshy fibers.

M. pronator teres originates from the *tuberculum epidcondylus medialis*, via fleshy. It lies down throughout the radius and inserts, via tendinous fibers, onto distal half of *corpus radii margo medialis* and onto caudal aspect of incisura ulnaris.

M. abductor digiti I longus originates from the depression next to the interosseous crest of ulna and lies down through the radius shaft. This muscle inserts via a robust tendon onto lateral aspect of metacarpal I.

M. extensor digit I et II originates from the lateral border of the proximal portion of ulna. It is fused with *m. flexor digitorum profundus capute humerale laterale* ventral-laterally in the second third of antibrachium. This muscle is very slim, and its tendon is large than its belly in the second third of length of this muscle. The tendon bisects in two in the *carpus*, the medial tendon goes to the first metacarpal, and the lateral tendon inserts onto a slender membrane up to metacarpal 2.

M. extensor carpi radialis longus originates, via fleshy fibers, from a flat area on the lateral epicondyle of the humerus. It is fused with *m. extensor carpi radialis brevis* proximally to its origin attachment. Its tendon pass over the belly of the *m. extensor carpi radialis brevis* lies down the *carpus* and inserts laterally onto metacarpal II.

The ***m. extensor carpi radialis brevis*** originates from the border of radial fossa of humerus, at a small ridge next to the epicondyle ridge. The tendon of the *m. extensor carpi radialis longus* passes over its belly, at distal portion. The *M. extensor carpi radialis brevis* inserts onto the proximal aspect of the metacarpal III. In UFMG 7046 the tendon of this muscle also sends some fibers to the tendon of *m. extensor carpi radialis longus* in the cranial portion of the *carpus*.

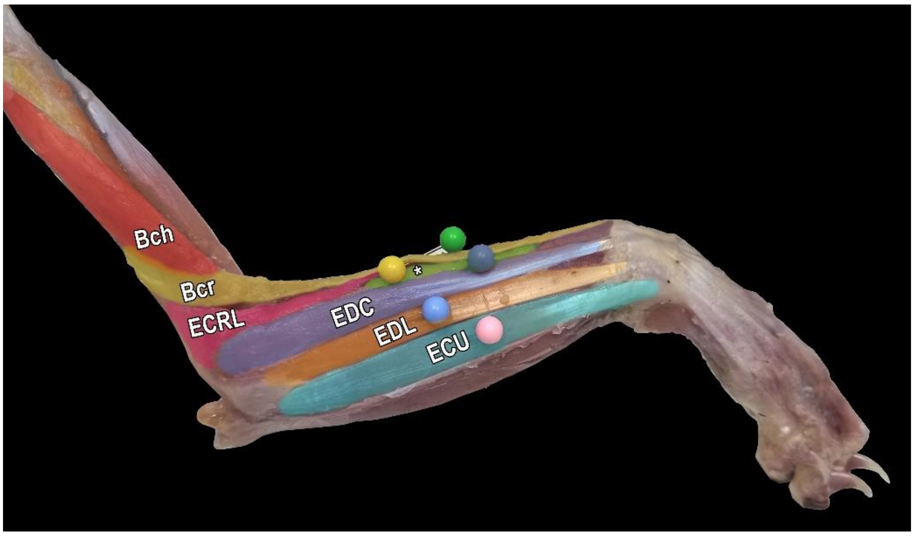

Figure 15 – Lateral view of antebrachum of UFMG 7045. Bch - Brachialis; Bcr - Brachioradialis; ECRL - Extensor carpi radialis longus; ECU - Extensor carpi ulnaris; EDC - Extensor digitorum communis; EDL - Extensor digitorum lateralis.

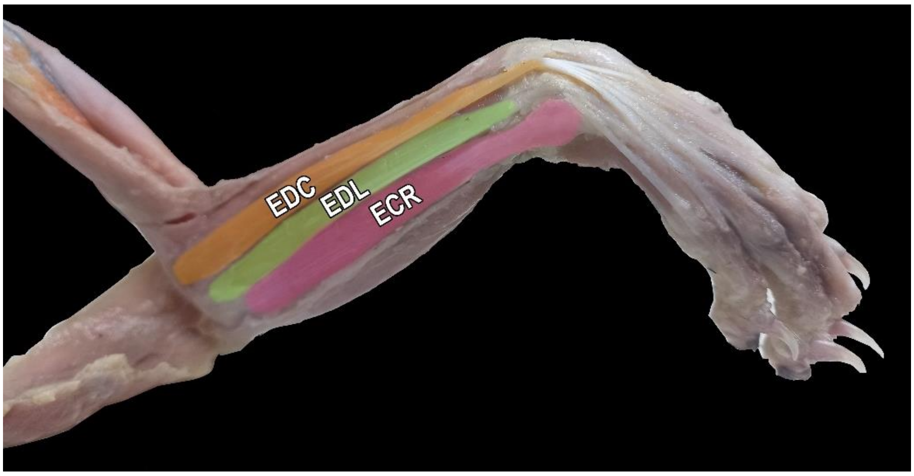

Figure 16- Lateral view of antebrachium of UFMG 7045. EDC - Extensor digitorum communis; EDL - Extensor digitorum lateralis; ECR - Extensor carpi radialis.

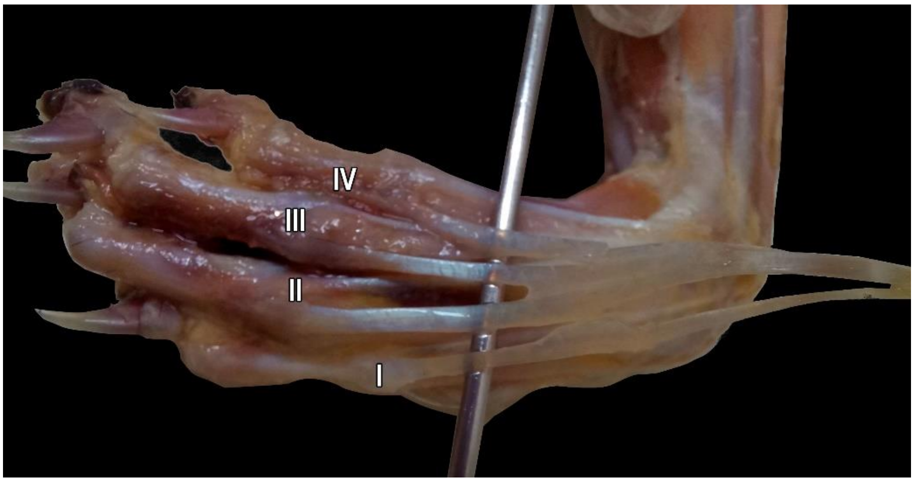

Figure 17- Cranial aspect of m. exensor digitorum communis insertion (specimen UFMG 7045).

Figure 18- Lateral view of m. extensor digitorum lateralis (EDL)(specimen UFMG 7045).

Figure 19- Lateral view of EDI-II - Extensor digiti I et II (UFMG 7045)

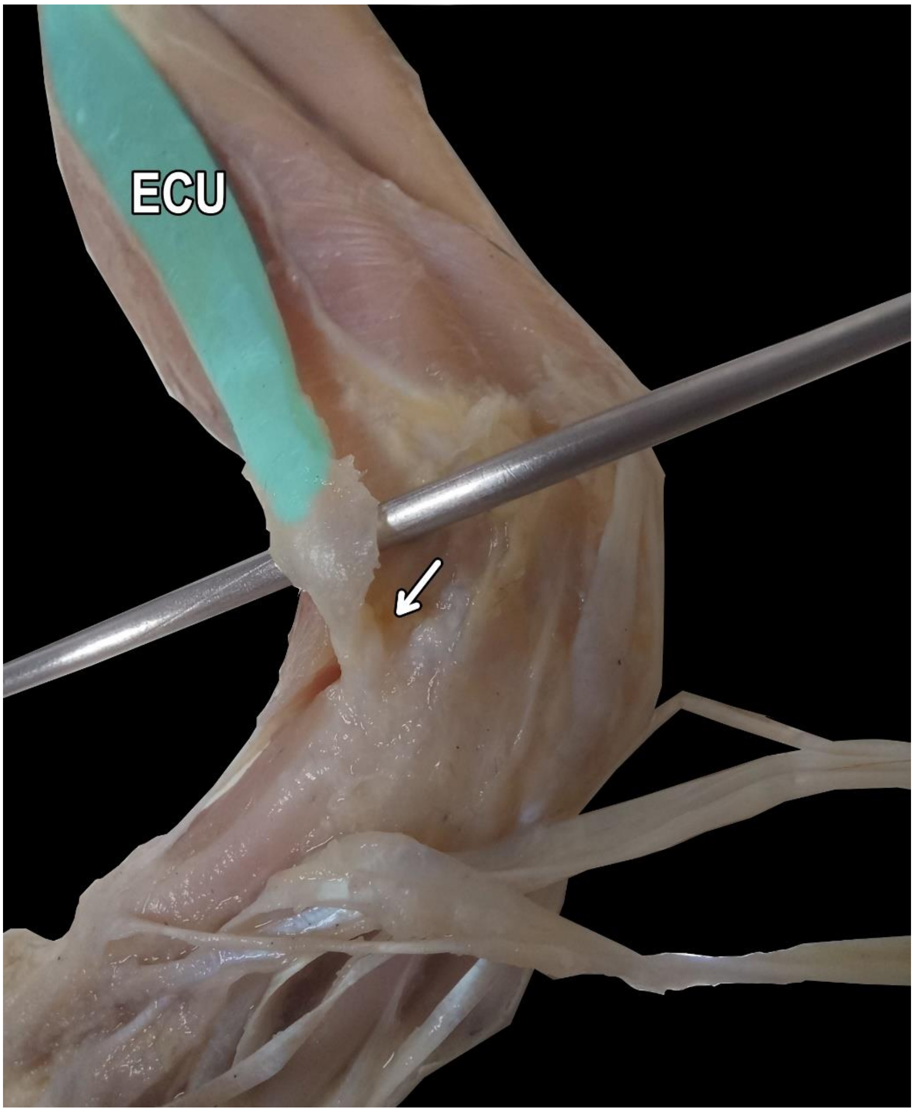

Figure 20- Cranio-lateral aspecto of ECU - Extensor carpi ulnaris. Arrow signs the insertion by a tendon (specimen UFMG 7045).

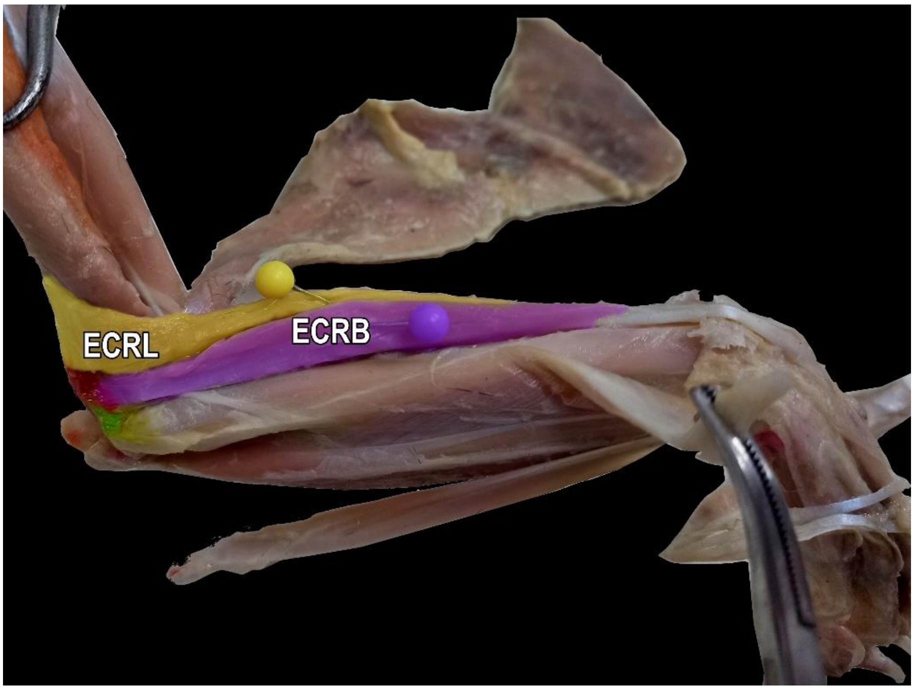

Figure 21- Lateral view of UFMG 7045' forearm. ECRB - Extensor carpi radialis brevis; ECRL - Extensor carpi radialis longus.

Figure 22- Dorsal aspect of UFMG 7045 manus showing the insertion (arrow) of ECRB - Extensor carpi radialis brevis and ECRL - Extensor carpi radialis longus.

1.1.3. Caudal aspect of antebrachium

The ***m. flexor carpi ulnaris*** is divided in two heads, the *caput ulnare* and *caput humerale*. The ***caput ulnare*** originates from *corpus ulnae facies lateralis* and the ***caput humerale*** originates from the *epicondylus lateralis* of humerus. The two caputs come together and inserts onto the posterior border of pisiform bone (*os pisiforme*), deep to *m. flexor retinaculum*, via fleshy fibers.

The ***m. abductor digit V*** originates, via fleshy, from cranial aspect of the *os pisiforme* and the medial aspect of base of V metacarpal. It lies down to the digit V via slender and long tendon that inserts laterally onto the proximal phalanx V.

The ***m. palmaris longus*** originates from the *epicondylus lateralis* of the humerus. This muscle inserts via tendon onto the digits I-V and partially to the retinaculum of the carpus. The tendon that serves the digit I is the shortest and is the first to divide from the common tendon, it inserts medially onto the proximal phalanx I. The tendons II-V inserts onto *lig.metacarpeum transversum* II to V.

The ***m. flexor digitorum brevis manus*** originates, via fleshy, from the belly of *m. palmaris longus,* next to the carpus. This muscle has only one caput that diverges in three tendons. The tendon lateral serves the digit V and inserts onto the proximal phalanx V, while the other tendons insert onto digit IV, juxtaposed.

The ***m. flexor carpi radialis*** originates from *tuberculum epicondylus medialis*, next to the origin of *m. flexor digitorum profundus caput humerale mediale*. It crosses the *m. flexor retinaculum* and inserts, via tendon onto palmar aspect of metacarpal II.

M. flexor digitorum superficialis originates from the tendon communis of the *m. flexor digitorum profundus*, via fleshy. It has two bellies onto righ limb of UFMG 7045 and one in the left limb of this specimen and in both limbs of UFMG 7046. It inserts onto *annular ligamentum* of digits II, III and IV, via tendon.

The ***m. flexor digitorum profundus*** is divided in five caputs: caput humerale mediale, humerale laterale, humerale profundus, ulnare and caput radiale et ulnare. The *caput humerale mediale* originates from the medial epicondyle, right down to the origin of *m. flexor carpi ulnaris caput humerale*. It is fused with *m. flexor carpi radialis* next to its origin. The *caput humerale laterale* also originates from the medial epicondyle of humerus, laterally to the origin of *caput humerale mediale*. The *caput humerale profundus* originates from the medial epicondyle of humerus, right down to the origin of *capita humerale mediale*. The caputs humerale mediale, humerale laterale and humerale profundus are fused proximally. The *caput ulnare* originates from the proximal half of the ulna, this insertion range from the border of ulna to the shaft of it, next to the interosseous crest of radius. The *caput radiale et ulnare* originates from the interosseous crest of radius and of the ulna. All caputs converge to a robust tendon, the tendon communis, that divides into five tendons, each one inserts onto cranial aspect of phalanx distalis I-V.

The ***m. pronator quadratus*** originates, via fleshy fibers, from the half distal part of *corpus ulna facies medialis*, the *margo interosseus* and the *corpus radii facies caudalis*. It lies down throughout the radius and inserts also via fleshy onto palmar aspect of carpus.

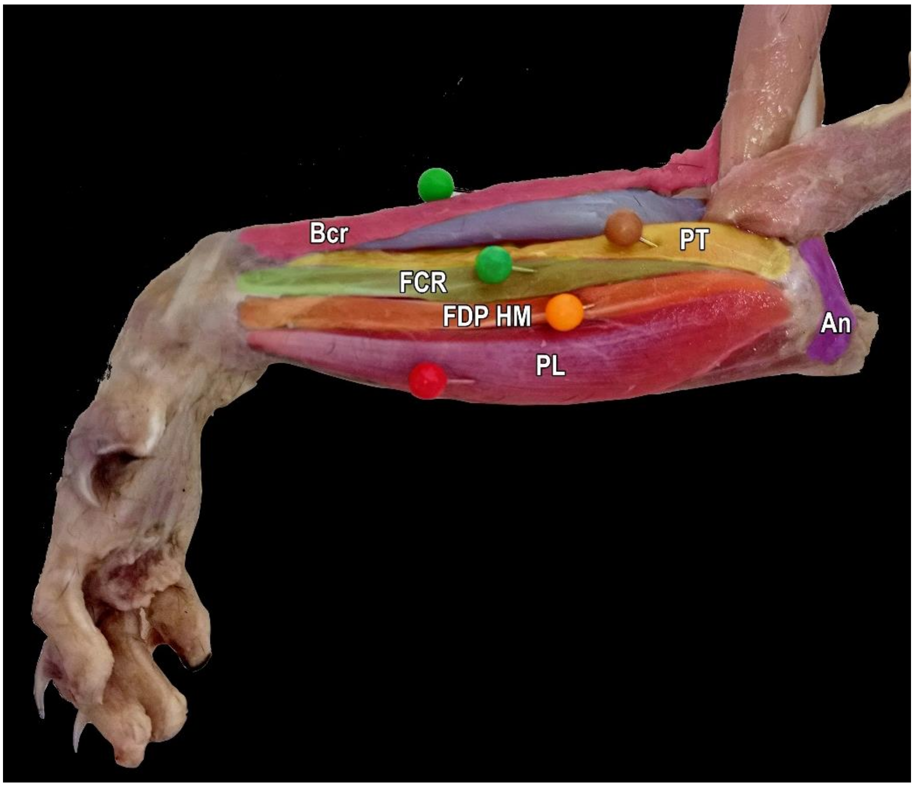

Figure 23 - Medial view of UFMG 7045' antebrachium. An - Anconeus; Bcr - Brachioradialis; FCR - Flexor carpi radialis; FDP HM - Flexor digitorum profundus caput humerale mediale; PL - Palmaris lonus; PT - Ponator teres.

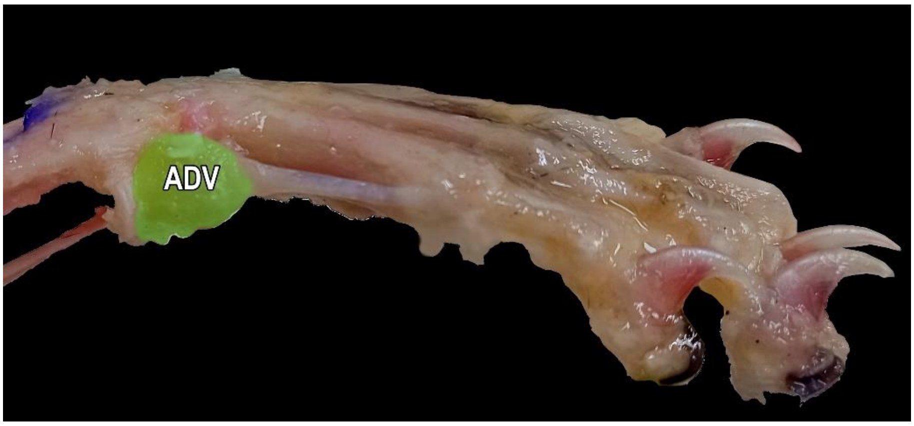

Figure 24 – Lateral aspect of UFMG 7045'manus showing the ADV - Abductor digit V in green.

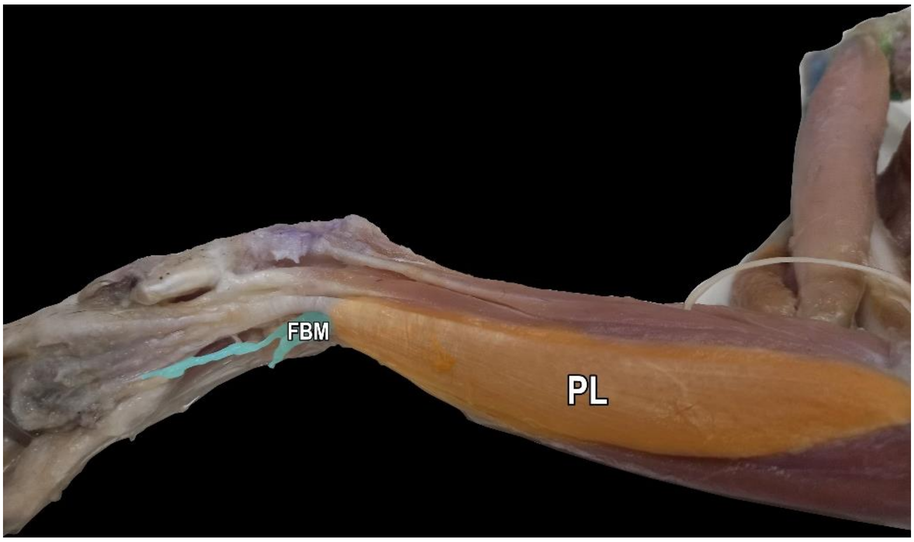

Figure 25 – Ventral aspecto f UFMG 7045' forearm. PL - Palmaris longus; FBM - Flexor brevis manus (Caudal view).

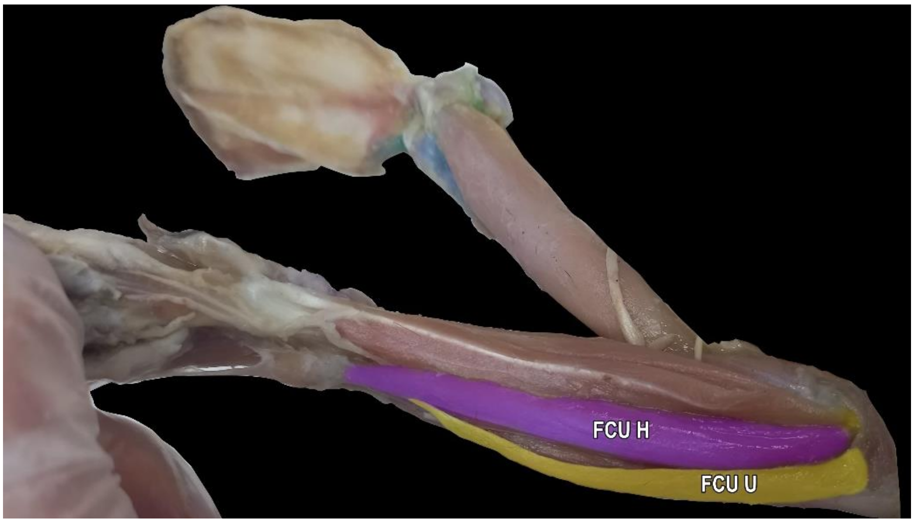

Figure 26 – Ventral aspet of UFMG 7045' forearm. FCH- Flexor carpi ulnare caput humerale (purple); FCU - Flexor carpi ulnare caput ulnare (yellow).

Figure 27 – Caudal aspect of UFMG 7045' antebrachium showing the FCR - Flexor carpi radialis (cian).

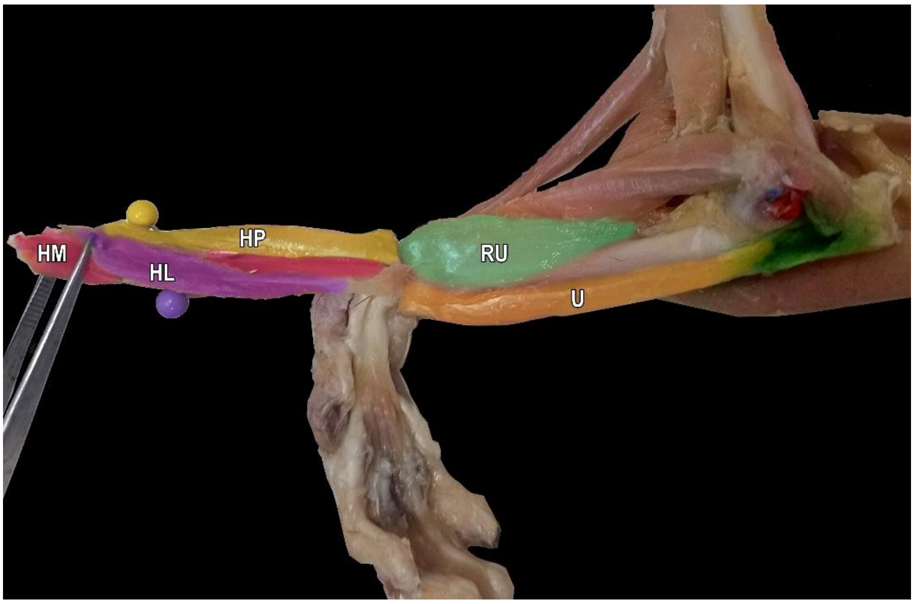

Figure 28 – Caudo-lateral aspect of UFMG 7045' antebrachium showing the m. flexor digitorum profundus. HL - caput humerale laterale; HM - caput humerale mediale; HP - caput humerale profundus; RU - caput radiale et ulnare; U - caput ulnare (Lateral view).

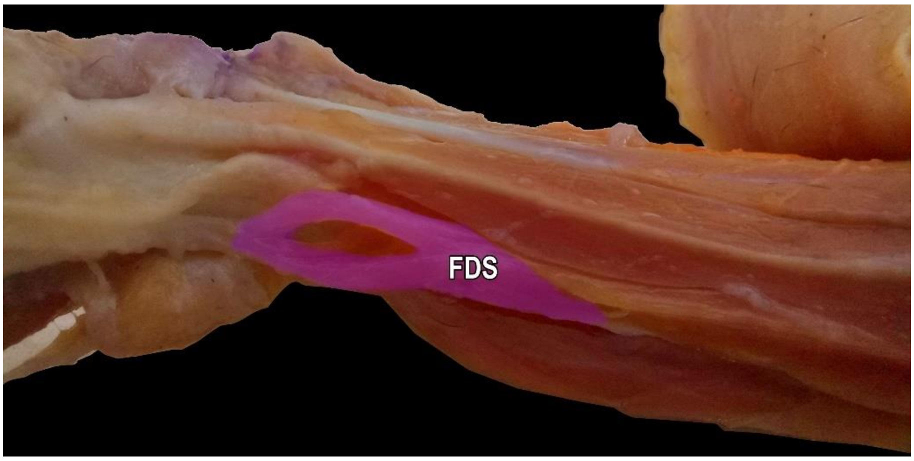

Figure 29 – Caudal aspect of antebrachium of UFMG 7045 showing the two bellies of m.flexor digitorum superficialis (FDS).

Figure 30 – Caudal aspect of UFMG 7045' antebrachium showing the m. pronator quadratus (PQ – light yellow).

1.1.4. Manus

The ***m. lumbricalis*** is a multipennate muscle originates from the surface of common tendon of the *m. flexor digitorum profundus* and composed of five bellies that lies down between the digitorum tendons of *m. flexor digitorum profundus*. This muscle inserts via mixed fibers onto proximal phalanx II-V.

The ***addutores digitorum*** is a group composed of three muscles: the *adductor digit I, adductor digit II* and *adductor digit V*. This complex originates from the ventral aspect of carpus. The *m. adductor digit I* has a triangle shape and serve the digit I, inserts onto the medial aspect of proximal phalanx I. The *mm. adductor digit II* and *adductor digit V* inserts onto the medial aspect of proximal phalanxs II and V, respectively. These two last muscles are fused proximally and the *m. adductor digit V* also received some fleshy fibers from the *m. flexores breves profundi V*.

The ***mm. flexores breves profundi*** in jaguarundi is composed of four muscles that serves the digits II to V. These muscles have two bellies each one and originates from the ventral and lateral aspect of the metacarpals II-V. The medial belly of *m. flexor breve profundi V* send some fleshy fibers to *m. adductor digit V*. The *mm. flexores breves profundi* lies down through the metacarpus and inserts onto dorsal aspect of distal phalanx of digits II-V.

Figure 31- Caudal aspect of UFMG 7045'manus showing the m.lumbricales (Lum/cyan color).

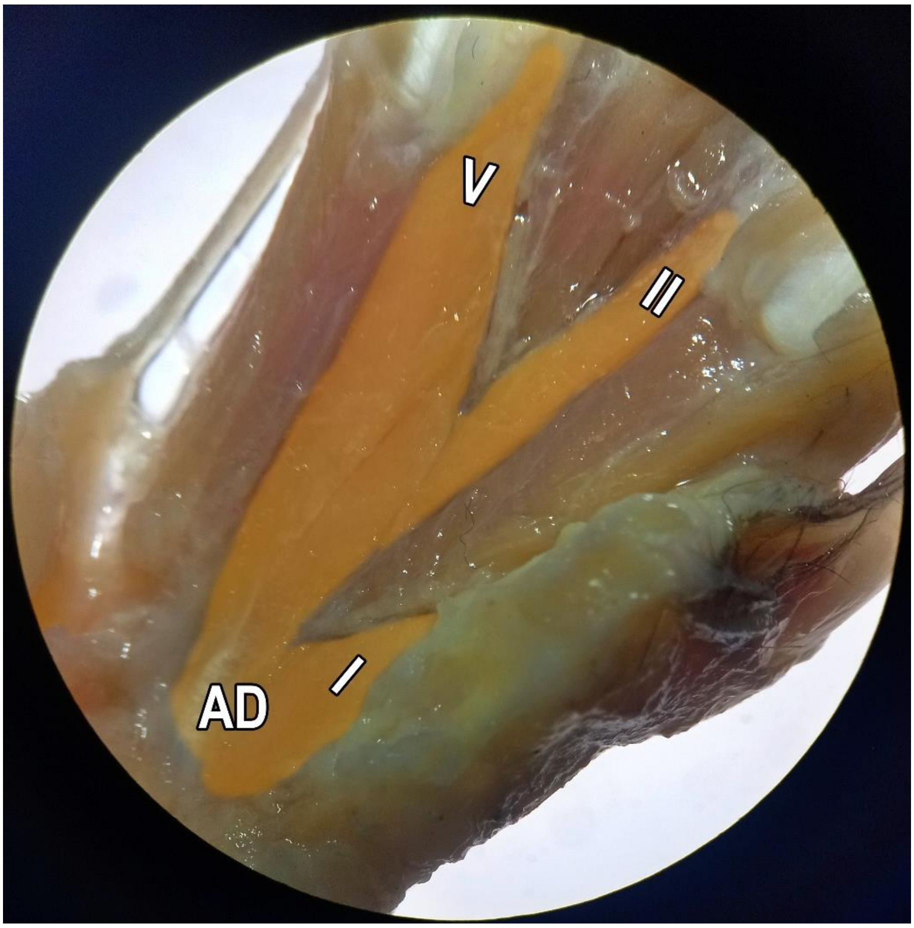

Figure 32 – Caudal view of UFMG 7045' manus showing the mm. adductores digitorum (AD I, II and V).

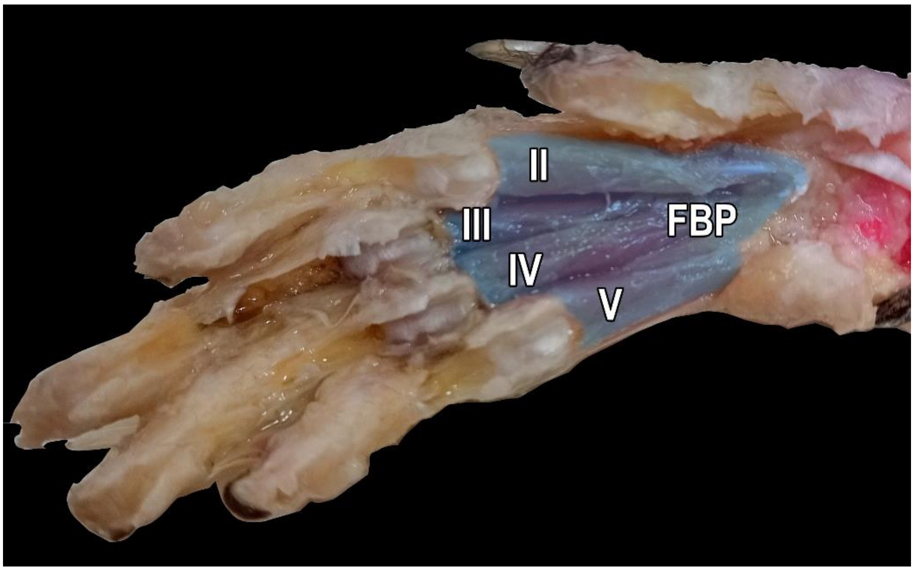

Figure 33 - Caudal view of UFMG 7045' manus showing the mm.flexores breves profundi (FBP).

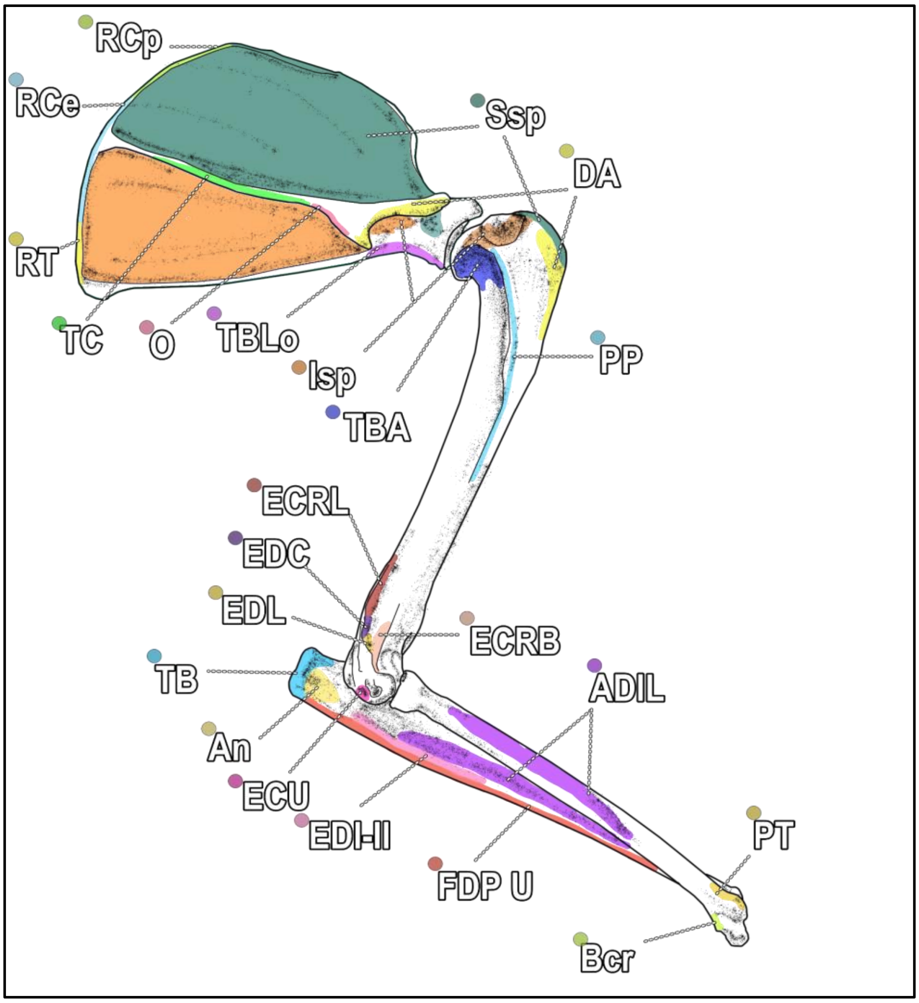

Figure 34- Lateral view of forelimb muscle attachments. ADIL – Adductor digiti I longus; An – Anconeus; Bcr – Brachioradialis; DA – Deltoideus pars acromialis; ECRB – Extensor carpi radialis brevis; ECRL – Extensor carpi radialis longus; ECU – Extensor carpi ulnaris; EDI-II – Extensor digiti I et II; EDC – Extensor digitorum communis; EDL – Extensor digitorum laterales; FDP U – Flexor digitorum profundus caput ulnare; Isp – Infraspinatus; O – Omotransversarius; PP – Pectoralis profundus PT – Pronator teres; RCe – Rhomboideus cervicis; RCp – Rhomboideus capitis; RT – Rhomboideus thoracis; Ssp – Supraspinatus; TB – Triceps brachii; TBA – Triceps brachii caput accessorum; TBLo – Triceps brachii caput longum.

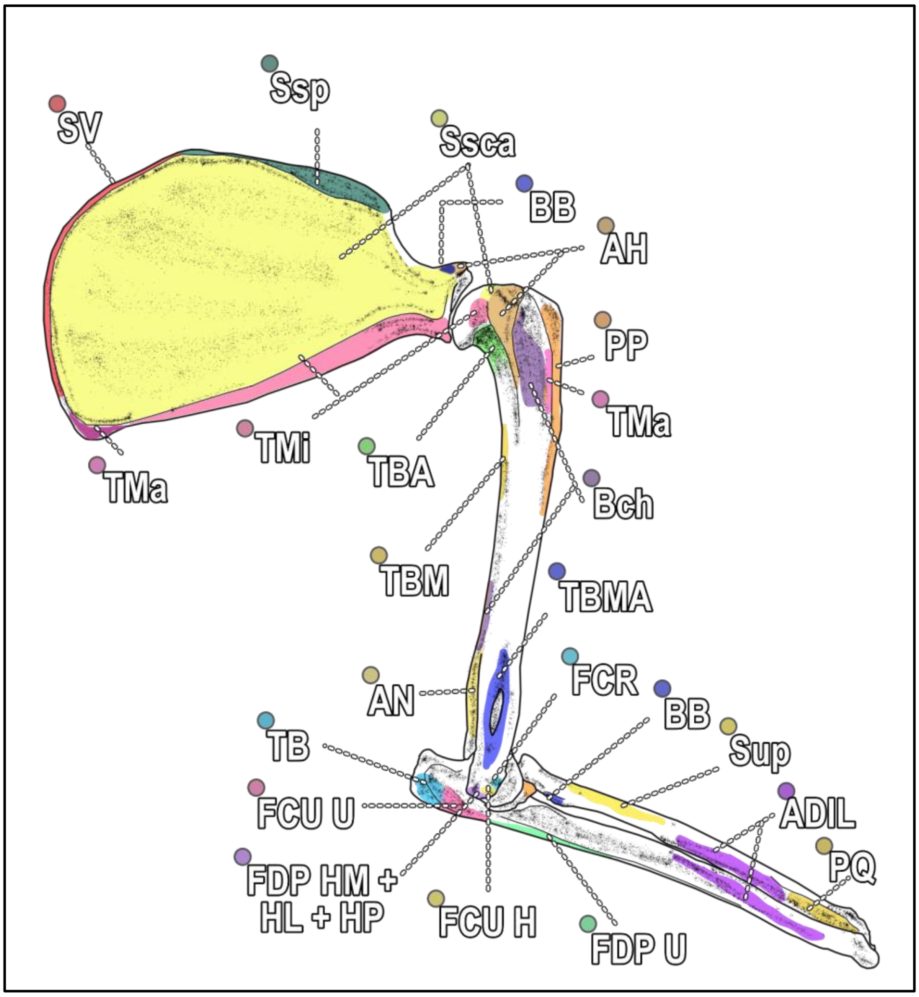

Figure 35 - Medial view of forelimb muscle attachments. ADIL - M. aductor digiti I longus; AH - M. articularis humeri; An - M. anconeus; BB - M. biceps brachii; Bch - M. brachialis; Bcr - M. brachioradialis; DA - M. deltoideus pars acromialis; DS - M. deltoideus pars scapularis; ; FCR - M. flexor carpi radialis; FCU H - M. flexor carpi ulnaris caput humerale; FCU U - M. flexor carpi ulnaris caput ulnare; FDP HM - M. flexor digitorum profundus caput humerale mediale; FPD HL - M. flexor digitorum profundus caput humerale laterale; FDP HP - M. flexor digitorum profundus caput humerale profundus; FDP U - M. flexor digitorum profundus caput ulnare; FDP RU - M. flexor digitorum profundus caput radiale et ulnare; PP – M. pectoralis profundus;; PQ - M. pronator quadratus; Ssca - M. subscapularis; Ssp - M. supraspinatus; SV - M. serratus ventralis; TBA - M. triceps brachii caput accessorium; TBLa - M. triceps brachii caput laterale TBLo - M. triceps brachii caput longum;; TBM - M. triceps brachii caput mediale; TBMA - M. triceps brachii caput mediale accessorium; TMa - M. teres major; TMi - M. teres minor;

2. DESCRIPTION OF THE FORELIMB MUSCULATURE OF *PUMA CONCOLOR* (FELIDAE, CARNIVORA)

2.1.1. Extrinsic muscles of shoulder

M. trapezius

The trapezius is composed by *pars cervicalis* and *pars thoracis*. The *pars cervicalis* originates from median fibrous raphe of vertebras C7-T9, via aponeurosis while the *pars thoracis* originates from spinous process of T5-10 and from surface of *m. latissimus dorsi*. Both *trapezius* inserts onto scapula partially fused, while the *pars cervicalis* inserts onto almost entire length *spina scapulae*, via fleshy fibers, the *pars thoracis* attach by a short aponeurosis that inserts only at caudal portion of *spina scapulae*. The *pars cervicalis* also has a fusion point with *m.* cleidocephalicus. So, *m. trapezius* stabilizes the scapula, move it dorsad and caudad.

The **rhomboideus** are three band-shape muscles. In puma, these muscles are fused next to the scapula, so they cannot be removed individually. The *m. rhomboideus capitis* is the longest and its origin range from superior nuchal line, at level of vertebrae C1-C3. The *m. rhomboideus cervicis* originates immediately after to *m. rhomboideus capitis*, from the *lig. nuchae* at level of C3-T4, and *rhomboideus thoracis* originates sequentially from the supraspinous ligament at level of T4. The origin of all *mm. rhomboideus* is via fleshy fibers and they inserts together onto *margo caudalis* also via fleshy fibers.

The ***omotransversarius*** is a band-shape muscle that elevates the scapula anteriorly. This muscle had differences in the two specimens: in the LEM 003 it originates from transverse process of atlas, via mixed fibers, lies down from the neck and inserts via aponeurosis, onto proximal aspect of spina scapulae, the border of acromion and onto surface of *m. triceps brachii caput laterale*. Otherwise in the specimen LOM 952 this muscle originates via fleshy fibers from transverse process of atlas and inserts onto *acromion* and the surface of *m. infraspinatus*, also via fleshy fibers.

The ***m. serratus ventralis*** is multipennate and triangle-shaped muscle, that traditionally is divisible in one part that serve the neck (*par cervicalis*) and one part that serve the thorax (*pars thoracica*). In puma this muscle has 14 fascicles, 7 fascicles by each part. This muscle originates from *facies serrata* of scapula, via fleshy fibers and it insertion ranges from the transverse process of vertebrae C3-T2 and the lateral aspect of ribs 1-8, via fleshy fibers. The m. *serratus ventralis* is partially fused with *m. rhomboideus capitis* next to scapula, helps to supports trunk and move the ribs craniad and caudally, supporting breathing.

The ***m. pectoralis superficialis*** originates from the *manubrium* to half portion of 3th *sternebrae*, via fleshy fibers. This muscle in puma has two bellies overlapped: the first insert onto pectoral ridge of humerus (a tuberosity of *corpus humeri facies cranialis* next to *tuberositas deltoidea*) and the second onto *tuberculum supraglenoidale*, via *apponeurosis* with the *m. pectoralis profundus*. In the specimen LOM 952 the second belly is shorter and range predominantly onto *tuberculum major*, via mixed fibers, but it has a slim aponeurosis that cove the *tuberculum supraglenoidale*. It is also fused with *m. supraspinatus* next to the *tuberculum major* and with *m. pectoralis profundus*. The lateral border of *m. pectoralis superficialis* fuses with *m. cleidobrachialis* and it inserts with it onto proximal part of *corpus ulnae margo laterais*, next to *processus coronoideus medialis*, via tendon. The *m. pectoralis superficialis* abducted the forelimb.

The ***pectoralis profundus*** originates from the entire length of *sternum* and bifurcated in two bellies: the cranial and caudal. The caudal belly inserts onto humerus, via tendinous fibers, from the *tuberculum minor* to the proximal half of medial border of *corpus humeri* and the cranial belly inserts onto *tuberculum supragleinodale* with *m. pectoralis superficialis*, via a slim aponeurosis. The caudal belly also fuses with *m. latissimus dorsi* by a small area at lateral border. This muscle help to abducts the forelimb and draw it caudard.

The ***m. latissimus dorsi*** originates from *thoracolumbar fascia*, at level of T11-L4. It is fused with *m. pectoralis profundus* by anterior border and with *m. tensor faciae antibrachii* by dorsal border. It inserts onto *m. teres major*, via tendinous fibers and draws the forelimb.

The **brachiocephalicus** is a slender muscle group composed by *mm. cleidocephalicus*, *cleidobrachiais* and *cleidomastoideus*. The *m. cleidocephalicus* originates from dorsal aspect of vertebrae C1-C6, via a short aponeurosis and part from *basicranium*, via mixed fibers. It lies through the *brachium* and inserts via fleshy fibers onto clavicle and onto surface of *m. cleidobrachialis*. The *m. cleidomastoideus* originates, via fleshy fibers, from the mastoid process. It crosses the neck under *m. omotransversarius* and inserts, also via fleshy fibers, onto entire length of clavicle. The last compound, the *m. cleidobrachialis* originates via fleshy fibers from the surface of *m.*

cleidocephalicus and ventral aspect of clavicle. It is partially fused with *m. pectorals superficialis* by medial border and it could insert onto *antibrachii fascia*, as seen in the LEM 003, or deeply onto proximal part of *corpus ulnae margo lateralis*, via tendon, as seem in the specimen LOM 952.

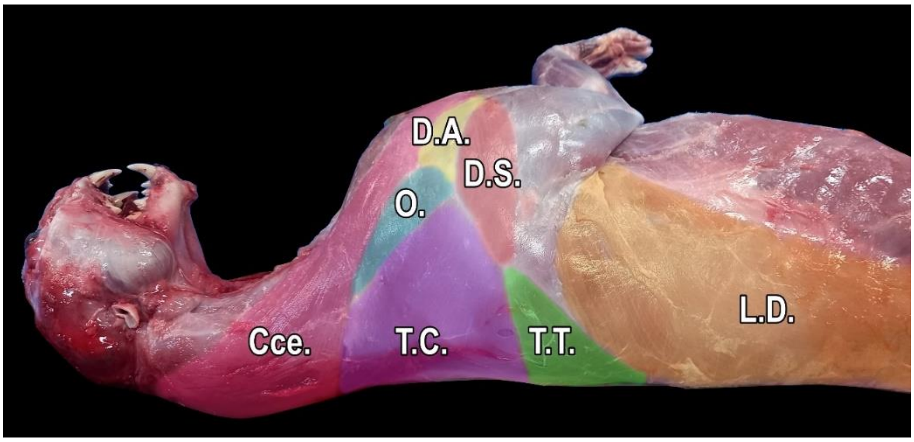

Figure 36 - Dorsad aspect of extrinsic muscles of shoulder (specimen LOM 952). Cce - Cleidocephalicus; DA - Deltoideus pars scapularis; DS - Deltoideus pars scapularis; LD - Latissimus dorsi; O - Omotransversarius; TC - Trapezius pars cervicalis; TT - Trapezius pars thoracis.

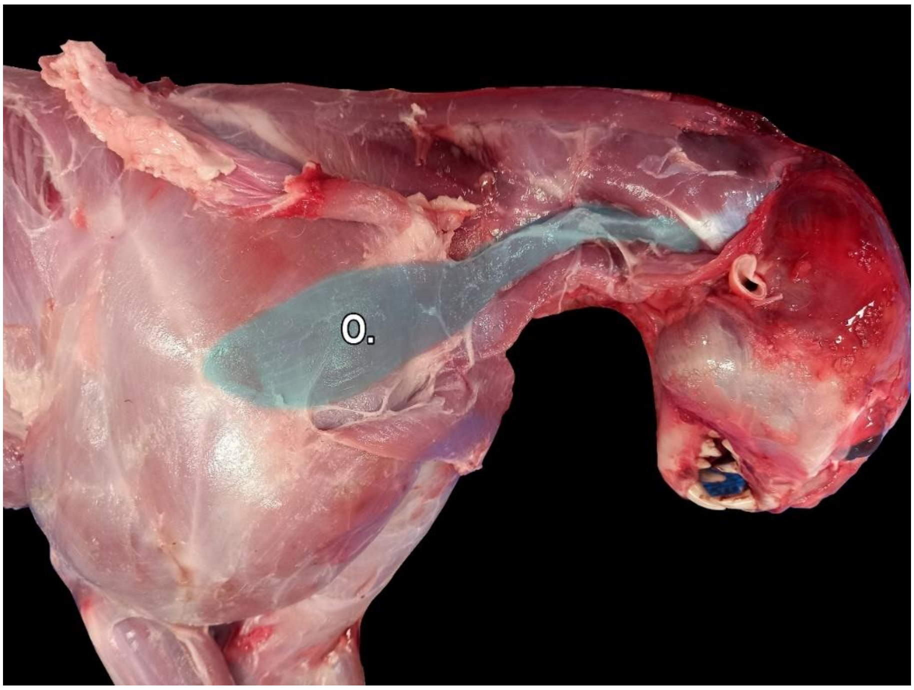

Figure 37 – Entire extension of *m.* omotransversarius (at light blue) *in situ* (specimen LOM 952).

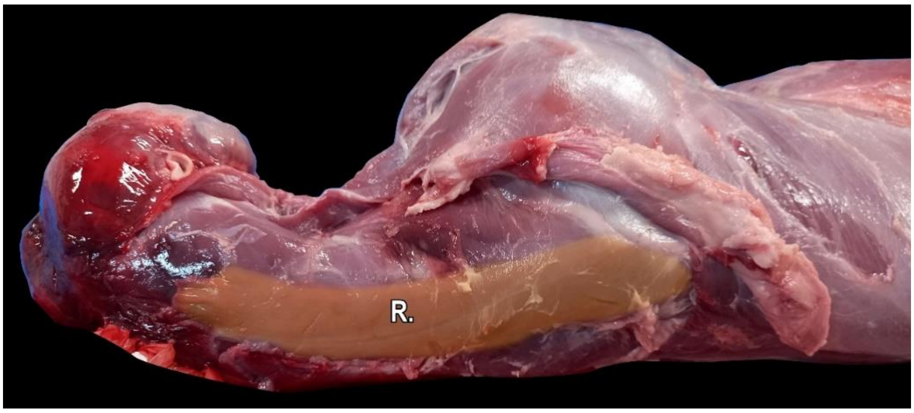

Figure 38- Dorsad aspecto of R – Rhomboideus *in situ* (Specimen LOM 952).

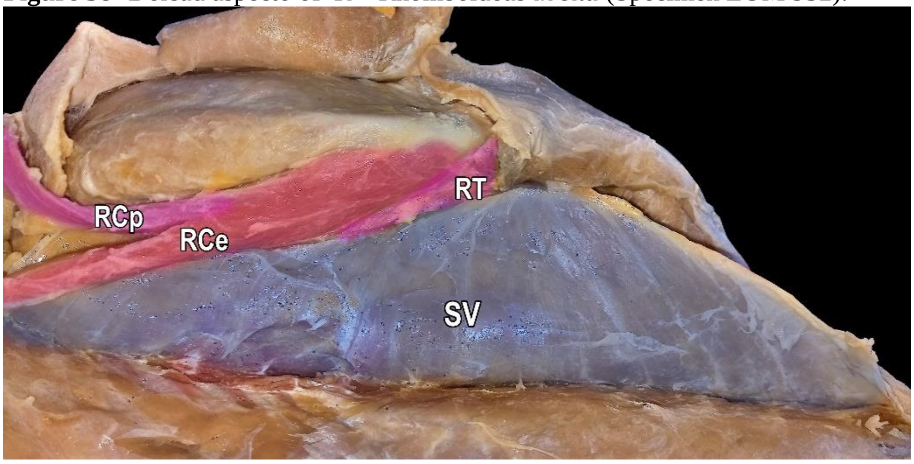

Figure 39 – Dorsal aspect of shoulder muscles of LEM 003. RCe - Rhomboideus cervicis; RCp - Rhomboideus capitis; RT - Rhomboideus thoracis; SV - Serratus ventralis.

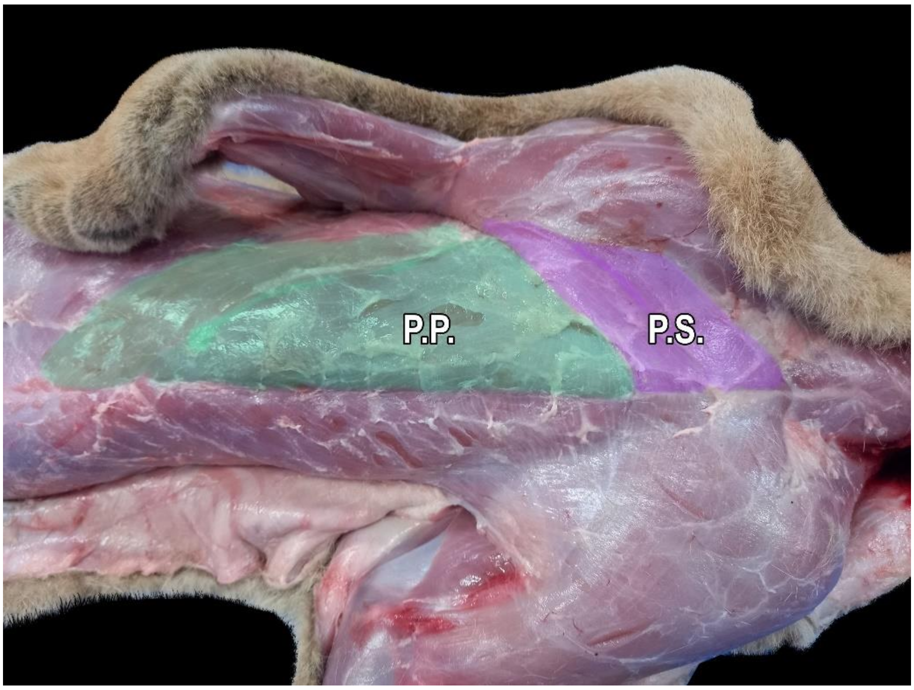

Figure 40 -Ventral aspect of *mm. pectoralis* of LOM 952**.** PS - Pectoralis superficialis; PP - Pectoralis profundus.

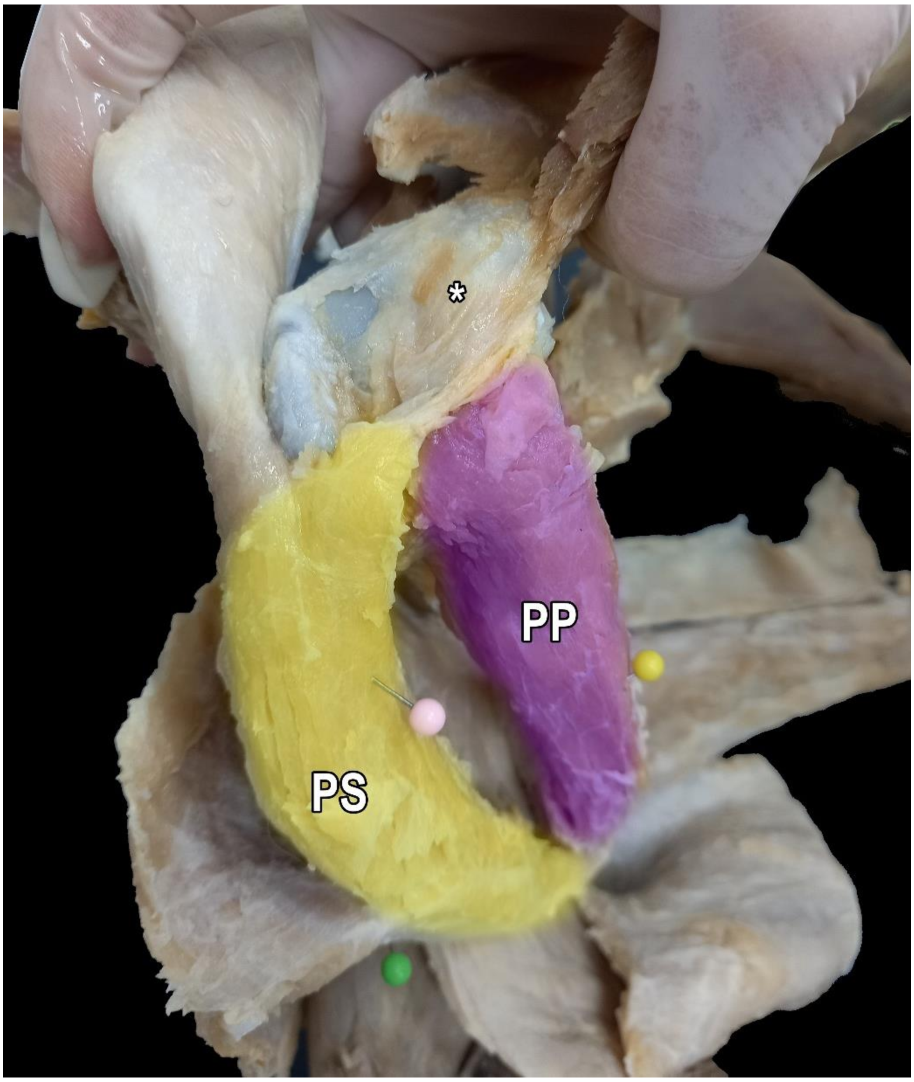

Figure 41 – Cranial aspect of the insertion of *mm. pectoralis* of LEM 003. PP - Pectoralis profundus; PS - Pectoralis superficialis; * Insertion.

2.1.2. Intrinsic Muscles of Shoulder

The *m. deltoideus* is divided two parts: the *pars scapularis* and *pars acromialis.* The *m. deltoideus pars scapularis* originates from medial third aspect of spinous process of scapulae and from surface of *m. infraspinatus,* via mixed fibers. The *m. deltoideus pars acromialis* originates from entire length of acromion, also via mixed fibers and fuses with *m. deltoideus pars scapularis* by lateral border. The both parts of deltoideus inserts together onto cranial aspect of dorsal portion of *corpus of humerus*, by fleshy fibers and also inserts by a slim aponeurosis onto *m. triceps brachii caput laterale*. In the specimen

LEM 003 this aponeurosis also covers the *pars scapulais.* The *m. deltoideus* flexes the glenohumeral joint.

The ***m. supraspinatus*** from entire length of *fossa supraspinata*, via fleshy fibers and part of surface of *m. subscapularis*. It inserts onto cranial aspect of *tuberculum majus*, via mixed fibers and fuses partially with *m. pectoralis superficialis*. The *m. supraspinatus* extends the shoulder.

The **m. infraspinatus** originates from entire *fossa infraspinata*, via fleshy fibers, pass over to lateral aspect of shoulder and inserts, via tendon, onto a small, rounded area at *tuberculum majus*.

The ***m. teres minor*** occupies the proximal third of dorsal aspect of *margo caudalis* of scapula. It originates by fleshy fibers from the surface of *m. infraspinatus* and cover the proximal aspect of the insertion of *m. triceps brachii caput logum.* The insertion is also fibrous and located onto lateral aspect of *corpus humeri*, immediately below *m. infraspinatus*' insertion. The *m. teres minor* usually helps to flex the shoulder, but when the muscle was submitted by mechanical traction no movement was seen, so ino this case, it might help to stabilize the scapula.

The ***m. teres major*** lies throughout the caudal border of scapula, its origin occurs by fleshy fibers and ranges from *angulus caudalis*, caudal border of *mm. subscapularis* and *infraspinatus*. It covers the caudal aspect of *mm. teres minor* and *triceps brachii caput longum* and the middle of its belly receives the *m. latissimus dorsi*, via tendinous fibers. It inserts onto *crista tuberculi minoris*, via a flat tendo and is responsible for flexes the shoulder.

The ***subscapularis*** is a multipennate muscle composed of 9 bellies in the right limb. It originates, via fleshy fibers, from fossa subscapularis and the anterior border (*margo cranialis*) of scapulae and inserts onto tuberculum minus of humerus, via tendinous fibers This muscle is fused with *m. supraspinatus* and with *m. teres major* and helps to stabilize the scapula.

The ***m. triceps brachii*** in puma is composed of five caputs: *caput longum. caput laterale, caput mediale, caput accessorium* and *caput mediale accessorium.* The *caput longum* originates from the proximal two thirds of *margo caudalis* of scapula and from the medial aspect of collum scapulae, via tendinous fibers.The *caput laterale* originates from lateral aspect of *collum humeri*, via fleshy fibers. The *caput mediale* and *caput accessorium* are partially fused and both originates via fleshy fibers, so *caput mediale* from *crista tuberculi minoris*, while the *caput accessorium* originates from caudal aspect of *collum humeri*. The *caput mediale accessorium,* also called by *m. epitrochleuanconeus*, and *m. anconeus mediales* is a triangle-shape caput originates, via fleshy, from a ridge that surrounding the *foramen supracondylar,* and part from *epicondylus medialis*. All caputs converge and inserts together onto *olecranon process*, via tendinous fibers. The *m. triceps brachii* is the most important muscle responsible for extends the elbow joint.

The ***m. anconeus*** is a triangle-shape muscle situated at caudal aspect of humerus. Its origin is fibrous type and ranges from the distal third of humerus *facies caudalis* to *facies lateralis*. The insertion is also fibrous onto lateral aspect of olecranon. The *m. anconeus* extends and stabilizes the elbow joint.

The ***m. tensor fascia antebrachii*** is a slim muscle that cover the medial aspect of *mm. triceps brachii caput longum* and *caput laterale*. It originates from the surface of *mm. teres major* and *latissimus dorsi*, via fleshy fibers and inserts onto elbow joint and *fascia antebrachia* via apponeurosis. This muscle also extends the elbow joint.

The ***m. articularis humeri*** was present only in left forelimb of LOM 952. It is a small fusiform muscle, originated from the proximal surface of *m. subscapularis* via fibrous fibers and inserted onto medial aspect of *corpus humeri*, just above to *tuberculum minus*, also by fleshy.

The ***m. biceps brachii*** is the principal flexor muscle of elbow joint, situates at cranial aspect of humerus. It originates from *tuberculum supraglenoidale*, by tendon that lies throughout *sulcus intertubecularis* and ends on belly. It inserts onto *tuberositas radii*, also via tendon. The *m. biceps brachii* also extends the shoulder joint.

The ***m. brachialis*** originates, via fleshy fibers, from lateral aspect of *collum humeri* and *sulcus m. brachialis* It lies down throughout the caudal and lateral aspect of *corpus humeri*, and inserts, via tendon, onto *corpus ulna facies medialis*, next to *articulatio cubiti* (elbow joint) (M. Constantinescu and Schaller, pag 87, n 7). The *m. brachialis* flexes the elbow joint.

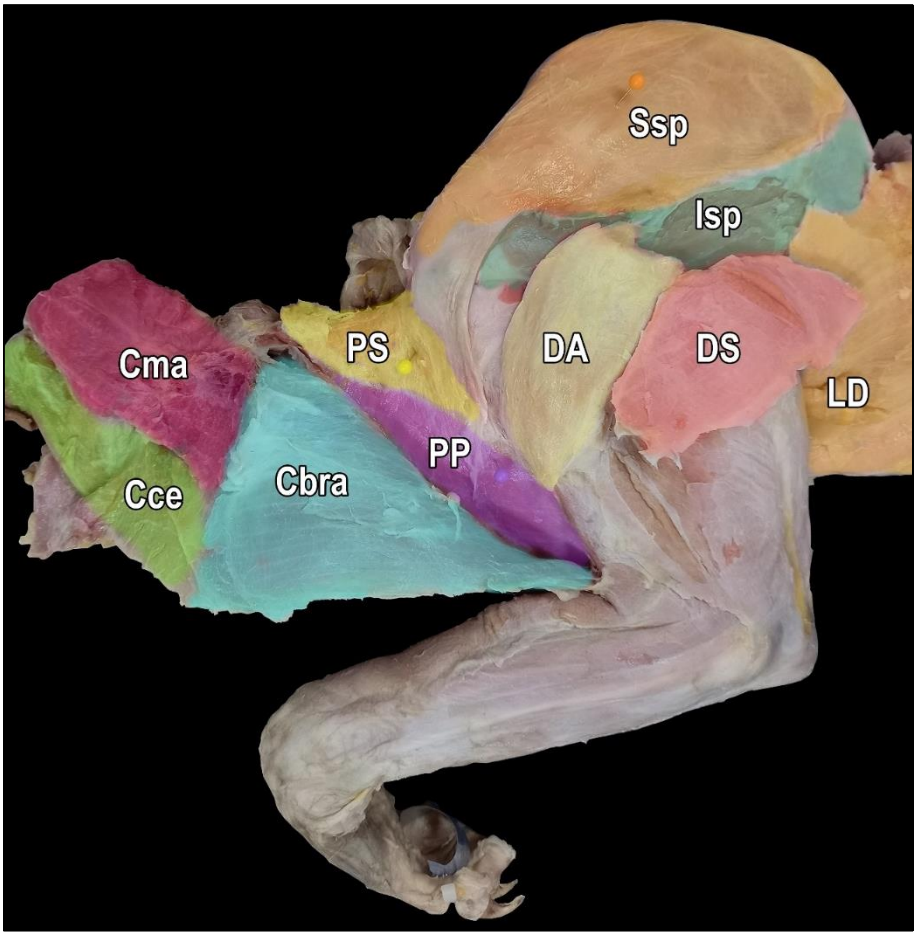

Figure 42 – Lateral aspect of extrinsecs muscles of puma arm (specimen LOM 952). Ssp - Supraspinatus; Isp - Infraspinatus; DA - Deltoideus acromialis; DS- Deltoideus spinatus; PS - Pectoralis superficialis; PP - Pectoralis profundus; Cma - Cleidomastoideus; Cce - Cleidocephalicus; Cbra – Cleidobrachialis.

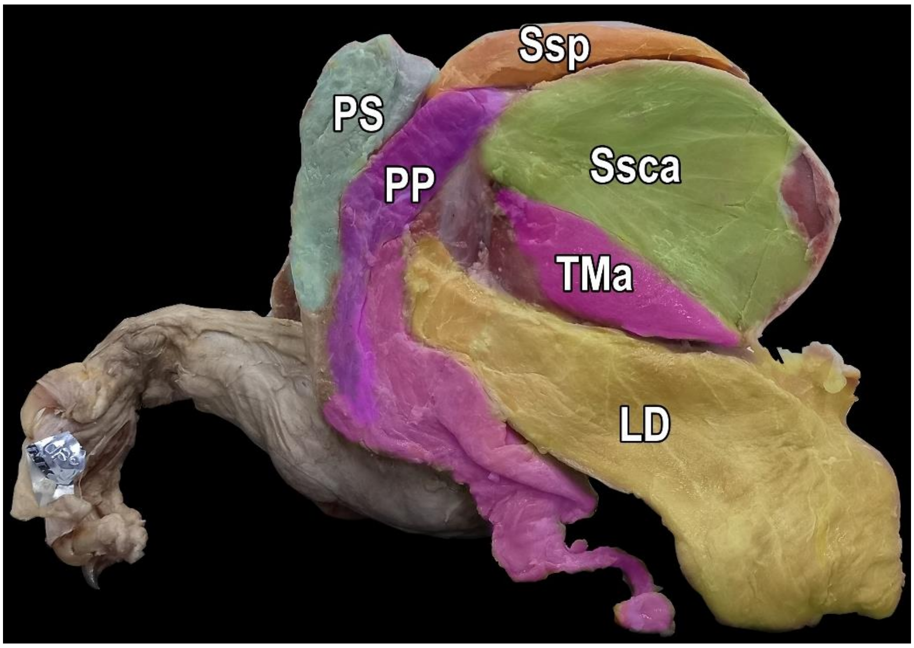

Figure 43 – Medial aspect of LOM 952 arm. LD - Latissimus dorsi; PP - Pectoralis profundus; PS - Pectoralis superficialis; Ssca - Subscapularis; Ssp - Supraspinatus; TMa - Teres major (Medial View).

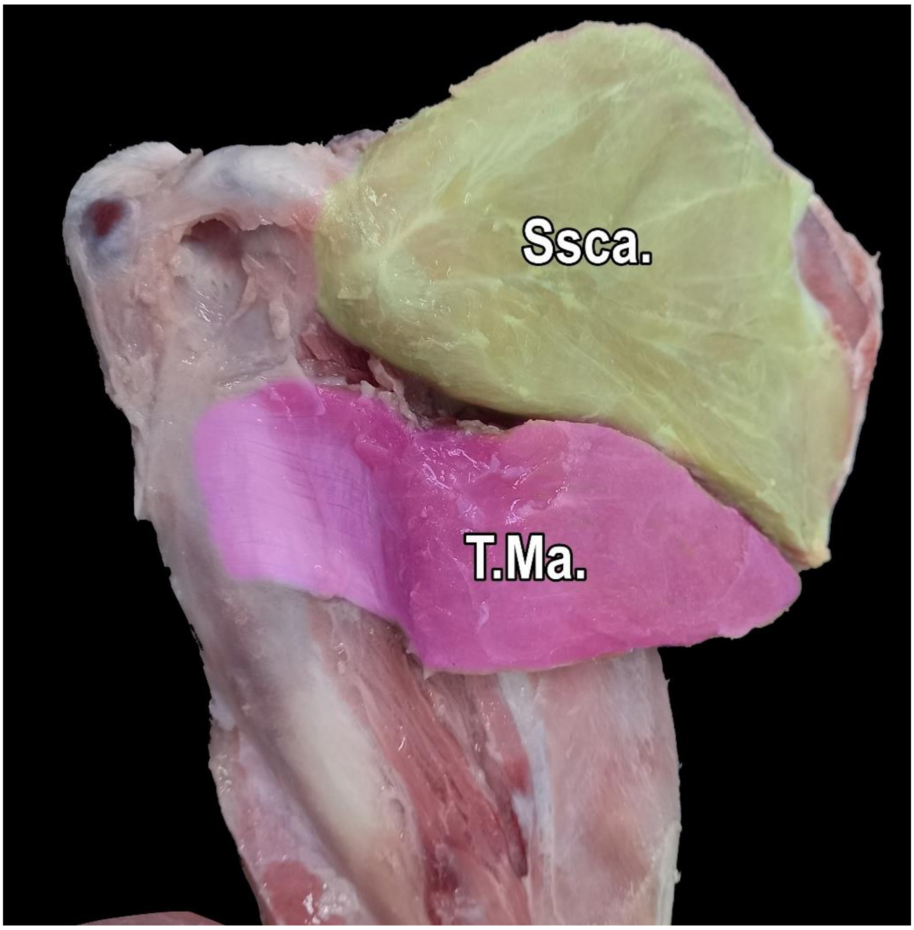

Figure 44 - Medial aspect of *brachium* of LOM 952. Ssca - Subscapularis; TMa - Teres major .

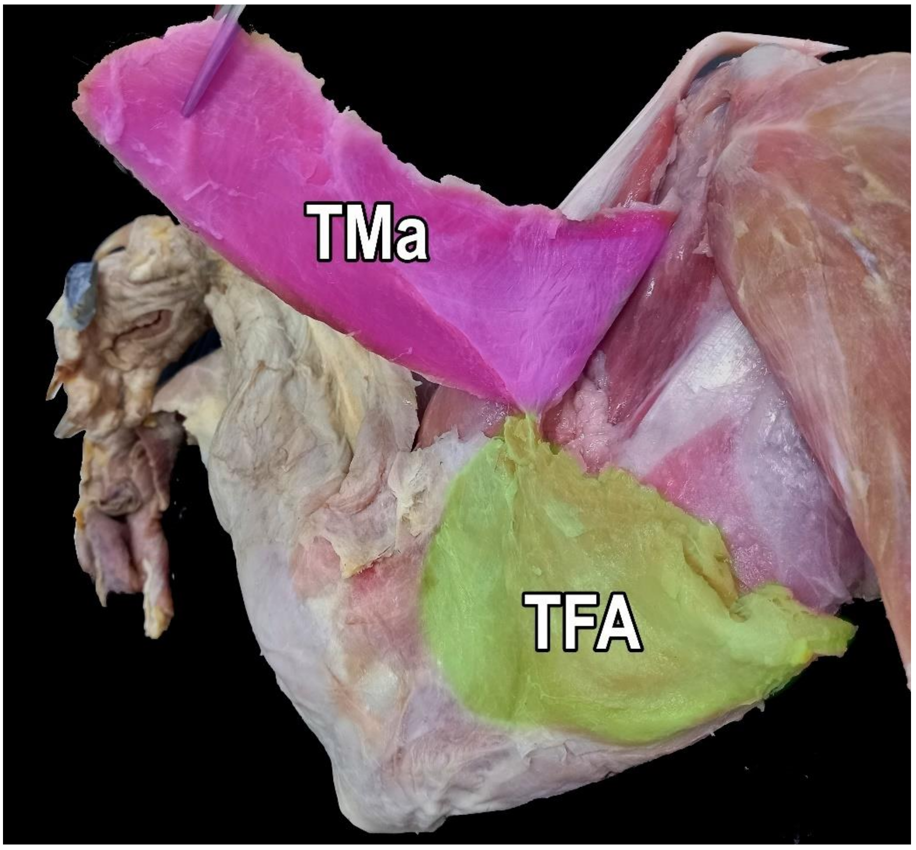

Figura 45 – Medial aspect of Lom 952 *brachium* showing the connection between the TFA - Tensor fascia antebrachii and TMa - Teres major.

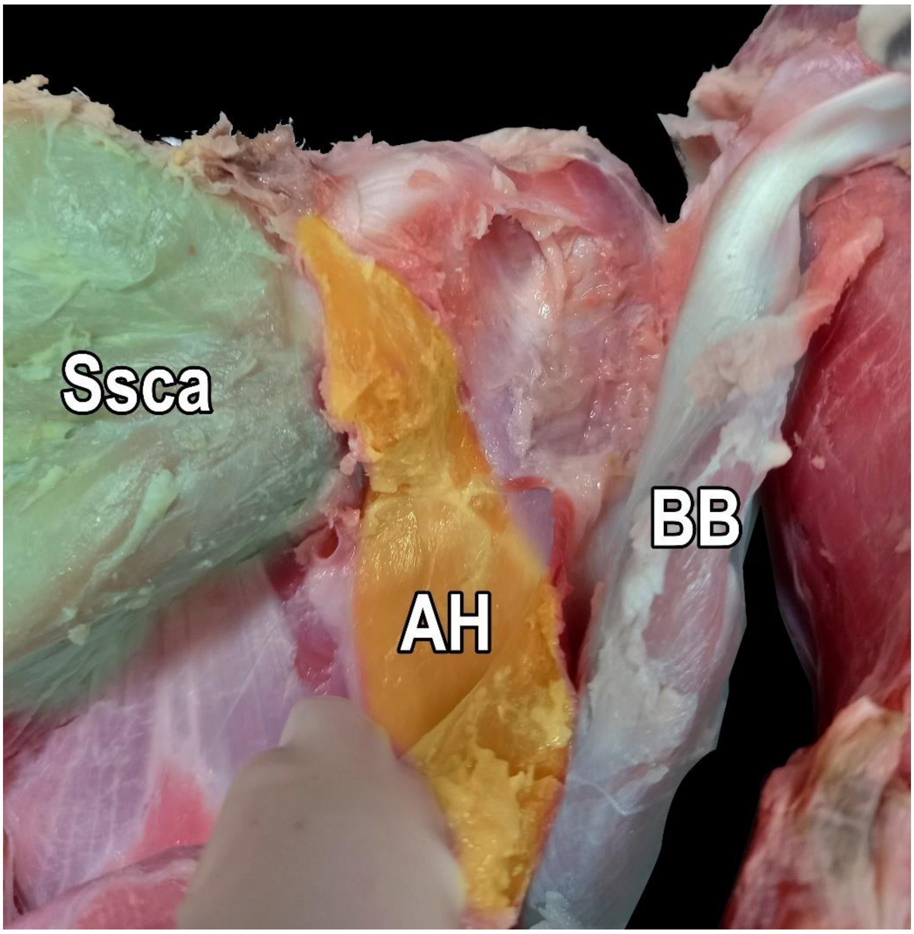

Figura 46 – Medial aspect of shoulder of LOM 952 showing the huge articularis humeri. AH - Articularis humeri; BB - Biceps brachii; Ssca - Suscapularis (Medial aspect of shoulder).

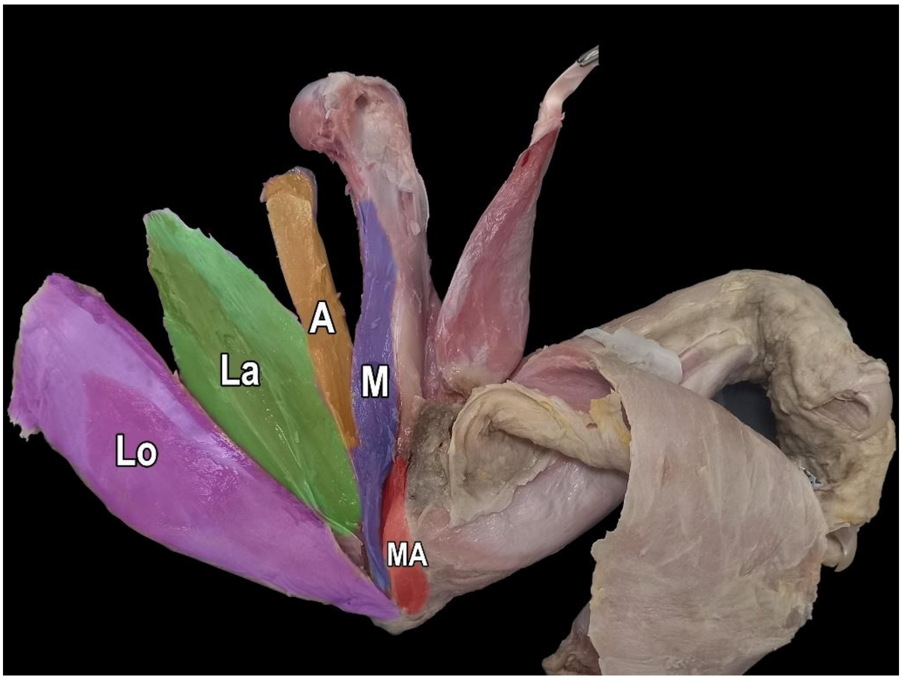

Figure 47 - Triceps brachii of LOM 942 at medial view. TBA - caput accessorum; TBLa - caput laterale; TBLo - caput longum; TBM - caput mediale; TBMA - caput mediale accessorum

Figure 48 – Caudal aspect of LOM 952 arm. An - Anconeus; Bch – Brachialis.

2.1.3. Cranial aspect of antebrachium

The ***m. brachioradialis*** is a band-shape muscle originates from the caudal aspect of *corpus humeri*, via mixed fibers, and from the lateral aspect of surface of *m. brachialis*. It inserts, via fleshy, onto surface of *m. extensor carpi radialis longus* and *m. abductor digit I longus* at level of *trochlea radii*. The *m. brachioradialis* supinates the forearm.

The *m. extensor carpi radialis longus* originates, via fleshy fibers, from *crista suracondylaris lateralis* and part of surface of *m. brachialis*. It is fuse with *m. extensor carpi radialis brevis* from their origin until the distal part of *antebrachium*. It passes over *extensor retinaculum* and its own *retinaculum* and insets via long tendon onto the basis of metacarpal II. The *m. extensor carpi radialis longus* extends the carpus.

The *m. extensor carpi radialis brevis* originates, via fleshy fibers, with *m. extensor carpi radialis longus* from *crista supracondylaris lateralis*. In specimen LEM 003 the origin of this muscle partially independent and from a rounded depression area at *condylus humeri* between the *epicondylus lateralis* and fossa *coronoidea*. It goes to the manus through *extensor retinaculum*, under the *m. extensor carpi radialis longus* and inserts onto the basis of metacarpal III, via long tendon. The *m. extensor carpi radialis brevis* extends the manus.

The *extensor digitorum communis* originates from *crista supracondylaris lateralis*, via fleshy fibers, between the origins of *m. extensor carpi radialis* and *m.extensor carpi ulnaris*. It crosses carpus's retinaculum and its own retinaculum and split in five tendons that serve the digits I-V, respectively. The tendon I inserts with the tendon I of *m. extensor digit I et II,* at phalanx proximal II with the tendon II of *m. extensor digit I et II,* the tendons III, IV and V inserts with the tendons of *m. extensor digitorum lateralis* onto the proximal phalanx of their respective digits. This muscle is proximally fused with *m. extensor carpi radialis longus* and *m. extensor digitorum lateralis* next to their origin. The *m. extensor digitorum communis* extends the digits I-V.

The *m. extensor digitorum lateralis* originates from the epicondylus lateralis, via mixed fibers. The proximal part of its belly is fused with *m. extensor digitorum communis*, but the distal portion goes free until the *retinaculum*, where it passes over by tendon. In LEM 003 it is divisible in two caputs, the caput lateral serves the digiti V via one long tendon (tendon III) that inserts onto the proximal phalanx V with the tendon V of *m. extensor digitorum communis*. The caput medial split in two tendons that serves the digits III and IV, the most medial (tendon I) inserts onto phalanx proximal III with the tendon III of *m. extensor digitorum communis* and the tendon mediale (tendon II) inserts onto proximal phalanx IV with the tendon IV of *m. extensor digitorum communis*. In LOM 952 this muscle has only one belly and split in the three tendons, that inserts as described above. The *m. extensor digitorum lateralis* extends the digits III, IV and V.

The *m. extensor carpi ulnaris* is the most lateral extensor of *antebrachium*. It originates from epicondylus lateralis, right down to the origin of *m. extensor digitorum* *lateralis*, where is fused with *m. anconeus*. It goes laterally to the carpus and inserts, via tendon, onto the basis of metacarpal V. Due to the flexibility of felids forearm, the *m. extensor carpi ulnaris* assume different functions as the position of the forearm, when it acts alone, it abducts the capus, but it act as extensor when the carpus is already extend and as flexor when the carpus is already flexed.

The *m. supinator* is a triangle-shaped muscle originated from cranial aspect of *epicondylus laterals*, via tendon. It lies throughout the radium and inserts onto half portion of *corpus radii facies cranialis*, via fleshy fibers. The medial border of this muscle is fused with m. *pronator teres.* The *m. supinator* supinates the forearm.

The *m. abductor digiti I longus* originates, via fleshy fibers, from the entire lateral border of corpus ulnae, the distal half of *corpus radii fascies cranialis* and *membrana interesossea antebrachii*. It inserts onto *os pisiforme* via tendon that pass under its own *retinaculum*. This muscle abducts and extends the digit I.

The *m. extensor digiti I et II* originates, via fleshy fibers, from *fascies lateralis* of *olecranon* and proximal third of *corpus ulnae fascies lateralis*. It ranges to the carpus and split in two tendons that inserts onto phalanx proximal I and onto extensor expansion at phalanx media II, via a long tendon. This muscle extends the digits I and II.

The *m. pronator teres* originates, via mixed fibers, from epicondylus medialis. Its belly lies down throughout *corps radii margo medialis* until the end of *m. supinator*, then it continuous via aponeurosis until the *trochlea radii*. The *m. pronator teres* pronates the radiulnar joint.

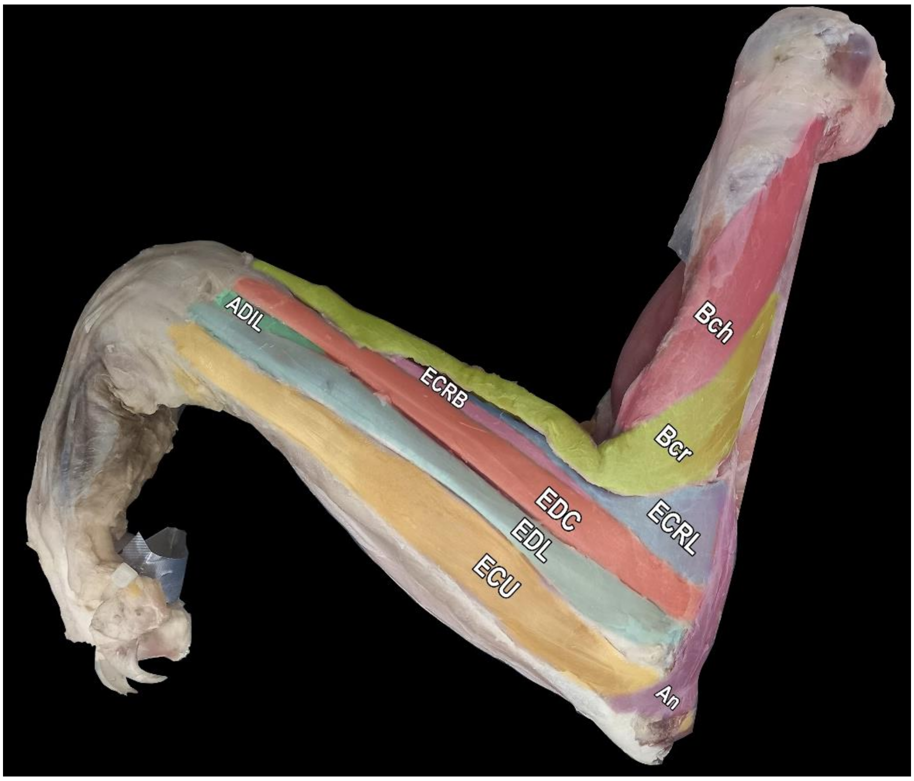

Figure 49 - Lateral aspect of antebrachium (specimen LOM 952). An - Anconeus; ADIL - Aductor digiti I longus; Bch - Brachialis; Bcr - Brachioradialis; ECRB - Extensor carpi radialis brevis; ECRL - Extensor carpi radialis longus; ECU - Extensor carpi ulnaris; EDC - Extensor digitorum communis; EDL – Extensor digitorum lateralis.

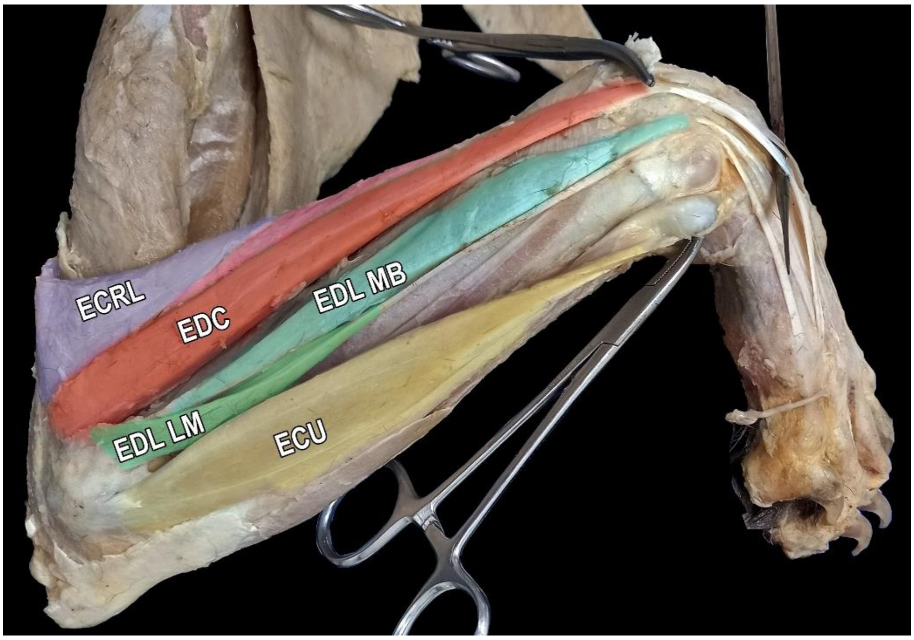

Figure 50 - Lateral aspect of extensores of antebrachium (specimen LEM 003). ECU – Extensor carpi ulnaris; EDC – Extensor digitorum communis; EDL LM – Extensor digitorum lateralis lateral belly; EDL MB – Extensor digitorum lateralis medial belly; ECRL – Extensor carpi radialis longus.

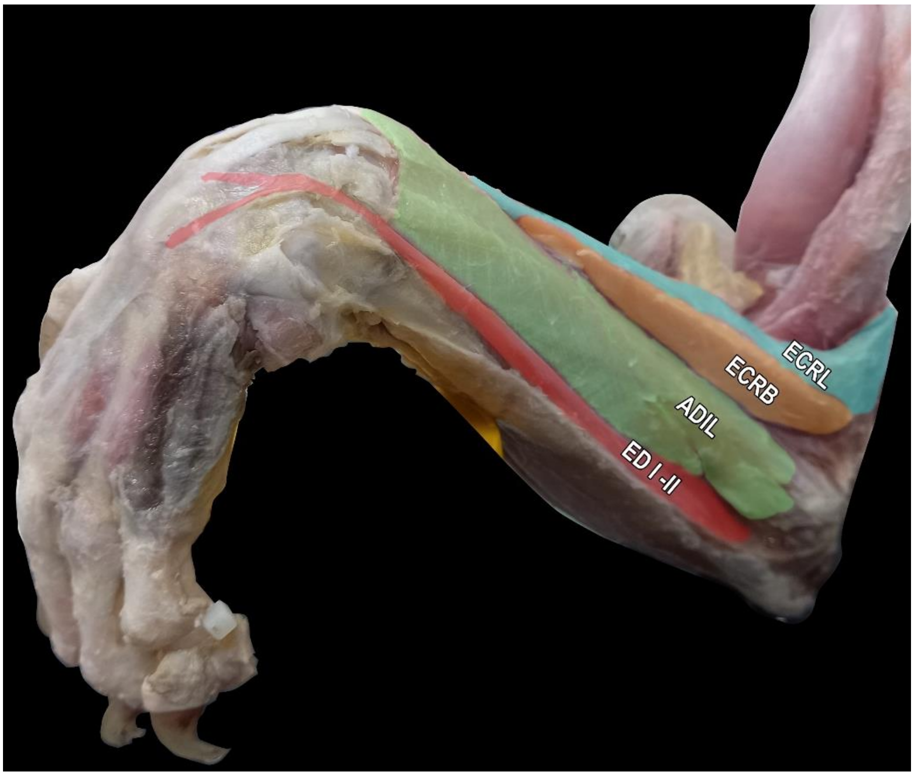

Figure 51 – Lateral aspect of antebrachium (specimen LOM 952). ADIL - Aductor digiti I longus; ECRB - Extensor carpi radialis brevis; ECRL - Extensor carpi radialis longus; EDI - II - Extensor digiti I et II.

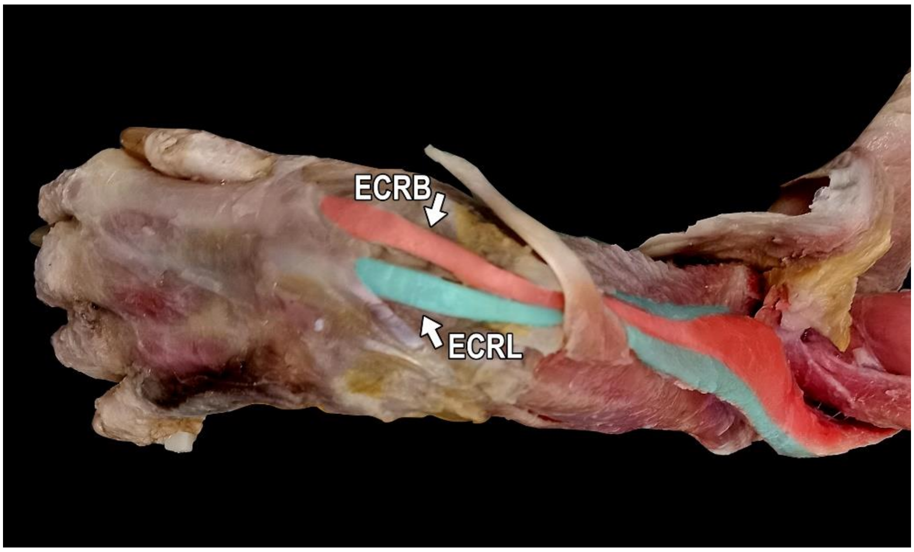

Figura 52 – Cranial aspect of distal portion of antebrachium and proximal part of manus showing the insertion of ECRB - Extensor carpi radialis breves; ECRL - Extensor carpi radialis longus (specimen LOM 952).

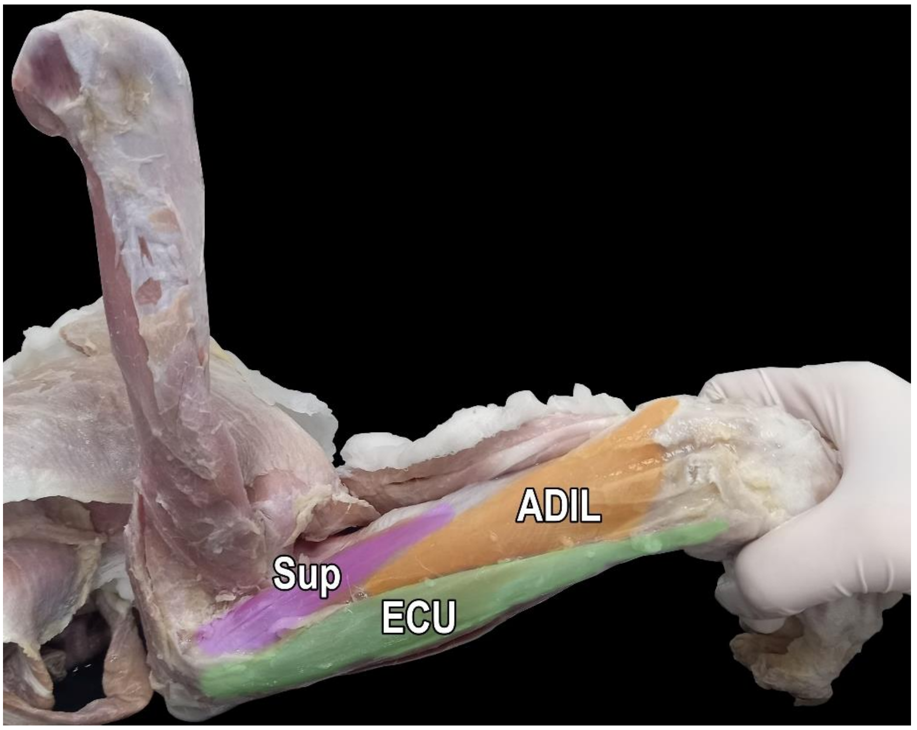

Figure 53 – Lateral aspect of deep muscles of forearm (specimen LOM 952). ADIL - Aductor digiti I longus; ECU - Extensor carpi ulnaris; Sup – Supinator.

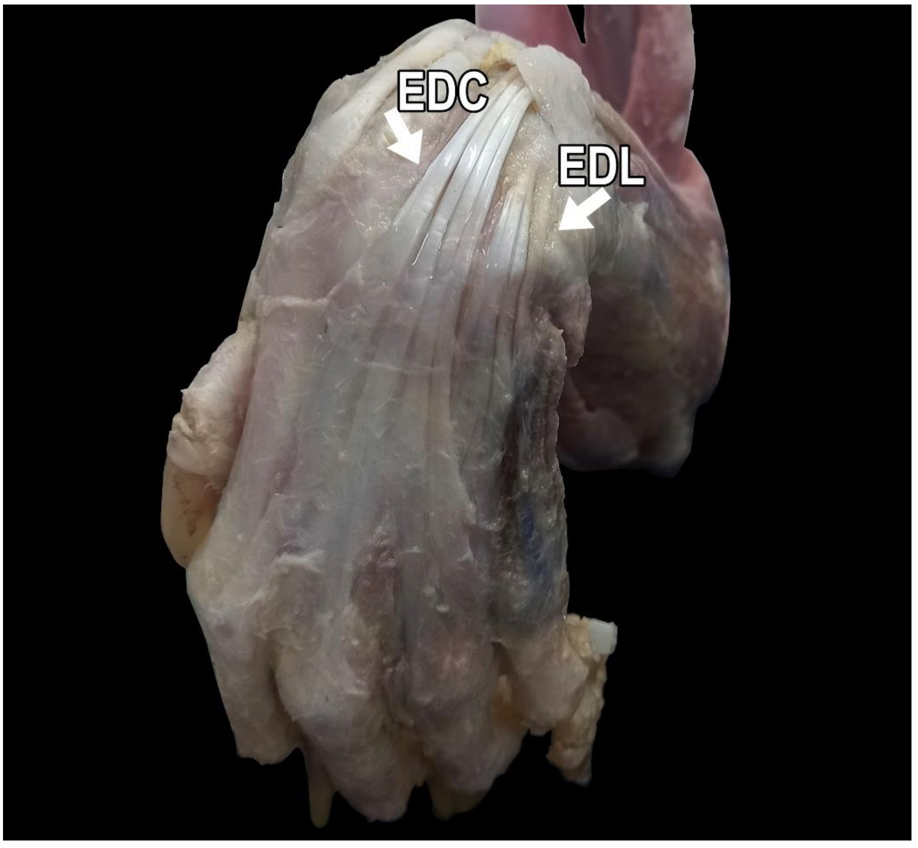

Figure 54 – Cranial aspect of manus sowing the insertion of EDC - Extensor digitorum communis and EDL - Extensor digitorum lateralis (specimen LOM 952).

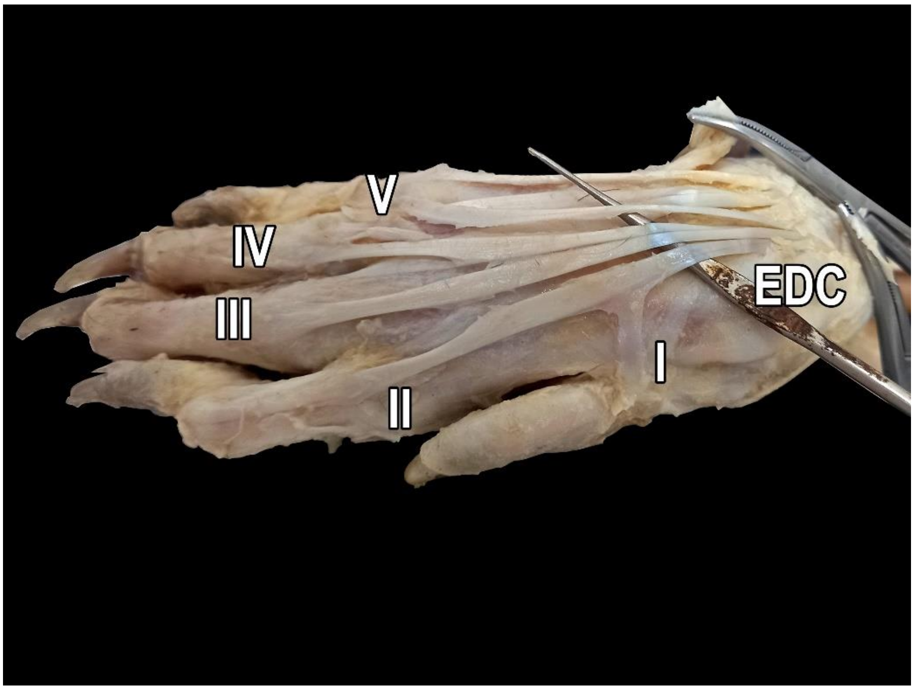

Figure 45 – Cranial aspect of manus of LOM 952 showing the 5 tendons of EDC - Extensor digitorum communis tendons.

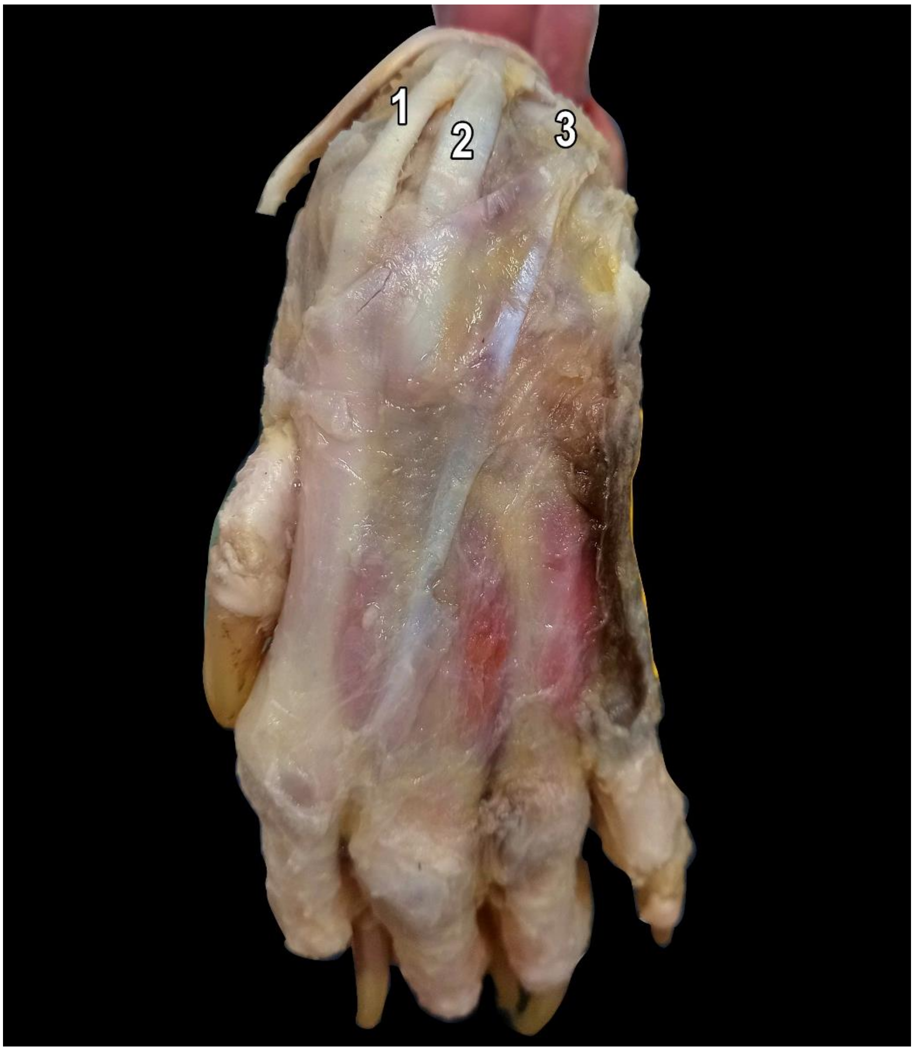

Figure 56 – Cranial aspect of manus of LOM 952. The numbers indicate the tendons of 1. Extensor carpi radialis longus; 2. Extensor carpi radialis brevis; 3. Extensor digiti I et II.

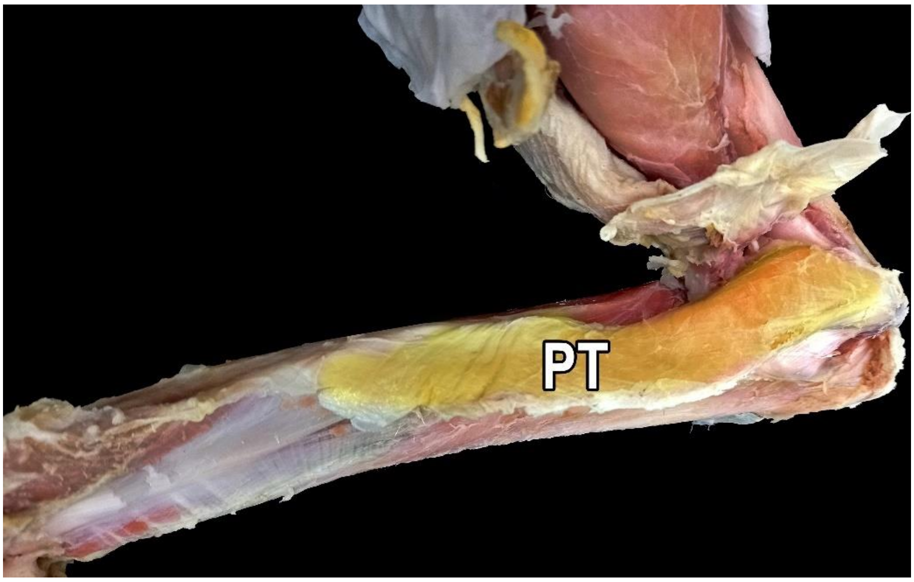

Figura 57 - Lateral aspect of LOM 952 antebrachium showing the PT - Pronator teres.

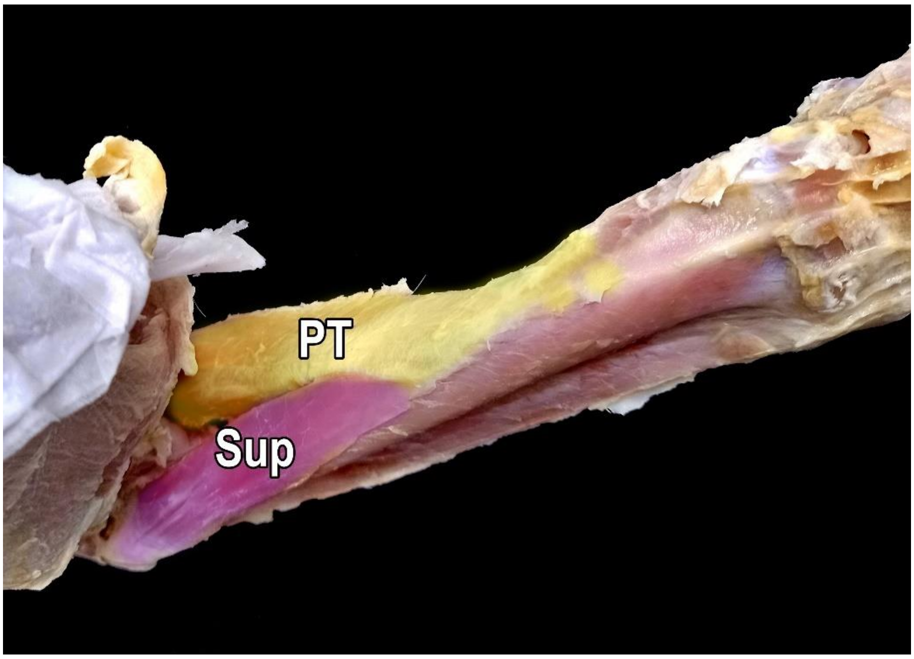

Figura 58 - Cranial aspect of LOM 952 antebrachium showing the PT - Pronator teres; Sup – Supinator.

2.1.4. Caudal aspect of antebrachium

The *m. flexor carpi* radialis situates at medial aspect of antebrachium, between *mm. pronator teres* and *flexor digitorum profundus caput humerale mediale.* It originates from *epicondylus medialis,* via a short tendon, cross the *flexor retinaculum* via long tendon and inserts onto proximal part of metacarpal II (ventral aspect). The *m. flexor carpi radialis* flexes the carpus.

The *m.palmaris longus* originates via tendon from the *epicondylus medialis*, between the origin of *mm. flexor digitorum profundus caput humeral* and *caput humerale mediale*. It cross its own *retinaculum* by a robust unique tendon (tendon communis) and after *retinaculum* it split in 5 tendons. The tendon I inserts onto medial surface of proximal phalanx I, while the tendons II-V inserts onto *lig. metacarpum transversum* of respective digits. The *m. palmaris longus* flexes the carpus and digits.

The *m. flexor carpi ulnaris* is the most caudal flexor at superficial layer, located at medial aspect of antebrachium, next to *m. palmaris longus*. It has two caputs: the *caput humerale* and *caput ulnare.* The *caput humerale* originates, via fleshy, from the distal part of caudal aspect of *condylus humeri* and is partially fused with *m. flexor digitorum* *profundus caput humerale laterale*. The *caput ulnare* originates, also via fleshy fibers, from medial aspect of olecranon. The caputs com together and inserts, also via fleshy fibers, onto caudal aspect of *os carpi accessorium*.

The *m. flexor digitorum superficialis* originates from the tendon communis of *m. flexor digitorum profundus*, via fleshy fibers. In puma it has only one belly with one tendon that inserts onto *lig. annular digital proximal* of digit II. The *m. flexor digitorum superficialis* helps to flexes the metacarpophalangeal joint of digit II.

M. flexor digitorum profundus is the deepest flexor of antebrachium, and it has five caputs: *caput humerale mediale*, *humerale laterale*, *humerale profundus*, *ulnare* and *radiale et ulnare.* The *caput humerale mediale, caput humerale laterale* and *caput humerale profundus* are partially fused next to origin and originates from caudal aspect of *epicondylus medialis*, via tendon. The *caput ulnare* originates, via fleshy fibers, from proximal caudal aspect and the entire length of medial aspect of ulna. The *caput radiale et ulnare* originates, also via fleshy, from the second quarter of *corpus ulnae facies medialis* and second third of *corpus radii facies caudalis,* next to *lig. interosseum antebrachii*. All caputs come together by *tendon communis,* and this tendon pass under *mm. palmaris longus* and *flexor digitorum superficialis,* and at level of metacarpus it split in five tendons. Each tendon is cover by *mm. lumbricales* and go to inserts at cranial aspect of distal phalanx I-V. Furthermore, the tendons II-V bifurcates in two and pass under *lig. annular palmar*, *annular digital proximal* and *annular digital distal.* The *m. flexor digitorum profundus* flexes the digits I-V.

M. pronator quadratus lies down throughout caudal aspect of *antebrachium*. It originates, via fleshy fibers, from the distal half part of *corpus radii facies caudalis* and distal third of *corpus ulnae facies medialis*. It pass under the *m. flexor digitorum profundus* and inserts onto ventral aspect of carpal bones, via mixed fibers. The *m. pronator quadratus* pronates the forearm.

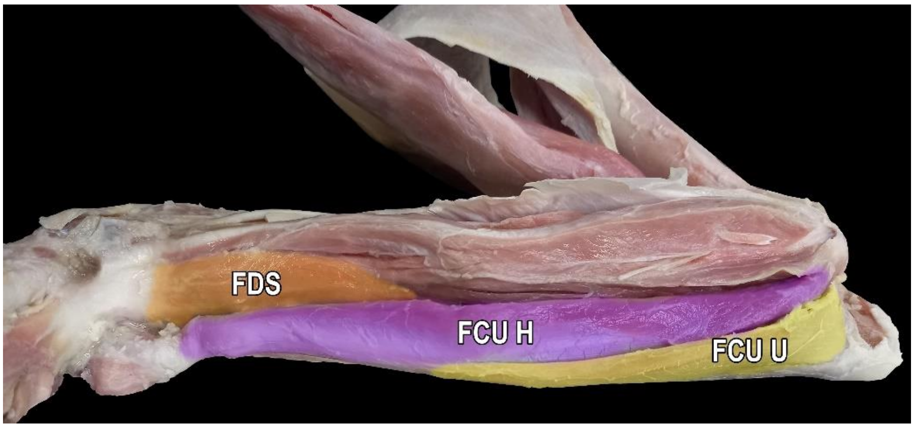

Figure 59 – Caudal aspect of antebrachium (specimen LOM 952)**.** FCU H - Flexor carpi ulnaris caput humerale; FCU U - Flexor carpi ulnaris caput ulnare; FDS - Flexor digitorum superficialis (Caudal aspect).

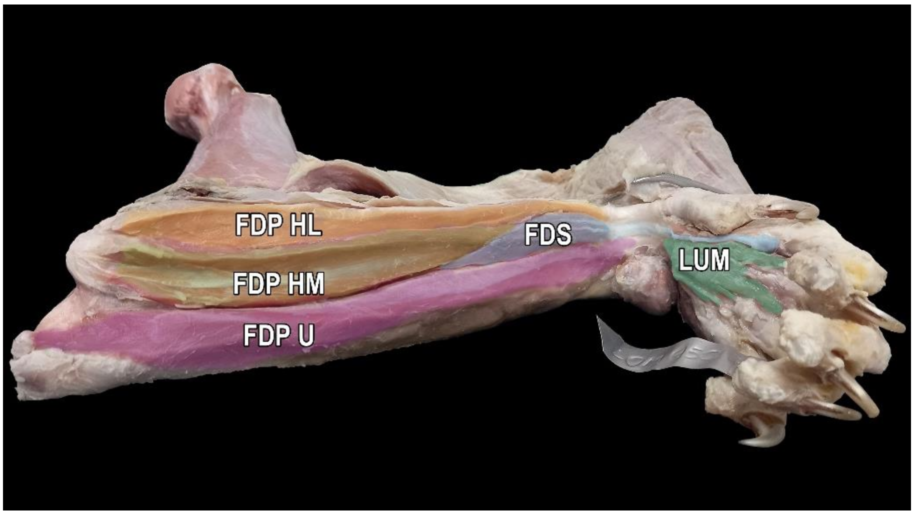

Figure 60 – Caudal aspect of antebrachium and manus (specimen LOM 952). FDP HL - Flexor digitorum profundus caput humerale laterale; FDP HM - Flexor digitorum profundus caput humerale mediale; FDP U – Flexor digitorum profundus caput ulnare; FDS – Flexor digitorum superficialis; LUM – Lumbricalis.

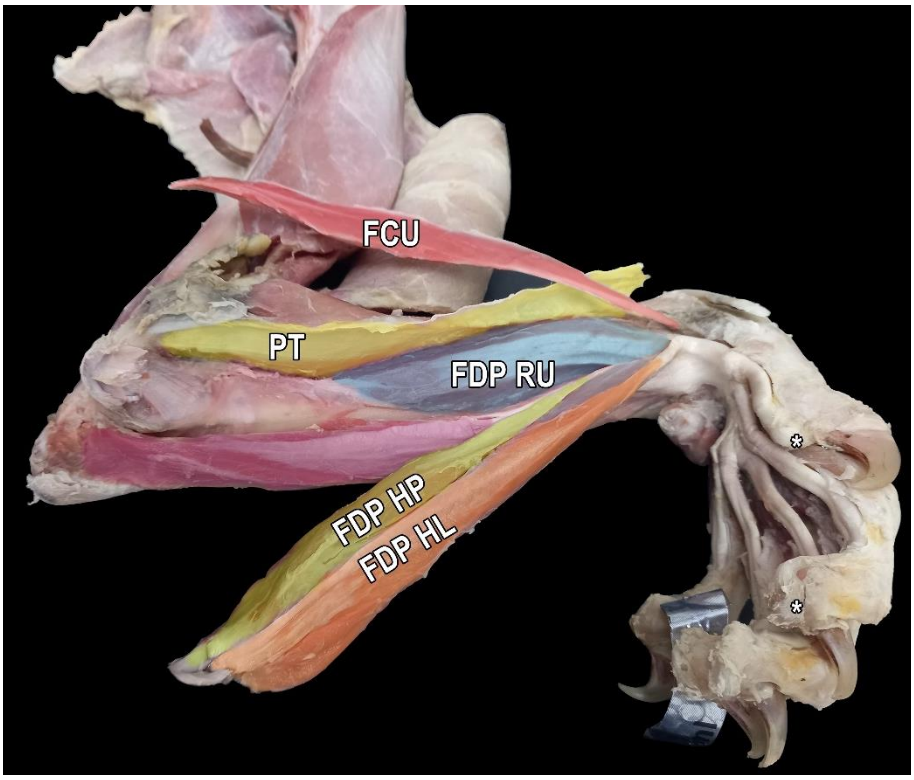

Figure 61 – Caudo-medial aspect of antebrachium and manus (specimen LOM 952). FCU - Flexor carpi ulnaris; FDP HL - Flexor digitorum profundus caput humerale laterale; FDP HP - Flexorigitorum profundus caput humerale profundus; FDP RU - Flexor dgitorum profundus caput radiale et ulnare; PT - Pronator teres. * Insertion of flexor digitorum profundus.

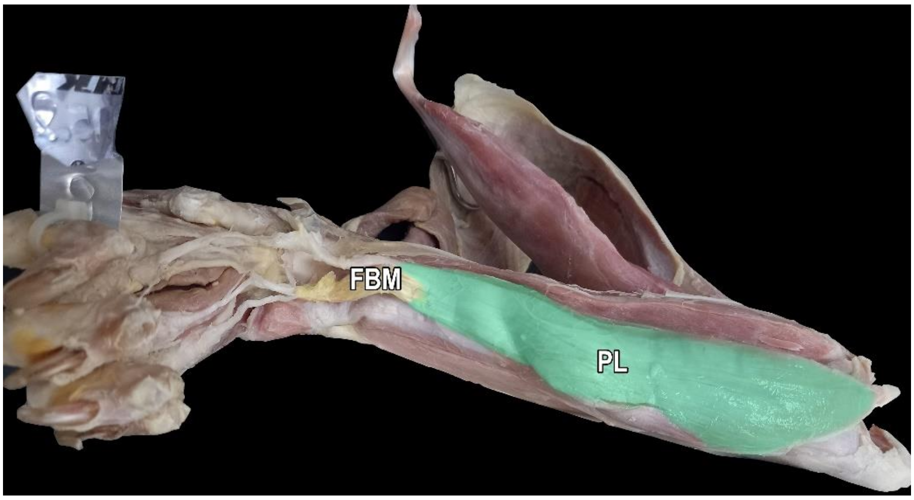

Figure 62 – Caudal aspect of antebrachium (specimen LOM 952). FBM - Flexor breves manus; PL - Palmaris longus.

Figura 63 - FBM - Flexor breves manus and PL - Palmaris longus isolated (specimen LOM 952).

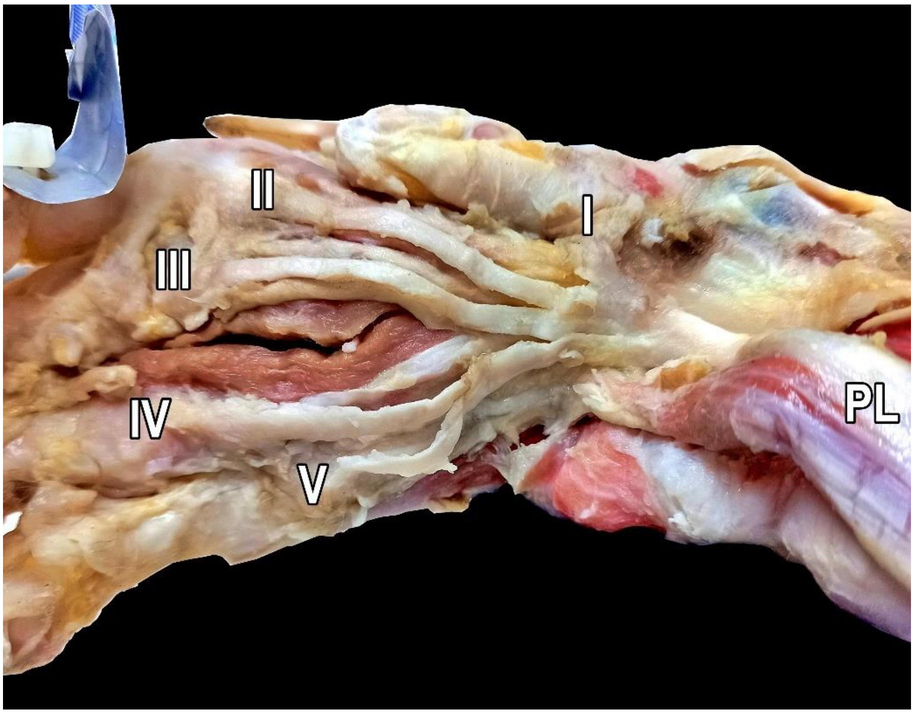

Figura 64 – Ventral aspect of manus showing the PL - Palmaris longus. Number I-V indicates palmaris longus' tendons (specimen LOM 952).

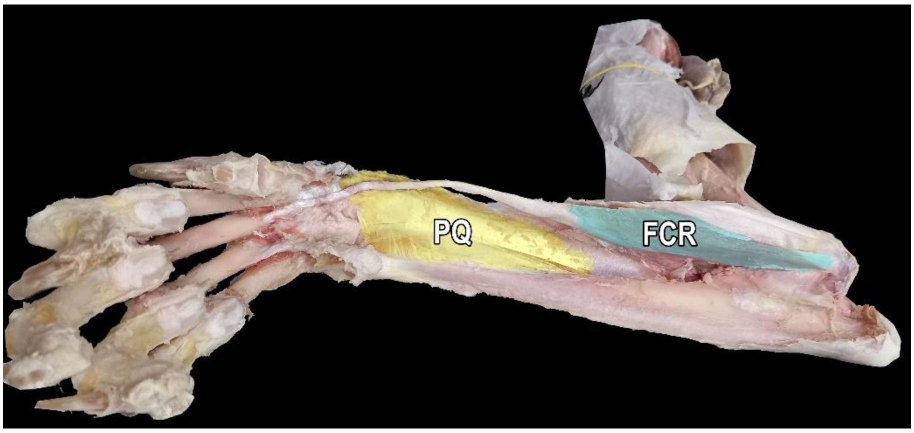

Figure 65 – Caudal aspect of antebrachium showing the FCR - Flexor carpi radialis and PQ - Pronator quadratus (specimen LOM 952).

2.1.5. Manus

M. palmaris brevis is a small triangle-shaped situated under carpal paw pad. Unfortunately, this muscle was damaged in both specimens.

The *flexor digitorum brevis manus* originates from the surface of *m. palmaris longus*, via fleshy fibers. In puma it shows only one belly that cross the *flexor retinaculum* with *m. palmaris longus* and then split into two tendons. The tendons are recover by *fascia digiti* with *nn. metacarpei palmares* and, due to similarity of position, they can easily be mistaken for nerves. The tendons insert onto *lig. metacarpum transversum superficiale* VI and V. The *flexor digitorum brevis manus* flexes the metacarpus-phalangeal joints.

The *m. abductor digiti V* situates at caudoventral aspect of manus and in the puma this muscle has two caputs, one more superficial and another deeper. They originates together, via fleshy fibers from cranial aspect of *os pisiforme* and they are separated by *lig. pisometacarpeum.* Each caput has its own tendon that inserts onto lateral aspect of proximal phalanx V. Though, in the left forelimb of LOM 952 only the superficial belly has a tendon. The *m. abductor digiti V* abducts the digit V.

The *mm. lumbricales* is a group of four muscles that lies throughout palmar aspect of manus. They originates together, via mixed fibers, from the *tendon communis* of *m. flexor digitorum profundus* and serves the digits II-V. The *m. lumbricales I* have one bely, that inserts via tendon onto lateral aspect of proximal phalanx II. The *m. lumbricales II* have one belly inserts onto medial aspect of proximal phalanx III. The *mm. lumbricales*

III and *IV* has two bellies, so *m. lumbricales III* inserts onto lateral aspect of proximal phalanx III and medial aspect of proximal phalanx IV, while the *m. lumbricales IV* inserts onto lateral aspect of proximal phalanx IV and medial aspect of proximal phalanx V. The *mm. lumbricales* weakly flexes the metacarpophalangeal joint of digits II-V.

Mm. addutores digitorum are composed by *mm. adductor digitorum I, adductor digitorum II* and *adductor digitorum V.* They originates together, via fleshy fibers, from the palmar surface of carpus, at level of *os carpale III* and *os carpale IV.* They insert, via short tendon, onto medial aspect of proximal phalanx I, II and V. The *mm. adductors digitorum* adducts the digits I, II and V.

Mm. flexores breves profundi is a group of four muscles that lies throughout the metacarpus II-V, and originates, via fleshy fibers, from the palmar aspect of carpus. *m. flexor breves profundi.* Each *mm. flexor breves profundi* split in two bellies, one medial and one lateral. The bellies has a point of insertion onto proximal sesamoid of their respective digits and then send a slim tendon to the distal phalanx. The tendon lateral and medial of each *mm. flexor breves profundi* comes together and inserts onto common extensor expansion, at dorsal aspect of digits. The *mm. flexores breves profundi* flexes the digits II-V.

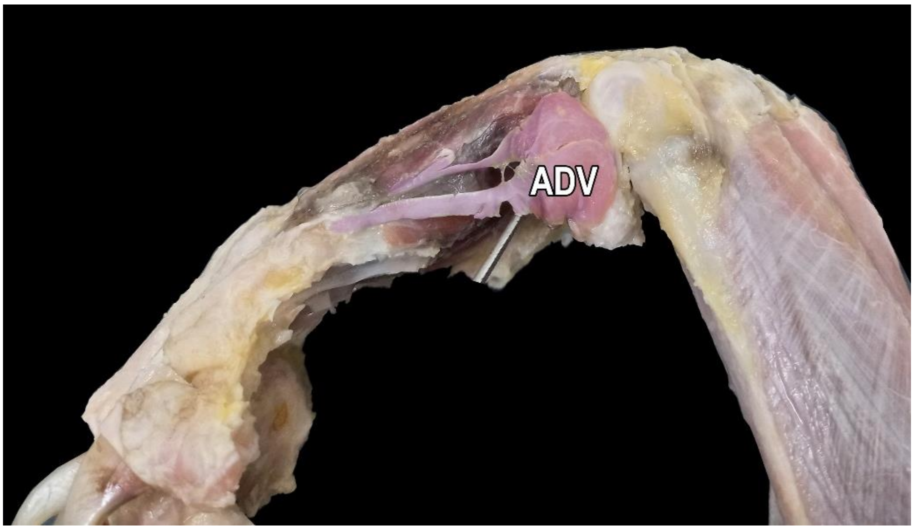

Figura 16 – Lateral aspect of ADV - Abductor digiti V (specimen LOM 952).

Figura 62 - Abductor digiti V isolated (specimen LOM 952).

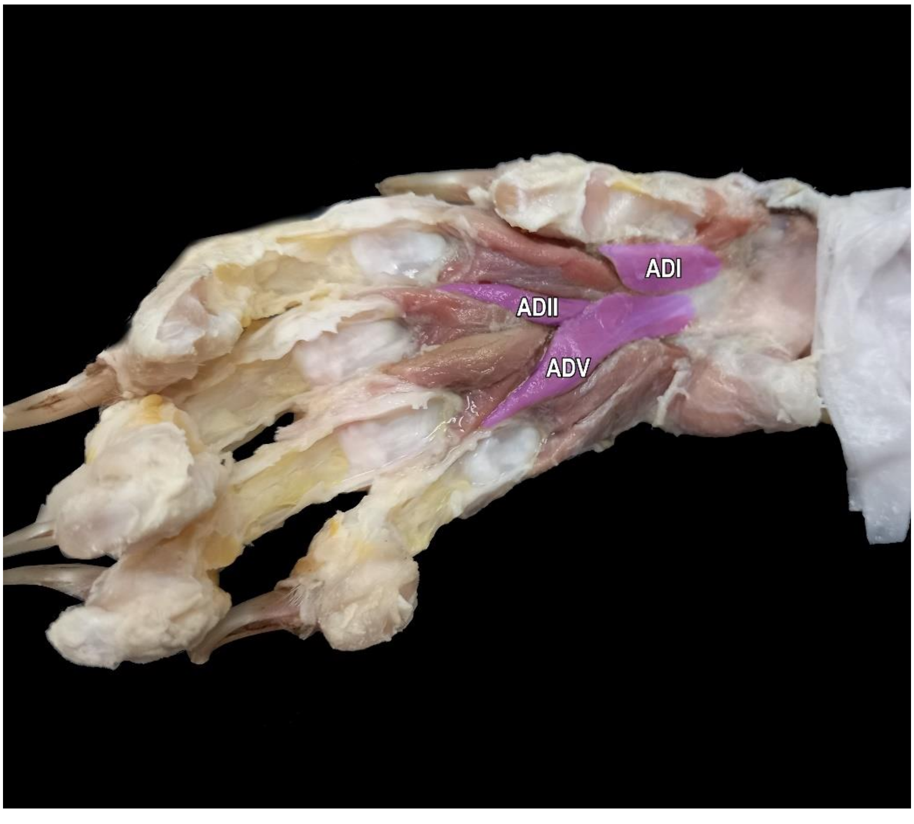

Figura 63 – Caudal aspect of manus showing the *mm.* adductores digitorum. ADI – Adductor digiti I; ADII – Adductor digit II. ADV – Adductor digiti V.

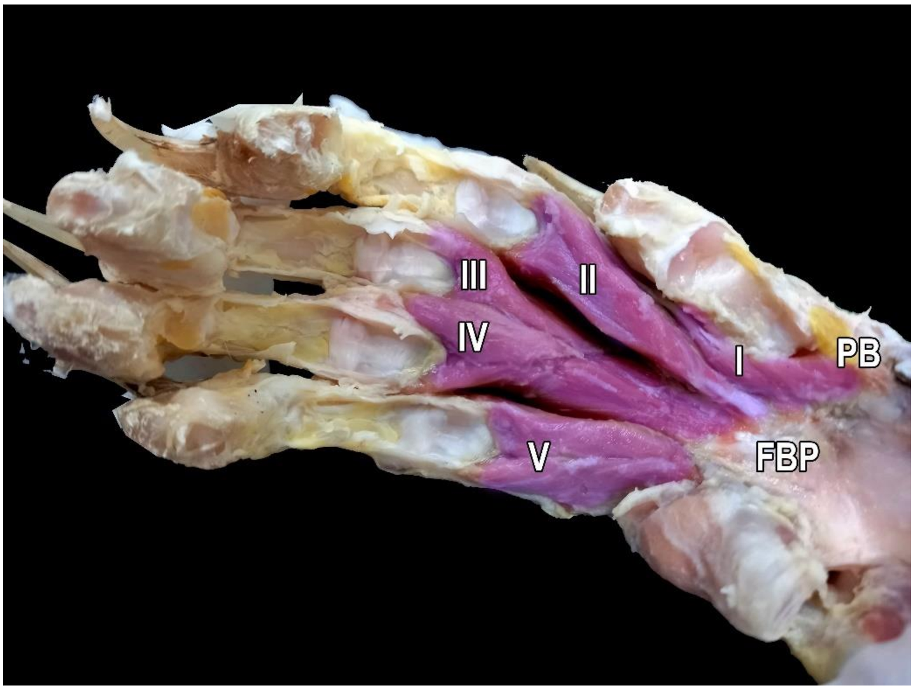

Figura 64 – Ventral aspect of manus (specimen LOM 952). FBP - Flexores breves profundi (I-V); PB - Palmaris breves.

3. COMPARATIVE ANALYSES AND DISCUSSION

3.1.1. Myological differences

The forelimbs of felids have a complex structure, resulting, majority, from the mobility of shoulder and elbow joints, that enable different locomotion behavior to explore landscape recurses (Gambarian, 1974; Böhmer et al., 2019; Giordano, 2016; Gonyea, 1978; Taverne et al., 2018). The extensor muscles of glenohumeral and elbow joints are responsible to increase the angle of forelimb during cursorial movements and proper the limb against the land, while their flexor muscles are responsible for decreasing the angle of forelimb, contributing to absorbing shock on landing (Gambarian, 1974). On the other away, climbing lifestyle also needs a lesser angle of shoulder and elbow joints, but it require great mobility of proximal radio-ulnar joint and grasping fingers joints to approximate the body to the surface and avoid falls (Böhmer et al., 2019; de Souza Junior et al., 2021; Gonyea, 1978a; Iwaniuk et al., 1999).

Both jaguarundi and puma have the *mm. pectoralis superficialis* and *pectoralis profundus* composed of two bellies, however, while in jaguarundi these bellies inserts juxtaposed (figure 59), in puma the caudal belly of m*m. pectoralis superficiais* and the cranial belly of *pectoralis profundus* inserts together onto *tuberculum supraglenoidale*, via diffuse tendinous fibers that cover the capsule articularis (figure 60). This distinct insertion could be seen only when the *m. supraspinatus* was removed first, carefully. When both *mm. pectoralis* were pulled down in the isolated limb, the scapulae didn't move, so this distinct insertion can't be able to extend the glenohumeral joint, as do *m. biceps brachii*, but when the *mm.pectoralis* were pull in the limb *in situ* the movement resulted was the adduction of the humerus and proximal part of scapula with less intensity. Even the action on the scapula be week, this insertion increase the attachment of *mm. pectoralis*, and, as a result, the resistece of this muscle. Concha and colleagues (2004) didn't describe the *mm. pectoralis supeficialis* and *prectoralis profundus* and this characteristic was not reported in previous works for puma and other felids.

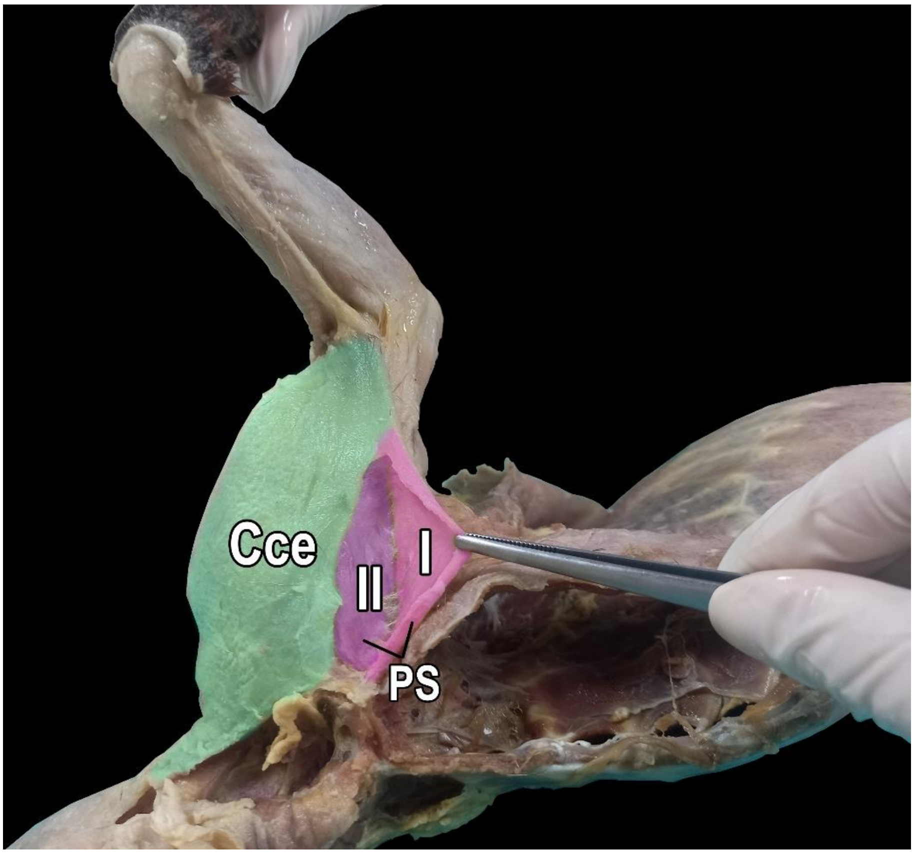

Figure 70 - Left limb of jaguarundi UFMG 7045 showing the two bellies of m. pectoralis superficialis juxtaposed and fused with m. cleidoephalicus.

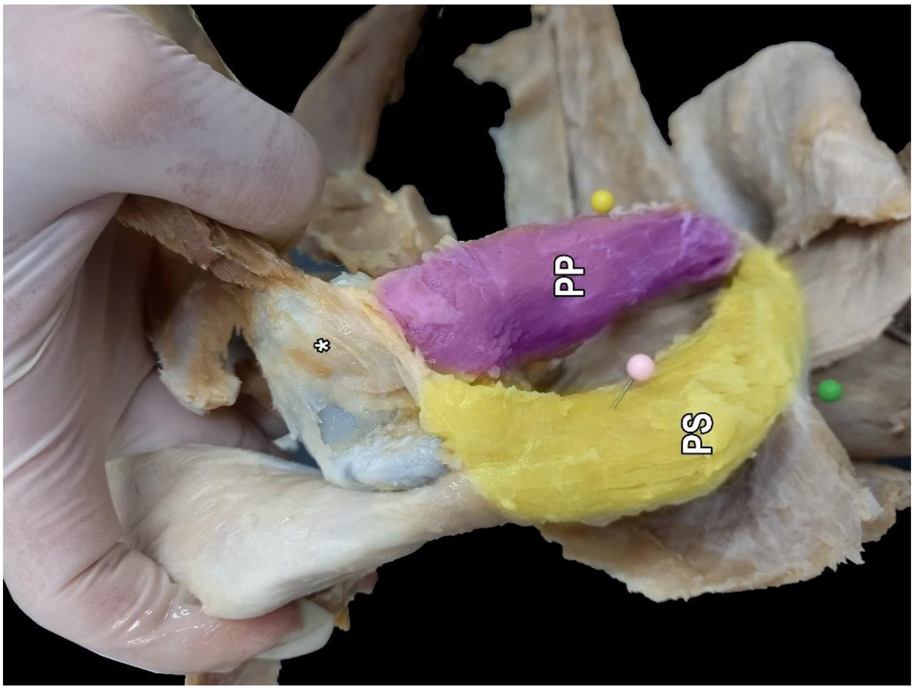

Figure 71 - Insertion of mm. pectoralis profundus (PP) and superficialis (PS) indicated by "*".

The absence of *m. articularis humeri* is another peculiar characteristic found in puma, just one of two specimens dissected has this muscle, and only in the left limb. However, this muscle was reported in pumas dissected by Concha and colleagues (2004), so this difference between Colombian and Brazilian puma may be a regional or an individual variation. The principal function of *m. articularis humeri* stabilize the scapula, without it, this function will do only by the *m. subscapularis*.

The jaguarundi and puma also differ in the origin of *m. teres minor,* while in jaguarundi it originates from the proximal two-thirds of caudal border of scapula, in puma the origin reduces to only the first proximal third. The *m. teres minor* of cheetah originates from the *m. triceps brachii caput longum*, according to Ross (1883) and its insertion is fibrous while in the puma and jaguarundi is tendinous or via mixed fibers. *M. teres minor* flexes the shoulder and its longer origin in jaguarundi than the other two acinonychinis suggest that the *m. teres minor* flexion is greater for jaguarundi.

Another muscle with significant importance for understanding the locomotion behavior of felids is the *m. brahioradialis*, a slender muscle that supinates the forearm. In jaguarundi, it is very narrow and originates from the distal surface of *m. brachialis*, via fleshy, while in puma this muscle is broader and originates from the caudal aspect of humerus shaft, occupying the middle third of all length of humerus shaft. On the other hand, the *m. brachioradialis* is absent in cheetah (de Souza Junior et al., 2015; Ross, 1883), which is congruent with cursorial specialization mode. For Carnivora, the *m. brachioradialis* is usually absent or poor developed in cursorial than in non-cursorials and tends to be wider in climbers and large-prey specialist species (de Souza Junior et al., 2015; Gonyea, 1978a; Julik et al., 2012; Taverne et al., 2018a), so the slim *m. brachioradialis* of jaguarundi is more congruent with cursorial locomotion than scansorial, as it was classified (Meachen-Samuels & van Valkenburgh, 2009). Meanwhile, the well-developed *m. brachioradialis* of puma contributes to both locomotion in rupicolous habitats (climbing) and capture of large prey.

The *mm. supinator* and *pronator teres* of jaguarundi, on the other hand, are very similar to scansorial felids, like ocelot and bobcat (Day & Jayne, 2007; Julik et al., 2012; Smith et al., 2021; Viranta et al., 2016). The *m. supinator* lies throughout the proximal third of radius shaft while the *m. pronator teres* range the two-thirds of lateral aspect of radius shaft, and the same was founded for puma. In cheetah these muscles are very short, similar to other cursorial carnivores, like canids (de Souza Junior et al., 2018, 2021). Although, a large extension of supinator and pronator muscles is also correlated with manipulation of prey, especially when it is large because felids use their forearm to subdue and direct the bite to the prey (Cuff et al., 2016; Gonyea, 1978b; Julik et al., 2012; Leyhausen & Tonkin, 1979). The diet of jaguarundi is usually generalist, englobe small vertebrates, mainly rodents and birds (da Silva et al., 2016; Migliorini et al., 2018; Silva-Pereira et al., 2011), but large animals have been reported in its stomach, such as brocked deer (*Mazama sp*), common opsum and armadillos (Giordano, 2016; Rocha-Mendes et al., 2010; Tófoli et al., 2009), so the large pronator and supinator muscles would help to capture great diversity of preys, especially the birds because they can fly and scapes more easily.

The extensors and flexors of antebrachium are associated with grasping ability (Böhmer et al., 2019; Gonyea, 1978a) and this behavior influences the manipulation of prey and the prehension on climbing. The jaguarundi and cheetah show the *m. extensor digitorum communis* as usual, with four tendons that serve digits II to V, but puma has one more tendon that serves digit I. In contrast, the jaguarundi and puma have the *m. palmaris longus* with five tendons, serving all digits, while the cheetah has only four (Ross, 1883). The puma also has a distinct *m. abductor digit V* with two bellies and two tendons, one characteristic never described before for another felid. These data suggest that the puma is the acinonychine with more ability to manipulate the hand, followed by the jaguarundi and, at last, the cheetah.

3.2.1. Quantitave comparation

The weight distribution of muscle has been used to understand the locomotor mode and prey preference of felids since the 19th century, however, few studies focus on neotropical felids (Cuff et al., 2016; de Souza Junior et al., 2021; Gambariân, 1974; Hudson et al., 2011; Julik et al., 2012; Miriam M. Morales et al., 2018).

The weight comparison of jaguarundi showed a sexual difference and a limb preference between the specimens. The male had havier muscles than the female, and both specimens had the righ limb muscles havier as was described for ocelot, lynx and other cats (Gonyea, 1978b; Julik et al., 2012; Ocklenburg et al., 2019; Viranta et al., 2016).

Cuff et al (2016) and Dunn and colleagues (2022) showed that big felids tend to have weaker shoulder muscles than small cats, although, the mean for jaguarundi (27,179%) was smaller than the mean for puma (30,960%). When the proportion of shoulder muscle is seen individually, the difference is not linear and the male jaguarundi had this group mass very similar to the pumas.

Table 6 - Percentual body mass for each muscle group. [1.] The righ pectoralis of male jaguarundi was damaged, so it was not weighed.

	Jaguarundi Male RL	Jaguarundi Male LL	Jaguarundi Female RL	Jaguarundi Female LL	Puma RL	Puma LL
Shoulder flexor	17,127	23,272	20,122	18,302	21,531	22,085
Shoulder extensor	9,712	10,858	7,397	7,470	9,394	8,909
Adductor brachium	0,000[1]	14,042	8,060	12,620	13,623	11,920
Elbow extensor	12,434	13,627	10,940	12,025	11,885	12,043
Elbow flexor	3,016	3,542	2,580	2,874	3,837	3,649
Supinator	0,836	0,709	0,440	0,445	0,732	0,696
Pronator	1,017	1,099	0,522	0,766	1,022	1,043
Carpal extensor	2,889	2,575	2,191	2,374	2,248	2,095
Carpal flexor	6,011	5,753	4,044	4,818	4,827	4,160
Carpal abductor	1,378	2,633	2,999	2,332	2,306	2,080
Digit extensor	12,747	11,072	1,726	8,560	7,329	6,173
Digit flexor	5,826	5,539	3,755	4,403	5,705	4,322
Digit abductor	0,065	0,063	0,067	0,238	0,068	0,067
Digit adductor	0,053	0,044	0,734	0,077	0,868	0,076

The comparative muscle mass distribution of forearm by radar chart shows that jaguarundi has more shoulder flexor than extensor, more elbow extensor than flexor and more carpal flexor than extensor (Figure 61). The same distribution was founded for puma, but it had more digit extensors than jaguarundi. The large felids also had more digit extensors (Figure 62; 66), so this characteristic for puma probably is allometric. Moreover, the cheetah has more adductor brachium and elbow flexor than the other two acinonychines. According to Gambaryan (1974), the adductors of brachium are important to cursorial movements for maintaining the forelimbs at sagittal plane, and the elbow flexor act to absorb the shock during the contact of the paw against the substrate.

Compared with other small felids, the jaguarundi is more similar to caracal (*Caracal caracal*). The jaguarundi differs from ocelot (*Leopardus pardalis*) for having less elbow flexor and supinator muscle and more adductor brachium. The adductor brachium of jaguarundi is considerably bigger than black-footed-cat (*Felis negripes)* and wildcat (*F. silvestris*). Comparatively, the jaguarundi is more able to support the forelimb in sagittal plane than ocelot, black-footed-cat and wildcat.

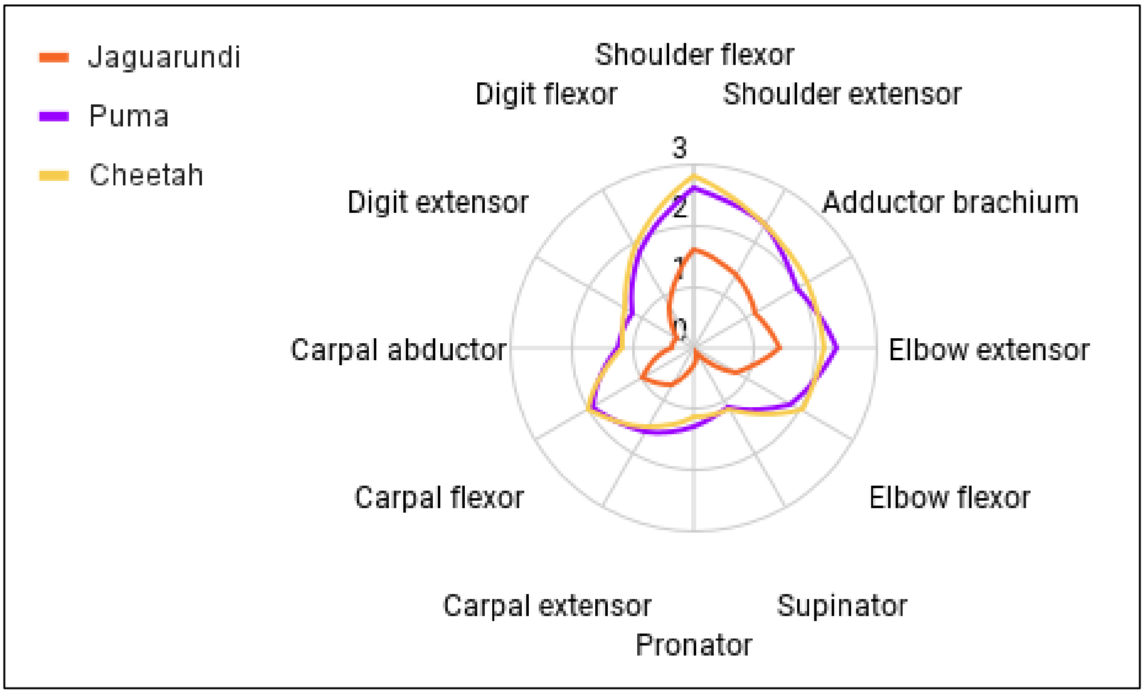

Figure 72 - Muscle mass distribution on Acinonychiini.

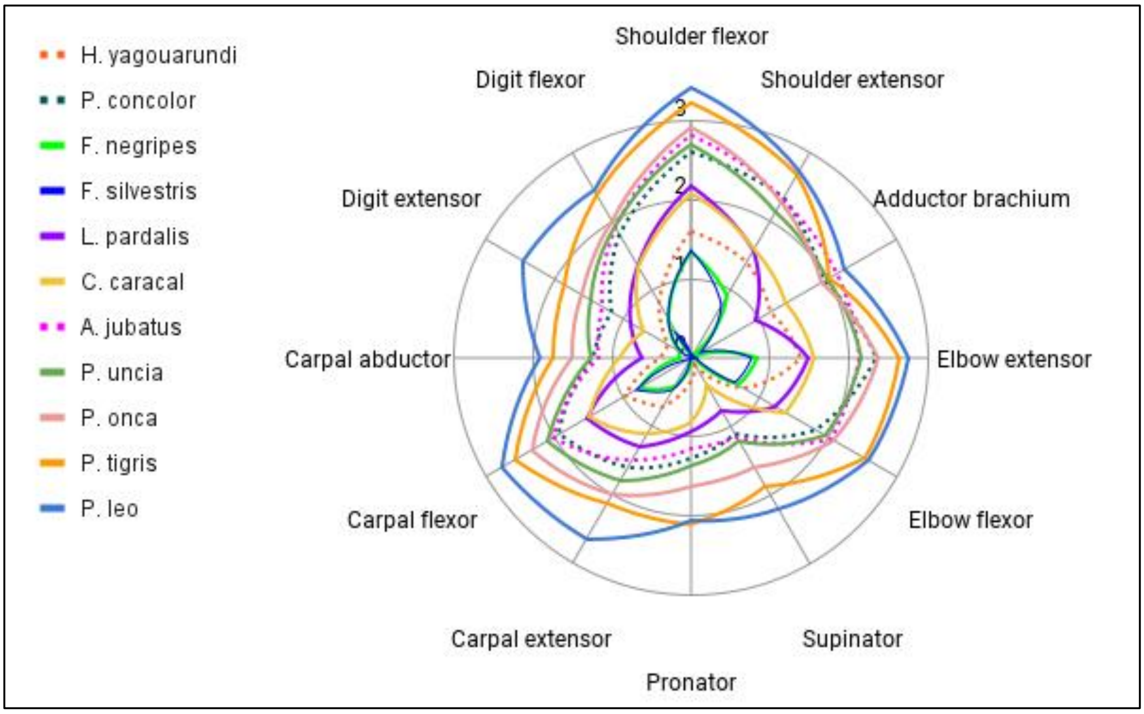

Figure 73 - Comparative muscle mass distribution for felids.

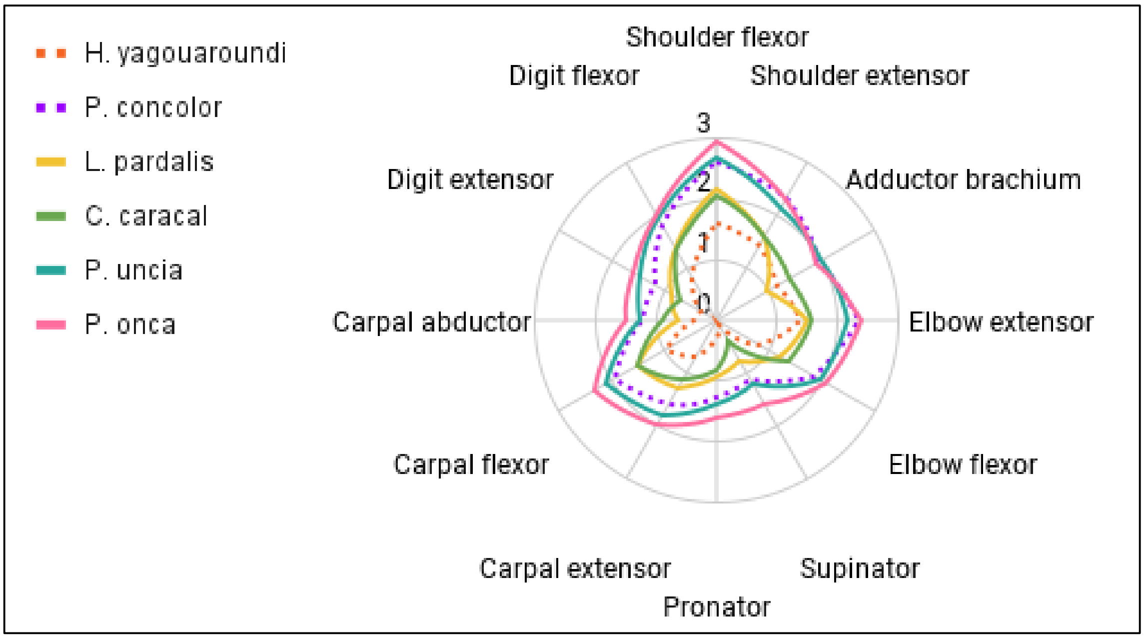

Figure 74 - Comparative forelimb muscle mass for scansorial felids.

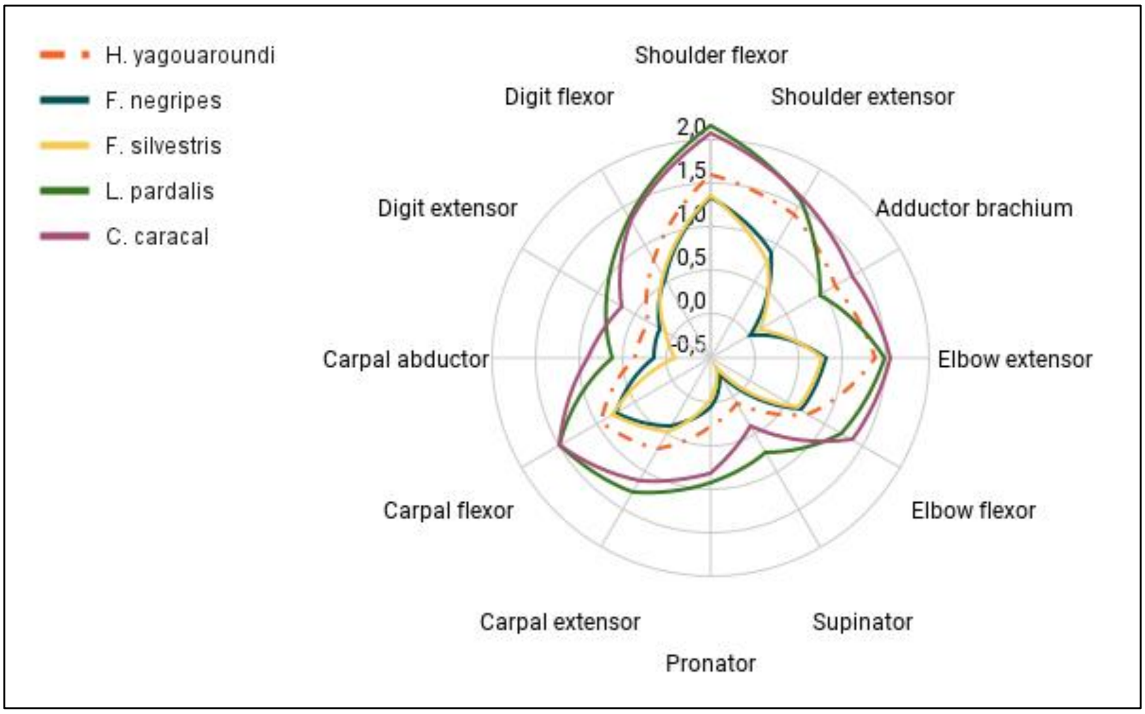

Figure 75 - Distribution of muscle mass in small felids.

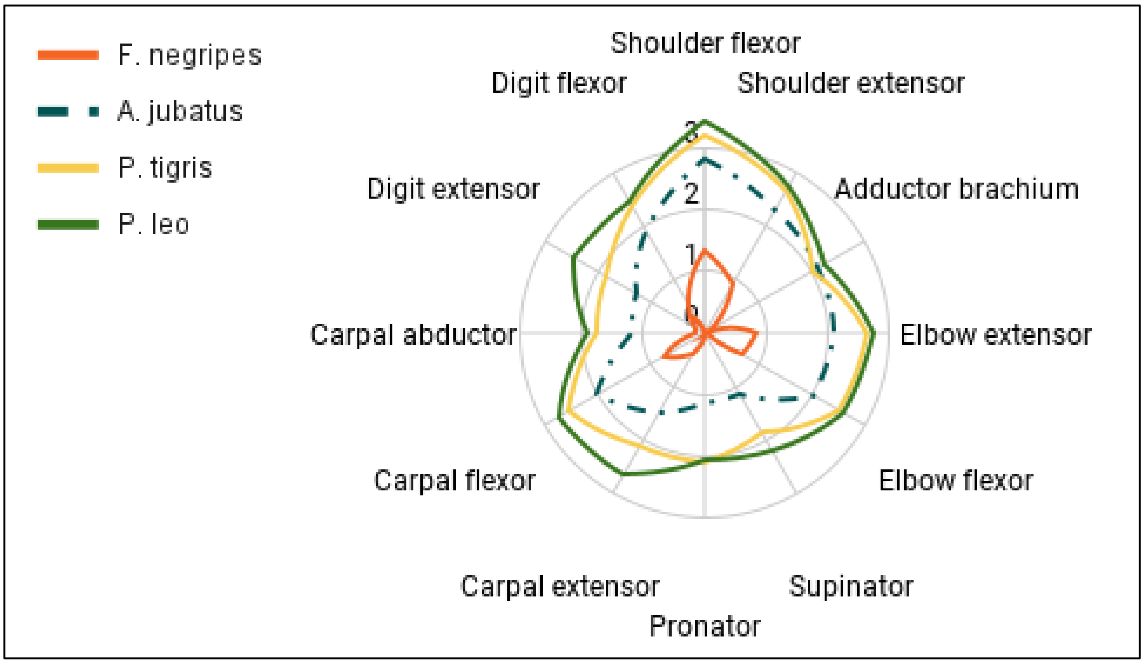

Figure 76 - Distribution of forelimb muscle mass for terrestrial felids.

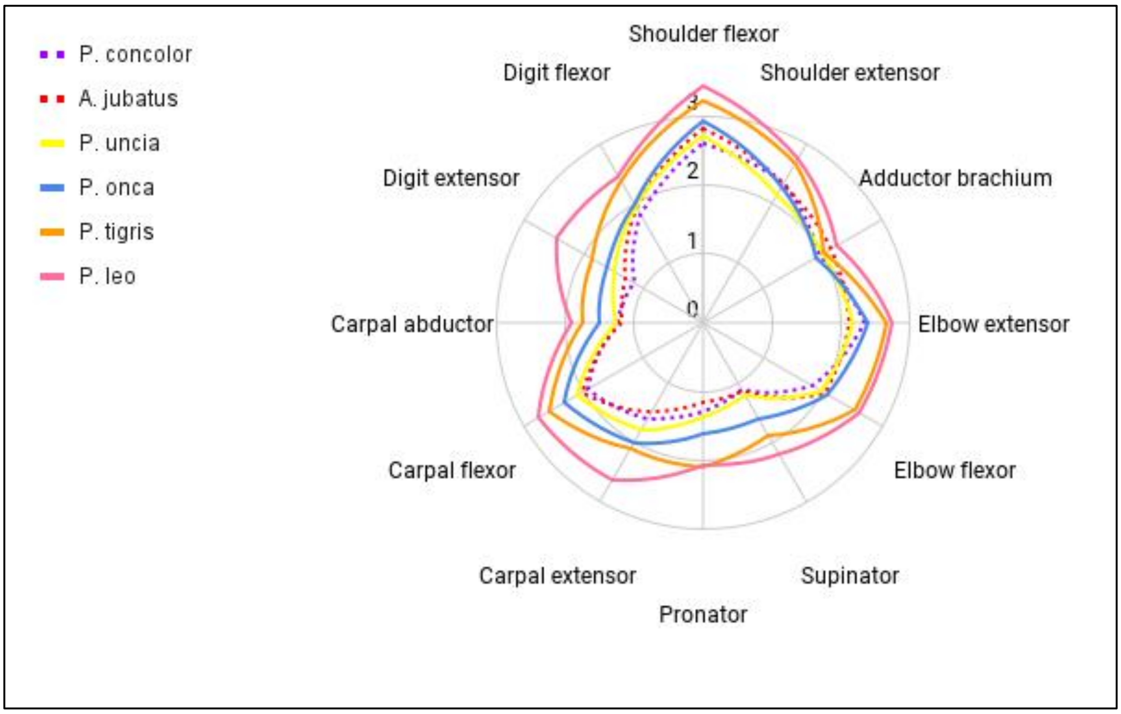

Figure 77 - Forelimb muscle mass distribution for large felids.

The lion has more carpal extensor and digit extensor than all felids in this study, which is congruent with previous works (Cuff et al., 2016, 2017). In cooperative hunt strategies, the lions usually remain attached to the prey until it collapses, so strong digit and carpal flexor muscles help them to grab the prey, while the supinator muscles help to change the forelimb position to direct the attack to the prey (Böhmer et al., 2019; Cuff et al., 2017; Gambarian, 1974; Hayward & Kerley, 2008; Julik et al., 2012; Stander, 1992).

The jaguar (*Panthera onca*) had a mass distribution similar to snow leopard (*Panthera uncia*), but the jaguar exhibits more supinator group mass than snow leopard, which is congruent with previous description that reported a well-developed *m. supinator* for jaguar, ranging almost the entire length of *corpus radii facies cranialis*, while this muscle for snow leopard range only the half proximal aspect of radius (Cuff et al., 2016; Sánchez et al., 2019; Smith et al., 2021). The pronator mass of jaguar also was bigger than snow leopard, and this difference might be despite the *m. pronator quadratus*, because the extension of *m. pronator teres* is very similar to both. The *m. pronator teres* of both felids originates from *medial epicondyle* of humerus and range throughout the radius until the carpus, however, this muscle in jaguar fuses with *extensor retinaculum* while in snow leopard it inserts onto tendon of *m. adductor digit I longus*, via tendon (Sánchez et al., 2019; Smith et al., 2021).

CONCLUSION

The three living species of the tribe Acinonychinii have forelimb musculature significantly different, and both qualitative and quantitative data can be associated with locomotor mode and prey preference, as suggested by Meachen-Samuels and Van Valkenburg (2009). The cheetah has adaptations for cursorial locomotion, but not for using the forelimbs to climb or apprehend prey, while the puma exhibits adaptations for climbing and grabbing. The jaguarundi has adaptations for cursorial locomotion and the ability to subdue prey with the forelimb.

The cursorial adaptations for cheetahs include the insertion of m. triceps brachii caput longum onto the entire length of the caudal border of scapula, the small m. supinator and m. pronator teres, and the absence of m. brachioradialis. The m flexor digitorum profundus with four heads and the fusion (Böhmer, et al. 2021) or absence of m. extensor carpi radialis brevis (Ross, 1883), as well as the poorly developed supinator muscles, is more associated with the use of the forelimb capture prey (Dunn et al., 2022; Gambari͡an, 1974; Julik et al., 2012; Randau et al., 2016).

On the other hand, the puma has the mm. extensor digitorum communis and palmaris longus with 5 tendons, the m abductor digiti V with two bellies and two tendons, and the presence of m. flexor digitorum profundus of digit I, which increases the capacity of extending and flexing the digits. These characteristics help to catch prey and to grab the small surfaces present in rupicolous environments. The puma also has a distinct insertion of the mm. pectoralis profundus and superficialis, which increase the adduction of the proximal aspect of scapula, but biomechanical analyses are necessary to understand how this affects the movement of the forelimb in this species.

The jaguarundi has an intermediary condition compared with puma and cheetah. It exhibits well developed mm. supinator and pronator teres, as the puma, but as well developed as in other medium-sized scansorial felids, such as the ocelot and lynx (Julik et al., 2012; Viranta et al., 2016). It also has the m. palmaris longus with five tendons, which increase its grabbing ability, and these characteristics combined may be associated to the specifics adaptations shown by this species for hunting small thourgh medium and, ocasionally, large prey, on the ground (Dunn et al., 2022; Gambari͡an, 1974; Gonyea, 1978b; Julik et al., 2012; Miriam M. Morales et al., 2018).

Our results show that the understanding of the muscle anatomy of felids, which is surprisingly only incipiently known, may help clarify many aspects about bone anatomy and locomotion and hunting behavior in these carnivores. It also may lay the ground to develop further studies using biomechanical, functional morphology, and kinematic approaches, further contributing to the understanding of many aspects of the evolutionary biology of felids.

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