Art. XXXIII.—*A New Family of Reptiles from the Permian of New Mexico;* by S. W. Williston.

It is now more than thirty years since the late Professor Marsh described in this Journal (May, 1878) three new genera and four new species of vertebrate fossils from the Permian of New Mexico. Three years later Professor Cope published a brief note on a small collection of vertebrate fossils from the same region, with descriptions of two new species.* The only other references to the New Mexico Permian deposits or fauna that I can find in the literature, either paleontological or geological, are brief descriptions by Professor Case of four new reptiles based upon the Cope collection, at present preserved in the American Museum of New York City.

The collections of Permian vertebrates in the Yale Museum, inclusive of Marsh's types, were made by the late David Baldwin of Farmington, New Mexico, in Rio Arriba County, in the interval between November 1877 and December 1880. Mr. Baldwin believed them all to be of Triassic age, and so labelled them. From 1880 to 1888 Mr. Baldwin was in the service of Professor Cope collecting fossils, chiefly from the adjacent Wasatch and Puerco formations; and sometime in the early part of this period made the relatively small collections of Permian fossils now in the American Museum, coming from the same horizons and localities as did his previous ones collected for Marsh.

The Yale collections have never been thoroughly studied till recently; a part, indeed, including the type of the genus and species herein described, had never been unpacked from the boxes in which it was originally received so long ago. And it is unfortunate for science that these specimens have remained so long buried in the basement of Peabody Museum. Although I was an assistant of Professor Marsh at the time of their reception, I had no suspicion that the collections were as extensive as they prove to be.

By the kindness of Professor Schuchert I have recently had the privilege of studying this material, a privilege for which I would here express my sincere thanks. Not only were all the Permian vertebrate fossils of the Yale collections brought together and placed at my disposal, but the full staff of preparators was engaged in their preparation for more than two months.

The known New Mexico Permian deposits, so far as I can learn from the notes of Mr. Baldwin, are chiefly in the vicin-

* American Naturalist, xv, 1020, 1881.

ity of the Gallinas mountains, east of the Nacimiento mountains, reaching as far east as the peak El Cobre north of the Chama river. They overlie the Carboniferous, apparently conformably, and are overlain by the Morrison beds of the Jura-Cretaceous, with more or less of the Trias doubtless intervening. The Permian fossiliferous strata are in the lower part of the Red Beds and are several hundred feet in thickness. The matrix in which the fossils are enclosed is variable, consisting of red, white, and reddish brown sandstones, and red and black clay. There is an entire absence of all concretionary material and pebbly conglomerates, both of which are highly characteristic of the Texas deposits.

In the examination of these Permian fossils preserved in the Yale Museum I have distinguished with more or less assurance at least ten genera of amphibians and reptiles; I found no trace whatever of fish remains. These genera are: *Nothodon* Marsh, indistinguishable from *Diadectes* Cope, published ten days earlier; *Sphenacodon* Marsh, the type of which is indistinguishable from *Dimetrodon* Cope, published five days later; *Ophiacodon* Marsh, closely allied to the genus which Case has called *Theropleura* Cope on somewhat questionable evidence; *Eryops* Cope, a species of which was described by Marsh as *Ophiacodon grandis*; *Clepsydrops* Cope, represented by very characteristic limb bones; "*Dimetrodon*" *navajoicus* Case, not a true *Dimetrodon*, but a short-spined Pelycosaur, probably belonging to a new genus; *Dimetrodon* Cope, represented by very characteristic specimens either closely allied to or identical with species from Texas; "*Ctenosaurus*" *rugosus* Case, which is not a real *Ctenosaurus* v. Huene from the Trias of Europe, but a new genus which I shall describe and figure later as *Platyhistrix*, gen. nov.; a pelycosaurian reptile with long flattened spines, probably new; one or two other reptiles which I cannot at present determine; *Aspidosaurus* represented by a new species which I shall describe as *novamexicanus*; and the genus *Limnoscelis* herein described. In addition, Case has named the genera *Elcabrosaurus* (melius *Elcobrosaurus*) and *Diasparactus* from vertebræ in the Cope collection.

In this examination I was especially struck by the absence of forms characteristic of the Upper or Clear Forks division of the Texas Permian, such as the Pariotichidæ, and especially *Labidosaurus*, *Diplocaulus*, etc. *Diplocaulus* may not be a characteristic guide fossil, because of its occurrence in the Illinois beds that are probably lower than the Wichita division, but the Pariotichidæ are reliable. Not only is there an absence of forms characteristic of the Clear Fork division, but forms such as *Diadectes* and *Clepsydrops* have never been found in Texas in the upper beds. The evidence thus seems to indicate,

almost conclusively, that the New Mexico beds are the stratigraphical equivalent of the lower or Wichita division of the Texas beds. The presence of certain forms, like those of *Dimetrodon*, either closely allied to or identical with Texas species, indicates a faunistic relationship between the New Mexico and Texas faunas. On the other hand, the majority of the New Mexico genera, and perhaps all the species, will be found to be distinct from those of Texas, indicating either interrupted communication between the two not very widely separated regions during these Permian times, or different environmental conditions. The latter conclusion seems the more probable one, since those forms most nearly allied are chiefly from the red clays and red sandstones quite like those of the Texas deposits, while most of the unlike forms come from sandstones or clays unlike anything in Texas. Furthermore, the entire absence of concretionary material, pebbly sandstones, and apparently of all fish remains, may also indicate different environmental conditions. Remains of sharks and dipnoans are rather abundant in Texas deposits, and while they may not be absolutely characteristic of marine or brackish waters, they probably are. Of interest is the fact that there is not a single fragment in the New Mexico collections that is even suggestive of *Naosaurus*, perhaps the most widely distributed, and at the same time fragmentary and tantalizing of Texas fossils.

A full discussion of the Yale collection of New Mexico Permian fossils would be beyond the limits of a single magazine article, and will be given elsewhere, with figures of some of the more characteristic specimens and of Marsh's types. I restrict myself here to a description of a remarkable new family of reptiles, coming from the very base of the deposits in the vicinity of El Cobre.

Limnoscelidæ, family new.

Limnoscelis paludis, genus and species new. (Figs. 1–7.)

The description of this genus and species is based upon two specimens, both from the same immediate locality in Rio Arriba County, New Mexico, and both enclosed in a like matrix, a dark, rather fine-grained sandstone, in nodular form. These two specimens seem to be specifically identical, as the slight differences observed between them may well be due to age or conditions of fossilization. Of one of them (No. 809), there is a nearly complete skeleton save the skull and front feet, and a part of one of the hind feet; the preserved parts lie, for the most part, in orderly articulation. The second specimen (No. 811) is almost perfect, the only missing parts that I

observe being the right hind foot, and perhaps a part of the left hind foot, both which had been more or less exposed and the bones somewhat weathered. This skeleton lies in the most orderly relations, with all its parts in close articulation, save such as had been disturbed by gravitation. It is without break, at least as far as the proximal third of the tail; some of the smaller caudal vertebræ may be missing, but, fortunately, the tail seems to be quite complete in the other specimen. This more perfect specimen (No. 811), which may be considered the type of the species, was found among unpacked material only a few weeks before my departure from New Haven became necessary, and its preparation has not been quite completed. When fully worked out from the matrix and prepared for exhibition, it will be one of the most notable specimens of a reptile ever obtained from the Permian deposits of America.

The skeleton is evidently that of an animal which had died peacefully in some pool or body of water undisturbed by waves or currents; nor does it show any indications of extraneous forces. The animal at death rested with its ventral side downward upon a hard bottom, since all the bones had fallen, so far as was possible with their natural articulations, to a level, as is the case with fossils preserved in marine deposits. The skull and limbs are in complete articulation, the vertebral column curved gently to the left, the pectoral and pelvic girdles intact and in position, and with all the bones of the limbs closely articulated, so far as they are preserved, at least, save a few of the terminal phalanges. The sacral vertebra is attached to the ilia, but the vertebræ immediately preceding and succeeding it had fallen to the level of the pubes and ischia. As the specimen lies in place it measures three feet and four inches to the hind end of the ischia, while the articulated or nearly articulated tail of No. 809 has a length of forty inches to where the centra measure ten millimeters in diameter. Yet smaller, unarticulated vertebræ among the unassociated material indicate a possible length of the tail of forty-four or forty-five inches, or a total length for the skeleton of about eighty-four inches.

Skull.—The skull of *Limnoscelis paludis* is remarkable in many respects, and fortunately this part of the specimen which serves as the type is remarkable for its completeness and perfection of preservation. Like the remainder of the skeleton, with which it was in close articulation, it lay upon its ventral side, slightly depressed by its own weight in fossilization, and a little skewed to the right. As collected, it was broken in eight or ten pieces, the bone so firm that it permits the matrix to be removed very completely, which has been done by the skillful head preparator of the Yale Museum, Mr. Hugh Gibb; not quite

completely yet, the anterior palatal region being still invisible. Since the mandibles are clearly in natural relations with each other save for the slight twisting, and the upper part of the

FIG. 1.

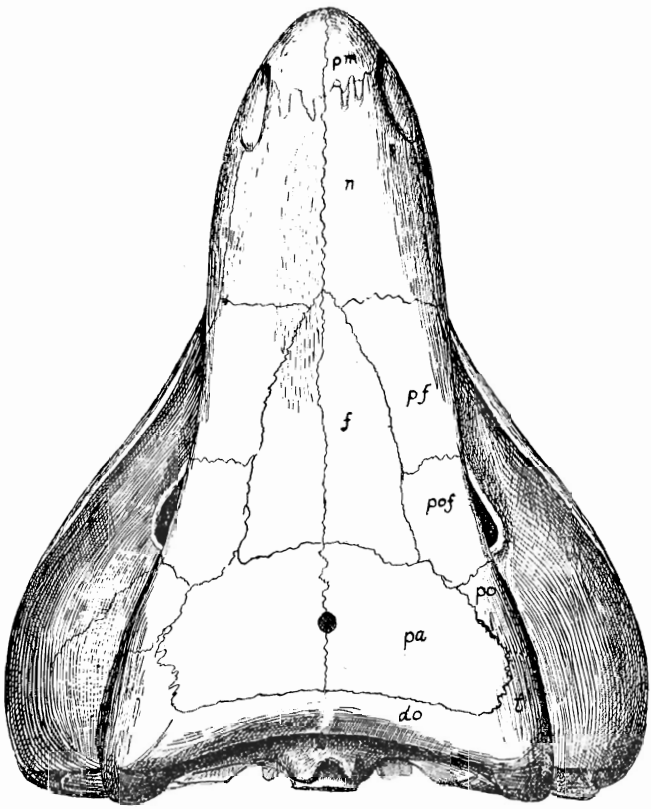

FIG. 1. *Limnoscelis paludis* Will. Skull, from above two-fifths natural size. *pm*, premaxilla; *n*, nasal; *l*, lachrymal; *f*, frontal; *pf*, prefrontal; *pof*, postfrontal; *po*, postorbital; *pa*, parietal; *do*, dermoccipital; *t*, tabulare.

skull is undisturbed: the obliquity has been corrected in the drawings—a matter of no difficulty. In a later paper, a restoration of the skeleton and photographs of the skull and other parts will be given. Some facts of interest, especially the mandibular and maxillary teeth, were made out from the separated pieces before they were cemented together, characters which will again become visible when the preparation of the

FIG. 2.

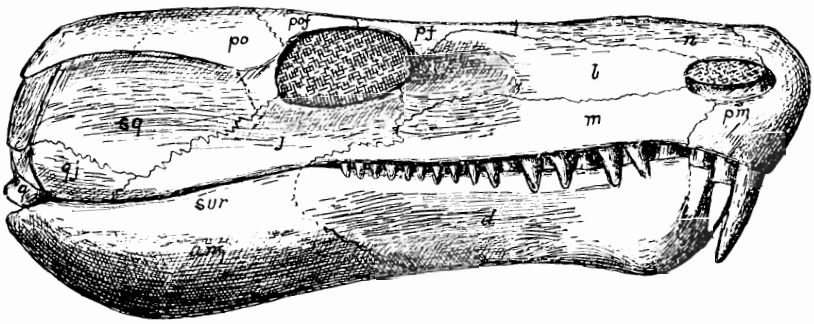

FIG. 2. *Limnoscelis paludis*, Skull, from side, two-fifths natural size. *pm*, premaxilla; *n*, nasal; *l*, lachrymal; *m*, maxilla; *pf*, prefrontal; *pof*, postfrontal; *po*, postorbital; *j*, jugal, *sq*, squamosal; *qj*, quadratojugal; *q*, quadrate; *d*, dentary; *sur*, surangular; *ang*, angular.

FIG. 3.

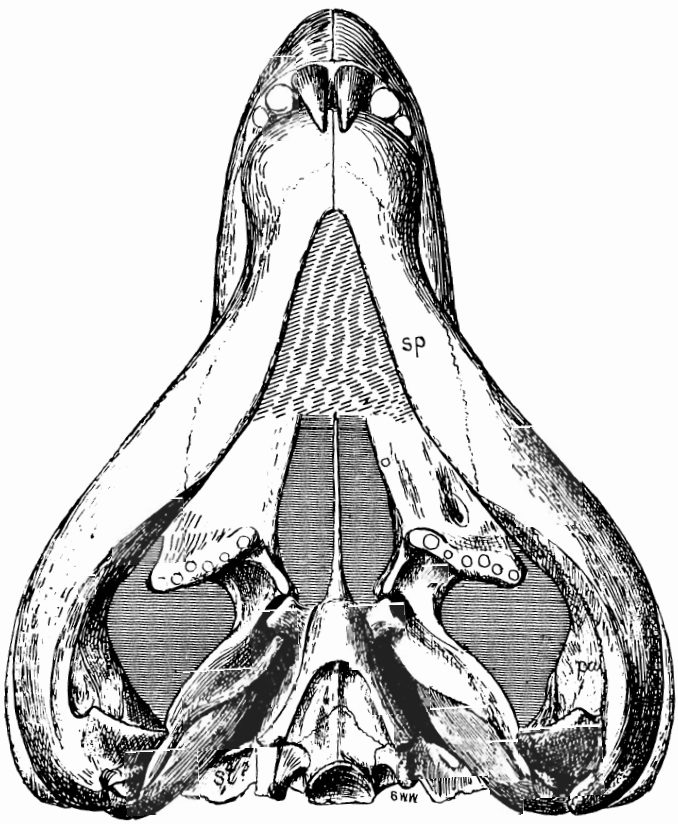

FIG. 3. *Limnoscelis paludis*. Skull, from below, two-fifths natural size. *sp*, splenial: *pa*, prearticular: *st*, (?) stapes.

skull is completed. The surface of the skull is almost smooth, with feeble indications of small pits.

The skull of *Limnoscelis* is remarkable among terrestrial reptiles for its elongated form and highly developed incisor teeth. The upper surface is nearly in one plane from the margin of the occiput to near the extremity of the rostrum, somewhat convex above in front of the eyes, and the parietal region is moderately convex on the sides. Fortunately the sutures of the skull nearly everywhere are quite distinct, even visible in the photograph as serrated or zigzag lines. A few cracks are present, but they are not confusing save in a few cases, but those are in the most important part of the skull, the posterior temporal and occipital region. The sides of the skull, with the mandibles in place, are of nearly uniform height, that at the nostrils being quite what it is at the temporal region, unless there has been a slight depression in the latter place. From just in front of the orbits the skull widens very rapidly, the orbits themselves being nearly wholly concealed in top view by the overhanging roof of the skull. In front of the orbits there is a rather deep depression on each side. Back of the orbits there seems to have been a nearly vertical wall for some distance, and then convex broadly outward. The nares are of considerable size, oval in shape and situated close to the anterior end of the skull. The orbits are relatively small and situated far back, the distance between orbits and nares being greater than the extent of the skull posteriorly. They are oval in outline, somewhat narrowed in the specimen, their planes nearly parallel to each other and nearly vertical, the posterior part turned a little outward.

The premaxillæ are very massive bones, strongly protuberant in front. The suture uniting them with the nasal is strongly digitative, beginning at the front end of the nares. Each premaxilla has three large, conical and recurved teeth. In the specimen the interior one on the right side had been lost before fossilization, but its mate is complete; the second and third teeth are successively smaller, but of the same character as the inner one, long, conical and recurved. The bases of two are present on one side, with indications in the matrix of their length. Doubtless when the skull is finally prepared, the missing parts will be found. The long tooth lies in the specimen as I have figured it, directed downward and backward, and closely applied to the end of the mandible.

The maxilla has quite the same relations as in the other American cotylosaurs where it is known, a rather narrow bone united with the premaxilla below the nares, with the lachrymal throughout nearly its whole length above, and with the jugal posteriorly below the orbit, which it joins by a long, oblique,

serrated suture. The precise number of teeth I cannot be sure of. On the left side the teeth are hidden by the obliquely compressed mandibles from the outer side; on the right they are not perfect. Before the parts were cemented together, Mr. Gibb worked out the left maxillary and mandibular teeth from the inner side in large part, and these have been used to complete the figures in the drawing. There are at least eighteen in the maxilla, and perhaps more. The anterior ones are longer and stouter, conical like the incisors, and somewhat recurved. Their attachment to the bone is more or less pleurodont. The posterior teeth are shorter, but are also nearly circular at their bases. There is but one row. The nasals are very large bones, occupying nearly the whole of the upper surface of the skull in front of the orbits, and are gently convex or flat. The lachrymals, as in probably all cotylosaurians, are elongate, forming the posterior border of the nares and a part of the anterior border of the orbits. As in the Diadectidæ, and quite unlike the condition in the Pariotichidæ, the small frontals do not take any part in the orbital border, which is formed by the prefrontals and postfrontals; as in the Diadectidæ, both these bones are short and broad, extending little beyond the orbit in front or behind. The parietals are short, broad bones forming most of the superior surface of the skull back of the orbits; the parietal foramen is of the usual size, very unlike the enormous one of the Diadectidæ. The sides of the skull back of the orbit are formed chiefly by the squamosal, very clearly distinct from the small quadratojugal on the lower posterior margin, but not distinguishable at present from the postorbitals and epiotics quite to my satisfaction. Back of the parietals are the narrow transverse dermoccipitals, which seem to be quite distinct from a small bone at the outer angle, which doubtless is the tabulare (epiotic). The structure of the posterior part, the occipital region, is somewhat confusing, and I do not feel at all sure of my determinations. The discussion of this region I reserve for a later paper, hoping that additional material may be forthcoming. The structure of the palate, so far as it has been developed in the specimen, is most interesting, so closely resembling the "rhynchocephalian" type, that a few years ago, had it been found without other parts of the skull it would have unhesitatingly been located in the "Diapsida" and "Diaptosauria." The specimen has not yet been thoroughly cleaned in the anterior part, so that I can say nothing of the vomers. The palatines and united pterygoids are, as in *Labidosaurus* and *Pariotichus*, separated by a more or less elongated interpterygoidal space. The eminence in the region of the transverse, if the bone be distinct as I think it is, is crowned by a row of five or six teeth, evidently more or

less conical in life, but unpreservable in the preparation of the skull. In front of these teeth I can find evidence of but a single tooth, located as I have marked; I am not quite sure of it, but in all probability there were others. Opposite the front end of the basisphenoid, the pterygoid on each side articulates with a stout basipterygoid process of the basisphenoid, quite as in the lacertilians, the first evidence I have seen among the Permian vertebrates of a real articulation at this place. The pterygoid has a pit or depression on the inner side for the head of this large process. Back of these processes the pterygoids resemble remarkably the like processes of the lizards, or *Sphenodon*, a not very wide, rather stout, obliquely placed process reaching backward to articulate with the lower inner side of the quadrate. In the middle the large basisphenoid is conspicuous; unlike that of the Diadectidæ, it is stout and rounded below, where it gives off the basipterygoid processes. Anteriorly it gives off the so-called parasphenoid. But the "parasphenoid" in this case is a thin vertical plate, thickened posteriorly to join the anterior end of the basisphenoid, very much as in *Trinacromerum* among the plesiosaurs. In the specimen the front part lies obliquely in the matrix an inch or more in width, with the lower margin, that visible in its normal position, narrow. Behind the rounded median convexity of the sphenoid, the bone is broadly concave in the middle, on either side of which the usual basisphenoid process is directed downward, backward and outward, to end in a rather stout projection. In the middle of this concavity the sutural line for union with the basioccipital is evident. The occipital condyle is quite flat or even concave, as in *Diadectes* and *Pareiasaurus*, a strong indication of relationship. On either side of the basioccipital I think I have interpreted the bones of the posterior palatal and occipital regions, but I prefer to wait before publishing my conclusions in the hope of getting material of this form the coming season.

The mandibles of *Limnoscelis* are very powerful, indicative of the carnivorous habits of the animal in life. They lie in perfect relation to each other, save that they are a little skewed to the right. They are broadly separated behind, with a long convexity on the sides, and again expanded at the front end. The teeth are only partly visible from without; the one or more large ones in front opposing the premaxillary teeth are wholly hidden, nor can the number be made out with certainty. The postarticular process is small, not extending back of the quadrate, or if so, but for a few millimeters only. Externally the suture separating the angular from the surangular passes forward near the middle of the bone, and backward nearly to the extremity, On the inner side of the mandible the structure

is peculiar. A broad flange is directed inward, nearly vertically, opposite the middle of the articular surface, concave in front. The suture separating the prearticular from the articular is very conspicuous, passing back over the flange. In front the prearticular passes far forward, between the upper opening to the cavity of mandible and the elongated foramen near the middle of the inner side before the middle of the bone antero-posteriorly. A fracture of the mandible a little in front of the articular shows a large cavity with an elongated opening above back of the teeth. The elongated vacuity is bounded by the angular below, by the splenial in front, by the prearticular above behind, anteriorly apparently by the coronoid. The splenial is very broadly visible on the under side of the mandible, the suture between it and the dentary beginning some distance in front of the posterior end of the median symphysis, and extending back nearly as far as the posterior end of the internal vacuity. On the left side a piece about two inches in extent of this bone has been peeled off from the dentary, showing the bone to be thin, not more than six or eight millimeters in thickness. In front, the splenial turns upward to cover the inner side of the mandible below the teeth and apparently partly covering the internal vacuity in front. Interesting is the fact that the existence of a separate prearticular is demonstrated beyond doubt in this specimen, and also that the splenials meet in a median symphysis in front as in *Labidosaurus*, and probably all the Cotylosauria.

Vertebræ.—Eighteen presacral vertebræ have been cleared of the matrix in a continuous series curved to the left. The lengths of these vertebræ are almost exactly the same throughout; in front of them the vertebræ above the pectoral girdle have not yet been exposed; the space in which they lie corresponds exactly with that of five vertebræ following them, and that is doubtless the number hidden in the matrix. In front of these the atlas and axis have been partially exposed, giving twenty-five as the total number of presacral vertebræ. The first of the series exposed below, the eighteenth presacral, has a shallow fossa or flattened surface on the under side in the middle, which fossa increases in depth posteriorly, a very characteristic feature which seems to separate this form from anything hitherto described and especially *Diasparactus* Case. The outline of the centra both on the sides and below, anteroposteriorly, is deeply concave. The arch has a marked resemblance to that of *Diadectes*, so far as they have been worked out, save that there is no trace of a hyposphene anywhere in the series and the rib articulation is continuous from the arch to the centrum, as in *Labidosaurus*. All the observed ribs are single-headed, but expanded, that is without an emargina-

tion distinguishing the head from the tubercle. In *Diadectes*, or at least in such species as I have been able to study of this genus, the ribs anteriorly are distinctly double-headed. The transverse processes are short throughout the series, scarcely extending on the sides beyond the margin of the zygapophyses. This character has been given by Case as a distinctive one for his genus *Diasparactus*, but, in a large species of *Diadectes* from Texas I do not find any appreciable difference in the prominence of the processes, at least in the posterior presacral region. The spines are moderately elongate through the series, thickened and somewhat rugose at the upper end. There are large intercentra between the centra below, and as the vertebræ lie in the matrix a considerable space is left between the adjacent vertebræ for cartilage, indicating a very flexible, though not very firm spinal column. The spines, of the posterior part of the column at least, are about one inch in length. The first presacral spine is rather broad and expanded above, the second and more anterior ones are more slender. There is but one sacral vertebra, which has a very broad, stout, sacral rib on each side, turned directly downward so as to cover nearly the whole of the inner side of the ilium at its junction with the ischium and pubis, its antero-posterior width being 60^{mm}, its vertical width where it joins the ilium, 40^{mm}. The ribs immediately in front and behind are small and slender and do not seem to touch the ilium at all. Case has described *Diadectes* as having two sacral vertebræ, but in the specimen in the Chicago collections, of a large species, the structure of the sacrum seems to be quite as in *Limnoscelis*; and this is also the case in a new genus of Diadectidæ, which Professor Case will describe from a specimen in the University of Chicago collections, collected by Mr Miller.

The first chevron occurs at the hind end of the third caudal vertebra, the first one visible above the ischia from below; the first three or four of the caudal vertebræ have short, free ribs, as in other genera of American Cotylosauria. The tail, as preserved in specimen No. 908, is rather slender, with rather short spines and chevrons, rather precluding the idea that the animal was marked natatorial in habit. The terminal vertebræ are a little elongated.

Pectoral Girdle and Extremity.—The pectoral girdle lies in very orderly arrangement, with little if any distortion. Both clavicles are in articulation with the interclavicle, scapulæ and cleithra. The clavicles have the usual cotylosaurian form, curving under the anterior end of the interclavicle and the anterior margin of the coracoid, curved and somewhat spoon-shaped below. The long, dilated, scapular part is curved upward in a vertical plane and obliquely backward in the artic-

ulated skeleton, reaching nearly to the upper end of the scapula, flattened from side to side above. The cleithrum is small and vestigial, smaller than in *Diadectes*, a slender, cylindroid bone, reaching quite to the superior anterior angle of the scapula, but not expanded over the end, as in the temnospondyls. It is dilated at its lower end to articulate with the attenuated upper extremity of the clavicle, lying between the clavicle and the front margin of the scapula. It is only a little more than

FIG. 4.

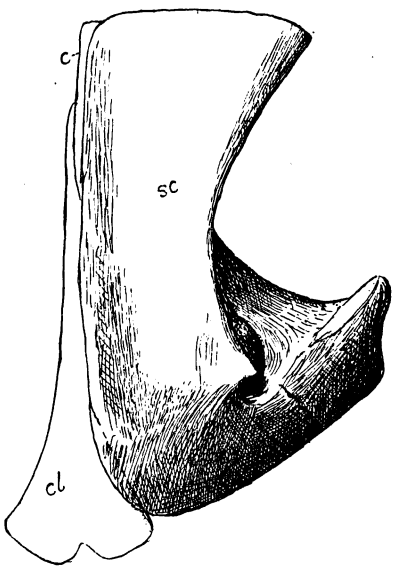

FIG. 4. *Limnoscelis paludis.* Left pectoral girdle, two-fifths natural size. *c*, cleithrum ; *cl*, clavicle ; *sc*, scapula.

two inches in length. The scapula is very short. The blade above is narrow, thinner and curved outward on its front part, thickened at its posterior superior border. Its upper end is truncated, and doubtless had a supra-scapular, cartilaginous continuation, possibly the representative unossified of the upper end of the cleithrum. The glenoid fossa is deep and large, the stout metacoracoid extending far back relatively. The posterior border of the scapula is curved nearly uniformly from the angle to the extremity of the preglenoid facet, which is large and flattened. There is a distinct supra-glenoid fossa a little below the middle of the bone, between the borders, which diverge nearly the middle of the length of the scapula; it is pierced in the usual temnospondyl way for the passage of the

FIG. 5.

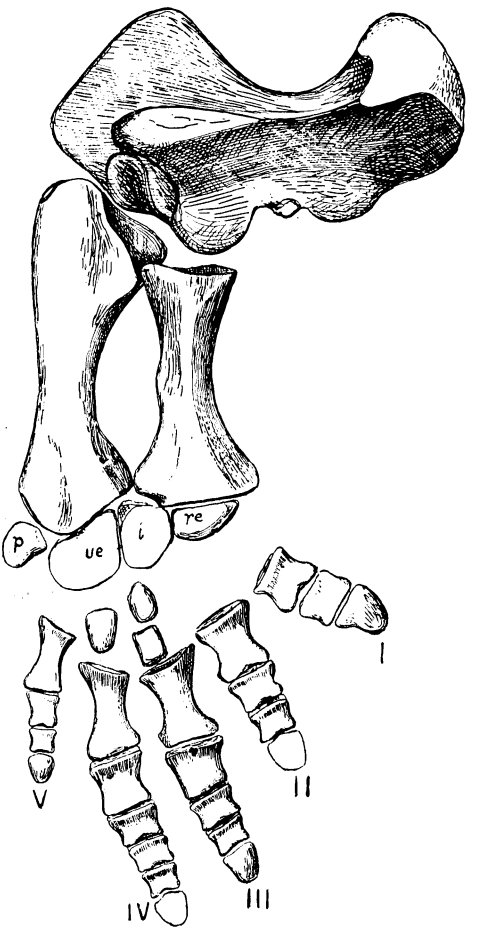

FIG. 5. *Limnoscelis paludis*. Right front leg, dorsal view, two-fifths natural size. *re*, radiale; *i*, intermedium; *ue*, ulnare; *p*, pisiform.

supraglenoid canal. I have observed this foramen in this position in scapulæ which I refer to the genus *Ophiacodon*, but usually in the *Pelycosauria* the opening pierces the bone in front of the scapular margin. I had supposed that this foramen was characteristic of these old orders of reptiles, never having seen any reference to it in literature of other orders of vertebrates. But, I am surprised to find that it is quite typical of certain lizards, and it perhaps occurs in other reptiles. In the present reptile I have observed for the first time in any form other

than the amphibia, the inner opening of the foramen or canal back of the border of the subscapular fossa which I have called the glenoid foramen. That the canal perforates the bone to open in the glenoid fossa I am not prepared to affirm. I find, however, that the foramen is also present in the Diadectidæ, and perhaps in all cotylosaurians. Its presence removes the last distinguishing character between the temnospondyl and cotylosaurian pectoral girdles. One may distinguish them now only by the smaller size of the cleithrum in the reptiles.

The suture separating the metacoracoid (coracoid auct.) is situated not far back of the supracoracoid foramen, which is unusually large. The limits of the coracoid (procoracoid auct.) are not distinguishable; the bone is thinned, rounded on the anterior angle, which is slightly underlapped by the clavicle, and, with the metacoracoid, is curved inward nearly to a horizontal plane, approaching its mate of the opposite side, but separated by the stem of the interclavicle. The interclavicle reaches a little further back than the hind angle of the metacoracoid, and is of moderate width; its front part is dilated and mostly hidden from view, as in the other Permian reptiles.

In each skeleton there is a pair of bones found lying just back of the coracoids, and nearly below the vertebræ, of the nature of which I am not fully satisfied, though there would seem to be little doubt but that they are unusually large hyoids. They are about three inches in length, greatly expanded on their distal, thin end, with a somewhat curved and narrowed shaft, deeply concave in outline on one side, less so on the other, thickened and truncate for articulation at the proximal end. The two bones in each specimen lie with the thin ends nearly in apposition, as though they had joined each other in life.

Humerus.—The humerus is a remarkably short and thickset bone, resembling that of *Diadectes* more closely than that of any other genus that I know. The ectocondyle is more expanded and turned inward than in that genus, however, nor is the proximal expansion so much twisted from the plane of the entocondyle as is the case with the humeri of more terrestrial Permian reptiles. The entocondylar foramen is large, situated not far from the lower extremity of the lateral process. The ulnar expansion is broad and flat, and occupies a plane divergent from that of the proximal inner side of about forty-five degrees. The capitellum is very large and rounded, situated on the outer angle of the bone, as seen from the ventral side, and is remarkably close to the lateral process. The ectocondyle is remarkably stout and protuberant, and is directed almost rectangularly, or even at an acute angle backward, terminating very near the middle of the bone transversely, and above

the groove for the ulna on the dorsal side. It is an interesting fact that not only the structure of the humerus, but also the whole anterior limb, resembles, not only that of *Diadectes*, but also that of the amphibian *Eryops*, suggesting similar habits in all three animals, and possibly too genetic affinities. There is a moderately stout ectepicondylar process, as in *Desmospondylus*, *Seymouria*, *Diadectes*, *Eryops*, etc. It is situated a little below the lateral process on the radial side.

Radius, Ulna.—The radius and ulna are very like those of *Diadectes* and *Eryops*, rather short and stout bones. The two lie in position on each side, as shown in the figure, the upper end of the radius partly lodged in the lower end of the sigmoid fossa, and the two are in one plane. The radius has the capitulum truncated and hollowed for articulation with the humerus, the extremity strongly convex on the dorsal, flattened on the ventral side. The shaft of the bone is moderately narrowed, and its two borders are nearly symmetrically concave. The lower extremity is more expanded, with its end truncate and flattened for articulation with the radiale and intermedium, the inner side the thicker. Just above the inner distal angle there is a characteristic protuberance, which evidently came in close contact with the ulna. The ulna is a more slender bone and is a little longer; it is thick and massive at its upper end, the shaft more slender than that of the radius, and the lower end moderately expanded. Its radial border is deeply concave, its inner border nearly straight to the lower fifth. The sigmoid fossa is deep, winding obliquely about the bone, and fits accurately the curved trochlear surface on the distal and dorsal side of the humerus. Evidently the elbow joint was a strong and firm one. The distal extremity of the ulna is subtruncate, its border somewhat oblique to that of the radius, but with the angle broadly rounded for articulation with the pisiform. Both radius and ulna have the dorsal side convex, the ventral more flattened.

Front Foot.—Lying in close articulation with the radii and ulnæ are the proximal carpal bones, four in number on each side, the radiale, intermedium, ulnare and pisiform. The pisiform is a small bone, thinned along its free border and articulating in its usual position between the ulna and ulnare. The ulnare, the largest of the carpal elements, is an irregularly oval bone, articulating rather broadly with the ulna and the intermedium, but without distinct facets for the other carpal elements. The smaller intermedium is much thickened, articulating with the ulna, ulnare and the radius, with a very small free border between the ulna and the radius. The radiale is the smallest of the three, almost vestigial in fact, elongate-ovate in shape, with the radial border straight and flat-

tened, the outer and obtusely pointed; it merely touches the intermedium. The ventral surface of all three of these bones is flattened, the dorsal more rounded, that of the radiale obsolete. Especially remarkable is the fact that all of these proximal carpal bones save the ulnare are very small, smaller than in *Diadectes* even, and much smaller than in other known Permian reptiles.

The remaining bones of the right foot were found nearly all connected, for the most part in the relations of the living animal. The foot had been slightly twisted in fossilization, disturbing somewhat the relations of the metapodials. Of the phalanges all were found in association save two terminal ones, the distal phalanges somewhat confused in the three middle fingers. The three distal carpal bones were found in the positions shown in the figure, but there were no traces of others, and they could have hardly escaped notice had they been fossilized with the others. Evidently these nodular bones represent the centrale and the third and fourth carpalia. Fortunately the bones of the left foot were found in the matrix in as natural relations as one could wish, and they will be so retained in the prepared skeleton. The block containing the distal carpals and the digital bones had been separated in collection from that containing the fore-arm and proximal carpals, and was not accurately readjusted. The three carpal nodules are quite as in the other hand with no traces of others; from which facts I have no doubt that they were the only ones ossified, and they but imperfectly. Of the digits the bones of the three middle toes were all in perfect articulation save the ungual phalanges of the second and fourth digits, which are missing. Of the first digit, the ungual phalange is also missing and the phalanges of the fifth have not been adjusted to the metacarpal. However, these digits were preserved in perfect articulation in the right foot. From these facts, which I have given in detail because of their importance, it is certain that the phalangeal formula is, as is seen in the figure, 2, 3, 4, 5, 3, fixing for the first time the foot structure in an American cotylosaurian, and save for *Procolophon*, which has been referred (wrongly I believe) to another group, in a member of the order. My figure was made by simply tracing the outlines of the various bones as they lie in position and transferring them. The only doubt that remains is the precise width of the space I have left for the carpal elements, it may be a trifle too broad. As is seen, the foot is remarkably broad and flat, lying in the matrix in nearly one plane, with the phalanges short, the ungual ones broad and hoof-like, as in *Diadectes*, and probably also *Eryops*. The foot resembles that of *Diadectes* somewhat save that the proximal carpal bones are large, and the distal row seems to be fully ossified in that genus.

Three years ago I expressed the opinion that the phalangeal formula 2, 3, 4, 5, 3(4) was the primitive one for land reptiles, if not for land vertebrates, as observed in *Eosauravus copei*. Broom is of the opinion that this is the formula in *Propappus* and he has proven it to be that of *Procolophon*. *Dromopus agilis* Marsh, as figured by the author and Matthew, shows a

FIG. 6.

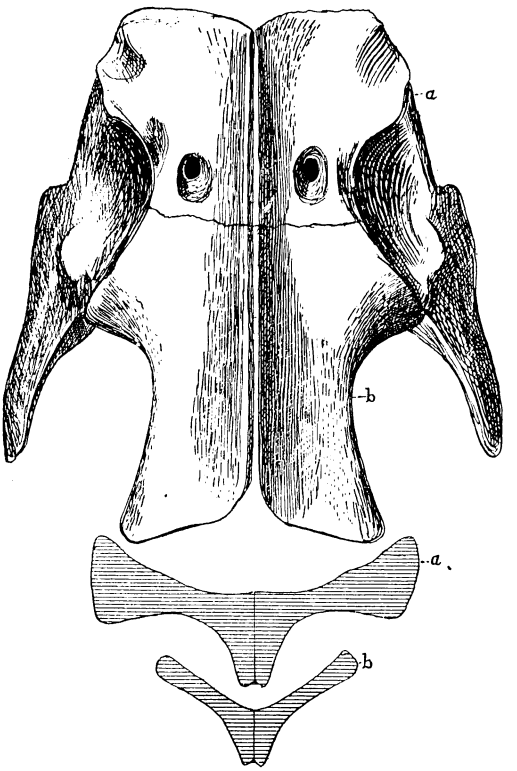

FIG. 6. *Limnoscelis paludis*. Pelvis, from below, two-fifths natural size. *a*, cross-section through pubes at *a*; *b*, cross-section through ischia at *b*.

similar phalangeal formula. These footprints are from near the upper part of the Coal measures in the vicinity of Osage, Kansas. Marsh thought that they were made by a lacertilian rather than an amphibian, a natural error considering the lacertilian form of the prints. They probably come from some microsaurian reptile not unlike *Eosauravus copei*.

Pelvic Girdle and Extremity.—The pelvic girdle lies in natural articulation, with but little disturbance; the right pubis is a trifle compressed, and the extremity of the left

ilium had been broken off and turned aside before fossilization. Both femora are closely articulated in the acetabula, directed obliquely dorsad and cephalad. The pubes and ischia lie in a subhorizontal position, with a protuberant carina along the middle, deeper anteriorly. This keel, however, is not formed by the downward deflection of the margin of the bones, but by the increased depth of the symphysis, as will be seen from the cross sections of the figure, sections made at points of fracture in the specimen. The ischia have an angular margination in the middle, the sides curving outward and upward to the rounded posterior angle. The sutural division between ischium and pubis is at about two-fifths of the length from the front end of the pelvis. The pubic foramen is remarkably large at the bottom of a rather deep fossa situated a little back of the ischio-pubic suture, and not far from the acetabular border. The acetabulum is deep and large, with an overhanging, nearly horizontal roof-like process, at the upper posterior part. In life the cavity looked almost directly outward. The ilium is relatively small; it is flattened and thinned above and in front, with a rather stout, narrow process directed backwards and a little outward, nearly horizontal. Upon the whole, the structure of the pelvis is nearly identical with that of *Diadectes* and *Pariotichidæ*, and even of *Eryops* and *Cacops*, save in the form of the ilium; in *Diadectes*, broader above and not produced backward; in the temnospondyls without iliac projections either in front or behind. While there is but a single sacral vertebra in *Limnoscelis* and *Diadectes*, in *Cacops* there are two, a precise reverse of what has always been supposed to be diagnostic characters of these two classes of vertebrates. The femur is of the characteristic *Diadectes* type, short, stout, and expanded, with a heavy, protuberant trochanter, and a large digital fossa. The trochanter has a large facet, 20 or more millimeters in diameter, looking backward, and is rugose; the adductor ridge is pronounced and oblique. The tibia, like the femur, is short and stout, with a greatly expanded upper end, and a strong cnemial protuberance. The outer side is deeply concave in outline, the inner nearly straight. The lower extremity is much thickened. The fibula is a more slender bone than the tibia, and is longer. Its proximal end is thickened and subquadrate in shape; the lower end is thin and considerably expanded.

Hind Foot.—As already stated, the foot bones of specimen No. 811 were more or less weathered. From the wash, numerous toe bones and the ends of the epipodials with attached tarsals had been gathered up by Mr. Baldwin, and some of them still retain enough of their original matrix to show their relationships, but how many of them are irretrievably lost

FIG. 7.

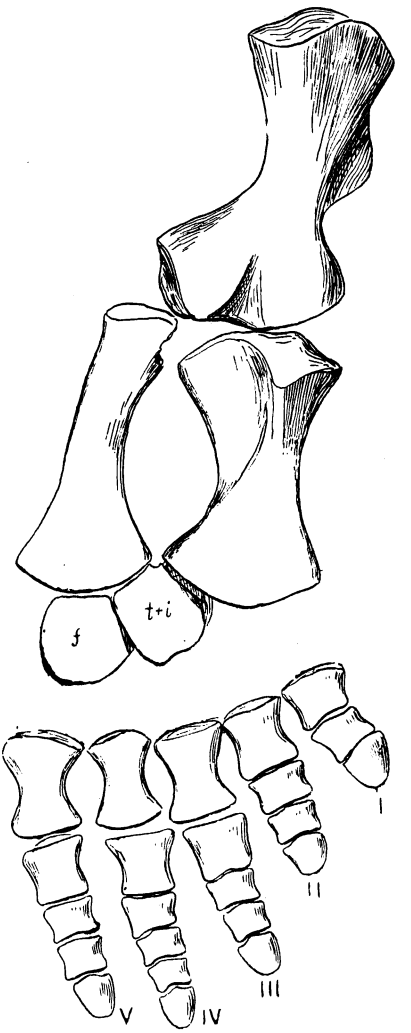

FIG. 7. *Limnoscelis paludis*. Right hind leg, dorsal view, specimen No. 809, two-fifths natural size. *t–i*, fused tibiale and intermedium; *f*, fibulare.

cannot be determined at present. Fortunately, however, in specimen No. 809, the tibiæ and fibulæ of both sides were preserved in position with the tarsal bones attached, fortunately so, since one would hardly have identified the tarsal bones correctly had they been found isolated, so very different are they from the corresponding bones of the *Pariotichidæ*

or *Pelycosauria*. The tibiale, or intermedium, is nearly cuboidal in shape, with a slight notch only between the articular faces for the tibia and fibula. Its outer facet is thickened for union with the fibulare, but I see no perforating foramen between the two bones. The distal and inner facets are also very broad, subquadrate in outline, with rounded angle. The fibulare is a larger bone, but much thinner than the tibiale; its tibial side is the thickest. I identify these two bones as the usual fused tibiale and intermedium, and the fibulare, but it is not impossible that the tibiale has been entirely lost, after fusion, and what really remains are the intermedium and fibulare. I have so far found no evidence satisfactory to me that the tibiale and intermedium are ever present in adult reptiles as distinct bones. I am aware that Broom has provisionally recognized a separate intermedium in *Howesia* and that other instances have been cited, but I think they are all open to doubt. The separation of the intermedium of the hand is a very persistent character in the Amniota, Man, himself, even having the same bones that are found in the temnospondyls in the proximal row of the carpus. In the tarsus, however, there was an early specialization, as far back as early Carboniferous times, and I do not think there was ever a reversion to the amphibian type.

Of the left foot of specimen 908 only these two tarsal bones and a number of separated toe bones have been recovered. Of the right foot, however, all the bones of the toes were preserved in their natural relations in the matrix, or with but slight distortions, the metatarsals all lying in one plane, apparently quite in the positions they occupied in life. The block containing them had the phalanges of the first toe, the first one of the second toe, the first two of the third toe and all four of the fifth toe in close articulation, those of the first and fifth toes strongly flexed. With this block, but separated, were the phalanges of the middle toes, the two each of the second and third and all five of the fourth toe severally connected by matrix, but not positively attachable to the basal bones of their respective digits, because of the effacement of the matrical surfaces in collecting. That they belong with these toes is, however, beyond doubt, both because of their perfect anatomical association and the peculiarities of the matrix. The formula as is thus seen is, like that of the front feet, the primitive one for reptiles, 2, 3, 4, 5, 4. The phalanges, as of the front feet, are all remarkably short and broad, and I may also add, relatively thin. The ungual phalanges, as have been described for *Diadectes*, which they resemble, are short, broad and hoof-like rather than claw-like, with a thin rounded extremity, the bones possibly encased in a horny nail in life. I can hardly conceive of a foot of this character being used for burrowing, notwithstanding Case's

comparison of the similar feet of *Diadectes* with those of the gopher. The right front foot, as preserved in the matrix, had the tibia and fibula, with their attached proximal carpals, pressed downward somewhat below the proximal ends of the metatarsals, but not a vestige is preserved in the matrix of centrale or tarsalia, nor is there any tarsal bone preserved with either specimen save the four sets of proximal ones. It is not at all impossible, however, that vestigial, nodular tarsalia may have been ossified, but it is not very probable that they were. Chondrification was evidently here a specialization, and in accordance with the almost universal rule among terrestrial vertebrates we should expect that the process would develop more rapidly in the hind than in the front feet.

No indications whatever of ventral ribs are present in either specimen. In their place, however, the whole ventral region was covered by a sort of plastral sheath of imperfectly ossified or calcified material. Patches of this sheath were found scattered about in the matrix below the posterior vertebræ and adjacent regions, some of them two inches or more in diameter. I have not yet had an opportunity to examine the substance microscopically, but to the unaided eye it appears to be loose bone tissue. It is quite certain that the animal did not have distinct ventral ribs, or osseous dorsal scutes.

Habits and Relationships of Limnoscelis.—It is almost superfluous for me to point out, so evident will it be to every one, that *Limnoscelis* must have been a subaquatic or marsh-dwelling reptile. Of the poorly ossified or cartilaginous carpus and tarsus the evidence is almost positive, and there can be but one explanation, subaquatic habits. The limbs as a whole indeed are strongly suggestive of the turtles. The relationships of the genus are unquestionably closest with *Diadectes* of any forms that we know, from which it differs chiefly in the elongated skull, the conical, prehensile teeth, the absence of the ear cavity posteriorly, the small size of the parietal foramen, the smoothness of the skull surface, the non-expanded ribs, their apparently single-headedness throughout, the absence of hyposphenes, and the feebly ossified carpus and tarsus. It agrees with *Diadectes* especially in the general structure of the limbs, the arrangement of the skull bones, especially the union of the prefrontal and postfrontal over the orbit, the general structure of the vertebræ, with the cylindric or prismatic spines, etc. It agrees with both *Diadectes* and *Pareiasaurus* in the very characteristic flattened occipital condyle; and I believe that when we know more of the structure of the skull of the latter genus, we shall also find more evidences of affinity in these groups, to such an extent that the three genera, and *Propappus* also, may perhaps be placed in the same suborder of reptiles.