A NEW DESCRIPTION OF SANIWA ENSIDENS LEIDY, AN EXTINCT VARANID LIZARD FROM WYOMING.

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INTRODUCTION.

In 1870 Dr. F. V. Hayden discovered the fossil remains of an extinct lizard in the Bridger deposits, Eocene, in the vicinity of Granger, Sweetwater County, Wyoming, which Dr. Joseph Leidy briefly described[1] as *Saniwa ensidens*.

The type specimen was deposited in the United States National Museum, where it has remained in the same unprepared condition as originally received 50 years ago. It was preserved in a considerable number of blocks of ash-colored rock, the only evidence of the embedded specimen being two vertebrae, which had been uncovered, and the numerous bones which protruded from the broken faces of the rock.

Recently this specimen has been fully prepared by Mr. N. H. Boss, preparator in the Section of Vertebrate Paleontology, and under his skillful manipulation all the contained bones have either been entirely freed from the matrix or worked out in bold relief. This work has resulted in uncovering many elements whose former existence was unknown, and especially important was the discovery of a considerable part of the vertebral column and the greater portion of the skull and lower jaws.

Since paleontology as yet affords very little information concerning the evolution of the more specialized land lizards, the unusual perfectness of the skeletal remains of the present specimen, coupled with the fact that *Saniwa ensidens* was the very first extinct lacertilian lizard to be described from North America, it is of sufficient interest to warrant a full and detailed description of the type specimen.

[1] Proc. Acad. Nat. Sci., Phila., 1870, p. 124.

OSTEOLOGY OF SANIWA.

Suborder SAURIA.

Family VARANIDAE.

Genus SANIWA Leidy.

SANIWA ENSIDENS Leidy, 1870.

Saniwa ensidens LEIDY, Proc. Acad. Nat. Sci. Phila., 1870, p. 124; U. S. Geol. Surv. of Wyo. and contiguous Terr., 2nd (4th) Ann. Rept. F. V. Hayden, U. S. Geologist, 1871, p. 368; U. S. Geol. Survey of Montana and portions of adjacent Terr., F. V. Hayden, U. S. Geologist, Washington, D. C., 1872, p. 370.—KING, C. U. S. Geol. Explor. 40th parallel, Clarence King, Geologist in charge, 1878, vol. 1, p. 608.—HAY, O. P. Bull. 179, U. S. Geol. Survey, 1901, p. 475.

Saniva ensidens (Leidy), MARSH, O. C. American Jour. Sci., ser. 3, 1871, p. 457.—COPE, E. D. U. S. Geol. Survey Terr. for 1872, 6th Ann. Rept., F. V. Hayden, U. S. Geologist, Washington, D. C., 1873, p. 632.—LEIDY, J. Report of U. S. Geol. Survey of Terr., F. V. Hayden, U. S. Geologist in charge, vol. 1, 1873, pp. 181–344, pl. 15, fig. 15; pl. 17, fig. 35.—NOPCSA, F. B. Beitr. Z. Kenntn, foss. Eid., Beitr. Z. Pal. U. Geol. Ost. Ung., vol. 21. Wien, U. Leipzig, 1908, p. 46.—FÉJÉRVÁRY, G. J. Ann. Müsei Nationalis Hungarici, vol. 16, 1918, p. 420.

Type specimen.—Cat. No. 2185, U.S.N.M. Collected by Dr. F. V. Hayden, 1870.

The following list shows the bones preserved of the type specimen:

Skull.—Basioccipital; basisphenoid; supraoccipital; exoccipital, right and left; opisthotic, right and left; prootic, left; postfrontal, right and left; postorbital, right and left; prefrontal, left; maxilla, right and left; lachrymal, left; jugal, left (?); quadrate, left; epipterygoid, right fragment and left; pterygoid, right and left; ectopterygoid, right and left; palatine, right and left; vomer, right and left; several teeth.

Lower jaw.—Dentary, right and left; splenial, left in part; articular + prearticular, right and left; angular, right and left; surangular, right and left; coronoid, right.

Vertebrae.—Atlas, axis, third, fourth, fifth, sixth, and seventh cervical vertebrae, articulated; eighth, ninth, tenth, and eleventh vertebrae, articulated; twelfth to twenty-first vertebrae, partially articulated; 13 caudal vertebrae.

Ribs.—Thoracic ribs (8 fairly perfect, parts of 10 others).

Limb bones.—Right humerus; femur, distal portion, left; tibia, distal portion, left.

Pectoral girdle.—Right coracoid.

Type locality.—Vicinity of Granger, Sweetwater County, Wyoming.

Horizon.—Bridger formation, Middle Eocene.

The original description by Leidy is as follows:

Saniwa ensidens.—Among the fossils obtained in Professor Hayden's expedition are the remains of a lacertian, labeled as having been discovered near "Granger." The bones consist of those of most parts of the skeleton, but are

all in a fragmentary condition, and are embedded in freshly broken pieces of an ash-colored rock. Before disturbance they appear to have been mostly entire and preserved nearly in conjunction. They are black, and their interior is occupied with crystalline calcite.

Fragments of bones exhibit well-developed limbs, with long toes, strong ribs, and a long tail, altogether indicating a form like that of ordinary living lacertians. The long bones, even to those of the toes, are hollow. The vertebrae exhibit the ball-and-socket articulation of their bodies, but only a single pair of zygapophyses in front and behind. No zygantral and zygosphenal articulation appears to have existed.

The articular ball of the vertebral body is much wider than high, and is directed upward, with an inclination backward.

The body of several dorsals is quite straight inferiorly, fore and aft, and measures half an inch in length. The ball is four lines wide and about half as thick. The breadth at the anterior zygapophyses is eight lines, and at the articulations for the ribs, just exterior to the latter, three-fourths of an inch.

Hypophyses for the articulation of chevrons are situated one-fourth the length of the body from the posterior extremity.

A tooth was found, after careful search, in proximity to what appear to be traces of the skull. It consisted of the crown, broken from its connection, the character of which, therefore, can not be ascertained.

The crown of the tooth is compressed conical, slightly curved inwardly and backward, sharp pointed, with abruptly impressed trenchent borders; is smooth and shining. It is hollow and has thick walls. The transverse section is rhomboidally oval, with acute poles. The length is about 1¼ lines; the breadth three-fourths of a line; thickness one-half a line.

The remains would indicate an animal as large as the largest of our living iguanians.

For the generic name of the animal I would propose to use the euphonious one of Saniwa which, according to Professor Hayden, is that used by one of the Indian tribes of the Upper Missouri for a rock lizard. The species may be named *Saniwa ensidens*.

DESCRIPTION OF THE TYPE SKELETON OF SANIWA ENSIDENS, LEIDY.

SKULL.

It will be seen from an examination of the preceding list of the bones preserved of the type of *Saniwa ensidens* Leidy that a very considerable part of the skull and lower jaws has been preserved. Most of these bones, excepting the palate shown in plate 1, were found disarticulated, though none of the bones were far removed from one another in the matrix. Curiously enough the larger and heavier elements of the skull, such as the parietals, frontals, nasals, and premaxillaries, are entirely missing. It is also unfortunate that the anterior ends of the articulated maxillaries and vomers, as well as the symphysial ends of the dentaries, are wanting. These parts extended into another block of the matrix, which was either rejected in the field or has since been lost.

The skull of *Saniwa*, as may well be inferred from the close resemblance of the various elements to those of the *Varanus*, had the same light, open construction as in that genus. The similarity of many of the individual bones is remarkable, especially when the Eocene age of the fossil is taken into consideration.

A skeleton of *Varanus salvator* (Cat. No. 29551, U.S.N.M.), having a skull of practically the same dimensions as the type of *Saniwa ensidens* Leidy, has a greatest length of (473 mm.) 4 feet 10 inches. I am of the opinion that the length of the complete skeleton of the fossil specimen would be somewhat less, because of the slightly smaller and shorter vertebrae, but it would certainly have exceeded 4 feet in length. Some of the extinct American species as *Saniwa major* Leidy or *Thinosaurus grandis* Marsh probably rivaled the largest of the existing Monitors (*Varanus salvator*), which often

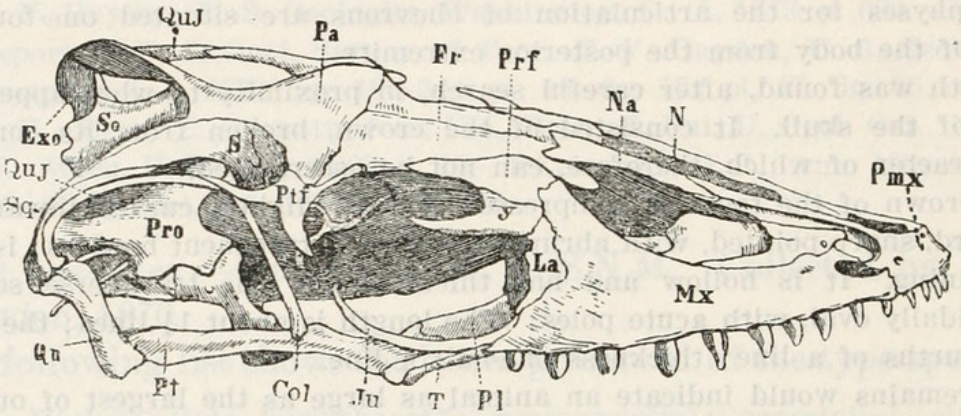

FIG. 1.—SKULL OF VARANUS NILOTICUS. *Col*, COLUMELLA; *Exo*, EXOCCIPITAL; *Fr*, FRONTAL; *Ju*, JUGAL; *La*, LACHRYMAL; *Mx*, MAXILLARY; *N*, EXTERNAL NARES; *Na*, NASAL; *Pa*, PARIETAL; *Pl*, PALATINE; *Pmx*, PREMAXILLARY; *Prf*, PREFRONTAL; *Pro*, PROOTIC; *Pt*, PTERYGOID; *Ptf*, POSTFRONTAL + POSTORBITAL; *Qu*, QUADRATE; *Quj*, QUADRATOJUGAL; *S*, SUPRATEM-ORAL FOSSA; *So*, SUPRAOCCIPITAL; *Sq*, SQUAMOSAL; *T*, ECTOPTERYGOID; *Y*, SUPRAORBITAL. (AFTER CUVIER.)

attains a length of 7 feet. The largest of the American species, however, are small as compared with the *Megalania prisca* from the Pleistocene of Australia with an estimated [2] length of 30 feet for the entire animal.

Basioccipital.—The basioccipital is perfectly preserved, except for the loss of its posterior median portion, which with the exoccipitals forms the occipital condyle. It thus forms the median boundary of the base of the foramen magnum, and ventrally is continuous laterally with the exoccipitals, which, as in *Varanus*, develop thin winglike plates that extend forward in a horizontal plane from the ventral sides of the proximal ends. The anterior, transversely broad, wedge-shaped end is received in a corresponding transverse depression on the posterior end of the basisphenoid. The dorsal surface of the basioccipital is medially depressed, forming a wide longitudinal valley.

[2] Lydekker, R. Cat. of Fossil Reptilia and Amphibia, Pt. L, 1888, p. 284.

Basisphenoid.—The basisphenoid of *Saniwa* as in living lizards generally sends downward two short processes or hypophyses with flattened expanded ends that abut against the pterygoids, as in *Varanus* (fig. 1). Between these processes at the middle it is drawn out in front into a short truncated rostrum which articulated with the presphenoid. The posterior margin is broadly notched for the articulation of the basioccipital. The dorsal surface slopes upward from the back toward the front, this inclination being continued on either side as divergent projecting processes which in the articulated skull are lapped by a slender projecting process of the proötic. Between, and ventral to these two processes the widened anterior end of the bone is deeply and broadly scooped out, forming the *sella tertica*, into which a pair of entocarotid canals open. On the lateral posterior surface is a foramen that in *Varanus* leads diagonally through the wall of bone into the median excavation described above. This bone in size and shape is remarkably similar to the basisphenoid of *Varanus salvator* (Cat. No. 29408 U.S.N.M.).

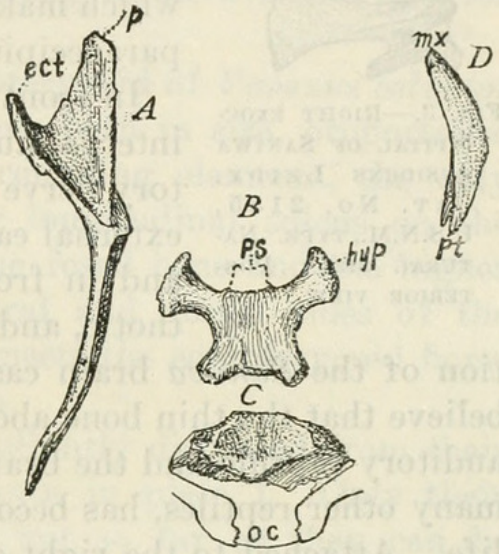

FIG. 2.—VENTRAL VIEW OF SKULL BONES OF SANIWA ENSIDENS LEIDY. CAT. NO. 2185. U.S.N.M., TYPE. ALL NATURAL SIZE. A, RIGHT PTERYGOID. *Ect*, PROCESS ARTICULATING WITH THE ECTOPTERYGOID; *p*, PROCESS THAT UNITES WITH THE PALATINE. B, BASISPHENOID; *hyp*, HYPOPHYSES; *ps*, PRESPHENOID, WHICH IS MISSING. C, BASIOCCIPITAL; *oc*, OCCIPITAL CONDYLE RESTORED. D, RIGHT ECTOPTERYGOID, DORSAL VIEW; *mx*, ANTERIOR END THAT MEETS THE MAXILLARY; *pt*, POSTERIOR BIFURCATED END THAT MEETS THE OUTER BRANCH OF THE PTERYGOID.

Exoccipital and opisthotic.—Both exoccipital bones are present, the left having the proötic of that side attached to it. The exoccipital contributes to the basal as well as forming all of the side boundary of the foramen magnum. The basal portion extends backward and forms the lateral portion of the occipital condyle. Articulated it would extend outward and backward as a flattened paraoccipital process having a vertically expanded, truncated end, which probably articulated with the supratemporal and quadrate as in *Varanus*. A foramen leads diagonally through this bone into the brain cavity, having its external exit ventral to the lower border of the paraoccipital process. Beneath and forward of this vagal foramen, a small, thin, winglike horizontal plate is developed which joins the lateral border of the basioccipital. In the comparatively limited development of this platelike process, with a decided notch between it and its junction with the paraoccipital process, it resembles the *Iguana* much more closely than *Varanus*, where this process extends outward on the lower side of the para-

occipital process for fully one-half its total length, while in *Saniwa* its extent would be less than one-fourth the total length. On the anterior side of the paraoccipital process, a sharp median longitudinal ridge divides the lower nonarticular from the upper articular surface with which it unites with the posterior branch of the proötic by squamous suture. On the inner anterior end a deep pit, a part of the auditory capsule, extends down into this bone. Immediately within the foramen magnum the exoccipital is perforated by a small foramen for the passage of the hypoglossal nerve, which makes its exit beneath the base of the lateral paraoccipital process.

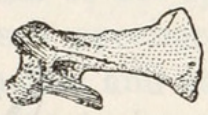

FIG. 3.—RIGHT EXOCCIPITAL OF SANIWA ENSIDENS LEIDY. CAT. NO. 2185, U.S.N.M., TYPE. NATURAL SIZE. POSTERIOR VIEW.

In front of this foramen is a slitlike aperture, the internal auditory meatus, through which the auditory nerve leaves the cranial cavity and enters the external ear. In the crocodile the thin bone above and in front of this slitlike opening is the opisthotic, and from the close resemblance of this portion of the *Saniwa* brain case to that of the crocodile leads me to believe that the thin bone above the slit, forming a wall between the auditory capsule and the brain cavity, is the opisthotic, which, as in many other reptiles, has become united with the exoccipital early in life. Attached to the right exoccipital is a fragment of the rodlike columnella auditoris.

Supraoccipital.—The supraoccipital has a more pronounced median keel than in *Varanus*, and in this respect is intermediate between *Iguana* and *Varanus*. As in the latter genus, it forms the superior boundary of the foramen magnum. The upper end terminates obtusely, but is not so broad as in *Varanus*. Latterly it joins the exoccipitals; anteriorly the proötics and opisthotics, superiorly the parietal but by cartilagenous attachment only.

FIG. 4.—RIGHT EPIPTERYGOID OF SANIWA ENSIDENS LEIDY. TYPE. CAT. NO. 2185, U.S.N.M. NATURAL SIZE. POSTERIOR VIEW.

Epipterygoid.—The complete left epipterygoid and a portion of the right are present. It is a rounded bar with slight, but about equally expanded ends. The lower end is cut off obliquely, the upper is flattened on the inner side, where it laps against the forward extremity of the proötic. This bone has a total length of 16 mm.

Pterygoid.—The right pterygoid is present in its entirety, the left nearly as perfect. The latter was found in the matrix but little separated from its proper articulation with the ectopterygoid (see pl. 1) and palatine bones. The pterygoid in *Saniwa* is a long, slender, slightly curved bone, having a bifurcated anterior end and a flattened tapering posterior extremity which laps the inner distal side of the quadrate (see A, fig. 2). The slender rodlike posterior por-

tion is grooved on the dorsal and ventral sides by longitudinal sulci. On the dorsal surface forward of the center of the bone the development of a shallow pit marks the point of articulation with the epipterygoid. Anterior to this cuplike depression the bone rapidly widens, being terminated at the anterior extremity by two projecting articular processes, the larger inner process uniting with the palatine; the smaller outer process with the ectopterygoid. The thin notchlike border connecting these two processes forms much of the inner and all of the posterior boundaries of the infraorbital vacuity. The right pterygoid has a greatest length of 43 mm.; greatest width of anterior end, 10 mm.

The resemblance of this bone to the pterygoid of *Varanus salvator* (Cat. No. 29408, U.S.N.M.) is very close both in size, proportions, and method of articulation with surrounding elements, the only differences observed being the deeper longitudinal sulcus on the ventral side of the posterior half of the fossil bone and the higher and sharper ridges on both the ventral and dorsal sides of the border leading up to the process that meets the ectopterygoid bone. There is no evidence of pterygoid teeth.

Palatine.—Both palatine bones, but slightly displaced from their proper position in the palate, are shown in plate 1. Only their dorsal surfaces have been uncovered, but so far as they can be compared they appear very similar to the corresponding bones in the *Varanus* palate. The wide, flattened posterior end unites with the pterygoid. On the external side, near the middle of the bone, a heavy process extends outward to meet the posterior end of the maxilla. As in *Varanus*, this process is perforated by a longitudinal foramen, which leads into a cavity within the maxilla. A slender, pointed projection of this process extends backward along the maxilla, that, when articulated, probably met the ectopterygoid and entirely excluded the maxilla from participation in the formation of the boundary of the pterygoid or infraorbital aperture. Anteriorly the palatine sends forward a slender tapering process that laps the posterior end of the vomer on the inner side. The forward ends of the palatines are in contact on the median line, as shown in plate 1, but I am inclined to the belief that this has been brought about by transverse crushing and that originally they were separated, but probably not so wide apart as in the living *Varanus*. The character of the dorsal surface appears to indicate that it was in contact with the prefrontal and lachrymal bones as in *Varanus*.

Vomers.—The vomers are relatively wider transversely than in *Varanus* and they also differ in having a broader and deeper longitudinal depression on the dorsal surface. They appear to have been in contact on the median line throughout the greater part of their

length. Viewed from above, the outer border, which stands up as a vertical plate, curves in toward the median line and nearly if not quite meets the ridge on the vomer of the opposite side. From this point forward the outer border curves outward to meet the maxillary. The anterior ends of the vomers are missing in the type, as shown in plate 1.

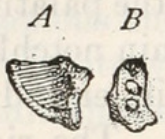

FIG. 5.—LEFT LACHRYMAL OF SANIWA ENSIDENS LEIDY. TYPE, CAT. NO. 2185, U.S.N.M. NATURAL SIZE. *A*, LATERAL VIEW; *B*, POSTERIOR VIEW.

Ectopterygoid.—Both ectopterygoid bones are present, but the right element is the more perfectly preserved. It is a curved bone, having a bifurcated posterior end that straddles the small outwardly turned process on the pterygoid, lapping above and below, thus forming a strong union of these two bones. Its curved and rounded inner border forms the greater part of the outer boundary of the infraorbital vacuity. The anterior end tapers out to an obtuse point having a groove on the external side that joined the posterior end of the maxillary. The anterior, outer border was in sutural contact with the jugal for half its entire length. Its greatest length over all is 16.5 mm.

Lachrymal.—The left lachrymal is almost perfectly preserved, lacking only a little of its external posterior border. Viewed from the side, it is a flat bone, subtriangular in outline, with a thickened posterior border that is slightly concave vertically. This end, which contributed to the boundary of the orbit, is perforated by two oval foramina, one above the other. The larger is above and separated from the lower one by a very narrow filament of bone. These appear to have a common exit on the median internal side of the bone. In *Varanus* the lachrymal is perforated by the usual lachrymal foramen, but the larger and more dorsal foramen of *Saniwa* is in the *Varanus*, represented by a notch, the inner border being formed by the lower branch of the prefrontal. A striated articular surface on the postero-inferior border appears to indicate the point of articulation with the forward end of the jugal as in *Varanus*. Its greatest length is 7.5 mm.; greatest height, 6.5 mm.

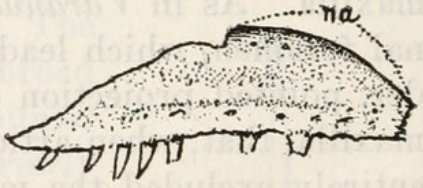

FIG. 6.—RIGHT MAXILLARY OF SANIWA ENSIDENS LEIDY. TYPE, CAT. NO. 2185, U.S. N.M. NATURAL SIZE. LATERAL VIEW. *na*, BORDER THAT CONTRIBUTES TO THE BOUNDARY OF THE EXTERNAL NARIAL OPENING.

Maxillary.—Both maxillae retain their natural relationships to the interposed palatal bones as shown in plate 1. The right is the better preserved, though it lacks the anterior extremity and a portion of the median superior border. In so far as comparison can be made it closely resembles the maxillary of *Varanus*. The principal differ-

ence detected is that the lower posterior extremity of the fossil is more slender and tapering. It is pierced by a number of foramina that form a row slightly above, but parallel to the dental border. The sloping superior border anterior to where it joins the perfrontal forms the outer boundary of the anterior nares. This border turns inward toward the median line posterior to its anterior extremity, but the anterior portion of the bone is missing.

The right maxillary contains eight teeth and there are spaces for five more, making 13 teeth within a space 35 mm. long. The same space in *Varanus* contains only nine teeth. It is estimated that the missing portion would have carried two, possibly three more, so that in all the maxillary of *Saniwa* would have had at least 15 teeth, probably more. Because of the fragile nature of the bone and teeth no attempt has been made to free the internal or palatal side from the matrix. Posteriorly this bone certainly articulated with the palatine, ectopterygoid, prefrontal, and lachrymal, and probably also with the jugal.

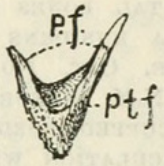

FIG. 7.—RIGHT POSTFRONTAL OF SANIWA ENSIDENS LEIDY. TYPE, CAT. NO. 2185, U.S.N.M. NATURAL SIZE. VIEWED FROM ABOVE. *p.f.*, CUPPED SURFACE WHICH ARTICULATES ABOUT EQUALLY WITH THE LATERAL PROJECTIONS OF THE PARIETAL AND FRONTAL.

Postfrontal.—The postfrontal is a moderate-sized trihedral bone, articulated by its expanded cranial end to the frontal and parietal by a cupped articular area between the divergent anterior and posterior branches (see *p.f.*, fig. 7), that fits in under and along the outer borders of these bones at their junction. On the posterior side of the pointed distal projection a roughened striated surface indicates the sutural contact of the postorbital, which in *Saniwa* exists as a distinct element. The left postfrontal and postorbital were found articulated (fig. 8), the suture distinctly shown, so that the manner of their articulation may be considered as absolutely determined. In all of the illustrations of the *Varanus* skull[3] and in three of the four skulls of this animal now before me the postfrontal-postorbital complex appears as a single bone. It is called postfrontal in all the illustrations of the *Varanus* skull, there being no mention made of the presence of a postorbital. However, on the ventral side of the right postfrontal of the skull *Varanus* (Cat. No. 29408, U.S.N.M.), the suture between it and the postorbital is visible under the glass. This suture takes essentially the same course as in the fossil specimen. Probably in a juvenile specimen the division between these two elements would be more clearly indicated. It is evident they coalesce early in life, so that in adult specimens all traces of the sutures are obliterated.

[3] Gadow, H. Amphibia and Reptilia, 1901, p. 542, fig. 138. Gadow recognizes these elements as the fused postorbital and postfrontal.

Postorbital.—Both postorbital bones are present, the left articulated with the postfrontal, the right detached. The latter has an expanded anterior end which articulates with the postfrontal by a cupped articular surface developed on the upper anterior border. In position it extends downward below the postfrontal as a pointed process (see fig. 8), but apparently not reaching the jugal. Extending posteriorly the postfrontal develops a slender tapering process which articulated with the squamosal, thus forming the supratemporal arcade as in other members of the Varanidae.

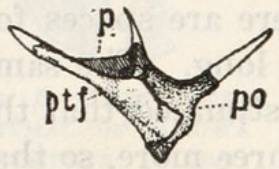

FIG. 8.—ARTICULATED LEFT POSTFRONTAL AND POSTORBITAL BONES OF SANIWA ENSIDENS LEIDY. TYPE, CAT. NO. 2185, U.S.N.M. NATURAL SIZE. *p*, CUPPED BORDER FOR ARTICULATION WITH PARIETAL AND FRONTAL; *po*, POSTORBITAL; *ptf*, POSTFRONTAL.

Proötic.—The left proötic was found attached by matrix to the left exoccipital, but slightly displaced from its proper articulation with that element (see fig. 9). It closely resembles the corresponding bone in *Varanus salvator*, being a curved bone having a narrowed posterior half that laps along the upper anterior side of the paraoccipital process by squamous suture, and a flattened broader anterior half that turns upward from the horizontal at an angle of 45° to meet the parietal on the external side at about the middle of the supratemporal fossa. The inner posterior border forms a junction with the supraoccipital, exoccipital, and opisthotic. The inner surface of this flattened end contributes to the formation of the lateral wall of the brain cavity and to the boundary to the auditory capsule. The ventral process, which in *Varanus* extends forward and downward to articulate with the basiphenoid, is missing in the fossil, but presumably it will be found to be much like that of *Varanus*.

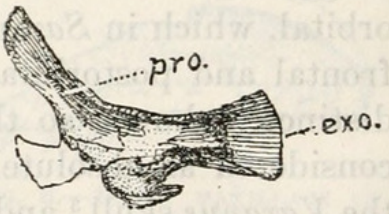

FIG. 9.—LEFT PROÖTIC ATTACHED TO EXOCCIPITAL OF SAME SIDE OF SANIWA ENSIDENS LEIDY. TYPE, CAT. NO. 2185, U.S.N.M. NATURAL SIZE. LATERAL VIEW. *exo*, EXOCCIPITAL; *pro*, PROÖTIC.

Prefrontal.—The left prefrontal was found in the matrix but little disturbed from its proper articulation with the underlying bones of the palate. It is an irregularly shaped bone (see fig. 10) that forms the greater part of the anterior boundary of the orbit and contributes to both the dorsal and lateral surfaces of the skull. Internally it also develops a partial postlateral wall for the rhineocephalic chamber. The contribution to the dorsal surface is of considerably greater extent, both transversely and anteroposteriorly, than in a *Varanus* skull of equal dimensions. Posteriorly a tapering process extends backward along the outer edge of the frontal, which, as in *Varanus*, probably termi-

nated at about the center of the orbit. The anterior extension of this bone is missing. A decidedly roughened ridge is developed along the angle where it turns downward to form the lateral surface. This ridge probably marks the seat of attachment for the supra-orbital bone, which is missing in this specimen. On the ventral part of the lateral surface there is an indented articular area, which marks the point of articulation with the separate lachrymal bone. Posterior to the lachrymal articulation the bone turns inward, forming a wide contribution to the anterior border of the orbit. The ventral edge of this orbital portion is slightly expanded anteroposteriorly for articulation with the underlying palatine, to which it is joined in the articulated skull. Anteriorly it appears to have articulated with the maxillary as in *Varanus*. It probably was also in contact with the nasal, but of this I am not entirely certain.

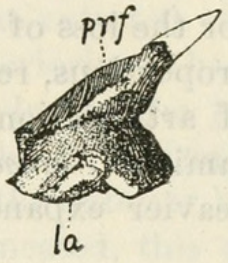

FIG. 10.—LEFT PREFRONTAL OF SANIWA ENSIDENS LEIDY. TYPE, CAT. NO. 2185, U.S.N.M. NATURAL SIZE. *la*, SURFACE FOR ARTICULATION FOR LACHRYMAL; *prf*, FRONTAL BORDER.

Quadrate.—The complete left quadrate shows this element in its general characteristics to closely resemble the corresponding bone in the *Varanus* skull. It is a strong bone of moderate length, having a wide articular end for articulation of the lower mandible. This end has a transverse width of 8 mm. Viewed from the side, the quadrate is narrow anteroposteriorly at the lower end but rapidly widens in the same diameter toward the proximal end. This widening is brought about by the inner half of the bone being inclined strongly backward from the perpendicular. The upper articular end of the inner portion rises considerably above the upper extremity of the outer portion of the bone. In the articulated skull it is presumed that the inner articulated with the supratemporal, squamosal, and paraoccipitat bones as in *Varanus*. The outer half of the quadrate measures 15 mm. in length; the inner, 18 mm. On the inner side of the distal end a flattened facet evidently marks the place of contact with the posterior extremity of the pterygoid.

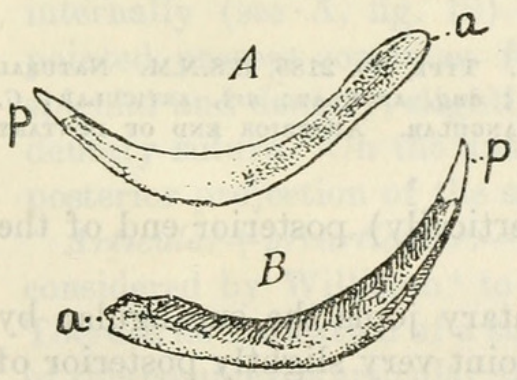

FIG. 11.—LEFT JUGAL OF SANIWA ENSIDENS LEIDY. TYPE, CAT. NO. 2185, U.S.N.M. NATURAL SIZE. *A*, INTERNAL VIEW; *B*, EXTERNAL VIEW; *a*, ANTERIOR END; *p*, POSTERIOR END.

Jugal.—A long curved bone is provisionally identified as the left jugal. If this determination is correct it shows this bone to be considerably more robust than the jugal in a *Varanus* skull of equal dimensions (see fig. 1). The pointed posterior extremity is miss-

ing, but at the break it is triangular in section. On the ventral and internal sides of the anterior half of the bone it is longitudinally grooved for articulation with the ectopterygoid, maxillary, and palatine bones.

LOWER JAW.

Both rami of the lower mandible are fairly well preserved, except for the loss of the anterior halves of the dentaries. In their general proportions, relative extent of the various elements, and the manner of articulation of the component bones they closely resemble the rami of *Varanus*, the chief differences noted being the shorter but heavier expanded posterior extension back of the cotylus of the

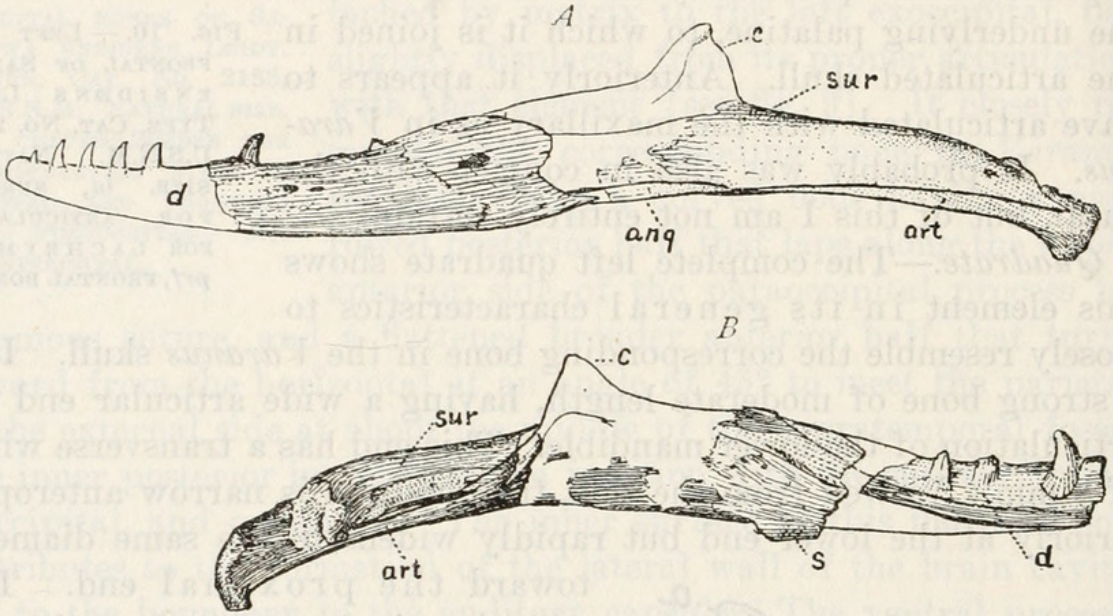

FIG. 12.—LEFT RAMUS OF SANIWA ENSIDENS LEIDY. TYPE, NO. 2185, U.S.N.M. NATURAL SIZE. A, EXTERNAL VIEW; B, INTERNAL VIEW; *ang*, ANGULAR; *art*, ARTICULAR; *C*, CORONOID; *d*, DENTARY; *s*, SPLENIAL; *sur*, SURANGULAR. ANTERIOR END OF DENTARY RESTORED FROM VARANUS.

ramus and the relatively narrower (vertically) posterior end of the dentary in *Saniwa*.

Dentary.—Viewed laterally the dentary joins the surangular by a nearly straight vertical suture at a point very slightly posterior of the center, as in *Varanus*. The union of these two bones, however, is not as weak as it would first appear, for the surangular extends forward on the inside of the dentary, thus forming an effective and strong articulation. Dorsally it meets the coronoid and ventrally the small angular, which sends forward a short process that is wedged in between the dentary and the splenial. The latter bone laps along the inner side of the dentary, covering the V-shaped mandibular fossa of that side.

Viewed from the side the dentary narrows toward the front. Near its posterior end the bone is perforated, as in *Varanus*, by a large oval foramina. Smaller perforations at intervals form a row immediately below and parallel to the dental border (see A, fig. 12).

The upper internal side of the dentary presents a beveled surface, on which the expanded bases of the pleurodont teeth are attached. This surface slopes downward from the outer alveolar border of the jaw, and gradually increases in width from the posterior end to the point where the bone is broken off.

Surangular.—The surangular is the largest bone of the posterior half of the ramus and forms the greater part of the external view of this portion of the jaw (see A, fig. 12). Posteriorly it has a pointed extremity which ends posterior to the cotylus of the jaw. Ventrally the posterior half of this bone unites by a horizontal suture with the underlying articular + prearticular, the anterior half with the smaller angular. The anterior end is truncated, this end passing 5 mm. inside the posterior end of the dentary. On the anterior, superior and upper lateral surfaces depressions of the bone distinctly marks the depth of overlap of the dentary. On the superior anterior border a grooved surface marks the seat of the coronoid bone which is detached. The posterior end of the surangular is trasversely expanded and contributes slightly to the formation of the anterior border of the cotylus for the articulation of the quadrate. On the inside of the jaw the surangular meets the prearticular by a horizontal suture somewhat below the middle of the ramus and continues forward to their contact with the overlying splenial.

Angular.—The angular is a small pointed bone that underlies the surangular externally and the forward extension of the prearticular internally (see A, fig. 12). As in the living Monitor, a slender pointed process continues forward, being intercalated between the splenial and dentary, slightly in advance of the vertical surangular-dentary suture. On the anterior internal side it is overlapped by a posterior projection of the splenial.

Articular+prearticular.—The so-called articular in the lizards is considered by Williston[4] to be the articular+prearticular complex. There is no indication of a suture in this specimen to show which part of this complex is articular and which is the prearticular portion. As a matter of convenience in describing this part of the ramus, that part of the complex lying in front of the cotylus will be arbitrarily considered the prearticular portion, and the posterior part, including the cotylus, the articular portion.

The articular + prearticular complex is an elongate bone that forms the whole of the lower boundary of the ramus posterior to the angular and all of the extension of the jaw behind, including the cotylus (see fig. 12). The prearticular portion extends forward beneath the surangular to meet the angular, where it passes from a lateral view, but internally it continues forward, the anterior end being intercalated between the splenial and dentary. Posteriorly it forms the

[4] Journ. of Geol., vol. 22, 1914, p. 411.

ventral margin of the posterior inframeckelian foramen. In front of this foramen in *Varanus* the prearticular is in contact with the coronoid and it is presumed that a similar condition would prevail in the completely articulated *Saniwa* ramus.

The articular portion of this ramus presents from a dorsal view a shallow concave, antero-posterior, but wide cotylus, behind which the articular is slightly contracted, the truncated end being enlarged, this latter expansion being especially pronounced in a ventral-internal direction. This posterior extension differs from *Varanus* in being shorter, relatively heavier, and in the development of a hooklike internal-ventral expansion of this end. The pointed posterior extremity of the surangular laps along the upper external side, ending about midway between the center of the cotylus and the posterior end of the ramus.

Splenial.—Although only the thin vertically expanded posterior portion of the left splenial is preserved (see B, fig. 12), an examination of the dentary along which this bone laps on the inner side shows that in shape and extent anteriorly it is approximately the same as in *Varanus*. It covers the inner side of the meckelian groove on the dentary and extends posteriorly, overlapping the anterior ends of the surangular, prearticular, and angular. It appears also to have been in contact with the coronoid.

Coronoid.—The right coronoid was found detached from the rest of the jaw and in a fair state of preservation. It is a small bone, curved from end to end, deeply grooved on the ventral side, which sets astride of the striated superior border of the surangular. The inner process that extends down to meet the prearticular is missing. Anteriorly when articulated it was in contact with the dentary and splenial as in *Varanus*.

TEETH.

The teeth of *Saniwa ensidens* are pleurodont. The right maxillary contains intact five of the six posterior teeth of the series in addition to two stumps more anterior, probably the ninth and tenth, counting from the back; the left maxillary contains the basal portions of four teeth; the left dentary two, and the right dentary has the three posterior teeth of the series, and the fifth from the back. Including three detached teeth found in the matrix, there are 20 teeth in all.

All of these teeth are sharply pointed, slightly curved backward, like the saber-shaped fangs of *Varanus*. The teeth are compressed from side to side, with trenchent borders fore and aft. The detached teeth as mentioned by Leidy are hollow, with thick walls.

As in *Varanus* the bases of the teeth are expanded, being anchylosed by the whole of their bases to the oblique surface of the bone which on the outside lead upward to slight depressions in the alveolar

borders. The base of the teeth are finely striated. The striations Owen [5] observes in *Varanus* are "produced by inflected folds of the external cement, as in *Ichthyosaurus* and *Labyrinthodon*, but they are short and straight as in the former genus."

The teeth throughout both upper and lower series are smaller than in a living *Varanus salvator* of the same size, and whereas there are 12 teeth in both the maxillae and dentaries of a *Varanus salvator*, in *Saniwa* there are not less than 14, probably more teeth in each series.

VERTEBRAE.

The vertebral column of *Saniwa* is represented by 33 fairly well-preserved vertebrae, with fragments of at least two more. Twenty of these may be classed as presacral, the remaining 13 as anterior caudal. The presacral vertebrae as now preserved are in three short series. The first, commencing with the complete atlas, consists of the first six of the column (see fig. 13) and a remnant of the centrum of the seventh, all articulated. The next block contains a series of four, there probably being one vertebra missing, of which only a fragment of the spine is preserved in the matrix. Although slightly disarranged, as shown in the matrix, plate 3, figure 2, it appears that those preserved were continuous in the series with those shown in plate 2, figure 2. Thus, the presacral series, with the possible exception of one centrum thought to be missing between blocks 1 and 2, form a continuous series from the skull back to the twenty-second vertebra. Since the living *Varanus* has 29 presacrals, it appears reasonable to suppose that *Saniwa* had an equal number in the complete series. Thus, there would be only seven vertebrae missing from the presacral series—one between the seventh and eighth, the remainder between the twenty-first and the sacrum. The caudal series is now preserved in three separate blocks of matrix, though probably all were originally joined, but the contacts have now been lost. There are 13 vertebrae in all of which the larger number, seven (see pl. 3, fig. 1), are so little disassociated as to show they were in series and probably form the anterior part of the tail.

Atlas.—The atlas is almost perfectly preserved and was but little disturbed from its proper relation with the axis. It consists of the strongly-keeled intercentrum, odontoid, and the two lateral neuropophyses, as shown in figure 13.

The centrum of the atlas (odontoid) is suturally united with the axis, and as in most reptiles its place is taken by the octogenous hypophyses or intercentrum. It presents a cupped articular surface for the basioccipital and a similar surface behind for the odontoid. The

[5] Owen, R. Anatomy of Vertebrates, 1866, vol. 1, p. 404.

base of each neurapophyses has an antero-internal articular surface that contributes to the formation of the cupped end for the reception of the occipital condyle, a middle surface for union with the neuropophyses, and a postero-internal surface for the upper and lateral parts of the odontoid. Above this articular end the neuropophyses is constricted fore and aft, above which it is widely expanded and arches over the neural canal, meeting on the median line without coalescing. There is no neural spine. Each neuropophyses develops from its upper and hinder border short zygapophyses which articulate with the axis. From its posterior side below a shorter diapophyses is developed.

The odontoid is wider than high and presents a convex face in front, which completes the articular cavity for the occipital condyle; below is the surface for the intercentrum, and above and behind it are the two articular surfaces for the neuropophyses. The whole pos-

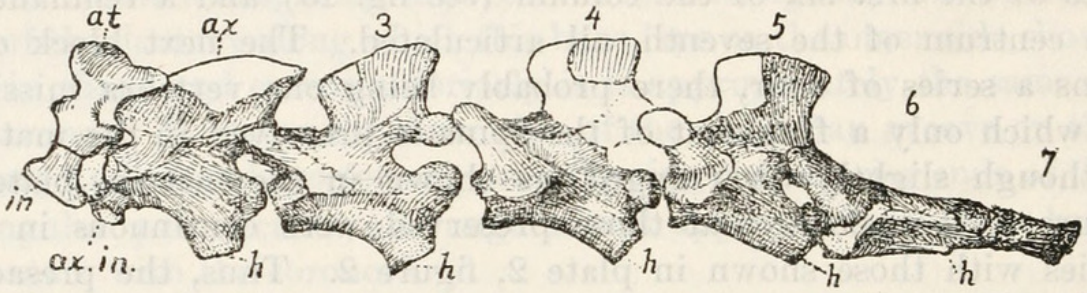

FIG. 13.—CERVICAL VERTEBRAE OF SANIWA ENSIDENS LEIDY. TYPE, CAT. NO. 2185, U.S.N.M. NATURAL SIZE. *at*, ATLAS; *ax*, AXIS; *ax in*, AXIS INTERCENTRUM; *h*, HYOPOPHYSES; *in*, INTERCENTRUM OF ATLAS; 3, 4, 5, 6, 7, CERVICALS THREE TO SEVEN, RESPECTIVELY.

terior part is sutured to the centrum of the axis and in part anchylosed to its hypophyses.

Axis.—The centrum of the axis measured nearly 15 mm. in length. Much of the spinous process is lacking. The forward part is thin and overhangs the odontoid. On the neural arch there is no trace of a diapophysis. On either side of the neural arch in front are articular surfaces representing the prezygapophyses, and on the posterior end the transversely expanded neural arch develops well-defined postzygapophyses. The centrum, as in all Varanids, terminates in a ball behind. Below this ball it sends downward and backward a heavy exogenous process with a cupped end which looks downward and backward for the articulation of the hypophysis which is missing. (See *h*, fig. 13.) This process is the heaviest of the series, whereas in *Varanus* they grow progressively heavier from the axis back to the sixth cervical.

Vertebrae posterior to the axis.—Articulated with the axis was the third, fourth, fifth, sixth, and anterior end of the centrum of the seventh vertrebrae, counting backward from the skull (see fig. 13). The vertebrae of *Saniwa* as compared with those of *Varanus*,

having a skull of equal size, are considerably smaller throughout the presacral series. The principal changes to be observed in the structure of the vertebrae between the third and seventh are: First, the development on the cervicals of forwardly projecting divergent anterior zygapophyses, which become longer and heavier in each succeeding vertebra back to the sixth of the series; second, the exogenous process for the hypophyses, which is largest on the axis, becomes rapidly reduced in size posteriorly, until on the sixth only a vestige[6] remains; third, the small parapophyses first developed on the third vertebra is decidedly larger on the fourth and increasingly so on each succeeding vertebra. It would appear that the fourth, fifth, and sixth vertebra bore short ribs as in *Hatteria*, whereas in *Varanus salvator* the seventh is the first to have a cervical rib; in *Sauromalus* the first rib is on the fourth cervical.

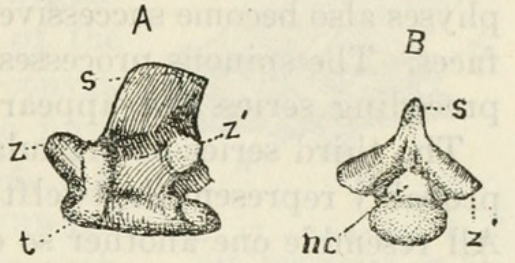

FIG. 14.—DORSAL VERTEBRA OF SANIWA ENSIDENS LEIDY. TYPE, CAT. NO. 2185, U.S.N.M. NATURAL SIZE. A VIEWED FROM LEFT SIDE; B VIEWED FROM POSTERIOR END; *nc*, NEURAL CANAL; *s*, SPINOUS PROCESS; *t*, TRANSVERSE PROCESS; *z*, ANTERIOR ZYGAPOPHYSIS; *z'*, POSTERIOR ZYGAPOPHYSIS.

The centra in this series are approximately the same length throughout, with a cup in front and ball behind, a feature common to most lizards, and which continues throughout the vertebral column.

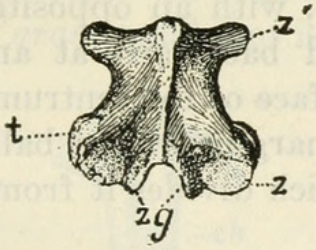

FIG. 15.—DORSAL VERTEBRA OF SANIWA ENSIDENS LEIDY. TYPE, CAT. NO. 2185, U.S.N.M. NATURAL SIZE. SUPERIOR VIEW. *t*, TRANSVERSE PROCESS; *z*, ANTERIOR ZYGAPOPHYSIS; *z'*, POSTERIOR ZYGAPOPHYSIS; *zg*, ZYGANTRA.

The neural spines of the cervical series in *Saniwa* are badly damaged, but they do not appear to have been taller than in the succeeding dorsals, whereas in *Varanus* they are higher, and wider fore and aft, than any that follow them in the presacral series. These spines are thin transversely, but wide (anteroposteriorly) plates of bone that terminate dorsally with truncated extremities without transverse expansion. The posterior zygapophyses do not protrude beyond the ball of the centrum.

The second series of four articulated vertebrae (see pl. 2, fig. 2) are thought to represent the eighth, ninth, tenth, and eleventh of the vertebral series enumerated from the skull. These exhibit a flattened ventral surface of the centra so typical of all the members of the family Varanidae. The nonarticular surfaces of the centra are slightly shorter than in the preceding series, as may be seen by referring to the table of measurements.

[6] In this feature *Saniwa* resembles *Varanus griseus*, where the hypophyses end with the sixth cervical, there being only a slight elevation on the seventh, while in *V. salvator* hypophyses extend back to the seventh and sometimes a vestige is found on the eighth.

The articular ball of the centrum in all the succeeding vertebrae available for measurement are nearly twice as wide as high, the articular surface being inclined upward and backward. The diapophyses extending outward from the anterior side of the centra gradually grow more robust, proceeding posteriorly. The anterior zygapophyses also become successively shortened, but with broader articular faces. The spinous processes remain about the same height as in the preceding series, but appear broader antero-posteriorly.

The third series of articulated dorsals, consisting of 10 vertebrae, probably represent the twelfth to the twenty-first. (See pl. 3, fig. 2.) All resemble one another so closely that a description of one will do for all. Except for their relatively shorter spines and smaller size, I am unable to find any other features that would distinguish them from the corresponding vertebrae in the skeleton of *Varanus salvator*, from Java (Cat. No. 29551, U.S.N.M.) now before me.

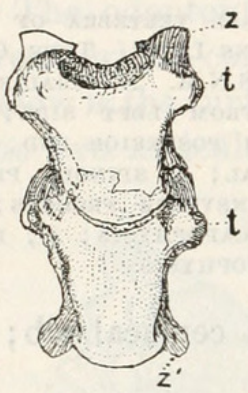

FIG. 16.—DORSAL VERTEBRA OF SANIWA ENSIDENS LEIDY. TYPE, CAT. NO. 2185, U.S.N.M. NATURAL SIZE. *t*, TRANSVERSE PROCESSES; *z*, ANTERIOR ZYGAPOPHYSIS; *z'*, POSTERIOR ZYGAPOPHYSIS.

The anterior articular concavity of the centrum is a transverse ellipse, obliquely placed, looking downward and forward, the under surface of the body being flattened anteroposteriorly and slightly convex transversely. The articular convexity corresponds in size and shape with the anterior cup, with an opposite aspect, looking upward and backward at an angle of 45° to the lower surface of the centrum (see fig. 16). The lateral margins of the ball project a little beyond the narrow constriction which divides it from the rest of the centrum.

In advance of this constriction the sides of the body rise, expanding outwardly at the anterior end to form the projecting costal tubercle, which appears to be supported by both the neurapophyses and centrum, though nowhere in the series is there a trace of the neurocentral suture to be found. The tubercle for the ribs in this section of the column presents a hemispherical articular surface as in the living Monitor. In front of the tubercle the heavy support of the prezygapophyes rises, extending upward and slightly forward, the upper articular surface being flat looks inward and upward, the whole projecting but slightly anterior to the forward end of the centrum.

The upper surface of the broad neural arch between the anterior zygapophyses is, roughly speaking, concave, but traversed longitudinally by a median elevation that develops on its anterior margin,

two flattened forwardly projecting processes between which on the median line is a broad notch. I regard these processes as rudimentary zygosphenes (see *zg*, fig. 15). Marsh[7] notes a similar articulation on the dorsal vertebrae of *Thinosaurus paucidens*. The absence of zygantry, however, shows that they no longer function as a true zygosphene-zygantrum articulation. The posterior half of the upper surfaces of the neural arch is convex and expands outward at its back part to form the posterior zygapophyses (see fig. 14, B), the articular surface of which looks downward and outward. The median part of the arch develops a wide (anteroposterior) spine of moderate height. This spine is very thin, but thickens posteriorly, especially its posterior upper extremity. The posterior part of the arch, including the zygapophyses, overhangs the centrum, but terminates forward of its most posterior extension.

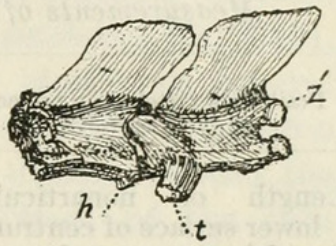

FIG. 17.—ANTERIOR CAUDAL VERTEBRAE OF SANIWA ENSIDENS LEIDY. TYPE, CAT. NO. 2185, U.S.N.M. NATURAL SIZE. VIEWED FROM LEFT SIDE. *h*, HYPOPHYSIS FOR ARTICULATION OF CHEVRON; *t*, TRANSVERSE PROCESS; *z'*, POSTERIOR ZYGAPOPHYSIS.

Caudal vertebrae.—There are 13 caudal vertebrae present, all apparently from the proximal fourth of the tail. These are in three blocks of matrix, of which the better-preserved vertebrae, four in number, remain articulated (see pl. 3, fig. 1). These, however, indicate one important difference when compared with the tail of *Varanus* and that is the low, broad, spinous processes of the presacral region continue back much further in the caudal series. Though they do gradually increase in height posteriorly, it appears very doubtful if they ever attained the great height found in the living Monitor, *Varanus salvator* (see fig. 17). Nor do any of the 13 vertebrae indicate a fore-and-aft narrowing of this process such as begins to take place in the third vertebra back of the sacrum in *Varanus*. The caudal centra are more elongate than in the mid dorsal region; the middle ventral surface is traversed longitudinally by a shallow depression. They retain the cup-and-ball articulation found in the presacral series. On the posterior third of the ventral surface of the centrum a pair of short articular protuberances indicate the point of attachment for the chevron (see fig. 18).

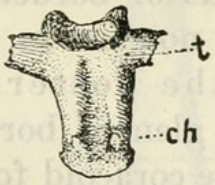

FIG. 18.—ANTERIOR CAUDAL VERTEBRA OF SANIWA ENSIDENS LEIDY. TYPE, CAT. NO. 2185. U.S.N.M. NATURAL SIZE. VENTRAL VIEW. *ch*, HYPOPHYSIS FOR CHEVRON; *t*, TRANSVERSE PROCESS.

The apparent absence of caudal vertebrae, having high spinous processes, suggests that *Saniwa* was a terrestrial form having a

[7] Amer. Journ. Sci., ser. 3, vol. 3, 1872, p. 299.

rounded rather than a transversely flattened tail. The dissection of a specimen of *Varanus griseus* from Egypt, a strictly terrestrial form shows that the spinous processes do not increase so rapidly in height from the sacrum backward as in *V. salvator.*

Measurements of vertebrae of Saniwa ensidens, No. 2185, U.S.N.M.

Position of vertebrae in presacral series.	Axis.	Third.	Fifth.	Eleventh.	Twelfth	Eighteenth.	Nineteenth.	Caudal.
Length of nonarticular lower surface of centrum..	*mm.* 13	*mm.* 13	*mm.* 13	*mm.* 10.5	*mm.* 10.5	*mm.* 11	.....	*mm.* 13
Breadth of centrum forward of ball.....	4.5	.....	.....	7	7.5	7.5	.....	6
Breadth of neural arch across diapophyses.....	8	11	.....	16	17	16	.....	17
Vertical diameter of ball of centrum.....	.....	.....	.....	4	4.5	.....	.....	4
Transverse diameter of ball of centrum.....	.....	.....	.....	7.5	8	8	.....	7
Greatest vertical diameter of vertebræ.....	.....	20	17	15.5	.....	.....	15	17

GIRDLE AND LIMB BONES.

Coracoid.—The scapular arch is represented only by the right coracoid which lay in the matrix at the proximal end of the humerus of that side and opposite the ninth and tenth vertebrae of the series, as shown in plate 2, figure 2. Only the ventral side has been exposed. It is a broadly expanded bone having a single deep notch on the anterior border as contrasted with the two deep notches in the *Varanus* coracoid. Between the posterior border of this notch and the glenoid border the bone is perforated by a large coracoid foramen. The pointed posterior projection is more slender than in *Varanus.* (Compare figs. 19 and 20.) The precoracoidal process has suffered the loss of its articular end, as has the anterior extremity of the coracoid internal to the notch.

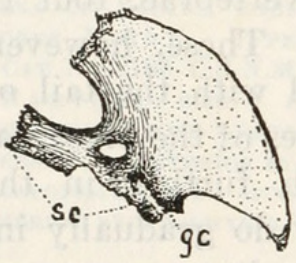

FIG. 19.—LEFT CORACOID OF SANIWA ENSIDENS LEIDY. TYPE, CAT. NO. 2185, U.S.N.M. NATURAL SIZE. VENTRAL VIEW. *gc*, CORACOID CONTRIBUTION TO THE FORMATION OF GLENOID FOSSA; *sc*, BORDER THAT ARTICULATES WITH SCAPULA.

The presence of a single notch and the long sweeping convex curve of its inner border, this bone resembles the coracoid of *Loemanctus longipes*, as figured by Parker.[8] The bone is much thickened dorso-ventrally at the border of the glenoid cavity. The ventral surface is slightly convex antero-posteriorly as in the Monitor. The coracoid measures 15 mm. in width from the glenoid border to the inner edge. As preserved it measures 17 mm. antero-posteriorly. The notch at its widest expanse measures 6 mm. across.

[8] Reynolds, S. H. The Vertebrate Skeleton, 1897, p. 286, fig. 54.

Humerus.—The right humerus is present and in a fair state of preservation. Some portions of the anterior side of the distal half of the shaft and the condylar articular surface for the radius on the distal end are missing. Compared with the corresponding element in a skeleton of *Varanus salvator*, No. 29551, U.S.N.M., it agrees very closely in general form except for the more abrupt expansion of the ulnar side of the distal end and the apparent reduction in extent of the thin sharp ridge on the radial or outer border. This ridge is perforated by the ectepicondylar foramen. The ridge appears to have been restricted in height and also in the distance it extended upward on the shaft of the bone, as contrasted with the *Varanus* humerus (see fig. 21). In the abrupt outward expansion of the ulnar border of the distal end, this bone more nearly resembles the humerus of *Iguana tuberculata*. In *Varanus* the same expansion is achieved, but by a gradual curve outward, beginning higher up on the shaft of the bone. *Varanus sivalensis*, as figured[9] by Falconer, is intermediate in respect to the contour of this end of the humerus.

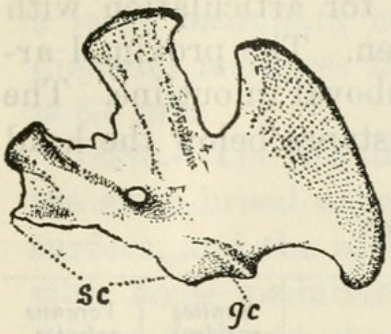

FIG. 20.—LEFT CORACOID OF VARANUS SALVATOR. CAT. NO. 29551, U.S.N.M. VENTRAL VIEW. NATURAL SIZE. COMPARE WITH FIG 19 *gc*, GLENOID CAVITY; *sc*, SCAPULA ARTICULATION.

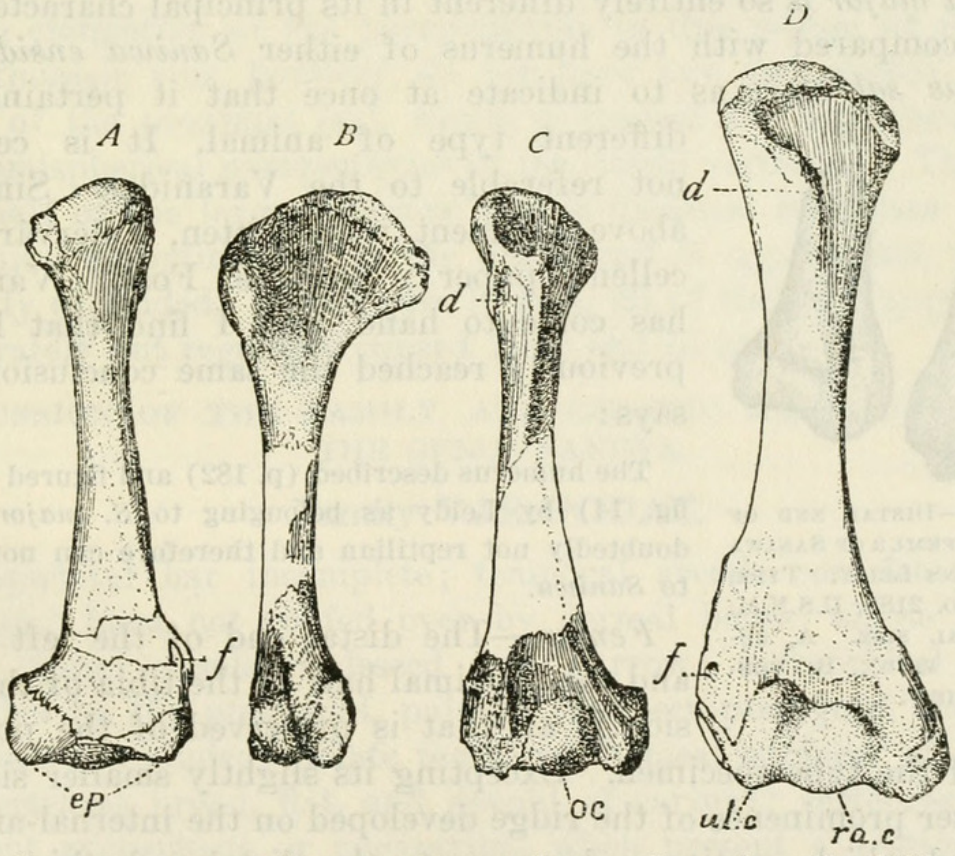

FIG. 21.—LEFT HUMERUS OF SANIWA ENSIDENS LEIDY. TYPE, CAT. NO. 2185, U.S.N.M. A, SUPERIOR VIEW; B, OBLIQUE INFERIOR VIEW; C, VENTRAL VIEW; D, LEFT HUMERUS OF VARANUS SALVATOR. CAT, NO. 29551, U.S.N.M. VENTRAL VIEW. *d*, DELTOID CREST; *ep*, EPIPHYSIS; *f*, FORAMEN; *oc*, OUTER CONDYLE; *ra.c*, RADIAL CONDYLE; *ul.c*, ULNAR CONDYLE. ALL NATURAL SIZE.

[9] Paleontological Memoirs, vol. 1, 1888, pl. 32.

The shaft is nearly straight and subcylindrical, as in most other Lacertilians, with a large medullary cavity. The transversely expanded distal end has two condyles; the one for articulation with the radius, however, is missing in this specimen. The proximal articular head is transversely elongated, being suboval in outline. The radial crest projects from the shaft at some distance below the head of the bone.

Comparative measurements of humeri.

	Saniwa ensidens, 2185, U.S.N.M.	*Varanus salvator*, 25551, U.S.N.M.
	mm.	*mm.*
Greatest length	54	68
Greatest width, proximal end	19	24.5
Greatest width, distal end	17.5	23
Least diameter of shaft	5	6

The distal end of the humerus figured[10] by Leidy as pertaining to *Saniwa major* is so entirely different in its principal characteristics, when compared with the humerus of either *Saniwa ensidens* or *Varanus salvator*, as to indicate at once that it pertains to a different type of animal. It is certainly not referable to the Varanidae. Since the above comment was written, Fejérváry's excellent paper[11] on the Fossil Varanidae has come to hand, and I find that he had previously reached the same conclusion. He says:

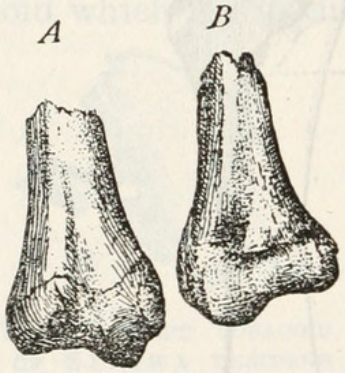

FIG. 22.—DISTAL END OF RIGHT FEMUR OF SANIWA ENSIDENS LEIDY. TYPE, CAT. NO. 2185, U.S.N.M. NATURAL SIZE. A, SUPERIOR VIEW; B, VENTRAL VIEW.

> The humerus described (p. 182) and figured (pl. and fig. 14) by Leidy as belonging to *S. major* is undoubtedly not reptilian and therefore can not belong to *Saniwa*.

Femur.—The distal end of the left femur and the proximal half of the tibia of the same side is all that is preserved of the posterior limb of the type specimen. Excepting its slightly smaller size and the lesser prominence of the ridge developed on the internal-anterior side and which continues down on to the distal end, this portion of the femur is very similar to the corresponding bone in the *Veranus* skeleton. The principal features of the distal portion of the femur are well shown in figure 22. The articular surface, which is well toward the posterior side, is broadly concave transversely. On the anterior side external to the center of the bone is a well-defined

[10] Leidy, J. Rept. U. S. Geol. Survey of Terr. F. V. Hayden, U. S. Geologist in charge, vol. 1, 1873, pl. 15, fig. 14, p. 182.

[11] Ann. Mus. Nat. Hung., vol. 16, 1918, p. 421.

groove which extends for a short distance up on the shaft of the bone. The epiphysis of the distal end of this bone is as distinctly defined as in the living *Varanus*. The broken end of the shaft shows a large medullary cavity, now filled with calcite. The transverse diameter measures 13.2 mm.; the fore and aft diameter at the center is 8.5 mm.

Tibia.—The proximal half of the left tibia (see pl. 2, fig. 2) shows the same broad expansion of the upper end with flattened anterior surface, and the same contracted subtriangular shaft at the middle with large medullary cavity as in the living Monitor. In fact, I fail to find any characters by which it may be distinguished from *Varanus*. The proximal end of the tibia has a greatest transverse width of 13 mm.

Ribs.—In the three blocks of matrix containing the presacral vertebrae there are parts of more than 18 ribs (see pl. 3, fig. 2), several being nearly complete. All of the ribs appear to be single headed. A rib lying in the matrix near the right coracoid has a vertically expanded head, indicating that it probably pertains to the posterior cervical series, the expansion of the head corresponding to the elongation of the parapophyses in this region of the neck. The thoracic ribs, however, do not have any appreciable enlargement of the proximal end, which is cupped for articulation with the hemispherical parapophyses of the dorsal vertebrae. The proximal half of the larger thoracic ribs is flattened both fore and aft, becoming subcylindrical as the distal end is approached, which is slightly expanded. These ribs, in fact, all of the ribs, appear to be moderately but regularly curved from end to end.

DISCUSSION OF THE FAMILY, AND GENETIC RELATIONSHIPS OF THE GENUS SANIWA.

Family VARANIDAE.

Postorbital bar incomplete; temporal arcade complete; supratemporal fossa not roofed over by dermal bones; single premaxillary bone; nasals coalesced and narrow; infraorbital vacuity bounded by the pterygoid, palatine, and ectopterygoid, the maxillary being excluded; palate toothless; hameal surfaces of the dorsal vertebrae broad, flat, and devoid of carina; vertebrae usually without zygosphene or zygantrum, when present a vestigal zygosphene only. No dermal ossifications.

In the characterization of the family Varanidae as given above I have selected from the definitions of Lydekker,[12] Boulenger,[13] and Fejérváry[14] such parts of their family characterizations as

[12] Catalogue of Fossil Reptilia and Amphibia in British Museum, pl. 1, 1888, p. 281.
[13] Fauna Brit. India, Rept. and Batr., London, 1890, pp. 160–161.
[14] Ann. Mus. Nat. Hung., vol. 16, 1918, p. 365.

relate to the bony structure, thus making the definition applicable to the fossil members of the family, and add remarks of my own on the presence of a vestigal zygosphene.

The Varanidae or Monitors form a group comprising both recent and fossil representatives. In 1918 Fejérváry[15] listed 43 forms as being referable to the family Varanidae. Forty-one of these pertain to the genus *Varanus* and two to the genus *Saniwa;* the latter, although included under the Varanidae, was regarded by him of "Uncertain systematical position."

His more extended remarks[16] are quoted in their entirety below:

> It must be here remarked that the genus *Saniva* described by Leidy and originating from the Eocene of Wyoming, in America, is also held by Nopcsa as a Varanid, and taking this supposition for granted, the *Neartis* should also be involved in the history of the evolution of the *Varanidae.* However, Lydekker, Zittel (op. cit.), as well as Broili (1911) (op. cit., p. 216) range this problematical genus with the *Anguidae,* so that, according to their opinion, it would not even be related to the *Platynota* but to the suborder of *Lacertilia vera* (= *Kionocrania*). After a conscientious perusal of Leidy's descriptions and drawings, I am obliged to confess to the genus *Saniva* yet appearing a complete mystery to me. Neither the description nor the drawings throw sufficient light on even the most important characters. The humerus, for instance, presents a particularly birdlike appearance, as Leidy himself very judicially remarks. The vertebrae, on the other hand, do, indeed, resemble those of *Varanus,* although the figures allow no perspective as to the shape of the dorsal surface. It must be taken into consideration, however, that the vertebrae of an *Anguidae* and *Varanidae* in many respects bear great likeness to each other, for which reason the resemblance with *Varanus* can not be judged as a decisive phenomenon. Moreover, it does not seem impossible that the vertebrae will ultimately prove to belong to *Varanidae* and will thus have to be separated from at least a part of the remains left.

The observation recorded above is a very logical and concise summary of the status of the genus *Saniwa,* based on the scanty information then available (1918) to Fejérváry.

The more recent preparation of the type materials, however, now shows the genus *Saniwa* to be based on an adequate specimen, and it thus removes some of the uncertainties of which Fejérváry justly makes mention.

The incompleteness of the postorbital bar; the toothless palate; pterygoids and palatines, widely separated; infraorbital fossa bounded by pterygoid, palatine, and transverse, the maxillary being excluded; pleurodont dentition; teeth pointed; dorsal centra with flattened haemal surfaces devoid of carina; and the absence of dermal scutes constitute a combination of characters, together with the close resemblance of most of the bones of the skeleton to the living

[15] Ann. Mus. Nat. Hung., vol. 16, 1918, pp. 444–445. [16] Idem, pp. 362–363.

genus *Varanus*, indicating *Saniwa* to be a true member of the family Varanidae.

Although Leidy studied only a few of the bones of the type specimen, he more than any subsequent authority correctly diagnosed its true relationships. He says:[17]

> The remains belong to a lacertain about the size of the existing monitor of the Nile, to which it appears to be closely related. The bones indicate a robust body, a long tail, and limbs with long toes.
>
> The vertebrae resemble those of the Nilotic monitor in form and proportions, and like them possesses no zygosphenal articulation.

The last statement is now known to be incorrect as there are vestigal zygosphenes present on the dorsal vertebrae, but I do not consider their presence of sufficient morphological importance to bar the assignment of *Saniwa* from the Varanidae, especially since they appear to be undergoing reduction, thus tending toward the conditions found in the *Varanus* vertebrae, where they have entirely disappeared. It was the discovery of similar reduced zygosphenal articulations of the vertebrae that led Marsh[18] in 1872 to establish the genus *Thinosaurus*, which he recognized as being closely related but distinct from *Saniwa* because of the supposed absence of zygosphenes in that genus. A careful study of Marsh's description and measurements of the genotype *Thinosaurus paucidens* leads me to the conclusion that *Thinosaurus* and *Saniwa* are congeneric. The latter being the older by two years, *Thinosaurus* thus becomes a synonym, and the described species will hereafter be designated respectively *Saniwa paucidens* (Marsh), *S. leptodus* (Marsh), *S. crassus* (Marsh), *S. grandis* (Marsh), and *S. agilis* (Marsh).

It would also appear quite probable that a comparative study of the type specimens on which the above species were founded would show one or more of them to be referable to *Saniwa ensidens* Leidy.

Tinosaurus, which Fejérváry[19] regards as being equivalent of *Thinosaurus*, probably represents a distinct genus, as is apparently indicated by Marsh's meager description,[20] in which the teeth are described as having cusps, whereas all of the known Varanidae have simple coned teeth without auxilliary cusps.

The family Varanidae therefore contains the genus *Varanus*, largely made up of living species of lizards, and the genus *Saniwa*, which at this time includes six or more extinct species.

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[17] Leidy, J. Rept. U. S. Geol. Survey Terr., F. V. Hayden, U. S. in charge, vol. 1, 1873, p. 181.

[18] Marsh, O. C. Amer. Journ. Sci., vol. 4, 1872, pp. 299–300.

[19] Ann. Mus. Nat. Hung., vol. 16, 1918, p. 362.

[20] Amer. Journ. Sci., ser. 3, vol. 4, 1872, p. 304.

The distinctness of the two Varanid genera *Varanus* and *Saniwa* is clearly set forth by the enumeration of their more important characters as contrasted in the two paralled columns below:

Genus *Varanus*.	Genus *Saniwa*.
1. Dorsal vertebrae without zygospheneal articulations.	1. Dorsal vertebrae having vestigal zygosphene articulations.
2. Coracoid having two anterior notches.	2. Coracoid having a single anterior notch.
3. Postorbital usually fused with postfrontal.	3. Postorbital distinct from postfrontal.
4. Hypophyses on first six or seven cervical vertebrae, vestigal on the seventh or eighth.	4. Hypophyses on first five cervical vertebrae, vestigal on the sixth.
5. First rib carried on the seventh cervical.	5. First rib appears to have been carried on the fifth cervical, possibly the fourth.
6. Humerus with gradually expanded ulnar border at distal end.	6. Humerus with abruptly expanded ulnar border at distal end.

A critical comparison of *Saniwa*, especially with the existing members of the family, appears to show a few of the evolutionary changes undergone by the Varanid skeleton since Middle Eocene times. These are: 1, the loss of the vestigal zygosphene; 2, a reduction in the number of teeth in the jaws; 3, the complete coalescence (usually) of the postfrontal postorbital bones; and 4, an increase in the number of cervical vertebrae bearing hypophyses.

The living members of Varanidae, Monitors as they are often called, form a group of about 30 species, all belonging to the one genus *Varanus*. Living members of this genus inhabit the tropical parts of Africa, Southern Asia, Malasia, and Australia. All are carnivorous in habit, feeding upon small backboned animals, insects, and especially upon eggs, which they crush between their teeth while holding them aloft. Most species live wholly upon the land and some are arboreal. Others, especially those found along the Nile, live about water and are excellent swimmers. The terrestrial species are said [21] to have "a round tail and small external nostrils, but the water species have the tail much flattened and the nostrils have large cavities."

Most of the species live wholly upon the land. *V. prasinus* is supposed to be arboreal. Others, as *V. salvator* and *V. niloticus*, owing to the fact of their tail being strongly compressed, are excellent swimmers and deserve the name of water lizards. The terrestrial species, as *V. griseus*, have rounded tails. The apparent absence of caudal vertebrae having high spinous processes suggest that *Saniwa* was also a terrestrial species, having a rounded rather than a flattened tail.

[21] Williston, S. W. Water Reptiles of the Past and Present, 1914, pp. 144–145.

The extinct members of the genus *Varanus* have been thoroughly reviewed and discussed in Fejérváry's excellent paper, Contributions to a Monography on Fossil Varanidae and on Megalanidae, and, as he has so clearly pointed out, are very unsatisfactorily known. Of the 10 extinct species described, he regards only four of "established specific value." At this time very little satisfaction was obtained in attempting to contrast the extinct American forms with the European species, except that *Saniwa* from the Bridger (Middle Eocene) has the distinction of being the most ancient Varanid lizard yet discovered in North America, if not in the world.

List of North American fossil Varanidae.

Names.	Locality.	Formation.
Saniwa ensidens Leidy.....	Near Granger, Wyoming....	Bridger, Middle Eocene.
Saniwa major Leidy.....	Lodge Pole Trail crossing, Dry Creek, Wyoming.	Do.
Saniwa paucidens (Marsh)..	Grizzly Buttes, Wyoming...	Do.
Saniwa leptodus (Marsh).....	.....do.....	Do.
Saniwa crassus (Marsh)	Henry's Fork, Wyoming....	Do.
Saniwa grandis (Marsh).....	Grizzly Buttes, Wyoming...	Do.
Saniwa agilis (Marsh).....	Henry's Fork, Wyoming....	Do.

EXPLANATION OF PLATES.

PLATE 1.

Palate of *Saniwa ensidens* Leidy. Cat. No. 2185, U.S.N.M. Type. Twice natural size. Viewed from above. Shown as found articulated in the matrix. *mx*, maxillaries; *pl*, palatines; *pt*, pterygoids; *v*. vomers.

PLATE 2.

FIG. 1. Cervical vertebrae *of Saniwa ensidens* Leidy. Cat. No. 2185, U.S.N.M. Type. Natural size. Viewed from the left side. Shown as found articulated except that the atlas has been removed.

FIG. 2. Dorsal vertebrae and other bones of *Saniwa ensidens* Leidy. Cat. No. 2185, U.S.N.M. Type. About natural size. Shown as found in the matrix. *a*, four anterior dorsal vertebrae, ventral view; *b*, left coracoid; *c*, right humerus; *d*, distal end of femur; *e*, proximal half of tibia.

PLATE 3.

FIG. 1. Caudal vertebrae of *Saniwa ensidens* Leidy. Cat. No. 2185, U.S.N.M. Type. About natural size. Shown as found in the matrix.

FIG. 2.—Dorsal vertebrae and ribs of *Saniwa ensidens* Leidy. Cat. No. 2185, U. S. N. M. Type. About natural size. The two vertebrae on the right with ventral surfaces exposed are the ones figured by Leidy. *a*, distal end of humerus.