

Article VIII.—NOTES ON THE POSTCRANIAL SKELETON IN THE CROCODILIA¹

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PLATES XIII AND XIV

CONTENTS

	PAGE
INTRODUCTION.....	67
CERVICAL VERTEBRÆ.....	68
DORSAL VERTEBRÆ.....	71
LUMBAR VERTEBRÆ.....	75
SACRAL VERTEBRÆ.....	76
CAUDAL VERTEBRÆ.....	77
CHEVRONS.....	79
RIBS.....	79
STERNUM.....	86
PECTORAL GIRDLE AND FORE LIMB.....	86
PELVIC GIRDLE AND HIND LIMB.....	92
RATIOS OF LENGTH OF LIMB AND GIRDLE BONES OF <i>Crocodylus americanus</i> (Amer. Mus. No. 7139).....	99

INTRODUCTION

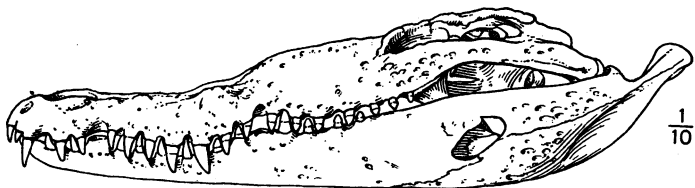
The following notes on the crocodilian skeleton are the result of a study of the skeletons of several of the genera of Recent crocodilians, made for the purpose of providing a basis of comparison for fossil material. The crocodilian skeleton has been described by Cuvier, Gadow, Brühl, Bronn, Reese, and others, but none of the descriptions by these writers are well adapted for comparison with fossil remains, which are often very incomplete. Many of these descriptions are highly valuable, however, and have proved very useful in the present study. The material which forms the basis of the present study consists, first, of a large, nearly complete skeleton of *Crocodylus americanus* in the American Museum collection (Amer. Mus. No. 7139), of which the vertebral column, ribs, pectoral, and pelvic bones, many of the limb bones, the chevrons, and part of the sternal apparatus, as well as the skull, are figured; second, a skeleton of *Tomistoma schlegelii* in the collection of the Museum of Comparative Zoology (Mus. Comp. Zool. No. 12459), a skeleton of *Caiman niger* (Mus. Comp. Zool. No. 4043), and a skeleton of

¹Contributions to the Osteology, Affinities, and Distribution of the Crocodilia. No. 5.

Alligator mississippiensis (Amer. Mus. No. 7130) which have been used for comparison with the American crocodile skeleton; third, a number of skeletons of *C. americanus*, *C. rhombifer*, *C. intermedius*.

CERVICAL VERTEBRÆ

PRO-ATLAS.—The pro-atlas is represented by a small V-shaped bone which is situated immediately posterior to the occiput, slightly above the foramen magnum; it has contact anteriorly with the supraoccipital of the skull, and antero-inferiorly with the exoccipitals; postero-inferiorly it rests upon the neural arch of the atlas. This element has been interpreted in a number of ways. It may represent a vestigial vertebra between the atlas and the skull, all of the components except this small remnant having vanished during the evolution of the group. Reese



Amer. Mus. No. 7139

Fig. 1. Skull of *Crocodilus americanus*. Amer. Mus. No. 7139. One-tenth natural size. Lateral view, left side. Introduced for comparison of size with postcranial bones.

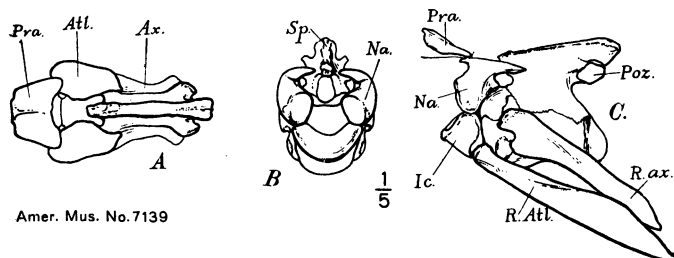
states that the pro-atlas has been considered as a membrane bone; Gadow considers it as the detached neural spine of the atlas; Marsh figured a similar bone in the dinosaur "*Morosaurus*" as a "postoccipital bone." Of these various views the first-mentioned is probably the correct one, although the evidence in its favor is not conclusive.

ATLAS.—The atlas consists of the paired neural arches, or neural arch pedicles, and the intercentrum. The two neural arch elements are connected superiorly by cartilage, and in some specimens are fused into a single bone. These pedicles are connected with the axis by zygapophysial articulations; anteriorly they are overlapped by the pro-atlas in an articulation which allows free movement between the two bones. The pro-atlas is evidently fixed in position with respect to the skull. Postero-inferiorly and medially the two stout neural arch pedicles of the atlas unite with the odontoid process of the axis (which is morphologically the pleurocentrum of the atlas); inferiorly the pedicles of the atlas articulate directly with the intercentrum of the same vertebra. The latter articulation is very slight, the two elements barely

coming in contact. Antero-inferiorly the atlas neural arch pedicles articulate with the occipital condyle of the skull. The condyle articulates with four vertebral elements, namely, the two neural arch pedicles of the atlas, the intercentrum of the atlas, and the odontoid process of the axis.

AXIS.—The axis vertebra is characteristic. In the large specimen figured (Amer. Mus. No. 7139) the neural arch, odontoid process, and intercentrum are all united by open sutures only.

The **SPINE** is very low vertically and long antero-posteriorly. It projects backward beyond the postzygapophyses and terminates slightly above their level; anteriorly it projects forward beyond the limits of the neural arch proper but not quite so far as the prezygapophyses, termina-



Amer. Mus. No. 7139

Fig. 2. Proatlas, atlas, and axis of *Crocodilus americanus*. Amer. Mus. No. 7139. One-fifth natural size. A, superior view; B, anterior view; C, lateral view, left side. Atl., atlas; Ax., axis; Ic., intercentrum of atlas; Na., neural arch of atlas; Poz., postzygapophysis; Pra., pro-atlas; R. Atl., left rib of atlas; R. Ax., left rib of axis.

ting anteriorly at a level slightly higher than that of the prezygapophyses and at about the same level as the postzygapophyses. The antero-superior border of the spine is somewhat rugose and is slightly thickened.

The **PREZYGAPOPHYSES** are small. They are situated somewhat lower than the postzygapophyses but are not any closer together. The articular surfaces are very small and indistinct; the processes which support them are distinct, but, at the same time, small. The prezygapophyses face almost directly upward.

The **POSTZYGAPOPHYSES** are relatively large. They face obliquely downward and outward. They are situated relatively close together and partially upon free processes. They are higher in level than the prezygapophyses.

The **NEURAL ARCH PEDICLES** are low vertically and elongated antero-posteriorly. Their anterior portions, where they come in contact with the massive odontoid, are considerably thickened.

The RIB FACETS are peculiar in their positions. The tubercular, or diapophysial, facets are situated entirely on the odontoid process, which is morphologically a part of the atlas. The capitular, or parapophysial, facets are situated partly on the odontoid process, and partly on the centrum of the axis itself. The two processes are not far apart from each other. The greatest breadth of the vertebra is across the tubercular rib facets.

The NEURAL CANAL is large in diameter.

The ODONTOID PROCESS is large and prominent. It articulates with the neural arch and with the centrum by suture. Morphologically this process is the pleurocentrum of the atlas. The superior portion of the process is long antero-posteriorly; the inferior portion is short in that direction. The superior surface is marked by a conspicuous groove, which lodged the spinal cord. A broad antero-inferior surface is situated between the two tubercular rib facets and between the anterior ends of the capitular facets.

The CENTRUM (pleurocentrum) of the axis is slightly keeled inferiorly. The anterior end of the keel is slightly broadened and is rugose. The posterior end is strongly convex.

CERVICALS 3 TO 8 INCLUSIVE.—The cervical vertebræ posterior to the axis are characterized by great height in proportion to their breadth. They also possess very distinctive cervical ribs.

The SPINES are low and thick in the anterior direction in the anterior cervicals, increasing in height and decreasing in thickness on approaching the dorsal region. The anterior spines have single posterior edges; the posterior ones have two lateral flanges of bone on the posterior edges. The transition between the two types of edge is gradual.

The ZYGAPOPHYSES are small and close together anteriorly, and farther apart and broader posteriorly. This increase in size is fairly regular, but the regularity has one or two exceptions (see table of measurements).

The rib facets are small and rather far apart on Cervical 3; on Cervicals 4, 5, 6, and 7 they are larger and closer together; on Cervical 8 they are again smaller and far apart; the facets on each side of Cervical 8 are farther apart than those of any other cervical. The capitular facets are all situated on the centra; in Cervical 3 they are near the inferior border; they gradually rise in position in the cervical series, until in Cervical 8 they are near the superior border. The tubercular facets are situated on the ends of the transverse processes, or diapophyses. In Cervical 3 they are low in position, the processes projecting slightly

below the level of the neural arch-centrum sutures; the facets face obliquely outward and downward, and the processes are very short in this vertebra. There is a progressive rise in position, a progressive change in the form, and especially a progressive lengthening of the processes, until in Dorsal 1 the facets face directly outward and are situated high above the level of the neural arch-centrum sutures on long diapophyses.

All of the centra have very deep anterior cups and pronounced posterior balls. The inferior surface of each cervical centrum is strongly keeled, and the anterior portion of each keel is extended into a prominent downward-projecting process. This process is short and strongly rugose in the anterior portion of the cervical series, and is longer and smoother near the dorsals.

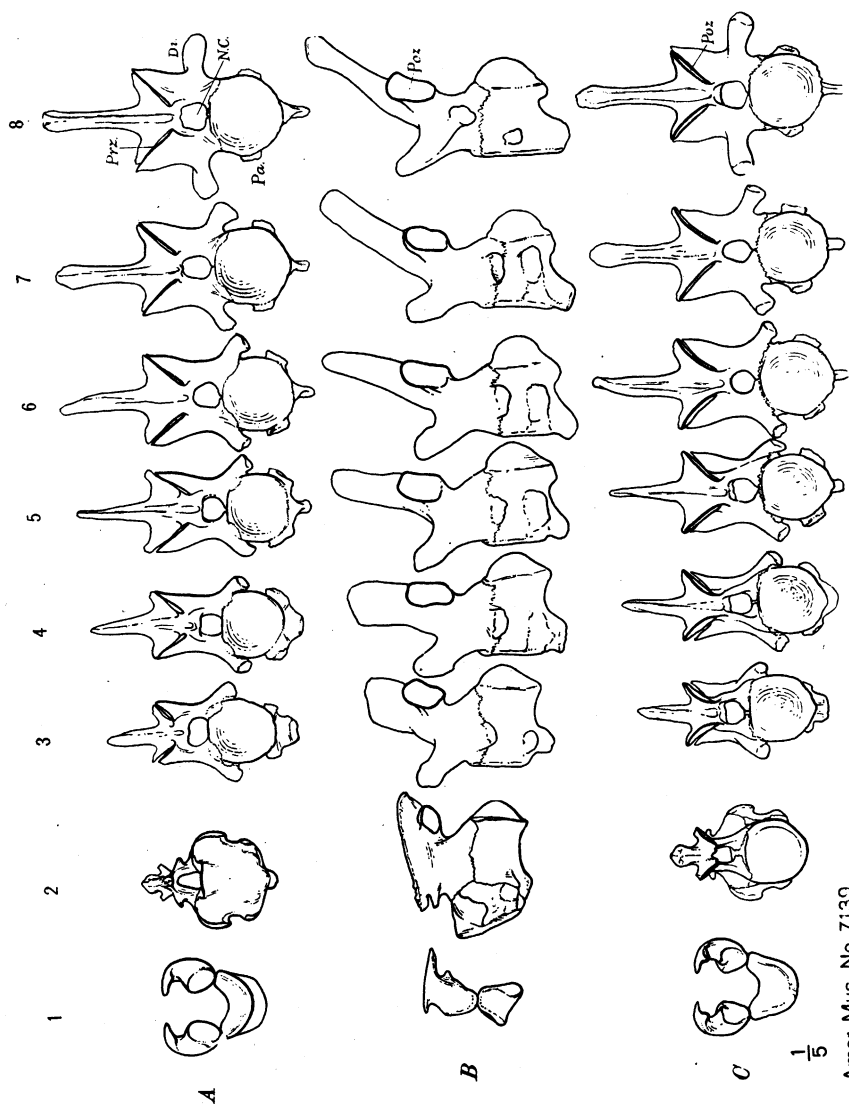
Measurements of Cervical Vertebrae (Amer. Mus. No. 7139)

	Length of Centrum	Breadth of Centrum, Anterior End	Height of Centrum, Anterior End	Spread of Prezyga- pophyses	Spread of Post- zygapophyses	Spread of Diapophy- ses	Spread of Para- pophyses	Height, Total
Cervical 2	9.45cm.	4.6cm.	4.6cm.	3.0cm.	3.3cm.	6.2cm.	5.3cm.	8.7cm.
" 3	6.7	4.0	4.0	4.0	4.1	6.55	3.55	12.7
" 4	6.8	4.3	4.1	4.4	4.9	6.6	4.9	14.0
" 5	6.6	4.4	4.1	5.4	5.4	7.0	5.5	15.6
" 6	6.5	4.4	4.7	6.1	5.8	7.8	5.8	16.6
" 7	6.4	5.2	4.8	6.4	6.4	8.9	6.3	16.7
" 8	6.55	5.6	4.6	6.85	6.35	11.2	6.45	17.5

DORSAL VERTEBRÆ

There are twelve, possibly thirteen, dorsal vertebrae in the large specimen (Amer. Mus. No. 7139), the uncertainty depending upon the identification of Post-cervical 13 as a dorsal or a lumbar. Thirteen is probably correct for the dorsals. The first two dorsals resemble the cervicals very closely in form, and the third resembles them somewhat.

The SPINES of the anterior dorsals are relatively high and narrow antero-posteriorly; they are thicker, however, than those of the posterior cervicals. Farther back they are lower and thicker. The posterior surfaces of the spines are all single and rugose.



Amer. Mus. No. 7139

Fig. 3. Cervical vertebrae of *Crocodilus americanus*. Amer. Mus. No. 7139. One-fifth natural size. A, anterior views; B, lateral views, left side; C, posterior views; 1-8, first to eighth cervical vertebrae, inclusive. Di., diapophysis; N. C., neural canal; Pa., parapophysis; Poz., postzygapophysis; Prz., presyngapophysis.

The ZYGAPOPHYSES have a greater transverse diameter than in the cervicals in the anterior dorsals, but are still relatively narrow. They broaden as far back as Dorsals 5 and 6 and then remain constant in breadth to the lumbar.

The DIAPOPHYSES increase steadily in length from Dorsal 1 to Dorsal 9, which is the longest. Posterior to this point the processes decrease slightly in length. The tubercular rib facets face directly outward.

Measurements of Dorsal Vertebrae (Amer. Mus. No. 7139)

	Length of Centrum	Breadth of Centrum, Anterior End	Height of Centrum, Anterior End	Spread of Prezyga- pophyses	Spread of Postzy- gapophyses	Spread of Diapo- pophyses	Spread of Parapo- pophyses	Height, Total
Dorsal 1	6.3cm.	5.4cm.	4.8cm.	6.8cm.	6.2cm.	12.9cm.	6.3cm.	18.0cm.
" 2	6.5	5.6	4.0	6.6	6.3	14.8	6.1	18.5
" 3	6.6	5.3	4.6	6.7	7.0	17.9	6.6	18.0
" 4	6.8	5.0	5.2	7.6	7.9	21.1	10.7	18.1
" 5	6.8	4.8	5.4	8.2	8.1	25.2	15.6	16.0
" 6	7.1	4.9	4.8	8.4	7.9	28.0	18.3	15.0
" 7	7.3	4.95	5.1	8.2	7.6	29.1	20.0	14.8
" 8	7.3	5.0	5.0	8.0	7.8	30.2	21.3	14.5
" 9	7.4	5.0	4.9	8.15	7.8	30.4	21.8	14.0
" 10	7.6	5.1	4.8	8.00	7.9	30.3	23.0	14.0
" 11	7.8	5.7	4.7	8.0	8.3	29.0	24.2	13.6
" 12	7.9	5.5	4.7	8.6	8.1	28.5	27.5	13.9
" 13	7.8	5.5	4.5	8.3	8.1	27.8	27.7	13.4

The CAPITULAR FACETS are situated on the centra in Dorsals 1 and 2. In both of these vertebrae they are carried on distinct parapophyses. In the third dorsal they are situated above the centrum and are farther apart. In this vertebra and in the vertebrae succeeding they are not carried on distinct parapophyses, but upon the diapophyses; they occupy notches which indent the anterior borders of these processes.

In Dorsal 3 the distance between the tubercular and capitular facets is greater than in any other vertebra. In Dorsal 4 the capitular facets are situated about half-way between the bases of the diapophyses and their distal ends; they are slightly lower in position than the tubercular facets. In Dorsal 5 the capitular facets are only slightly lower than

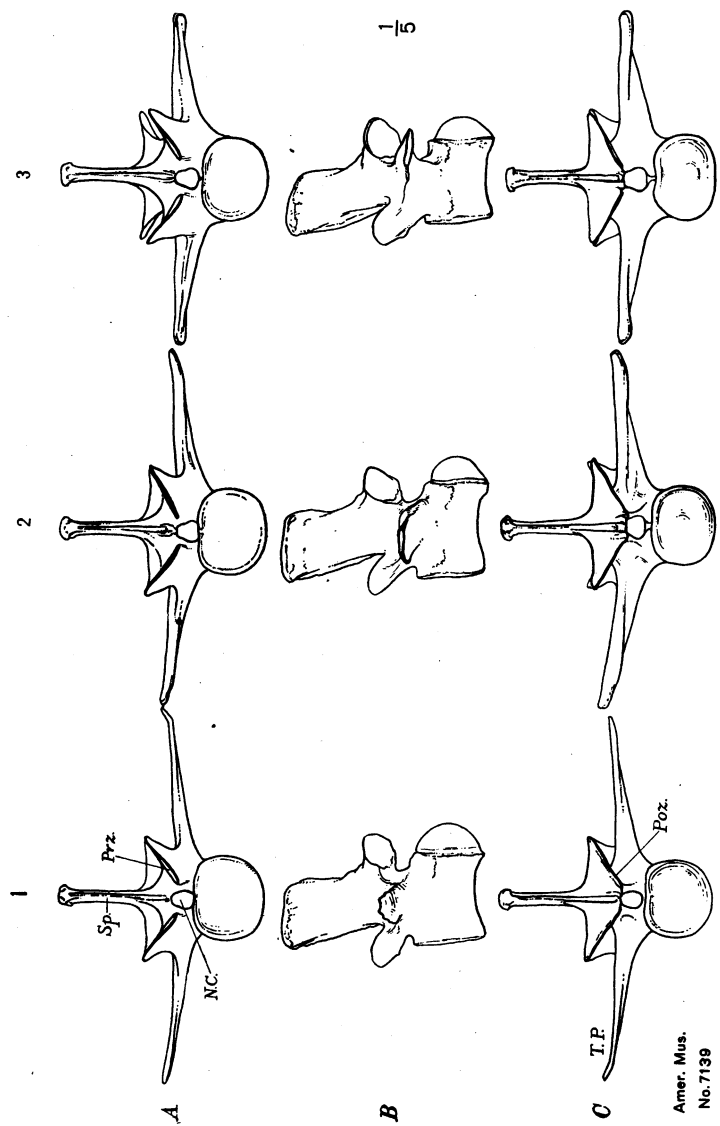


Fig. 4. Lumbar vertebrae of *Crocodilus americanus*. Amer. Mus. No. 7139. One-fifth natural size. A, anterior views; B, lateral views, left side; C, posterior views; 1-3, first to third lumbar vertebrae, inclusive. N. C., neural canal; Poz., postzygapophysis; Prz., prezygapophysis; Sp., spine; T. P., transverse process.

Amer. Mus.
No. 7139

the tubercular facets and are closer to them than in Dorsal 4. In Dorsal 6 the capitular and tubercular facets are on the same level, and are closer together than in Dorsal 5. From Dorsal 7 to Dorsal 11, inclusive, the capitular facets are situated farther and farther out on the diaphyses, approaching the tubercular facets in position. In Dorsals 12 and 13 the tubercular and capitular facets cannot be distinguished from each other. In Dorsal 13 the combined facets are very small.

The CENTRA of all the dorsals are strongly and equally procœlous. In the first four dorsals the inferior surfaces are keeled, and have distinct inferior processes, like the cervicals. The centrum of Dorsal 5 is constricted somewhat inferiorly, but is not distinctly keeled. From Dorsal 5 back to the lumbar the inferior surfaces of the dorsal centra become progressively more and more broadly rounded.

LUMBAR VERTEBRÆ

There are three lumbar vertebræ. These resemble very closely the twelfth and thirteenth dorsals.

The SPINES are short; their antero-posterior diameters are slightly less than those of the posterior dorsals. The ZYGAPOPHYSES are very broad, being the broadest in the entire vertebral series. The DIAPOPHYSES are long, but less so than in the posterior dorsals. The length of the CENTRA is considerable, but is less than that of the posterior dorsals. They are strongly procelous, as in the dorsals and cervicals, and are broadly rounded inferiorly.

Measurements of Lumbar Vertebræ (Amer. Mus. No. 7139)

	Length of Centrum	Breadth of Centrum, Anterior End	Height of Centrum, Anterior End	Spread of Prezygapophyses	Spread of Postzygapophyses	Spread of Diapophyses	Height, Total
Lumbar 1	7.7cm.	5.6cm.	4.4cm.	8.25cm.	8.1cm.	25.0cm.	13.3cm.
" 2	7.7	5.6	4.3	8.5	8.5	23.5	13.2
" 3	6.9	5.5	4.3	8.8	8.4	21.8	13.2

SACRAL VERTEBRÆ

The two sacral vertebræ are both stout. The SPINES are low and considerably extended antero-posteriorly. The PREZYGAPOPHYSES are broad on the first sacral and much narrower on the second. The POSTZYGAPOPHYSES are narrow in both sacrals. The TRANSVERSE PROCESSES are very stout. Those of the first sacral are considerably longer than those of the third lumbar or of the second sacral. The processes of both

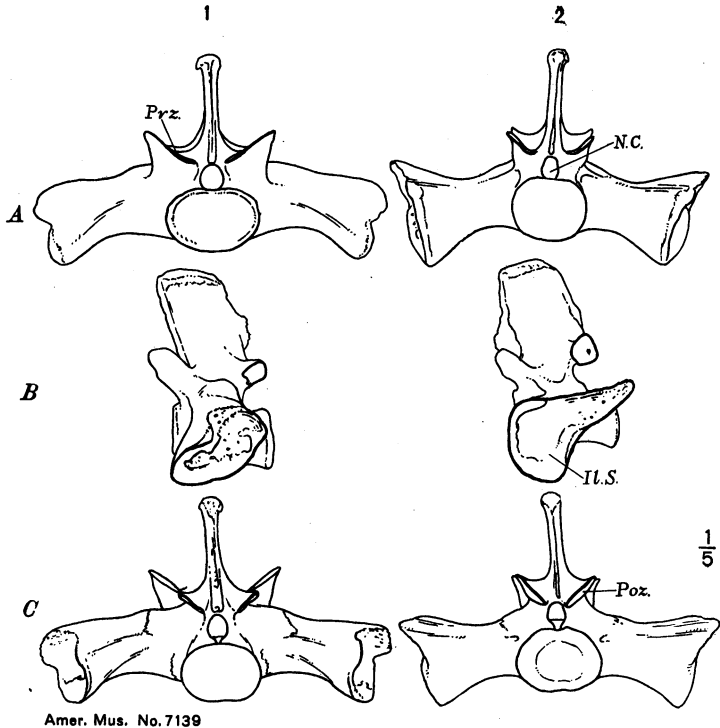


Fig. 5. Sacral vertebræ of *Crocodilus americanus*. Amer. Mus. No. 7139. One-fifth natural size, A, anterior views; B, lateral views, left side; C, posterior views; 1, 2, first and second sacral vertebræ respectively. IL.S., iliac surface; N.C., neural canal; Poz., postzygapophysis; Prz., prezygapophysis.

sacrals are expanded at their distal ends, those of the second much more so than those of the first sacral. The expansions are gradual and not abrupt. The articulations between the sacral processes and the ilia are complex and strong. The sutures between the free portions of these processes and their fixed bases indicate their morphological origin as ribs.

The CENTRA are relatively short. Their inferior surfaces are very broad; the inferior surface of the first sacral centrum is slightly grooved. The anterior surface of the centrum of the first sacral is concave; the posterior surface is nearly flat. The anterior surface of the second sacral centrum is nearly flat, and the posterior surface is concave.

Measurements of Sacral Vertebrae (Amer. Mus. No. 7139)

	Length of Centrum	Breadth of Centrum, Anterior End	Height of Centrum, Anterior End	Spread of Prezygapophyses	Spread of Postzygapophyses	Spread of Sacral Ribs	Height, Total, at Median Line	Height, Total, Including Extremities of Sacral Ribs
Sacral 1	5.9cm.	6.0cm.	4.0cm.	8.7cm.	5.25cm.	23.0cm.	12.6cm.	13.5cm
" 2	6.2	5.0	3.8	5.5	5.35	20.2	12.5	14.2

CAUDAL VERTEBRÆ

The number of caudal vertebrae in the large specimen which comprises the chief basis of the present description (Amer. Mus. No. 7139) is thirty-seven. The number varies somewhat among the various species of crocodiles and also among the individuals of the same species.

The SPINES are of moderate height in the anterior caudals, increasing in length toward the mid-caudal region, the tallest spine being that of Caudal 18. From Caudal 18 back to the end of the tail the spines decrease steadily in height; the last four caudals have no spines, and the spine of Caudal 33 is vestigial. The anterior caudal spines are relatively thick antero-posteriorly. The spines gradually decrease in this respect until in the region from Caudal 14 to Caudal 24 they are very slender. Posterior to Caudal 24 they are slender, but are also very low, so their slenderness is not conspicuous. The spines of Caudals 2 to 7 have sharp posterior processes projecting back from their bases between the postzygapophyses.

TRANSVERSE PROCESSES are present in only the first fourteen caudals. They are long in the first and second caudals, and decrease in length regularly and rapidly in the posterior direction. There are faint traces

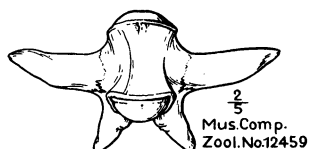


Fig. 6. First caudal vertebra of *Tomistoma schlegelii*. Mus. Comp. Zool. No. 12459. Two-fifths natural size. Inferior view. The sutures between the transverse processes and the centra indicate the costal nature of the processes.

Measurements of Caudal Vertebrae (Amer. Mus. No. 7139)

		Length of Centrum	Breadth of Centrum, Anterior End	Height of Centrum, Anterior End	Spread of Prezyga- pophyses	Spread of Postzy- gapophyses	Spread of Trans- verse Processes	Height, Total
Caudal	1	7.3cm.	5.1cm.	4.6cm.	5.85cm.	5.2cm.	19.6cm.	13.0cm.
"	2	6.9	5.0	4.3	5.95	4.8	19.5	13.4
"	3	7.0	4.55	4.4	5.4	4.3	18.6	13.5
"	4	7.3	4.6	4.2	5.0	4.0	17.5	13.5
"	5	7.5	4.45	4.1	4.65	3.85	16.6	13.6
"	6	7.6	4.3	3.85	4.50	3.60	15.7	13.0
"	7	6.7	4.05	3.70	4.20	3.20	14.1	13.25
"	8	7.7	4.40	4.40	3.7	2.95	13.05	11.8
"	9	6.8	3.45	3.65	3.7	3.20	12.0	10.3
"	10	7.8	3.55	3.30	3.65	3.20	11.8	10.15
"	11	7.7	3.35	3.05	3.8	2.7	12.0	10.00
"	12	7.4	3.2	2.9	3.4	2.7	10.7	10.70
"	13	7.8	3.2	2.8	3.3	2.35	8.85	10.40
"	14	7.5	3.1	2.6	2.8	2.5	4.45(inc.)	10.20
"	15	7.2	2.95	2.6	2.8	2.45		10.20
"	16	7.5	2.85	2.6	2.8	2.15		10.60
"	17	7.45	2.7	2.4	2.5	1.80		10.50
"	18	7.3	2.5	2.5	2.2	1.80		11.30
"	19	7.05	2.04	2.3	1.9	1.50		10.90
"	20	7.00	2.25	2.2	1.8	1.10		8.80(inc.)
"	21	6.6	2.10	2.00	1.50	1.15		9.6
"	22	6.6	2.00	2.00	1.45	.75		8.7
"	23	6.5	1.80	1.80	1.25	.50		8.2
"	24	6.3	2.00	1.80	1.05	.35		6.5
"	25	6.05	1.60	1.70	.95	.35		5.0(inc.)
"	26	5.90	1.50	1.50	.80	.25		5.0
"	27	5.70	1.35	1.40	.65	.10		4.2
"	28	5.30	1.30	1.20	.55	.10		3.5
"	29	4.90	1.20	1.10	.35	.10		
"	30	4.60	1.05	1.00	.25	.05		2.7
"	31	4.50	1.00	.90	.30	.30		2.25
"	32	3.40	.90	.80	.40(est)	.25(est)		
"	33	3.40	.75	1.10		.10		1.35
"	34	2.75	.50	.60				.70
"	35	2.05	.45	.50				.60
"	36	1.60	.30	.40				.50
"	37	1.80						

of a sutural connection of the free portions of the processes with their bases in the anterior caudals. This is usually not visible. In a specimen of *Tomistoma schlegelii* (Mus. Comp. Zool. No. 12459) the sutures are clearly visible. The presence of these sutures is an indication of the morphological origin of the processes as ribs.

The ZYGAPOPHYSES of the caudal vertebræ are relatively small and close together, compared with those of the lumbar and dorsals. They decrease in size gradually and steadily, ending in a tiny vestige in Caudal 36.

The CENTRUM of the first caudal is biconvex. The caudals from the second to the end of the tail have centra which are concave anteriorly and convex posteriorly. The degree of anterior concavity is much greater in the anterior caudal region than near the extremity of the tail, where the surfaces are nearly flat. In length the centra increase gradually, but irregularly, from Caudal 1 to Caudal 16, then decrease to the end of the tail. Caudal 37 is very slightly longer than Caudal 36, however. The inferior surfaces of the centra are smooth in the first two caudals. From Caudal 3 to the vicinity of Caudal 18 each inferior surface is characterized by two longitudinal, parallel, keel-like processes. Posterior to Caudal 18 these processes are separated into anterior and posterior portions by a central flat space.

CHEVRONS

Twenty-five chevrons are present in the large specimen measured. Other specimens have more or less than that number. The first chevron appears to articulate with the inferior surfaces of the second and third caudals at their junction with each other. The anterior chevrons have single articular surfaces and conspicuous foramina; farther back the chevrons are Y-shaped, having two articular processes; still farther back they lose the inferior processes and become V-shaped in cross-section, at the same time becoming more elongate antero-posteriorly. In form these chevrons bear a remarkable resemblance to those of the sauropod dinosaurs.

RIBS

The ribs of the Crocodilia are characteristic. The superior cervical and dorsal ribs are relatively stout and well ossified; those of the ventral series are slender and more or less cartilaginous. The double heads are very distinct in all of the superior ribs except those of the atlas and of the last two dorsal vertebræ. The number of ribs, both total and of

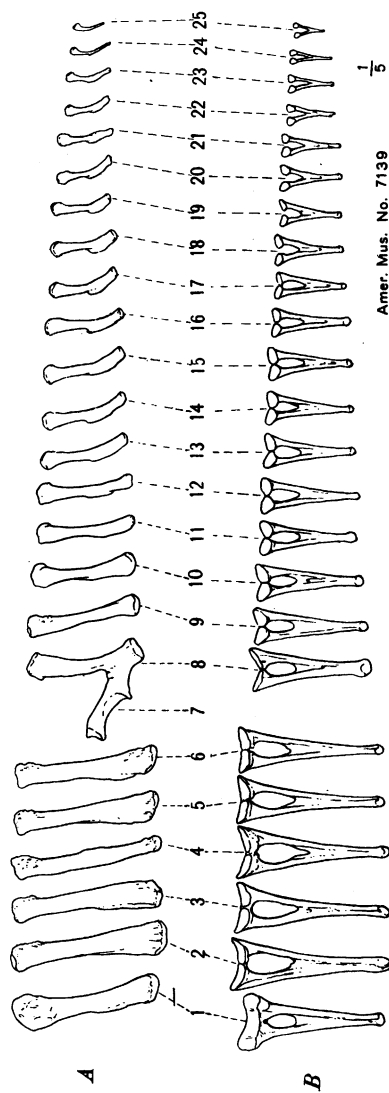


Fig. 7. Chevrons of *Crocodilus americanus*. Amer. Mus. No. 7139. One-fifth natural size. A, lateral views, left side; B, posterior views; 1-25, first to twenty-fifth chevrons respectively, as estimated.

the separate regions of the vertebral column, vary somewhat among the different genera and species. The transition in form from cervical ribs to dorsal ribs is more or less abrupt, though in some specimens the last cervical ribs are intermediate in character between typical cervical and typical dorsal ribs.

CERVICAL RIBS.—Each of the cervical vertebræ (except the problematical pro-atlas) bears a pair of ribs. The ribs of the atlas and axis are readily distinguishable from each other and from the remainder of the cervical ribs.

The ribs of the atlas are single-headed; they are long and flat, somewhat longer, in fact, than the ribs of the axis; their broadest portions are nearer the distal than the proximal ends; from their points of greatest breadth these ribs diminish in size rapidly to the slender extremities.

The ribs of the axis are intermediate in structure between those of the atlas and those of the post-axial cervicals. They are double-headed, and in most specimens one head is larger than the other. In the large specimen described (Amer. Mus. No. 7139) the tubercular facets and the processes which carry them are much larger than the capitular facets and their processes; the same is true of a smaller specimen of *C. americanus* studied (Amer. Mus. No. 15182); in some other specimens of the same species the two processes and their respective facets are equal in size. One specimen of *Caiman niger* (Mus. Comp. Zool. No. 4043) has the capitular elements larger in size than the tubercular. In *Tomistoma*, as shown by a young specimen (Mus. Comp. Zool. No. 12459), the tubercular portion of the axis rib is much greater than the capitular. In a small skeleton of *Crocodylus intermedius* (Amer. Mus. No. 8790) the capitular process is much larger than the tubercular. In *Osteolemus tetraspis* (Amer. Mus. No. 4087) the same is true. In a medium-sized skeleton of *Crocodylus rhombifer* (Mus. Comp. Zool. No. 4042) the two processes are equal in size.

The ribs of the axis resemble those of the atlas in being long and flat; the point of greatest breadth in each rib is, however, at the capitular process, near the proximal end, and not below the center of the bone; the axis rib is slightly shorter than the atlas rib. Immediately below the capitular process the bone contracts somewhat, then remains practically uniform in breadth to a point very near the distal end, where it suddenly contracts.

The ribs of Cervicals 3 to 7 inclusive are very similar to each other, differing only in very slight characters. Each rib consists of a shaft which extends horizontally, parallel with the longitudinal axis of the

vertebral column, and the capitular and tubercular processes, which join the shaft almost perpendicularly. The lower, or capitular, process, is larger than the upper, or tubercular, process; the capitular articular surface is larger than the tubercular. The capitular process extends horizontally from the shaft to the parapophysis of the vertebra; the tubercular process extends obliquely upward to the diapophysis of the vertebra. The shaft extends both anterior to and posterior to the articular processes; in the third and fourth cervicals the anterior processes are considerably shorter than the posterior processes; in the fifth, sixth, and seventh cervicals they are only slightly shorter.

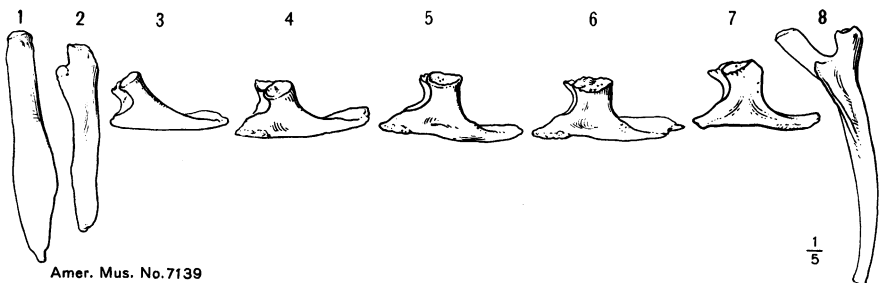


Fig. 8. Left cervical ribs of *Crocodilus americanus*. Amer. Mus. No. 7139. One-fifth natural size. Lateral views, 1-8, first to eighth ribs respectively.

The ribs of the eighth cervical are intermediate in form between typical cervical and typical dorsal ribs. They vary considerably among the genera and species of crocodilians. In *Crocodilus* and *Tomistoma* the eighth cervical ribs resemble the dorsal ribs closer than the other cervical ribs; in *Caiman* they are very close in form to the preceding cervical ribs; in *Alligator* they vary somewhat, in some specimens being long like dorsal ribs and in others short like typical cervical ribs. In all the specimens examined, however, they exhibit characters which are easily recognizable. They differ from typical cervical ribs in that their shafts are not perpendicular to the tubercular and capitular processes, but rather are extensions of them. The shaft of each is homologous with the posterior portion of the shaft of the typical cervical rib; it extends outward, downward, and backward in contrast with the longitudinal position of the typical shaft of a cervical rib. The anterior process of the shaft of the typical cervical rib is represented in the rib of Cervical 8 by a thin process, which extends forward from the shaft, below the articular processes; this thin process partly encloses a long round fossa on the anterior surface of the shaft. The tubercular process is shorter and thicker

than the capitular process. The rib is distinguishable from the dorsal ribs in general by the lesser length and the relatively acute termination of the shaft; it is distinguishable from the anterior dorsal ribs also by the lesser degree of curvature and by the smaller size of the articular processes and their closer proximity to each other; it may be distinguished from the mid-dorsal ribs by its lesser length and by its stouter and more prominent articular processes; it differs from the posterior dorsal ribs in being stouter and in having large, distinct articular processes.

DORSAL RIBS.—Considering Vertebra 9 as the first dorsal, there are thirteen pairs of dorsal ribs, including two pairs of floating ribs, in the large skeleton discussed (Amer. Mus. No. 7139); other skeletons possess only twelve dorsals.

The dorsal ribs are typically long, stout, and greatly curved, and have distinct tubercular and capitular facets (except in Dorsal Ribs 12 and 13). The first three dorsal ribs on each side have distinct capitular and tubercular processes; posterior to Dorsal Rib 3 the ribs have capitular processes only, the tubercular facets occupying the ends of the shafts without distinct processes. The two small posterior free ribs on each side possess no distinct articular processes and each has only one small articular surface.

The tubercular and capitular processes are far apart on Dorsal Rib 1, farther apart on Dorsal Rib 2, and still farther apart on Dorsal Rib 3; posterior to this point the tubercular processes disappear, and the articular surfaces approach each other until they merge together in the first free rib. In length the ribs increase steadily from Dorsal Rib 1 to a maximum in Dorsal Rib 8, then progressively decrease in length to the end of the costal series.

Several of the anterior dorsal ribs have prominent anterior processes for muscle attachment; these appear to be homologous with the anterior processes of the shafts of the cervical ribs. The number of ribs bearing these processes varies considerably among the various species of crocodiles, and among different individuals of the same species. In Amer. Mus. No. 7139 the first four dorsal ribs have this process strongly developed; it is absent altogether in Dorsal Rib 5. Other specimens of various species have only two or three dorsal ribs with these processes; the number appears to be somewhat greater in old individuals than in young ones. The distal extremities of all the dorsal ribs except the first are somewhat expanded. Some of the anterior dorsal ribs, usually the third, fourth, and fifth, plus a few others, carry uncinat processes; these are usually cartilaginous, but in some cases are slightly ossified. They are particularly noticeable in *Alligator*.

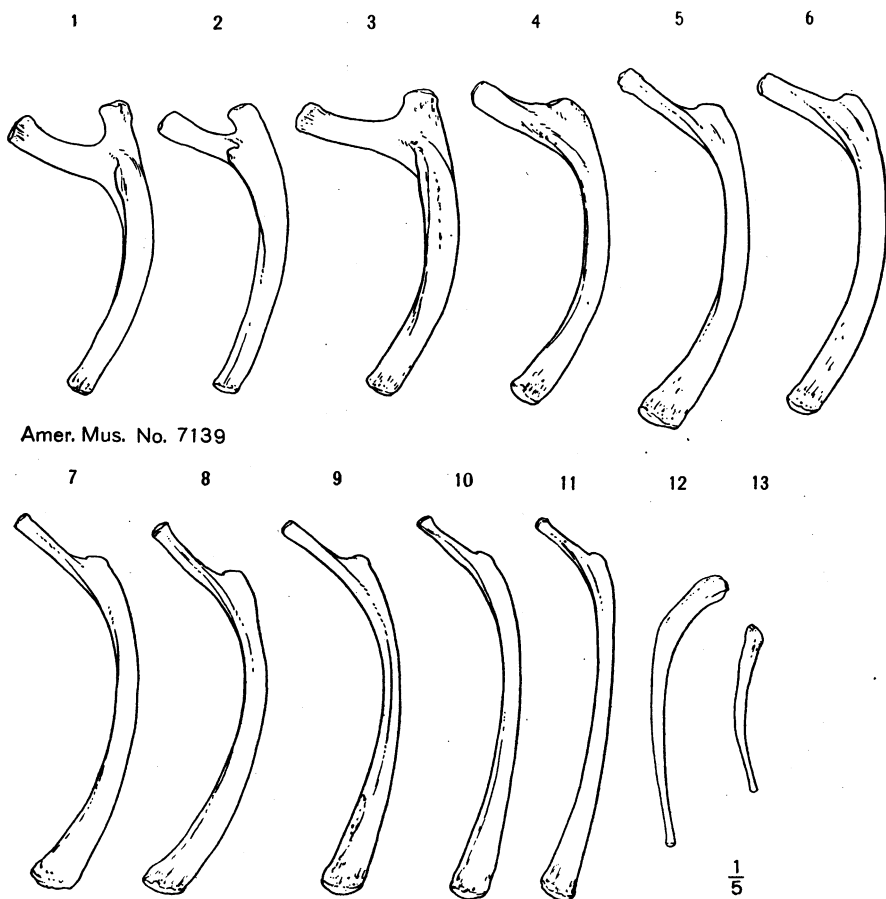
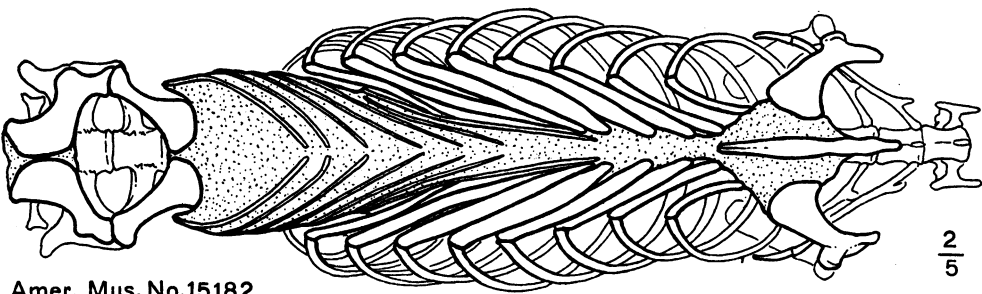


Fig. 9. Left dorsal ribs of *Crocodilus americanus*. Amer. Mus. No. 7139. External views. 1-13, first to thirteenth ribs, respectively, as estimated.

The posterior free ribs are small in size and simple in form; they are short and very slender, with acuminate extremities; they have no articular processes and but single simple articular surfaces; in cross-section they are almost circular.

Measurements

	CERVICAL RIBS			DORSAL RIBS	
	Length, Total	Breadth Across Capitular and Tubercular Processes		Length, Total	Breadth Across Capitular and Tubercular Processes
C. R. 1	15.4cm.	2.5cm.	D. R. 1	19.0cm.	6.40cm.
C. R. 2	12.1	4.3	D. R. 2	18.8	8.05
C. R. 3	7.7	4.0	D. R. 3	20.0	9.10
C. R. 4	8.5	3.7	D. R. 4	21.5	6.40
C. R. 5	9.4	3.7	D. R. 5	23.8	6.40
C. R. 6	9.1	4.2	D. R. 6	22.4	6.10
C. R. 7	8.2	5.5	D. R. 7	25.0	6.00
C. R. 8	17.1		D. R. 8	24.4	6.10
			D. R. 9	25.0	6.00
			D. R. 10	25.4	5.50
			D. R. 11	25.1	4.70
			D. R. 12	18.3	
			D. R. 13	11.0	



Amer. Mus. No.15182

Fig. 10. Ventral view of portion of skeleton of *Crocodilus americanus*, indicating the positions of the ventral ribs. Amer. Mus. No. 15182. Two-fifths natural size. The dotted areas represent cartilage.

VENTRAL RIBS.—The system of ventral ribs in the crocodiles is complex. It consists of the ventral thoracic ribs proper, the bars connecting them with the dorsal ribs, and the abdominal ribs. Associated with these elements are the sternum and its associated structures. The

ventral thoracic ribs and the bars which connect them with the dorsal ribs are broad and flat; they are usually imperfectly ossified. The connecting bars extend downward and backward in direct line with the dorsal ribs; the ventral thoracic ribs extend inward and forward from the connecting bars to the sternal cartilage. The abdominal ribs are very large and are more perfectly ossified than the ventral thoracic ribs; they are parallel to the latter in position and are imbedded in cartilage. The last pair of abdominal ribs is larger than the rest.

STERNUM

The anterior portion of the sternal apparatus consists of the completely ossified median interclavicle; the cartilaginous mass which connects this structure with the coracoids; the median sternal cartilage or imperfectly ossified bone to which the ventral thoracic ribs are attached; and the abdominal cartilage, which lodges the ossified abdominal ribs and which is connected with, and wedges between, the pubes.

PECTORAL GIRDLE AND FORE LIMB

SCAPULA.—The scapula is expanded near its summit into a broad, flat blade. Its shaft is thick and strong. The inferior end is expanded in several directions; half of the glenoid surface, which articulates with the humerus, is situated on the inferior corner of the postero-external portion of the scapula; at this point the latter is very thick. Above the glenoid surface is a roughened area of muscle attachment, which is situated on an oblique ridge near the posterior edge of the bone. The inferior portion of the anterior edge is elevated into a roughened ridge immediately below the shaft; near the antero-inferior corner of the bone this ridge dies out. Between this ridge and the process on which the glenoid surface is situated is a concave surface, which lodges a large mass of muscle. The surface which articulates with the coracoid is very broad near its posterior end, both scapula and coracoid being thick at that point to resist the thrust of the humerus; toward its anterior end this surface becomes narrower.

The inferior edge of the bone makes a very oblique angle with the longitudinal axis of the bone. The scapula extends somewhat backward as well as upward and inward over the ribs. The entire external surface is slightly convex; the internal surface is strongly concave. The superior portion of the bone makes a distinct angle with the inferior portion.

The scapula is considerably shorter than the humerus and femur, slightly shorter than the tibia, slightly longer than the fibula, ischium, and coracoid, and considerably longer than the radius, ulna, ilium, and pubis.

Measurements of Right Scapula (Amer. Mus. No. 7139)

Length, Total	22.0cm.
Antero-posterior Diameter of Superior Border	8.30
Antero-posterior Diameter of Inferior Border	8.90
Maximum Thickness of Distal End	3.40

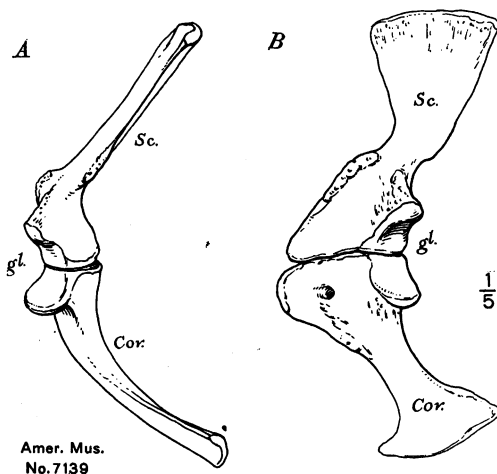
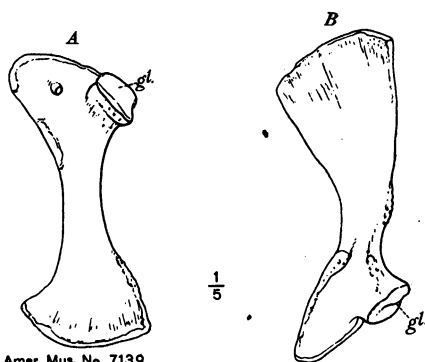


Fig. 11. Scapula and coracoid of *Crocodilus americanus*. Amer. Mus. No. 7139. One-fifth natural size. A, posterior view; B, external view. Cor., coracoid; gl., glenoid surface; Sc., scapula.

CORACOID.—The coracoid resembles the scapula in form in many respects; this resemblance is in many characters a symmetrical rather than a direct one. The surface of the coracoid which articulates with the scapula corresponds in outline with the corresponding surface of the latter bone. The external border of this surface makes an oblique angle with the longitudinal axis of the bone. The coracoid therefore extends obliquely backward, as well as downward and inward around the ventral surface of the thorax. The glenoid surface faces downward and outward. It is situated on a process which is sharply set off from the main mass of the bone. The entire superior surface of the bone is thick; its antero-posterior diameter is slightly greater than the same diameter of the inferior end of the scapula. The shaft is thick. The inferior end is ex-

panded antero-posteriorly and flattened laterally, but not to the same degree as in the scapula. The anterior part of the inferior expansion is considerably greater than the posterior part. The external surface is strongly convex and the internal surface is strongly concave. The coracoid foramen is large and conspicuous. It extends obliquely inward and backward from the external surface; on this surface it opens at a point about one-third of the distance back from the anterior border to the posterior border, while on the internal surface it opens at a point about two-fifths of the total distance back from the anterior border.

The coracoid is considerably shorter than the humerus and femur, slightly shorter than the scapula, ischium, tibia, and fibula, slightly longer than the pubis, and considerably longer than the radius, ulna and ilium.



Amer. Mus. No. 7139

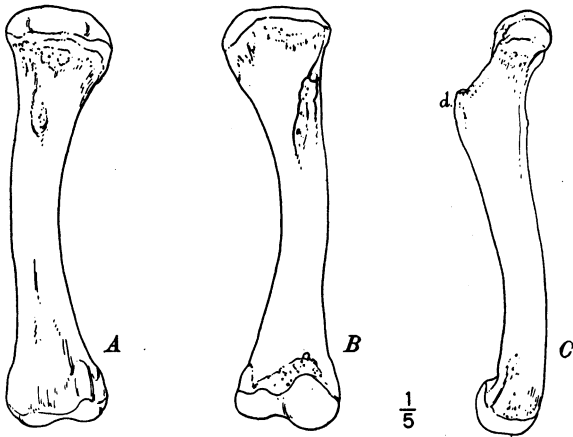
Fig. 12. Left scapula and coracoid of *Crocodilus americanus*. Amer. Mus. No. 7139. One-fifth natural size. External views. A, coracoid; B, scapula. gl., glenoid surface.

Measurements of Right Coracoid (Amer. Mus. No. 7139)

Length, Total	19.9cm.
Antero-posterior Diameter of Superior Surface	8.4
Antero-posterior Diameter of Inferior Surface	8.3
Maximum Thickness of Superior Surface	3.7

HUMERUS.—The humerus is moderately stout in proportion to its length. It is expanded at both proximal and distal ends; the planes of the proximal and distal expansions are practically parallel. The articular surfaces are distinctly marked; the articular surface of the proximal end faces upward and slightly backward; that of the distal end faces downward and slightly forward. In correlation with this the proximal

end of the bone curves slightly backward and the distal end curves slightly forward. The anterior and posterior surfaces of the bone immediately below the proximal articular surface and the anterior surface above the distal articular surface are greatly roughened, evidently in connection with the attachment of strong ligaments. The proximal articular surface is broad laterally and narrow antero-posteriorly; its anterior and posterior borders are nearly parallel, except near the internal margin, where the bone thickens; at the internal margin itself the bone is narrow. The distal articular surface is divided into two distinct condyles.



Amer. Mus. No. 7139

Fig. 13. Left humerus of *Crocodilus americanus*. Amer. Mus. No. 7139. One-fifth natural size. A, posterior view; B, anterior view; C, lateral view. d., deltoideus crest.

When viewed from either the anterior or the posterior direction, the external border of the humerus is seen to be slightly convex and the internal border slightly concave. There is, thus, a certain amount of lateral curvature in the bone. On the posterior surface, about one-fourth of the total length of the bone below the proximal end is a small, elongate rugose area, which serves for muscle attachment. The lower portion of the distal articular surface, between the two condyles, is somewhat grooved.

The deltoideus crest is large and prominent. It is near the proximal end of the bone. It is supported superiorly by a thin, sharp-edged process, but inferiorly it merges into the stout shaft of the bone. It rolls forward and inward strongly, and partially encloses a deep concavity on

the anterior surface of the bone for lodgment of muscles. Prominent rugosities are situated on the superior shoulder and inner surface of the process; its outer surface is smooth.

The humerus is considerably shorter than the femur; it is considerably longer than all the other limb and girdle bones.

Measurements of Right Humerus (Amer. Mus. No. 7139)

Length, Total	16.8cm.
Breadth of Proximal End	7.1
Breadth of Distal End	6.7
Circumference of Shaft	6.9
Index of Circumference over Length	.410

RADIUS.—The radius is a relatively small bone. It is much shorter than the ulna, besides being more slender. It is expanded at both proximal and distal ends. The distal expansion is fore and aft only; the proximal expansion is both fore and aft and lateral. The shaft is elliptical in cross-section. The ulnar articular surfaces are distinct. Near the distal end, on both the ulnar and the free surface, is a low ridge. The radius is shorter than all the other limb and girdle bones.

Measurements of Left Radius (Amer. Mus. No. 7139)

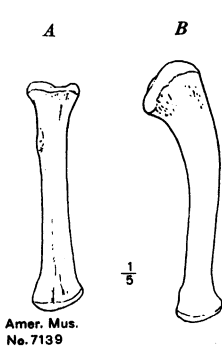


Fig. 14. Left radius and ulna of *Crocodilus americanus*. Amer. Mus. No. 7139. One-fifth natural size. A, anterior view of radius; B, lateral view of ulna.

Length, Total	14.9cm.
Maximum Diameter, Proximal End	3.4
Maximum Diameter, Distal End	3.1

ULNA.—The ulna is characteristic in form. It is very thick at its proximal end and small at its distal end. Its distal end is compressed laterally, so that its antero-posterior diameter is considerably greater than its transverse. The shaft is somewhat flattened and is decidedly curved. The large proximal articular surface faces forward as well as upward; the distal articular surface faces slightly inward as well as downward. On the internal surface of the bone, at the distal end, are situated two small oblique processes. The posterior border of the ulna is strongly convex and the anterior border is strongly concave.

The ulna is shorter than the scapula, coracoid, humerus, pubis, ischium, femur, tibia, and fibula; it is equal in length to the ilium, and is longer than the radius.

Measurements of Right Ulna (Amer. Mus. No. 7139)

Length, Total	17.2cm.
Antero-posterior Diameter of Proximal End	4.3
Antero-posterior Diameter of Distal End	3.1

CARPUS.—The proximal row of carpals consists of three bones; these are the radiale, ulnare, and pisiform. The distal row consists of one bone only. The radiale is much larger than the ulnare. Its greater length is correlated with the shortness of the radius; the length of radius plus radiale is approximately equal to that of ulna plus ulnare. Both radiale and ulnare are long in proportion to their breadth; and both are expanded at their ends like limb bones. The pisiform is very small.

The carpi of Amer. Mus. No. 7139 are incomplete. Measurements and ratios are given for several other specimens.

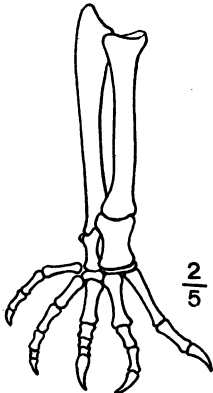


Fig. 15. Right radius, ulna, carpus, and manus of *Caiman sclerops*. Adapted from Brühl's figure. Two-fifths natural size. Anterior view.

Measurements and Ratios

Specimen No.	Length, Left Radiale	Length, Left Ulnare	Length, Left Radiale Length, Left Radius	Length, Left Ulnare Length, Left Ulna	Length, Left Radiale Length, Left Mtc. III	Length, Left Ulnare Length, Left Mtc. III
Mus. Comp. Zool. No. 4043 (<i>Caiman niger</i>)	2.5cm.	1.5cm.	.274	.141	.694	.416
Mus. Comp. Zool. No. 5082 (<i>Caiman sclerops</i>)	1.0	.58	.262	.126	.666	.386
Amer. Mus. No. 15182 (<i>Crocodylus americanus</i>)	1.4	.80	.274	.140	.777	.444

MANUS.—The five digits in the manus are all well-developed. The phalangeal formula is 2, 3, 4, 4, 3. The second and third digits are longer than the first, fourth, and fifth. The second metacarpal is the longest; the third metacarpal is second in length; the first metacarpal is third in length; the fourth metacarpal is fourth in length; and the fifth metacarpal is the shortest. The manus is shorter than the pes and is relatively broader in proportion to its length.

Measurements

Specimen No.	Length, Left Mtc. I	Length, Left Mtc. II	Length, Left Mtc. III	Length, Left Mtc. IV	Length, Left Mtc. V
Mus. Comp. Zool. No. 4043 (<i>Caiman niger</i>)	3.08cm.	3.8cm.	3.60cm.	2.75cm.	1.53cm.
Mus. Comp. Zool. No. 5082 (<i>Caiman sclerops</i>)	1.30	1.50	1.40	1.10	.075
Amer. Mus. No. 15182 (<i>Crocodylus americanus</i>)	1.40	1.73	1.80	1.52	1.08

Specimen No.	Length, Left Digit I	Length, Left Digit II	Length, Left Digit III	Length, Left Digit IV	Length, Left Digit V
Mus. Comp. Zool. No. 5082 (<i>Caiman sclerops</i>)	2.73cm.	3.41cm.	3.42cm.	2.47cm.	1.87cm.

Ratios

Specimen No.	Length, Right Mtc. III Length, Right Humerus	Length, Right Mtc. III Length, Right Radius	Length, Right Mtc. III Length, Right Ulna
Mus. Comp. Zool. No. 4043 (<i>Caiman niger</i>)	.241	.395	.339
Mus. Comp. Zool. No. 5082 (<i>Caiman sclerops</i>)	.238	.337	.305
Amer. Mus. No. 15182 (<i>Crocodylus americanus</i>)	.224	.340	.302

PELVIC GIRDLE AND HIND LIMB

ILIUM.—The ilium is very irregular in outline. It is produced backward into a conspicuous posterior process; at its anterior end it does not extend forward beyond the anterior process which articulates with the ischium. The superior border is very irregular, especially near the anterior end, where it is broken into two distinct portions by a sharp process which extends upward and forward; the superior border is very rugose. The external surface of the ilium is deeply concave between the two processes which articulate with the ischium; this concave portion constitutes a closed acetabulum. The external surface of the posterior process is smooth. The ilium has two distinct articulations with the ischium and none with the pubis directly; both of the ischiadic surfaces

are situated on stout processes. The anterior ischiadic surface is rather smoothly rounded; the posterior one is more nearly flat, but is also strongly rugose. The two articular processes are separated inferiorly by a thin wall of bone.

The superior portion of the internal surface of the ilium is smooth. The greater portion of the internal surface of the posterior process is contained in this smooth area. The inferior portion of the internal surface is occupied by the exceedingly rugose areas which articulate with the sacral vertebræ. These areas are separated from each other by a prominent vertical ridge. They are very irregularly shaped and are excavated into deep concavities and elevated into processes and ridges, all of which are greatly roughened. The anterior of the two articular surfaces is short in the antero-posterior direction; the posterior surface extends back on the posterior process. A smooth triangular area is situated partly between and partly below the articular surfaces.

The ilium is considerably shorter than the scapula, coracoid, humerus, ischium, femur, tibia, and fibula; slightly shorter than the pubis; about equal in length to the ulna; and slightly longer than the radius.



Amer. Mus.
No. 7139

Fig. 16. Left ilium of *Crocodilus americanus*. Amer. Mus. No. 7139. One-fifth natural size. External view.

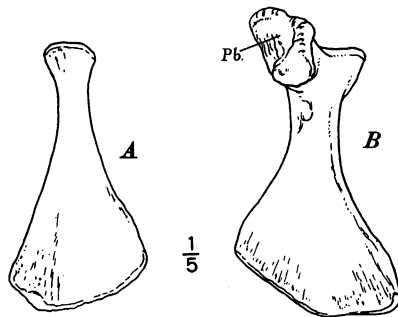
Measurements of Right Ilium (Amer. Mus. No. 7139)

Length, Total, Oblique	17.1cm.
Length, Total, Antero-posterior	15.3
Distance Across Both Ischiadic Processes	10.7

ISCHIUM.—The ischium is a large bone, much larger than the pubis. In outline it is complex. It articulates with the ilium at two distinct points. The anterior of the iliac articulations is situated on a distinct process, which excludes the pubis from contact with the ilium. The inferior surface of the anterior iliac process is partly rugose, where muscles or ligaments attach, and smooth where the bone articulates with the pubis. The posterior articulation with the ilium is situated at the head of the bone, above the shaft. Between the two iliac articular surfaces the superior surface of the ischium forms an infra-acetabular boundary. The superior portion of the shaft is roughly semicircular in cross-section. Between this portion of the shaft and the head a conspicuous foramen enters the bone; it does not completely pierce it, however.

The distal portion of the shaft is greatly expanded; the maximum diameter of this expansion is oblique in position. The entire external surface of the ischium is somewhat convex and the internal surface concave. The two ischia do not articulate with each other distally.

The ischium is considerably shorter than the humerus and femur; slightly shorter than the scapula, tibia, and fibula; slightly longer than the coracoid and pubis; and considerably longer than the radius, ulna, and ilium.



Amer. Mus. No. 7139

Fig. 17. Left pubis and ischium of *Crocodilus americanus*. Amer. Mus. No. 7139. One-fifth natural size. A, external view of pubis; B, external view of ischium. Pb., pubic surface of ischium.

Measurements of Right Ischium (Amer. Mus. No. 7139)

Maximum Length, Oblique	17.5cm.
Antero-posterior, Diameter, Proximal End	3.1
Maximum Diameter Distal End	8.8

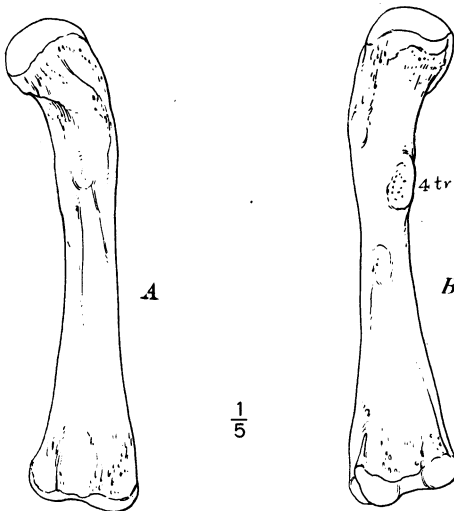
PUBIS.—The crocodilian pubis is a characteristic bone. It is roughly triangular in outline, the relatively narrow base of the triangle being at the distal end. The surface which articulates with the ischium is moderately smooth and is subcircular in outline; it is situated on the expanded proximal end of the bone. The shaft of the bone, immediately below the proximal process, is subcylindrical in form. Distally the shaft becomes thinner in the lateral direction and increased in antero-posterior diameter, merging into the flattened distal end. The external surface of the bone is gently convex, and the internal surface gently concave. The bone articulates with its fellow at the median line along a thin edge.

The pubis is considerably shorter than all the other limb and girdle bones except the radius, ulna, and ilium, which it exceeds in length.

Measurements of Right Pubis (Amer. Mus. No. 7139)

Length, Total	17.5cm.
Maximum Diameter, Proximal End	3.1
Minimum Diameter, Proximal End	2.7
Breadth, Distal End	8.7

FEMUR.—The femur is by far the longest of the crocodilian limb bones. It is expanded at both proximal and distal ends. The planes of the proximal and distal expansions are not parallel, as in the humerus, but oblique to each other. The articular surface of the head is large and round. The antero-internal border near the proximal end is convex and



Amer. Mus. No. 7139

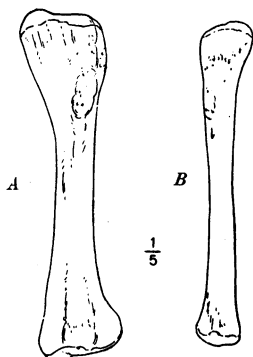
Fig. 18. Left femur of *Crocodilus americanus*. Amer. Mus. No. 7139. One-fifth natural size. A, posterior view; B, anterior view; 4 tr., fourth trochanter.

the postero-external border is concave. The anterior surface is very rough near the proximal end. The posterior surface, above the fourth trochanter, is concave. The fourth trochanter is large and prominent; it is much nearer the proximal than the distal end. On it, and also internal to it, are deep rugosities. The shaft is nearly circular. The bone is curved near the distal end, so that the condyles are oblique in position with reference to the shaft; the external surface, near the distal end, is convex and the internal surface is concave. Both external and internal surfaces are grooved and rugose.

Measurements of Right Femur (Amer. Mus. No. 7139)

Length, Total	32.5cm.
Breadth, Proximal End	6.8
Breadth, Distal End	7.05
Circumference of Shaft	11.0
Distance from Center of Fourth Trochanter to Proximal End	11.55
Distance from Center of Fourth Trochanter to Distal End	20.95
Index	.338
Ratio, $\frac{\text{Center of 4th Trochanter-Proximal End}}{\text{Center of 4th Trochanter-Distal End}}$.551

TIBIA.—The tibia is a stout, massive bone. Its proximal end is especially strong. The proximal surface is characteristic. It is triangular in outline, with the apex of the triangle directed forward; it is also slightly concave. The proximal portion of the shaft is stout and is triangular in outline; on its anterior margin it is compressed into a ridge; the ridge carries a conspicuous rugosity. The central portion of the shaft is much more slender than the proximal end; its anterior horizontal profile is semicircular; it is compressed into a low ridge posteriorly, so that the posterior horizontal profile is not semicircular. The distal portion of the shaft is expanded in the direction of the distal end of the bone. At its distal end the tibia is expanded in an oblique antero-external postero-internal direction and flattened in a direction perpendicular to this. The distal surface is obliquely truncated, the bone being longer at the postero-internal angle of the distal end than at antero-external angle.



Amer. Mus. No. 7139

Fig. 19. Tibia and fibula of *Crocodilus americanus*. Amer. Mus. No. 7139. One-fifth natural size. A, anterior view of tibia; B, lateral view of fibula.

The distal surface rolls backward somewhat, in the posterior direction. Near its central portion, on the postero-external surface, is a small, but conspicuous, concavity, which lodges the distal portion of the fibula.

The tibia is considerably shorter than the humerus and the femur; slightly longer than the scapula, coracoid, ischium and fibula; and considerably longer than the radius, ulna, ilium, and pubis.

Measurements of Right Tibia (Amer. Mus. No. 7139)

Length, Total	22.7 cm.
Maximum Diameter, Proximal End	5.0
Maximum Diameter, Distal End	5.1

FIBULA.—The crocodilian fibula is long and slender. At the proximal end it is expanded and at the same time flattened. The inner surface, near the proximal end, has a smooth surface for articulation with the tibia; below this surface is a rugosity. On the external surface of the shaft, about one-fifth of the total length of the bone below the proximal extremity, is a conspicuous muscle rugosity. The central portion of the shaft is cylindrical in cross-section. The distal extremity is expanded, but is not flattened at the proximal end. The plane of maximum expansion at the distal end is oblique to the plane of maximum expansion at the proximal end. A distinct process at the distal end articulates with a grooved surface on the tibia.

The fibula is considerably shorter than the humerus and femur; slightly shorter than the scapula, ischium, and tibia; slightly longer than the coracoid, ilium, and pubis; and considerably longer than the radius and ulna.

Measurements of Right Fibula
(Amer. Mus. No. 7139)

Length, Total	21.1cm.
Maximum Diameter, Proximal End	3.35
Maximum Diameter, Distal End	3.10
Circumference of Shaft	5.20
Index $\frac{\text{Circ. Shaft}}{\text{Total Length}}$.246

TARSUS.—The proximal row of tarsal bones consists of a large, irregular tibiale, or astragalus, and a prominent fibulare, or calcaneum. The distal row consists of three bones. The tibiale is of moderate size; besides its articulation with the tibia this bone has contacts with the fibula, fibulare, the innermost of the distal tarsals, and Metatarsal I. The fibulare extends backward with a shaft and an expanded distal end. It forms contacts with the fibula, tibiale, and the inner of the three distal tarsal bones. The innermost distal tarsal lies external to the proximal end of Metatarsal I, above Metatarsal II, and partly above Metatarsal III. The middle

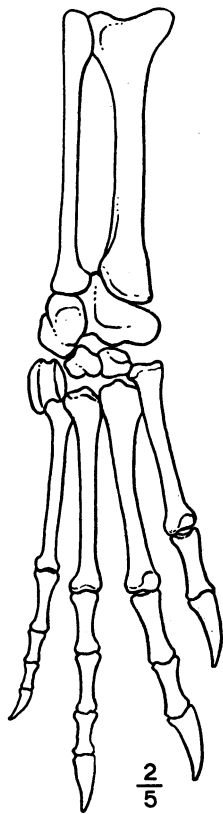


Fig. 20. Right tibia, fibula, tarsus, and pes of *Caiman sclerops*. Adapted from Brühl's figure. Two-fifths natural size. Anterior view.

distal tarsal lies above the third and fourth metatarsals. The external distal tarsal has a very slight contact with the fourth metatarsal. It extends backward as a free process.

Measurements and Ratios

Specimen No.	Maximum diameter, Left Tibiale	Length, Left Fibulare	Max. Diam. Left Tibiale	Length, Left Fibulare	Max. Diam. Left Tibiale	Length, Left Fibulare
			Length, Left Tibia	Length, Left Fibula	Length, Left Mtt. II	Length, Left Mtt. II
Mus. Comp. Zool. No. 4043 (<i>Caiman niger</i>)	3.2cm. e.	4.0cm.	.217	.289	.326	.308
Mus. Comp. Zool. No. 5082 (<i>Caiman sclerops</i>)	1.3	1.52	.222	.259	.372	.416
Amer. Mus. Mo. 15182 (<i>Crocodilus americanus</i>)	1.45(est.)	2.00	.210	.298	.329	.454

PES.—The pes consists of four digits only. It is much longer than manus. The phalangeal formula is 2, 3, 4, 4. The first digit is somewhat stouter than the others. The third digit is the longest; the second digit is second in length; the fourth digit is third in length; and the first digit is the shortest. The metatarsals are relatively long compared with the phalanges. The digits all support claws and are pressed closely together.

Measurements and Ratios

Specimen No.	Length, Mtt. I	Length, Mtt. II	Length, Mtt. III	Length, Mtt. IV	Length, Mtt. II	Length, Left Mtt. II	Length, Left Mtt. II
					Length, Left Femur	Length, Left Tibia	Length, Left Fibula
Mus. Comp. Zool. No. 4043 (<i>Caiman niger</i>)	8.7cm.	9.7cm.	9.2cm.	8.1cm.	.510	.638	.413
Mus. Comp. Zool. No. 5082 (<i>Caiman sclerops</i>)	3.2	3.7	3.6	3.2	.510	.649	.654
Amer. Mus. No. 15182 (<i>Crocodilus americanus</i>)	4.0	4.3	4.25	3.9	.477	.623	.641

RATIOS OF LIMB AND GIRDLE BONES OF *CROCODYLUS AMERICANUS*

(Amer. Mus. No. 7139)

<u>Length Coracoid</u>	.904	<u>Length Coracoid</u>	.938
<u>Length Scapula</u>		<u>Length Fibula</u>	
<u>Length Scapula</u>	.814		
<u>Length Humerus</u>		<u>Length Radius</u>	.550
<u>Length Radius</u>	.677	<u>Length Humerus</u>	
<u>Length Scapula</u>		<u>Length Ulna</u>	.629
<u>Length Ulna</u>	.772	<u>Length Humerus</u>	
<u>Length Scapula</u>		<u>Length Ilium</u>	.633
<u>Length Ilium</u>	.777	<u>Length Humerus</u>	
<u>Length Scapula</u>		<u>Length Ischium</u>	.688
<u>Length Ischium</u>	.845	<u>Length Humerus</u>	
<u>Length Scapula</u>		<u>Length Pubis</u>	.648
<u>Length Pubis</u>	.795	<u>Length Humerus</u>	
<u>Length Scapula</u>		<u>Length Humerus</u>	.830
<u>Length Scapula</u>	.676	<u>Length Femur</u>	
<u>Length Femur</u>		<u>Length Tibia</u>	.844
<u>Length Tibia</u>	.964	<u>Length Humerus</u>	
<u>Length Scapula</u>		<u>Length Fibula</u>	.785
<u>Length Fibula</u>	.963	<u>Length Humerus</u>	
<u>Length Scapula</u>			
		<u>Length Ulna</u>	.994
<u>Length Coracoid</u>	.737	<u>Length Ilium</u>	
<u>Length Humerus</u>		<u>Length Ulna</u>	.913
<u>Length Radius</u>	.748	<u>Length Ischium</u>	
<u>Length Coracoid</u>		<u>Length Ulna</u>	.971
<u>Length Ulna</u>	.854	<u>Length Pubis</u>	
<u>Length Coracoid</u>		<u>Length Ulna</u>	.523
<u>Length Ilium</u>	.859	<u>Length Femur</u>	
<u>Length Coracoid</u>		<u>Length Ulna</u>	.745
<u>Length Pubis</u>	.879	<u>Length Tibia</u>	
<u>Length Coracoid</u>		<u>Length Ulna</u>	.801
<u>Length Ischium</u>	.934	<u>Length Fibula</u>	
<u>Length Coracoid</u>		<u>Length Radius</u>	.876
<u>Length Coracoid</u>	.612	<u>Length Ulna</u>	
<u>Length Femur</u>			
<u>Length Coracoid</u>	.872	<u>Length Radius</u>	.871
<u>Length Tibia</u>		<u>Length Ilium</u>	

<u>Length Radius</u>	.801
<u>Length Ischium</u>	
<u>Length Radius</u>	.851
<u>Length Pubis</u>	
<u>Length Radius</u>	.458
<u>Length Femur</u>	
<u>Length Radius</u>	.653
<u>Length Tibia</u>	
<u>Length Radius</u>	.702
<u>Length Fibula</u>	
 <u>Length Ilium</u>	 .919
<u>Length Ischium</u>	
<u>Length Ilium</u>	.977
<u>Length Pubis</u>	
<u>Length Ilium</u>	.526
<u>Length Femur</u>	
<u>Length Ilium</u>	.754
<u>Length Tibia</u>	
<u>Length Ilium</u>	.806
<u>Length Fibula</u>	

<u>Length Pubis</u>	.940
<u>Length Ischium</u>	
<u>Length Ischium</u>	.580
<u>Length Femur</u>	
<u>Length Ischium</u>	.815
<u>Length Tibia</u>	
<u>Length Ischium</u>	.877
<u>Length Fibula</u>	
 <u>Length Pubis</u>	 .538
<u>Length Femur</u>	
<u>Length Pubis</u>	.767
<u>Length Tibia</u>	
<u>Length Pubis</u>	.825
<u>Length Fibula</u>	
 <u>Length Tibia</u>	 .701
<u>Length Femur</u>	
<u>Length Fibula</u>	.652
<u>Length Femur</u>	
 <u>Length Fibula</u>	 .929
<u>Length Tibia</u>	

PLATE XIII

PLATE XIII

Dorsal vertebræ of *Crocodilus americanus*

Amer. Mus. No. 7139

One-fifth natural size

A.—Anterior views

B.—Lateral views, left side

C.—Posterior views

1-13.—First to thirteenth dorsal vertebræ, inclusive

Di., diapophysis; N. C., neural canal; Pa., parapophysis; Poz., postzygapophysis; Prz., prezygapophysis; Sp., spine.

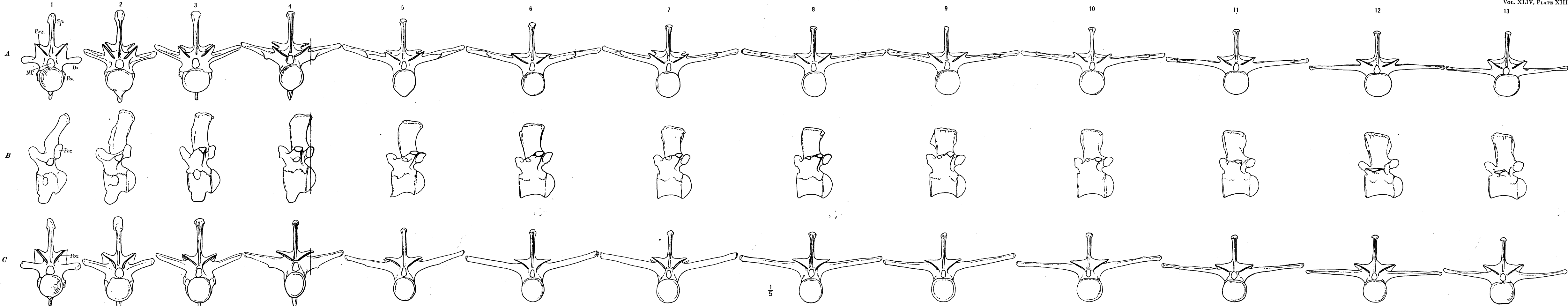


PLATE XIV

PLATE XIV

Caudal vertebræ of *Crococilus americanus*

Amer. Mus. No. 7139

One-fifth natural size

A.—Anterior views

B.—Lateral views, left side

C.—Posterior views

1-37. First to thirty-seventh caudal vertebræ, inclusive

N. C., neural canal; Poz., postzygapophysis; Prz., prezygapophysis; Sp., spine; T. P., transverse process.

