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A Descriptive Analysis of The Musculature And Osseous Systems of The Kangaroo Rat, Dipodomys Ordii

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A DESCRIPTIVE ANALYSIS OF THE MUSCULATURE AND OSSEOUS SYSTEMS OF THE KANGAROO RAT, *DIPODOMYS ORDII*

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INTRODUCTION

The kangaroo rats constitute the only genus, Dipodomys, of the subfamily Heteromyinae, now extant. There is fossil evidence of two other genera which are now extinct.

The kangaroo rat, Dipodomys ordii richardsoni, is one of the common rodents of western Kansas. According to Hibbard (3, p. 76), "Its range extends northeastward along the Kansas river into Riley County."

These animals are easily distinguished from other rodents by their long tail, long hind legs and feet, small hands, fur lined external cheek pouches, and their saltating method of locomotion.

These rodents are seldom seen by the casual observer, being strictly nocturnal and very timid. A good way to observe their activity is to drive by automobile through a pasture at night. It is not uncommon to see numbers of them bounding along in front of the headlights.

Not often are the kangaroo rats considered of much economic importance. They build their shallow burrows in gravelly or more frequently sandy soil. They seem to thrive best around old sand pits, sand dunes or valley borders. They are chiefly inhabitants of desert country, but may thrive in out of the way places in semi-arid regions.

Apparently almost all kinds of seeds are utilized as food by these animals. Woodhouse has reported finding in their cheek pouches great numbers of seeds of wild sunflowers (Helianthus and Ximenesia)

and also hard beans of a legume (Parosela). Goldman has observed them gathering seeds of the common mesquite (Prosopis glandulosa). In an examination of the pockets Goldman found in various specimens the seeds of the rag bush (Gaertheris acanthicarpa), ripening seeds of the desert willow (Chilopsis linearis), seeds of tumble weed (Atriplex expansa), capsules of the common purslane (Portulaca oleracea), seeds of creosote bush (Covillea tridentata), and others. (Bailey, 1, p. 268)

From the appearance of their burrow entrances, they must be rather neat "housekeepers". These openings are often strewn with seed husks which have been thrown out from their dens. This writer found the seed husks of the sandbur (Cenchrus pauciflorus), and the seed pods of the Rocky Mountain bee plant (Cleome serrulata) literally forming a carpet of refuse at some of the burrow entrances.

One other highly important adaptation of these animals to their environment is their ability to live indefinitely without water. The animal is capable of utilizing enough metabolic water to carry on all life processes.

Pearse (6, p. 100) has stated that, "Physiology is the keystone of ecology"; Howell (5, p. 1) has mentioned that, "The internal anatomy of all but a few mammals has been woefully neglected"; and Hall (2, p.7) believes, " . . . that taxonomic characters of considerable value will be found in the musculature when more forms have been studied." These needs form the stimulus for this research.

This being an anatomical problem, and not an ecological one, the remainder of the paper shall deal with the animal solely from the

point of view of anatomy.

The specimens collected for this study were caught in live traps baited with oatmeal. Eight specimens were caught in an old abandoned sand pit twelve miles south of Hays, Kansas. Six of these, four males and two females, were measured for total length, length of tail, and length of pes, and preserved in a ten per cent solution of formalin for study. These six specimens were dissected. No muscles requiring microscopy were considered. Not in every case were all the muscles compared but wherever variation was found or any degree of doubt persisted it was checked in all six specimens.

An attempt is made to describe the muscular system with extreme thoroughness. The ossesous system is not nearly as intricate and is treated in much less detail.

The writer regrets that this subject lends itself only to the technical language of anatomy.

Related Studies

There has been little work done on the internal anatomy of all but a few of our small mammals. Anatomists have thoroughly treated the cat and the rabbit but have failed to continue with many of our common rodents.

Howell (5, p. 1-225) has made a comparative anatomical study, in minute detail, of three common North American rodents, Homodontomys, Neotoma, and Teonoma. His work has been used as a basic guide in this research. The same author also made a similar study of the three genera,

Allactaga, Dipodomys, and Scirtopoda (Howell, 4, p. 377-536).

It should be borne in mind that all quotations from the last mentioned works deal with a different species from that of this research.

Similar studies, but not of rodents, have been made by Hall (2, p. 7-38) of three mustelid mammals, Mephitis, Spilogale, and Martes. In another study Hall has given an account of the muscular anatomy of the American badger.

Much is yet needed to be done in the field of anatomy before it can be said to be adequately explored.

MYOLOGY

There is slight individual variation in the musculature of all animals, no two animals being exactly alike. It is impossible to define some muscles with exactness, especially those arising or inserting within fascia, or muscles which are partly or wholly inseparable from each other. Specimens that have been kept in preservative often give a false impression of the true nature of the muscle, because never do the muscles "set" precisely the same.

The muscles which are about to follow are grouped for the sake of convenience only, and do not necessarily constitute group relationship.

Muscles of the Head

Superficial Facial Musculature

Levator labii arises from a considerable area upon the rostrum, mainly the premaxilla. Insertion is into the extreme dorso-cranial fold of the pouch and the mystacial pad.

Dilator naris has its origin mostly mediad but deep to the levator labii. Two long tiny tendons develop, the dorsal one inserting just dorso-caudad of the nostril, the other extending to the extreme tip between the nostrils.

Orbicularis oculi arises on the maxilla immediately laterad to the suture of the frontal bone. Its fibers circumvent the eye. The muscle functions as a sphincter, closing the eye. A greater amount of fibers being on the lower lid would indicate it does most of the movement in closing the eye.

Orbicularis oris has strong tendinous fibers inserting into the margin of the lower lip. Attempts to follow these fibers through the tenuous fascia were unsatisfactory.

Depressor nasalis consists of short stout fibers extending between the ventral center of the nostrils and the extreme cranial portion of the upper lip.

Maxillonasolabialis arises from the maxillary deep to the ectal head of the masseter major. Several long tendons extend to insertion upon the ventro-lateral portion of the nostril. Other tendons emanating from what appears to be this same muscle, but is in all likelihood a separate slip, insert into the upper lip.

Orbiculoris sacculi lies beneath the skin but external to the pouch at its opening, or in other words in the groove formed by the

infolding of the pouch. It appears as a partial continuation of the ventral sphincter colli profundus, but most of the fibers arise from the pouch itself, inserting into the mystacial pad.

Auricularis posterior and the following muscle form a superficial sheet overlying the dorso-caudal mastoids. This muscle arises from the nuchal ligament, insertion is upon the dorso-caudal base of the ear.

Occipitalis is a thin, superficial sheet of muscular tissue arising from the cranial portion of the nuchal ligament. The muscle diverges with insertion upon the dorso-caudo-medial portion of the mastoid.

Buccinatoris must be considered in two parts. The larger and more important one could not be satisfactorily dissected by this worker. The smaller arises within the premaxillary fossa for several millimeters caudad of the incisors. Insertion is upon the margin of the lip and roof of the mouth.

Howell (4, p. 420) has written that:

> In the kangaroo rats the part of the mouth posterior to the incisors can evidently be much more tightly closed than in most rodents. Whereas in the wood rat there is an oral pad upon either side which the normal tone of the buccinators keeps in contact, thus closing the mouth posterior to the incisors, in Dipodomys the more caudal part of the buccinators themselves have differentiated, they being attached to the lower rostrum above and the mandible below, in such fashion that the pair can operate practically as a single, circular sphincter, thus closing the mouth very tightly. The anterior part of the buccinator, however, descends from the side of the rostrum as usual.

Auriculo labialis is a long, slender, tenuous muscle not well

developed, arising ventro-craniad of the ear. There is strong attachment to the caudal portion of the pocket. For the most part it lies immediately dorsad to the pouch with insertion into the mystacial tissue.

Ventral sphincter colli profundus has considerable individual variation, therefore a description can hardly hold generally. Suffice it to say, origin is from the fascia of the midline at least as far caudad as the manubrium. The muscle forms a gular sheet with anchorage or insertion upon the ventral surface of either pocket as far craniad as the ventral opening to the pouch. The cranial portion of this sheet is bound to the fascia caudad of the symphysis menti.

Platysma is complex and very much altered in Dipodomys, because of the cheek pocket. The platysma originates as a single slip from fascia near the mid-dorsal line slightly to the rear of the last rib and immediately craniad and superficial to the latissimus dorsi. The muscle extends craniad to the caudo-dorsal portion of the pouch, and here is where complexity begins. The auriculolabialis, sphincter colli primitivus, and platysma all become intimately associated in this region. The platysma appears to trifurcate, with the more dorsal fibers inserting immediately upon the dorso-caudal margin of the pouch and also joining those of the auriculo labialis. The middle slip inserts into the medio-caudal half of the pouch. The last slip is well defined, being a long slender affair. It turns ventrad from the trifurcation and follows the border of the pouch superficial to the gular sheet to insert within the tough fascia of the chin.

Sternoauricularis can hardly be called a superficial muscle but had best be treated with this group. It lies deep to all other facial muscles. Origin is from the manubrium caudad to the third rib. It extends cranio-dorsad superficial to the parotid gland to insertion on the cartilage of the ear ventrad to the auditory aperture.

Sphincter colli primitivus is a thin, somewhat fragile sheet of muscle tissue arising from the nuchal ligament, mostly caudad and partly deep to the postauriculo-occipitalis layer. The muscle passes deep to the platysma at the dorso-caudal surface of the pouch and apparently fuses with it. The writer was unable to follow it further.

Howell (4, p. 416) has stated:

> It took origin from the midline chiefly deep to the postauriculo-occipitalis complex and passed deep to the two divisions of the platysma. A part, indicating its homology, then extended for a short distance over the shoulder before disappearing, but the main portion had secondarily invaded the side of the head to the mystacial pad. After passing deep to the platysma it expanded, as suggested in fig. 6, its relationship with the labial extension of the auriculolabialis being so intimate that the two could not be readily separated. Although it closely approached the orbicularis sacculi and the fibers were parallel, the latter was not derived from this sheet.

Masticatory Musculature

Howell (5, p.27) states that, "In rodents the chief muscles of mastication are divisible in varying degree, but they had best be treated as occurring as parts of four main muscles, ..."

Masseter has been further divided into the pars superficialis, pars zygomaticus, and pars major. The pars superficialis has origin by a strong tendon five millimeters ventro-posterior to the infra-

orbital foramen. It broadens out as it extends caudad to insertion on the ventral border of the angular process of the mandible. A very tough shiny fascia covers this portion of the masseter. Pars zygomaticus has origin by fibers of all but the ental surface of the complete zygomatic arch. Insertion is on the whole angular process of the mandible. Pars major arises by three heads, ectal, ental, and infra-orbital. The ectal head arises on the lateral crest of the premaxilla four millimeters craniad to the suture of the maxilla and premaxilla. Its origin continues caudad from the superior margin of the maxilla, premaxilla, and cranial portion of the jugal. Insertion is caudad on the masseteric ridge of the mandible. The ental head has origin from the orbital surface of the septum of the maxilla. It extends obliquely ventrad, fusing with the infraorbital head and inserting by tendinous fascia on the masseteric ridge of the mandible. The infra-orbital head arises from the infra-orbital fossa, passing ventrad through the infra-orbital foramen, and descends to fusion with the ental head.

Temporalis is easily divisible into two parts. The orbital division is not very well developed, but arises as a sheet from the entire squamosal within the orbit. The muscle converges to insert upon the dorsal and medial surfaces of the coronoid. The other head is well defined and arises from the squamosal, ventro-caudad of the orbit. Insertion is immediately to the rear of the coronoid process of the mandible.

Pterygoideus externus is a heavy well defined muscle but is relatively short, being about five millimeters in length. It arises

on the exterior surface of the parapterygoid plate. The muscle semi-circumvents the mandibular condyle to insertion upon its medial side. A thin tough fascia covers the dorsal portion of the condyle.

Pterygoideus internus is broader and longer than the preceding muscle. Origin is by a broad tendon from the parapterygoid fossa, and insertion is onto the craniocental surface of the angular process of the mandible.

Interramal Musculature

Digastricus is an excellent example of a twin bellied muscle, both bellies being of equal proportion. This muscle arises by fibers from the paroccipital process. It first becomes tendinous caudad of the hyoid. Passing over the hyoid there is partial insertion by tendons upon the raphe of the mylohyoideus. For the most part the muscle again becomes fleshy extending craniad to a final strong tendinous insertion upon the ventral surface of the mandible just caudad of the symphysis menti.

Stylohyoideus has origin from the cranial border of the paroccipital process deep to the digastricus. The origin is by a long aponeurosis. It extends craniad deep to the digastricus with insertion on the caudodistal portion of the horn of the hyoid.

Transverse mandibularis is a triangular muscle with transverse fibers attaching to the ventral border of either ramus. This muscle lies immediately caudad of the symphysis menti extending posterior as much as six millimeters.

Mylohyoideus originates ventrad to the second molar on the medial surface of the ramus. It extends obliquely caudad to insertion with its fellow onto the medial raphe and onto the cranial border of the hyoid bone.

Muscles of the Tongue

Styloglossus arises by an aponeurotic tendon which is inseparable from that of the stylohoideus. It lies immediately deep to the latter. Insertion is continuous from the ventro-caudal base of the tongue to the tip.

Hyoglossus has origin with its fellow from the complete hyoid bone. The muscle extends latero-craniad with insertion upon the lateral border of all but the tip of the tongue.

Genioglossus is cranially divisible into two parts. Both arise as one, deep to the hyoglossus, from the hyoid bone. The insertion of the lateral part is by aponeurosis upon the cranio-ventral portion of the ramus. The other part forms the medial portion of the tongue, with weak insertion upon the symphysis menti.

Muscles of the Anterior Limb

Muscles of the Shoulder Girdle

Supraspinatus arises from the dorsal border of the spine and supraspinous fossa of the scapula. It extends craniad to insertion by tendon upon the greater tuberosity of the humerus.

Infraspinatus is a relatively large muscle originating from

the infraspinous fossa of the scapula. Insertion is by tendon on the greater tuberosity of the humerus.

Clavo-acromiodeltoideus is a combination of the clavotrapezius and the acromiotrapezius which in many animals are two distinct muscles. In the kangaroo rat no distinction between the two can be found. The muscle originates on the acromion process of the scapula, extending its origin along the ventral border of nearly the entire clavicle. It descends to insertion on the distal end of the pronounced deltoid process of the humerus. This muscle gives the appearance of a muscular cap over the shoulder joint. The clavo-acromiodeltoideus, pectoralis superficialis, and spinodeltoideus all have insertions immediate to each other on the deltoid ridge of the humerus.

Teres minor is a very small slender muscle, partly fused with the infraspinatous, and difficult to follow with exactness. Its origin is half way along the axillary border of the scapula, extending deep to the infraspinatous with suspected insertion on the greater tuberosity of the humerus. The writer was not sufficiently skilled to trace this muscle to its exact point of insertion.

Teres major is an exceedingly large muscle originating on the ventral glenovertebral angle of the scapula. Insertion is deep to that of the latissimus dorsi. Unless careful observation is made it would be easy to assume these two muscles fuse, with common insertion upon the medial crest of the humerus.

Subscapularis is a very complex muscle. It is the only muscle having its entire origin on the ental surface of the scapula. It lies

between the teres major and supraspinatous, with origin from the infraspinous fossa. As it nears insertion it develops an aponeurosis on its ental belly with an apparent series of tendinous insertions on the whole of the lesser tuberosity of the humerus.

Spinodeltoideus has origin on the cranial half of the spine of the scapula, descending obliquely to insertion on the deltoid process of the humerus.

Muscles of the Upper Arm

The following first three muscles are the flexors, the remaining five are the extensors of the upper arm.

Biceps brachii is in two easily distinguishable parts. The smaller lies on the medial side and arises by tendon from the glenovertebral border of the scapula. This portion passes craniad over the head of the humerus. The bicipital groove, through which this tendon normally passes, is absent in the kangaroo rat. The larger part lies lateral to the smaller on the cranial portion of the arm and arises by tendon from the coracoid tip of the scapula. Their insertions being adjacent, the tendons never join but appear to intertwine. The smaller head inserts upon the medial border of the ulna, the larger head upon the radius.

Coracobrachialis is a double muscle in the kangaroo rat, being quite different from the form in which it usually exists. The pars media is a very slender slip arising by tendon almost common with that of the medial biceps brachii, on the coracoid process of the scapula.

Insertion is upon the distal half of the medial shaft of the humerus. The pars breve is extremely short and easily overlooked, but quite thick and well developed for its length. It lies immediately deep to the pars media, arising also from the coracoid. Insertion is craniomediad on the humerus just above the tendon of the teres major.

Brachialis arises by two heads. The longer and larger has origin at the base of the greater tuberosity. This muscle passes along the lateral side of the deltoid ridge where it joins the smaller head. The smaller head arises on the cranial border of the shaft of the humerus immediately distad to the deltoid ridge. These two heads become as one at insertion, which is tendinous, on the brachial ridge of the ulna.

Epitrochlearis is a thin sheet like muscle covering the caudo-medial surface of the upper arm. It has origin upon the tendinous fascia of the teres major and slightly from the latissimus dorsi at the point of the latter's insertion. Its insertion is by superficial fascia upon the olecranon.

Triceps longus is the largest muscle of the upper arm. Origin is immediately craniad to that of the teres minor, near the distal end of the axillary border of the scapula. Its origin is by an exceedingly strong tendon with an aponeurosis being developed upon its medial belly. The muscle inserts by a tough tendon on the extreme end of the olecranon.

Triceps medialis arises immediately distad to the insertion of the teres major with continued origin broadening all along the

posterior border of the humerus. Insertion is on the dorsal surface of the olecranon. The muscle is relatively large at its insertion.

Anconeus is a very small but well defined superficial muscle. It has origin on the medio-cranial portion of the medial epicondyle of the humerus. It recedes posteriorly to insertion on the medial extremity of the olecranon. It is obvious that this is a weak muscle, not because of its size but because of its position.

Triceps lateralis has origin by an aponeurosis from the greater tuberosity of the humerus. Insertion is by fascia upon the caudal border of the ulna, immediate to that of the triceps longus.

Muscles of the Forearm

The following first seven muscles are the flexors, the remaining eight make up the extensors of the forearm.

Palmaris longus is a superficial muscle arising on the distal portion of the medial epicondyle. The fleshy part of this muscle is comparatively short, only eight millimeters in length, but its long thin tendon runs parallel with the tendon of the flexor carpi ulnaris to insertion in the palmar fascia.

Flexor digitorum sublimis arises by an aponeurosis upon its ental belly from the medial epicondyle of the humerus. It lies deep to the palmaris longus. Midway along the arm this muscle divides into three fleshy parts each giving rise to a tendon, two of which extend parallel to each other giving the appearance of one. These three tendons can with difficulty be traced through the palmaris

tissue to their insertions. Each tendon inserts on the tendon of the flexor digitorum profundus at the distal end of each of the three middle digits.

Flexor digitorum profundus arises by three heads. Caput one lies mediad and deep to the digitorum profundus sublimis. It arises by an aponeurosis from the distal portion of the medial epicondyle of the humerus. It has deep attachment on the distal fleshy part of caput three. Caput two is a small slender muscle, lying midway between caput one and caput three. It arises on the distal end of the medial epicondyle. There are apparently no muscle fibers connecting it with either of the other heads. Caput three arises from the second to third-fifths of the mediocaudal shaft of the ulna with deep attachment to the proximal three-fifths of the shaft of the radius. There is further attachment or fusion at the distal fleshy portions of caput one and three. The tendons of these three heads apparently come together, forming a powerful broad tendon which extends beneath the palmar tissue to insertion on the distal portion of each digit.

Flexor carpi ulnaris has origin on the medio-ventral portion of the olecranon and for about three millimeters along the medial ridge of the proximal portion of the ulna. An aponeurosis is developed upon its ental belly, forming a strong tendon which inserts on the pisiform bone of the carpus.

Pronator teres arises on the lateral border of the medial epicondyle of the humerus, immediately dorsad to the flexor digitorum

profundus. A broad aponeurosis is developed, with insertion upon the proximal one-third of the medial surface of the radius. It is obvious that this muscle rotates the forearm.

Flexor carpi radialis is a superficial muscle lying between the pronator teres and the flexor digitorum profundus. It is a relatively long slender muscle with origin on the medial epicondyle. Its tendon extends deep to the ligaments and tissue of the hand with insertion on the proximal portion of metacarpus two.

Pronator quadratus can easily be traced under the miscroscope. The fibers of this muscle are only slightly more than one millimeter in length. Origin is deep to the flexors on the distal half of the ulna, insertion is upon the neighboring border of the radius.

Extensor digitorum communis arises by three heads having a common origin on the lateral epicondyle of the humerus. The two medial muscles lie in close proximity to each other but no fusion of fibers can be detected. The lateral muscle is separated from the other two by the extensor digiti quinti. Insertion of the three heads is by long tendons, passing under the transverse ligament, on the dorsal surface of the second, third, fourth and fifth digits. More specifically, the lateral head inserts on the dorsal surface of the second phalanx of digit five. The middle head gives rise to two tendons with insertions on the dorsal surface of the second phalanx of digit four, and the dorsal surface of the second phalanx of digit three. The medial head gives rise to one tendon with insertion on the second phalanx of digit two.

Extensor metacarpi pollicis is a bipinnated muscle arising from the proximal three-fifths of the radial surface of the ulna and half the ulnar surface of the radius. This may be considered the deepest of all muscles of the forearm, being very neatly nestled between the radius and ulna. Its strong tendon can be seen to emerge obliquely from under the extensor digitorum communis and pass over those of the extensor carpi radialis to insertion on the dorsomedial surface of the falciform.

Extensor indicis is a very slender muscle lying lateral to the smaller head of the extensor digitorum communis and deep to the extensor carpi ulnaris. A stout ligament which extends from the lateral epicondyle of the humerus to one-third the distance of the ulna gives rise near its distal end to this muscle. Its tendon passes deep to those of the extensor digitorum communis under the transverse ligament, becoming forked, with insertions on the first and second digits.

Extensor digiti quinti is partially superficial, lying between the first and second head of the extensor digitorum communis. It arises by a broad tendon from the lateral epicondyle of the humerus. It is with some difficulty separable from the medial head of the last mentioned muscle. Its tendon passes laterally with those of the extensor digitorum profundus under the transverse ligament inserting on the phalanges of digit five.

Extensor carpi radialis longus is the most proximal muscle, having origin upon the lateral epicondyloid ridge of the humerus.

Its tendon passes with that of the extensor carpi radialis brevis over the carpus mediad to its center and is inserted upon the medial dorsum of metacarpus two. The tendon of extensor carpi radialis longus with that of the extensor carpi radialis brevis passes deep to the tendon of extensor metacarpi pollicis just before passing over the carpus.

Extensor carpi radialis brevis is a muscle much larger and lies deep to the former. It has origin from the lateral epicondyloid ridge of the humerus. Its broad tendon passes deep to that of the extensor metacarpi pollicis, over the carpus mediad to its center. It passes deep to the tendon of the extensor digitorum two with insertion on the medial surface of metacarpus three.

Extensor carpi ulnaris has origin from the distal portion of the lateral epicondyle of the humerus and for two millimeters along a band of connective tissue extending from the lateral epicondyle to the ulna. It also takes origin from three to four millimeters along the proximal shaft of the ulna. Following this shaft, its tendon passes under the transverse ligament to insertion of the lateral side of metacarpus five.

Supinator is a small, short, deep, and proximal muscle arising from the annular ligament on the dorsal surface of the head of the radius. Insertion is by fibers on the medio-dorsal surface of the proximal one-third of the shaft of the radius.

Muscles of the Body

The muscles of the body are treated in two major divisions:

muscles of the neck and muscles of the trunk.

Muscles of the Neck

The muscles of the neck are divided according to position; superficial muscles, supra-and infrahyoid muscles, and deep lateral and subvertebral muscles.

Superficial muscles

There are only two muscles constituting this group.

Sternomastoideus is with some difficulty separable from the cleidomastoideus. Origin is by an aponeurosis from the cranial portion of the manubrium of the sternum. The muscle extends deep to the parotid gland, with insertion on the ventro-cranial surface of the mastoid bulla.

Cleidomastoideus is slightly smaller and lies directly against the preceding muscle. Origin is on the cranial surface of the proximal one-fourth of the clavicle. Insertion is on the ventral surface of the mastoid bulla immediately caudad to the sternomastoideus.

Supra - and infrahyoid muscles

Omohyoideus can more easily be found near its insertion, lying between the digastricus and the sternohyoideus. It has origin from the dorso-cranial border of the scapula. Insertion is on the hyoid bone deep to that of the sternohyoideus. The greater part of this muscle from its origin is fleshy and well defined but near its insert-

ion it becomes thin and fragile.

Sternohyoideus is the chief muscle of this region, lying immediately ventrad of the trachea. Origin is on the ental surface of the second costal cartilage and the adjacent portion of the sternum. This muscle extends directly craniad to its insertion on the body of the hyoid bone.

Sternothyroideus in Dipodomys is extremely difficult to trace because of its fragility and its position. The cranial half of the muscle can be found lying laterad to the trachea and deep to the sternohyoideus. Its origin was not accurately determined. It is thought to arise from the ental surface of the sternum, as its name would imply, in close proximity but deep to the sternohyoideus. Its insertion is almost membranous on the ventro-lateral surface of the thyroid cartilage.

Thyrohyoideus is one of the smallest muscles to be considered in this paper, being slightly less than two millimeters in length. By careful dissection and with proper illumination this muscle can easily be observed. It is a well defined muscle in relation to its size. However, at first glance it might be mistaken for an extension of the sternothyroideus or could be overlooked because of its appearance, being somewhat transparent due to the white thyroid cartilage on which it inserts. Origin is on the ental border of the hyoid bone, insertion is on the laterocventral surface of the thyroid cartilage.

Geniohyoideus is a well defined muscle lying deep to the mylohoideus and against its fellow along the medial line. Origin is

along the medial surface of the ramus caudad to the symphysis menti. The fibers run parallel to each other and caudad to insertion on the cranial border of the hyoid bone deep to that of the mylohyoideus.

Deep lateral and subvertebral muscles

Scalenus is a complex muscle arising by at least two heads. The cranio-dorsal head arises from the caudal portion of the transverse processes of the cervix and the cranio-dorsal portion of the first rib. This is a short, broad, apparently bipennated muscle inserting by a strong aponeurosis on the ventro-lateral portion of the atlas in common with that of the more superficial part. The remainder of the muscle, which constitutes the major portion, arises from the second, third, and fourth ribs. This writer suspects that this portion of the muscle may be further divided into two parts; however so much difficulty was encountered that it was thought best to treat it as one part in this paper. This portion was found to have two distinct insertions, one by a very strong aponeurosis in common with the first head, the other by tendons on the cranial portion of the transverse process of the cervix deep to that of the first head. The more dorsal of these origins, being on the fourth rib, lies deep to the ventral slip of the levator scapulae. As it extends craniad it makes its appearance from beneath this slip extending on to insertion superficial to the latter muscle. The muscle interdigitates with at least two slips of the levator scapulae.

Longus colli lies with its fellow of the opposite side between the esophagus and the vertebrae. It arises from the ental and proximal

surfaces of the first four ribs and their vertebrae. There is further origin from each of the transverse processes of the cervical vertebrae. The fibers converge and insert by a tendon upon the tubercle of the ventral arch of the atlas. Those fibers of thoracic origin insert superficially to those of the cervix.

Longus capitus is one of the best defined muscles of this region. It arises from a tubercle on the extreme proximal and cranio-ental border of the first rib. Insertion is upon the extreme cranial surface of the basioccipital.

Rectus capitis anterior is a very short out heavy muscle lying just behind and dorsal to the longus colli. Origin is from the ventrolateral rim of the atlas; insertion is upon the basioccipital.

Muscles of the Trunk

The muscles of the trunk are divided into six different categories, namely: muscles of the thorax, muscles of the abdomen, lumbar muscles, muscles of the back, muscles of the tail, and perineal musculature.

Muscles of the thorax

Panniculus carnosus is a muscular layer within the superficial fascia of animals with a hairy coat. As a muscle of the integument, its function is to shake the pelt and it is used in rodents to shake moisture from the body. In other animals it serves to dislodge annoying insects.

In the removal of the pelts this muscle was badly damaged, therefore the writer feels that his description would be misleading.

Howell (4, p. 439) has written:

> In Dipodomys the main part of the panniculus was extensive. Origin of the dorsal part was from the vicinity of the midline, from a point above the axilla to and onto the base of the tail. In the latter situation the sheet was continuous over the midline and was heavier, as I have found to be the usual case in long-tailed rodents. Anterior to the tail base the fibers almost disappeared but became better defined once more over the dorsal part of the abdomen. Insertion of all of this dorsal sheet was upon the proximal part of the deltoid crest near the head of the femur and adjoining insertion of the superficial pectoral. Near insertion, however, the ventral border of the sheet separated to become tucked in deep to the remainder (fig.6). There was also a ventral panniculus sheet in this animal arising from the midline almost as far forward as the gular sphincter colli profundus and posteriorly to just beyond the level of the groin. Its anterior fibers passed caudodorsally deep to the ventral fibers of the dorsal panniculus, where they soon disappeared over the side, but farther to the rear the fibers were parallel and the two sheets became continuous.

Pectoralis superficialis is a large powerful muscle with origin on the mid-ventral line of the complete sternum. This broad muscle converges to insert on the deltoid spine of the humerus. This convergence forms a nearly perfect right-angled triangle. Many writers choose to divide this muscle into parts, pectoralis major and pectoralis minor and even the latter into parts. In this species the muscle is apparently indivisible, and with its origins and insertions immediately adjoining, the writer feels that pectoralis superficialis is appropriate for this paper.

Pectoralis profundus posterior is a long and extremely slender, ribbon-like muscle lying parallel and partly deep to the profundus superficialis. Its origin is on the cranial portion of the xiphoid process. Insertion is by an aponeurosis on the deltoid ridge of the humerus immediately craniad and deep to the pectoralis superficialis.

Pectoralis profundus anterior has origin midway along the sternum between the third and fifth ribs deep to the pectoralis superficialis. It extends obliquely craniad to insertion, which is apparently continuous with the joint capsule, on the head of the humerus.

Sternocostales externus is a very thin band type muscle arising by a broad transparent band of extremely long connective tissue from the sternum and cartilage of the fourth rib. This muscle could be easily overlooked. It lies deep to the pectoralis profundus anterior. Insertion is upon the caudal border of the first rib immediately dorsad to the subclavius muscle.

Pectoralis abdominalis has origin along the midventral line overlying the xiphoid process. The caudal origin is not separable from the rectus abdominis. Insertion is on the proximo-medio-cranial portion of the humerus.

Subclavius is a well defined muscle in Dipodomys, arising from the cartilage of the first rib. Insertion is upon the entire ental surface of the clavicle.

Serratus magnus ordinarily has origin from the ectal surface immediately dorsad to the ventral curvature of ribs four to seven inclusive. The origin is deep to the obliquus abdominis externus. Each slip interdigitates with the latter muscle, converging to insertion

at a point on the inferior angle of the scapula. However, there is individual variation in this muscle. In one male specimen there was definitely a fifth slip, occurring on either side, arising from the eight rib. This slip is considerably smaller and passes between the obliquus abdominis externus and the serratus posterior inferior, joining the other slips with the same insertion.

Levator scapulae is a sheet type muscle except the caudo-ventral portion which arises as a slip from the third rib. The muscle is inseparable from, and appears as a cranial continuation of, the serratus magnus. Origin is from the whole transverse process of the ankylosed cervicals and from the first three ribs. The muscle slightly converges toward insertion on the ental surface of the entire vertebral border of the scapula.

Howell (5, p. 40) has suggested:

> A better name for it would really be depressor scapulae, as that is its present function brought about by the change in the relational position of the shoulder due to the posture of the animal; but it was thought wiser to retain the usual term.

Intercostales externi are muscle fibers joining each rib to its neighbor. The dorsal fibers extend between the ribs parallel to the axis of the body. The lateral fibers extend dorso-craniad between the ribs. There are no fibers of this muscle extending between the costal cartilages. The more dorsal fibers of the second, third, and fourth ribs insert by an aponeurosis upon the distal end of the transverse processes.

Intercostales interni are similar and deep to the intercostales

externi. They too join each rib to its neighbor. The fibers of these muscles extend dorso-caudad between the ribs. The fact that the fibers of this and the former muscle lies in opposite planes makes them separable with ease. From the fifth costal cartilage craniad the fibers may be seen at the surface, there being no intercostales externi arising from the costal cartilages.

Sternocostales lie within the thoracic cavity. They arise as bands of fibers from immediately craniad of the xiphoid process to the second rib, upon the ental border of the sternum. Insertion is upon the ental, distal surface of the rib next craniad of the origin.

Muscles of the abdomen

Rectus abdominis is a paired muscle arising by two slips from the cranial border of the pubis. There is only slight tendency of the two slips to decussate, as is sometimes the case in rodents. The two slips become fused along the linea alba and extend as far craniad as the sternum where a slight dorsal divergence occurs. Insertion is farther craniad on the cartilage of the first rib and on the sternum between the first and second rib.

Obliquus abdominis externus is a large muscle superficially surrounding the abdomen. Origin is by slips from the last eight ribs, and from the tough lumbo-dorsal fascia. The first four slips interdigitate with those of the serratus magnus. Insertion for the most part is superficial upon the rectus abdominis, and upon the whole of Poupart's ligament. The caudal part of this muscle is strongly

inserted upon the pubis caudad to the inferior tuberosity of the ischium.

Obliquus abdominis internus arises from the lumbo-dorsal fascia along the mid-dorsum. Insertion is upon the last two costal cartilages and upon the transversalis. The fibers appear to be fused with or at least inseparable from the latter muscle. There is further rather weak insertion upon the whole of Poupart's ligament, and strong insertion upon the pubis just laterad to the symphysis.

Transversalis arises from the ental surfaces of the ninth to twelfth costal cartilages, with few fibers arising from the diaphragm, and from fascia deep to the obliquus abdominis internus. Insertion is by an aponeurotic sheet upon the linea alba deep to the rectus abdominis and upon the border of Poupart's ligament.

Cremaster is present only in the male and may for that matter be considered as part of the obliquus abdominis internus. It is merely a continuation of the latter muscle forming a pouch within which lies the testis.

Lumbar muscle

There is but a single muscle restricted to this region.

Quadratus lumborum occurs between the lumbar diapophyses. The posterior attachment is chiefly to a process of the first sacral transverse process, well developed for this purpose, and to a lesser extent upon the adjoining ilium. In Dipodomys the diapophyses are virtually lacking on the first two lumbars and are reduced upon the third,

therefore, the quadratus muscle passes over these vertebral spaces to attachment upon the last rib (Howell, 2, p. 434-435).

Muscles of the back

The muscles of the back are separated into two divisions: superficial, secondary back muscles, and deep, intrinsic back muscles.

The superficial, secondary back muscles are further considered in three separate layers. The most superficial or first layer consists of the following four muscles.

Acromiotrapezius has origin along the mid-dorsal line continuous with and inseparable from the clavotrapezius. From this mid-dorsal line the muscle descends ventrally to insertion on the cranial portion of the spine of the scapula, and to a considerable extent upon the distal portion of the clavicle.

Clavotrapezius has origin on the mastoid and along the occipital angle. This origin is continuous caudad along the mid-dorsal line and is considered as the preceding muscle. This and the former muscle are so well fused that neither is discernable from the other. For the sake of convenience this muscle could be considered absent, but more likely fusion with the acromiotrapezius has occurred instead of loss. Therefore, this writer feels that the name "clavo-acromiotrapezius" better fits the situation and should be considered as one muscle.

Spinotrapezius arises lateral to the mid-dorsal line, and immediately craniad to the platysma. It extends obliquely craniad to

insertion on the dorsal portion of the spine of the scapula, immediately caudad to the insertion of the acromiotrapezius.

Latissimus dorsi is a broad muscle originating obliquely on the lumbo-dorsal fascia. The muscle extends obliquely to insertion upon the tendon of the teres major.

The second layer of the superficial, secondary, back muscles includes the following four muscles.

Rhomboideus anticus has origin extending from the supra-occipital caudad along the mid-dorsal line, becoming continuous with that of the rhomboideus posticus. The origin lies deep to the trapezius muscles and extends caudad as much as fifteen millimeters. From its origin it soon becomes distinct from the rhomboideus posticus. It extends beneath the vertebral border of the scapula, making insertion on the ental surface, immediately dorsal to the inferior angle of the scapula.

Rhomboideus posticus has origin continuous with the above muscle. It converges and lies against the entire vertebral border from the spine to the inferior angle of the scapula. The posticus is the larger of the two rhomboideus muscles and lies porterior to the anticus. This muscle has the appearance of meeting head on, and being continuous with, the serratus magnus. However, this is not the case.

Occipitoscapularis lies dorsal to and parallel with the spine of the scapula. Origin is from the ventro-lateral surface of the mastoid, ventrad to the auditory aperture and just caudad to the

insertion of the cleidomastoideus. Insertion is for four millimeters upon the vertebral border of the scapula.

Atlantoscapularis superior is a rather long slender muscle arising from the latero-caudal border of the atlas. The muscle at first gives the appearance of being a part of the levator scapulae, but it is easily separated from the latter muscle. Insertion is upon the superior angle of the scapula.

Atlantoscapularis inferior has origin on the cranioventral crest of the atlas. The muscle extends obliquely to insert for five millimeters along the distal, cranial portion of the clavicle. This is a well defined muscle about ten millimeters in length. Both origin and insertion can easily be seen after decapitation.

The third layer of the superficial, secondary back muscles is made up of the following two muscles.

Serratus posterior superior arises by slips from the fifth to the ninth rib inclusive. On the ninth rib this muscle becomes inseparable from the serratus posterior inferior. The muscle is thin and membranous at its origin. It converges slightly as it ascends to insertion on the medial raphe near the nuchal ligament.

Serratus posterior inferior arises deep to the obliquus abdominis externus, although the major portion of the muscle is superficial. It can be seen to arise by slips from each of the last four ribs, however, the last slip is not easily distinguished from the obliquus abdominis internus. Insertion is upon the tough lumbodorsal fascia.

The deep, intrinsic back muscles constitute an extremely complex system. This group is by far the most difficult to analyze. The writer is not yet fully satisfied with some of the results in this system.

The deep, intrinsic back muscles are made up of the following four, highly complicated muscles.

Splenius is the deepest muscle arising from the nuchal ligament. The major portion of this muscle lies deep to the serratus posterior superior. The splenius is a well defined muscle. It arises from the nuchal ligament just caudad of the occiput. Insertion is by an aponeurosis upon the mastoid and laterad to a point just ventrad of the auditory aperture.

Iliocostalis as a whole lies latero-ventrad to the longissimus lateralis. It is not very well developed and is here considered in three partly separable parts. The pars lumborum arises from the extreme cranial tip of the ilium and the deep fascia. The muscle partly fans out mediad, inserting upon ribs eleven and twelve deep to the longissimus lateralis; however the main portion extends cranialward to the ninth rib. The pars dorsi arises by slips from the sixth to the ninth rib with insertion by three long distinct tendons upon the third, fourth, and fifth ribs. The pars cervicis arises from ribs five to eight. It is broader than the pars dorsi and extends dorsocraniad to insertion upon the transverse processes of the caudal half of the cervicals.

Longissmus dorsi constitutes the major muscle of the back. Some

of the subdivisions of this muscle are obscure and beyond the ability of this writer to orient with exactness. However, an attempt is made to treat it in two subdivisions; the pars thoracis, and the pars lumborum.

The pars thoracis of the longissimus constitutes the cranial subdivision. The pars cervicis, which is sometimes separable but here not very well differentiated is treated with the pars thoracis. Origin is chiefly by strong aponeurotic tendons from the enlarged metapophyses of the third to fifth lumbar vertebrae, and from the lumbo-dorsal fascia, with some fibers appearing to rise from the spines of the last two thoracic and first two lumbar vertebrae. Deep insertion is by bundles of fibers on the caudo-dorsal border of the ribs; the more superficial fibers inserting by a broad aponeurosis upon the ventral half of the transverse processes of the cervicals.

The pars lumborum constituting the other subdivision is further divided into two parts, the lateralis and the medialis. The lateralis is a large muscle arising from the cranial border and medial surface of the anterior ilium. Insertion begins immediately upon an aponeurotic sheet investing the transverse processes of all the lumbar vertebrae.

The pars medialis is the most complex muscle in Dipodomys. After many attempts so treat this muscle with exactness the writer was not satisfied with his analysis. The medialis apparently arises from both the metapophyses and anapophyses of the second or third lumbar vertebrae caudad to the first sacral. Further origin is from the dorsal surface of the entire ilium, the dorsal surface of the

sacrum, caudad, including the first four transverse processes of the caudal vertebrae. No doubt that which arises from the first four caudal vertebrae and from a deep portion of the ilium constitutes the pars entalis of the extensor caudae lateralis which is in reality a caudal continuation of the pars medialis. The fibers which arise from the lumbar vertebrae join with those from the ilium upon aponeurotic tendons giving the appearance, but not actually being, of a bipinated muscle. This portion of the muscle is composed of layers each overlying the other and each layer having an individual tendon. These tendons pass caudad through a ligamentous sheath upon the lateral surface of the tail, inserting farther caudad.

Howell (4, p. 422-425) has divided the longissimus dorsi into two separate muscles, the longissimus lateralis, and the longissimus medialis, with these each in turn further divided.

> M. Longissimus lateralis, parties capitis, cervicis, dorsi, lumborum (et caudalis?). It is not at all improbable that a part of the extensor caudae lateralis as found is homologous with the longissimus lateralis, but this is not certain and for convenience it will be discussed with the medial division. In this connection it should be stated that the homology of the caudal muscles of long-tailed mammals has received so little attention that disposition of the caudal components in any phylogenetic scheme can be only tentative.
>
> In Dipodomys pars lumborum of the lateral longissimus was extraordinarily robust. Its fibers arose partly from the medial surface of the ilium (but not from the sacrum) and from the dorsal fascia. From the ectal surface of the latter the more lateral fibers originated, and from the ental surface the deeper ones; and in the lumbar region all fibers curved laterocranially around the loin in a heavy, semicylindrical mass to insert upon the ventral surface of the anapophyses of the last two thoracic and first four lumbar vertebrae. As the curvature of the fibers was such that those caudally inserted no farther back than the fourth lumbar, well

defined anapophyses were lacking upon the last three lumbars. All but the last two thoracics were also lacking in sharp anapophyses, and here the pars dorsi was accordingly of a different character. Its posterior, superficial fibers continued from the dorsal fascia but origin of the remainder was by small tendons, apparently from the dorsal metapophyses, with insertion upon the ribs considerably farther forward. The whole continued uninterruptedly into the pars cervicis, with tendinous attachment to the transverse processes of the last six cervicals. Pars capitis, constituting a trachelomastoid, was entirely separate. It seemed not to have attachment to any of the cervical vertebrae but arose from the first eight thoracics (metapophyses?) and inserted upon the audital bullae caudoventrally to the meatus.

. . . . . .

. . . in Dipodomys the cervical part of this division was definitely associated with pars dorsi and inseparable from it. . . .

M. longissimus medialis should be treated as of the trunk and of the tail. Part of the caudal division, or extensor caudae lateralis, certainly belonged with the longissimus medialis, and perhaps all of it did. At any rate, as an accompaniment of the extreme specialization of the longissimus the fleshy part of the lateral extensor of the tail was perfectly divisible into three portions, which may be termed ectalis, intermedius and entalis (fig 8, D2). In Dipodomys pars ectalis arose from the caudal aspect of the ilial aponeurosis and from the sacral transverse processes, and a single tendon extended from it upon the lateral side of the tail; so its functions are as much those of an abductor as an extensor. The pars intermedius had the same origin as the pars ectalis but farther forward, and the two were separated by a deep fascia. At the base of the tail this part was entirely deep to the ectalis but its three long, caudal tendons occurred upon both sides of that of the ectalis. It also sent shorter, deeper tendons to insert upon the metapophyses of the first few caudal vertebrae. Pars entalis was really nothing but a caudal continuation, by a single long tendon, of the middle division of the longissimus medialis, although shorter tendons from the muscle also inserted deep upon the basal caudal vertebrae. One gained the impression that upon contraction of this division of the longissimus farther forward the tail would be extended automatically, unless controlled by antagonistic action of this caudal flexors.

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The part of the longissimus medialis occurring upon the body proper of Dipodomys was also divisible into three parts, more distinct transversely than axially. These may be termed anterior, intermediate and posterior divisions. The anterior of these was really the most superficial (although all were mostly hidden by the longissimus lateralis) and its fibers took origin from the lateral side of the tendons of the semispinalis dorsi, which arose from the metapophyses of the first five lumbars. The fibers inserted upon the articular processes of the last four thoracics. Next, the posterior division arose from the aponeurosis attached to the superior border of the ilium. The fibers twisted around mostly deep to the intermediate division to insert upon the anapophyses of the first five lumbars and last two thoracics. Finally, the intermediate division arose under cover of the semispinalis lumborum from the sacrum and the tendons of the extensor caudae lateralis and also inserted, but dorsal to the posterior division, upon the anapophyses of the first five lumbars and possibly the last thoracic as well.

Semispinalis is here considered in three parts, the pars capitis, pars cervicis, and pars dorsi. The pars capitis corresponds to what is often termed the complexus in other animals. The pars capitis arises from the dorsolateral surface of the entire cervicals except the atlas. Extended origin is caudad to the eighth or tenth, there being individual variation, thoracic vertebrae. It arises as bundles of fibers from each of the metapophyses and lies mediad to the longissimus dorsi. From its origins it rises mostly vertically and converges as it extends craniad to insertion on the superior angle of the occiput. The pars cervicis is a very short broad muscle lying immediately mediad to the former head. Origin is by bundles of fibers from what apparently would constitute the last two cervical vertebrae and from the metapophyses of the first to the sixth or seventh thoracic vertebrae. Insertion is by an aponeurosis upon the cranio-latero-dorsal portion of the axis. There

is apparently another slip which arises from the sixth and seventh metapophyses, the cranial part of which lies deep to the main portion of the pars cervicis. Insertion of this slip is at the medial base of the last cervical. The pars dorsi arises by exceedingly strong tendons from the metapophyses of the first six lumbar and the last two thoracic vertebrae. The muscle is not separable from the superficial lumborum but has origin deep to the latter. Insertion is by fibers upon the short spines of the anterior thorax. There is a small but distinct superficial slip arising from the main body of the muscle with insertion upon the nuchal ligament.

Semispinalis lumborum may be called superficial, for it lies underneath the transparent dorsal fascia. It lies along the middorsum as far craniad as the eleventh thoracic vertebra. The cranial portion is hardly discernable from the pars dorsi of the preceding muscle. Origin is from tough fascia given off from the ilium and from the lumbo-dorsal fascia. Insertion is upon all the lumbar and the first two thoracic spines. The caudal portion of this muscle is not well separated from the extensor caudae medialis.

Transversospinales are short but well rounded muscles connecting each vertabra with the next. They were best observed in the lumbar region extending from the lateral surface of one diapophyses to the medial surface of the one next craniad.

Interspinales are short fibers connecting each lumbar spine with the next one. They are observed in the lumbar region only.

Rectus capitus posterior major arises from the whole of the

spine of the axis. It passes craniad over the atlas to insertion on the superior angle of the occiput.

Rectus capitus posterior minor has origin by strong tendinous aproneurosis from the medio-cranial border of the atlas. From its origin it extends deep to the preceding muscle. Insertion is upon the decending angle of the occiput.

Rectus capitis lateralis arises from the craniodorsal border of the transverse process of the atlas. The muscle extends medio-craniad to a broadened insertion on the surface of the medial and ventral half of the mastoid.

Obliquus capitis superior is one of the smallest muscles mentioned in this paper, being only two millimeters in length. It can best be exposed by removing the muscles from the lateral surface of the neck. It lies immediately deep and slightly laterad to the rectus capitus lateralis. Insertion is upon the medial plane of the paraoccipital process.

Obliquus capitis inferior is about four millimeters in length and is relatively broad. Origin is laterad to the caudal portion of the spine of the axis. It extends latero-craniad to insertion by tendon on the caudo-dorsolateral border of the transverse process of the atlas.

Longus atlantis is the most poorly defined muscle of this system. Fragile fibers can be seen arising from the transverse processes of the cervicals with a tendinous insertion upon the ventro-lateral border of the transverse process of the atlas.

Muscles of the tail

The tail is a highly important organ of equilibrium in Dipodomys. The muscles of the tail are therefore well developed but some are intricately involved with the muscles of the back.

Extensor caudae medialis is a small superficial muscle lying far back on the mid-dorsum. Origin is from the first to about the fifth caudal spines. Small tendons from this muscle insert upon the metapophyses of the third vertebra craniad of their origin.

Extensor caudae lateralis is obliquely divisible into three parts, pars ectalis, pars intermedius, and pars entalis. The pars ectalis arises from deep fascia of the ilium with extended origin caudad from the sacral and first four caudal transverse processes. The fleshy part can be more easily seen dorsad and caudad of the acetabulum. Three aponeurotic slips are given off forming a compound tendon lying along the lateral surface of the tail, inserting farther caudad. Pars intermedius, larger than the former, arises strongly from the cranial portion and mediоventral border of the ilium, from the iliacal aponeurosis, and the first four caudal transverse processes. The caudal half, all but a portion of the extreme tip, lies deep to the pars ectalis and is separated from it by deep fascia. The intermedius remains fleshy into the tail farther than any other muscle. Numerous tendons develop which pass into the dorso-lateral surface of the tail with insertion much farther caudad. These tendons do not insert on the first few caudal vertebrae as stated by Howell (4, p. 424) in his dissection of

Dipodomys spectabalis. Pars entalis was a continuation of a portion of tne longissimus medialis. Two large tendons of this slip pass far back in the tail to insertion. Another slip which this writer is at a loss to place arises from the anapophyses of the last four or five lumbar vertebrae and from the dorsal portion of the sacral transverse processes near the spines. Several tendons develop which pass far back into the tail deep to the two given off by the pars intermedius.

Illocaudalis arises from the cranial portion of the pubis and strongly from the medial surface of the inominate craniad to the acetabulum. Tendons develop, some of which are common also with the pars media of the flexor caudae internus and extend into the ventrolateral surface of the tail with insertion farther caudad.

Pubocaudalis is a broad sheet type muscle which arises upon the medial surface of the ischium along nearly the entire pubis including the symphysis pubis. Insertion is upon the cartilaginous sacral margin from the sacrospinous muscle to the fifth caudal vertebra. No tendons are found to arise from this muscle. The caudal portion is fasciately inserted upon the iliocaudalis.

Flexor caudae externus is a strong muscle arising from the ventral surfaces of all the sacral and first three caudal transverse processes. Numerous tendons develop extending into the ventrolateral portion of the tail, inserting farther caudad.

Flexor caudae internus may be separated into three parts, pars antica, pars media, and pars postica. Pars antica arises from the centra of the sixth and seventh lumbar and first and second sacral

vertebrae. Many tendons develop which extend into the ventro-lateral portion of the tail. Pars media arises from all the sacral vertebrae. More caudally it becomes so intimately associated with the iliocaudalis that the tendons which develop are common to both. Pars postica is a small rounded muscle arising from the centra of the first three caudal vertebrae. A single tendon develops extending farther caudad through the ventral part of the tail.

Perineal musculature

These are the muscles confined to the perineum or that area between the anus and the genital organs. It is bounded craniad by the pubic arch, on either side by the rami of the ischium, and behind by a line joining the tuberosities of the ischia. In this region three muscles are sufficiently defined, and a fourth included, for consideration in this paper, and of these the sphincter ani externus is the only one common to both sexes, the others being found only in the male.

Sphincter ani externus is a broad band type of muscle circumventing the anus. Insertion is mainly on the urethra with slight attachments on the proximal ental surfaces of the corpus cavernosum.

Ischiocavernosus is a well defined and comparatively large sex muscle. It has origin on the complete caudal border of the ischium. Insertion begins on the proximal ventral portion of the corpus cavernosum, turning laterally to its final insertion on the dorsal border of the corpus cavernosum.

Compressor urethrae is an unpaired sheet type muscle with attachments on the ventral borders of the proximal half of the corpus cavernosum. There appears to be slight attachment or fusion of fibers with the sphincter ani externus.

Bulbocavernosus is a muscle which is hardly discernible or at least not well defined when animals are not sexually active. These specimens were preserved at a period of probable sexual inactivity, for this writer was unable to find any trace of this muscle. However, Howell (4, p. 436) states, "This was relatively large in Dipodomys. Some of its fibers were attached to the posterior ligament described under the ischiocavernous, and the rest to the surface of the crus; . . .". It is quite possible that Howell's specimens were preserved during the peak of sexual activity.

Muscles of the Posterior Limb

The posterior limb provides nearly all the propelling force of these animals and is thereby far superior in development than the anterior limb. It is quite natural to divide the muscles of this region into muscles of the hip, muscles of the thigh, muscles of the leg, and muscles of the foot. No attempt is made to treat the last mentioned division.

Muscles of the Hip

The muscles of the hip are treated in three separate groups, iliopsoas group, gluteal group, and obturator group.

Iliopsoas group

Psoas minor is a well defined muscle lying superficially medio-craniad to the psoas magnus. It has origin from the ventral body of the first, sometimes second, lumbar vertebrae to the fifth inclusive. The muscle lies parallel with the body, extending caudad to insertion by a long, strong, and shiny white aponeurosis upon the psoas process cranio-ventrad of the acetabulum.

Psoas magnus is undoubtedly a very strong muscle. It lies laterad and deep to the psoas minor. Origin is from the centra of the third to the seventh lumbar vertebrae inclusive. Fibers of this muscle are attached to an aponeurosis which is also common to the iliacus just before insertion upon the lesser trochanter.

Iliacus is a large muscle that arises from the inferior border of practically the entire ilium. Insertion is by a broad transparent aponeurosis and by fibers upon the lesser trochanter of the femur.

Gluteal group

Gluteus superficialis is a large superficial muscle covering the gluteal region. It is here treated in two parts, pars anterior, and pars posterior. The pars anterior is easily separable from the posterior part except for a few fibers near the origin. It arises by strong aponeurosis from the cranio-ventro-lateral border of the ilium. The muscle lies along the frontal border of the thigh. It is anchored in the superficial fascia along either side, terminating with weak insertion upon the fascia of the knee. Pars posterior arises from the

ventral border of the ilium and the dorsal fascia. This part also extends around the frontal proximal half of the thigh deep to the pars anterior and forms a superficial covering for the whole gluteal region. The muscle extends latero-caudad, with a broad strong aponeurotic insertion upon the pronounced lateral crest of the femur.

Gluteus maximus is a thin muscle, the deeper fibers of which are not easily separable from the gluteus medius. Origin is from the deep fascia. The muscle extends caudad, medially superficial to the latter, passing over the head of the great trochanter to insertion, for a distance of four millimeters, upon the medio-caudal border of the great trochanter.

Gluteus medius is a large and meaty muscle arising for twelve millimeters from the superior gluteal fossa and from an aponeurotic sheet extending caudad from the dorsal border of the ilium. The superficial fibers arise from the dorsal fascia. Groups of fibers form tendons giving an appearance of bipennation; the tendons in turn converge to form a broad strong aponeurosis with insertion upon the dorsal and medial surfaces of the great trochanter.

Howell (4, p. 452) has spoken somewhat differently of this muscle.

> This was by far the most massive part of the gluteal complex. In Dipodomys origin was slightly from the fascia investing the iliocostalis, but mostly from the anterior part of the superior gluteal fossa of the ilium, and for a short distance ventrally along the crest. Insertion was robustly upon the greater trochanter superior to the vastus lateralis.

Gluteus minimus lies deep and is hardly separable from the

gluteus medius. Origin is for twelve millimeters along the medial ridge and the superior fossa of the ilium. Insertion is upon the dorso-lateral surface of the great trochanter, partly deep and lateral to the insertion of the previous muscle.

Obturator group

Gemellus superior cannot be separated with certainty from the gluteus medius in these specimens, and is here considered to be a caudal continuation of the latter muscle. The fibers which arise from the dorso-lateral border of the sacrum, adjacent to the fourth sacral vertebra and overlying the sciatic nerve, are considered to be those of the gemellus superior. Insertion is upon a broad aponeurotic sheet common to this muscle and the gluteus medius, which in turn is inserted upon the head of the great trochanter. A few of the extreme caudal fibers are inserted upon the medial surface of the great trochanter.

Pyriformis cannot be separated from the gemellus superior with surety. It is here considered as a caudal continuation of the gemellus superior. Origin is from the iliacal ridge. The muscle extends ectad over the cranial third of the acetabulum to insertion upon the dorso-lateral surface of the head of the great trochanter.

Obturator internus arises as two entirely separate muscles. The posterior part, being less extensive than usual, covers only the caudal part of the obturator foramen. The accessory part arises from the fossa, situated medial to the acetabulum. Each of these parts gives off separate tendons which pass over the well defined obturator notch. The two tendons join to insert into the obturator fossa (Howell, 4, p. 456).

Gemellus inferior is a short, broad muscle, the cranial portion being somewhat fragile. Origin is from the gemellus fossa cranial to half the dorso-caudal surface of the acetabulum. Insertion is onto the strong tendons of the obturator internus which in turn inserts into the trochanteric fossa.

Quadratus femoris arises by fibers from practically the entire ischium above the foramen, except for one millimeter along the caudal border and for a slightly larger area near the greater tuberosity. A somewhat separate slip arises by tendon from the gemellus ridge. Insertion is mainly upon the head of the lesser trochanter and slightly upon the caudal border of the greater trochanter.

Obturator externus arises by fibers from the obturator foramen except along the dorso-cranial border. An aponeurosis develops upon its ectal belly with insertion into the trochanteric fossa deep to all other muscles inserting within this same fossa.

Sacrospinalis may be easily overlooked. It is slightly more than one millimeter in length and three millimeters in breadth. The fibers arise from the spine of the ischium, immediately craniad of the obturator internus tendons. The fibers extend dorsally with insertion on the margin of the cartilaginous sacral complex at the termination of the last sacral transverse process.

Muscles of the Thigh

The muscles of the thigh consist of extensors, flexors and adductors.

The extensors of the thigh consist of the following four muscles.

Rectus femoris is a large strong muscle lying mostly craniad along the thigh, the distal half being superficial. Origin is mainly by strong aponeurosis from the cranio-medial portion of the acetabulum and the femoral process of the ischium. A white and shiny aponeurosis arises from the medial and ental bellies inserting strongly upon the proximal border of the patella.

Vastus lateralis is a strong major muscle lying for the most part along the cranio-lateral surface of the thigh. It extends over the frontal portion of the leg for a short distance to where it is anchored in strong fascia along the cranio-medial surface of the leg. The muscle arises by a strong aponeurosis upon its ectal belly from the cranio-lateral border of the great trochanter. Insertion is upon the cranio-lateral portion of the patella by a strong aponeurosis which is continuous with tough fascia covering the region of the knee.

Vastus femoris is not a large muscle but has an extensive origin. It lies deep to all other muscles of the thigh, directly against the cranial portion of the femur. It is considered to arise in these specimens by two separate slips. The longer and larger arises strongly from the greater trochanter and to a lesser extent from the base of the head of the femur and lesser trochanter. A broad transparent aponeurosis develops which passes for the most part in the femoral groove, becoming semi-cartilaginous before

insertion upon the patella. The smaller and shorter head lies deep to the former and arises by fibers from the cranial surface of the distal two-thirds of the femoral shaft. The muscle diverges somewhat and the aponeurosis which develops forms the knee capsule.

Vastus medialis constitutes another large extensor. Some of the deeper medial fibers are difficult to separate from the vastus femoris. Origin is from the medial surface at the base of the femoral head. Insertion of the deep cranial fibers is upon the knee capsule. The more superficial caudal fibers insert upon the medial margin of the patella.

The flexors number six as follows.

Semimembranosus anticus is a long strong muscle arising strongly for a short distance from the gemellus fossa. Caudad the origin is by an aponeurosis from the ischium caudo-ventrad to the superior tuberosity and deep to the semimembranosus posticus. The muscle passes to insertion mainly upon the medio-distal surface of the femur with some fibers also extending around to the caudal surface of the femur.

Semimembranosus posticus is slightly the less robust of the two. It arises for five millimeters along the ischial border and fossa, caudad of the superior tuberosity. The muscle extends to the medial surface of the lower leg, and inserts upon the medial tuberosity of the fibula and adjoining knee fascia.

Semitendinosus has origin by two heads. The more superficial and broader head arises from the dorsal fascia near the second caudal

vertebra. The deeper head arises from the superior tuberosity of the ischium. The two heads soon become fused. As the muscle extends to insertion it bifurcates, with the smaller slip passing to the lateral surface and inserting by fascia upon the cranial border of the lower leg. The larger slip passes to the medial surface and inserts by an aponeurosis at a point upon the proximal one-fourth of the cranial border of the tibia. The two slips are further attached by a very tough superficial fascia covering all the distance between the two insertions.

Biceps femoris anticus is fully separable from the biceps femoris posticus. It lies craniad to the posticus. Origin is from deep dorsal fascia and the superior tuberosity of the ischium. Insertion is by strong aponeurosis upon the lateral border of the patella.

Biceps femoris posticus and the former muscle constitute more than half the superficial muscles of the lateral surface of the posterior limb. Origin is by thin aponeurosis craniad and deep to the semitendinosus, upon the dorso-cranial surface of the ischium, immediately caudad to the superior tuberosity. The muscle greatly expands, with insertion by fascia continuous with the biceps femoris anticus upon the lateral surface of the proximal half of the foreleg.

Tenuissimus is a fragile, narrow band of muscle arising from the dorsal margin of the ischium craniad of the superior tuberosity. Insertion is fascial upon the anterior surface, midway along the lower leg, and deep to the lateral slip of the semitendinosus. The

muscle is also weakly anchored in connective tissue which surrounds what is apparently a lymph node located on the calf.

The adductors of the thigh are the following six muscles.

Pectineus is a relatively short but heavy-set muscle lying within Scarpa's triangle. Origin is from the extreme cranial portion of the pubic bone and the pectineal process. Insertion is by a broad transparent aponeurosis upon the caudal border of the femur, extending from the base of the lesser trochanter to one-fourth the length of the shaft.

Gracilis anticus is a thin muscle, but broad, that arises by fibers from practically the entire pubic bone craniad of the symphysis. Its cranial origin lies deep to the adductor longus. Insertion is into the fascia of the knee overlying the patellar ligament. The insertions of the two gracilis muscles are separated by the insertion of the semimembranosus posticus.

Gracilis posticus is a superficial muscle lying on the caudomedial surface of the thigh. Origin is from the ischium, from the inferior tuberosity craniad to the caudal three-fourths of the pubis. The muscle converges to insert by tough fascia for five millimeters upon the proximocranial border of the tibia.

Adductor longus is a small but long triangular muscle arising from the ventral border midway of the pubic bone. The muscle develops a long thing aponeurosis inserting medio-caudally upon the shaft of the femur immediately below the insertion of the pectineus.

Adductor brevis is a large, broad muscle arising strongly from the caudo-ventral border of the ischium, from just dorsad of the inferior tuberosity to just craniad of the symphysis pubis. Insertion is upon the lateral border of the femur extending from the dorsal portion of the lateral crest to nearly the distal end.

Adductor magnus is a large muscle lying upon the caudo-medial surface of the thigh. Origin is from the caudal two-thirds of the pubic bone, not from the symphysis pubis. Insertion is upon the caudal portion of the shaft of the femur, from near the lateral crest to within a few millimeters of the distal end. The distal fibers extend to the medial surface of the femur as well.

Muscles of the Leg

The muscles of the leg are arranged into groups containing flexors, extensors, and peroneal muscles. The flexors and extensors have been grouped according to their function, the peroneal muscles according to their position.

The flexor group is composed of the following eight muscles.

Gastrocnemius medialis is a broad superficial medial muscle arising by strong aponeurosis upon its ectal belly from the medial sesamoid bone and by fleshy fibers from the deeper part of the adjoining femur. There is also a narrow aponeurosis arising from the femur which broadens to form a sheet covering the ental belly. This latter aponeurosis half twists around the tendo-calcaneus, being inserted upon the lateral surface of the calcanium.

Gastrocnemius lateralis is somewhat more complicated than the former muscle. Superficially it is not separable but the deep fibers are partially separable into at least two parts. The larger part is superficial and arises from the lateral sesamoid bone and the surrounding knee fascia. The smaller and deeper part arises from the sesamoid deep to the first part. Fibers of both parts are not fully separable from the plantaris, therefore some fibers are considered to arise from the aponeurosis of the last mentioned muscle. Insertion is upon the tendo-calcaneus.

Plantaris lies upon the caudal portion of the leg between the two gastrocnemii. Origin is by a strong white aponeurosis on its lateral belly from the lateral sesamoid bone deep to the gastrocnemius medialis. The fibers attach mediad upon a tendon which extends beyond the tendo-calcaneus. Passing over the hee the tendon trifurcates with each resulting tendon passing to the ventral base of the three middle digits where each again bifurcates with insertion at the distal end of the first phlanx of the three middle digits, deep to the flexor digitorum longus.

Soleus is well defined and the deepest of the Achillean muscles. It arises by a rather long aponeurosis from the caudal part of the head of the fibula. Insertion is by a tendon into the cranio-proximal portion of the tendo-calcaneus.

Popliteus is the most proximal muscle to be found on the lower hind leg. The muscle has origin from the popliteal fossa upon the extreme distal portion of the lateral epicondyle of the femur

deep to the extensor digitorum longus. The proximal portion of the muscle is also anchored in the tough fascia of the knee. The muscle descends mediad to insertion upon the proximal one-fifth of the medial shaft of the tibia.

Flexor digitorum longus has fleshy origin from the second to third fifths of the medial border of the tibia. Its proximal origin adjoins the insertion of the popliteus. The long, strong tendon which develops passes through a groove enclosed by a ligamentous sheath over the medial malleolous of the ankle. Here the tendon bifurcates. The larger part joins the tendon of the flexor digitorum fibularis; the smaller and fragile tendon inserts upon the medial sesamoid.

Flexor digitorum fibularis is a large muscle lying along the caudal portion of the leg between the tibia and fibula. The strong aponeurotic tendon which develops from this muscle is nearly as large and strong as the tendo-calcaneum. Origin is from the medio-caudal head of the tibia and very slightly from the adjacent head of the fibula. The origin from the tibia extends for two-thirds the length of the leg to a point immediately distad of the fusion of the tibia and fibula. The strong tendon passes just mediad of the calcaneum to the sole where it broadens, sending a branch to the extreme tip of each the five digits.

Tibialis posticus is a very slender but well defined muscle lying deep to the flexor digitorum longus. Origin is by an aponeurosis from the peroneal process of the fibula and by fibers from the caudo-medial border of the proximal one-fourth of the tibia. The tendon which

develops is the longest of the lower leg and passes in a groove over the medial ankle to insertion on the extreme caudal tip of the sesamoid.

The extensors of the lower leg consists of the three following muscles.

Tibialis anticus is a robust muscle arising by strong aponeurosis from the latero-cranial head of the tibia, and less strongly from the entire tibial fossa. Its strong tendon passes beneath the transversus cruris ligament and beneath a smaller ligament just before insertion upon the medial surface of the entocuneiform.

Extensor hallucis longus is a very small and slender muscle arising from the latero-caudal border of the tibia midway proximad of the junction, and from the crural interosseous membrane. Two tiny tendons develop which pass beneath the transverse ligament. One of these passes to the medial side of the foot becoming greatly diverged and giving off a branch which inserts upon the last phlanx of the first digit and continuing on to insertion upon the last phlanx of the second digit. The second tendon, being much more fragile upon the foot, inserts along the medial side of digit three.

Extensor digitorum longus arises by a distinct and somewhat lengthy aponeurosis from the medio-dorsal surface of the lateral epicondyle of the femur near the patellar ligament. The muscle is slender and extends two-thirds the length of the tibia. Four tendons are developed, being easily traced along the dorsal foot to the extreme dorsal distal surface of the last phlanx of each of the four

lateral digits. The tendon enters the second toe upon the lateral side, the third toe over the center, and the fourth and fifth toes upon the medial side. Two smaller tendons are given off from the main tendons before entering digit two and four and are inserted upon either side of the first phlanx of the second digit.

The peroneal muscles are intimately associated. Their tendons pass as a group, being somewhat comparable to the tendo-calcaneus. The following four muscles compose the peroneal group.

Peroneus longus lies laterally craniad and remains fleshy slightly more distad than the other peronei. The muscle arises from the cranial portion of the head of the fibula. Its tendon extends over the lateral malleolus passing to the sole mediad and deep to all other tendons, inserting upon a pronounced tubercle of the proximo-medial portion of the metatarsus of digit one.

Peroneus brevis arises from the ental surface of the head of the fibula and its entire shaft; a few fibers arise from the tibia at the junction of the two bones. Its tendon, slightly more robust than those of the other peronei, passes just mediad of the lateral malleolus to insertion upon the dorso-lateral base of metatarsus five.

Peroneus digiti quarti is a small muscle, inseparable and arising from the ental belly of the peroneus digiti quinti. Its distinct tendon extends with that of the quinti to the dorsal foot, there passing beneath one of the tendons of the extensor digitorum longus to insertion upon the dorsal proximal surface of the second

phlanx of digit four.

Peroneus digiti quinti arises mainly from the lateral portion of the fibular head and lies against, and anchored by fascia to, the shaft of the fibula through its course. No fibers could be found arising from the shaft proper. Its tendon passes just mediad of the lateral malleolus and deep to the tendon of the peroneus brevis. The tendon is easily observable on the dorsum of the foot. Insertion is upon the dorso-proximal surface of the second phlanx of digit five.

OSTEOLOGY

To give a complete account of the osseous system it had best be treated as a comparative study with that of another Genus or Species. This not being a detailed account, the writer has chosen to describe mainly its pecularities and proportions. Therefore only such description of the bones is here included as is deemed necessary for a general knowledge of the osseous system of Dipodomys ordii.

Skull

The skull of Dipodomys is extremely light, smooth, much depressed, and comprises sixty and three-tenths per cent of the total body length. The broad posterior portion is sixty per cent as wide as the skull is long. The skull tapers anteriorly to a point with the rostrum extending well beyond the incisors. The slender and fragile zygomatic bone abuts against the tympanics.

The tympanics are peculiar by being inflated and having a nontubular orifice of the meatus. Furthermore, they are not bounded on either side by bone but are separated, from the squamosal on the ectal side and the basioccipital on the ental side, by fissures. The enormity of the mastoids and their extension caudad of the occipital condyles are among the most striking features of the skeletal system. It is estimated that the mastoids and their accompanying tympanic bullae make up at least one-third of the cranial area. The squamosals are very much reduced. Practically the entire squamosal lies within the orbit, no more than one millimeter of it extends dorsal to the orbit. The parietals are of triangular shape and lie dorso-caudad to the orbit. The interparietal is small and lies between the forks of the occipital. It is not bounded on either side by the mastoids as one might first assume. The basioccipital is long, narrow, and acuminate, and joins with the tympanics at their juncture. The dental formula for the incisors is $\frac{1--1}{1--1}$, and for the molars is $\frac{4--4}{4--4}$. The upper incisors point well backward and are once sulcated. The molars are rootless, but deeply imbedded and have a tendency likewise to point backward. The mandible is characterized by a rather weak coronoid process and a prominent lateral extension of the angular process. The incisors of the mandible of Dipodomys ordii are rounded and awl-like, a feature which can be used at once to distinguish it from Dipodomys microps.

Trunk

Cervical Vertebrae

The cervical vertebrae provide a very interesting feature of anatomy. They are very much shortened, the seven cervicals constituting only ten per cent of the body length. In Dipodomys ordii the atlas is fully free to articulate but the second, third, fourth, and fifth cervicals are fused together. The dorsum of the cervicals is more cartilaginous than osseous. However, the ventral surface of the cervicals is so well ossified that this writer is not sure of any articulation ventrally excepting the atlas.

Thoracic Vertebrae

There are twelve thoracic vertebrae in Dipodomys. This is one less than the amount which comprises the generalized rodents. The spines are absent or nearly so in the first two or three thoracic vertebrae. The remaining spines, all but the last, are progressively enlarged, with the ninth, tenth, and eleventh quite prominent, the twelfth being somewhat reduced. The eleventh and twelfth spines are vertically extended whereas the others extend dorso-caudally. The thoracic vertebrae constitute thirty-two and seven-tenths per cent of the total body length.

Lumbar Vertebrae

There are seven lumbars, " . . . in all the leaping sorts and 6 in the wood rat." (Howell, 4, p. 513). The proportion of the lumbars to body length is thirty-three and two-tenths per cent. The centra of the vertebrae, especially the more caudal ones, are quite enlarged. The spines are all prominent, the caudal ones exceedingly so, and all point craniad. The metapophyses are well pronounced, especially the more cranial ones, and extend equally as high as the spines. The diapophyses are all but lacking on the first four but are well defined on the remaining three vertebrae.

Sacral Vertebrae

These seven vertebrae are reduced in size from the lumbars and are fused together forming the sacral complex. The first sacral vertebra is strongly fused with the ilium. The first two spines are much reduced, but not absent, whereas the last three are comparable with the lumbar spines. The sacral vertebrae compose twenty-four and one-tenth per cent of the body length.

Caudal Vertebrae

In Dipodomys ordii there are twenty-six caudal vertebrae. The metapophyses of the first three or four vertebrae and the diapophyses of the first two vertebrae are quite prominent. All the rest are very much reduced or lacking. The first three vertebrae

compare favorably in length with the lumbars, whereas the remaining vertebrae, except the most distal ones, are much elongated. Many of the caudal vertebrae are as long as all the combined cervicals. In a typical specimen the tail was two-hundred-three and eight-tenths per cent of the total body length.

Sternum

The manubrium is variable in form in these rodents. However, the sternebrae remain constant, there being six in each specimen. The xiphoid process consists of a cartilaginous circular plate attached to the last slender sternebra. The sternum, including the xiphoid process, is thirty-six and nine-tenths per cent of the body length. This is twelve and eight-tenths per cent longer than the combined thoracic vertebrae.

Costae

There are twelve pairs of costae. The first nine of these have capitular and tubercular attachment to the vertebrae. These same nine extend and attach to the sternum.

Extremities

Clavicle

Nothing unusual is found in this bone. It is proportionally well developed, being thirteen and nine-tenths per cent as long as the body.

Scapula

The scapula is a fragile bone, the fossae being semi-transparent. The infraspinosus fossa is about twice the size of the supraspinosus fossa. The falciform inferior angle of the scapula is highly pronounced. The suprascapular notch is very gently curved, not appearing as a notch. The metacromion is entirely absent. The cornoid process seems well defined, as is the slender acromion, The scapula is twenty-one and three-tenths per cent as long as the body.

Humerus

The bicipital groove is so slight in these animals that it can hardly be considered of functional value. The deltoid crest is highly pronounced. The humerus is twenty-one and one-tenth per cent as long as the body.

Radius and Ulna

These two bones lie in close proximity and are bound together with a tough interosseous membrane which give the appearance of being fused. Upon separating these two bones there is found a prominent ossified ridge upon the radial border of the ulna. From this one might assume a possible tendency toward fusion and also a tendency to restrict pronation. The radius is twenty-four and four-tenths per cent as long as the body, the ulna being twenty-nine and eight-tenths per cent as long as the body.

Innominate

All components of the innominate bone are well fused. The ilium of this bone is strongly united with the first sacral vertebra. The position of the innominate is nearly parallel with the body axis. The rectus femoris process seems well developed. The length of the innominate is forty-three and one-fourth per cent of the total body length. A more significant comparison is that of postacetabular to preacetabular measurement. The former, expressed in percentage of the latter, is seventy-eight and four-tenths per cent. Howell's (4, p. 519) research indicates, " . . . that the degree of change is in direct ratio with saltatorial specialization."

Femur

There is very little that is unusual in this bone. The great trochanter extends above and is comparable in size to the head of the femur. The percentage of the femur to body length is forty-one and two-tenths per cent.

Tibia and Fibula

The fibula fuses with the tibia upon the latero-caudal surface of the latter at a point midway along the tibia. It is interesting to note that by measuring from where fusion first occurs the fibula is shorter than the radius of the forearm. The fibula is twenty-one and three-tenths percent as long as the body, the tibia being fifty-three and eight-tenths per cent.

CONCLUSION

This is hardly a problem within itself, but is more a minute portion of the great problem which lies before the anatomist, that of thoroughly analyzing and describing the anatomy of all forms of animal life.

This writer, strongly upholds the opinion set forth by Hall (2, p. 7), " . . . that taxonomic characters of considerable value will be found in the musculature when more forms have been studied." It is further believed, by this worker, that other systems, especially the osseous, may also play important roles in taxonomy. Some examples are here given to substantiate this belief.

1. In Dipodomys ordii the platysma is found consistently to arise by a single slip, whereas in Dipodomys spectabilis it arises by two slips.

2. The vastus femoris is of two distinct slips in these specimens, only one being mentioned by Howell in Dipodomys spectabilis.

3. Dipodomys ordii being a five-toed rat, the musculature of the lower leg is accordingly modified from that of Dipodomys spectabilis, a four-toed rat.

4. Dipodomys ordii has twenty-six caudal vertebrae, while Dipodomys spectabilis has thirty or thirty one, the tail of the latter being proportionally longer.

5. Numerous other proportions are found in this species which differ considerably from those of Dipodomys spectabilis. A note-

worthy one is that of postacetabular to preacetabular lengths. The per cent of postacetabular to preacetabular length in Dipodomys spectabilis is seventy-one, in Dipodomys ordii seventy-eight and four-tenths. If the lengthening of the ilium is directly proportional to saltatorial specialization, as has been suggested by Howell, then the latter species is better adapted to its method of locomotion.

6. The rounded awl-like incisors of Dipodomys ordii is a distinguishing feature between it and Dipodomys microps.

It seems logical that if one animal is to be classified differently from another, these differences should first be borne out in its anatomy.

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