A C T A   T H E R I O L O G I C A

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Comparative Studies on the Muscles of the Limbs in Some Species of *Rodentia*

[With 1 Table & 46 Figs.]

An analysis was made of the musculature of the limbs in *Citellus citellus, Sciurus vulgaris, Citellus suslicus* and *Cricetus cricetus*. It was found that the muscles of the limbs are almost identical in the two species of sousliks, the only difference being the absence of *caput breve* in *m. biceps brachii* of *Citellus citellus*. There are distinct differences in the musculature of the limbs, particularly the pelvic limb, between the squirrel and sousliks. In the hamster some of the muscle units occurring in squirrels and sousliks are absent and conversely, muscles occur in the hamster which do not occur in the above-named representatives of *Sciuridae*. The structure of the muscles suggests that the squirrel has the most effective thoracic limb, while the foot of the hamster is more effective than the autopodia of the pelvic limbs in the other species of rodents examined.

I. INTRODUCTION

Rodents form a very varied group of animals in respect of their activity, the way in which they obtain their food and of their type of locomotion. Hatt (1932) gives the following types — living in trees, swimming, digging and moving in »ricochet« jumps, using the pelvic limbs. As a result of the different way in which they move about these animals differ from each other in respect of many characters, among which is the morphology of the muscular system.

Variations connected with the adaptation processes of different animal forms, due to the influence of changing habitat conditions, have interested researchers for a very considerable time. It has, however, proved impossible to establish with complete certainity all the factors determining the direction taken by such variations, or to find which of them plays a decisive part (Yakovleva, 1965).

Studies on the formation of the locomotor system of animals, its function and morphology are often fragmentary and not always carried out by uniform methods, which makes it difficult to compare results. M a ž u g a (1955) published a study on the origin and function of one muscle only *(m. popliteus)* in mammals. G a u g h r a n (1954) analyzed the bone and muscle systems of the capitocervical region in *Blarina brevicauda* and *Scalopus aquaticus,* without weighing or measuring the bones and muscles. Y a k o v l e v a (1963) examined the musculature of the under arm, B o d r o v a (1963) the muscles of the arm and scapula, S o k o l o v (1964) — the bone and muscle systems of the pelvic limb, taking into consideration the topography, weight and also the dimensions of muscles in species belonging to the family *Sciuridae.* The whole muscular system was examined in four genera of *Dipodidae* and four of *Cricetinae* by R i n k e r (1954) and K l i n g e n e r (1964). P e t e r k a (1937) compared the skeleton and muscles in animals with different modes of locomotion.

Studies of this kind, despite the varying research methods used, make it possible to examine changes arising from adaptation to different types of locomotion, and to carrying out activities proper to the given species (G a m b a r i a n, 1960; D a s t u g u e, 1963 and other). They may also be of great importance in establishing phylogenetic connections between different groups of animals (B r y a n t, 1945), and may extend the range of discovered characters connected with the systematics of mammals.

The results of many studies on the locomotor apparatus and problems connected with its formation have been published, but the subject remains unexhausted.

The purpose of the present study is: 1. to determine variations in the muscles of the two limbs in mammals belonging to the same family, living in different habitats and differing in their type of locomotion; 2. to examine the characters of the muscular system in the limbs of animals belonging to different families with similar ways of locomotion, living in similar habitats; 3. to make a comparative analysis of the muscles in the limbs of species very closely connected systematically, with similar ways of locomtion and occuring in similar biotopes; 4. to define from the qualitative aspect the changes caused by living conditions.

II. MATERIAL AND METHODS

Studies were made on 27 adult rodents from four species:

1. *Citellus suslicus* G u l d e n s t a e d t, 1770, n=8,
2. *Citellus citellus* (L i n n a e u s, 1776), n=8,

3. *Sciurus vulgaris* Linnaeus, 1758, n=6,
4. *Cricetus cricetus* (Linnaeus, 1758), n=5.

The first three rodents belong to the family *Sciuridae*, and the last to *Cricetidae* (Kowalski, 1964). The squirrel is a species with an arboreal type of locomotion, while both sousliks and the hamster are fossorial animals (Hatt, 1932; Gambarian, 1960; Yakovleva, 1963).

After removing the skin the material was fixed by the method given by Rinker (1954) — in 2% formalin solution saturated with common salt, except for 1 individual of each species, which was conserved in 70% methyl alcohol solution which made the preparation of the distal parts of the limbs far easier. The muscles were dissected using a binocular eyepiece with magnification of 5.5×.

Nomenclature used was based chiefly on Olborth's study (1964), and names of muscles not included in the above publication were taken from studies by Klingener (1964), Greene (1935), Taylor & Weber (1961) and from *Nomina anatomica veterinaria* (1969).

III. RESULTS

The results of these studies are given in the most synthetic form possible in Table 1, which contains definition of the place of insertion of 91 separate muscle units found in the species of rodents examined. Particular attention has been paid in this connection to differentiation between the various species.

The same numeration of muscles has been used in Table 1 as in the figures, which always represent the muscles of the left limbs.

IV. DISCUSSION

Muscles, as active organs of movement, play an important part in locomotor processes, this applying particularly to their location and structure in the limbs. The formation and development of the various muscle units of these organs are most certainly not only closely connected with the kind and range of movements they perform, but also with the phylogenetic characters of the given group of animals (Peterka, 1937). Movements often appear to be similar to each other, despite the fact that the animals lead a different way of life and live in different habitats. It may be assumed from this that the musculature of the limbs in the rodents examined ought not to exhibit any great differences, and analysis of this musculature confirms this supposition, since it shows that only a small number of muscles are differently formed and have features characteristic of the different species. This of course applies to differences which may possibly point to a different function of the given muscle.

Table 1

List of muscles and their insertions. (C. c. — *Citellus citellus*, C. s. — *Citellus suslicus*, C. cr. — *Cricetus cricetus*, S. v. — *Sciurus vulgaris*).

№	Name of muscle	Origin	Terminal insertion	No. of figure; Remarks
		A. Thoracic limb		
		TRUNK-LIMB MUSCLES		
1	*m. sternocleidocephalicus*			
1a	*m. sternocephalicus*	*manubrium sterni*	*processus mastoideus*	1
1b	*m. cleidocephalicus*	clavicula — ventral surface		
2	*m. trapezius*			
2a	*m. clavotrapezius*	clavicula — ventral surface	*crista nuchalis superior*	1, 2, 3; C. cr. — broadest origin
2b	*m. acromiotrapezius*	*proc. spinosus* C_1—Th_4; C. cr.—C_1—Th_2;	*acromion, spina scapulae*	2, 3
2c	*m. spinotrapezius*	*proc. spinosus* Th_4—L_2; C. c. —Th_4—L_3; C. cr. —Th_2—L_1;	*spina scapulae* — hear vertebral margin S.v. — *spina scapulae* — middle part	
3	*m. levator claviculae*	atlas — *arcus ventralis*	*acromion*	2, 4
4	*m. rhomboideus*			
4a	*m. rhomboideus capitis*	*crista nuchalis superior*	*spina et margo dorsalis scapulae*	3, 4, 5, 7
4b	*m. rhomboideus minor*	*proc. spinosus* C_1—Th_4		5, 6
4c	*m. rhomboideus major*			
5	*m. subclavius*	I costa — peristernal end	clavicula — acromal end	9
6	*m. latissimus dorsi*	*proc. spinosus* Th_2—Th_9, *fascia lumbodorsalis, costae* 7—9-peristernal ends; S. v. —Th_3—L_2, fascia, costae 11 et 12; C. cr. —Th_4—L_1 et fascia	humerus — proximal end	2, 3, 6, 13

7	*m. pectoralis superficialis*			
7a	*pars transversa*	*manubrium sterni*	*tuberositas deltoidea*	7, 12
7b	*pars humeri descendens*	*manubrium sterni,* sternebrae I—III	*tuberositas deltoidea*	7, 8, 12
8	*m. pectoralis profundus*			
8a	*pars clavicularis*	sternebrae II—V; C. cr. — sternebra I	*caput humeri, proc. coracoideus;* C.cr. — *tuberculum majus humeri*	7, 8, 9
8b	*pars humeri ascendens*	sternebrae II—V C. cr. — sternebra I	*tuberculum majus et corpus humeri*	7, 8, 9, 12
8c	*pars abdominalis*	*proc. xiphoideus, linea alba;* C. cr. — *linea alba*	*tuberculum majus,* humerus — below head; C.cr. — *proc. coracoideus,* humerus — below head.	7, 8, 9
9	*m. serratus ventralis*			
9a	*m. serratus cervicis*	*proc. transversus* C_2—C_7	*facies serrata scapulae*	10
9b	*m. serratus thoracis*	costae 1—7 halway along length; C.c., C. cr. — costae 1—8 halway along length; S. v. — costae 1—8 at different level		
		MUSCLES OF SHOULDER AND ARM		
10	*m. deltoideus*			
10a	*m. acromiodeltoideus*	acromion	*tuberositas deltoidea;*	2, 3, 6, 11, 12
10b	*m. spinodeltoideus*	*spina scapulae*	C.cr. — *tuberositas deltoidea, corpus humeri* — proximal end	2, 3, 11
10c	*m. clavodeltoideus*	clavicula — ventral surface		2, 12
11	*m. supraspinatus*	*margo dorsalis scapulae*	*tuberculum majus humeri*	6, 13, 14
12	*m. infraspinatus*	*fossa infraspinata, spina, margo dorsalis et caudalis scapulae*	*tuberculum majus humeri*	1, 6, 13
13	*m. teres minor*	*margo caudalis scapulae*	*tuberculum majus humeri*	13
14	*m. subscapularis*	*fossa subscapularis*	*tuberculum minus humeri*	15
15	*m. teres major*	*margo caudalis scapulae*	*corpus humeri* — pericentral surface of proximal end	6, 13, 15
16	m. *coracobrachialis*	*proc. coracoideus*	*epicondylus medialis humeri;* S.v. — *corpus humeri* — pericentral surface of distal end	15, 17

17	*m. biceps brachii*			
17a	*caput breve*	*proc. coracoideus* — base	*tuberositas radii*	15, 17; C.c. — does not occur
17b	*caput longum*	*proc. coracoideus* — *base*		15, 17, 21
18	*m. brachialis*	*tuberculum majus humeri;* S. v., C. cr. — humerus — lateral surface below *tuberculum majus*	ulna — pericentral surface of proximal end	16, 20
19	*m. triceps brachii*			
19a	*caput longum*	*margo caudalis scapulae* — part near acetabulum		2, 3, 6, 13, 14, 15, 16, 17, 18
19b	*caput laterale*	humerus — lateral surface below *epicondylus medialis, tuberositas deltoidea*	olecranon	2, 13, 14, 16, 18
19c	*caput mediale*	humerus — pericentral surface of proximal end		17
	caput accessorium	*tuberculum minus humeri*		—
20	*m. anconeus*	humerus — distal end (2/3 of length of posterior surface); S. v. —1/3 of length of posterior surface	*proc. anconeus;* S.v. — *proc. anconeus*, ulna — proximal end at $^{1}/_{3}$ of length	16
		MUSCLES OF FOREARM		
21	*m. supinator*	*epicondylus et crista epicondyli lateralis humeri*	radius — proximal half of pericentral surface; S.v., C.cr. — pericentral surface at $^{2}/_{3}$ of length	19
22	*m. brachioradialis*	*crista epicondyli lateralis humeri*	*proc. styloideus radii*	20, 23; C.cr. — does not occur
23	*m. extensor carpi radialis longus*	*crista epicondyli lateralis humeri*	Mc II — *facies dorsalis*	20, 21
24	*m. extensor carpi radialis brevis*	*crista epicondyli lateralis humeri*	Mc III — *facies dorsalis*	20, 21
25	*m. extensor carpi ulnaris*	*epicondylus lateralis humeri;* C. cr. — *epicondylus lateralis humeri, facies lateralis ulnae* proximal end	Mc V — *facies dorsalis*	20, 21

26	*m. extensor digitalis communis*	*crista epicondyli lateralis humeri*	dorsal surface of third segments of digits II—V	20, 21
27	*m. abductor pollicis longus*	ulna — proximal half; S. v. — 5/6 of length from elbow joint	palmar surface of first phalange of thumb	20, 21, 22, 26
28	*m. extensor pollicis brevis*	C. cr. — *facies cranialis ulnae* 1/4 of length starting from midway	C.cr. — *os falciformis*	22 C. c., C. s., S. v. — does not occur
29	*m. extensor indicis proprius*	ulna — halfway along length	dorsal surface of first phalange of digit II	21
30	*m. extensor digiti quarti et digiti quinti proprius*	*epicondylus lateralis humeri*	dorsal surface of first phalanges of digits III—V; S.v., C.cr. — dorsal surface of first phalanges of digits IV and V	20, 21
31	*m. pronator teres*	*epicondylus medialis humeri*	*margo medialis radii* — $^{1}/_{4}$ of length beginning from midway; S.v. — distal half; C.cr. — $^{1}/_{3}$ middle part	19, 23
32	*m. pronator quadratus*	*margo caudalis ulnae* — distal end	*facies caudalis radii* — distal end	24
33	*m. flexor carpi radialis*	*epicondylus medialis humeri*	Mc II — palmar surface of base	19, 23, 26
34	*m. flexor carpi ulnaris*	olecranon, *epicondylus medialis humeri*; S. v., C. cr. — olecranon, *facies medialis ulnae* — proximal end, *epicondylus medialis humeri*	*os accessorium*	20, 23, 26
35	*m. palmaris longus*	*epicondylus medialis humeri*	*fascia palmaris*	23
36	*m. flexor digitalis superficialis*	*epicondylus medialis humeri*	palmar surface of bases of second phalanges of digits II—V; C.cr. — digits II—IV	23, 26
37	*m. flexor digitalis profundus*			20, 23, 26 25; C. cr. — *caput humerale* contains 1 belly, in remaining animals-2
37a	*caput humerale*	*epicondylus medialis humeri*		
37b	*caput ulnare*			
37c	*caput radiale*	*facies caudalis radii* — 3/4 of length from proximal end	palmar surfaces of third phalanges of digits II—V	
37d	*caput mediale*	*margo caudalis ulnae* — proximal half		

		MUSCLES OF PALM		
38	*m. adductor pollicis*	*os hamatum*, Mc III — base C. cr. — Mc II — base	pericentral surface of base of first phalange of thumb	27
39	*m. abductor pollicis* ***brevis***	*os falciformis*	lateral sesamoid bone of metacarpal-digital joint I	27
40	*m. flexor digiti quinti brevis*	*os carpale* III et IV	pericentral surface of first phalan-sesamoid bones of joint V	27
41	*m. abductor digiti quinti*	*os accessorium;* S. v., C. cr. — *os accessorium, m. flexor carpi ulnaris*	sesamoid bone of metacarpal-digital joint V	27
42	*m. m. interossei*	distal row of carpal bones, bases Mc II—V	sesamoid bones of metacarpal-digital joints II—IV and pericentral sesamoid bones of joint V S.v., C.cr. — sesamoid bones of metacarpal-digits joints II—V	27
43	*m. m. lumbricales*	*m. flexor* ***digitalis profundus*** — tendons	aponeurosis — hear pericentral sesamoid bones of metacarpal-digits joints II—V	
		B. Pelvic limb		
		LOIN-LIMB MUSCLES		
44	*m. psoas minor*	L_2—L_6 — ventral surfaces of shafts; C. cr. —L_1—L_3 et L_6—S_1	*tuberculum m. psoas minoris*	28
45	*m. psoas major*	L_2—S_1 — ventral surfaces of shafts and transverse processes	*trochanter minor*	28 S. v. — most strongly formed
46	*m. ilicus*	*fossa iliaca*	*trochanter minor*	28
47	*m. quadratus lumborum*	ventral surfaces of shafts of last 3 thoracic vertebrae, vertebral ends of last 2 ribs, lateral surfaces of L_1—L_5 shafts	tranverse processes of all lumbar vertebrae, *crista iliopectinea*	28

		EXTERNAL HIP MUSCLES		
48	*m. tensor fasciae latae*	*tuber coxae*	*fascia lata*	29, 34, 36
49	*m. gluteus superficialis*	*fascia iliaca, tuber coxae, procc. transversi* L_6 and of all sacral vertebrae	*trochanter major, trochanter tertius*	29
50	*m. tenuissimus*	fascia — in region of Ca_1	fascia — halfway along length of leg	30 C. cr. — does not occur
51	*m. gluteus medius*	*fascia caudalis, corpus et ala ossis ilii, tuber coxae*	*trochanter major*	30, 32
52	*m. gluteus accessorius*	*m. gluteus medius*	*trochanter major*	32
53	*m. gluteus profundus*	*corpus ossis ilii*	*trochanter major*	32
54	*m. piriformis*	*vertebrae sacrales — procc. transversi*	*trochanter major*	32; C. cr. — does not occur
		THIGH MUSCLES		
55	*m. sartorius*	S.v. — *ligamentum inguinale;* C.cr. — *symphysis pelvis*	S.v. — aponeurosis — in region of *patella* et *margo cranialis tibiae;* C.cr. — *margo cranialis tibiae*	33, 35 C. s., C. c. — does not occur
56	*m. gracilis*	*arcus ischiadicus, symphysis pelvis;* C.cr. — *arcus ischiadicus*	*margo cranialis tibiae;* C.cr. — *margo medialis tibiae* — halfway along length	34, 35
57	*m. pectineus*	*pecten ossis pubis;* S.v. — *pecten ossis pubis, symphysis pelvis;* C.cr. — *ramus cranialis ossis pubis* — near pubic symphysis	femur — below *trochanter minor*	34, 35, 36, 37
58	*m. adductor longus*	*ramus cranialis ossis pubis;* C. cr. — *ramus cranialis et symphysis ossis pubis*	femur — below terminal insertion of *m. pectineus*	34, 35, 36, 37

59	*m. adductor magnus*	*symphysis pelvis, ramus cranialis et caudalis ossis pubis, ramus ossis ischii*	*corpus femoris* — whole posterior surface	37
60	*m. adductor brevis*	*symphysis pelvis, ramus cranialis ossis pubis*	femur — distal half of pericentral surface	34, 36, 37
61	*m. biceps femoris*			
61a	*caput vertebrale*	*procc. spinosi* S_3—Ca_2, *fascia caudalis*	*condylus lateralis tibiae*, patella	29, 30
61b	*caput pelvina*	*tuber ischiadicum*		
62	*m. semitendinosus*	*tuber ischiadicum, fascia lumbodorsalis* at Ca_1	*margo cranialis tibiae* — below terminal insertion of *m. gracilis*	29, 30, 34, 35, 36, 37; C. cr. — most strongly formed
63	*m. semimembranosus*	*tuber ischiadicum, arcus ischiadicus* — near *tuber ischiadicum*	*epicondylus medialis femoris, condylus medialis tibiae*	34, 36, 37
64	*m. caudofemoralis*	*tuber ischiadicum*; S. v. *tuber ischiadicum, proc. transversus* Ca_1	*epicondylus lateralis et epicondylus medialis femoris*; S.v. — *epicondylus lateralis, epicondylus medialis*, femur — distal half	31, 37 C. cr. — does not occur
65	*m. quadriceps femoris*			
65a	*m. rectus femoris*	acetabulum — dorsal margin, *corpus ossis ilii* — part near acetabulum		30, 34, 36
65b	*m. vastus lateralis*	*trochanter major*, femur — proximal end	*margo cranialis tibiae*	29, 30, 34, 36
65c	*m. vastus medialis*	*collum femoris, corpus femoris* — proximal end		34, 36
65d	*m. vastus intermedius*	*corpus femoris* — anterior surface		30
		INTERIOR AND VENTRAL MUSCLES OF PELVIS		
66	*m. obturator internus*	ischium — pericentral surface	*fossa trochanterica*	38

67	*m. obturator externus*	*foramen obturator* — edge from exterior surface of pelvis	*fossa trochanterica*	38
68	*m. quadratus femoris*	*ramus ossis ischii* — lateral surface	*trochanter major, trochanter tertius*	38
69	*m. m. gemelli*			
69a	*m. gemellus tuberalis*	*corpus ossis ischii* — posterior part, *tuber ischiadicum*		
69b	*m. gemellus spinalis*	*spina ischiadica, corpus ossis ischii* — anterior part	*fossa trochanterica*	38
		MUSCLES OF LEG		
70	*m. tibialis anterior*	*condylus lateralis, tuberositas et margo cranialis tibiae*	pericentral surface of base Mt I	39, 44
71	*m. extensor digitalis pedis longus*	*epicondylus lateralis femoris*	dorsal surface of third phalanges of digits II—V	39, 44
72	*m. fibularis longus*	*condylus lateralis tibiae, caput fibulae*	plantar surface of Mt II base	39, 43
73	*m. fibularis brevis*	*caput et facies lateralis fibulae;* S. v. — *facies lateralis fibulae* — central part	dorso — lateral surface of base Mt V	39, 44
74	*m. extensor hallucis longus*	*margo cranialis corporis fibulae* — proximal half, *caput fibulae, membrana interossea cruris;* S. v., C. cr. — *margo craniali corporis fibulae* — central part, *membrana interossea cruris*	dorsal surface of base of second phalange of I digit	40, 44
75	*m. fibularis digiti quarti*	*corpus fibulae* — distal end; S. v., C. cr. — *corpus fibulae* central part	dorsal surface of proximal end of third phalange of digit IV	40, 44
76	*m. fibularis digiti quinti*	*caput fibulae*	dorsal surface of proximal end of third phalange of digit V	39, 44
77	*m. triceps surae*			
77a	*m. gastrocnemius caput laterale*	*epicondylus lateralis femoris*		
77b	*m. gastrocnemius caput mediale*	*epicondylus medialis femoris*	*tuber calcanei*	41
77c	*m. soleus*	*caput fibulae*		

78	*m. popliteus*	*epicondylus lateralis femoris*	*margo medialis corporis tibiae* — proximal end	42
79	*m. flexor digitalis pedis superficialis*	*epicondylus lateralis femoris*	plantar surfaces of bases of second phalanges of digits II—V	41, 43, 45
80	*m. flexor digitalis fibularis*	*caput et facies medialis fibulae* — $^{2}/_{3}$ of length, *facies lateralis tibiae*	plantar surfaces of third phalanges of digits I—V	42, 43, 45
81	*m. flexor digitalis tibialis*	*condylus lateralis tibiae, caput fibulae*	talus; C.cr. — *aponeurosis plantaris* — at level of base Mt I	42, 43
82	*m. tibialis posterior*	*condylus lateralis tibiae, caput fibulae*	*os naviculare*, praehallux	42, 43
		MUSCLES OF PES		
83	*m. extensor digitalis pedis brevis*	calcaneus	pericentral surface of base of first phalange of digit II and second phalange of digit III	44
84	*m. flexor digitalis pedis brevis*	*m. flexor digitalis fibularis;* C. cr. — *tuber calcanei*	*m. flexor digitalis pedis superficialis* — tendons running to digits III—IV; C.cr. — the same muscle-tendons running to digits II—V	45
85	*m. abductor digiti quinti*	calcaneus	lateral surface of base of first phalange of digit V; C.cr. — plantar and lateral surfaces of this base	46
86	*m. quadratus plantae*	calcaneus	*m. flexor digitalis fibularis*	45 C. cr. — does not occur
87	*m. abductor hallucis brevis*	*os naviculare*	pericentral sesamoid bone of metatarso — digital joint I	46

88	*m. flexor digiti quinti brevis*	*os cuboideum*	lateral sesamoid bone of metatarso-digital joint V; S.v. — both sesamoid bones of metatarso-digital joint V	46
89	*m. adductor digiti quinti*	*m. m. interossei digiti pedis* II — origins	pericentral surface of base of first phalange of digit V	46; C. cr. — most strongly formed
90	*m. m. interossei*	*os naviculare, os cuboideum*	sesamoid bones of metatarso-digital joints II—IV, lateral of joint I, pericentral of joint V; S.v. — sesamoid bones of joints II—IV, lateral of joint I	46
91	*m. m. lumbricales*	*m. flexor digitalis fibularis*	pericentral surface of first phalanges of digits II—V	

Among the muscles of the thoracic limb the greatest differences are exhibited by *m. latissimus dorsi,* flexing the acromion and pulling the arm back. It is the most strongly formed in the squirrel and its insertion on the trunk of the animal extends further caudad than in the other rodents examined, and consequently, as it is longer and contains longer muscle fibres, it appears to be more dynamic (K r a s u s k a j a, 1923). It may cause stronger flexing of the acromion and movement of the limb farther backwards. This is undoubtedly connected with the arboreal way of life of these animals, which makes it necessary for the body to be constantly hauled up during climbing. It is difficult to explain the weaker formation of *m. latissimus dorsi* in the hamster than in sousliks as due to a different type of locomotion, as these animals lead a similar way of life. It is possible that it is connected with the closer relationship between sousliks and squirrels than between squirrels and hamsters.

Greater diferences in the group of the trunk-limb muscles are exhibited only by *m. spinotrapezius,* which acting with *m. latissimus dorsi* draws the scapula in a dorsocaudad direction. Its insertion on the trunk of the squirrel extends further backwards and the terminal insertion is situated nearer the scapular acetabulum than in sousliks and hamsters. The way this muscle is attached widens the range of the movement made by the limb as the muscle contracts to a greater degree than in the other three species.

When the muscles of the shoulder and arm are compared attention must be given primarily to the strong formation exhibited by *m. spinodeltoideus* in the squirrel. Acting independently, it causes supination of the limb and when acting together with the other parts of *m. deltoideus* abduces the arm and flexes the shoulder. Movements of these kinds would appear to play a particularly important role in animals living on the trees, especially during leaps, in the final phase of which the animal is obliged to seize a support from various angles and from different distances.

The stronger development of *mm. flexores* of the shoulder in the squirrel in comparison with other members of *Sciuridae* was also demonstrated in the studies of weights of muscles made by B o d r o v a (1963).

The structure of certain parts of the shoulder girdle, for instance the scapulae, is evidence of the efficiency of the thoracic limb in *Sciurus vulgaris* (M a g e r l, 1928). The scapula is widest in the middle part, which the above author considers a characteristic feature of animals in which the thoracic limbs are adapted to perform a large number of varied functions.

The strong system of tendons of *m. subscapularis* in the hamster must also be emphasised, and it suggest that this muscle becomes fatigued less quickly (and can therefore work over a considerable period) than in the other rodents examined in which it is formed chiefly of muscle elements. Its function consists in adducting and raising the arm, undoubtedly of great importance when the animal digs its burrows.

The absence of *caput breve* of *m. biceps brachii* in *Citellus citellus* is also remarkable. This fact, bearing in mind the very close relationship and almost identical way of life of *Citellus suslicus* and *Citellus citellus,* would seem very difficult to interpret.

The absence of this head was also found by Parsons (1894) in *Hystrix, Dasyproctidae, Caviidae* and *Castor,* and by Klingener (1964) in some species of *Dipodidae (Zapus, Jaculus).*

In the study group of animals the formation of *m. brachioradialis* and *m. supinator,* causing supinating movements, are very interesting. In both species of sousliks and in squirrels they are similary formed, except that in the latter animal *m. supinator* would appear more massive. *M. brachioradialis* does not occur in the hamster, but *m. supinator* is very strongly formed. This can probably be explained by the function of two weaker muscles being taken over by one stronger one. The precision of movements of the hand is less important in fossorial animals than their strength, which enables it to overcome considerable opposition. The above assumption would appear to be confirmed by the difference in the structure of *m. palmaris longus* and *mm. flexores digitorum* in the hamster in comparison with the other rodents examined. In this case the flexor muscles of the digits, relatively more weakly formed but permitting of more precise movements of the hand, *m. flexor digiti superficialis et profundus,* are balanced by the more strongly formed *m. palmaris longus* acting on the carpus and metacarpus and not on the various digits. *M. extensor pollicis brevis,* which does not occur in sousliks or squirrels, but only in the hamster, is also evidence of the need for strong movements in the carpal joint. In some animals, for example in *Ondatra zibethica* (Eble, 1955), this muscle has a terminal insertion on the first segment of the thumb, whereas in *Cricetus cricetus,* it is on *os falciformis.*

A similarly located terminal insertion of this muscle to that in the hamster was found by Rinker (1954) in other species of *Cricetinae,* and by Klingener (1964) in *Dipodidae.*

In the pelvic limb among the loin-limb muscles of the only *m. psoas major* exhibits different formation. In the squirrel it is far more strongly developed than in sousliks and hamsters. Its action makes it possible for the hip joint to flex and draw the limb forwards, which is of importance when the animal is climbing.

The general connection of the spine with the girdle of the pelvic limb is also different in the squirrel, as shown by the studies made by Dornescu & Nitescu (1965) on the structure of the sacral bone in dormice formed of three vertebrae, and the squirrel (formed of four vertebrae). The plane of contact between the ilio-sacral bones is smaller in the latter, permitting of greater mobility of the spine.

Differences in the group of external hip muscles consist in some of the muscle units occurring in representatives of the family *Sciuridae*, and not in the hamster. These are: the abductor muscle of the thigh, *m. tenuissimus* and the muscle opposing it, *m. piriformis*. Their presence in sousliks and squirrels is evidence of the greater capacities for movement of the pelvic limb of these animals in comparison with the limb of *Cricetus cricetus*. This applies to movements in both the adductor and abductor plane.

There are no great differences in the musculature of the thigh but it may be mentioned that its superficial layer of central muscles is differently formed in sousliks and squirrels from the analogical muscles in the limb of the hamster. In representatives of *Sciuridae m. sartorius* has either a rudimentary form *(S. vulgaris)* or does not occur at all *(C. citellus* and *C. suslicus)*, whereas in the hamster it is strongly formed. The relations are the reverse in the case of *m. gracilis*, since this muscle is far more weakly formed in *C. cricetus* than in other species of rodents examined. As both muscles adduce the thigh, and in functioning assist each other, it is difficult to interpret such morphological relations from the aspect of function. It can only be assumed that similar formation of these muscles in squirrels and sousliks is connected with the close relationship between these species.

M. pectineus — a strong extensor muscle of the hip joint, is most weakly developed in the hamster, and most strongly in the squirrel. This muscle plays an important part during the leaps made by squirrels which form one of the important elements of the activities connected with an arboreal type of locomotion.

M. caudofemoralis is also distinguished by different structure in the animals examined. It does not occur in the hamster and in the squirrel, is far better formed than in sousliks. In addition its initial insertion in the case of *Sciurus vulgaris* is attached not only to *tuber ischiadicum*, as is the case with *Citellus suslicus* and *Citellus citellus*, but also to the transverse process of the first cocygeal vertebra. In thus performs the function not only of extensor of the hip joint and abductor of the pelvic limb but also cooperates with muscles lowering the tail. During jumps (particularly over considerable distances) the tail, covered with long dense hair, plays a very important role as a steering organ and also markedly increases the area of the animal's body, thus reducing the rate of falling. In the squirrel there must be strong muscles capable of maintaining it in the correct position in overcoming considerable air resistance during flight.

Hatt (1932) has emphasised the very important part played by the tail in certain species. He observed that leaps made by *Zapus hutsonius*, which has lost this organ, were completely devoid of precision. Disturbance had occurred in control of the direction of movement, despite the fact that the strength of the leap had been retained.

Attention must be drawn to the fact that up to the present it has not proved possible to establish a uniform nomenclature for certain of the muscles of the thigh. *M. caudofemoralis* is considered by the majority of authors as a muscle homologous with *m. presemimembranosus* (Hill, 1934; Rinker, 1954; Gupta, 1965). In particular the first of these authors carried out very detailed studies on *m. presemimembranosus* in many species of rodent and reached the conclusion that it cannot be identified with the iliac part of *m. adductor majus* in man (Alezais, Parsons, Leche — cited after Hill, 1934). Hill (1934) is very definitely of the opinion that *m. caudofemoralis* and *m. presemimembranosus* are homologues. Kerr (1955), on the basis of studies on the musculature of the pelvic limbs of different species of animals, assumes that *m. caudofemoralis* in the cat is a homologue of *caput breve m. biceps femoris* in the rabbit and *m. femorococcygeus* in the opossum.

There is no such agreement in the case of the group of adductor muscles of the thigh. Koch (1955), in examining the musculature of the nutria, distinguished only one *m. adductor* composed of three or four parts, and found no justification for describing the various parts as independent muscle units. Different views as to the nomenclature of this group of muscles are emphasised in their studies by numerous authors (Rinker, 1954; Klingener, 1964; Sokolov, 1964 *et al.*).

The internal and ventral muscles of the pelvis and muscles of the leg are similarly formed in all the species of rodents examined.

The muscles of the foot in sousliks and squirrels, apart from certain small exceptions (in *Sciurus vulgaris m. interosseus* does not occur by the fifth digit), are almost identical. There are greater differences in this respect between the representatives of the family *Sciuridae* examined, and the representatives of *Cricetidae*, the hamsters. The latter has no *m. quadratus plantae* assisting the action of the flexors of the digits. In addition its fifth digit is far more strongly supplied with muscles. The adductors and abductors (*m. adductor digiti quinti et m. abductor digiti quinti)* are far better formed. In addition *m. flexor digitalis pedis brevis* sends out branches in the form of a tendon extending to the fifth digit in *Cricetus cricetus* only. It would seem that the differences described are connected with the fossorial way of life, proper to the hamster. The capacity for greater abduction of the external digit produces increase in the surface of the foot and the stronger musculature permits the animal to overcome the considerable opposition it encounters when emerging from its burrow or when clearing away the soil it has excavated, and as a whole the work performed by the pelvic limb becomes more effective. It is probable that the fifth digit plays a particularly important part in this.

The results of analysis of the muscles of the foot in the hamster confirm Elby's opinion (1955), reached on the basis of his studies on the locomotor apparatus of the limbs of the musk-rat, that the muscles of the digits are particularly well formed in swimming and digging animals, and this is especially true of their adductor and abductor capacities.

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PORÓWNAWCZE BADANIA NAD UMIĘŚNIENIEM KOŃCZYN NIEKTÓRYCH GATUNKÓW *RODENTIA*

Streszczenie

Poddano analizie umięśnienie kończyn 4 gatunków gryzoni: *Citellus suslicus* Guldenstaedt, 1770, (n=8); *Citellus citellus* (Linnaeus, 1776), (n=8); *Sciurus*

vulgaris Linnaeus, 1758, (n=6); *Cricetus cricetus* (Linnaeus, 1758), (n=5). W kończynie piersiowej przeanalizowano 43 mięśnie, w miednicznej — 48.

Muskulatura kończyn obu gatunków susłów (zwierząt bardzo blisko ze sobą spokrewnionych i prowadzących podobny tryb życia), jest niemal jednakowa. Jedyną istotną różnicę stanowi brak głowy krótkiej w mięśniu dwugłowym ramienia u *Citellus citellus*.

Istnieją wyraźne różnice w umięśnieniu, zwłaszcza kończyny piersiowej między wiewiórką, a susłami. (Bliskie pokrewieństwo, odmienny tryb życia).

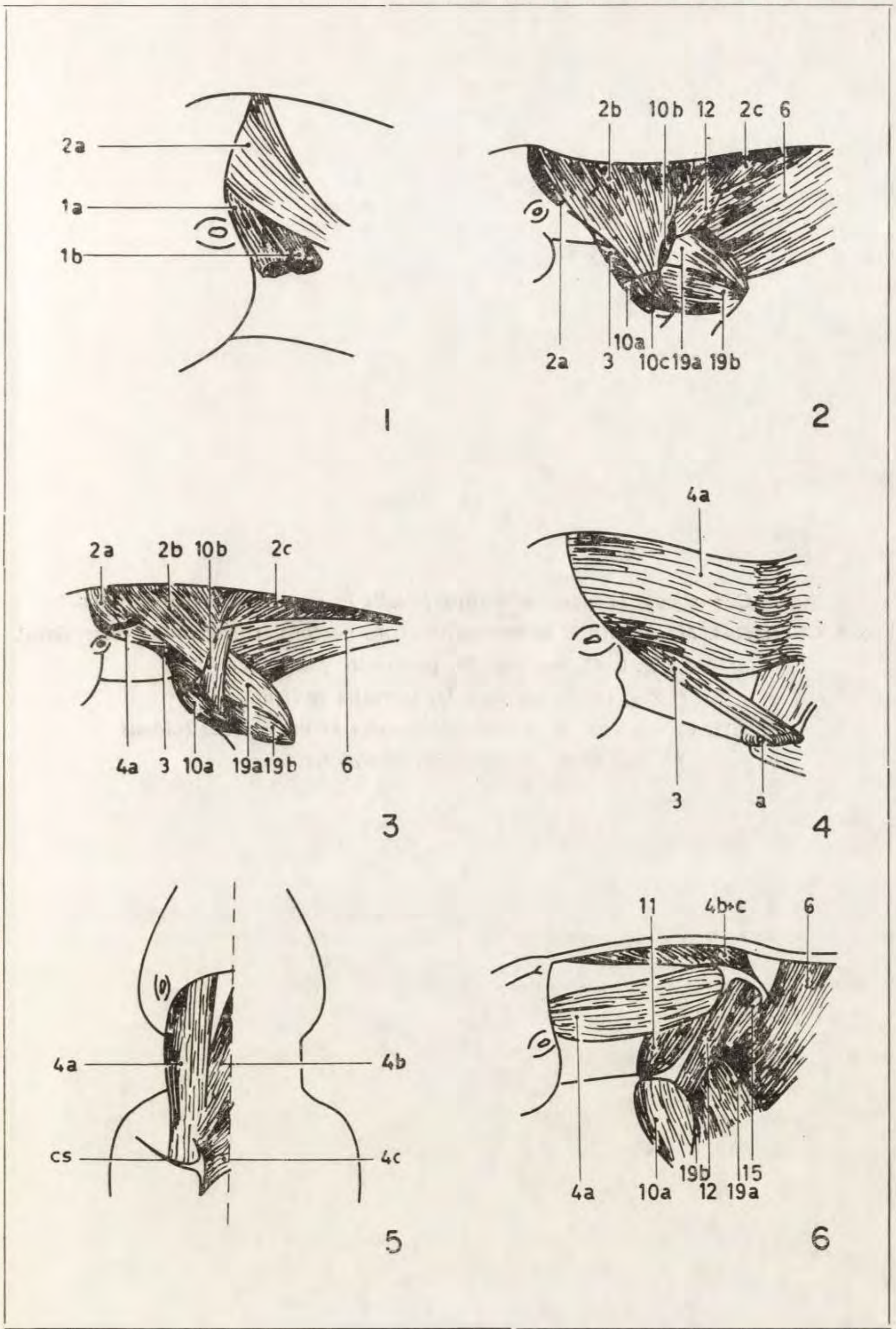
U chomika brak niektórych jednostek mięśniowych występujących u wiewiórki i susłów i odwrotnie — u chomika występują takie, których nie ma u badanych *Sciuridae*. Z jednej strony istnieją więc różnice między zwierzętami prowadzącymi podobny tryb życia, ale stojącymi dalej od siebie w układzie systematycznym (chomik — susły); z drugiej — podobieństwo wśród zwierząt systematycznie sobie bliskich, ale o odmiennym trybie życia (susły — wiewiórka).

Budowa umięśnienia świadczy o tym, że najbardziej sprawną kończynę piersiową ma wiewiórka, natomiast stopa chomika jest bardziej sprawna niż autopodia kończyn miednicznych pozostałych gatunków badanych gryzoni.

FIGURES 1—46

THORACIC LIMB

Fig. 1. *C. suslicus. M. sternocephalicus et m. clavotrapezius* (terminal insertions).
Fig. 2. *C. suslicus.* Trunk-limb muscles, muscles of shoulder and arm (superficial layer).
Fig. 3. *C. cricetus.* Trunk-limb muscles and muscles of shoulder and arm (superficial layer).
Fig. 4. *C. suslicus. M. levator claviculae et m. rhomboideus capitis.*
Fig. 5. *C. suslicus. M. rhomboideus.*
Fig. 6. *C. cricetus.* Trunk-limb muscles and muscles of shoulder (deep layer).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1a
1b
1
2b 10b 12 2c 6
10a
2a 3 10c 19a 19b
2
2a 2b 10b 2c
4a 3 10a 19a 19b 6
3
4a
3 a
4
4a
4b
cs
4c
5
11 4b+c 6
19b 15
4a 10a 12 19a
6

Fig. 7. *C. suslicus. M. pectoralis superficialis et m. pectoralis profundus.*

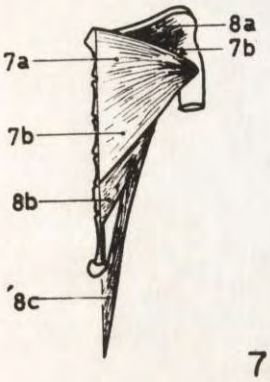
Fig. 8. *C. cricetus. M. pectoralis superficialis et m. pectoralis profundus* (insertions).

Fig. 9. *C. suslicus. M. pectoralis profundus.*

Fig. 10. *C. suslicus. M. serratus ventralis.*

Fig. 11. *C. suslicus. M. acromiodeltoideus et m. spinodeltoideus.*

Fig. 12. *C. suslicus. M. clavodeltoideus.*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7b
7a
7b
8b
8c

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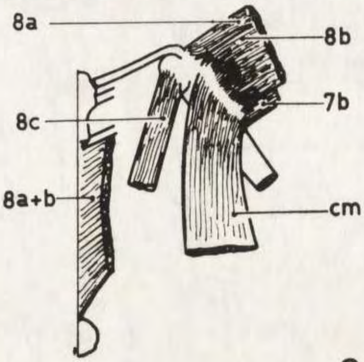
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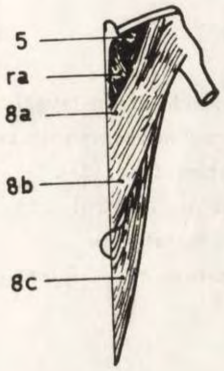
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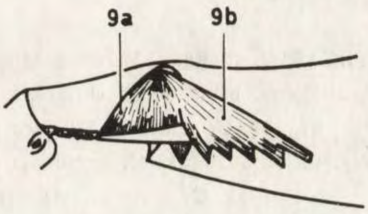
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9b

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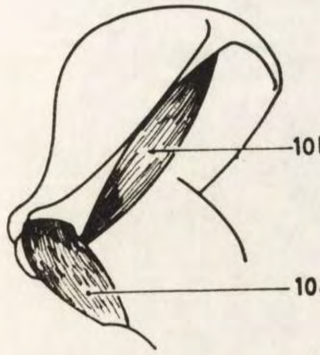
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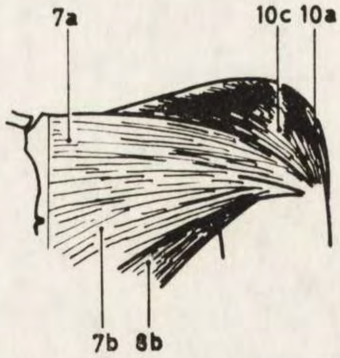
7a
10c 10a
7b 8b

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Fig. 13. *C. suslicus.* Muscles of shoulder (lateral side, deep layer).

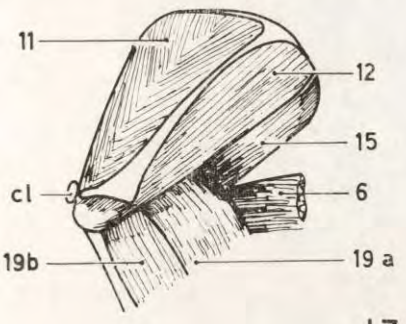
Fig. 14. *C. suslicus.* Muscles of shoulder (lateral side, *m. infraspinatus* removed).

Fig. 15. *C. suslicus.* Muscles of shoulder (pericentral side).

Fig. 16. *C. suslicus. M. anconeus et m. brachialis* (pericentral side).

Fig. 17. *C. suslicus.* Muscles of arm (pericentral side).

Fig. 18. *C. suslicus. M. triceps brachii (caput longum et caput laterale).*



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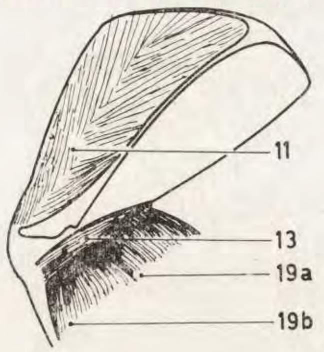

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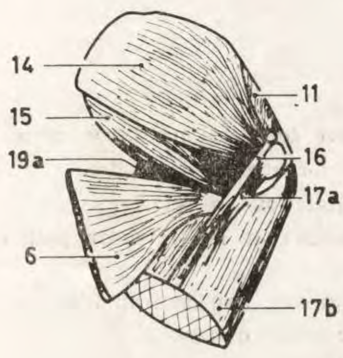

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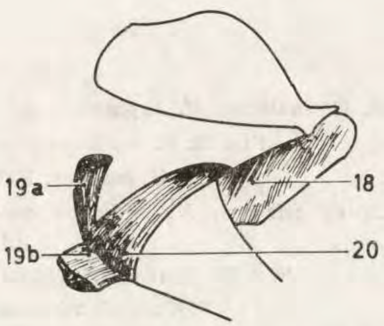

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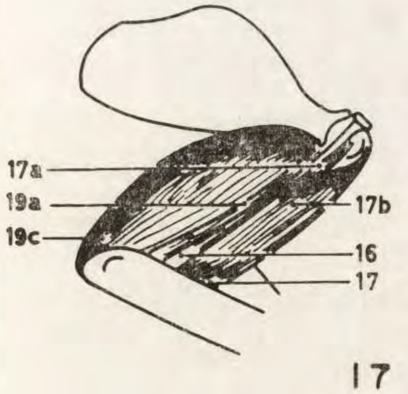

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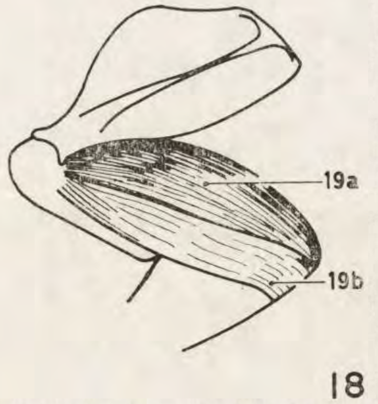

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Fig. 19. *C. suslicus. M. supinator, m. pronator teres et m. flexor carpi radialis.*

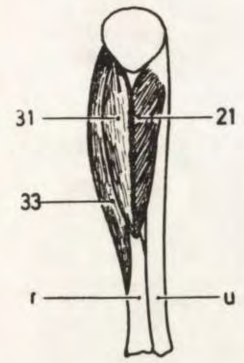
Fig. 20. *C. suslicus.* Muscles of forearm (lateral side).

Fig. 21. *C. suslicus.* Palm — insertions of extensors.

Fig. 22. *C. cricetus. M. abductor pollicis longus et m. extensor pollicis brevis* (insertions).

Fig. 23. *C. suslicus.* Muscles of forearm (pericentral side).

Fig. 24. *C. suslicus. M. pronator quadratus.*



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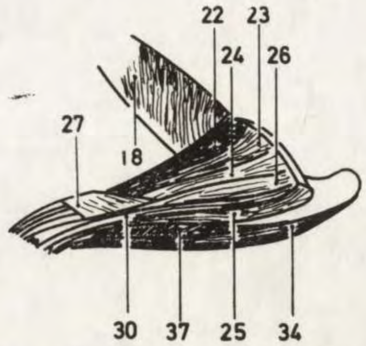

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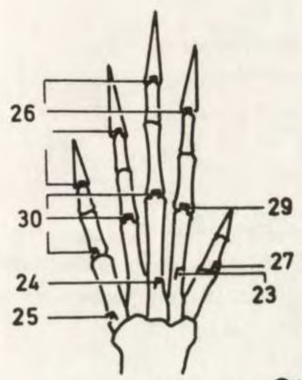

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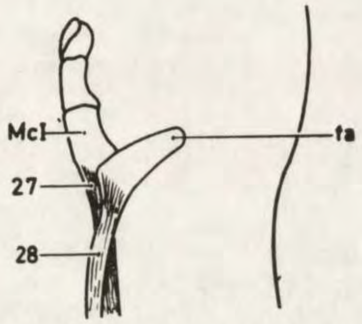

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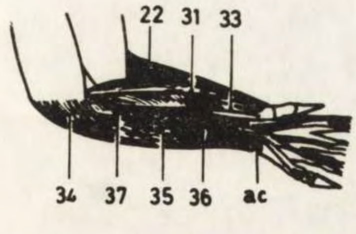

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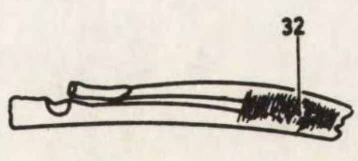

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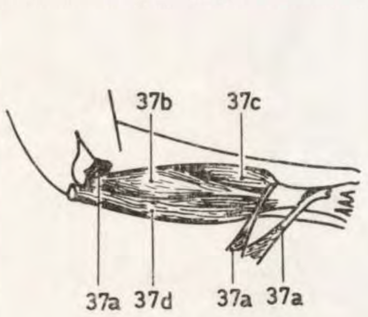
Fig. 25. *C. suslicus. M. flexor digitalis profundus.*
Fig. 26. *C. suslicus.* Palm — insertions of flexors.
Fig. 27. *C. suslicus.* Muscle of palm.

PELVIC LIMB

Fig. 28. *C. suslicus.* Loin-limb muscles.
Fig. 29. *C. suslicus.* Exterior hip muscles and thigh muscles (superficial layer).
Fig. 30. *C. suslicus.* Exterior hip muscles and thigh muscles (deep layer).



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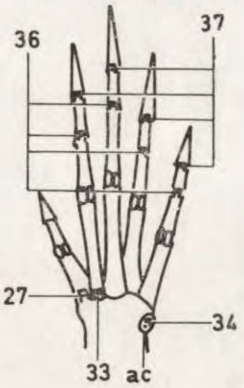

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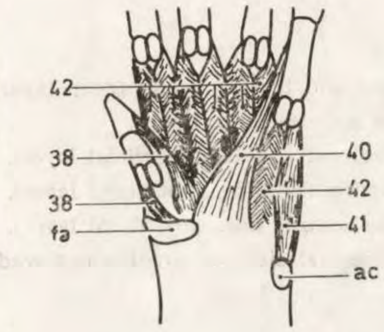

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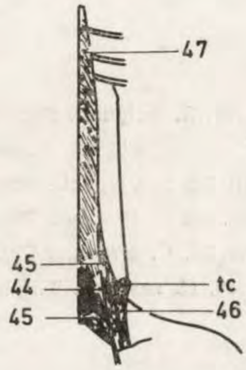

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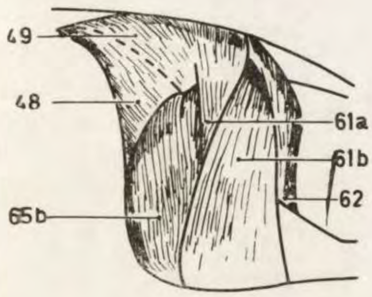

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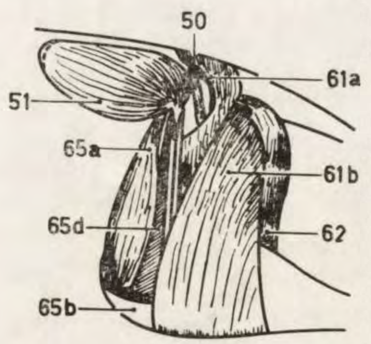


30

Fig. 31. *S. vulgaris.* External hip muscles and thigh muscles (deep layer).

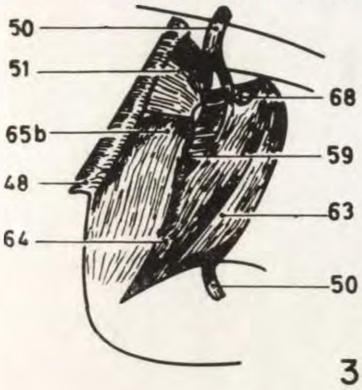
Fig. 32. *C. suslicus.* Gluteal muscles (deep layer).

Fig. 33. *S. vulgaris.* Thigh muscles (pericentral side, superficial layer).

Fig. 34. *C. suslicus.* Thigh muscles (pericentral side, superficial layer).

Fig. 35. *C. cricetus.* Thigh muscles (pericentral side, superficial layer).

Fig. 36. *C. suslicus.* Thigh muscles (pericentral side, *m. gracilis* removed).



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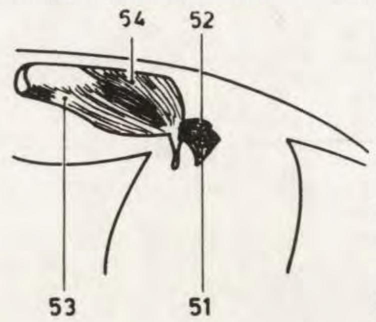

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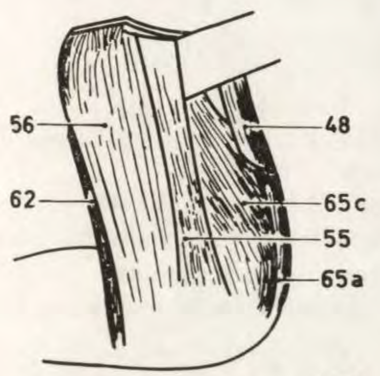

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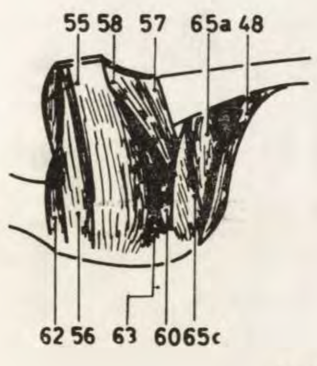
34



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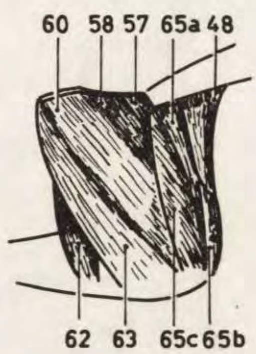


36

Fig. 37. *C. suslicus*. Thigh muscles (pericentral side, deep layer).

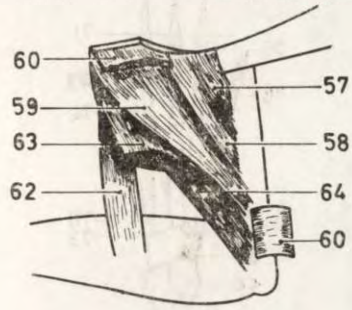
Fig. 38. *C. suslicus*. Internal and ventral muscles of pelvis (*m. quadratus femoris* removed).

Fig. 39. *C. suslicus*. Muscles of leg (dorsolateral side).

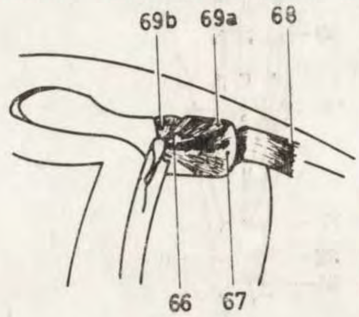
Fig. 40. *C. suslicus*. *M. extensor hallucis longus et m. fibularis digi quarti.*

Fig. 41. *C. suslicus*. *M. triceps surae* (posterior side).

Fig. 42. *C. suslicus*. Muscles of leg (pericentral side, deep layer).



37



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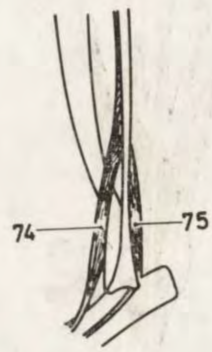

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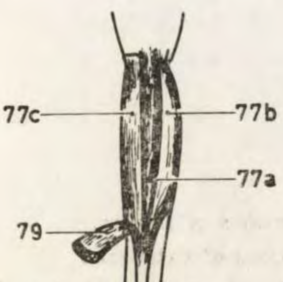

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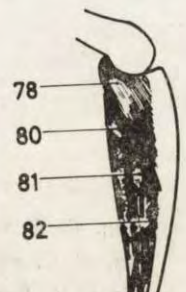

42

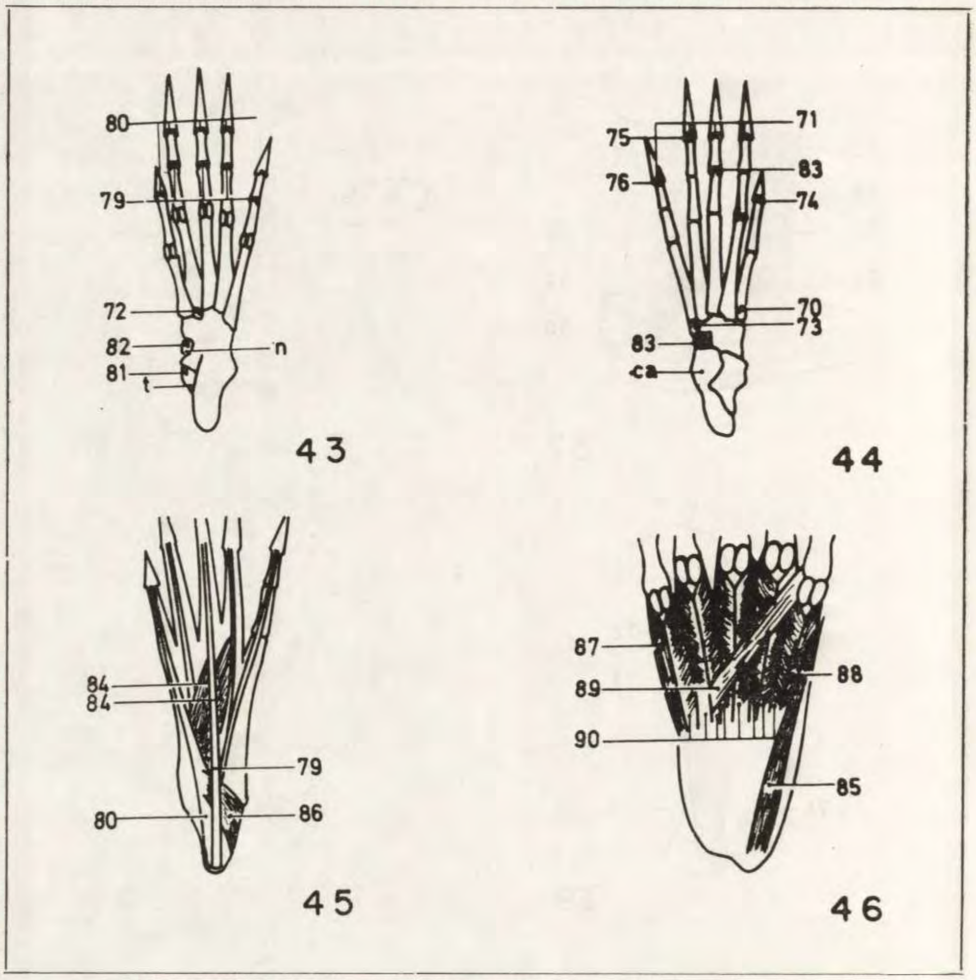

Fig. 43. *C. suslicus*. Pes — insertions of flexors.

Fig. 44. *C. suslicus*. Pes — insertions of extensors.

Fig. 45. *C. suslicus*. *M. flexor digitalis pedis brevis et m. quadratus plantae.*

Fig. 46. *C. suslicus*. Muscles of pes.