NOTES ON THE ANATOMY OF THE BABIRUSA

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Recent studies of the phylogeny of the pigs have been based on comprehensive examination of fossil material. Interpretations in these studies are necessarily based chiefly on dental characters. The large differences in the soft anatomy of various living genera may, however, be accompanied by only slight differences in dentition. It is therefore evident that the interpretations derived from fossil material require a check in the light of the whole anatomy of the living forms. Unfortunately there prove to be large gaps in knowlledge of the Suidae, and these must be filled out by studies of various genera as they become available. The babirusa is outstandingly different from other suids in external appearance, and certain equally unusual features of its soft anatomy have long been known.

Nearly a century has passed since Vrolik (1844) dissected two male babirusas that died in the Amsterdam zoological garden. Modern standards leave much to be desired in his brief and incomplete descriptions, which with a few exceptions represent all that is known of the anatomy of this animal. Beddard (1909) studied two babirusa brains, but concluded that the divergences from other suids were "only slight."

Therefore, when a fine adult *Babirussa babyrussa* Linnaeus in the collection of the Chicago Zoological Society died recently and was presented to Field Museum through the generosity of the authorities of the Society, it was embalmed and injected and the following notes made before it was reduced to a skeleton. It is to be regretted that circumstances did not permit complete dissection of the cadaver, since the anatomy of the Suidae, except the domestic hog, is almost unknown. This has made it difficult to evaluate the results of the present study. For the most part such evaluation must await future work on other members of the family.

The animal was an adult male, with a head-and-body length of 1040 mm.; the tail measured 275 mm. The skull has a total length of 310 mm. and a maximum zygomatic breadth of 120 mm. Unfortunately, the animal was not weighed.

Armour and Company of Chicago supplied material of domestic animals needed for comparison, and grateful acknowledgment is hereby made to that organization, especially to Dr. J. B. Porsche

of its chemical research department. Certain comparisons have also been made with the viscera of a white-lipped peccary (*Tayassu pecari*) obtained at Belize, British Honduras, by the recent Mandel Caribbean Expedition of Field Museum. I am under continued obligation to my colleagues: to Mr. Karl P. Schmidt for help in translating difficult German passages, and to Mr. Bryan Patterson for helpful advice and criticism. The drawings, which have been planned and executed with great care, are the work of Miss Elizabeth Story, who is also to be credited with much of the painstaking dissection of the blood vessels.

MUSCULAR SYSTEM

Attention has been directed chiefly to the muscles of the limbs and limb girdles, and examination of the rest of the musculature was more or less incidental and unsystematic. The classic studies of Windle and Parsons on the myology of ungulates (1901, 1903) greatly facilitated this part of the study, and comment is in general restricted to conditions that differ from their summaries. Vrolik apparently studied the muscles of his babirusas in considerable detail, but his descriptions are so general that they are often of little value.

MUSCLES OF THE HEAD AND BODY

M. platysma forms a rather heavy, wide sheet, 110 mm. in width, arising over the shoulder just caudad of the scapulo-humeral articulation, and running down over the ventral side of the ramus of the mandible. It meets its fellow of the opposite side at the midline of the sublingual region. The muscle terminates on the external side of the mandible at the level of the corner of the mouth.

M. sternofacialis is well developed and lies superficial to the platysma, as is usual in the Suidae. It arises from the tip of the manubrium sterni, separated from its mate of the opposite side by an interval of 6 mm., and expands in fan shape over the front of the shoulder. It terminates in the fascia over the platysma at about the level of the shoulder articulation.

M. masseter is composed of a superficial and a deep layer. The zygomatic half of the superficial layer is covered with a heavy tendinous aponeurosis. Origin is from the entire length of the ventral border of the zygoma. The deep layer is somewhat less extensive anteriorly; its entire external surface is covered with a heavy tendinous aponeurosis.

M. temporalis is divided into superficial and deep layers. The superficial layer is much the smaller, and arises from the entire

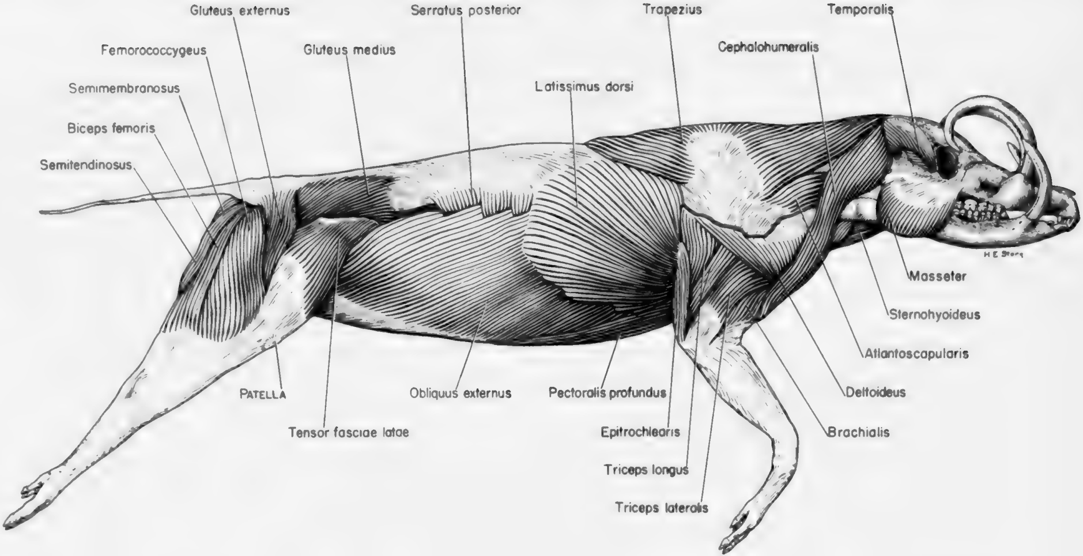

FIG. 14. Superficial musculature after removal of the panniculus. **Tendons of the deltoideus and tensor fasciae latae have been largely removed.**

postorbital length of the zygomatic arch. The deep layer has the usual origin from the temporal fossa. The fiber direction of the superficial layer is nearly horizontal, while that of the deep layer is diagonal.

M. digastricus is composed of a single belly, which arises by means of a stout tendon from the paroccipital process and inserts extensively on the ramus of the mandible.

M. sternomastoideus arises from the side of the manubrium and passes craniad, diverging from the midline, to the paramastoid process, where it inserts.

M. cleidomastoideus arises from the tendinous intersection in the cephalohumeral and passes craniad to its insertion on the paramastoid process, deep to the insertion of the sternomastoid.

M. sternohyoideus arises from the anterior tip of the manubrium. At its origin it is very narrow from side to side and very deep dorsoventrally. It gradually widens in the gular region, running forward in contact with its mate at the midline.

M. atlantoscapularis (omo-trachelian of Windle and Parsons) is a flat band arising from the fascia over the acromial region of the scapula. It is visible superficially in the interval between the trapezius and cephalohumeralis. Insertion is made into the transverse process of the atlas.

Mm. scaleni dorsales are composed of two entirely separate muscles, both of which are dorsad of the brachial plexus. One, wider and more superficial and apparently representing the longus, arises from the first, third, and fourth ribs, apparently with no attachment to the second, and inserts on the transverse processes of the fourth and fifth cervical vertebrae. The other arises from the anterior border of the first rib, beneath the origin of the foregoing part, and inserts on the transverse processes of the third and fourth cervical vertebrae; the insertion into the fourth is craniad of the insertion of the long division of the scalenus.

M. scalenus ventralis arises from the first rib and inserts on the transverse processes of the fourth, fifth, sixth, and seventh cervical vertebrae.

M. panniculus carnosus forms an extensive sheet covering the lateral and ventral surfaces of the body. Posteriorly the fibers run down on the front of the thigh about halfway to the knee. The ventral edge of the muscle reaches the midline in front of the prepuce. The most ventral fibers insert into the ventral fascia, while the more dorsal fibers converge toward the axilla, to insert with the latissimus.

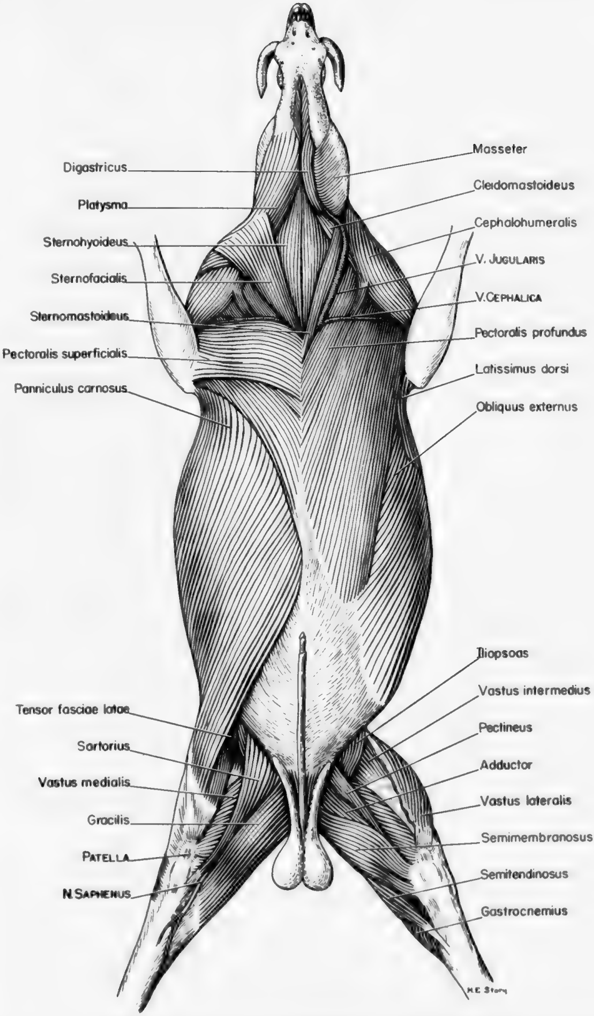

FIG. 15. Musculature from the ventral side. Superficial layers are on the left, deeper muscles on the right.

M. pectoralis superficialis is composed of separate anterior and posterior divisions. The *anterior* division is heavier and narrower than the posterior one, and is slightly overlapped by it. It arises from the manubrium sterni and inserts into the pectoral ridge of the humerus at about the middle of the shaft of the humerus. A narrower deeper slip has the same origin and inserts into the pectoral ridge partly deep to and partly distad of the main part. The *posterior* division is a thin rectangular sheet arising from the sternum, and inserting into the medial end of the bicipital arch and the fascia of the medial side of the forearm.

M. pectoralis profundus arises from the ventral midline, from the posterior sternebrae and continues to a point 80 mm. caudad of the end of the sternum. The most anterior fibers (pectoralis minor of most authors) arise from the side of the manubrium and pass over the front of the shoulder, to insert into the fascia over the supraspinatus. Immediately caudad of and parallel to this is another slip which forms a tendinous intersection with the cephalohumeralis at the former site of the clavicle. The main mass of the profundus (quartus of Windle and Parsons) inserts into the proximal end of the pectoral ridge and the greater tuberosity; the most anterior fibers accompany the coracobrachialis beneath the supraspinatus, inserting with the former.

MUSCLES OF THE SHOULDER AND FORELIMB

M. trapezius is very well developed, as is usual in the Suidae. It is in contact with the cephalohumeralis for 130 mm. dorsally. Origin is taken from the lambdoidal crest and back along the dorsal midline of the neck. The most posterior fibers do not reach the midline, but arise by means of an aponeurotic sheet. The fibers running toward the coracoid border of the scapula stop abruptly at the scapular border and are replaced by a heavy aponeurosis, which continues across the supraspinatus to the usual insertion on the scapular spine. The fibers running toward the neck of the scapula insert into the fascia over the scapular muscles.

M. cephalohumeralis arises from the entire occipital crest. The division between the clavotrapezius and clavodeltoid parts of this muscle is indicated only by a slight tendinous intersection on the ventral border, where a few of the most anterior fibers of the deep pectoral leave the main pectoral mass and join the cephalohumeral. The cleidomastoid division of the cephalohumeral also leaves the main mass of the muscle at this level.

M. latissimus dorsi takes origin from ribs 9–11; its dorsal fibers are continued, as usual, onto the dorsal fascia by aponeurosis, which continues caudad from the sixth thoracic vertebra. The antero-dorsal border of the muscle is overlapped slightly by the trapezius. The latissimus joins the teres major where the two muscles lie across the triceps longus, and they insert by a common tendon into the shaft of the humerus.

M. rhomboideus is composed of two parts, which apparently represent the so-called *capitis* and *colli.* The capitis is much more extensive, arising from the lambdoidal crest and from the ligamentum nuchae as far back as the fourth thoracic vertebra. The colli lies beneath the preceding part, the posterior borders of the two muscles being approximately coextensive; the anterior fibers of the colli arise aponeurotically, the origin extending forward to about the third cervical vertebra.

M. supraspinatus forms a heavy mass arising from the supraspinous fossa and around the coracoid border onto the subscapular surface, where it forms a tendinous intersection with the subscapularis. Insertion is by fleshy fibers into the prominent curved border running mesad from the greater tuberosity.

M. infraspinatus arises from the infraspinous fossa of the scapula and suprascapula, and inserts into the prominent infraspinous scar on the greater tuberosity of the humerus.

M. deltoideus arises by means of an extensive aponeurosis from the scapular spine, from the fascia of the supraspinatus, and on its internal face even from the tendon of the triceps lateralis. Insertion is chiefly into the deltoid ridge, some of the ventral fibers going to the fascia of the forearm.

M. teres major arises from the posterior part of the axillary border of the scapula and from the fascia separating the teres major and the subscapularis. Insertion is made, by a flat tendon common to it and the latissimus dorsi, into the usual scar on the external side of the shaft of the humerus. The latissimus dorsi lies deep (external) to the teres major at this point.

M. teres minor arises, as usual, from the teres minor fossa along the axillary border of the scapula; many of the fibers arise from the heavy fascia separating this muscle from the infraspinatus. Insertion is into the prominent tubercle on the lower border of the greater tuberosity, immediately below the insertion of the infraspinatus.

M. subscapularis is divided into four bundles. Its entire inner surface is covered by a heavy tendinous aponeurosis. Origin is from about the ventral two-thirds of the subscapular fossa, and insertion is by means of a stout tendon into the lesser tuberosity of the humerus.

M. biceps arises by a stout, somewhat flattened tendon, from the bicipital tubercle immediately ectad of the coracoid process; the

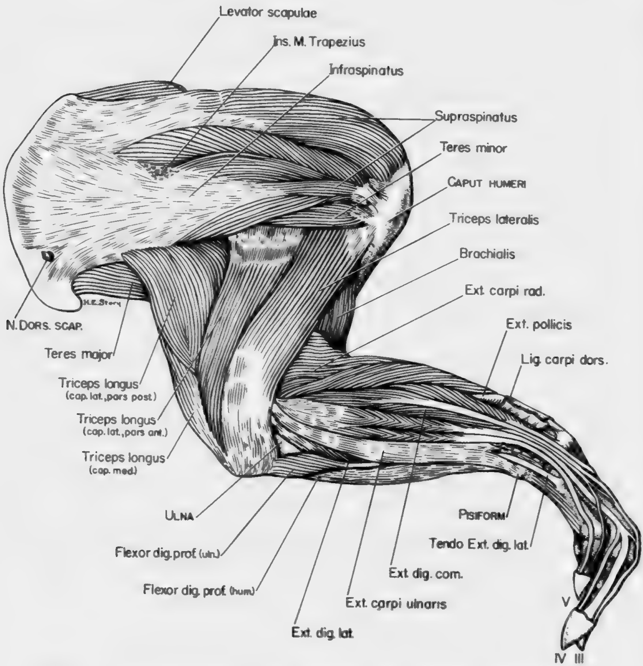

FIG. 16. Musculature of right shoulder and foreleg, lateral aspect.

tendon passes through the shoulder capsule. Insertion is chiefly into the radius, although the tendon continues across the medial side of the radius onto the ulna. There is a fibrous expansion, corresponding in position to the lacertus fibrosus of human anatomy, that joins the fibrous vestige of the pronator teres.

M. coracobrachialis is divided into well-marked short and long heads, between which passes the branch of the musculocutaneus nerve that supplies the biceps and the internal circumflex humeral artery. In the presence of both heads *Babirussa* apparently differs strikingly from *Sus* (Windle and Parsons; Sisson); Vrolik's description is not clear as to whether more than one head was present in his specimens. The two heads arise by a wide, flat tendon from the coracoid process and the surrounding shoulder capsule. The short

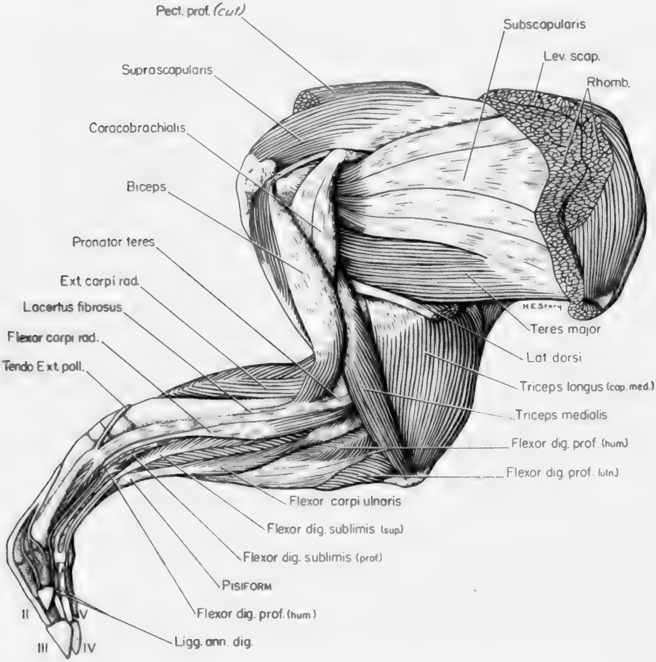

FIG. 17. Musculature of right shoulder and foreleg, medial aspect.

head inserts fleshily into the neck of the humerus immediately above the tendon of the latissimus and teres major. The long head forms a very wide flat tendon where it passes beneath the biceps. This tendon inserts into the anterior edge of the shaft of the humerus about midway between the two ends of the bone.

M. brachialis has the usual origin from the lateral side of the surgical neck of the humerus. Insertion is exclusively into the radius, attachment being into its medial border immediately laterad of the insertion of the biceps. Windle and Parsons were inclined to believe that this muscle invariably inserts on the ulna in ungulates, while Sisson gives both the radius and ulna for the domestic hog.

M. epitrochlearis is a thin but extensive muscle covering the whole posterior and about half of the medial parts of the upper arm. It arises, by a thin tendon medially which gradually gives way to fleshy fibers posteriorly, from the latissimus dorsi. Insertion is into the posterior and medial borders of the olecranon.

M. triceps longus is, as usual, much the largest element of the triceps complex. It is composed of lateral and medial heads. The

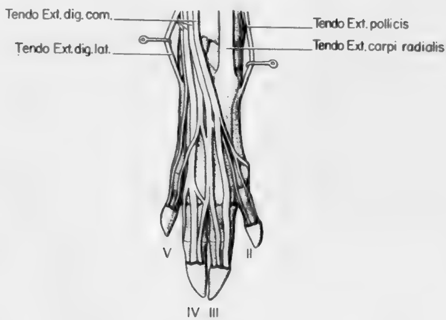

FIG. 18. **Tendons of right manus, anterior view.**

lateral head in turn is divided into distinct anterior and posterior elements. The anterior part of the lateral head arises tendinously from the axillary border of the scapula near the head; the posterior part arises similarly just posteriorly, with accessory origin from the fascia over the infraspinatus. The medial head arises from the axillary border opposite the origin of the anterior part of the lateral head. The two heads fuse and insert into the tip of the olecranon.

M. triceps lateralis arises, by means of a wide tendon, from the neck of the humerus. Proximally, it covers a considerable part of the brachialis. Insertion is made into the external surface of the olecranon, by means of a tendinous aponeurosis.

M. triceps medialis arises extensively from the postero-medial surface of the shaft of the humerus, from a point just below the head distad. Insertion is into the medial border of the olecranon.

M. pronator teres is represented by a heavy tendinous band running from the internal condyle of the humerus to the distal end of the radius.

M. flexor carpi radialis is a slender fusiform muscle arising from the internal condyle of the humerus. It terminates, at about the juncture of the middle and distal thirds of the radius, in a long tendon that inserts into the base of metacarpal II.

M. palmaris longus is absent, as is usual in the higher ungulates according to Windle and Parsons.

M. flexor carpi ulnaris is a narrow ribbon-like muscle arising from the internal condyle immediately below the origin of the flexor

FIG. 19. Tendons of right manus, posterior view.

carpi radialis; the olecranal head is absent. The muscle crosses over the flexor digitorum sublimis to reach the tip of the pisiform, where it inserts, chiefly by fleshy fibers.

M. flexor digitorum sublimis is composed of two heads, which arise from the internal condyle between the origins of the two condylar heads of the profundus. The tendon of the deeper head passes through a tunnel formed by the common tendon of the profundus. The terminal tendon of the deep head of the sublimis inserts into the second phalanx of digit III; that of the superficial head inserts into digit IV (fig. 19).

M. flexor digitorum profundus is composed of three heads, two condylar and one olecranal. This agrees with the description given by Sisson; Windle and Parsons state that there are five heads in the Suidae. The condylar heads are very unequal, the one on the ulnar side of the forearm greatly exceeding its mate in size. The olecranal head is short and triangular, terminating abruptly in a long flattened tendon, which maintains its independence as far as the carpus; there it joins the powerful common tendon of the condylar heads. The common tendon splits into four divisions, which are distributed to the terminal phalanges of the four digits; as usual, the tendon divisions to the two middle toes are larger than those to the lateral toes (fig. 19).

M. brachioradialis is absent, as usual in the Suidae.

M. extensor carpi radialis is represented by a single muscle, apparently the brevis. It is a heavy muscle taking extensive origin from the lateral supra-condylar ridge. Distally as it passes beneath the dorsal carpal ligament it forms a stout flat tendon, which inserts into the proximal end of metacarpal III.

M. extensor digitorum communis arises from the external condyle of the humerus. It is composed of four fleshy bellies, which have a complex tendon arrangement. Numbering these bellies from the medial (radial) side outward, the tendons are distributed as follows (fig. 18): The tendon from the *first* belly splits, the resulting two tendons going to the second and third digits. There are two tendons from the *second* belly. The more medial of these gives off a slender tendon to the second digit, then splits near the distal end of the metacarpus; further subdivisions of the resulting two tendons supply each phalanx of the third and fourth digits. The more lateral tendon subdivides again, one branch joining the medial tendon, while the other goes to the fifth digit. The tendon from the *third* belly goes exclusively to the fourth digit, except for a short medial branch that joins the tendon of the second belly to digit IV. The tendon from the *fourth* belly goes to the fifth digit. No record of this muscle being divided into four bellies in *Sus* was found, although Windle and Parsons cite Cuvier and Laurillard's record of a peccary in which there were four.

M. extensor digitorum lateralis lies mostly beneath the extensor carpi ulnaris. It arises from the external condyle partly beneath and partly distad of the extensor carpi ulnaris. Insertion is by means of a long, somewhat flattened tendon into the proximal end of metacarpal V. Tendons normally go to IV and V in *Sus;* there was a single tendon to V in the *Sus* (=*Potamochoerus*) *porcus* dissected by Windle and Parsons.

M. extensor carpi ulnaris agrees with that of other Suidae in being entirely tendinous. It has the usual origin from the external condyle of the humerus, and inserts into the pisiform. Near its insertion the tendon is pierced by the tendon of the extensor digitorum lateralis.

M. extensor pollicis is a bipinnate muscle arising from the distal half of the shaft of the ulna and radius. It terminates in a narrow tendon that crosses over that of the extensor carpi radialis, to insert into the proximal end of metacarpal II.

MUSCLES OF THE HIP AND THIGH

M. psoas major is asymmetrically developed on the two sides of the body (fig. 20). On the left side, which is apparently normal, it is a wide, flat sheet extending forward to the thirteenth rib; posterior to the fourth lumbar it presents a glistening tendinous surface ventrally. Insertion is into the lesser trochanter. On the right side the psoas major is composed of independent slips. The more anterior of these extends from the twelfth rib to the third lumbar, where it forms a stout round tendon that continues caudad, to insert into the fascia below the ilium. The second slip arises tendinously from the fourth lumbar and fleshily from the succeeding lumbars, and has the normal insertion of the psoas major.

M. psoas minor is a narrow muscle extending forward to the centrum of the thirteenth thoracic vertebra. Insertion is, as usual, into the pectineal eminence.

M. iliacus is not laterally compressed, as Windle and Parsons state that it is in ungulates, but is rather wide, and spatulate at its origin. It has the usual origin from the ventral surface of the ilium and the margin of the sacrum. The muscle is more or less inseparable from the psoas major, and inserts by a common tendon with it into the lesser trochanter.

M. quadratus lumborum arises from the last two ribs and the transverse processes of all the lumbar vertebrae. Insertion is by means of a narrow, flat tendon into the ventral side of the ilium near the sacro-iliac articulation.

M. gluteus externus arises by two heads, which fuse near the insertion. The anterior head, which is considerably smaller and slightly overlaps the posterior head, arises from the gluteal fascia; its fibers fail to reach the dorsal midline by about 80 mm. The posterior head arises from the spines of the posterior sacral and anterior caudal vertebrae. The insertion of the muscle is into the fascia of the anterior (not external) surface of the femorococcygeus.

M. gluteus medius is somewhat larger than the gluteus externus, and has the usual origin from the dorsal part of the gluteal surface of the ilium as far back as the greater sciatic notch. Insertion is into the external and posterior surfaces of the greater trochanter.

M. gluteus minimus lies immediately beneath the gluteus medius, and is slightly less extensive than that muscle. The minimus shows

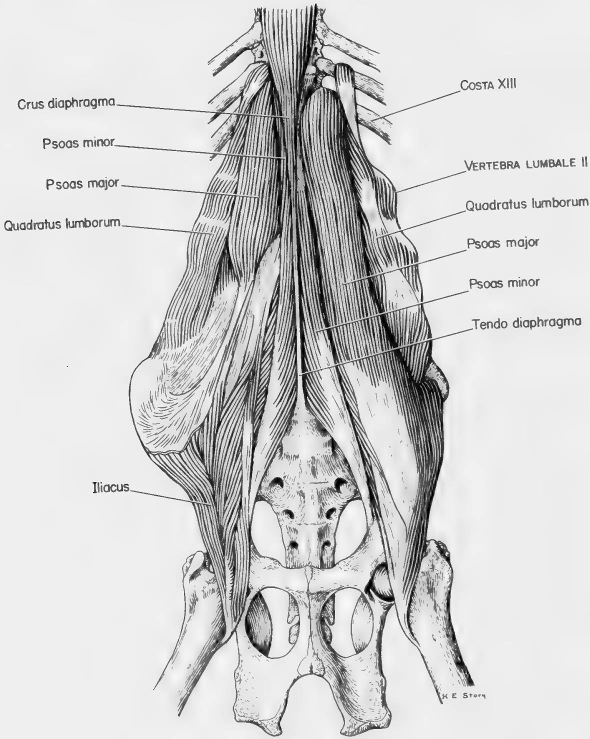

FIG. 20. Lumbar musculature, ventral view.

more or less of a division into four subequal bundles proximally. It arises from the ventral part of the gluteal surface of the ilium, and inserts into the anterior and external sides of the great trochanter.

M. gluteus ventralis is quite distinct from the gluteus minimus, beneath which it lies, with its anterior edge projecting beyond the

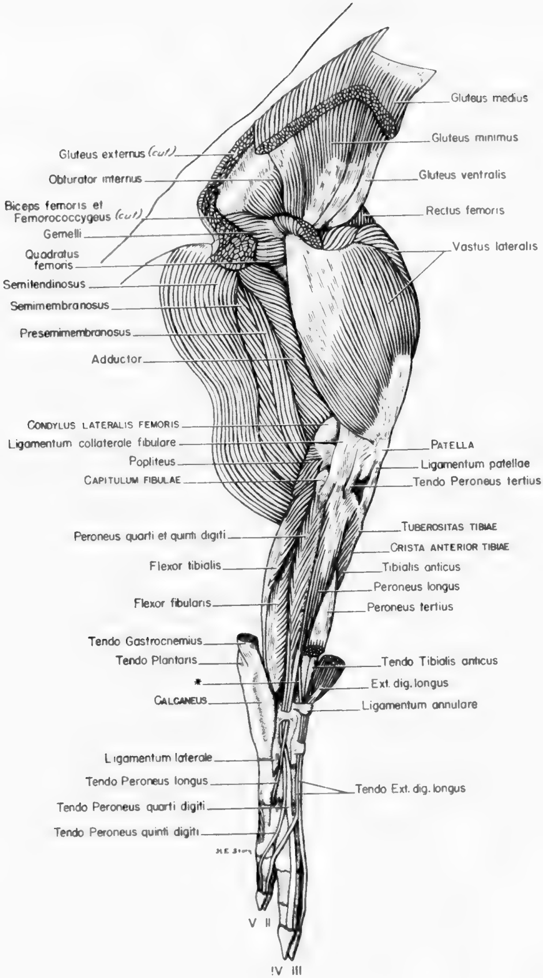

FIG. 21. Musculature of right thigh and hind leg, lateral view (*=tendon of extra muscle of peroneal group).

minimus. Origin is from the ventral border of the ilium, and insertion into the antero-internal side of the great trochanter.

M. gluteus profundus.—Four small muscles connecting the pelvis with the proximal end of the femur lie immediately caudad of and in the same plane as the gluteus ventralis. The first of these (the others are the obturator internus, the gemelli, and the quadratus femoris), lying just caudad of and in contact with the gluteus ventralis, apparently represents the gluteus profundus. It is a small muscle arising from the ilium above and in front of the acetabulum and inserting into the anterior surface of the femur mesad of the great trochanter.

M. tensor fasciae latae arises from the iliac crest, internally for about 60 mm. along the sacro-sciatic ligament, and externally from the fascia over the gluteus medius for some distance caudad of the iliac crest. The muscle spreads out in fan shape from its origin, becoming particularly heavy over the anterior edge of the thigh, and inserts into the fascia lata in a long curved line. The muscle fibers reach about two-thirds of the way to the patella.

Mm. gemelli.—The third and smallest of the four muscles on the same plane as the gluteus ventralis apparently represents the gemelli, although Windle and Parsons state that the gemelli are fused with the obturator internus in those animals in which the latter muscle arises outside the pelvis. The gemelli are represented by a single small independent muscle lying between the obturator internus and the quadratus femoris. It arises from the side of the ischium near the tuberosity, and inserts into the ventral part of the trochanteric fossa.

M. piriformis is apparently indistinguishably fused with the gluteus medius.

M. obturator internus (using Windle and Parsons' terminology; this is the externus of most authors) lies caudad of the gluteus profundus, which it scarcely exceeds in width. It arises from the ischium above and behind the acetabulum, and inserts into the trochanteric fossa.

M. obturator externus arises from the pelvic surface of the pubis and ischium and from the outer surface of the ischium laterad of the obturator foramen. No demarcation between the obturator externus and the "obturator tertius" of Windle and Parsons could be found. Insertion is into the trochanteric fossa laterad of the insertion of the obturator internus.

M. quadratus femoris is slightly narrower than the obturator internus. It arises from the ventral side of the ischial tuberosity and inserts into the posterior side of the proximal end of the shaft of the femur. It completely hides the distal end of the obturator externus.

Mm. semimembranosus et presemimembranosus are fused at their common origin, becoming separate only near their distal ends. Origin is chiefly from the tuber ischii, although the anterior fibers, including all the fibers going to the presemimembranosus, arise from the sacro-sciatic ligament. The presemimembranosus inserts into the internal condyle of the femur. The semimembranosus inserts into the head of the tibia, deep to the medial collateral ligament.

M. semitendinosus has a single head of origin, from the tuber ischii, where it is wedged in between the origins of the semimembranosus and biceps. It has the usual insertion into the inner side of the second quarter of the shaft of the tibia.

M. sartorius is a rather slender muscle arising from the inguinal ligament at about its middle and from the fascia covering the iliopsoas, and inserting by means of a long tendinous aponeurosis into the shaft of the tibia immediately below the knee. The muscle covers the femoral vessels throughout almost its entire length.

M. rectus femoris is entirely covered, except at its extreme proximal end, by the vastus lateralis. It arises, by a flat tendon common to it and the vastus intermedius, from the ilium in front of the acetabulum. Careful dissection failed to reveal a second head of origin, although Windle and Parsons state that they have not met with a single ungulate in which evidence of two heads could not be found. A few of the external fibers insert into the inner surface of the terminal tendon of the vastus lateralis; the main mass of the muscle inserts fleshily into the proximal border of the patella.

M. vastus lateralis is very extensive. It almost completely encases the rectus, except the medial side of the rectus, which lies against the vastus intermedius. Origin is from the great trochanter. Proximally the muscle shows a slight tendency toward bilamination. The anterior fibers form a wide tendon distally, which inserts into the proximal border of the patella. The more lateral fibers insert partly into the side of this tendon and partly into the lateral side of the patella.

M. pectineus is a rather small muscle arising from the transverse ramus of the pubis near the symphysis. Its lateral and medial surfaces, which lie against adjacent muscles, are covered with glistening fascia. Insertion is into the distal two-thirds of the medial surface of the shaft of the femur.

M. gracilis is a very extensive flat muscle, covering the whole posterior half of the medial surface of the thigh. It arises from the entire pubic symphysis, and inserts by means of an extensive aponeurosis, which is continuous anteriorly with that of the sartorius, into the medial side of the tibia for nearly its entire length. The posterior fibers join the fascia that runs down to the tendon of Achilles.

M. adductor is composed of a single prismatic mass, which shows no tendency to separate into magnus, longus, and brevis. It arises, along the entire length of the symphysis, from the pubis and ischium. Insertion is into the distal two-thirds of the shaft of the femur.

M. biceps femoris arises from the tip of the ischial tuberosity, its origin wedged in between that of the femorococcygeus and that of the semitendinosus, and inserts into the fascia of the leg below the patella. As usual, a fibrous sheath passes down from its lower border to help ensheath the tendon of Achilles.

M. femorococcygeus is very large, considerably exceeding the biceps in size (fig. 14). Origin is exclusively from the ischial tuberosity, anterior to and opposite the origin of the semitendinosus, with the origin of the biceps embraced between. Thus the femorococcygeus and biceps lie in the same plane. As usual, the femorococcygeus and biceps are very intimately united. Insertion is into the side of the patella and into the fascia above and below the patella.

M. tenuissimus, as usual in ungulates, is either absent or blended so completely with the biceps that it is indistinguishable.

M. vastus intermedius is closely associated with the rectus femoris. It arises from the ilium in front of the acetabulum by a common tendon with the rectus femoris. It has no contact with the femur, its deep surface being separated from the bone by the great medial extension of the posteromedial edge of the vastus lateralis. It inserts extensively into the adjacent surface of the rectus femoris, none of its fibers reaching the patella.

M. vastus medialis (fig. 35) is the only muscle of the quadriceps extensor group that has any attachment to the femur. It is somewhat smaller than the vastus lateralis, and arises extensively from the entire length of the anterior and medial surfaces of the shaft of the femur. Insertion is into the distal end of the adjacent surfaces of the vastus intermedius and rectus femoris and into the medial side of the patella.

MUSCLES OF THE LEG AND FOOT

M. gastrocnemius arises by the usual two heads, from the femur just above each of the condyles. The medial head is considerably the larger. The two heads are distinct only near their origin, fusing almost at once and forming a stout tendon that inserts into the posterior part of the tendon of Achilles. As usual in ungulates, the tendon of the gastrocnemius and that of the plantaris are twisted around one another through 90°, so that the plantar tendon comes to lie externally (fig. 36).

M. plantaris is embraced by the lateral head of the gastrocnemius. It is a rather large muscle arising from the shaft of the femur above the external condyle. Its terminal tendon divides into four slips, which are distributed to the four digits. Vrolik also found four terminal tendons in the *Babirussa* material he studied; the tendon to the fifth digit is absent in other suids, so far as known.

M. soleus is usually described as wanting in the Suidae, and Vrolik so described it in the babirusas he dissected; Sisson, on the other hand, describes and figures it for the domestic hog. In the specimen at hand there is proximally a sharp separation between a wide mass of fibers on the external side of the leg and the adjacent part of the gastrocnemius. These two muscles are separated, in addition, by the large trunk of the common peroneal nerve, which passes between them. The lateral fibers, which apparently represent the soleus, arise chiefly from the head of the fibula, although their origin extends up onto the external condyle. There is also extensive origin from the lateral fascia of the leg, fibers coming from it for about the proximal third of the leg. Insertion is made extensively into the lateral side of the gastrocnemius tendon.

M. popliteus (figs. 21, 36) has the usual origin from the postero-internal surface of the external condyle of the femur, and inserts into the proximal half of the posterior surface of the tibia. The external fibers also insert extensively into the overlying fascia.

M. flexor tibialis (Flexor digitorum longus) is a slender muscle lying superficial to a part of the much larger flexor fibularis. It arises from the external surface of the tendon of the flexor fibularis, and thus has no relation whatever with the tibia. It forms a slender distal tendon, which joins that of the flexor fibularis at the level of the distal end of the tibia.

M. flexor fibularis (Flexor hallucis longus) is a comparatively large muscle. It has an extensive origin, from the posterior surface of the tibia, from practically the entire posterior surface of the fibula, and from the intermuscular septa on either side of it. Its stout distal tendon divides into four slips near the distal end of the

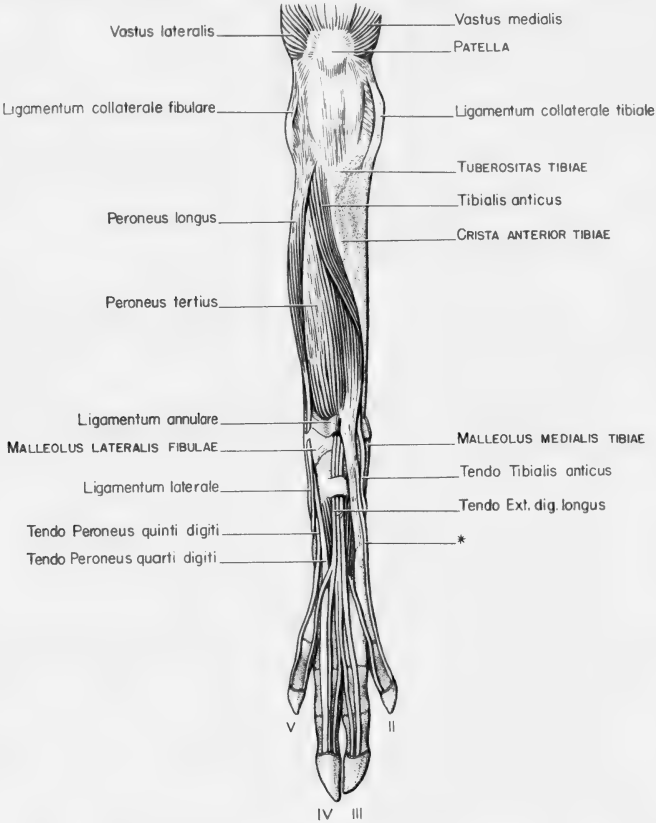

Fig. 22. Musculature of lower right hind leg, anterior view (*=tendon of extra muscle of peroneal group).

metatarsals, which are distributed to the four digits. As usual, the slips to the two middle digits are much stronger than the others.

M. tibialis posticus arises from the medial side of the posterior surface of the tibia along its entire length, the most proximal fibers even reaching the head of the fibula. Its long and rather slender terminal tendon runs along the posterior side of the tendon of the flexor fibularis from the distal end of the calcaneum on, and although it partly unites with that tendon at the level of the tarso-metatarsal articulation, it becomes free farther distad and divides to form two tendons, which go to the middle toes.

M. tibialis anticus (the tibialis anticus of Windle and Parsons includes the peroneus tertius) is a rather slender muscle arising from the lateral surface of the tibia near its head. It terminates in a long slender tendon that accompanies the tendons of the peroneus tertius and extensor digitorum longus through an annular ligament at the distal end of the tibia, and inserts into the first cuneiform and metatarsal II.

M. extensor digitorum longus arises with the peroneus tertius from the external condyle of the femur, and is completely encased by that muscle on all but its deep surface, as far distad as the beginning of the terminal tendons. The extensor gives off three tendons. The most lateral of these divides again, sending one branch to digit V and one to digit IV. The middle tendon also divides, branches going to digit IV and digit III. The medial tendon goes only to digit III. This is the same tendon arrangement as Sisson gives for *Sus*, except that he records a third branch, which goes to digit II, from the lateral tendon.

M. peroneus longus arises from the lateral condyle of the tibia and the head of the fibula. Its anterior border is intimately attached to the anterior crural fascia. The muscle completely hides the proximal end of the peroneus tertius. Its terminal tendon passes across the distal end of the fibula and calcaneum, and beneath the lateral ligament through the aperture between the cuboid and metatarsal V, to the usual insertion on the first cuneiform.

Mm. peroneus quarti digiti et quinti digiti are fused to form a common muscle, which ends in two terminal tendons. The muscle arises from about the proximal two-thirds of the fibula. The two terminal tendons remain side by side as far as the metatarsals, then diverge to go to the fourth and fifth digits. That to the fifth digit is more slender, and arises somewhat higher than the other.

In addition to this common muscle there is another very slender muscle lying immediately in front of it that cannot be homologized with anything that I can find in the literature for any ungulate. This muscle is in contact with the tibia, along the crest that marks the juncture of its posterior and antero-external surfaces, and thus lies very deep between the peroneus quarti et quinti digiti and the peroneus longus. It is separated from the peroneus longus by the peroneal nerve and branches of the anterior tibial artery, but is in very intimate contact with the peroneus quarti et quinti digiti. Origin is taken from the head of the fibula, in common with the latter muscle, and it terminates near the distal end of the tibia in a slender tendon, which passes beneath the tendon of the peroneus tertius, perforates it just distad of the tibio-astragular articulation, and continues to its insertion on the first phalanx of digit II (figs. 21 and 22,*). This tendon arrangement is reminiscent of the perforation of the tendon of the peroneus tertius by the tendon of the tibialis anticus in the Bovidae.

M. peroneus tertius (Pars femoralis of tibialis anticus, Windle and Parsons) completely covers the extensor digitorum longus, and is inseparably united to it proximally, becoming separable only near its distal end. The common origin of these two muscles is by a long round tendon from the front of the external condyle of the femur. The flat terminal tendon of the peroneus tertius inserts into the third cuneiform and the base of metatarsal III. The tendon is perforated by the slender tendon of a muscle associated with the peroneus quarti et quinti digiti, as described above.

SUMMARY OF MYOLOGICAL CHARACTERS

Of the 31 myological characters selected by Windle and Parsons in tabulating the results of their studies on the ungulates there are two with which the present study is not in agreement. (1) The records available to these authors indicated that M. coracobrachialis has two heads (medius and longus) only in the Cervidae and Bovidae among artiodactyls and that the longus is not always present even in these two families. Thus this character, although not constant, would tend to bracket off the Pecora from the remaining Artiodactyla, which invariably had a single head (the condition in the Giraffidae is unknown). The discovery of a second head in *Babirussa* shows that its presence is not limited to the Pecora. (2) M. obturator tertius was present in all artiodactyls of which Windle and Parsons had records. No structure corresponding to this muscle could be found in *Babirussa,* although I can speak with less certainty on this point than with respect to the coracobrachialis. It may have been overlooked, in spite of careful examination of the obturator externus.

In addition to these two general points, there are several others applying specifically to the Suidae. Although the myology of *Ba-*

birussa is typically suid in nearly all respects, the following characters represent departures from the suid pattern as hitherto known. Their significance, if any, cannot be assessed until other members of the family have been studied.

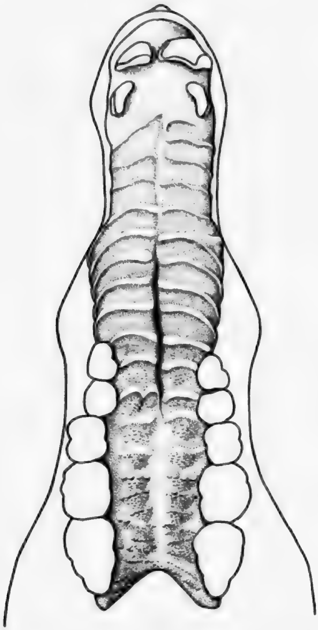

FIG. 23. Roof of mouth, showing appearance of hard palate.

(1) The middle slip of M. pectoralis profundus, which inserts into the tendinous intersection in the cephalohumeralis, is not known in other suids.

(2) M. brachialis inserts into the radius instead of the ulna (*Potamochoerus* and all other ungulates, Windle and Parsons) or the radius and ulna (*Sus*, Sisson).

(3) M. extensor digitorum communis has four bellies instead of the three normally found in *Sus*.

(4) M. extensor digitorum lateralis sends a tendon only to digit V, instead of to IV and V as in *Sus*.

(5) M. plantaris has four terminal tendons, instead of three as in other suids; this was true also in the babirusas studied by Vrolik.

(6) Mm. peroneus quarti digiti et quinti digiti are fused to form a common muscle with two terminal tendons, instead of remaining distinct.

(7) The presence of an extra muscle in the peroneal complex is a unique feature whose significance must remain uncertain until further studies and comparisons can be made.

DIGESTIVE SYSTEM

The *hard palate* (fig. 23) does not present any particularly noteworthy features. It is long and narrow, expanding somewhat at the level of the tusks. There is a well-marked median furrow, flanked on either side by about 22 transverse ridges. These are slightly convex anteriorly; the most posterior ones are much less pronounced and are crenulated. Posteriorly the space between the ridges is slightly tuberculated. The area enclosed by the incisors is devoid of ridges.

The *tongue* has the long, narrow form characteristic of ungulates. There is a prominent median glosso-epiglottic fold, bounded on either side by a well-marked depression.

The entire dorsum of the tongue is covered with a velvety mat of *conical papillae.* These are longer and denser on the so-called intermolar eminence anterior to the vallate papillae. *Fungiform papillae* are small, numerous, and quite evenly distributed over the dorsum of the tongue. They are absent on the ventral surface, but on the sides of the tongue at the level of the molars they become enormously enlarged. No *foliate papillae* could be found, but there is a pair of *vallate papillae* occupying approximately the same position as do those of *Sus.*

THE STOMACH

(Figs. 24, 32)

The stomach differs from that of the domestic hog chiefly in the enormous size of the diverticulum ventriculi, in the prominence of the constrictions that delimit its three main divisions, and in the size and complexity of the cardia. The stomach is large, measuring 880 mm. along the greater curvature, from the pylorus to the base of the diverticulum. It is much more elongate than that of *Sus;* this is true particularly of the cardia, which is continued beyond the entrance of the esophagus for a distance exceeding all the remaining length of the stomach. The esophagus enters the stomach at an oblique angle, as in the domestic hog, although the angle is considerably less acute in *Babirussa*. The lesser curvature is 155 mm. in length. The fundus and cardia are abruptly reflected against each other at right angles to the greater curvature (fig. 24), and the pylorus in turn is reflected back against the fundus along the lesser

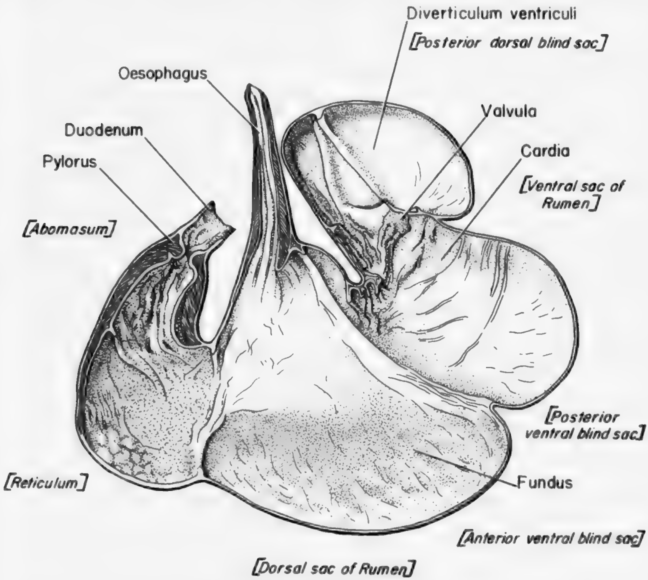

FIG. 24. Stomach sectioned and laid out flat. Regions corresponding to parts of the ruminant stomach are labeled in brackets.

curvature, so that the topographical relations of the parts of the stomach are very complex. The diverticulum is 165 mm. long and 135 mm. wide. It is completely encased in a snugly fitting fold of the lesser omentum, and in the normal position lies closely against the fundus.

The walls of the stomach are thin throughout, except in the pyloric region and at the mouth of the diverticulum along the lesser curvature. The wall of the cardia is only about 0.5 mm. thick in the region of the greater curvature; this is increased to 1.5 mm.

in the region of the lesser curvature. The wall in the fundus region is about 1 mm. in thickness. The pyloric wall is heavy, with a maximum thickness (along the lesser curvature) of 13 mm. The wall of the diverticulum has a maximum thickness of 3.5 mm., which is near its mouth along the lesser curvature; along the greater curvature it has a thickness of only 0.5 mm.

The lining of the esophagus is thrown up into longitudinal ridges near the stomach, and these are continued into the stomach lining for a short distance. The lining of the stomach is esophageal in character over a small area (40–50 mm. in diameter) around the entrance of the esophagus. The remainder of the stomach lining is rather devoid of macroscopic character, except in the pyloric region where it has a reticulated, honeycomb appearance.

In the dorsal half of the bisected stomach a prominent fold, corresponding to the reflection of the cardia upon itself, appears on the inner surface of the stomach. This fold, which is 25 to 30 mm. high, begins at the esophagus and runs diagonally across the dorsal wall of the stomach; it thus corresponds to the "left longitudinal groove" of veterinary anatomy in the ruminant stomach. A similar but much less prominent fold runs outward from about the center of the lesser curvature. There are no corresponding folds on the ventral wall of the stomach. The entrance to the diverticulum is guarded by a heavy muscular projection extending inward from the lesser curvature and a thin non-muscular fold extending inward 50 mm. from the greater curvature; these structures are not continuous with one another. Prominent rugae radiate from the former into the diverticulum and into the adjacent part of the cardia, while a low but well-defined fold runs from the latter completely around the wall of the diverticulum, dividing the cavity into subequal parts.

When seen in longitudinal section (fig. 24), the stomach of *Babirussa* presents striking similarities to a relatively simple ruminant stomach (e.g., the domestic sheep). Every part except the omasum, even including a rudimentary reticulum, is represented and occupies the same relative position. The arrangement is scarcely such that true rumination could take place, however, and it is certain that the similarity is due to convergence, and consequently is without much phylogenetic significance.

THE INTESTINES

(Fig. 34)

The *small intestine* is 5.5 meters (about 20 ft.) long, measured with the mesentery attached. This is five times the length of the head and body, and thus agrees with the proportions found by Owen in *Phacochoerus*, while contrasting sharply with the great length (ten times head-and-body length) in the domestic hog. The duodenum, which is 370 mm. long (measured to the beginning of the mesentery of the jejuno-ileum), is a simple loop, as noted by Mitchell (1905). The posterior part of the colon curves around through this loop on its way to the pelvic canal. The bile duct enters the wall of the duodenum 15 mm. beyond the pylorus; the papilla is situated 25 mm. beyond the pylorus. The ampulla is 18 mm. in length, and its lining is raised into several faint longitudinal

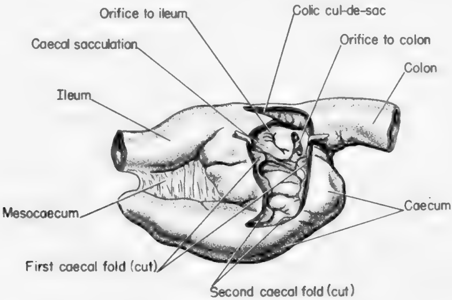

FIG. 25. Caecum, with wall opened to show internal structure.

folds. The jejuno-ileum is arranged in a series of tight loops around a rather narrow and somewhat crescent-shaped mesentery. This part of the intestine has a diameter of about 15 mm.

The *caecum* (figs. 25, 34) apparently agrees with the findings of Vrolik and Mitchell, although the descriptions and figures given by both these authors are inadequate. The caecum is composed of a large and rather complex proximal part and a simple conical terminal part. The ileum opens into the caecum at an oblique angle, its orifice guarded by a prominent valve. The colon is continued beyond the terminus of the ileum, so that the ileum and colon appear to overlap at this point. Thus the colon forms a cul-de-sac behind the terminal part of the ileum, but opens into the caecum by a simple orifice near the outlet of the ileum.

The proximal part of the caecum is divided into four sacculations by constrictions in its wall, which are associated with thickening of the wall itself. Thus the lining of this part of the caecum appears to be thrown up into prominent folds. The terminal part of the caecum is a simple diverticulum, 65 mm. in length, which is reflected toward the ileum and held in place by a short fold of the mesocaecum. The diameter of the proximal part is about 40 mm., while that of the terminal part is only about 15 mm.

The *large intestine* is 3 meters (about 10 ft.) long, which is only three times the head-and-body length of the animal. This compares with four times given by Owen for *Phacochoerus;* it is also about four times in the domestic hog. Except for its terminal part it is arranged in the enormous double spiral coil that is characteristic of the Suidae. The terminal part arches craniad through the loop of the duodenum, then runs straight caudad along the midline to the rectum.

The spiral coil agrees with that of *Sus* in that the proximal (centripetal) part of the coil exceeds the distal (centrifugal) part in diameter. The difference between these two regions is much less striking in *Babirussa.* The centripetal part has a diameter of only about 20 mm., which exceeds that of the jejuno-ileum only slightly; the diameter of the centrifugal part is about 10 mm.

THE LIVER

(Fig. 26)

The liver weighs 1115 g. (preserved), which is only about half the weight of this organ in the domestic hog, but is almost exactly the weight of the liver in the *Phacochoerus* dissected by Owen (1119 g.). It measures 235 mm. in long diameter by 145 mm. in short diameter. The general arrangement and proportions of the lobes are similar to those in the domestic hog. The most notable difference is the much smaller size of both left lobes, particularly the left lateral, in *Babirussa;* this gives the liver a triangular appearance when viewed from either the diaphragmatic or the visceral surface. The fossa for the gall bladder is entirely in the right central lobe. The posterior vena cava runs along the surface of the caudate lobe, and is only partly embedded in its substance.

The *gall bladder* is a narrow, elongate structure, 55 mm. in length, almost completely embedded in the substance of the right central lobe. Its tip reaches the lateral margin of the liver, and in this it contrasts sharply with the gall bladder of the domestic hog. The cystic duct, which is smaller than the hepatic duct and 50 mm. in length, joins the hepatic duct at an acute angle just beyond the portal fissure. The opening of the ductus choledochus into the duodenum was described above.

The *pancreas* was damaged in removing the viscera from the body, and its structure and relations could not be determined.

The *spleen* (fig. 32) is a long, narrow organ, very loosely attached to the stomach by a long gastro-lienal ligament. The anterior end is triangular in cross section, and is wider than the posterior end,

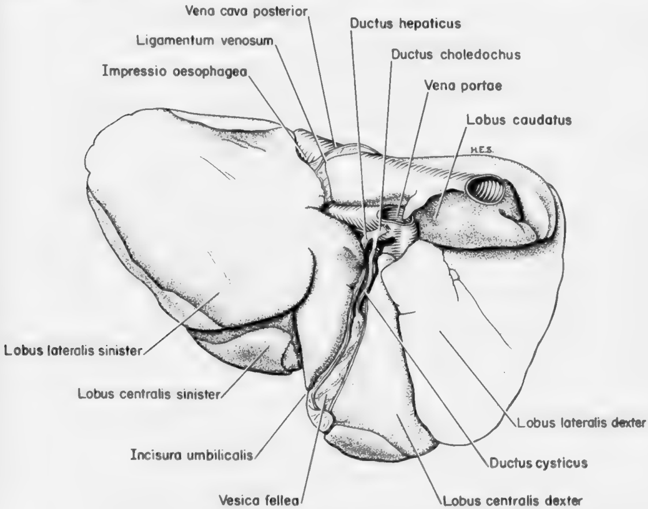

FIG. 26. Visceral view of liver.

which is thin and flat. The length of the spleen is 275 mm., and its maximum width at the anterior end is 65 mm.

SUMMARY OF DIGESTIVE CHARACTERS

The digestive system presents several unusual features, the significance of which it is difficult to evaluate without further knowledge of other members of the family.

(1) As has long been known, the stomach differs notably from that of other suids in its size and complexity. It exhibits a rather striking parallelism with a simple ruminant stomach. The significance of this is not clear, but the similarity is certainly due to convergence; the complex stomach of *Babirussa* is easily derived from the simple stomach of *Sus*. On the other hand, the stomach

of *Babirussa* seems to have little in common with that of the peccaries (cf. also below, under the celiac circulation).

(2) The small intestine agrees in length with that of *Phacochoerus;* in both it is strikingly shorter than in the domestic hog.

(3) The caecum appears to be not dissimilar from that of *Phacochoerus;* it is much smaller than that of the domestic hog.

(4) The large intestine is somewhat shorter than in either *Phacochoerus* or the domestic hog. *Babirussa* also differs from the domestic hog, at least, in the relatively small diameter of the centrifugal part of the spiral coil.

(5) The liver differs from that of the domestic hog in the small size of both left lobes and in the fact that the gall bladder is entirely in the right central lobe. The gall bladder is elongate, its tip reaching the margin of the liver instead of only about halfway, as in the domestic hog.

RESPIRATORY SYSTEM

The *larynx* (fig. 27) differs rather notably from that of the domestic hog in a number of features. The cricoid cartilage has a very long and rather narrow lamina, which projects backward beyond the origin of the arch. The anterior border of the lamina is produced in ʌ-shape. The median ridge is elevated into a prominent keel, whose contour forms a smooth arch when the larynx is viewed laterally. The cricoid arch is very narrow antero-posteriorly, and is directed backward much more sharply than it is in the domestic hog. The thyroid cartilage is heavily calcified posteriorly; Vrolik states that it was almost completely ossified in both the old and young animals that he dissected. Its general form differs from that of the domestic hog only in details. Its posterior border is less curved when viewed laterally than it is in the domestic hog, due to the fact that the posterior cornu is not carried backward as it is in *Sus.* There is a shallow but distinct median notch in the anterior border. The arytenoid cartilages differ from those of *Sus* chiefly in the less conspicuous elongation of the apex; the narrow backwardly curving tip of the apex is absent in *Babirussa.*

The *epiglottis* is much smaller than that of *Sus,* and lacks the tri-lobed outline characteristic of this structure in the domestic hog. It is a narrow spout-like structure, with a distinct median notch in its anterior border. It resembles that of *Sus* in having the middle part of its base turned forward and resting on the thyro-hyoid membrane, and in being closely attached to the hyoid bone by the hyo-epiglottic ligament and a strong hyo-epiglottic muscle.

The *trachea* is 168 mm. long and is composed of 27 incomplete rings. It has a diameter of 20 mm. A special bronchus to the right anterior lobe comes off the trachea at the level of the twentieth

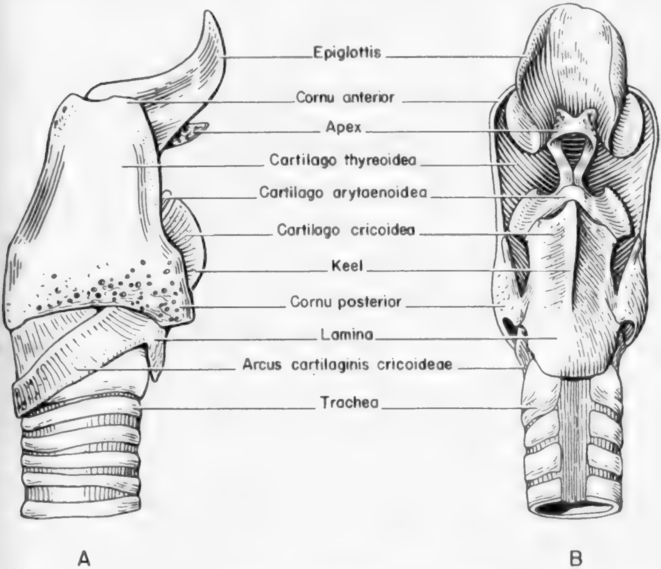

FIG. 27. Larynx; A, lateral, and B, dorsal views.

ring. The right bronchus bifurcates after about 20 mm.; the left first gives off a small bronchus to the anterior lobe, then divides, one of the resulting bronchi going to the anterior lobe, the other to the posterior lobe. The small bronchus to the azygos lobe comes off at the base of the bronchus to the right posterior lobe.

The *lungs* are asymmetrical, the right considerably exceeding the left in size. They are made up of incompletely separable lobes. The right lung is composed of three lobes. The large anterior lobe is subdivided, the anterior of its two divisions curving ventrad over the right auricle, as Garson described for *Porcula salvania;* this is also true in the specimen of *Tayassu* examined. The medial lobe is very small and very incompletely separated from the other two lobes dorsally. The posterior lobe is the largest, and is extensively molded by the diaphragm posteriorly. The left lung is composed of two lobes—a chevron-shaped anterior lobe and a much larger posterior one that corresponds in shape to its mate on the opposite

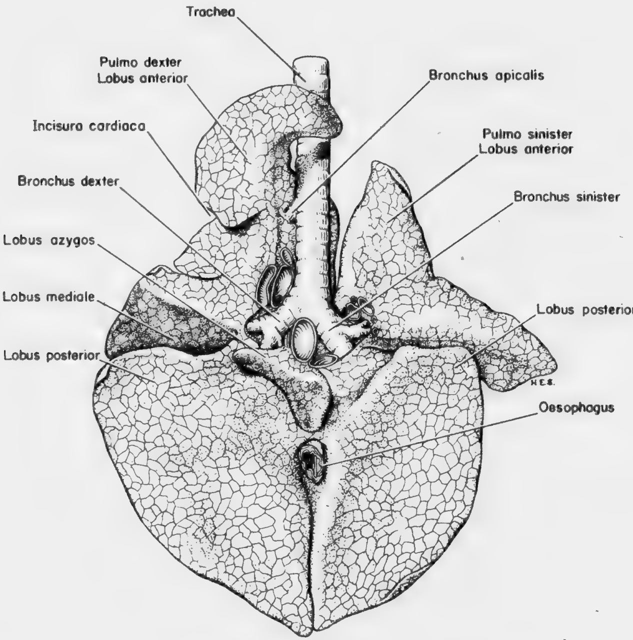

FIG. 28. Trachea and lungs, ventral view.

side. The azygos lobe is small, wedge-shaped, and situated along the midline.

KIDNEYS

The kidneys (fig. 31) are very asymmetrical, the right one measuring 132 mm. in length while the left is only 93 mm. The right kidney, which is apparently normal, is a flat bean-shaped structure, 68 mm. wide and 25 mm. thick. In form it is quite similar to that of the domestic hog.

The kidney structure is similar to that of the domestic hog. The hilum, which is 30 mm. wide, is situated slightly behind the middle of the inner border. The pelvis has the usual funnel shape, and divides into two major calyces as it does in the hog. Five pyramids, with wide and flattened papillae, are visible on a longitudinal section of the kidney. The renal artery bifurcates just before entering the hilus, one of the branches passing dorsad of the ureter while the other passes ventrad. The ureters are wide (15 mm. flattened out) and thin-walled. They pursue a rather tortuous course down to the bladder.

THE ARTERIES

No adequate account of the arteries in any member of the Suidae (including the domestic hog) is available to me. Such descriptions of the circulation of certain regions in the domestic hog as were available have been consulted, however, with the result that the following account is partly purely descriptive and partly critical. Apparently no one has hitherto examined the circulation in a non-domestic member of this family. Final evaluation of the characters afforded by the arteries must await much further work.

The animal died of a heart rupture, and the accumulation of coagulated blood in and around the heart rendered it unfit for study.

THORACIC AORTA

The arch of the aorta gives rise to two branches of nearly equal caliber: the innominate and the left subclavian. These leave the arch immediately beyond the heart, and are very close to one another at their origins.

A. anonyma is short. About 35 mm. beyond its origin it bifurcates to form the right subclavian and a smaller very short trunk that gives rise to the common carotids (fig. 29, B). Parsons (1902) recognized five types of arrangement of the aortic branches in ungulates, and he states that the Suidae of "all authors" belonged to type A (fig. 29). The two specimens of *Babirussa* dissected by Vrolik also belonged to this type. Thus the present specimen of *Babirussa,* which falls into type B, apparently offers the first exception among the Suidae.[1]

Each common carotid runs craniad alongside the trachea to the level of the larynx, where it divides to form the external carotid and a trunk from which the internal carotid and other posterior

[1] The aortic branches in the specimen of *Tayassu* studied were of the same type as those of our *Babirussa,* differing only in that the carotid trunk was greatly elongated (fig. 29, C).

cranial arteries arise. *A. thyreoidea anterior* arises from the ventral wall of the common carotid a few millimeters before the latter bifurcates. *A. laryngea* takes origin at the level of the bifurcation.

At its bifurcation the common carotid gives rise to a large lateral trunk from which the internal carotid, occipital, auricular, and superficial temporal arteries arise, and is continued craniad as the external carotid. *A. lingualis* arises from the medial wall of the external carotid a few millimeters craniad of the origin of the latter.

A. subclavia gives rise to four vessels. *A. mammaria interna* arises from the concave (posterior) side of the curve as the sub-

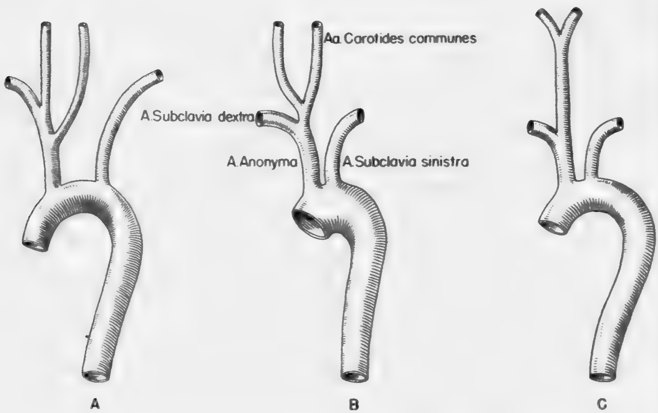

FIG. 29. Branches of aorta in suids. A, *Sus* (after Parsons); B, *Babirussa;* C, *Tayassu.*

clavian arches back toward the axilla. *A. thoracalis anterior* also arises from the inside of the curve, immediately beyond the origin of the internal mammary. The good-sized *Truncus costocervicalis* comes off from the outside of the curve directly opposite the origin of the internal mammary. It promptly breaks up to form several smaller vessels. *A. thyreocervicalis* comes off just beyond the costocervical trunk, and opposite the anterior thoracic.

If the axillary artery is regarded as that part of the main vessel of the foreleg that lies between the origin of the thyrocervical axis and the origin of the subscapular trunk, then in *Babirussa* the axillary is merely a short length of this trunk that gives origin to no vessels. *A. brachialis* accompanies the median nerve across the medial side of the upper arm, terminating at the elbow by bifurcating to form the median and the recurrent radial arteries.

Truncus subscapularis (fig. 30), which arises at the distal end of the axillary, is as large as the brachial, or even exceeds it slightly in

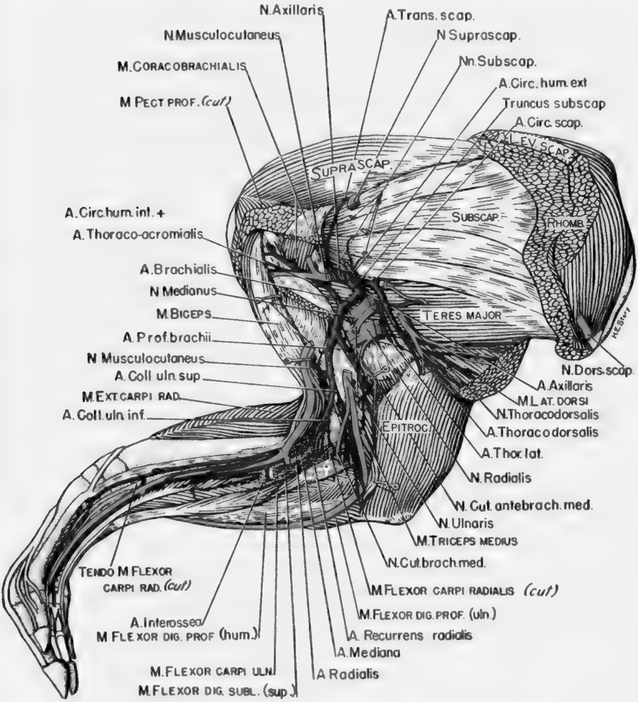

FIG. 30. Arteries and nerves of foreleg, medial view.

caliber. Thus the axillary appears to bifurcate to form these two vessels. The subscapular trunk curves upward and backward from its origin, giving rise to all the vessels of the shoulder region except the internal humeral circumflex. The arteries arising from the subscapular are as follows: (1) *A. transversa scapulae* (A. suprascapularis of veterinary anatomy) is a slender vessel arising from the anterior wall of the trunk near its base and running up between the suprascapular and subscapular muscles. (2) *A. circumflexa humeri externa* (BNA: posterior) is a large vessel arising from the anterior wall a few millimeters beyond the transverse scapular. Passing ectad between the subscapular and teres major, it emerges on the external side of the shoulder between the medial and lateral heads of the triceps. (3) *A. circumflexa scapulae* is likewise a large branch arising from the same side of the trunk. It passes onto the infraspinous fossa of the scapula. (4) *A. thoracodorsalis* is the continuation of the trunk after several muscular branches have been given off.

A. brachialis gives rise to the following vessels in its course along the upper arm: (1) A good-sized vessel arises from the anterior wall of the brachial just distad of the origin of the subscapular trunk. This branch is referred to as the anterior (internal) humeral circumflex in veterinary anatomy, but apparently represents the combined *A. circumflexa humeri interna* and *A. thoracoacromialis* of human anatomy. It accompanies the bicipital branch of the musculocutaneous nerve between the heads of the coracobrachialis, supplying that muscle, the biceps, the pectorals, and some of the antero-external shoulder muscles. (2) *A. profunda brachii* is a large branch arising from the posterior wall of the brachial at the level of the ventral border of the teres major. (3) *A. collateralis ulnaris superior* is a slender branch arising from the posterior wall 25 mm. below the origin of the profunda brachii. (4) *A. collateralis ulnaris inferior* is a still more slender branch from the posterior wall at the elbow articulation. (5) Just below the inferior ulnar collateral, and immediately before the origin of the ulnar artery, the brachial gives rise to a small vessel that is the main source of a rete mirabile that encloses the median and ulnar arteries and the median nerve. This rete is apparently quite similar to that described by Hyrtl for *Phacochoerus* (Leche and Göppert, 1905). (6) A branch from the root of the rete just described runs down the forearm, along the anterior border of the tendinous band representing the pronator teres, to the carpus. This vessel, which is considerably more slender than the median artery, represents the *A. radialis*. (7) A good-sized *A. recurrens radialis* arises from the brachial just below the origin of the rete. It passes, as usual, beneath the distal end of the biceps to supply the extensor muscles of the forearm. Beyond this point the main trunk becomes the median artery. (8) The usual small muscular branches arise from the anterior wall of the brachialis.

A. mediana accompanies the median nerve along the volar side of the forearm, dividing at the distal end of metacarpal III to form the digital arteries. *A. interossea* arises from the deep surface of the median just beyond the tendon of the biceps, and immediately enters the usual opening into the space between the ulna and radius.

ABDOMINAL AORTA
(Fig. 31)

The abdominal aorta runs along the midline, with the posterior vena cava lying to the right of it. It gives rise to the usual visceral

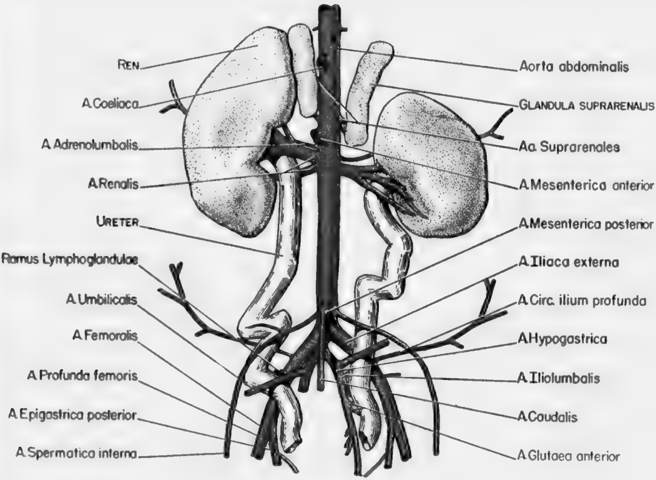

FIG. 31. Abdominal aorta and its branches.

branches before breaking up at the level of the lumbo-sacral articulation to form the terminal aortic branches.

A. coeliaca (Figs. 31, 32) arises from the ventral wall of the aorta at the level of the second lumbar vertebra, which is 50 mm. beyond the emergence of the aorta from the diaphragm. The celiac is a very short trunk, breaking up 10 mm. beyond its origin to form the usual three vessels: hepatic, splenic, and left gastric. These vessels arise from a common center.

(1) *A. hepatica* passes craniad beside the portal vein to the liver. Near the origin of the duodenum it gives off a large right gastroepiploic, which in turn gives rise to the anterior pancreatico-duodenal at the origin of the duodenum; the gastroepiploic continues along

the pylorus onto the ventral side of the stomach, where it anastomoses with the left gastroepiploic. The hepatic artery itself continues toward the liver, giving off a small cystic branch and a large right gastric branch and dividing in the portal fissure into four branches that supply the liver; this conforms closely to the description given by Sisson (1910) for the domestic hog. A small anastomotic twig from the base of one of the hepatic branches runs down and joins the left gastric.

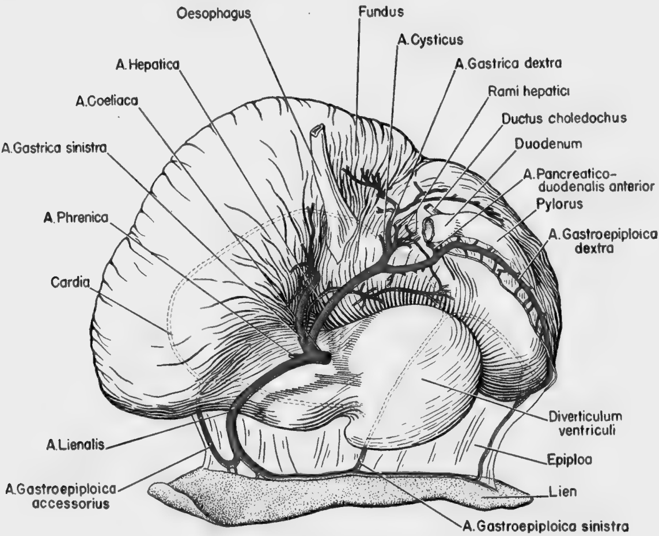

FIG. 32. Dorsal view of stomach, showing celiac circulation.

(2) *A. lienalis* runs across the neck of the caecal appendage of the stomach to the head of the spleen. Immediately beyond its origin it gives rise to (a) *Aa. phrenicae*, which take origin as a common trunk that bifurcates at once. Just before entering the hilus of the spleen the splenic artery divides to form two vessels almost equal in caliber. One of these apparently represents the small vessels that Sieber called the Rr. gastrici of the spleen. It arches around to reach the ventral surface of the cardia, gives off a large branch that supplies the diverticulum, then continues across the fundus to meet the right and left gastroepiploics in a common junction near the

beginning of the pylorus. This vessel, which is here called (b) *A. gastroepiploica accessorius*, is obviously a neomorph to supply the greatly enlarged fundus, cardia, and diverticulum.[1] (c) *A. lienalis* proper runs along the hilus of the spleen, giving off (d) *A. gastroepiploica sinistra* near the middle of the spleen. (e) A small

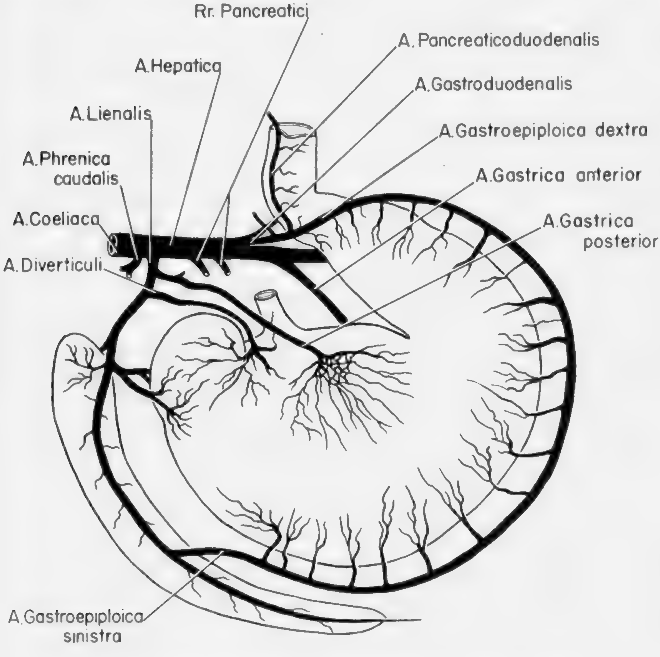

FIG. 33. Celiac circulation in the domestic hog (after Sieber).

anastomotic branch leaves the splenic in the tail of the spleen, to join the right gastroepiploic near the base of the pylorus.

(3) *A. gastrica sinistra* follows the lesser curvature, giving off numerous twigs to the cardia in this region; its terminus anastomoses with the hepatic where that vessel breaks up to form the hepatic rami.

[1] It may be noted that both the cardiac diverticuli in *Tayassu* are supplied by branches of A. gastrica sinistra, which indicates that the posterior diverticulum is not homologous with the diverticulum found in suids, as has been suggested.

A. mesenterica anterior (Figs. 31, 34) arises from the ventral wall of the aorta 40 mm. caudad of the celiac artery, at the level of the third lumbar vertebra. It runs across the mesentery in a very gentle arc whose distal end completely fails to loop back upon itself. According to Mitchell (1905) it does loop back in most mammals (including *Sus* and *Phacochoerus*), but the excellent X-ray photograph of an injected anterior mesenteric presented by Latarjet and Forgeot (1910, pl. 13) shows that the distal end of this vessel does not do so in the domestic hog.

The mesenteric gives rise to the following branches: (1) *A. colica media* (colica dextra+colica media of Sieber) arises from the convex side of the arc 13 mm. beyond the base of the mesenteric. The main part of the vessel passes down through the mesentery of the spiral coil along with the much larger anterior colic, supplying the smaller (centrifugal) coils of the colon; near the distal end of the spiral coil it anastomoses with the anterior colic. A small branch comes off near its base and passes along the straight terminal part of the colon, to anastomose with the posterior colic. (2) *A. pancreaticoduodenalis posterior* (Rr. pancreatici of Sieber) arises from the concave side of the arc immediately opposite the middle colic. (3) *A. colica anterior* (R. colicus of ileo-caeco-colica of Sieber) and (4) *A. ileocolica* (R. ileo-caecalis of Sieber) arise by a short common trunk from the concave side of the arc 30 mm. beyond the posterior pancreatico-duodenal. The anterior colic furnishes the blood supply to the large (centripetal) coils of the colon; the main vessel runs down through the spiral coil, giving off innumerable fine twigs to the intestinal wall. These twigs inter-anastomose to form a rete mirabile similar to that formed by the Aa. intestinales on their way to the small intestine. The ileocolic supplies the caecum, sending off in addition a fine anastomotic branch to the distal end of the mesenteric arc. (5) *Aa. intestinales* arise from the convex side of the arc and pass through the mesentery to the intestinal wall. An extensive and extremely fine rete is formed in these vessels between the mesenteric artery and the intestine. This extraordinary rete is practically identical with that found in the domestic hog (Latarjet and Forgeot, 1910, pl. 13), in which it has long been known as a unique structure. Its occurrence in *Babirussa* suggests that it may characterize all members of the Suidae.[1]

Aa. suprarenales, paired, are given off from the lateral walls of the aorta a few millimeters in front of the renals, and even slightly

[1] A similar rete was found in *Tayassu*.

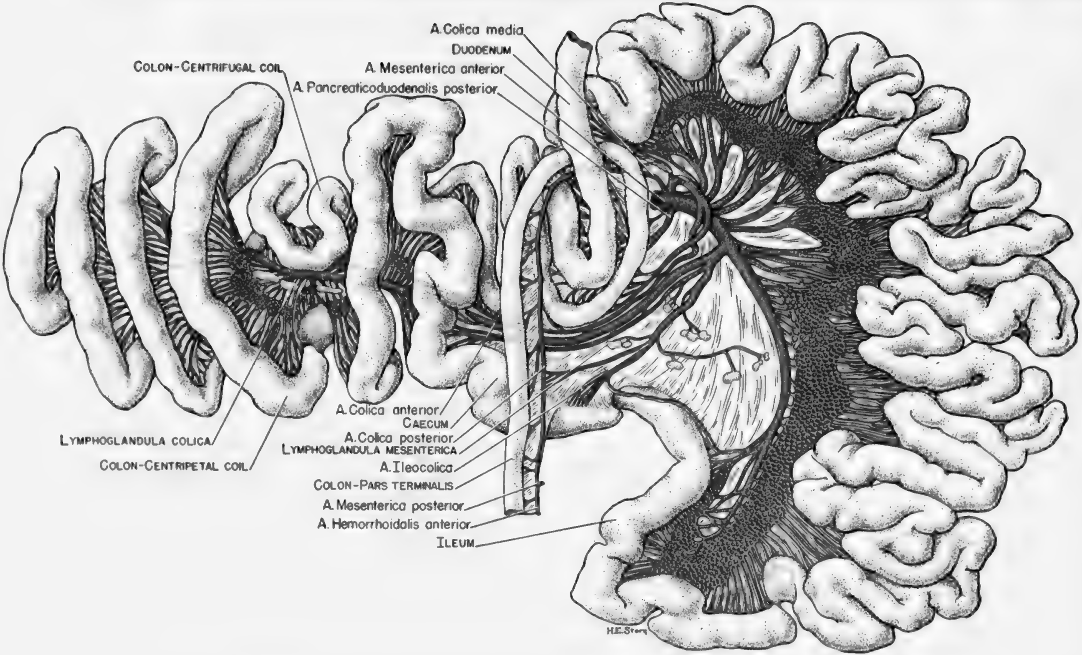

Fig. 34. Mesenteric circulation. The coils of the intestines have been spread apart somewhat.

craniad of the anterior mesenteric. There are two vessels, separated by a considerable distance, on the right side of the body; on the left side these arise from a common trunk.

Aa. phrenicoabdominales (Sieber) are a pair of fine vessels arising from the lateral walls of the aorta immediately anterior to the renals. Each passes straight laterad, bifurcating after about 10 cm. to form phrenic and abdominal rami.

Aa. renales arise immediately below the anterior mesenteric. The right comes off somewhat higher than the left. Each bifurcates a short distance (15 mm.) beyond its origin, the two resulting vessels breaking up into smaller branches before entering the kidney.

A. mesenterica posterior is a small vessel arising from a trunk common to it, the left spermatic, and the caudal artery (Fig. 31). This small trunk arises from the ventral midline of the aorta 25 mm. before its bifurcation to form the external iliacs; and the posterior mesenteric comes off a few millimeters beyond its origin. The posterior mesenteric bifurcates almost immediately to form the posterior colic and anterior haemorrhoidal arteries. *A. colica posterior* arises from the posterior mesenteric near its origin and follows the terminal straight part of the colon craniad, sending numerous twigs to it, and finally anastomosing with a branch of the colica media. *A. haemorrhoidalis anterior* is the caudal continuation of the posterior mesenteric after its bifurcation; it slightly exceeds the posterior colic in caliber.

Aa. spermaticae internae come off somewhat asymmetrically. The right arises independently beside the trunk referred to above, while the left arises from the trunk itself, near its origin. Each arches backward to the abdominal inguinal ring, through which it passes.

A. caudalis (sacralis media) arises from the bifurcation of the aorta in all cases of which I can find record.[1] In the present animal, however, it is the continuation of the above trunk into the tail. This is doubtless an individual anomaly.

About 20 mm. beyond the origin of the posterior mesenteric-caudal trunk, at the level of the lumbo-sacral articulation, the aorta bifurcates to form the external iliacs. A very short, slightly asymmetrically placed hypogastric trunk is continued caudad beyond this. The hypogastric trunk divides almost immediately to form the hypogastric arteries.

A. hypogastrica runs caudad along the roof of the pelvic cavity, gradually diverging from the midline and decreasing in size as

[1] This vessel was completely absent in the specimen of *Tayassu* examined.

branches are given off. It was not traced beyond the anterior border of the symphysis. *A. umbilicalis* arises from its external wall

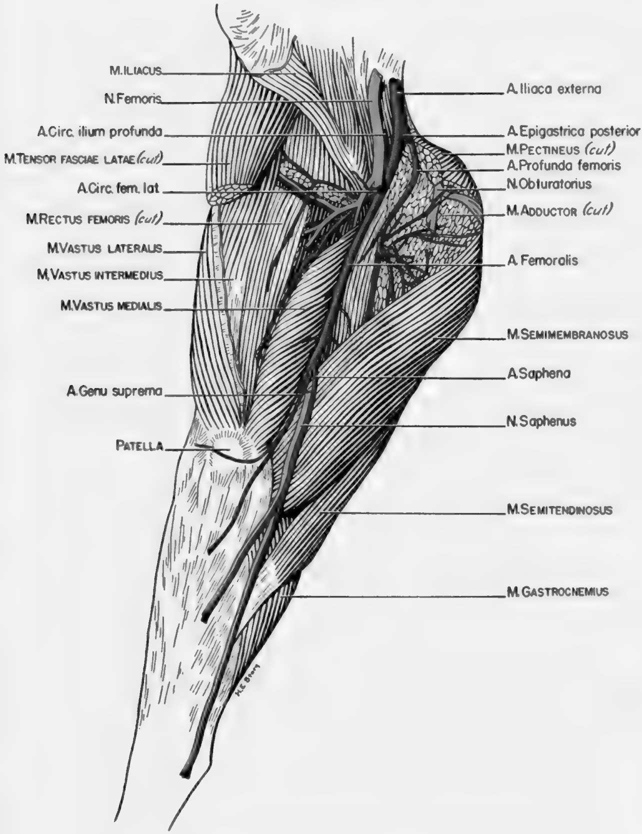

FIG. 35. Arteries and nerves of thigh, medial view.

immediately beyond its origin, and the small *A. iliolumbalis* arises similarly a few millimeters beyond. A pair of small vessels, representing *A. glutaea anterior*, come off from its external wall 20 mm. farther caudad, at the level of the great sciatic notch. Several small twigs, of uncertain homology, are given off beyond this, and the hypogastric continues back into the pelvic cavity as a vessel of considerable size.

A. iliaca externa (figs. 31, 35), as usual, considerably exceeds the hypogastric in caliber. About 30 mm. beyond its origin it gives off the small *A. circumflexa ilium profunda,* which runs laterad across the psoas muscles, accompanied by two veins, to the body wall. Another small twig arising just beyond the circumflex iliac supplies a large iliac lymph gland. About 10 mm. before reaching the body wall the external iliac gives off the *A. profunda femoris* from its medial wall, and beyond this itself takes the name *A. femoralis.*

A. profunda femoris passes out onto the medial surface of the thigh, first giving off the *A. epigastrica posterior* within the abdominal cavity. On the thigh the deep femoral lies successively beneath the pectineus, adductor, and semimembranosus, giving off numerous twigs to the flexor muscles of the thigh. Near the middle of the thigh it emerges from beneath the semitendinosus and continues distad with the V. saphena parva and N. ischiadicus.

A. femoralis gives off small twigs to the iliacus and psoas muscles before leaving the pelvic cavity. Within the femoral triangle it gives rise to the large *A. circumflexa femoris,* which immediately breaks up to form branches to the extensor muscles of the thigh. About two-thirds of the distance down the thigh the femoral artery gives off the *A. saphena,* which accompanies the saphenus nerve distad on the medial side of the leg. Immediately below the saphena the smaller *A. genu suprema* is given off to the knee. These two vessels pass external to the semimembranosus, while the femoral artery itself continues across the popliteal space as *A. poplitea,* which breaks up between the femoral condyles to form the vessels of the leg.

A. poplitea gives rise to the following eight branches (fig. 36):

(1) *A. genu superior medialis* arises from its medial wall above the medial condyle. (2) *A. genu media* arises from the same side of the popliteal, 15 mm. farther distad. (3) *Aa. surales* are represented by three branches from the lateral side of the popliteal. The first of these (*A. femoris posterior* of veterinary anatomy) supplies the lateral head of the gastrocnemius, the second its medial head, and the third the soleus. At the proximal border of M. popliteus the popliteal artery breaks up to form five branches that run distad onto the leg. These are (4) *A. genu inferior medialis,* which is a slender vessel passing deep to M. popliteus; (5) *A. tibialis posterior,*

which runs beside the peroneal artery external to M. popliteus, accompanied by the tibial nerve; (6) *A. peronaea;* (7) *A. tibialis anterior*, which runs deep to M. peroneus, and is the largest branch

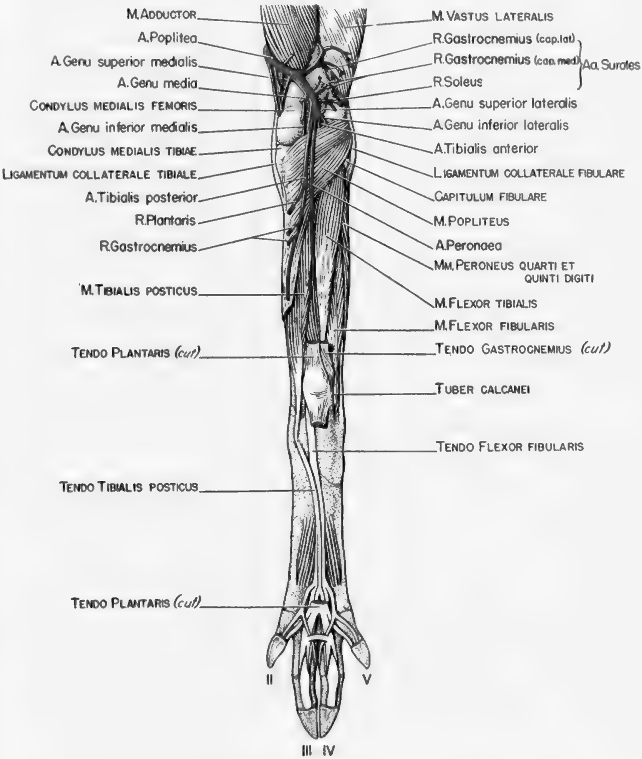

FIG. 36. Arteries of lower right hind leg, posterior view.

of the popliteal artery; it passes deep to the fibula, gives off the anterior recurrent tibial artery, and continues beneath M. tibialis anterior; (8) a short trunk that gives rise to *A. genu superior lateralis* and *A. genu inferior lateralis*. Unfortunately the injection was not complete enough to permit tracing the vessels into the foot.

THE BRACHIAL PLEXUS

(Fig. 37)

The brachial plexus is derived from the fifth to eighth cervical and first thoracic nerves.

N. cervicalis V gives slightly less than the posterior half of its substance to a loop that passes back to C6. *N. phrenica* arises from this loop, so that all of its fibers come from C5.

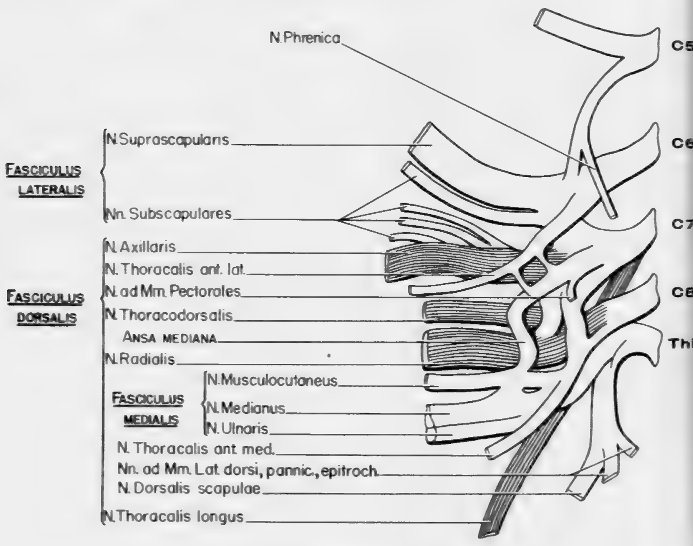

FIG. 37. Right brachial plexus, ventral view.

N. cervicalis VI gives most of its substance to the formation of a very large suprascapular nerve. Posteriorly it forms an extremely stout communicating branch with C7, which gives rise to one of the subscapular nerves. Immediately proximad of this communicating branch C6 gives off a branch which, after receiving two short communicating branches from the ansa mediana, becomes the *N. thoracalis anterior lateralis.*

N. cervicalis VII gives most of its substance to the formation of *N. axillaris.* In addition, however, it gives off the following four branches: (1) *N. thoracalis longus* arises from its dorsal side near its emergence from the cervical foramen. (2) The anterior root of the *ansa mediana* arises from its ventral surface distad of the foregoing. (3) A root of *N. radialis* arises from its posterior border. (4) Immediately proximad of (3) a communicating branch with Th1 arises.

N. cervicalis VIII gives most of its substance to the formation of *N. radialis*. Its anterior fibers form *N. thoracodorsalis*, and its posterior fibers form a short communicating branch that joins the communicating branch from C7.

N. thoracalis I forms *N. musculocutaneus*, *N. medianus*, and *N. ulnaris*, the musculocutaneus and median nerves being augmented by fibers from the ansa mediana. *N. dorsalis scapulae*, from which branches arise that supply the latissimus dorsi, the panniculus, and the epitrochlearis, is formed by the posterior fibers of the first thoracic.

CONCLUDING REMARKS

The extremely scanty nature of our knowledge of the soft anatomy of the Suidae makes it impossible to draw far-reaching conclusions from the present study. In general it may be said that the results of the renewed examination of *Babirussa* emphasize the compactness of the family. This is particularly true of the musculature, in which this genus, with a few striking exceptions, exhibits all the peculiarities of the Suidae.

Externally *Babirussa* is the most aberrant of the living pigs, and it differs internally in a number of features, some of which may prove to be significant. The presence of four terminal tendons on M. plantaris as a unique feature among the suids that have been studied is suggestive, since the tendon to digit V could hardly be redeveloped once it was lost. This is true also of the complex structure of M. extensor digitorum communis. The presence of a second head in the coracobrachialis shows a fundamental difference from known suids, and study of other members of the family may show it to be of prime importance. The complex stomach, with its apparent convergence with the stomach of ruminants, cannot be interpreted on the basis of available data. Conspicuous differences between the larynx of *Babirussa* and that of *Sus* suggest that study of this organ in other suids might yield interesting results.

The anatomy of the Suidae can be discussed intelligently only after the outstanding genera have received adequate study, and it is obvious that such knowledge would become extremely important as a check on and a complement to the phylogeny indicated by the fossil material (see Colbert, 1935; Pearson, 1928).[1] Data on intestinal length and liver size in wild races of *Sus* are needed, since both of these are enormously greater in the domestic hog than in any known wild pig. The musculature cannot be regarded as known until it has been studied in such forms as *Phacochoerus, Potamochoerus,* and *Hylochoerus.* Finally, competent study of the anatomy of the peccaries would probably aid materially in interpreting the anatomy of the typical Suidae and their degree of relationship to the peccaries (cf. Colbert, 1935; Pearson, 1923).

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[1] Neither of these authors mentions *Babirussa.* This may be due to the fact that the cheek teeth are in general very similar to those of *Sus.* In view of the resemblances in dentition it is extremely interesting to find rather wide divergences between the two genera in some details of the soft anatomy.

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