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THE POST-CRANIAL MYOLOGY OF TARENTOLA ANNULARIS, AGAMA MUTABILIS AND CHAMAELEON VULGARIS IV- FORE LIMB MUSCLES: HAND REGION

(With 5 Figs.)

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العضلات خلف الجمجمة للبرص الأسود (تارينتولا انيولاريس) ،
قاضي الجبل (اجاما ميوتابيلس) والحرباء (كاميليون فولجاريس) .
٤ ـ عضلات الطرف الأمامي (منطقة اليد)

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في هذا البحث تم وصف ١٤ عضلة لمنطقة اليد في كل من السحالي الثلاثة التالية : البرص الأسود (تارينتولا أنوبولاريس) ، قاضي الجبل (أجاما ميوتابيلس) والحرباء (كاميليون فولجاريس) . وقد تبين من الدراسة الحالية أن حركة البرص الرشيقة والسريعة ، وكذلك قابلية الحرباء للتعلق بفروع الأشجار ، ويمكن أن تعزي إلي القابلية العالية للحركة الحرة لأصابع اليد ، كنتيجة لعدم وجود الصفاق اليدوي (Palmar aponeurosis) ، وغياب بعض العضلات المتصلة به ، مثل العضلات المرقمة ٦٧ ، ٦٨ ، ٦٩ ، ٧٠ ، ٧٢ ، ٧٤ ـ كما أن ترتيب أصابع اليد للحرباء في مجموعتين متقابلتين يمثل درجة عالية من التكيف الوظيفي .

SUMMARY

Fourteen hand muscles in three lizards having different modes of life were accurately described and compared. The elegant and quick movements of Tarentola, and the ability of holding the branches of trees in the case of Chamaeleon is due to the free and highly mobile movements of the digits of the hand, as a result of the absence of palmar aponeurosis. In fact, the arrangements of the digital scales in Tarentola, and the digits of Chamaeleon in two opposing groups represent high degree of functional adaptations.

INTRODUCTION

Details of the hand musculature of lizards are still fragmentary and always described related to the forearm flexor-extensor muscles (HAINES, 1946; ROMER, 1922 and STRAUS, 1942). Also, the form and structure of digits of some lizards were found to be of great intrest (ERNST and RUIBAL, 1966; ROBINSON, 1975; RUSSEL, 1977; RUSSEL and BAUER, 1988; STEPHENSON, 1960 and WILSON, 1975). Concerning many geckos, the morphological differences of the subdigital pads were discussed as species specific and used as taxonomic feature (RUIBAL and ERNST, 1965 and RUSSEL, 1976 & 1979). In addition, fine details of the blood network of the fore limb with special attention to the hand region were studied as a good approach to evaluate the degree of functional adaptation of some lizards (DeSILVA, 1956; DUDA, 1974; EDWARDS, 1960; KASHYAP and NIGWEKAR, 1964; RUSSEL, 1975 & 1981 and ZUG, 1971). However, myological studies of some parts of the reptilian body are found in the literature, but a full list of the whole body muscles is still incomplete and less accurate (GEORGE, 1948 and MIVART, 1870).

So, the authors of the present work were stimulated to start a great project of comparative study on the myology of different reptile animals. The first study was conducted on Uromastyx aegyptia (KHALIL, et al. 1977). The next one was on Psammophis sibilans (KHALIL, et al. 1987 1-5). In the present stage the same authors are intended to select three lizards having different modes of life:

a: Tarentola annularis which is an excellent climber animal on walls and ceilings.

b: Agama mutabilis which is a good runner on the substrate.

c: Chamaeleon vulgaris representing an arboreal lizard while on the ground it is a bad and slow walker.

The present work represents one of the authors' series on studying the post-cranial myology of the above mentioned lizards. The hand muscles of these lizards are the aim of the present paper, while the other body regions are given in separate ones (WAHBA, et al. 1992 a,b,c).

MATERIAL and METHODS

The three lizards examined in the present work are Tarentola annularis, Agama mutabilis and Chamaeleon vulgaris. Animals were collected and treated for dissection. Then muscles were exposed by normal technique but with very high accuracy, and dissected parts were first photographed and then drawn. Skeletal elements were obtained by cleaning and macerating soft parts, then bleached by oxygen peroxide to be ready for investigation.

RESULTS

a) Dorsal Muscles:

61- Dorsal carpo-digital
62- Dorsal metacarpo-digital
63- Dorsal metacarpo-metacarpal

Tarentola annularis

The dorsal carpo-digital (61) (Fig. 1 a,b & c)

It comprises five units, arising on the dorsal side of the ulnare. The first unit which supplies the first digit gains an additional origin from the dorsal side of the distal end of the ulna. That unit is inserted by three tendons. The first tendon is attached on the dorsal side of the proximal end of the basal phalanx of the 1st digit. The second tendon is attached on the dorsal side of the proximal end of the second phalanx of that digit. Finally, the third tendon is inserted on the dorsal side of the proximal end of the terminal phalanx. Each of the other four units of muscle (61) extends along the dorsal side of the corresponding digit, and ends by a long tendon which runs in between the units of muscles (62) and (63) to be inserted on the dorsal side of the terminal phalanx of the corresponding digit. The independent insertion ligaments of the units of muscle (61) give more free action for units which fit with the type of walking of that gecko.

The dorsal metacarpo-digital (62) Fig. 1 a,b & c)

Muscle (62) consists of five units, each unit originates on the dorsal side of each metacarpal bone.

The dorsal metacarpo-metacarpal (63) (Fig. 1 a,b & c)

Muscle (63) consists of four units, each unit arises on the posterior side of the proximal half of anterior metacarpal bone. Hence the pollex has no unit of muscle (63). Each unit of muscle (62) lies posterior to the corresponding metacarpal, while the unit of muscle (63) lies anterior to that metacarpal. At the base of each digit the unit of (62) ends by a broad tendon which fuses with the terminal tendon of unit of (63). That common tendon gives numerous fine branches which are inserted on the dorsal side of scales of the corresponding digit. In the case of the first digit, which has only a unit of (62), the distal insertion tendon of the unit (62) gives fine branches which are inserted on the first digital scales.

Agama mutabilis (Fig. 1 d & e)

The dorsal hand muscles are quite similar to those of Uromastyx aegyptia previously described (KHALIL, et al. 1977). The main anatomical arrangement may be summarized in the following. The muscle units of (61) originate on the dorsal side of the ulnare, and those of muscle (62) originate on a transverse line found at the base of the corresponding metacarpal. Finally, each unit of muscle (63) originates on the base of the posterior side of the anterior metacarpal. Then, the three tendons of insertion of the three units for each digit fuse together to form a very strong tendon, that extends along the dorsal side of the corresponding digit and is inserted on the base of its terminal phalanx. The only difference from that of Uromastyx is concerned with the unit of muscle (61) supplying the fifth digit which gains additional origin on the dorsal surface of the distal epiphysis of the ulna.

Chamaeleon vulgaris (Figs. 3 a,b,c & 4 a)

As expected due to the special type of movement of Chamaeleon, the levator muscles (61, 62 & 63) have a special type of arrangement that serves for a special type of movement.

For the muscle (61) the units of that muscle are arranged into two divergent sets. The morphologically preaxial or topological ventral set which supplies the anterior group of three digits is directed preaxially, while the set of muscle which supplies the postaxial group of two digits is directed postaxially. The units of the preaxial set originate together on the dorsal surface of the epiphysis of the ulna, while the units of the postaxial group originate on the compound carpal bone resulting from the fusion of the radiale and ulnare. The first unit of the preaxial set is inserted on the dorsal surface of the first metacarpal, while the second and third units are inserted each on the dorsal surface of the basal phalanx of the corresponding digit. In the case of the postaxial units there is, in fact, a single unit which corresponds to the fifth digit and is inserted on the dorsal surface of the basal phalanx of that digit.

In the case of muscle (62), each unit originates on the metacarpal of the corresponding digit, whether on one point or two, and is inserted by a relatively long ligament on the terminal phalanx of that corresponding digit.

In the case of muscle (63), seven units could be identified which have a complicated arrangement. All of these units originate on the metacarpalia and are inserted on the digits in different directions. The first unit originates on the second metacarpal and its insertion tendon is fused with the insertion tendon of the first unit of muscle (62) which corresponds to the first digit. The second unit originates on the fourth metacarpal and again its insertion tendon is fused with the insertion tendon of muscle (62) unit which corresponds to the fifth digit. The third unit also originates, but independently, on the fourth metacarpal and its insertion tendon is also fused with the insertion of muscle unit (62) that corresponds to the fifth digit. The fourth unit originates on the second metacarpal and its insertion ligament is inserted on the basal phalanx of the second digit. The fifth unit originates on the third metacarpal and its insertion tendon is attached to the basal phalanx of the third digit. In fact, the sixth and seventh have antagonistic directions of pull and they could be considered as weak adductors of the divergent two groups of digits. The sixth unit originates on the fourth metacarpal, its insertion tendon is fused with the fifth unit to be inserted together on the proximal end of the basal phalanx of the third digit. Finally, the seventh unit which is relatively the largest unit originates on the third metacarpal and is inserted by a short ligament on the proximal end of the basal phalanx of the fourth digit. All those units, belonging to muscles 61, 62, and 63, are dorsal abductor of the two groups of digits (dorsal extensors of the digits in the other lizards studied).

b) Ventral Muscles

64- Ventral lower carpo-digital (Figs. 2 a,b, 4 b, 5 b,c & d)

The anatomical relationships of that muscle are similar in all the lizards studied. It is a small muscle that originates on the ventral surface of the pisiform and is inserted by a long tendon which extends along the fifth metacarpal and finally is attached on the basal phalanx of the fifth digit. That muscle has an abductor effect on the fifth digit.

It should be noticed that the muscles which are located ventral to the palmar aponeurosis have their names preceded by the term subpalmar, while those muscles which were found dorsal to the palmar aponeurosis have their names preceded by the term suprapalmar.

65- Ventral subpalmar carpo-digital

Tarentola annularis (Fig. 5 a)

The ventral subpalmar carpo-digital consists of five units, originating on a tendon that extends between the radiale and ulnare. At the metacarpus, each unit divides into two branches. The distal end of each branch gives fine ligaments which are inserted on the ventral digital scales. Further, some muscle fibers of those branches are inserted on the basal phalanx of the corresponding digit. The state of origin of the units in question as well as their mode of insertion and the duplication of each unit make those units purely and very efficient depressors of the digits.

Agama mutabilis (Fig. 2 a & b)

This muscle consists of five component units, each of which corresponds to one digit. All these units originate on the ventral surface of the pisiform. The muscular tissue of each unit extends up to the base of its corresponding digit before it produces its insertion tendon. In the case of the first digit the muscle unit of (65) is inserted by a pair of short tendons on the base of the basal phalanx. The foramen between that pair of insertion tendons allows for the passage of the tendon arising from the palmar aponeurosis. In case of the second and fifth units of (65), the insertion tendon possesses a sort of a foramen at its base, through which passes the tendon arising from the distal end of the palmar aponeurosis. That tendon, of muscle (65), is distally inserted on the ventral surface of the penultimate phalanx of the corresponding digit. In the case of the third digit, the unit of muscle (65) produces distally a pair of tendons. The anterior of those tendons fuses with the tendon arising from the unit belonging to muscle (66), and the joint tendon is inserted on the ventral surface of the base of the penultimate phalanx of the third digit. The postaxial tendon of muscle (65) is inserted on the ventral surface of the base of the pre-penultimate phalanx of that digit. In the case of the fourth digit, the unit of muscle (65) produces a single tendon which is inserted separately on the base of the pre-penultimate phalanx of the fourth digit. Finally, the tendon arising from the lateral side of the palmar aponeurosis runs between the above mentioned two tendons elonging to (65 & 66). The first to third units belonging to muscle (65) could produce. an adductor effect on the first to the third digits, while its fourth and fifth units cannot have except a depressor effect on the fourth and fifth digits respectively.

66- Subpalmar palmo-digital

Tarentola annularis (Fig. 5 b)

The subpalmar palmo-digital comprises four units, the first and second of which supply the third digit, while the third and fourth supply the fourth digit. The first, second and third units originate from the third insertion tendon of the humero-palmar muscle (56), while the fourth unit of muscle (66) originates from the fourth insertion tendon of muscle (56). It should be noted that the fourth unit of muscle (66) is biforked to supply both sides of the fourth digit. It is clear that this muscle has a good and efficient depressor effect on the digits.

Agama mutabilis (Fig. 2 a, b)

That muscle comprises three units which correspond to the second, third and fourth digits. The first of those units is the smallest in size while the third is the largest. The units of muscle (66) originate on the ventral surface of the palmar aponeurosis. The first unit, which corresponds to the second digit, is directly inserted on the base of the pre-penultimate phalanx. The insertion of the second and third units, which correspond to the third and fourth digits, are described above in connection with the units belonging to the muscle (65). The units of muscle (66) are pure depressors of the second to fourth digits.

67- Carpo-palmar

Tarentola annularis (Fig. 5 b)

It consists of two units, that originates on the distal carpalia and is inserted on the posterior sides of each of the first and second insertion ligaments of the humero-palmar muscle (56). That muscle has a binding function.

Agama mutabilis (Fig. 2 c)

It consists of a group of short muscle fibers which extend between the proximal rim of the dorsal surface of the palmar aponeurosis and the first, second and distal carpalia. That muscle has a binding function.

Chamaeleon vulgaris

That muscle is absent.

68- Suprapalmar palmo-digital

Tarentola annularis and Chamaeleon vulgaris

Also that muscle is absent due to the absence of the palmar aponeurosis.

Agama mutabilis

The muscle comprises three units which correspond to the second, third and fourth digits. The units are small in size and all originate on the dorsal side of the palmar aponeurosis. Each of those units is directly inserted on the base of the basal phalanx of its corresponding digit.

69- Ventral suprapalmar metacarpo-fifth digital

Tarentola annularis and Chamaeleon vulgaris

That muscle is absent.

Agama mutabilis (Fig. 2 c)

The muscle has the same common origin of muscles (70 & 71) on a ligament that extends between the fourth and fifth distal carpal bones and is inserted on the preaxial side of the basal phalanx of the fifth digit.

70- Ventral suprapalmar carpo-first digital

Tarentola annularis and Chamaeleon vulgaris

The muscle is absent.

Agama mutabilis (Fig. 2 c)

The muscle originates with muscle (69) and is inserted on the base of the first phalanx of the first digit. It is an adductor muscle of the first digit.

71- Ventral suprapalmar carpo-digital

Tarentola annularis (Fig. 5 b & c)

It consists of five units, which all originate on the third distal carpal bone. Each unit supplies a digit. In such a case the median group of muscle fibres are inserted on the basal phalanx of the digit while the lateral group of fibers are inserted on the ventral scales of the lateral side of that digit.

Agama mutabilis (Fig. 2 c)

It consists of five units, the first of which extends between the radiale and the ventral surface of the base of the basal phalanx of the first digit. The posterior four units originate on the second to the fifth distal carpals respectively and are inserted on the ventral surface of the base of the basal phalanx of the corresponding digit. The units of this muscle could have a depressor effect on the digits.

72- Suprapalmar oblique carpo-metacarpal

Tarentola annularis

The muscle is absent.

Agama mutabilis (Fig. 2 d)

It originates by a biforked ligament whose branches are attached on the fifth carpal and metacarpal bones. The muscle itself is broad and short, and gives distally three short branches which are inserted on the ventral sides of the proximal ends of the first, second and third metacarpal bones.

73- Ventral metacarpo-metacarpal

(Figs. 2d & 5d)

In case of Tarentola, Uromastyx and Agama that muscle is found with the same morphological and anatomical relationships, i.e. it consists of four units. Each of those units is in the form of a sheet of muscle fibres that extends in an oblique direction, between the ventral surface of two successive metacarpals. Obviously, the units of that muscle have a binding function.

74- Ventral metacarpo-digital

(Fig. 2 d)

That muscle is absent in the case of Tarentola annularis. While in Agama mutabilis, it consists of four units. The first of those units extends, in an oblique direction, between the ventral surface of the second metacarpal and the posterior side of the base of the basal phalanx of the first digit. The fourth unit extends between the ventral surface of the fifth metacarpal and the posterior side of the base of the first phalanx of the fourth digit. Obviously, those units have an adductor effect on the digits.

Hand musculature of Chamaeleon (Fig. 4 a,b,c & d)

The hand of Chamaeleon is highly modified to save the function of holding branches. That modification affected both of the skeletal and myological structures. Generally, the digits are arranged into two opposing groups, an anterior group of three digits and a posterior group of two digits. The depressor function of the ventral hand muscles has changed to the function of adduction of the two groups of the digits. The structure of the carpus is described by WILLISTON (1925). Although the ventral hand muscles are described below, yet it is highly preferable not to suggest their true homology with these found in normal lizards like Uromastyx. So, one can say with reasonable safety that the ventral muscles found in Chamaeleon may belong to the ventral muscles (65 and 66) in Uromastyx list (KHALIL, et al. 1977).

The ventral musculature of the hand of Chamaeleon can be described as follows:

1 - The ventral lower carpo-fifth digital muscle (64) has the same pattern of that of Uromastyx and other lizards (Fig. 4 b).

2 - There is a muscle (Ch.h.I = 65) which originates on a transverse ligament that extends between the proximal epiphyses of both the third and fourth metacarpal bones. The bundles of that muscle are inserted along the preaxial sides of the phalanges of the third and fourth digits (Fig. 4 c). Another similar muscle originates on a ligament extending between the proximal epiphyses of both the 1st and 5th metacarpal bones, its bundles are inserted along the postaxial sides of the phalanges of the first, second and fifth digits.

3 - A third muscle (Ch.h. 2 = 66) consists of two units, one of these units originates on the tendon of the humero-palmar muscle (56) that supplies the third digit. That unit is inserted on the terminal phalanx of the third digit. The second unit originates on the tendon of muscle (56) that supplies the fourth digit, and is inserted on the ventral sides of the distal phalanges of the fourth digit (Fig. 4 d).

4 - Three feather-shaped muscles (Ch.h. 3 = 74') originate on the fused fourth and fifth carpal bone (WILLISTON, 1925) by three ligaments. The first muscle is inserted on the opposing sides of the first and second digits. The second muscle is inserted on the opposing sides of the second and third digits, and finally the last muscle is inserted on the opposing sides of the phalanges of the fourth and fifth digits (Fig. 4 d). Most probably, the whole ventral musculature of the hand of Chamaeleon acts as abductor of the two groups of digits.

DISCUSSION

Studies on the locomotor adaptation of reptiles were interested to deal with the different ways of movements (HAINES, 1946 & 1952 and SNYDER, 1949). For example, terrestrial chelonians are walking slowly on all four limbs (AUFFENBERG, 1966 and HENDRICKSON, 1958). Other examples are the crawling of crocodilians on their bellies in a primitive way (COTT, 1961) and bipedal movements which are more efficient in some lizards (STEPHENSON, 1960 and WORRELL, 1963). Also, climbing adaptation among chamaeleons and geckos attracted the attention of some workers (ALI, 1948 and MAHENDRA, 1941). However, osteological as well as morphological details of the claws, digital pads and setae have been much studied with this respect (EL-TOUBI and KHALIL, 1955; ERNST and RUIBAL, 1966; MADERSON, 1966; ROMER, 1956 and RUIBAL & ERNST, 1965). So, the aim of the present work is to discuss the comparative myological details of the hand region of three lizards with different ways of movements: the first is a good runner on walls and ceilings (Tarentola annularis), the second is a good runner on the ground and to some extent can move bipedally (Agama mutabilis) and the third is an arboreal lizard (Chamaeleon vulgaris).

Inspite of characteristic specific anatomical differences one could safely say that the units of the dorsal carpo-digital (61), dorsal metacarpo-digital (62) and dorsal metacarpo-metacarpal (63) of all lizards examined are extensors or levators of the digits (or abductors of the two groups of digits of Chamaeleon). Although the ventral lower carpo-fifth digital (64) is an abductor of the fifth digit and is found in all of the lizards examined, yet the muscles concerned with the normal adduction and abduction of the digits will be neglected in the present discussion because those functions are primitive in the case of lizards when compared with man and are of insignificant phylogenetic value. On the other hand, the depressor function of the digits is the more important in the case of lizards in general and very particularly in Tarentola and to a lesser extent in Chamaeleon. The digital depressors in all lizards examined are the ventral subpalmar carpo-digital (65) and the subpalmar palmo-digital (66). In the case of Uromastyx and Agama the ventral suprapalmar carpo-digital (71) and the suprapalmar oblique carop-metacarpal (72), are also depressors. In Tarentola the ventral suprapalmar carpo-digital (71) is also a depressor composite muscle. When the muscles affecting the movement of the hand are studied, any functional anatomist could easily come to the conclusion that, although from a phylogenetic or a morphological point of view the muscles are the same yet the arrangement of those muscles is a resultant of the habits of movements of the lizards in question.

Accordingly, the lizards examined could be divided into three groups. The first group includes Uromastyx and Agama which are normal walking lizards. Interesting enough is that these lizards possess a strong plate-like palmar aponeurosis, which strenghthens the ventral surface of the palm and protects the animal against the hot surface of the desert substratum. However, the presence of that aponeurosis, as an intermediate structure intersecting the depressor muscles of the digits, lessens the effeciency of the working of those digits in both the strength of depression and general mobility. At the same time, for a normal walking lizard on a hot substratum the presence of the palmar aponeurosis is of a great help for the animal. The second group of lizards is represented, in the present work, by Tarentola annularis which lives mainly in houses or shaded places and could walk on vertical walls or upside down on ceilings. The third group of lizards is represented in the present work by the arboreal Chamaeleon vulgaris whose hand, foot and tail muscles are arranged to serve efficiently that type of movement. In fact, Chamaeleon is a bad walker on land. One should notice that Tarentola could display very elegant and quick movements and jumps than Chamaeleon. In addition, the elegant movement of Tarentola and the slow movement of Chamaeleon are due to several skeletal and muscular anatomical features. The palmar aponeurosis is absent in both Tarentola and Chamaeleon.

Further, it should be mentioned that units of muscle (61) in case of Tarentola are characterised by independent insertion ligaments giving free action of the digits. Also, the tendons of muscles (62, 63) fused together and are inserted on the dorsal sides of corresponding digital scales. Such type of arrangement may help in the function of subdigital pads of Tarentola during its movement on walls and ceilings. On the other hand, in the case of Agama the tendons of muscles (61, 62 & 63) fuse together and are inserted on the terminal phalanx of the corresponding digit giving them very good efficiency during its running coarse on the land. It is important to notice that Tarentola and Chamaeleon which live holding themselves to walls or trees are characterised by the absence of some muscles as 68, 69, 70, 72 & 74 while those muscles are found in walking lizards (first group) like Agama and Uromastyx.

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EXPLANATION OF FIGURES

Fig. 1: **a)** Dorsal view of the distal part of the fore arm and hand regions of Tarentola annularis showing the dorsal hand muscles.

b) Dorsal view of the skeletal elements of the hand region of Tarentola annularis showing the different areas of muscle attachments.

c) Diagramatic drawing of fused tendon of muscles 62 and 63 showing its relation to the scales of a digit.

d) Dorsal view of the distal part of the fore arm and hand regions of Agama mutabilis showing the different dorsal hand muscles.

e) Dorsal view of the skeletal elements of the hand region of Agama mutabilis showing the different areas of muscle attachments.

Fig. 2: **a,b,c & d)** The ventral layers of the hand region of Agama mutabilis.

Fig. 3: **a & b)** Dorsal views of the skeletal elements of the hand and the distal end of the fore arm of Chamaeleon vulgaris showing the attachments of different muscles: a- the anterior group of digits (I-II-III). b- the posterior group of digits (IV-V).

c) The distal end of the fore arm and the first three digits of Chamaeleon vulgaris showing the related muscles.

Fig. 4: **a)** Antero-dorsal view of the fore arm and hand regions of Chamaeleon vulgris showing the different successive muscles.

b) General view of the hand region of Chamaeleon vulgaris illustrating muscles numbered 64 and 65.

c & d) The ventral successive layers of the hand region of Chamaeleon vulgaris.

Fig. 5: **a,b,c & d)** The ventral successive muscles of the hand region of Tarentola annularis.

EXPLANATION OF LETTERING

C - centrale, D.C. 1 & 5 - first and fifth distal carpals, H - humerus, M.C. 1 & 5 - first and fifth metacarpals, PI - pisiform, R - radiale, RD - radius, U - ulnare, UL - ulna.

Fig.(1)

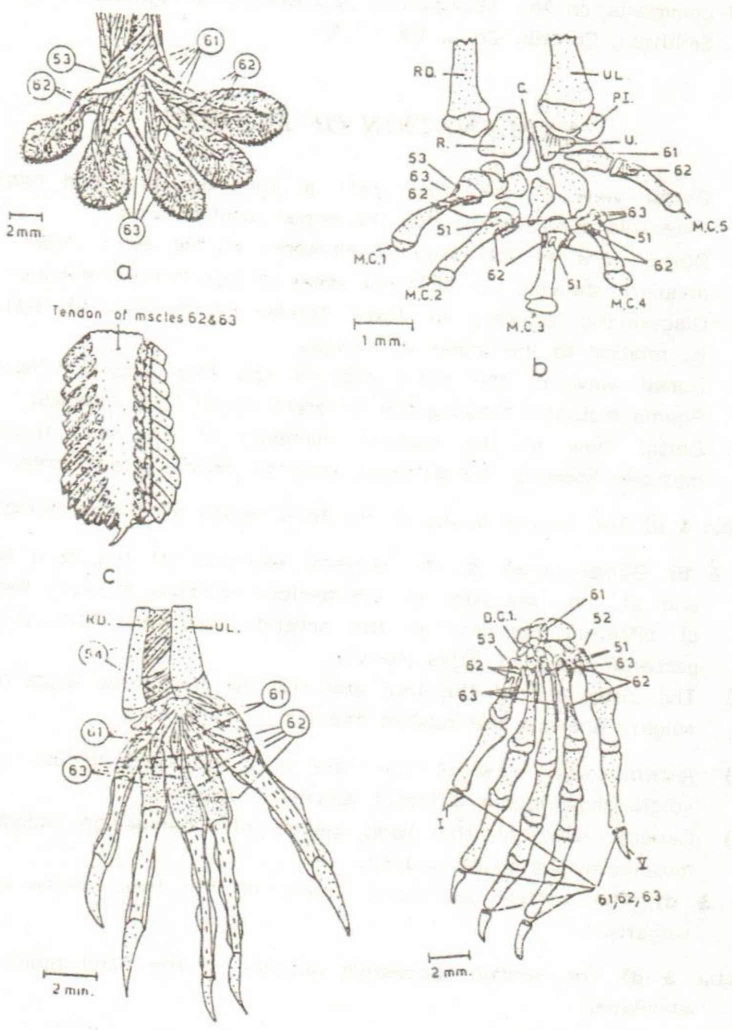


Fig.(2)

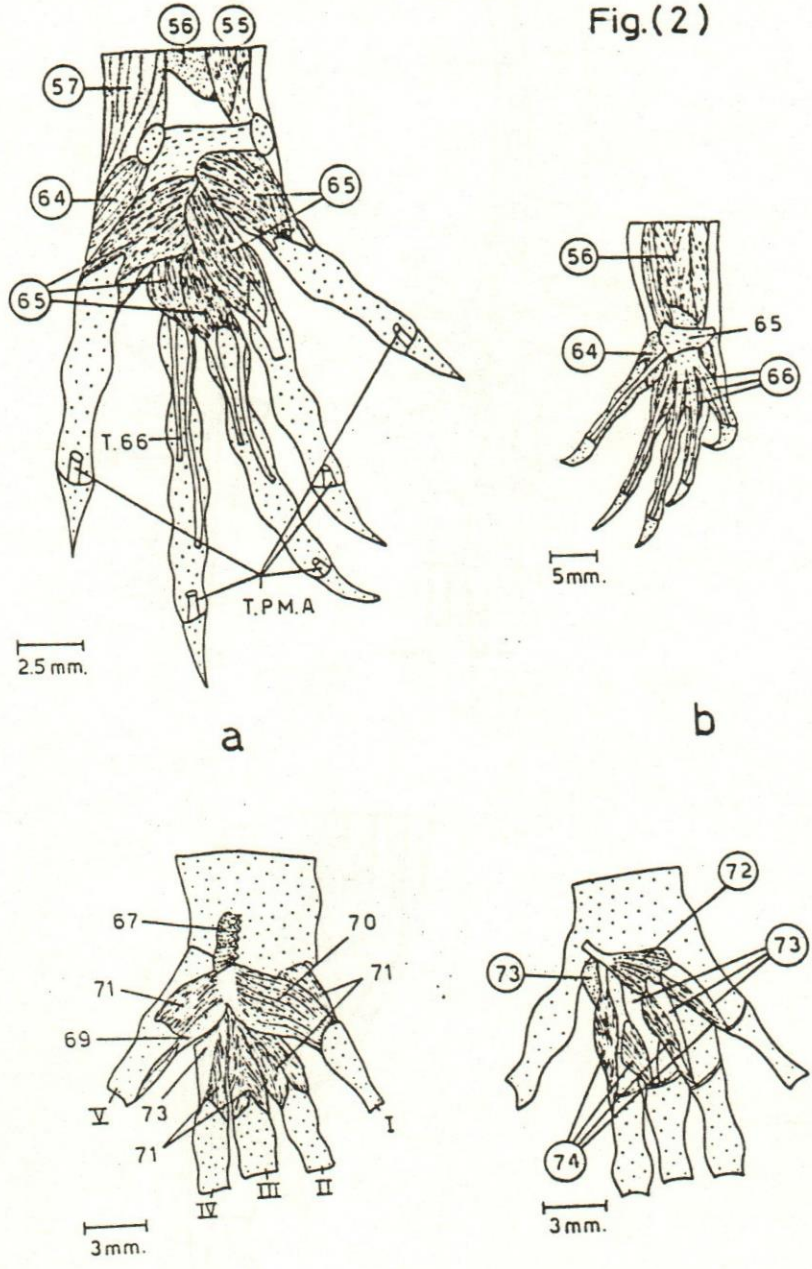
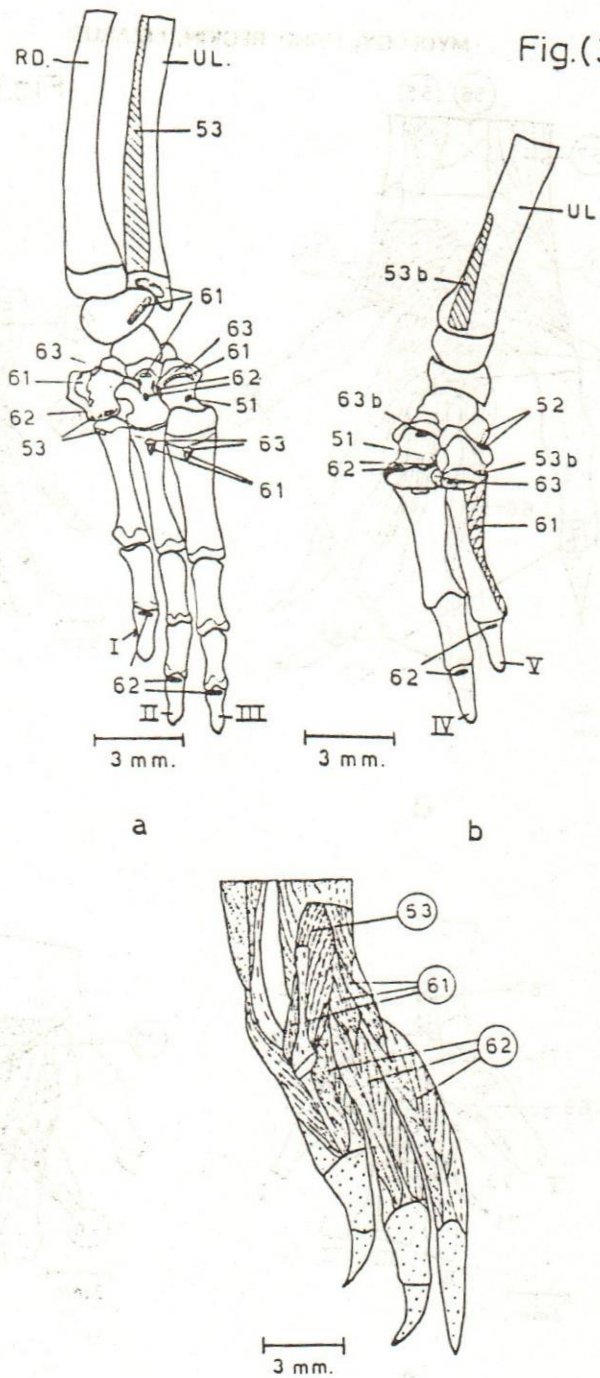

56
55
57
64
65
65
65
T.66
T.PM.A
2.5 mm.
a
56
65
64
66
5mm.
b
67
70
71
71
69
V
73
71
I
IV
III
II
3mm.
c
72
73
73
74
3mm.
d

Fig.(3)


RD.
UL.
53
61
63
61
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63
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62
53
63
61
I
62
II
III
3 mm.
UL.
53 b
63 b
52
51
53 b
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63
61
62
V
IV
3 mm.
53
61
62
3 mm.

a

b

c

Fig.(4)

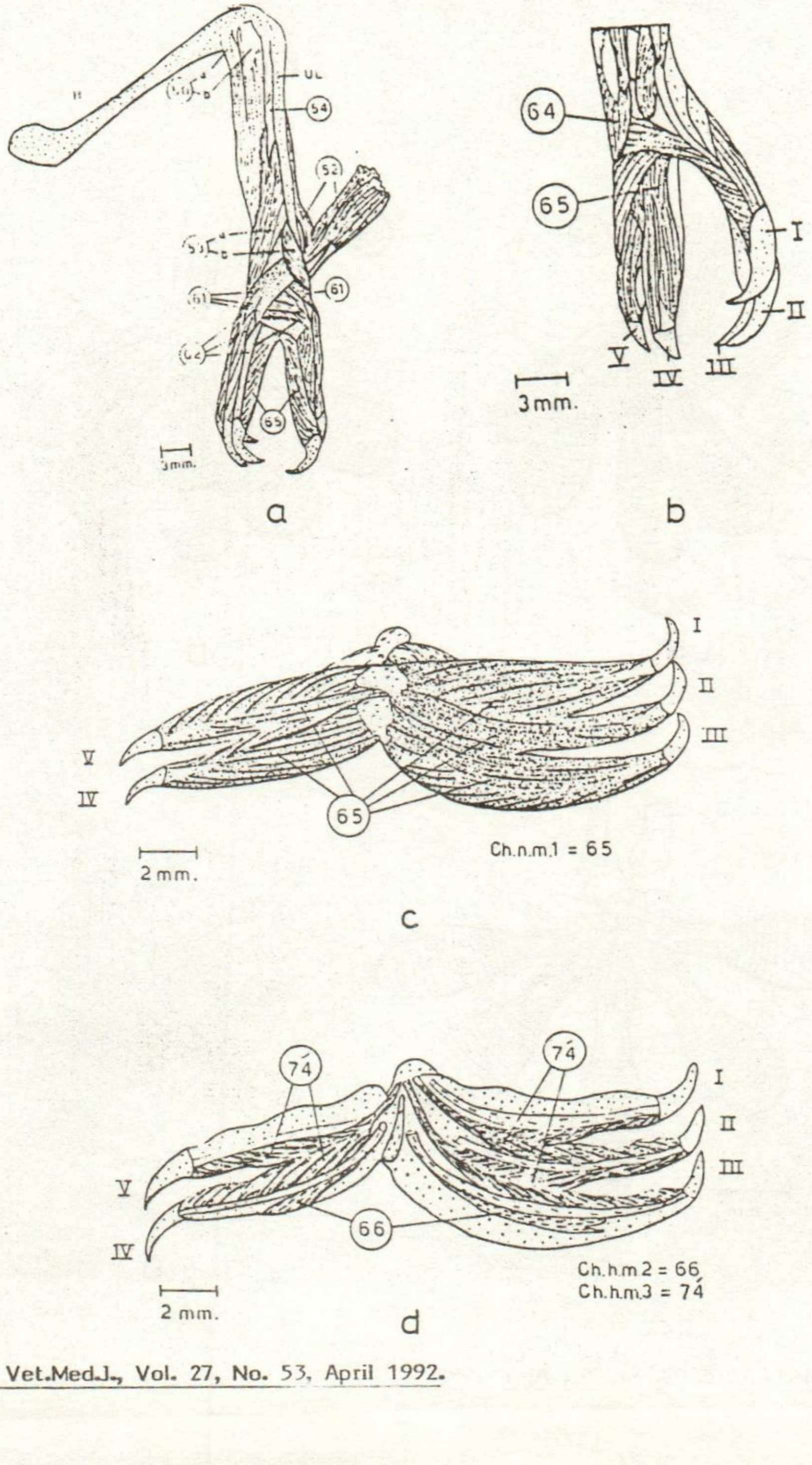
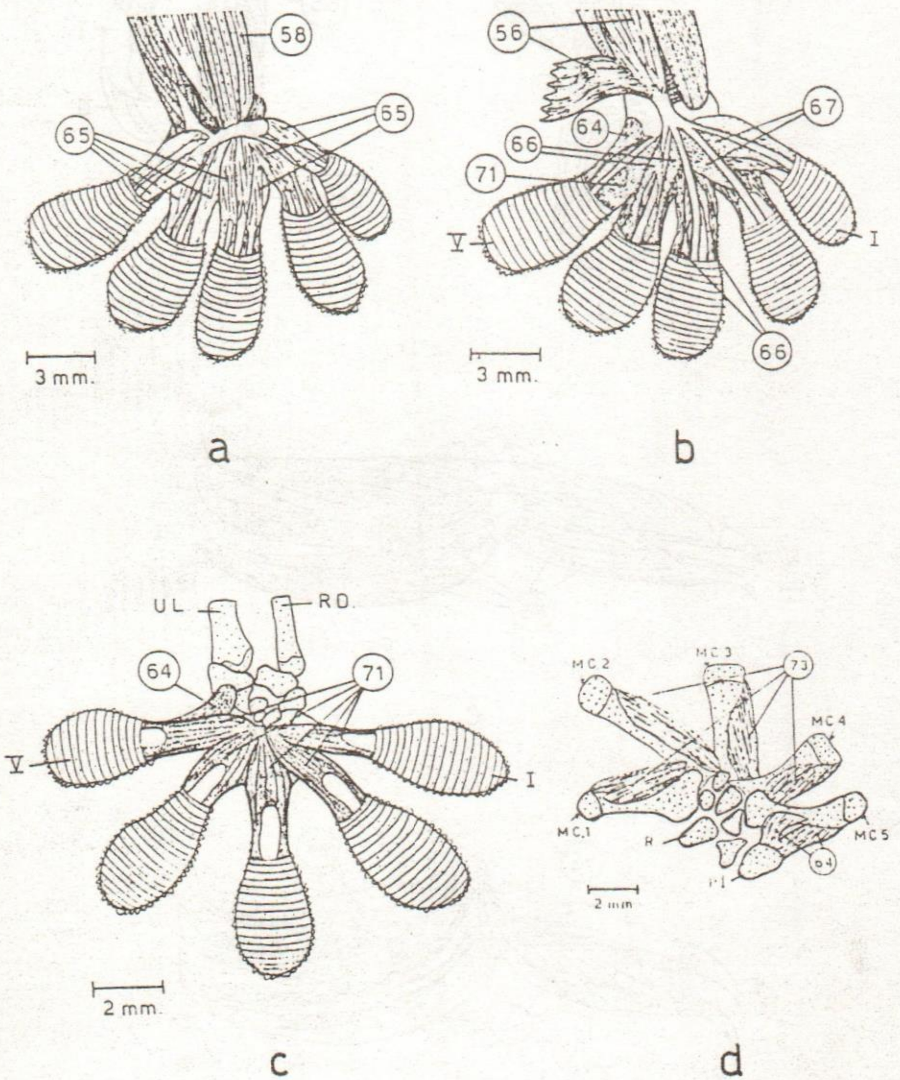

UL
54
52
53
61
61
62
65
3mm.
a
64
65
I
II
III
IV
V
3mm.
b
I
II
III
V
IV
65
Ch.n.m.1 = 65
2 mm.
c
74́
74́
I
II
III
V
IV
66
Ch.h.m 2 = 66
Ch.h.m.3 = 74́
2 mm.
d

Fig.(5)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56
65
65
64
67
66
71
V
I
66
3 mm.
3 mm.
a
b
UL
RD
64
71
V
I
MC 2
MC 3
73
MC 4
MC,1
R
MC 5
64
2 mm.
c
d