56.81,94(117:71.2)

Article XX.—A NEW TRACHODONT DINOSAUR, *HYPACROSAURUS*, FROM THE EDMONTON CRETACEOUS OF ALBERTA.

By Barnum Brown.

During the brackish water Edmonton division of the upper Cretaceous the aquatic and semi-aquatic shore-living dinosaurs were more numerous than at any time in their history and displayed a considerable variety in form and structure.

Three distinct genera of the family Trachodontidæ are so far known from this horizon. From the number of remains preserved, the crested duck-bill *Saurolophus* was apparently most abundant. Second to it in numbers was the genus *Trachodon*. A third member of the family, now to be described, was relatively not so abundant although represented in the American Museum collection by four partial skeletons and several separate bones.

This new form is of gigantic proportions and in many respects strikingly different from its allied contemporaries. It is largest of all known Trachodonts, approaching in size the great carnivorous dinosaur *Tyrannosaurus* of the later Lance formation. So far it has not been recognized in the Lance or Belly River formations.

No part of the skull or jaws is at present known but I suspect, from similarity of pelves, that, like *Saurolophus*, it was a crested duck-bill. In development of the vertebral column and proportion of the elements of the front and hind limbs it is strikingly different from allied genera.

Hypacrosaurus altispinus[1] gen. et sp. nov.

Type of genus and species. No. 5204 Am. Mus. Coll., last eight dorsal vertebræ, two anterior caudal vertebræ, ilia, right ischium, right pubis, and several ribs.

Locality. Red Deer River, Alberta, Canada. Four miles above Tolman Ferry. Fifty feet above river, five-hundred? feet below top of formation.

Horizon. Edmonton formation, Upper Cretaceous.

Paratypes. No. 5206. Three mid-dorsal vertebræ, from same horizon and locality, 2 miles above Tolman Ferry.

No. 5217. Sacrum and last ten dorsal vertebræ, nine ribs, left ilium, right pubis, left femur, left tibia, right and left fibulæ, four metatarsals, five phalanges and sections of epidermis. From same horizon and locality, thirty feet above river at Tolman Ferry.

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[1] *Hypacrosaurus:* ὕπακρος, nearly the highest; σαύρα, lizard.

No. 5272. Front limb, nine cervical vertebræ, left tibia, fibula and foot. From same horizon and locality; seventy feet above river; sixteen miles below Tolman Ferry.

Generic and Specific Characters. Skull not known. Cervical vertebræ strongly opisthocœlus, spines reduced or absent, ribs stout. Dorsal vertebræ with centra reduced in size, spines high and massive, five to seven times the height of respective centra. Sacrum with eight vertebræ. Scapula long and very broad, radius much longer than humerus. Ilium deep and strongly curved. Ischium long with large terminal foot-like expansion. Pubis with anterior blade short and broadly expanded. Femur, tibia and fibula of nearly equal length. Pes long and massive.

This genus is distinguished from *Trachodon* and *Saurolophus* by the following comparison of similar parts.

In *Trachodon* the cervical vertebræ have short spines, transverse processes moderately wide, ribs slender. Dorsal vertebræ with centra large, highest spines three times height of respective centra. Sacrum with nine vertebræ. Humerus longer than radius. Ilium elongate, not strongly curved. Ischium long and slender terminating in rounded point. Pubis long with anterior end expanded from a long neck. Femur much longer than tibia and fibula. Pes large not elongate.

In *Saurolophus* the mid-dorsal spines are about three times the height of respective centra. Sacrum with eight vertebræ. Radius as long as humerus. Ilium deep and strongly curved. Ischium long with terminal foot-like end. Pubis with anterior blade broadly expanded from short neck. Femur slightly longer than tibia and fibula. Pes large, not elongate.

Vertebræ. The *cervical vertebræ* are all opisthocœlus, a character as strongly pronounced as in the Crocodilia but with peculiar modification. In specimen No. 5272 nine cervicals are preserved from the middle and the posterior end of the series. The four most anterior lack neural arches. The opisthocœlus character is more pronounced than in *Trachodon.* The centra are wider than high and as long as they are wide across the posterior end. The anterior end is a flattened hemisphere, wider than high with a broad shoulder below formed by the anterior border of the ventral surface of the centrum. The ventral surface is quite broad and flat in anterior centra and rounded more in those posterior in the series. On the sides a prominent ridge carries the capitular rib facet. The floor of the neural canal is depressed in the center forming a shallow bowl. The posterior end is deeply excavated, the upper border short and thin, the lower border extended backward and thickened for abutment against the before mentioned shoulder of the succeeding centrum. The neural arches are actually and relatively larger than in any known species of the genus *Trachodon.* The neural canal is broadly oval. Posterior zygapophyses are long, massive and widely divergent. Transverse processes longer than in corresponding

vertebræ of *Trachodon* and more massive. The neural spines are relatively less prominent than in *Trachodon* and greatly reduced or absent. The ball and socket type of centrum with wide zygapophyses allowed great lateral and vertical movement between individual vertebræ as well as in series. Each of the four *cervical ribs* present have a large capitulum, long stout neck, large tuberculum and rather stout, short blade.

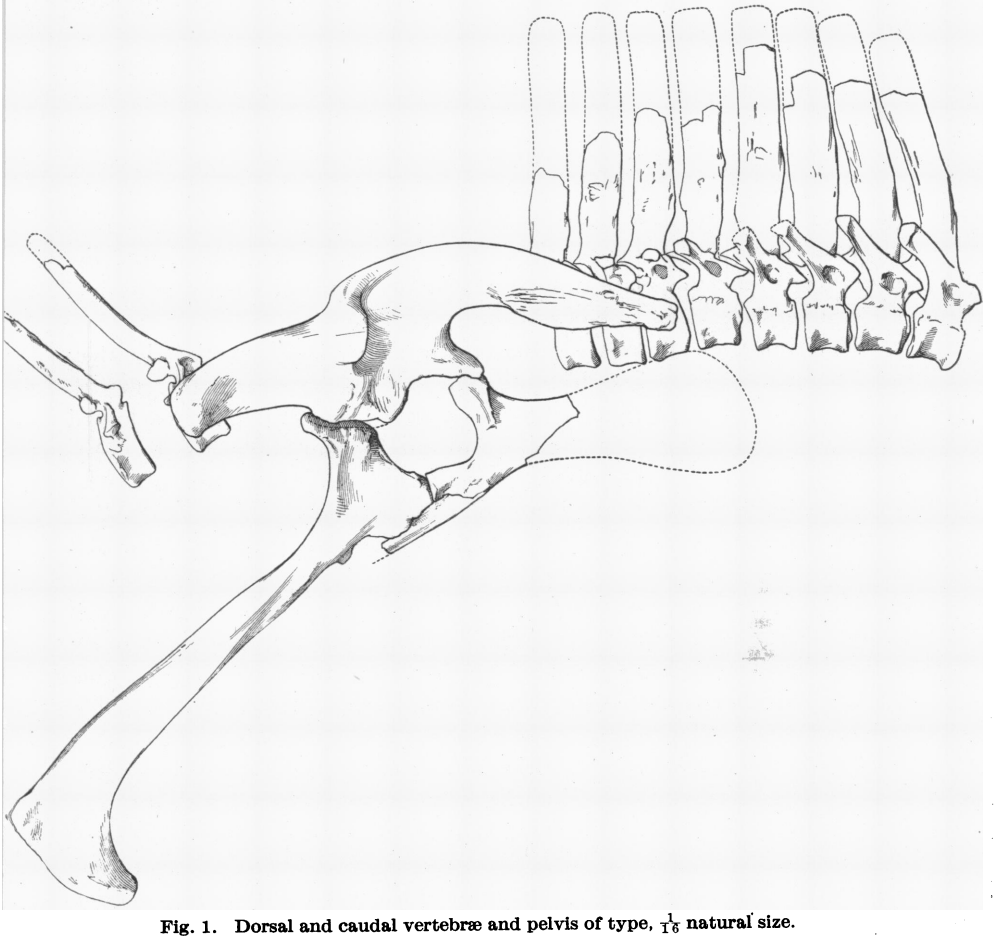

Fig. 1. Dorsal and caudal vertebræ and pelvis of type, $\frac{1}{16}$ natural size.

The *dorsal* vertebræ are characterized by extremely high, massive spines and comparatively small centra. The type of the species No. 5204 (Fig. 1) is the largest in the collection and represents an animal of gigantic proportions. Where broken, the spines have been restored equal to the length of

those in No. 5206 and 5217 in which they are complete. The centra are opisthocœlus and the posterior cupping is pronounced throughout the series but the anterior end, which is so prominent in the cervicals, becomes less oval through the anterior dorsals, is gently rounded in mid series and is almost flat in the last four dorsals. The anterior centra are about as long as wide but the last four are much wider than they are long. They are all constricted in the center, sides deeply excavated and marked by large nutritive foramina.

The neural arches are comparatively weak considering the development of the massive spines. In all specimens the scar of the sutural union with centrum is prominent. The anterior zygapophyses look inward, are close together and much lower than the posterior zygapophyses, an arrangement that gives a decided arch to the middle of the vertebral column. In the posterior dorsals they are wider apart and look upward. From the posterior zygapophyses, a thin narrow plate descends to the upper border of the neural canal and this plate is pierced by a large opening from side to side, a character that seems to be constant in this genus.

The transverse processes are comparatively small. Anteriorly they are triangular and incline decidedly upward and backward, the seventh from the sacrum being longest in the series. From that point backward they decrease in length and become horizontal. Each carried a rib. Anterior in the series the capitular facet is above the level of the upper border of the neural canal. On the third from the sacrum the capitular head is shifted to the transverse process. The last rib appears to have been single-headed.

The spines of the dorsal series were developed to enormous size in this genus. They are not only very high but massive, long anteroposteriorly and thick. Those from the middle of the dorsal series are largest. One of these (Fig. 2) in No. 6206 is seven times the length of the centrum and five times its height. In *Trachodon* the highest spine is only about three times the length of the centrum. Anteriorly in the series they incline backward, in mid series they are erect and in the last four dorsals incline forward.

The *sacrum* in No. 5217 is nearly complete. It is composed of eight vertebræ thoroughly coössified. All are true sacrals, each giving off para- and diapophyses. Seen from below the anterior are smaller than the posterior centra and all are slightly compressed in the center to form a longitudinal keel. The parapophyses of the first six are coössified at the ends and increase in size backward, those of the third, fourth and fifth forming the inner border of the acetabulum. The seventh and presumably the eighth touch but are not coössified. Between the centra and parapophyses are large oval foramina that increase in size from the anterior to the posterior

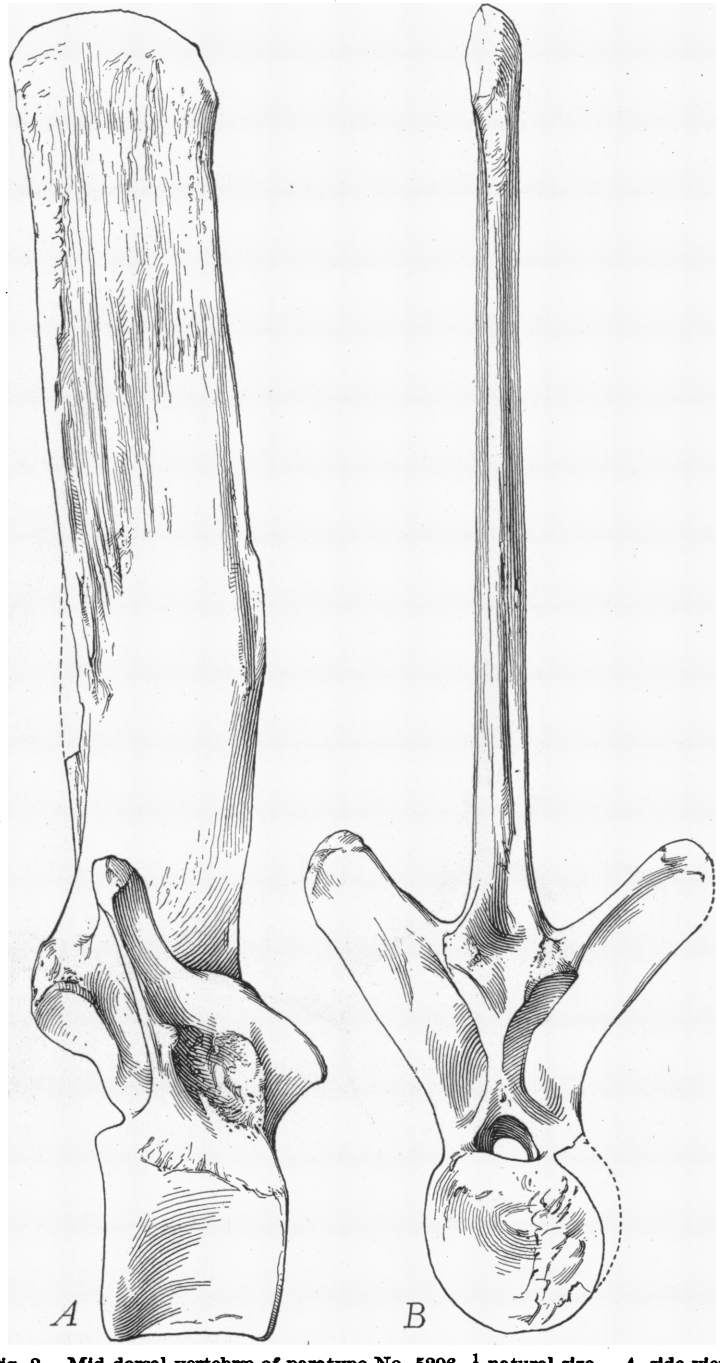

Fig. 2. Mid dorsal vertebræ of paratype No. 5206, $\frac{1}{4}$ natural size. *A*, side view. *B*, posterior end view of succeeding vertebræ.

end of the series. The diapophyses terminate above in rounded ends for abutment against the inner side of the ilium, and vary in length to follow the curve of the ilium. A vertical plate of bone connects dia- and parapophyses of each vertebra thus forming pockets between succeeding verte-

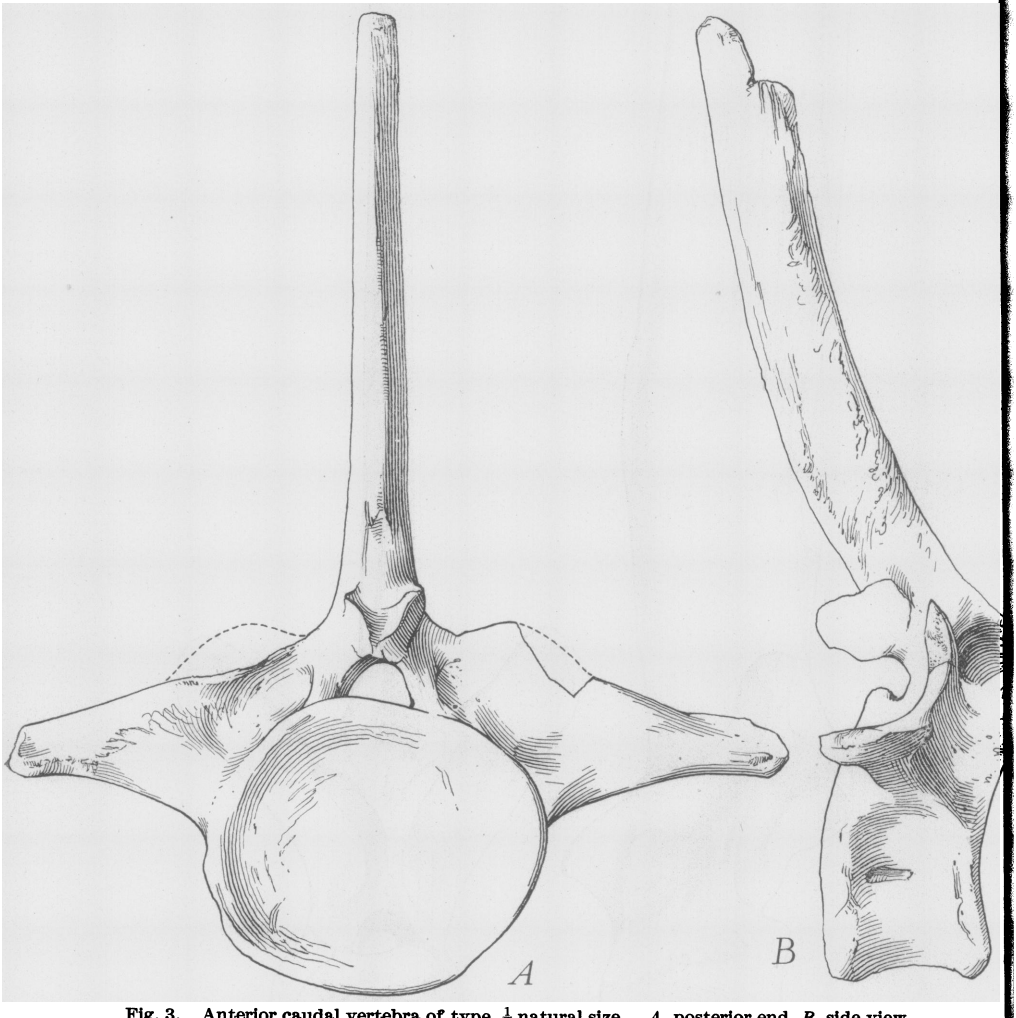

Fig. 3. Anterior caudal vertebra of type, $\frac{1}{4}$ natural size. *A*, posterior end, *B*, side view.

bræ. This form is modified, however, in the last three vertebræ where the diapophyses are short and connected with parapophyses and the posterior process of the ilium by separate thin plates. The spines are separate and are less massive and not so high as those in the mid-dorsal region but are higher than in *Trachodon*.

Two *caudal* vertebræ are preserved in the type specimen No. 5204 (Fig. 1). They are probably first and third in the series. The centra (Fig. 3) are large, ovate in section and short, the width equalling twice the length. The anterior end of each is plane and the posterior end is deeply concave. The sides are concave. The spines are high, elliptical in cross-section and strongly inclined backwards. The transverse process is large, massive, and connected with the spine by a high thin plate. In *Trachodon* they are simple horizontal bars, ovate in cross-section.

Pelvis. As in the closely related genus *Saurolophus*, the pelvis (Fig. 1) shows a marked departure from that of *Trachodon*.

The *ilium* (Fig. 4, A) has the same outline and form as in *Saurolophus*.

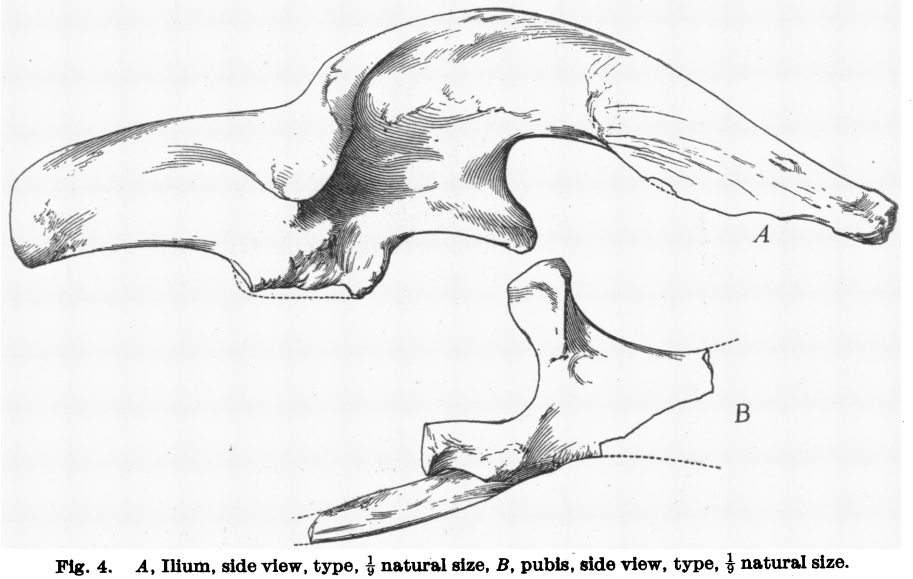

Fig. 4. *A*, Ilium, side view, type, $\frac{1}{9}$ natural size, *B*, pubis, side view, type, $\frac{1}{9}$ natural size.

It is curved more, much deeper vertically and more massive than in *Trachodon*. The preacetabular process is strongly decurved, and tapers to a thin blade of uniform thickness. In *Trachodon* this portion is triangular in cross-section where united with the anterior sacral vertebræ and but slightly decurved. The postacetabular process is a massive vertical plate, shorter than in *Trachodon*. From the upper border a large process overhangs the ischial peduncle as in other genera of this family. The inner face shows a curved rugose area for attachment of the sacrum. In *Trachodon* this attachment is parallel with the lower border of the vertebræ and straight.

The *ischium* (Fig. 5) presents the most striking feature of the pelvis and

is unlike that of *Trachodon*. The form is similar to that of *Saurolophus* and differs only in a greater development of the terminal expansion. It is remarkably massive for its length and united with its mate by ligamentous attachment along the distal two-thirds of the shaft which terminates in a large foot-like end strikingly like the pubic foot of Theropodous dinosaurs. It, however, takes a different position in relation to the skeleton. When the bones of the pelvis are assembled (Fig. 1) the ischial and pubic peduncles of the ilium determine the position of the other elements. Thus assembled the shaft of the ischium takes a position backward and downward parallel with the tail but considerably lower than in *Trachodon*. An ischium figured by Lambe, Contributions to Canadian Palaeontology, Vol. III, (Quarto) Part II, 1902, plate x, and described on page 75, is referred to *Trachodon marginatus* from the Belly River Cretaceous. The reference is obviously an error. It is certainly not *Trachodon* but may pertain to *Saurolophus* or *Hypacrosaurus*.

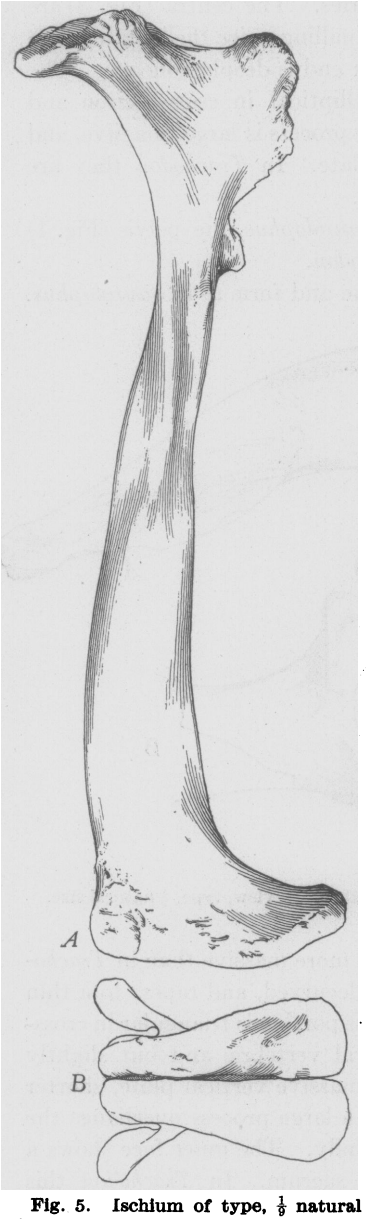

Fig. 5. Ischium of type, $\frac{1}{9}$ natural size. *A*, side view. *B*, expanded distal end with mate drawn in outline.

The *pubis* is light compared with the other pelvic bones. The preacetabular portion curves outward and expands immediately into a broad, thin blade with a very short intervening shaft or neck. This portion is much shorter than in *Trachodon* and somewhat shorter than in *Saurolophus*. The post-pubis was long as in *Trachodon*.

Fore-Limb. In the known genera of the Trachodontidæ the bones of the fore and hind limbs show a remarkable similarity of form and muscle attachments but the proportional development of bones is strikingly different in different

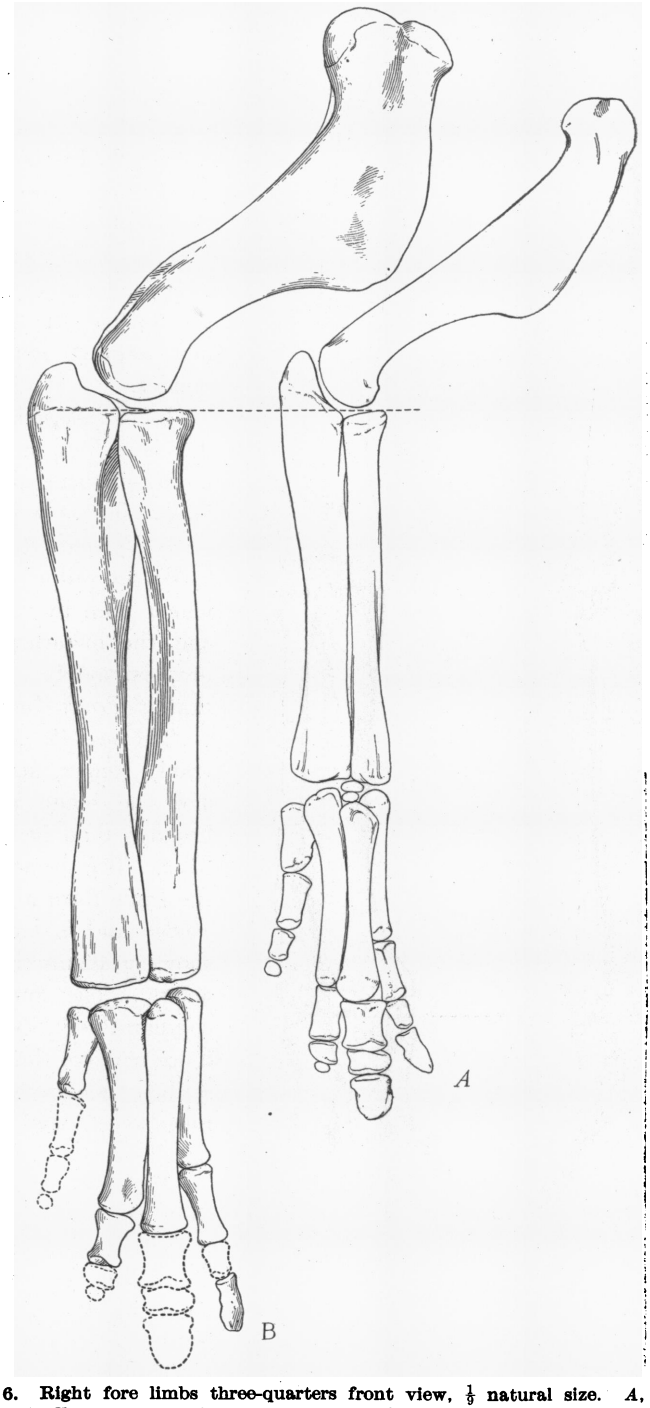

Fig. 6. Right fore limbs three-quarters front view, $\frac{1}{9}$ natural size. *A*, *Trachodon annectens*. *B*, *Hypacrosaurus altispinus*, paratype No. 5272.

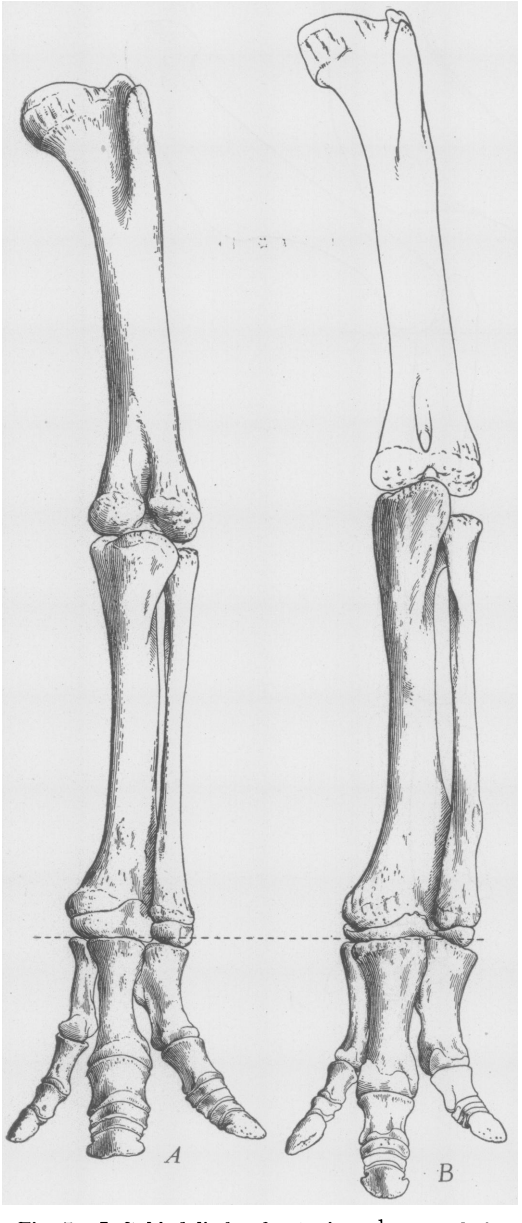

Fig. 7. Left hind limbs, front view, $\frac{1}{18}$ natural size. *A, Trachodon mirabilis. B, Hypacrosaurus altispinus,* paratype No. 5272, outlined femur enlarged proportionately from No. 5217.

genera. In comparisons it is preferable to use the radius which is more constant than the ulna.

In uncrushed limbs of the genus *Trachodon* (Fig. 6, A) the radius is much shorter than the humerus, metacarpals long and slender.

In *Saurolophus* the radius is as long as the humerus, metacarpals not so long as in *Trachodon.*

In *Hypacrosaurus* (Fig. 6, B) the radius is much longer than the humerus, and the metacarpals are proportionately shorter than in *Trachodon.*

The *scapula* is considerably longer, straighter, and the blade is much broader than in *Saurolophus.* The *coracoid* has the same form as in *Trachodon* and is larger but shows no distinctive characters. The *humerus* is comparatively short and more massive than in described genera and the radial crest extends to the middle of the shaft.

The *ulna* and *radius* show the same form and muscle attachments as in *Trachodon* but are much longer in proportion to the length of the humerus.

The *metacarpals,* how-

ever, are proportionately much shorter than in *Trachodon* or *Saurolophus* with Mt. V reduced in size. From the articulation and development of the metacarpals it is probable that only digits II and III terminated in hoofs as in other genera of this family.

The *carpals* are not known and only three *phalanges* have been preserved in No. 5272. These are II^1, II^3, and III^1, and they are not different from those of *Trachodon*.

Hind Limb. In the development of the hind limb (Fig. 7) this genus differs somewhat from the usual form in other genera, especially in the more nearly equal length of femur and tibia, also in the greatly lengthened metatarsals.

The *femur* closely follows the form of *Trachodon*, with long straight shaft; great trochanter slightly higher than the head; the lesser trochanter on the anterior outer border is separated from the great trochanter by a narrow channel; it is, however, higher than in *Trachodon*, reaching nearly to the summit of the great trochanter. The fourth trochanter terminates slightly below the middle of the shaft and is relatively not so prominent as in *Trachodon*. The condyles are long anteroposteriorly, and on the anterior face completely enclose the large foramen in the end of the femur.

The *tibia* is proportionately longer than in *Trachodon*. In No. 5217, the specimen in which femur and tibia are complete, the tibia is two inches shorter than the femur. In a *Trachodon* of the same size the tibia is eight inches shorter than the femur. In one specimen, too badly weathered to be preserved, the proximal end measured eighteen inches in width.

The *fibula* differs slightly from that of *Trachodon*, especially in the distal end which terminates on the inner side in a rounded knob articulating with the calcaneum and a thin flange on the outer border that is produced outward overlapping the tibia. A little above the distal end there is a prominent rugose area on the outer surface for muscular attachment.

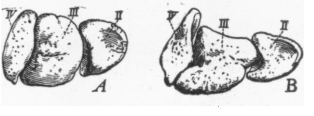

Fig. 8. Metatarsals in position, proximal end, $\frac{1}{3}$ natural size. *A*, *Trachodon mirabilis*. *B*, *Hypacrosaurus altispinus*, No. 5272.

Of the *tarsal* bones only the *calcaneum* and *astragalus* are preserved, and they do not appear to be different from those of *Trachodon*. In the distal row the one articulating with digit IV was certainly ossified and possibly those for digits II and III.

The *metatarsals* (Figs. 7 and 8) are remarkable for their great length and development. They are at least a third longer than in *Trachodon* or *Saurolophus*. Mt. II appears to be relatively reduced in proportion and the proximal end is narrower transversely and deeper vertically. Mt. III and Mt. IV are comparatively larger than in *Trachodon* or *Saurolophus*

and digits III and IV carried most of the weight. A separate bone in the collection, metatarsal III, represents the largest individual recorded in this family. It measures eighteen inches in length and seven inches transversely across the distal end.

Measurements.

				cm.
Dorsal vertebra,	9th?	from sacrum,	No. 5206, length of centrum	8
" "	10th?	" "	" 5206, width of centrum, anterior face	9
" "	9th & 10th?	" "	" 5206, height of spine above neural canal	58
Caudal, "	1st, type,		" 5204, length of centrum	9
" "	" "		" 5204, width " "	18
Ischium, extreme length		type	" 5204	114
" length of foot		"	" 5204	30
" across iliac & pubic heads		"	" 5204	34
Ilium, extreme length		"	" 5204	106
" height		"	" 5204	32
Pubis, narrowest width of blade		"	" 5204	12
Humerus, length			" 5272	58
Radius, "			" 5272	70
Ulna, "			" 5272	75
Metacarpal II length			" 5272	22
" III "			" 5272	26½
" IV "			" 5272	28
" V "			" 5272	11
Tibia "			" 5272	108
Fibula "			" 5272	100
Metatarsal II "			" 5272	35
" III "			" 5272	43
" IV "			" 5272	34