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lished a list[1] of the vertebrates known at that time from these shales. This list included twenty-five species of fishes and a single species of Amphibia, *Amphibamus grandiceps* Cope, which was all that was known of the higher vertebrates from these beds at that time. Since the publication of Eastman's essay the writer has described[2] an additional species from Mazon Creek, *Micrerpeton caudatum*. This form was shown to be an example of the order Branchiosauria. It was the first definite evidence of the occurrence of this order of Amphibia in America, or, in fact, in the Western Hemisphere.

The next year the writer described (Amer. Natl., XLIV, June, 1910, p. 367) and figured another branchiosaurian as *Eumicrerpeton parvum*, from these beds; and the following year he described (Proc. U. S. Natl. Museum, XL, p. 429-433, 1911) and figured further remains of the same species and described a new microsaurian as *Amphibamus thoracatus*.

There have been, thus, up to the present time, four species of Amphibia described from the Mazon Creek shales. These four species are represented by seven specimens. The type of *Amphibamus grandiceps* Cope was destroyed by fire, but there is an excellently preserved specimen of this species in the collection of Mr. L. E. Daniels, of La Porte, Ind. Other examples of the fossil Amphibia of Mazon Creek which have come to the writer's notice are specimens, representatives of the Branchiosauria and the Microsauria, in the collection of Mr. R. D. Lacoe, now the property of the U. S. National Museum. This small but highly interesting collection has recently been loaned the writer for study by Mr. Charles W. Gilmore. This was the sum total of Mazon Creek Amphibia known to the writer until some months ago. In November of 1909 a collection of nodules containing Amphibia was loaned the writer for study through the courtesy of Doctors Eaton and Schuchert, of Yale University. This lot consists of ten individuals, representing seven genera and eight species, all of which, save one, are regarded as unknown and have been described as new. This is an immense addition to our knowledge of the amphibian fauna of the Mazon Creek shales and adds much to our knowledge of the diversity of structure displayed by the Amphibia of the Carboniferous.

The forms described below are entirely unlike any of the

1. Eastman, C. R., Journ. Geol., vol. 10, p. 535, 1902.

2. Moodie, Roy L., Journ. Geol., vol. 17, p. 39, 1909.

forms occurring elsewhere in the Carboniferous or later ages. It has been the writer's good fortune during the past five years to examine all of the specimens of Carboniferous air-breathing vertebrates in North America, with the exception of Sir William Dawson's collection at McGill University. The European forms, as they have been described from time to time, are, unfortunately, known to him only through the literature, with the exception of a small collection of Branchiosauria recently received in exchange from Dr. Hermann Credner. It is hoped that in the near future this may be supplemented by actual observation, and until that time it can not be positively asserted that the forms described below are unlike those already known, but, so far as his knowledge goes, the writer is confident that they are new to science. The characters used for generic distinctions are such that even the most superficial observations must reveal. They are structural ones, and are those which are used by many eminent vertebrate paleontologists at the present time. Unfortunately, we know so little about the development of the class Amphibia that we can not always be sure that our characters are phylogenetic, as they must be to mean anything. So that until some idea of phylogeny is obtained, structural characters must be used which seem to the describer to be of generic significance.

The Amphibia so far discovered in the Mazon Creek shales, including those described in this paper, are:

1. *Amphibamus grandiceps* Cope, 1865.
2. *Amphibamus thoracatus* Moodie, 1911.
3. *Micrerpeton caudatum* Moodie, 1909.
4. *Eumicrerpeton parvum* Moodie, 1910.
5. *Mazonerpeton longicaudatum* Moodie.
6. *Mazonerpeton costatum* Moodie.
7. *Cephalerpeton ventriarmatum* Moodie.
8. *Erpetobrachium mazonensis* Moodie.
9. *Spondylerpeton spinatum* Moodie.
10. *Erierpeton branchialis* Moodie.

These ten species are distributed among eight genera, five families, and four orders, thus showing the amphibian fauna of Mazon Creek to be a diverse one. The arrangement of the species into groups is given below.

CLASS: AMPHIBIA, LINNE, 1758.

Subclass: EUAMPHIBIA, Moodie, 1909.
Order: Branchiosauria, Lydekker, 1889.
Family: Branchiosauridæ, Fritsch, 1879.
Micrerpeton caudatum Moodie.
Eumicrerpeton parvum Moodie.
Mazonerpeton longicaudatum Moodie.
Mazonerpeton costatum Moodie.
Order: (?) Caudata, Duméril, 1806.
Family: Cocytinidæ, Cope, 1875.
Erierpeton branchialis Moodie.
Subclass: LEPOSPONDYLIA, Zittel, 1887.
Order: Microsauria, Dawson, 1863.
Family: Amphibamidæ, Cope, 1875.
Amphibamus grandiceps Cope.
Amphibamus thoracatus Moodie.
Cephalerpeton ventriarmatum Moodie.
Family: Molgophidæ, Cope, 1875.
Erpetobrachium mazonensis Moodie.
Subclass: STEGOCEPHALA, Cope, 1868.
Order: Temnospondylia, Zittel, 1887.
Suborder: Embolomeri, Cope, 1885.
Family: Cricotidæ, Cope, 1884.
Spondylerpeton spinatum Moodie.

The discovery of the embolomerous amphibians in the Carboniferous fauna is not new, since the first embolomerous form known in North America was described from the deposits on Salt Creek, Illinois, as *Cricotus heteroclitus*, by Cope. Later the same or a closely related form was discovered in Texas by Cope and Case and in Kansas by Williston. The form described here is, however, much more primitive than any of the species of *Cricotus*. The rachitomous forms of Amphibia are known from the Carboniferous of North America and Europe through the researches of Fritsch and Case.

The content of the amphibian fauna of the Mazon Creek shales is peculiar on account of the presence of the four species of Branchiosauria. Unless Dawson's *Sparodus* is an example of this group, the forms in the Mazon Creek fauna represent the only known occurrence of this order in North America. Dawson was himself doubtful about the identity of the remains which he referred to *Sparodus*. Judging from his figures, there is a possibility that he may be right, since the form of the interclavicle is decidedly branchiosaurian, as we know the form of that element among the European species. Beside the presence of the Branchiosauria, the Mazon Creek

amphibians differ from the Canadian species in the almost total absence of any scaly covering such as occurs in *Dendrerpeton* and *Hylerpeton*, although *Micrerpeton* has very small scales over the body and tail. Furthermore, the Canadian species are more terrestrial than those from Mazon Creek, which, judging from their form, were either entirely aquatic or only partially terrestrial. The size of the members of the two faunas differs in no great degree. Large and small members are found in both localities. The Joggins Amphibia are hardly well enough known to judge their relationships other than those of an ordinal or family rank. These relations will be given in another paper.

The Linton fauna, which is more fully described in another paper, is quite unlike the Mazon Creek fauna. This is evident by the absence of branchiosaurian forms from the Linton deposits and by the presence of the legless Microsauria and the Proteid form *Cocytinus*, which is paralleled by *Erierpeton* in the Mazon Creek fauna. The limbed Microsauria also differ in a marked degree, in that the Mazon Creek forms have a strong tendency toward the Reptilia, as illustrated in the Amphibamidæ, *Amphibamus* and *Cephalerpeton*. The Linton fauna shows a wide divergence of types, illustrating different phases of amphibian development, and in the tendency of certain groups, such as the families Tuditanidæ and Macrerpetidæ, to approach the Stegocephala proper and through them certain of the stegocrotaphous reptiles. The Linton fauna is distinctive too in the abundant presence of such highly developed swimmers as *Œstocephalus*, *Ptyonius*, *Phlegethontia* and *Ctenerpeton*, and as such is interesting in displaying parallel development of the same structures in forms which are really widely separated in structure.

The fauna of the Cannelton slates is not very different from that of Linton, and the remarks made concerning the relationship of that fauna to the Mazon Creek fauna will also apply with reference to the Cannelton fauna. Outside of these four deposits, there are several minor deposits which have furnished amphibian remains, none of which agree in any essential respect with the Mazon Creek fauna. Attention has already been called to the fact of the occurrence of the embolomerous forms in the Mazon Creek, the Pitcairn, Pa., the Kansas, and the Salt Creek, Illinois, faunas.

A view of the entire amphibian fauna of the North American Carboniferous, as we know it at this time, shows us that the separate faunas were local, and as such indicate the ancient history of the group at that time. Such a high degree of developmtnt and such a wide dispersal of types would indicate a long antecedent history. Possibly the Amphibia of the Mississippian rocks will yield forms which will connect these local faunas; possibly we may have to look to the Devonian for these connections. The early Mississippian and Devonian forms are already indicated by footprints, but as yet we know nothing of the structure of the creatures which made the footprints.

Descriptions of Genera and Species.

Genus Erierpeton—New Genus.

All of the examples of Amphibia loaned the writer by the Yale University Museum are capable of identification. One of the most unusual forms is represented by a distinct impression on a weathered ironstone nodule from which all the bony matter had become eroded. It is so unusual in form and in the characters which it presents that it is deemed worthy of description. Since it is totally unlike anything described, it must be placed in a new genus, for which the term *Erierpeton* is proposed. The name refers to its early appearance. The specimen in question is No. 801 (222)5 of Yale Museum. The nodule which contains the impression is some three inches in long diameter.

The generic characters are found, first of all, in the presence of hyobranchial arches, which indicate its relationship to the formerly described *Cocytinus gyrinoides* Cope, from the Carboniferous of Ohio. The only other known extinct genera of Caudata which possess, or at least have preserved, the branchial arches are the Jurassic *Hylæobatrachus* from Belgium and *Lysorophus* from the Permian of Texas. The present form is widely distinct from both of these genera in the shape of the mandible and the form and arrangement of the hyobranchial arches. The new genus finds its closest ally in *Cocytinus* in the family Cocytinidæ which possibly belongs in the order Caudata and in the suborder Proteida of Cope.

Erierpeton branchialis, New Species.

(Plate 1, fig. 3; plate 2, fig. 1.)

The amphibian remains which are designated by the above name consist of a distinct mandible and some rather indefinite body impressions. Three elongate impressions occur between the rami of the mandibles, which, I suppose, must represent hyoid bones belonging to the branchial arches. The lateral elements are paired and the median impression is straight and lies between the paired portions of the hyoids. The paired portions probably represent the hypohyals, or hypohyals plus the ceratohyals, and the unpaired portion the first basibranchial, according to the nomenclature of Wiedersheim (Comparative Anatomy of Vertebrates, 1897, p. 86). If the impressions have been correctly interpreted, the present specimen is of very great interest since it is the first evidence we have of the hyobranchial arches in the Amphibia of Mazon Creek, and the second in the Carboniferous of North America. Dawson doubtfully identified some elements of the Joggins Amphibia as hyoids, but was uncertain as to their position. Cope described fully the well-developed hyobranchial apparatus of *Cocytinus gyrinoides* from the Coal Measures of Ohio. Among other Paleozoic Amphibia, Williston has described branchial arches in the peculiar form *Lysorophus tricarinatus* Cope, from the Permian of Texas.

The form of the impression of the mandible in the present specimen is unlike anything known to the writer among other Carboniferous or later Amphibia. The rami are long, slender, deep, slightly curved and pointed anteriorly. The anterior symphysis was not a complete sutural union, but was occupied partly by cartilage or connective tissue.

There are no definite traces of appendicular structures. The traces of the body, plate 2, fig. 1, indicate an elongated, rather slender animal, but further than that nothing can be said in regard to its structure.

The occurrence of a typically caudate form in the Carboniferous is unusual, and complicates still further our understanding of the origin and relationships of the early Amphibia.

MEASUREMENTS OF THE TYPE OF ERIERPETON BRANCHIALIS MOODIE.

	mm.
Length of entire impression	50
Length of mandible along median line	10
Width of mandibular ramus	9
Length of basibranchial	2.5
Width of basibranchial	.75
Length of hypohyal	2.4
Width of hypohyal	1.5

Genus MICRERPETON, Moodie, 1909.

This genus was established by the writer on a single excellently preserved specimen (No. 12,313, University of Chicago). The genus is readily distinguished from other members of the Branchiosauridæ by the large size of the orbits, the short, heavy limb bones, the slender ilium and the expanded, elongate and flattened tail.

Micrerpeton caudatum Moodie, 1909.

There is but a single species known. It is fully described in previous papers. (Journal of Geology, vol. xvii, No. 1, pp. 39-51, with seven figures, 1909; Journal of Morphology, vol. xix, No. 2, pp. 516-520, with three figures, 1908.)

Genus EUMICRERPETON, Moodie, 1910.

Amer. Natl., vol. XLIV, June, 1910, p. 367.

This genus is based on well-preserved remains of three individuals from the Mazon Creek shales. One of the specimens represents, apparently, an adult, and the others are immature. The manner of the impressions resembles in a marked degree those described by Thevenin from the Commentry beds of France (plate 14). The nodules which inclose the remains measure, respectively, two and one-quarter and two and one-half inches in long diameter.

The generic characters are found in the very broad posterior table of the skull, with its short longitudinal length, the reduction of the tympanic notch and the short length of the body. The body length of *Eumicrerpeton* is as 2 to 4, while that of *Micrerpeton* is as 2 to 5, and that of *Branchiosaurus fayoli* is as 2 to 4⅓. The entire impression of the branchiosaurians from Saxony are not preserved, so that comparative measurements are not possible. Other generic characters are found in the sharp supratemporal angle of the skull, and it is to be distinguished from *Micrerpeton* especially by the short, stumpy limb bones. Its distinctions from the genera of Euro-

pean Branchiosauria are the same as those which distinguish it from *Branchiosaurus*, to which it is closely allied. The narrow, elongate eye, placed close to the edge of the skull, is a character not observed hitherto in the Branchiosauria. It recalls the condition described by Credner for the young forms of *Branchiosaurus amblystomus* Cred.[3]

Eumicrerpeton parvum Moodie, 1910.

(Plate 3, figs. 3 and 4; plate 4; plate 5, fig. 1; plate 6, figs. 1 and 2.)

The specific characters are found in the anatomical details. The impression of the outline of the entire body is preserved in both animals, and in both are found impressions and molds of the alimentary tract which in the younger animal are remarkably complete and instructive.

The impression of the larger animal, which is probably an adult, presents the following elements: the entire skull; both humeri; impressions of posterior and anterior ventral armature; portions of the alimentary canal; one femur; portions of a fibula and tibia; and the entire impression of the tail, on which, as in *Micrerpeton caudatum* Moodie, there occur two definite dark lines, one beginning at the tip of the tail and running obliquely along the tail to where the impression is broken at the anal region; the other beginning at a distance of four and one-half millimeters from the tip and running almost parallel with the median line. These two lines undoubtedly represent the lateral line system.

The skull is especially noted for its shortness and the great posterior width, as well as for the almost entire absence of the tympanic notch. The pineal foramen is located on a line with the posterior border of the orbits. The eyes themselves are narrow and acuminate at each end, with a pronounced convexity inward and a flattening outward. They are located on the very border of the skull, but relatively further posterior than in *Micrerpeton*. No sclerotic plates are evident. The median suture can be indistinctly observed running the entire length of the skull. The sutures bounding the outside of the frontals and the squamosals are partially evident but not satisfactorily preserved. The mandible is represented by a mold which in a wax impression shows short, stumpy teeth.

Posterior to the skull, at a distance of one millimeter, there are two sharp impressions, which may represent the anterior

3. Zeitschrift d. Deutsch. Geol. Gesellschaft, 1886, Th. VI, Taf. XVI, fig. 1.

edges of the interclavicle, or they may be branchial elements. They are distinctly curved, however, and probably represent portions of the interclavicle. A wax impression does not show a discrete structure, but the boundaries of some larger element. No other remains of the pectoral girdle can be discerned. The humeri are short and relatively thick. Wax impressions show them to have had truncate or slightly concave ends, thus indicating the absence or slight development of endochondrium. No other elements of the arm are preserved.

The ventral armature is preserved in two small patches, and these show the chevron-shaped rods to have been very fine—much more delicate than in *Micrerpeton.*

The body impression is very interesting, both as showing the form of the body and because in it are preserved the impressions of the larger portion of the alimentary canal. The form of the body can best be discerned by reference to the figures. (Plate 3, figs. 3, 4; plate 6, figs. 1, 2.)

The portions of the alimentary canal preserved consist of the greater portion of the stomach, three coils or loops of the small intestine, the rectum, and a pit which undoubtedly represents the anal opening. The anus is found at a distance of 16 mm. from the tip of the tail, and is somewhat removed from the body portion, as in modern salamanders. On each side of the posterior end of the rectum there occurs a pair of enlargements, which probably represent the oviducts at their posterior extremity.

The tail impression is more acuminate than in *Micrerpeton,* but shows the same structures as that form, *i. e.,* the lateral lines, which have already been mentioned. *Micrerpeton* was a more rapid swimmer than the present form, on account of the greater development of the tail. The impression of an elongate femur and the heads of the tibia and fibula of the left side are preserved.

The second specimen of the species (No. 802, Yale Museum) shows much the same characters as the specimen already described, except that there are preserved impressions of small, blunt teeth on the mandible. The two humeri and the femur of the left side are preserved, and the interclavicle is represented by an identical impression as in the first described specimen. The tail impression, although similar in form, does not exhibit so much of the structure of the lateral lines. The

present specimen is considered as more immature than the former, on account of its smaller size. There are no positive evidences in either specimen of branchial arches.

The matter of especial interest in connection with the second specimen is the remarkably perfect preservation of the alimentary canal. It is entire except for the very anterior end of the œsophagus. The posterior portion of the œsophagus, which measures three and one-half millimeters, is clearly preserved. Its anterior end is thrown around posteriorly, and indicates that this end was loosened after death and became displaced before preservation. The length preserved possibly represents the entire œsophagus. The œsophagus is constricted before it enters the stomach, which shows the usual curvature found in modern salamanders. The stomach measures six millimeters in length by two in greatest breadth. It consists of a single enlargement, as in the modern *Ambystoma punctatum*. The stomach enlarges somewhat toward the pyloric end, and then very gradually constricts to the pyloris. Three diameters of the small intestine can be discerned. The most anterior one, corresponding with the duodenum, is segmented, as though the intestine were filled with food substance. The remainder of the intestine, corresponding to the ileum, is looped in the form of two figures "8," which are superimposed, with the upper portions of the "8" at right angles to each other. The rectum is clearly discernible, though its lower end is somewhat obscured by having the lower portion of the upper loop of the intestine lying over it. The anus lies at a distance of one and one-half millimeters posterior to the line from the upper end of the femur, and is quite well back on the tail, as in modern salamanders. In this specimen also occur two oval bodies, which may be identified as the lower ends of the oviducts; thus indicating, in all probability, that the animal was a female.

A dissection of several species of modern urodeles has resulted in the discovery that the adult condition of the alimentary canal of all species dissected—*Ambystoma punctatum*, *Necturus maculosus*, *Diemyctylus torosus*, etc.—is much more complex than that exhibited by the specimen under discussion. A very near approach to the condition found in *Eumicrerpeton parvum* is found in an immature branchiate individual of *Diemyctylus torosus*, 56 mm. in length, from a fresh-water

pond on Mount Constitution, on Orcas Island, Puget Sound, Washington.

The similarity of intestinal structure is of considerable importance to our understanding of the relationship existing between the Carboniferous Branchiosauria and the modern Caudata. This fact only confirms other arguments, offered in another place, concerning their immediate relationship. (American Naturalist, vol. xliv, June, 1910.)

The branchiosaurian affinities of the present species are almost too evident to need discussion. The entire structure is essentially similar to that of other genera of the order.

MEASUREMENTS OF EUMICRERPETON PARVUM MOODIE.

Specimen No. 803, (222) Yale University Museum.

	mm.
Length of animal	37.5
Length of skull	4.5
Posterior width of skull at table	6
Long diameter of eye	1.75
Transverse diameter of the eye	.65
Length of left humerus	1.5
Length of femur	1.75
Width across base of tail impression	3.5
Length of tail from base to tip	17
Number of ventral armature rods in 1 mm	10

Measurements of second specimen, No. 802, (471) Yale University Museum.

	mm.
Length of animal	30
Length of skull	4
Posterior width of skull	5
Length of œsophagus	3.5
Length of stomach	6
Width of stomach	1.33
Estimated length of intestine	18
Width across base of tail impression	2.5
Length of tail from base to tip	7

Eumicrerpeton parvum Moodie (an additional specimen).

(Plate 5, fig. 1.)

After the above had been written the writer received from Mr. C. W. Gilmore, of the U. S. National Museum, an additional specimen of this species. It is No. 4400 of the U. S. National Museum. The additional specimen serves to substantiate the above-described genus and species, and shows

more clearly characters which are distinct from *Micrerpeton*, the genus to which the present form is most nearly related.

The present specimen is almost as perfectly preserved as was the specimen of *Micrerpeton caudatum* Moodie. When the nodule containing the fossil was received the tail was embedded in matrix, but by careful use of chisel and hammer it was possible to lay bare the whole tail, the tip of which ends on the very edge of the nodule. This was at once perceived to be precisely similar to that of the above-described specimens. The skull structure, the intermediate position of the pineal foramen, the epiotic notch and the shape of the skull are so exactly similar to those of *Eumicrerpeton parvum* that the specimen was unhesitatingly referred to that species.

Most interestingly, too, the present specimen has the alimentary canal preserved almost as perfectly as in the other two specimens; so that the three specimens of this species now known show the alimentary canal. The present specimen is, however, much more developed than the other two, if we may judge from the relative sizes. There is not the slightest trace of branchiæ in any of the specimens. The matrix does not preserve the skeletal elements as well as does the hard dolomite from Saxony, in which Doctor Credner found such excellently preserved branchiæ.

The present specimen is nearly half again as long as the smallest of the above-described specimens, and the skull is proportionately longer and wider. There is preserved also an impression of the anterior edge of both clavicles, as has been described for the Yale specimens; no other portion of the pectoral girdle is preserved. The right humerus is imperfectly preserved, as is also the right femur and tibia; other than these the fossil is merely an impression.

The skull is so nearly like what has been described for the Yale specimens that additional description is unnecessary. The pineal foramen is quite large, and lies on a line which cuts the orbits into equal longitudinal parts. The interorbital space is about equal to the long diameter of the orbit, as in the Yale specimens. Traces of sclerotic plates are observed in the left orbit, but they are quite imperfect.

The alimentary canal is unlike that of the Yale specimens, in that the INTESTINE is longer and much more convoluted. It lies in five longitudinal folds and ends in an enlarged cloaca,

near which there are impressions of two glands, or they may be the posterior ends of the oviducts, as was suggested for the Yale specimens. Like the Yale specimens, the œsophagus is displaced and partially obscured. The creatures undoubtedly fed on small plants and animals, much as do our recent salamanders. The alimentary tract is preserved fully extended.

MEASUREMENTS OF ADDITIONAL SPECIMEN OF EUMICRERPETON PARVUM MOODIE.

(Cat. No. 4400, U. S. N. M.)	*mm.*
Length of entire animal	45
Length of skull	6
Width of skull	9
Transverse diameter of orbit	1.50
Long diameter of orbit	2.25
Interorbital space	2.50
Diameter of pineal foramen	.50
Length of body from back of skull to pelvis	22
Greatest width of body	9
Length of tail	16
Width of tail at base	5
Length of humerus	3
Length of femur	2.50
Length of tibia (fibula ?)	1.75
Length of stomach	7
Width of stomach	3
Length of intestine (estimated)	56
Width of intestine	1

Genus MAZONERPETON, new genus.

It was very gratifying to discover among the remains loaned the writer by the Yale Museum other specimens exhibiting characters of the Branchiosauria, for our knowledge of this order of Amphibia is as yet very incomplete in North America. The specimen represents by far the largest of the group discovered on this continent. It is more than twice as long as the specimen of *Eumicrerpeton parvum* and fully one-third longer than *Micrerpeton caudatum*. It is, however, distinctly a branchiosaurian. The ordinal characters are discovered in the heavy, straight ribs, attached to the transverse process of the centrum; in the low degree of development of the vertebræ; in the structure of the skull and the ventral armature, and in the degree of ossification of the limb bones.

It may be generically separated from other known Branchiosauria found in North America by the great length of the dorsal region, and by the elongate tail with its well-developed

caudal ribs. It is not so readily separable from the Branchiosauria of Europe. It is most closely related to *Branchiosaurus amblystomus* Credner of the Permian and Carboniferous of Saxony. From this genus, however, *Mazonerpeton* may be distinguished by the reduction of the posterior tympanic notch, the broad nature of the scapula, the elongate interclavicle and the slender ilium in the present form. The number of dorsal vertebræ is identical in the two genera.

The genus is so closely allied to *Branchiosaurus* of Europe that the two species here described must be located in the family Branchiosauridæ.

Mazonerpeton longicaudatum new species.

(Plate 3, figs. 1 and 2; plate 7, fig. 3; plate 10.)

The remains on which the above species is based consist of the following elements: an incomplete skull, nearly the entire vertebral column, consisting of cervical, dorsal, sacral and caudal vertebræ, 36 in number; several ribs preserved on each side of the vertebral column, a portion of the ventral armature, the scapulæ, a clavicle, the interclavicle, both humeri, the radius and ulna of one side and the ulna of the other, portions of both hands, the ilium of the right side, both femora, and a partial impression of the left tibia.

The skull is unfortunately very poorly preserved. Enough remains, however, to determine the essential characters. The skull bones, unlike any other American branchiosaurian, have an ornamentation consisting of sharp pits and elevations, which in places have a quincuncial arrangement and in others take the form of definite lines of pits or tubercles similar to the condition found in many of the Microsauria. The orbits are large and are situated back of the median transverse line of the skull. They are almost circular in form and contain six elongated sclerotic plates very closely arranged around the borders of the right orbit. The plates are twice as long as wide. The interorbital width is one and one-fourth as great as the transverse diameter of the orbit.

Not many of the sutures of the skull are discernible. Portions of the frontals, the nasals, the prefrontals, the parietals and the supratemporals can be identified. Their arrangement is shown in figure 3, plate 7. There is a decided posterior table to the skull, with a truncate posterior border. The tym-

panic notch is shallow, with its outer border not so well protected as in *Branchiosaurus*.

The cervical vertebræ are incomplete, but their number was four or five, as in *Micrerpeton*. The structure of the dorsal vertebræ is also uncertain, although the shape can be discerned. The vertebræ are short and thick, very unlike the long, cylindrical vertebræ of *Cephalerpeton*. The heavy transverse process is quite evident on the best preserved vertebræ. This process recalls that described by Credner for the Saxony Branchiosauria. Several of the vertebræ show the attachment of the ribs to this process. The ribs of the caudal region recall very strongly those of *Branchiosaurus*. They are quite heavy in the anterior caudal region and then diminish rather rapidly to the point where the tail is broken and lost.

The ventral armature is represented by a patch of chevron rods twenty-one millimeters in length. The rods take a very peculiar form. They are short, crescentic bundles of fine rods, hair-like in appearance. In one of the bundles I count five smaller rods. The bundles are arranged in rows similar to the pattern so characteristic of the Carboniferous Amphibia, as described elsewhere. The patch of ventral armature preserved belongs to the abdominal region, so nothing can be told of the gular and thoracic rods. A single row of the crescentic bundles measures 11 mm.

Both scapulæ are preserved in their entire form. They are quite different from those of any other genera. They resemble a broad crescent with a posterior concavity and an anterior protuberance. The articular surface of both scapulæ is obscured. Vascular foramina occur near the base of both scapulæ. There are three of them in the right element, arranged in the form of an isosceles triangle. The morphology of these three foramina is uncertain. They have never before been observed among the Carboniferous Amphibia, and, so far as I am aware, they are entirely unknown among the higher vertebrates.

The temnospondylous Amphibia of the Carboniferous and Permian possess, in the coössified scapula-coracoid, three foramina, very similar to the present ones, but they are confined to the coracoidal region, and in the Branchiosauria the coracoid, as identified by Credner, is a free element, although I have never been sure with regard to its identity among American forms. Williston, in *Trematops*, has called these foramina the glenoid, supraglenoid and supracoracoid foramina

(Journ. Geol., xvii, No. 7). These are not, however, to be correlated with the three foramina above mentioned, since in the Temnospondylia the foramina belong with the coracoid and not with the scapula. The condition of the Temnospondylia occurs in the bony fishes, *Xiphactinus audax* Leidy; and an analogous condition obtains in the reptiles, as in the mosasaurs and dinosaurs, where the separate coracoid is pierced by foramina. Doctor Williston informs me that the foramina are also found among the Cotylosauria, where the condition is not far different from what it is in *Eryops*.

Near the outer end of the right scapula there is a large fragment preserved which, I think, must be the misplaced clavicle. It is obscurely triangular, or, more exactly, spatulate. The interclavicle is represented by fragments only. It seems to have had a narrow form.

The humeri recall those of *Micrerpeton*. They are somewhat elongate and apparently cylindrical in their normal condition, though somewhat flattened in the fossil. The shaft is considerably constricted at the middle, and the ends are expanded, in which expansion the lower end exceeds. The ends are abruptly truncate, indicating a small amount of endochondral ossification or its entire absence.

The mesopodial elements, unlike what has been described for *Cephalerpeton*, are quite dissimilar in form, recalling the condition in *Mesosaurus brasiliensis* McGregor. The larger element I take to be the ulna. It has the lower end greatly expanded and the shaft is curved outward. It resembles very much a reptilian ulna.

The radius is much smaller than the ulna, lacks the lower expansion, and is shorter by one millimeter. Its ends are abruptly truncate.

The carpus is represented merely by a blank space. There are no evidences of impressions of cartilage in the sandstone. The hand of the left side contains four digits. There are two phalanges preserved in the first digit, including the sharp-pointed terminal phalanx. The second digit has only the metacarpal. The third has the metacarpal and the first phalanx, which does not differ in form, but only in size, from the metacarpal. The fourth digit contains only the metacarpal. No definite evidence of more than four digits has ever been given for the hand of the Branchiosauria. Of the right hand there are portions of three digits preserved, including

three metacarpals and one phalanx. In structure they are not different from those of the right hand.

The ilium of the left side is preserved, apparently entire. It is elongate and cylindrical. Its upper end lies adjoining the twenty-eighth vertebra.

The head of the femur lies close to the lower end of the ilium, so that that element must have been suspended in the flesh much as in the modern salamanders. It could not have been of much use in support. The form of the femur is not unlike that described for the humerus, save that its lower end is smaller than the upper, while in the humerus both extremities are alike. A portion of the right femur is preserved extending in an opposite direction to the left. No portions of the leg or foot are preserved.

MEASUREMENTS OF THE TYPE OF MAZONERPETON LONGICAUDATUM MOODIE.

	mm.
Length of entire specimen	64
Length of portion of skull preserved	6.5
Posterior width of skull preserved	7
Width across orbits	11
Long diameter of the orbit	3
Transverse diameter of orbit	1.75
Interorbital width	4.75
Length of dorsal vertebræ	48
Length of caudal series	11
Length of anterior dorsal vertebra; 1 centrum	2
Length of anterior dorsal rib	4
Length of anterior caudal rib	1.75
Length of scapula	5
Greatest width of scapula	4.25
Probable length of interclavicle	6
Width of interclavicle	3
Length of clavicle	4.5
Width of clavicle	1.5
Length of right humerus	6
Distal width of humerus	2
Length of ulna	3.25
Distal width of ulna	1
Length of radius	3
Width of carpal space	2
Length of metacarpal	1.74
Length of first phalanx	1.75
Length of distal phalanx of right hand	.35
Number of bundles of chevron rods in 1 mm	4
Length of ilium	2.25
Length of femur	4
Proximal width of femur	1.50

The type is specimen No. 795 (1234), with obverse, of the Yale University Museum. Collected at Mazon Creek, Grundy county, Illinois.

Mazonerpeton costatum new species.

(Plate 2, fig. 3; plate 8, fig. 4; plate 9, fig. 2; plate 10.)

The remains on which the present species is based are inclosed in a much-fractured nodule. The parts of the animal which have been identified are as follows: A part of the skull and left mandible, two clavicles, a humerus, impressions of several vertebræ, a portion of the dorsal region of the body, with several ribs, two portions of the caudal region, with several ribs, and some unidentified fragments.

The animal, from the shape and form of the ribs, is undoubtedly a representative of the Branchiosauria, since short, heavy, straight ribs have not yet been found to be associated with other than branchiosaurian structures. Its association in the same genus with *Mazonerpeton longicaudatum* is held to be correct, on account of the resemblance in structure of the pectoral elements, the form of the humerus, and the length of the tail. The present species is about one-half larger than *Mazonerpeton longicaudatum*, and the animal which represents the species perhaps attained a length of four and one-half inches, while the length attained by the type of *M. longicaudatum* was not more than three inches. The tail of the present species is very long and slender, more elongate than in any other described branchiosaurian.

The part of the skull preserved is very unsatisfactory, and, aside from the fact that it seems to represent the under side of the left half of the skull, little can be said. Portions of three sutures can be observed, but what sutures they are is undetermined. The left mandible lies crushed on the edge of the skull and partially obscures what little there is of that structure. The slightly curved impression, from which the bone has been either broken or weathered, measures thirteen millimeters in length by three in posterior diameter by one in anterior diameter. These measurements show the element to have been slender and pointed anteriorly.

Very little accurate information can be derived from the study of the vertebral column of the specimen. The dorsal vertebral formula can not be made out, since only a portion of the length of that region is preserved, and only a few rather indefinite impressions can be discerned. These impressions

show the vertebræ to be short and higher than in most Branchiosauria.

The caudal series is represented by two sections. One of these sections is apparently from near the base of the tail, judging from the size of the caudal ribs preserved. The other section is from near the tip of the tail, and it shows the constituents to have been long and slender. Ribs are apparently absent on this section. The position of the two caudal sections shows that when the animal died it was coiled up much like a snake, so that in the fractured nodule three sections of the body are preserved. The tail was probably half as long again as the body.

The ribs throughout the body are short, heavy and straight, with, in the dorsal series, a lateral and a distal expansion, which is taken as a distinctive specific character. Judging from imperfect impressions in the dorsal series, the ribs were attached to a transverse process of the centrum, thus agreeing with other branchiosaurians in this respect. The ribs show a progressive decrease in length from the cervical region to the point of their disappearance on the tail.

The pectoral girdle is represented by two elements, one of which is certainly the right clavicle, and the other is possibly the left clavicle, though its form is somewhat distorted by pressure. Both elements are in the form of an elongate spatula, with the dorsal surface greatly concave and the inner end acuminate.

The right humerus is imperfectly preserved, though the impression allows one to gain an exact knowledge of its form. It lies under the right clavicle. Its ends are truncate with a contracted shaft and expanded extremities. The bone was apparently hollow.

In another nodule (No. 804, Yale Museum) there is a single bone preserved, which resembles to a great extent a rib of the present species, although somewhat larger, and it has been provisionally identified as such. The element is very slightly curved, but it shows the expanded head of this species. (Plate 2, fig. 3.)

MEASUREMENTS OF THE TYPE OF MAZONERPETON COSTATUM MOODIE.

	mm.
Length of portion of skull preserved	14
Length of right clavicle	16
Width of right clavicle	4
Length of dorsal region represented	30
Length of cervical rib	8
Length of dorsal rib	6.5
Length of caudal rib	3
Length of caudal portion of the body preserved	55
Length of mandible	15
Greatest width	6
Length of right humerus	10
Greatest width of right humerus	2

The type is No. 800 (777) of the Yale University Museum. Collected at Mazon Creek, Grundy county, Illinois.

MEASUREMENTS OF SPECIMEN NO. 804 (332).

	mm.
Length of rib	11
Width of head of rib	2
Diameter of shaft	1

Amphibamus grandiceps Cope, 1865.

(Plate 1, figs. 1 and 2; plate 5, fig. 3; plate 7, fig. 1; plates 11, 12, 13.)

The collection of Carboniferous Amphibia loaned the writer for study by the Yale Museum contains an unusually perfect example of *Amphibamus grandiceps* Cope. The skull is nearly complete, although the sutures are indistinct. The following parts have been identified in the specimen: the greater part of the vertebral column, ventral armature, ribs, portions of the pectoral girdle, the pelvic girdle, and all four limbs, with the hands and feet in an unusually perfect condition, all very clearly and distinctly shown on a nodule from the Mazon Cheek shales of Illinois. The specimen was collected near Morris, Illinois, in 1870.

The writer (1909) published a restoration of this species, in which he gave to the vertebral column twenty-six vertebræ, the exact number being at that time uncertain. Professor Cope (1865) in his original description gave the number as thirteen between the interscapular region and the sacrum. Hay (1900) thought the number was less than twenty. The present specimen shows that there were twenty-two in the presacral region, not including the sacral vertebra; thus showing that in two cases too few vertebræ and in the third case too many vertebræ were assigned to the vertebral column.

The author's published restoration gave too great a length of tail. The present specimen shows only ten cadual vertebræ, the most anterior of which are provided with short ribs.

One of the most interesting features of the present specimen of *Amphibamus grandiceps* Cope is the preservation of a small patch of skin, evidently from the back. It lies off to one side, near the head, as though the skin had been loosened and floated away from the body or was moved in some manner. The remnant measures 5 mm. in length by 3 mm. in width. The fragment shows the skin to have been made up of tuberculated scales, four of which occur in the length of one millimeter. The scales are somewhat hexagonal, almost rounded, and were relatively quite thick. They lie in a close mosaic.

The cranial structure presents no new features. There are evidences of twenty small, oblong, sclerotic plates preserved in the right orbit. These form about two-thirds of the circumference of the iris, so that twenty-nine or thirty was probably the correct number of these plates. Their position near the center of the orbital space shows clearly that they were sclerotic plates, and not palpebral scales, as Professor Cope thought they might be from his study of the type. The obverse of the specimen shows that the skull bones were pitted, especially in the nasal region, as Hay has described for the specimen in the possession of Mr. Daniels. The sutures are very indistinct and uncertain and can not be described. They are well known, however, in other specimens.

The present specimen adds to our knowledge of the ventral scutellæ, as is shown in figure 1, plate 7. The plates of the throat, chest and belly have different directions. The arrangement of the plates on the throat and chest is almost exactly the reverse of what Credner has described for *Branchiosaurus amblystomus* Cred. On the throat, in the present form, the chevron points anteriorly, and it is the anterior prolongation of the belly scutes with the posterolateral projection of the gular plates which forms the chest and arm scutellation. The belly chevrons point anteriorly, as in the species from Saxony. The rods formed by the scutes are straight, and not curved as in *Branchiosaurus*. The entire ventral armature preserved is misplaced to the left of the animal, and only the anterior portion is preserved, containing a length of 18 mm. There are three scutes to the millimeter.

Nothing new can be ascertained of the structure of the pectoral girdle. Portions of the scapulæ, clavicles and interclavicle are represented, and perhaps the coracoid is indicated by a fragment.

The specimen in hand completes in a very satisfactory manner our knowledge of the structure of the pelvis. The relations, form and structure of the ilium, ischium and pubis are now known quite certainly. The form of the ilium as shown in previous restorations was slightly inaccurate. It was made a little too long and too curved. It is, instead, rather short and nearly straight, with the ends expanded. Heretofore nothing was known about the ischium, but the present example shows very clearly the form of that element on both sides of the vertebral column. Its form is almost identical with that of *Paleohatteria longicaudata* Credner, from the Rothliegenden of Saxony. They are apparently approximate in the median line, though this character is somewhat obscured by the impressions of the caudal vertebræ. Its relation with the ilium, other than that it was posterior to it, is uncertain. All three of the pelvic elements were undoubtedly hung loosely in the flesh of the animal, as in modern salamanders, since none of the elements present any marked articular surfaces.

The structure of the sacral vertebra and the sacral ribs still remains to be determined. There seems to have been but a single pair of sacral ribs, but the specimen is too obscured to shed much light on that point.

Nothing new is added to our knowledge of the arm. The number of phalanges can not be ascertained. Two of the digits are preserved entire, and there is nothing in their structure to contradict the number given in the restoration which is herewith republished. Each hand has a single digit of four segments preserved. They undoubtedly represent the third digit in each case.

The elements of the leg and foot are as they are given in the restoration. The right foot is preserved almost entire, and the digits have the formula 2-2-3-4-3. The distal phalanges of the third and fourth digits are lost. There are five digits in the foot.

The fifth anterior dorsal vertebra has a pair of long, curved ribs attached intercentrally. The ribs have the same bicipital

appearance as observed in Mr. Daniels' specimen. They are present throughout the dorsal series, apparently missing from the lumbar region, and appearing again in the caudal region. How much of this is due to accident is hard to determine.

The structure of the vertebræ can be partially observed in the specimen. The neural spine was a long, low crest, which ran the entire length of the centrum, with a median elevation, so that on lateral view the spine would be triangular in form. The body of the centrum is expanded laterally into a diapophysis which projects anteriorly. In the posterior region of the dorsal series the mold of the interior of the vertebra shows that the notochord was largely persistent and that the osseous portion of the vertebra was but a thin shell.

The structure of the zygapophyses can not be determined. That they were dorsal in position is, however, evident from several vertebræ. The points of these structures project laterally. There is a notch between the anterior zygapophysis and the roof of the neural canal.

The restoration of the skeleton of this species, given on plate 12, is a summary of existing knowledge of the skeletal anatomy of the genus. Much remains to be determined, such as the arrangement of the scutes of the ventral armature, the anatomy of the pectoral girdle, and the more exact knowledge of the feet and vertebræ. The restoration gives approximately the form of the body and the condition of the skeleton as we know it at present.

MEASUREMENTS OF THE SPECIMEN OF AMPHIBAMUS GRANDICEPS COPE.

	mm.
Length of skeleton	67
Length of skull	15
Posterior width	15
Depth of tympanic notch	4
Width of tympanic notch	6
Long diameter of the orbit	7
Transverse diameter of the orbit	5.5
Interorbital width	4.5
Diameter of the pineal foramen	.75
Length of cervical series of vertebræ	9
Length of dorsal series	35
Length of caudal series	13
Length of centrum of the dorsal series	1.5
Length of a dorsal rib	3.5
Length of arm	20
Length of humerus	7
Length of radius and ulna	4
Width of carpal space	3
Length of third digit	5
Length of leg	25
Length of ilium	3
Length of femur	9
Length of tibia and fibula	5
Length of carpal space	4
Length of first digit	3
Length of second digit	4.5
Length of fourth digit	7
Number of ventral scutellæ in 1 mm	3

The specimen, with obverse, is No. 794 (1234) of the Yale Museum.

Amphibamus thoracatus Moodie, 1911.

(Plate 5, fig. 2.)

The chief diagnostic characters which will at once distinguish the species are: the elongate arm, the large interclavicle, the shape of the vertebra, and the triangular skull.

The portions of the animal which are preserved are: the impression of the skull with one orbit, the right humerus and radius (ulna ?), the interclavicle, the left clavicle, a single vertebral centrum with portions of others, and traces of the scutellæ. These remains are so intermingled with the remains of plants that it has been quite difficult to distinguish bone impression from that of plants. This, however, has been done by whitening the fossils with ammonium chloride, when the texture of the fossils serves to distinguish the one from

the other. Parts of the plants have been converted into and destroyed by galena and kaolin, as have also parts of the bones, so that the task has been doubly difficult. There can be no doubt, however, that the observations recorded below are correct. The position of the arm in relation to the pectoral girdle and the position of the girdle in relation to the skull impression first called attention to the possible presence of a fossil amphibian.

There is little to be said of the skull. It is merely an impression in the nodule. It is triangular in form with the snout an acute angle. The angle is, however, exaggerated by the compression to which the fossil has been subjected. The right side of the skull lies over a portion of some plant. The animal is preserved on its back, so that this gives a good opportunity for the study of the pectoral girdle, which is partially preserved. The interclavicle is very large, and from that character the species has been given its name (thoracatus =armed with a breast plate). The interclavicle is an exaggerated "T" with the stem very short. Its anterior margin is curved and ends is a rather sharp, elongate point. The posterior spine is quite short and sharp-pointed, having a length of four millimeters. The interclavicle recalls, in a measure, the same element of *Branchiosaurus*, although it is much more expanded anteriorly and has a shorter spine. In these respects it resembles more nearly a reptilian element. The bone is quite smooth.

The clavicle is of the simple triangular form so characteristic of the Microsauria. It is somewhat displaced backward and its inner margin is slightly obscured.

The humerus is elongate, apparently cylindrical, and has expanded ends. It resembles closely the humerus of *Amphibamus grandiceps*, although its proportions are much greater than in that species. Its length is almost equal to the length of the skull, while in *A. grandiceps* the length of the humerus is only one-half that of the skull.

The radius (ulna ?) resembles in its general proportions those of the humerus. It is a more slender, lighter bone. The impression of the other bone of the fore arm is obscured.

A portion of a single vertebral centrum is preserved. It is from the posterior part of the dorsal series. The centrum is apparently amphicœlous. Its height is about one-half greater than its length. The neural spine is obscured.

The species *Amphibamus thoracatus* Moodie has been described in the Proceedings of the U. S. National Museum, volume 40, page 431, figure 2, 1911.

MEASUREMENTS OF THE TYPE OF AMPHIBAMUS THORACATUS MOODIE.
(Cat. No. 4306, U. S. N. M.)

	mm.
Length of entire specimen as preserved	60
Length of skull impression	18
Greatest width of skull impression	15.5
Long diameter of right orbit	4
Transverse diameter of right orbit	3
Transverse width of interclavicle	14
Long diameter of interclavicle	7
Long diameter of clavicle	9
Greatest transverse diameter	3
Length of humerus	10
Greatest diameter of humerus	4
Least diameter of humerus	1.5
Length or radius (ulna ?)	11
Length of vertebral centrum	2
Width of vertebral centrum	3

Genus CEPHALERPETON, new genus.

This genus is founded on remains of an incomplete individual of a relatively large microsaurian from the Mazon Creek shales. The genus is most immediately related to the family Amphibamidæ, of which two species are known. The present form differs from these species in many respects, notably in size. The skull in the present genus is nearly as long as half the entire body of *Amphibamus grandiceps*, inclusive of the tail. Other structural differences are the anisodont teeth, the large size and more median position of the orbits, and the absence of the posterior tympanic notch in *Cephalerpeton*. The form of the skull recalls that of *Melanerpeton* and *Pelosaurus* of Europe, but they are both branchiosaurians, while the present form, from the structure of the vertebræ and the long, curved ribs, is an undoubted microsaurian. Nothing like it occurs in the Kilkenny, Ireland, fauna described by Huxley, and it is totally different in structure from any of the Linton or Cannelton genera, and its like is not known among the forms from the continent of Europe. It is most nearly approached in certain respects by the various species of *Erpetosaurus*, but from this genus it can be readily distinguished by the smooth skull bones, the absence of a posterior table to the skull, and the presence of a highly de-

veloped ventral armature. The interorbital width is less than the transverse diameter of the orbit.

The generic characters are found in the broad skull, the anisodont teeth, the median position of the orbits, the absence of a tympanic notch or posterior table to the skull, the presence of sclerotic plates, the great length of the fore limb and the well-developed ventral armature.

Cephalerpeton ventriarmatum new species.

(Plate 1, fig. 4; plate 7, fig. 2.)

The remains on which the present discussion is based consist of an almost entire skull, twenty-six consecutive vertebræ, both fore limbs, twenty ribs preserved on the right side of the vertebral column, and a portion of the ventral armature.

The skull is very broad posteriorly, its width being one-third greater than its length, with due allowance for crushing. A pineal foramen is not preserved. The sutures bounding the premaxillæ, the maxillæ, the nasals, the prefrontals, the frontals, a portion of the parietals, the squamosal, the supratemporal, the quadratojugal and the quadrate (?) are fairly well preserved. The arrangement of these elements can be discerned by reference to figure 2, plate 7. The prefrontals are unusually large and are triangular in shape. The supratemporal is also quite large. The epiotics and the supraoccipitals are not preserved. The surface of the skull bones is smooth and there is nowhere an indication of sculpture.

Portions of four sclerotic plates are preserved in the right orbit. These measure one-half by three-quarters millimeters. The orbits are large and the interorbital space is less than the transverse diameter of the orbit. Thirteen teeth are preserved on the left maxilla. The teeth are apparently pleurodont. They are short, sharply pointed, smooth and unequal. The first two left maxillary teeth from the anterior end are short. Then follows a tooth which is one-third longer than these two. The fourth tooth is somewhat shorter than the third. The fifth and sixth are still shorter and are practically equal. The seventh, eighth and ninth are all large. The ninth is the largest and the diameter of the base is greater than the third. The last four teeth are practically equal in size, though somewhat larger than the first two.

The right mandible is preserved almost entire, though so badly eroded that little can be said of its structure. Impressions of twelve teeth are present on the mandible, and all

are apparently equal. The cotylus seems to have been far posterior and an angle of the mandible projected slightly back of the skull.

There remain only a few indefinite impressions of the cervical vertebræ. The union of the skull with the vertebral column is obscured and lost. Impressions of the dorsal vertebræ are well preserved. Wax molds made from these impressions show the structure of the dorsal vertebræ surprisingly well. The vertebræ are long and cylindrical, with the median portions slightly constricted by a deep pit on each side of the low neural ridge, which takes the form observed in *Thyrsidium, Molgophis, Phlegethontia, Dolichosoma* and other genera. The vertebræ are strongly amphicœlous and the notochord was probably persistent. The sides of the vertebræ are smooth.

The ribs are all intercentral in position, agreeing in this respect with all other Carboniferous Microsauria so far studied. The anterior ribs are very broad near the base and recall the broadly expanded ribs described by Schwarz for *Scincosaurus, Ptyonius, Thyrsidium* and other genera. Posteriorly the ribs become slender and cylindrical. They are all rather long and distinctly curved, with probably a cartilaginous tip.

There is preserved a single element of the right side of the pectoral girdle. This is, I think, the coracoid, an element which has hitherto escaped observation among the American Microsauria. It is long, and spatulate at both ends. Its median portion was apparently almost cylindrical. Its form is not unlike that described by Credner for the coracoid of *Branchiosaurus*, save that the lower end of the branchiosaurian coracoid is acuminate. In the present genus it is spatulate. Its relations with other elements of the pectoral girdle have never been satisfactorily determined.

The fore limbs are both partially preserved. The humerus of the right side is complete. It is greatly elongate for a microsaurian. The form of the element is not unlike that of a lizard. The lower end of the bone is spatulate. Endochondrium seems to have been well developed. Very little difference can be seen between the forms of the arm bones which represent the radius and ulna. They are both elongate, with constricted median portion and expanded truncate ends. The

carpus is unossified and the cartilage has left no impression on the stone.

The right hand has two metacarpals preserved, which are fully one-half as long as the radius and ulna. They are separated some little distance from the ends of these elements. This may be due to post-mortem shifting, though the carpus was undoubtedly broad. On the left side are preserved a portion of the humerus, the radius and the ulna, with three metacarpals lying next to the vertebral column. The carpal space is not so large on the left as on the right side. The ventral armature is well preserved in a narrow patch about one inch in length. The chevron-shaped rods are quite large, there being two of them in one millimeter.

The type specimen is No. 796 of Yale University Museum. Collected in 1871, at Mazon Creek, Illinois.

MEASUREMENTS OF THE TYPE OF CEPHALERPETON VENTRIARMATUM MOODIE.

	mm.
Entire length of fossil	98
Length of skull	22
Width across base of skull	28
Long diameter of the eye	10.5
Transverse diameter of the eye	8
Interorbital space	4
Length of mandible	26
Depth of mandible at the coronoidal region	3.5
Depth of dentary	2
Length of a long tooth	2
Diameter of long tooth at base	.5
Length of vertebral column preserved	64
Length of a centrum	3
Median width of centrum	1.5
Length of rib	6.5
Width of rib at base	.33
Length of coracoid	8
Width of coracoid at anterior end	2.5
Length of humerus	18
Width of shaft	1
Distal width of humerus	4
Length of radius or ulna	10.5
Width across proximal ends of ulna and radius	3
Length of carpal space	5
Length of metacarpal	6
Length of ventral armature preserved	24
Number of rods in a length of 5 mm	10

Genus ERPETOBRACHIUM, new genus.

The remains on which the discussion of the present genus is based are contained in a rounded nodule, with obverse, from the Mazon Creek shales, some three and one-half inches in diameter. The matrix is the usual reddish ironstone of the nodules contained in these beds, and the bones have been replaced by kaolin. The parts preserved are the scapula, clavicle, portion of the coracoid, the humerus, the ulna and radius, all of the right side of the body.

The generic characters are apparent in the greatly elongated fore limb, in the exceptionally broad scapula, the long radius and ulna, which almost equal the humerus in length —a character hitherto unknown among Carboniferous Amphibia.

Erpetobrachium mazonensis new species.

(Plate 2, fig. 2; plate 8, fig. 3.)

The scapula of the present form is exceptional in its shape. It resembles an asymmetrical pyramid, the anterior side of the lower edge of the bone being contracted so that the anterior edge is arcuate. Its top is very thin, and possibly terminated in a broad cartilage. The lower end is thick and heavy, and the articular surface is apparently well formed, though somewhat obscured.

The element identified as clavicle is lying on its edge and has the proportions of the clavicle of *Mazonerpeton costatum*. The exterior end is somewhat rounded and small. A portion of another element, which I suppose to represent the coracoid, lies alongside the humerus. Its form is quite obscured.

The humerus has a remarkably well-formed head. Its perfection of formation corresponds well with that of the higher reptiles. Its surface can even be divided into an anterior and posterior articulation. It projects posteriorly for the distance of one millimeter from the surface of the shaft. The shaft immediately below the head is somewhat flattened and has an ovoid section. Further on it becomes more flattened, a part of which is probably due to pressure during fossilization. The distal end is somewhat obscured.

The elements of the fore arm are both preserved, and are approximately equal in size. They are remarkable in that they exceed or at least equal the humerus in length, although they are not so heavy as that element. They are greatly

elongate and slender, with the middle of the shaft only moderately contracted. The articular surfaces are well formed, and both bones were hollow, as was also, apparently, the humerus. The ulna is taken to be represented by the most posterior of the two elements, though the relations of the elements may have been reversed.

The base of the left wing of an orthopterous insect, possibly allied to *Paolia gurleyi* Scudder, lies between the radius and the ulna. The nodule also contains impressions of plants, a portion of a frond of a *Neuropteris*, and the impression of one of the *Cordaites*. Lying next the radius is a slender, elongate element, which may be a rib or a portion of a metacarpal. If a rib it indicates that the animal belongs among the Branchiosauria. The fragment is only one-half as long as the radius and is entirely too obscure to base any conclusions upon. The other characters of the specimen point quite strongly to its microsaurian affinities.

The structure of the articular surfaces of the limb bones alone would indicate the microsaurian relationship of *Erpetobrachium*. It may be provisionally associated in the family Molgophidæ with such forms as *Molgophis brevicostatus* Cope, *Molgophis (Pleuroptyx) clavatus* Cope, and *Molgophis macrurus* Cope, from the Coal Measures of Linton, Ohio.

MEASUREMENTS OF THE TYPE OF ERPETOBRACHIUM MAZONENSIS MOODIE.

	mm.
Length of scapula	14
Distal width	6
Proximal diameter	3
Length of clavicle (?)	24
Length of humerus	25
Length of ulna	24
Proximal width	4
Diameter of the shaft	2
Distal width	3
Length of radius	25
Proximal width	4
Diameter of the shaft	3
Width of distal end	4

The type specimen is 799 (222) of Yale University Museum. Collected at Mazon Creek, Grundy county, Illinois.

Genus SPONDYLERPETON, new genus.

The specimen on which the genus is founded consists of nine imperfect vertebræ, from the caudal region, inclosed in a brown ironstone nodule from the Mazon Creek shales.

There have been, up to the present, but two *Carboniferous* genera of the embolomerous Stegocephala described. These are *Cricotus* from Illinois, Kansas and Texas, and *Diplospondylus* from Bohemia. Four, possibly five, species have been assigned to *Cricotus* and a single species to *Diplospondylus* (Fritsch, Fauna der Gaskohle, Bd. 2, Taflη 50, 52, 53). It is with considerable interest that the writer is able to add yet another form to the list of known Embolomeri by the description of the largest form of the Mazon Creek amphibian fauna. The present form exceeds *Diplospondylus* by twice its size and is about two-thirds the size of *Cricotus heteroclitus* Cope.

It differs in several important characters from the two genera above mentioned, but is for the present to be located in the same family, the Cricotidæ of the suborder Embolomeri and the order Temnospondylia.

The present form is distinct generically from any form which have been described. The generic characters are found in the form of the vertebral centrum and in the enlarged intercentra. The present vertebræ are twice as high as wide, differing thus from *Cricotus*, in which the centra are practically circular. A character which is of great importance is the large size of the intercentrum, which almost equals the pleurocentrum in size. It is similar to the pleurocentrum in structure, except for the attached neurocentrum and chevron. The present form differs from *Diplospondylus* in the greater length of the intercentrum and pleurocentrum, in the greater size, in the larger proportions of the neurocentrum and the greater proportionate size of the intercentra.

Spondylerpeton spinatum new species.

(Plate 8, figs. 1 and 2; plate 9, fig. 1.)

The species is very imperfectly known. Sufficient is present, however, to show its wide generic differences from other forms of the Cricotoidæ. These characters are of a phylogenetic nature, and indicate the more primitive nature of the present form, as we would expect from its geological position. The sutures separating the four vertebral elements are clearly

apparent. The pleurocentral-neurocentral suture is apparent in four vertebræ.

There is but a single pleurocentrum preserved complete. This shows the form of the attached neurocentrum and chevron, which corresponds to the hypocentrum pleurale, according to Fritsch. These structures are shown in the drawing, figure 1, plate 9. The pleurocentrum is flattened laterally, with a rather large canal for the notochord. Its sides are marked with four longitudinal grooves. Surfaces for the attachment of ribs are not present, and for this reason, as well as the presence of chevrons, the vertebræ are supposed to be caudals. As such, they represent an animal of some three or four feet in length. It was the giant of the Mazon Creek Amphibia.

Attached to the upper side of the pleurocentrum by a sutural union occurs the neurocentrum. The neural arch is quite large and is oval in outline, although somewhat constricted at the tip. The spine of the neurocentrum is rather long and broad at its base, measuring 12 mm. across the anterior zygapophysis. The nerocentrum is laterally flattened and ends in a rather acute and somewhat rugose point. It was probably tipped with cartilage. The anterior zygapophysis occurs well down on the neurocentrum; its lower edge being five millimeters from the suture separating the pleurocentrum and the neurocentrum. The posterior zygapophysis occurs quite high up on the neurocentrum, and lies at a distance of 15 mm. from the pleuro-neurocentral suture, thus indicating an extreme posterior inclination of the neural spine. The posterior zygapophysis of the best-preserved vertebra is separated from its mate, the anterior zygapophysis, on the next succeeding vertebra, by a space of five millimeters.

The ventral surface of the pleurocentrum bears a structure which is without doubt a chevron, although the character of the opening can not be determined. It is elongated and is united by a broad base to the pleurocentrum. Its union is by a clearly defined suture, which is apparent on three vertebræ. The condition represented by the specimen represents almost exactly the condition figured by Cope for the caudal region of *Cricotus crassidiscus* Cope[1].

The intercentrum of the present form is fully as large as the pleurocentrum. The significance of this has already been

1. Cope, E. D., 1890. Trans. Amer. Phil. Soc., vol. xvi, p. 246.

mentioned. There is no difference, except for the attached neurocentrum and chevron, in the form of the intercentrum and the pleurocentrum. Its body is pierced by the large notochordal canal.

The condition of the vertebral structures represented by the above-described form is so essentially similar to that of *Cricotus*, which has been fully described by Cope, that nothing new can be added to the phylogenetic relations of the separate pieces of the vertebral column. It is remarkable that such a type should be found so low in the geological scale, but it is not unexpected, since we must, without doubt, look to the early Devonian or late Silurian for the earliest types of the Amphibia, which are yet unknown, although they have left their footprints in the rocks of the Devonian and Mississippian epochs of this country and a single skeleton in the Subcarboniferous of Scotland. That our knowledge of the amphibian fauna of the Carboniferous is woefully incomplete is attested by the fact that nearly every specimen collected represents a type distinct from any hitherto known. Such is eminently true of the collection which has just been described. The characters on which the genera and species are based are apparently ones of value, for they have stood the test of time in other groups.

MEASUREMENTS OF THE TYPE OF SPONDYLERPETON SPINATUM MOODIE.
(No. 793 (26) and obverse, Yale University Museum.)

	mm.
Length of specimen	60
Length of pleurocentrum	11.5
Height of pleurocentrum to base of neurocentrum,	20
Length of neurocentrum	33
Width of neurocentrum at base	9
Width across anterior zygapophysis	12
Width across posterior zygapophysis	10
Length of intercentrum	10
Height of intercentrum	10.5
Height of chevron	3
Length of chevron	18
Width of notochordal opening	5
Height of notochordal opening	4.5
Height of neural canal	12
Greatest width of neural canal	6

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