THE VERTEBRATE FAUNA OF THE SELMA FORMATION OF ALABAMA

PART VII
THE MOSASAURS

DALE A. RUSSELL

PART VIII
THE FISHES

SHELTON P. APPLEGATE

FIELDIANA: GEOLOGY MEMOIRS
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CURATOR OF FOSSIL VERTEBRATES
NATIONAL MUSEUM OF CANADA

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THE MOSASAURS

INTRODUCTION

In the course of preparing a revision of the North American mosasaurs I visited the Field Museum of Natural History briefly during the spring of 1963. Dr. Rainer Zangerl very generously presented me with the opportunity of describing the Selma mosasaurs, and sent the collection to me at Yale the summer of the following year. Unfortunately, there was insufficient time for me to study the collection at Yale and Dr. John Ostrom, of the Yale Peabody Museum, undertook to transport it to Ottawa before my arrival at the National Museum of Canada. I am very grateful to both of these gentlemen for their much appreciated assistance and courteous forbearance.

The present paper was written after completion of the mosasaur monograph (Russell, 1967) and the reader is referred to this work for more complete generic and specific diagnoses of various American forms. The material under discussion was collected in 1945 and 1946 from the Mooreville Member of the Selma Chalk in central Alabama (see Zangerl 1948, pl. 3; 1953a, fig. 19 for locality maps). Much of it seems to have been found as surface float. Numbers preceded by P or PR refer to specimens in the Field Museum of Natural History, those preceded by USNM and YPM refer to specimens in the U. S. National Museum and Yale Peabody Museum respectively.

PREVIOUS WORK

The first mosasaur material known from the "Rotten Limestone of Alabama," and in all probability the Mooreville Member of the Selma Chalk, consisted of two badly weathered, otherwise unidentifiable vertebrae, three vertebrae of a plioplatecarpine or small tylosaurine, and a single tooth of a plioplatecarpine. These specimens were described and figured by Robert W. Gibbes (1850, 1851) as the name-bearers of three indeterminate taxa of mosasaurs, respectively *Amphorosteus brumbyi*, *Mosasaurus minor*, and *Holcodus acutidens*. Cope (1869) firmly established the species *Clidastes propython* on an unusually complete skull and skeleton, and later (1869–1870) based "*Liodon congrops*" on a cervical vertebra probably belonging to this species. His (*Ibid.*) *Tylosaurus*? *perlatus* is known only from a very poorly preserved vertebra.

Two inadequately known but highly interesting species of mosasaurs with inflated marginal dentitions have been discovered in the Mooreville Member. The identity of the first of these to be described, "*Platecarpus*" *intermedius* (Leidy, 1870), is based largely on two dentary fragments with closely spaced, bulbous teeth (see Leidy, 1873, pl. 34, figs. 1–5). The dentary terminates immediately in front of the first tooth as in *Platecarpus*, but new material will probably show the form belongs to a distinct genus. *Globidens alabamaensis* with its characteristic hemispherical teeth was described by Gilmore in 1912. The few skeletal fragments in the type indicate the animal was more closely related to *Clidastes* than any other mosasaur (Russell, 1967). It is unfortunate that subsequent collecting has not increased our knowledge of the morphology of these two unusual Selma mosasaurs.

More recently Renger (1935) has published a popular description of a skull and skeleton of *Tylosaurus*, and Dowling (1941) noted the occurrence of a small but rather completely preserved skeleton of *Platecarpus*. Both specimens were taken from the Mooreville Member. Before the Field Museum of Natural History began collecting in the Selma Chalk in 1945, the known mosasaur fauna consisted of:

Clidastes propython, near Uniontown, Perry County
Globidens alabamaensis, near Hamburg, Perry or Dallas County

Platecarpus sp., near Eutaw, Greene County

"*Platecarpus*" *intermedius*, Pickens County

Tylosaurus sp., near West Greene, Greene County

SYSTEMATICS

Subfamily Mosasaurinae

Halisaurus sternbergi

Clidastes sternbergi Wiman 1920, Bull. Geol. Inst. Upsala, **18**, p. 13, figs. 4–9, pls. 3–4.

Referred material.—PR 186 frontal, pterygoid, and dentary fragments, one dorsal, and one pygal vertebrae. From West Greene, Greene County, Alabama. Collected by C. M. Barber. PR 195 frontal, basioccipital, two cervical, 19 dorsal, and ten caudal vertebrae. From Harrell Station area, southeast of Marion Junction, Dallas County, Alabama. Collected by J. A. Robbins.

Revised generic diagnosis.—Premaxilla "U"-shaped in horizontal cross-section, no rostrum present anterior to premaxillary teeth. Premaxillo-maxillary suture rises

vertically from ventral jaw margin, makes abrupt turn and continues posteriorly in nearly straight line to position dorsal to eleventh maxillary tooth. Suture smoothly keeled and parallels longitudinal axis of maxilla. Sutures for prefrontal and postorbitofrontal very widely separated on undersurface of frontal. Lateral margins of frontal nearly straight, and converge only slightly anteriorly, median dorsal ridge rounded and large. Median dorsal surface of parietal very broad, parietal foramen moderately large. Foramen for cranial nerve VII enters prootic in center of prootic incisure. Suprastapedial process of quadrate moderately large, tympanic ala thick. Infrastapedial process absent on quadrate. Surangular does not extend behind mandibular cotylus.

Vertebral formula: 31 presacral vertebrae, 4 pygals, 72 chevron bearing caudals.

Articulating surfaces of cervical and anterior dorsal vertebral centra nearly twice as wide as deep, subrectangular in outline. Synapophysis located in center of lateral surface of cervical centra, occupies somewhat more posterior position in anterior thoracics. Ventral border of anteroventral extension of synapophysis weak and horizontal in anterior cervicals, becomes much enlarged in posterior cervicals and anterior thoracics, extending far below flattened undersurface of centrum. Anterior zygapophysis of cervical and anterior thoracics connected by gently rounded, posteriorly descending crest to synapophysis. Zygosphene-zygantrum weak or absent. Hypapophyseal peduncle located posteriorly on ventral surface of cervical centra, articulation for hypapophysis flat and lenticular, slightly inclined posteriorly. Neural spines of caudal vertebrae longest on postsacrals 30–32, do not become vertical.

Scapula much smaller than coracoid. Superior border of scapula gently convex, posterior border emarginate. Coracoid expands broadly behind glenoid articulation. Distal and proximal ends of slender humerus only slightly expanded, radial and ulnar tuberosities absent, well-developed spherical head present. Radius elongate, proximal end slightly expanded. Shaft of radius narrow. Distal end bears moderately well-developed anterodistal flange.

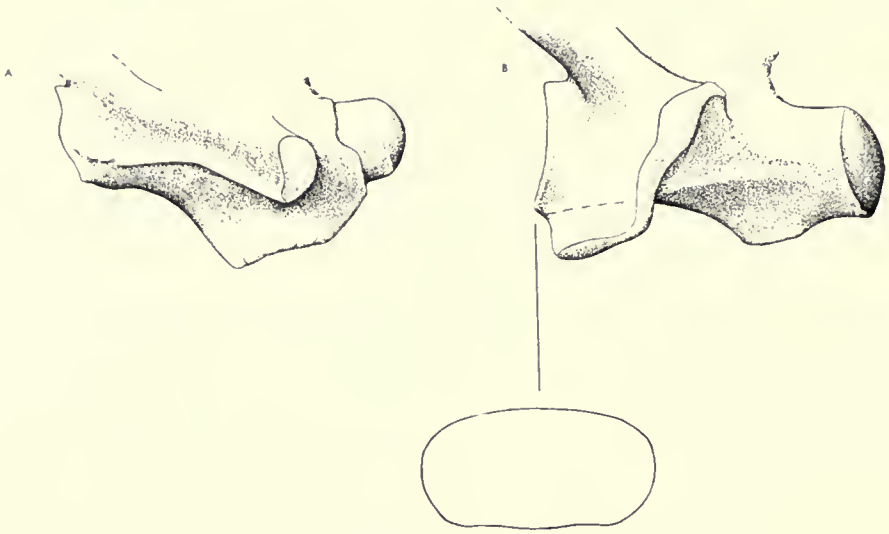

FIG. 164. Lateral view of A, anterior cervical, and B, posterior cervical or anterior thoracic vertebra of *Halisaurus sternbergi* (PR 195, × 1). The outline of the anterior central articulation is shown beneath B.

At least four ossified elements in carpus. Metacarpal one equal to metacarpal two in length, anterodistal flange small or absent. Proximal ends of metacarpals, especially of two and three, not greatly expanded.

Acetabular surfaces of pelvic elements convex, do not form solid smoothly-surfaced bowl. Obturator foramen located near center of proximal end of pubis, dorsoanterior process rudimentary. Ischiadic tubercle separated from acetabulum by short neck. Shaft of femur slender, distal end more expanded than proximal, well-developed spherical head present. Facets for tibia and fibula distally. Tibia and fibula slender, slightly expanded at distal and proximal ends.

Discussion.—*Halisaurus* was founded by Marsh (1869) on two peculiar vertebrae from the latest Cretaceous green sands of New Jersey. Merriam (1894) later recorded the presence of similar vertebrae in the Niobrara Chalk of Kansas, but the general body form of the reptile remained unknown. The two Selma specimens mark an important range extension of the genus and provide evidence showing that Wiman's (1920) remarkably complete skeleton of a clidastoid mosasaur from the Niobrara Chalk should be referred to *Halisaurus*.

The vertebrae of the anterior portion of PR 195 so closely resemble the two type vertebrae of *Halisaurus platyspondylus* from the Maestrichtian of New Jersey that there can be little doubt about their generic assignment. The intervertebral articulating surfaces are nearly twice as wide as deep and the ventral border of the anteroventral extension of the synapophysis, initially weak and horizontal, becomes heavily developed

and projects far below the flattened undersurfaces of the anterior dorsal vertebrae. The hypapophyseal facets are somewhat more circular than in the type of *H. platyspondylus*, although they are slightly dilated distally. Posteriorly, intervertebral articulations of the dorsal

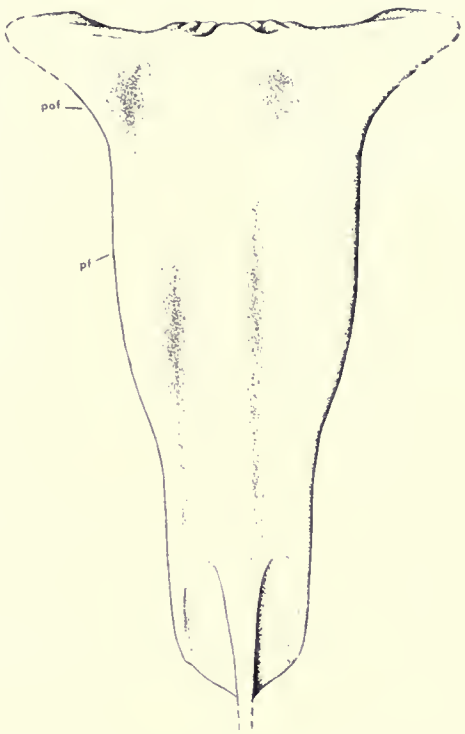

FIG. 165. Frontal of *Halisaurus sternbergi*, dorsal aspect (reconstructed after PR 195, × 2/3). Abbreviations: pf, posterior limit of prefrontal suture; pof, anterior limit of postorbitofrontal suture.

vertebrae become more circular, as Merriam (1894, p. 36) pointed out, and the vertebrae are difficult to distinguish from slightly crushed *Clidastes* dorsals. However, the zygosphene-zygantrum articulations are only about as well developed as they are in *Platecarpus*. The anterior caudal centra are indistinguishable from those of *Clidastes*.

The frontals of PR 186 and PR 195 resemble those of *Clidastes* very closely. The broad anterior end of the bone gives it a more rectangular outline than in *Clidastes liodontus* or *C. propython*, and the large rounded median ridge anterior to the orbits is nearly absent in these species. The sutures for the prefrontal and postorbitofrontal on the ventral surface of the frontal are much more widely spaced than in either of the above forms. However, these peculiarities are present in the frontal of "*Cliastes*" *sternbergi* (Wiman, 1920, fig. 4) and probably in another specimen from the Niobrara Chalk (USNM 3777) elsewhere referred to this species. On this basis it would seem likely that "*Clidastes*" *sternbergi* should be referred to *Halisaurus*, and there are certainly sufficient characters in the type skeleton to justify its removal from *Clidastes*. The quadrate and posterior half of the lower jaw included by Merriam (1894) in his type of *Halisaurus onchognathus*, also from the Niobrara Chalk, probably belong to the type of *Ectenosaurus clidastoides*, and the peculiar nature of the retroarticular process in the latter element may be due to distortion, as I have never seen a similarly shaped element in any of the extensive Niobrara collections.

The basioccipital of PR 195 is similar to that of *Clidastes*. Teeth preserved in a pterygoid fragment of PR 186 are rounded in cross-section and distinctly posteromedially recurved. The enamel surface is smooth and there is a faint posteroexternal carina.

Measurements:—

PR 186

length median dorsal vertebra	41 mm.
length pygal vertebra	34
interorbital width frontal	43

PR 195

length anterior cervical vertebra	39
length anterior dorsal vertebra	45
length posterior dorsal vertebra	54
length pygal vertebra	42
length anterior caudal vertebra	31
interorbital width frontal	47

Clidastes propython

Clidastes propython Cope, 1869, Proc. Boston Soc. Nat. Hist., **12**, p. 258.

Referred material.—Harrell Station Area, Southeast of Marion Junction, Dallas County, Alabama: P 27324, disarticulated skull, presacral vertebrae. Collected by C. M. Barber. P 27428, pterygoid, six vertebrae. Collected by C. M. Barber. P 27439, parts of skull, atlas, cervical vertebrae. Collected by C. M. Barber. P 27440, scapula and coracoid fragments. Collected by R. Zangerl. P 27449, humerus. Collected by C. M. Barber. P 27478, tooth, metacarpal. P 27484, fragmentary disarticulated skull, presacral vertebrae. Collected by R. Zangerl and W. Turnbull. P 27545, humerus. Collected by R. Zangerl. P 27546, quadrate. Collected by C. M. Barber. PR 37, cranial elements, humerus. Collected by C. M. Barber. PR 38, disarticulated skull, vertebrae. Collected by A. Zangerl. PR 39, cranial elements, presacral vertebrae. Collected by A. Zangerl. PR 40, disarticulated skull, most of vertebral column, appendicular elements. Collected by A. Zangerl. PR 41, cranial elements, vertebrae, hind limb. Collected by R. Zangerl. PR 42, vertebrae. Collected by A. Zangerl. PR 43, vertebrae. Collected by A. Zangerl. PR 45, cranial elements, presacral vertebrae, pectoral elements. Collected by A. Zangerl. PR 46, vertebrae. Collected by R. Zangerl. PR 47, presacral vertebrae. Collected by C. M. Barber. PR 48, cranial elements, presacral vertebrae, humerus. Collected by R. Zangerl. PR 49, pygal vertebrae. Collected by C. M. Barber. PR 50, dorsal vertebrae. Collected by R. Zangerl. PR 52, disarticulated skull, atlas. Collected by C. M. Barber. PR 53, caudal vertebrae. Collected by A. Zangerl. PR 138, quadrate, marginal tooth, caudal vertebra. PR 142, cranial elements, vertebrae. Collected by C. M. Barber. PR 192, pectoral elements, vertebrae. Collected by J. A. Robbins. PR 200, pygal vertebra, phalanges. Collected by C. M. Barber. PR 211, postorbitofrontal. PR 238, dentary.

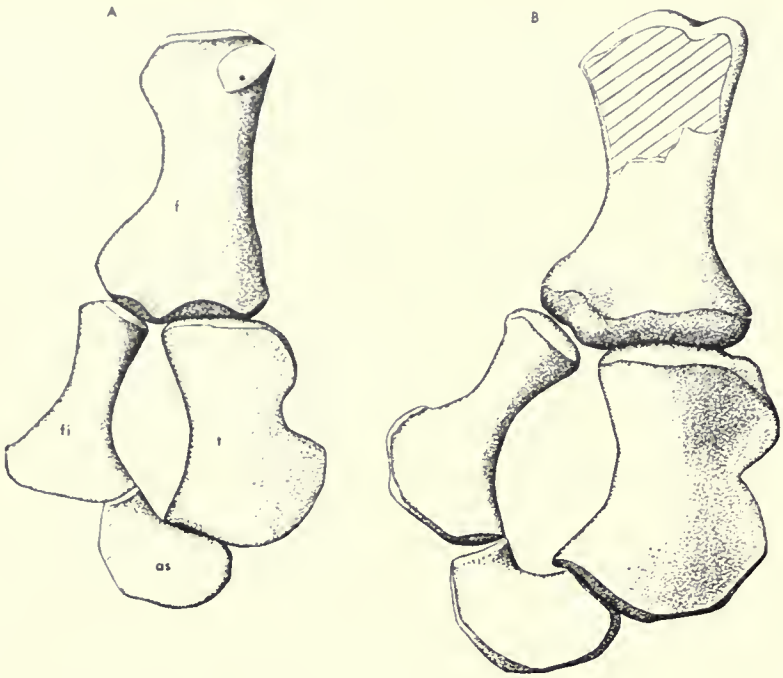

FIG. 166. The hind limb of *Clidastes*, ventral aspect. A, *C. liodontus* (after Williston, 1898, pl. 34, × 2/3), B, *C. propython* (PR 40, × 2/3). Abbreviations: as, astragulus; f, femur; fi, fibula; t, tibia.

Cedarville, Hale County, Alabama: PR 51, vertebrae. Collected by A. Zangerl.

Boligee, Greene County, Alabama: PR 63, humerus. Collected by W. Turnbull.

Mount Hebron, Greene County, Alabama: PR 150, cranial elements, cervical vertebrae. Collected by J. A. Robbins.

West Greene, Greene County, Alabama: PR 148, cranial elements, vertebrae. Collected by J. A. Robbins. PR 156, cranial elements, vertebrae, humerus. Collected by R. Zangerl. PR 162, quadrate, vertebrae. Collected by C. M. Barber. PR 164, disarticulated skull, most of vertebral column, appendicular elements. Collected by J. A. Robbins. PR 175, dorsal vertebrae. Collected by J. A. Robbins. PR 176, caudal vertebrae. Collected by J. A. Robbins. PR 183, radius. Collected by C. M. Barber.

Locality unknown.—P 27355, dentary and splenial.

Specific diagnosis.—Posteroventral portion of root of second premaxillary tooth exposed on sutural surface with maxilla. Premaxillo-maxillary suture rises posteriorly in gentle curve to terminate at point above seventh maxillary tooth. Premaxillary suture of maxilla smoothly keeled and parallels longitudinal axis of maxilla. Sixteen to 18 teeth in maxilla. Median dorsal surface of parietal moderately broad. Infrastapedial process present on quadrate. Sixteen to 18 teeth in dentary.

Discussion.—*Clidastes propython* was first described from the Selma Chalk of Alabama and has subsequently been found in the upper Niobrara and lower Pierre Formations of Kansas and South Dakota. It is well represented in the Chicago collection from the Selma, comprising about three-quarters of all mosasaur specimens. Relative to individuals of the species from the Niobrara Chalk, those from the Selma tend to be larger, ranging from an estimated 7½ ft. in length (PR 148) to 20½ ft. (P 27324, PR 156, PR 162), the latter specimens being the largest known. The fact that the ventral surface of all the preserved parietals in the collection (PR 37, PR 40, PR 52, PR 164, P 27324) is not as deeply excavated behind the parietal foramen as is the type of *C. propython* or in referred specimens from the Niobrara Chalk is of unknown significance. It is of interest to note that one complete dentary (P 27355) has only 16 teeth, the least number recorded for the species.

Complete skeletal material of *Clidastes propython* has never been described and it was provisionally assumed (Russell, 1967) that the body of this species closely resembled that of *C. liodontus*. The presacral vertebral count may have been very close in the two species, for in PR 164 there were at least 38 vertebrae from this region, while in a complete skeleton of *C. liodontus* there are 42 (Williston, 1898, p. 143). However, in certain poorly-preserved tails of *C. propython* (PR 40, PR 53, YPM 24901, see also Cope, 1869–1870, pl. 12, fig. 11) it seems likely that the posteriormost transverse processes are present beneath the longest neural spines in the dilated portion of the caudal fin. In *C. liodontus* they occur about 9–10 vertebrae in front of this region.

Elements of the hind limb preserved in several specimens (PR 40, PR 41, PR 164) also show differences in detail from those of *Clidastes liodontus* (see Williston, 1898, p. 165, pl. 34), reflecting the specific distinctness of these two forms. On the distal end of the femur the facets for the tibia and fibula meet at a slightly higher angle in *C. propython* and the fibular facet occupies a more posterodistal position on the bone. Distal and proximal portions of the anterior flange on the tibia are separated by a relatively wide sulcus in *C. liodontus*, which has been reduced to a notch in *C. propython*.

There seem to be facets on the tibia and astragulus for a centrale in the latter species, which are absent in Williston's descriptions and figures of *C. liodontus*.

One specimen (PR 164) is of particular interest in that many vertebrae in the posterior dorsal and anterior caudal regions have been fused, and the vertebral centra are swollen, especially around the former location of the intercentral articulation. The resulting rigidity of the vertebral column must have seriously impaired the animal's ability to swim, and it very likely starved to death as a result of this disability.

Globidens alabamaensis

Globidens alabamaensis Gilmore, 1912, Proc. U. S. Nat. Mus., 41, p. 479.

Referred material.—PR 196, frontal fragment and pygal vertebra. From Harrell Station area, southeast of Marion Junction, Dallas County, Alabama. Collected by C. M. Barber and J. A. Robbins.

Discussion.—A piece of the right side of a heavily constructed frontal may belong to *Globidens*. The supraorbital border is rounded and, as in the type, the sutures for the prefrontal and postorbitofrontal do not meet on the undersurface. The pygal vertebra measures 65 mm. in length but is too poorly preserved to show other significant features.

Subfamily Plioplatecarpinae

Platecarpus sp.

Referred material.—P 27399, disarticulated skull, nearly complete vertebral column, ribs, elements of pectoral and pelvic appendages. From Harrell Station area, southeast of Marion Junction, Dallas County, Alabama. Collected by C. M. Barber.

Discussion.—*Platecarpus* is represented by a well-preserved skeleton of a single individual. The animal was probably about 15 feet long, being of slightly less than average size. It could belong to *P. ictericus* or *P. coryphaeus*, but the jaws are not complete enough to assign it to one of these species. It most likely belongs to *P. ictericus*, for the Mooreville Member of the Selma Chalk is stratigraphically equivalent to the upper portion of the Niobrara Chalk in Kansas where *P. coryphaeus* evidently does not occur.

Prognathodon sp.

Referred material.—Harrell Station Area, southeast of Marion Junction, Dallas County, Alabama: PR 143, tibia. PR 193, tibia, fragmentary ischium. Collected by Kirtley Brown.

Eutaw, Greene County, Alabama: PR 146, surangular fragment. Collected by C. M. Barber.

West Greene, Greene County, Alabama: PR 165, fragmentary skull, 17 presacral and 38 caudal vertebrae, elements of pelvic appendage.

Description.—A fragmentary skull and skeleton (PR 165) and a few isolated bones indicate the presence of a very large plioplatecarpine in the Selma Chalk. The abbreviated premaxilla, massive jaws and teeth, and relatively slender splenial and angular suggest the specimen should be referred to *Prognathodon*. The remains indicate an animal somewhat larger than *P. overtoni* and *P. rapax*, and approximately twice as large as *P. solvayi*.

The premaxilla is short and broad, and is very similar to that of *Platecarpus*. Sutural surfaces on the anterior end of the frontal show that the internarial bar terminates in two small tongues, one on either side of the midline of the skull, in front of the posterior end of the external nares. The preserved anterior portion of the frontal seems to be narrower transversely than that of *Prognathodon overtoni*. The posterior end of the external naris is contained in a notch between the anterior edges of the frontal and prefrontal, and does not lie entirely within the frontal as it does in *Platecarpus*. The squamosal is indistinguishable from that of *Platecarpus*. There is an extremely large postero-inferior process on the jugal, very unlike *Prognathodon overtoni* and *P. solvayi* where the process is nearly absent. A poorly preserved left quadrate appears to closely resemble that of *Platecarpus*, as the tympanic ala was thin, the suprastapedial process is unconstricted dorsally, and the supra- and infrastapedial processes may not have been fused. There is a bilobate channel through the basioccipital for the basilar arteries.

The anterior end of the dentary is more massive than in both *Prognathodon overtoni* and *P. solvayi*, but otherwise bears a closer resemblance to that of the latter species. Its alveolar margin is similarly more concave upward than in *P. overtoni*, and the anteriormost teeth

FIG. 167. Dentary of *Prognathodon* sp. (PR 165, × 1/3), lateral aspect.

in the dentary are procumbent, as are those of the premaxilla. The enamel surfaces of the marginal teeth in the Selma *Prognathodon* and in *P. solvayi* are divided into vertical prisms, while in *P. overtoni*, *P. rapax*, and *P. giganteus* the enamel surfaces are smooth. The dor-

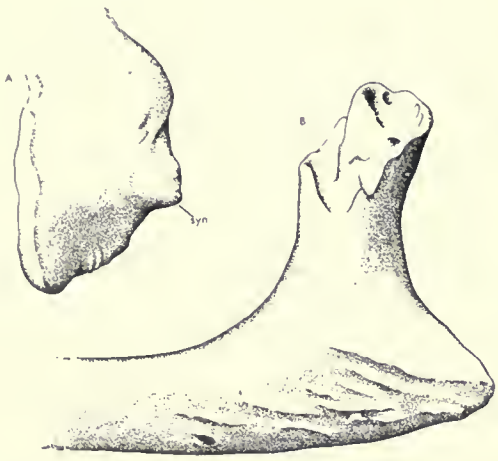

FIG. 168. A, Lateral view of left atlas arch, and B, lateral view of left jugal of *Prognathodon* sp. (PR 165, × 1/2). Abbreviation: syn, synapophyseal process.

sal edge of the surangular is wide and rounded in cross-section in front of the mandibular cotylus in the present form.

Although the vertebral column is poorly preserved in PR 165, a few vertebrae are complete enough to show several interesting characters. The body of the atlantal neural arch is a relatively thick and heavily built piece of bone, with a small synapophyseal process located slightly above the center of its posterior border. In *Clidastes*, *Mosasaurus*, *Platecarpus*, *Ectenosaurus*, and *Tylosaurus* the synapophyseal process is usually larger and much more ventral in position. A small, longitudinally compressed ridge near the posterior base of the spinous process of the atlas marks the site of a tendonous attachment of much of the cervical longissimus muscles. On the axis centrum the facet for the hypapophysis is located close to the suture for the axis intercentrum, as in *Tylosaurus* but not in *Platecarpus* and *Clidastes*, where it occupies a more posterior position. In the dorsal series the zygosphene-zygantral articulations are about as well developed as in *Platecarpus*, being for the most part rudimentary. The haemal arches articulate with the caudal centra as in all species of *Prognathodon* except *P. overtoni*.

There are several elements of the posterior appendages in PR 165 which were previously unknown in *Prognathodon*. Facets on the ilium for the ischium and pubis are more distinctly developed than is usual in *Platecarpus* and the central portion of the ilial shaft seems to have been more anteroposteriorly expanded than in this genus. However, the proximal portion of the ischium is very much like that of *Platecarpus*. Only the distal halves of both femora are preserved and these conform in shape to that of *Prognathodon crassartus* figured by Cope (1875, pl. 26, fig. 10). The femur of *Prognathodon* differs from that of *Platecarpus* in that the edges of the central portion of the shaft parallel each other between the expanded distal and proximal ends. This gives the bone a dumbbell-shaped outline unlike the more smoothly hourglass-shaped outline of the femur of *Platecarpus*. The tibia is a columnar bone. Its equally expanded ends were probably finished in thick cartilage in life. A weathered astragulus appears to be generally similar to that of *Platecarpus*.

It is apparent from the foregoing description that the Selma *Prognathodon* may be distinguished from all the known species of the genus with the exception of *P. crassartus*, from the lower Pierre Shale of Kansas. In view of the fact that the humerus of the Selma form is unknown and that it is from a horizon equivalent to the lower Pierre in stratigraphic position, a proper evaluation of the affinities of both forms should await the discovery of new material.

Measurements:—

PR 165

height of quadrate	139 mm.
length between 1–6 tooth, right dentary	252
length between 1–6 tooth, left dentary	246
length median cervical centrum	68

Subfamily Tylosaurinae

Tylosaurus zangerli new species[1]

Type.—P 27443, humerus and femur. Collected by C. M. Barber.

Horizon and locality.—Lower, marly member of the Selma Formation (Mooreville Chalk), Late Cretaceous. High river exposures, Moore farm, southeast of Marion Junction, Dallas County, Alabama.

Description and diagnosis.—A small but excellently preserved humerus and femur mark the occurrence of a new and relatively primitive species of *Tylosaurus* in the Mooreville Chalk. The humerus is more slender than in Niobrara species of the genus and the ends are much more abruptly terminated. It may at once be distinguished from the similarly proportioned humerus of *Halisaurus* by the absence of a spherical head. The pectoral and deltoid crests are separated from each other by a deep sulcus, typical of *Tylosaurus*. The pectoral crest is nearly as anteriorly located on the shaft of the humerus as is that of *Clidastes*, and it extends proximally to the glenoid surface, while in Niobrara tylosaurs these two regions are partly or completely separated by a transverse groove. The deltoid crest is less well developed than in Niobrara specimens, although it occupies a similar position. On the distal end of the bone a radial process is completely lacking, which is normal for *Tylosaurus*, and a well-marked ectepicondylar foramen penetrates the anterodorsal edge. The ulnar process is exceptionally well developed for the genus. As may be seen from Figure 6, the areas of muscle attachment are very clearly defined.

[1] The species is named for Dr. Rainer Zangerl of the Field Museum of Natural History.

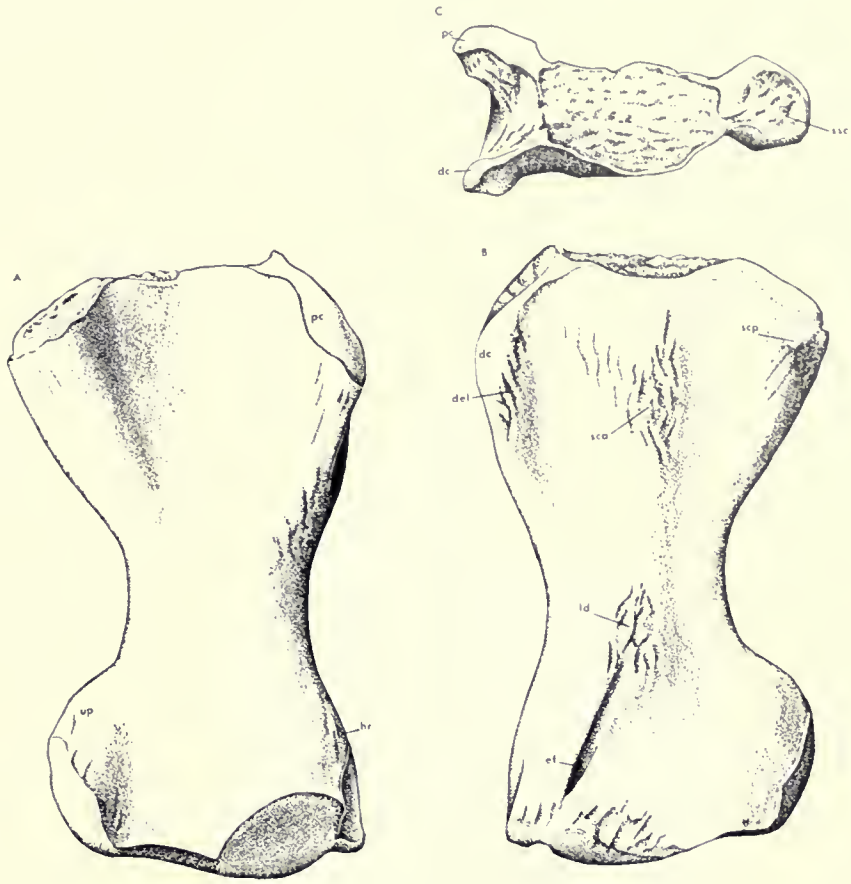

FIG. 169. Humerus of *Tylosaurus zangerli* (P 27443, × 1). A, ventral view, B, dorsal view, C, proximal view. Abbreviations: dc, deltoid crest; ef, ectepicondylar foramen; pc, pectoral crest; up, ulnar process. Muscle scars: del, M. deltoides, undivided; hr, M. humeroradialis; ld, M. latissimus dorsi; sca, M. scapulohumeralis anterior; scp, M. scapulohumeralis posterior; ssc, M. subscapulocoracoideus.

The femur is also slender, relative to its proportions in Niobrara specimens. The internal trochanter is narrower and slightly more posteriorly located. The distal end is squarely terminated in dorsal or ventral aspect and lacks the bell-shaped profile characteristic of the femur in Niobrara tylosaurs.

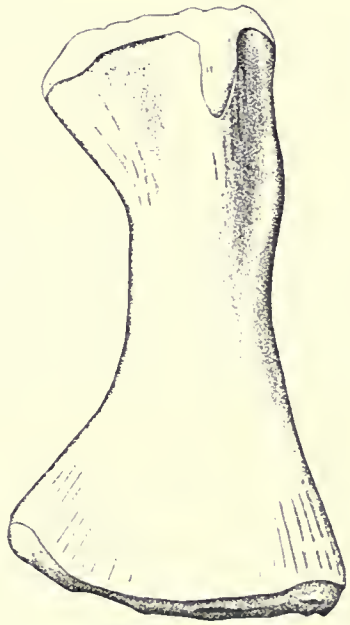

FIG. 170. Femur of *Tylosaurus zangerli* (P 27442, × 1), ventral aspect. Abbreviation: it, internal trochanter.

Measurements:—

femoral length	82.2
humeral length	82.2

Tylosaurus sp.

Referred specimens.—Harrell Station Area, southeast of Marion Junction, Dallas County, Alabama: PR 204, cranial fragments, one dorsal and 28 caudal vertebrae, elements of pelvic appendage. Collected by C. M. Barber.

Eutaw, Greene County, Alabama: P 27474, internarial bar of premaxilla.

FIG. 171. Splenio-angular articulation of *Tylosaurus* sp. (PR 204, × 1/2), medial aspect. Abbreviations: an, angular; p, process of splenial; sp, splenial.

Discussion.—Remains of a medium-sized *Tylosaurus* (PR 204), which may have originally measured 20 ft. in length, are present in the Field Museum collections. There is a small conical process on the posterior rim of

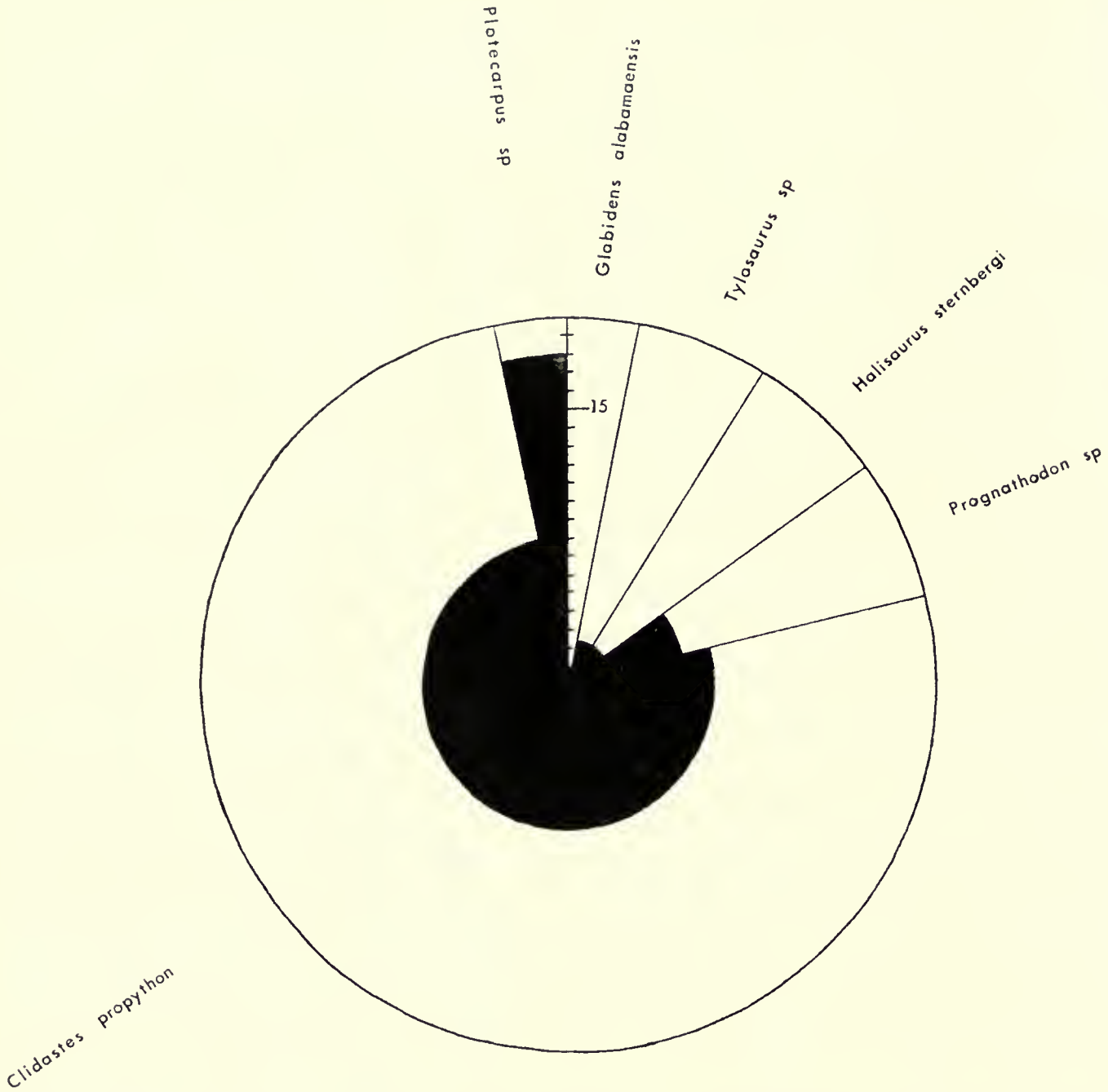

FIG. 172. Mosasaur crania from the Mooreville Member of the Selma Chalk in the collections of the Field Museum of Natural History. The arc intercepted by radii adjacent to a specific name is proportional to the percentage of individual crania of that species compared with the total number of crania in the collection (= 33). The radius of the darkened area in each specific section indicates the average number of recognizable cranial elements per individual skull for the species. Thus, eight elements on the average are present for each cranium of *Clidastes propython* that was collected. It should be noted that the resemblance of this diagram to those of Shotwell (1955, Ecology, **36**, pp. 327–337, 4 figs., 2 tables) is only superficial. His diagrams describe the relative abundance and completeness of representation of all animal species from a single locality, based on all of the bones collected and without regard to possible associations of bones belonging to a single individual. This diagram and the next (fig. 10) only attempt to illustrate an approximation of the relative abundance of mosasaurian species from a stratigraphic unit, based on cranial elements of widely-scattered individuals. All vertebrate material seen was collected by the Chicago expeditions (Zangerl, 1948, p. 3).

the splenial that fits into a groove on the medial surface of the angular. This peculiar process has been observed only in a specimen of *Dollosaurus* (see Iakovlev, 1906, fig. 3), a prognathodontine from the Campanian of Russia. There are no other exceptional osteological characters.

Subfamily Plioplatecarpinae or Tylosaurinae

Indeterminable plioplatecarpine or tylosaurine vertebrae occur under the following specimen numbers.

Harrell Station Area, southeast of Marion Junction, Dallas County, Alabama: P 27445, eight caudals. Col-

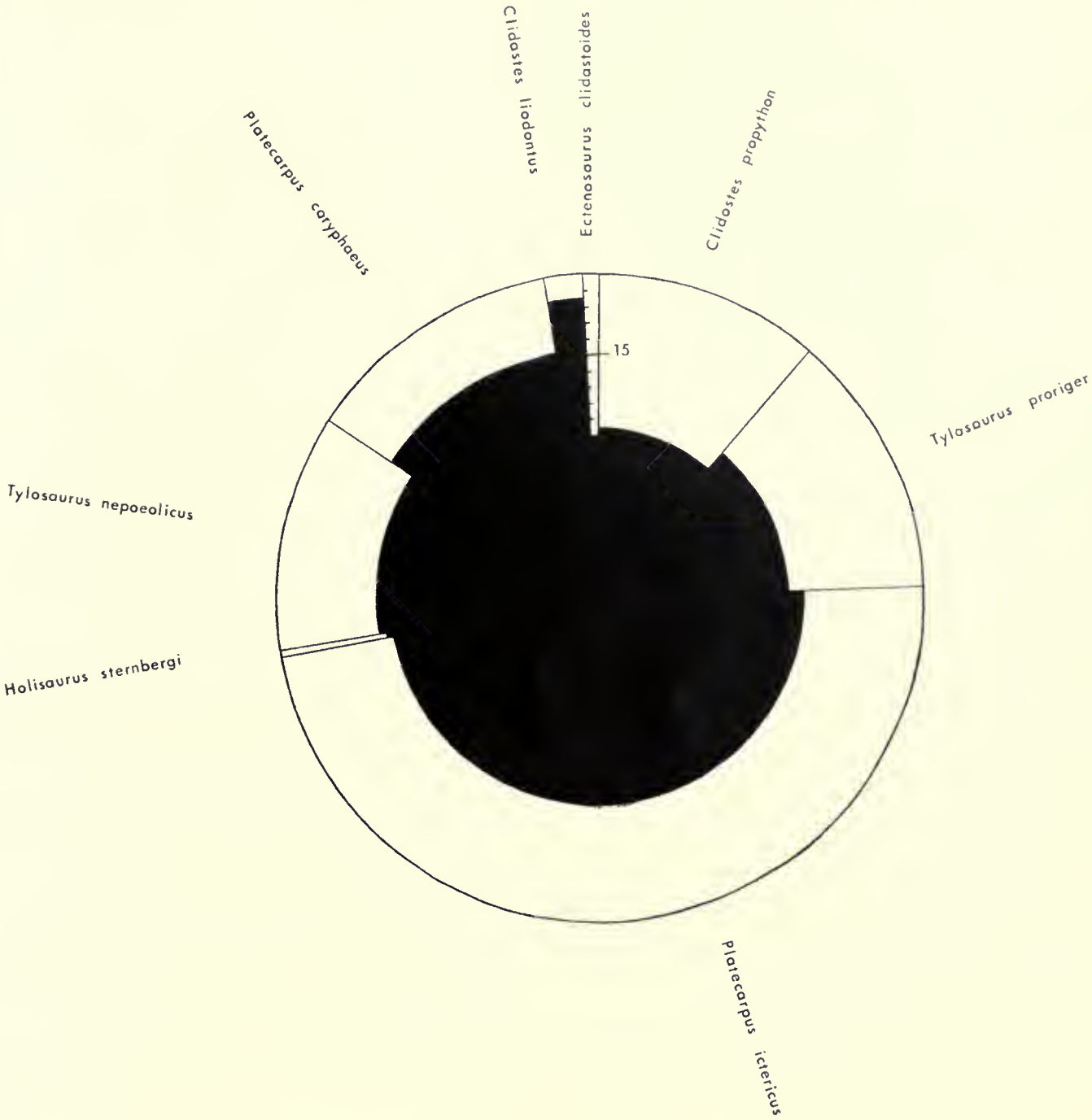

FIG. 173. Mosasaur crania from the Niobrara Chalk of Kansas in the Marsh collection of the Yale Peabody Museum and the U. S. National Museum. It is probable that Marsh's men collected nearly every vertebrate specimen seen with little regard to completeness. The collection includes cranial elements from 398 individuals. The data from which this diagram was drawn differs from that of Figure 9 only in that the relative abundance of *Clidastes*, *Platecarpus*, and *Tylosaurus* in the collection is based on the number of generically-determinable specimens. Only a certain number of these specimens could also be identified to the species, but the relative abundance of the two species within each genus was determinable and this ratio is assumed to have held constant in the specifically indeterminable specimens as well (see also Russell, 1967).

lected by C. M. Barber. PR 42, nine dorsal vertebrae. Collected by A. Zangerl. PR 212, large caudal vertebra lacking transverse processes.

Cedarville, Hale County, Alabama: PR 51, four presacral vertebrae. Collected by A. Zangerl.

Eutaw, Greene County, Alabama: PR 173, nine caudal vertebrae. Collected by C. M. Barber.

West Greene, Greene County, Alabama: PR 237, caudal vertebrae. Collected by C. M. Barber.

FAUNAL COMPARISONS

In recapitulation, it is seen that the mosasaur fauna from the Mooreville Member of the Selma Chalk includes at least eight distinct species. These are:

Halisaurus sternbergi
Clidastes propython
Globidens alabamaensis
Platecarpus sp.
"Platecarpus" intermedius
Prognathodon sp.
Tylosaurus zangerli
Tylosaurus sp.

More than 75 per cent of the cranial material in the Field Museum collections belongs to *Clidastes propython* (see fig. 9). This species also occurs in the Niobrara Chalk and lower Pierre Shale of the Interior. Although the Selma *Platecarpus* and *Tylosaurus* have not yet been identified to the species level, they are morphologically indistinguishable from species of these genera occurring in the latter units. Since the Mooreville Member is an age equivalent of the upper Niobrara and lower Pierre (see Jeletzky, 1955; Young, 1963, Table 13), it will be instructive to compare their mosasaur assemblages.

The Niobrara Chalk has yielded mosasaurian remains in great abundance. The following forms have been identified from the Chalk of western Kansas (see Russell, 1967):

Halisaurus sternbergi
Halisaurus onchognathus
Clidastes liodontus
Clidastes propython
Mosasaurus ivoensis
Platecarpus coryphaeus
Platecarpus ictericus
Ectenosaurus clidastoides
Tylosaurus nepaeolicus
Tylosaurus proriger

As has been pointed out (Russell, *Ibid.*), *Clidastes liodontus*, *Platecarpus coryphaeus*, and *Tylosaurus nepaeolicus* may not occur in the uppermost levels of the Niobrara. This portion of the formation was deposited at the same time as was the Mooreville Member in Alabama. In marked contrast to the conditions in Alabama, *Platecarpus* is the most common Niobrara genus, amounting to more than 60 per cent of the crania in the Marsh collection (see fig. 10), while only 13 per cent of the crania belong to *Clidastes*.

The lower portion of the Pierre Shale will undoubtedly produce a large mosasaur fauna, but so far only a few individuals have been collected from widely scattered localities (see Russell, 1967, appendix B):

	Specimens
Clidastes propython	2
Globidens alabamaensis	1
Platecarpus ictericus	7
Platecarpus cf. *somenensis*	3
Platecarpus undetermined species	6
Tylosaurus proriger	3

In spite of the difference in lithology, the mosasaur fauna of the lower Pierre is virtually identical to that of the Niobrara. It is apparent that the most striking difference between the composition of the mosasaur assemblage from Alabama and those from the Interior is the predominance of *Clidastes* in the former region, and of *Platecarpus* in the latter. This may be due to several factors.

Zangerl noted that the marine protostegid (1953a, p. 131) and toxochelyid (1953b, p. 273) turtle populations of the Niobrara Chalk showed some effects of geographic separation from those of Alabama. He suggested this was due to an emergent peninsula extending southwest across Texas, which widely separated the two depositional areas. This barrier did not greatly affect the dispersal of mosasaurs, as is shown by the occurrence of many of the same species in both regions.

Williston (1897) thought that the presence of turtles, small pterodactyls and toothed birds in the upper levels of the Niobrara (*"Hesperornis* beds") indicated shallowing water and an approaching shoreline. He stated that *Clidastes* was restricted to these upper beds, and largely on this basis Russell (1967) considered *Clidastes* to be a shallow-water mosasaur. Zangerl (1948, p. 4; 1953b, p. 263; *in* Langston, 1960, p. 319) is of the opinion that the Mooreville Chalk was deposited a few miles offshore from the strand line. This would lead one to the conclusion that the abundance of *Clidastes* in the Mooreville was due to a very shallow water nearshore environment of deposition.

Lowenstam (1964, pp. 232–233), on the basis of oxygen isotope ratios derived from belemnite endoskeletons, stated that a thermal high occurred in northern hemisphere waters approximately during Santonian time. If *Clidastes* was a warm water form perhaps this would explain its abundance in the more southerly Mooreville Chalk. Its absence in the lower portion of the Niobrara would be then attributable to relatively cool water conditions, before the Santonian thermal optimum brought them north into the southern part of the interior sea. *"Platecarpus" intermedius* and *Globidens alabamaensis*, with their presumed habits of feeding on heavily-shelled molluscs, lend a definite Tethyan or tropical cast to the mosasaur assemblage from the Mooreville Chalk.

The climatically-controlled southern limit of the boreal belemnite zone may have had some effect on the distribution of mosasaurs. If belemnites normally formed a large proportion of the diet of slender-toothed plioplatecarpines (*Platecarpus*, *Plioplatecarpus*, *Ectenosaurus*) it might be expected that these animals would be less abundant in southern waters. During the early Campanian the southern boundary of the belemnite zone may have occurred at about latitude 45° north (Lowenstam, 1964, p. 247), although Jeletzky (personal communication, 1965) would extend the boundary further south to include the Niobrara Chalk of Kansas. Jeletzky also informs me that Campanian belemnites are unknown from Texas and Alabama. Thus, the boundary of the boreal zone seems to have passed between the outcrop areas of the Kansas and Alabama chalks.

SUMMARY

1. The vertebrate fauna of the Mooreville Chalk is now known to contain at least eight species of mosasaurs.

2. Two fragmentary specimens of a small clidastoid mosasaur are conspecific with Wiman's complete type skeleton of *Clidastes sternbergi* from the Niobrara Chalk, and provide evidence indicating that the species should be referred to *Halisaurus*.

3. The presence of a large plioplatecarpine with massive teeth (*Prognathodon* sp.) is recognized in the Mooreville Chalk.

4. *Tylosaurus zangerli* is described as a new and primitive species of *Tylosaurus*.

5. *Clidastes* is by far the most abundant genus in the Mooreville Chalk, while *Platecarpus* is similarly characteristic of the contemporaneously deposited Niobrara Chalk and lower Pierre Shale of the Interior. This may be due to:

A. A shallow water environment present during the deposition of the Mooreville Chalk, which was preferred by *Clidastes* and not by *Platecarpus*;

B. Warmer water conditions during the deposition of the Mooreville Chalk, which may have been more favorable to *Clidastes* than the generally cooler waters of the interior sea;

C. The absence of belemnites in the Mooreville Chalk. These cephalopods may have formed a significant proportion of the diet of *Platecarpus* and tended to restrict the genus to the interior sea.

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