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TYRANNOSAURUS AND *TOROSAURUS*, MAESTRICHTIAN DINOSAURS FROM TRANS-PECOS, TEXAS

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ABSTRACT—Discovery of a maxilla of *Tyrannosaurus rex* Osborn and a portion of the frill of *Torosaurus utahensis* (Gilmore) [new comb.] indicates that the lower part of the Tornillo Group of authors is probably Late Maestrichtian in age.

INTRODUCTION

In 1970 and 1972, respectively, a small left maxilla of *Tyrannosaurus rex* and a portion of the frill of a ceratopsian dinosaur here assigned to *Torosaurus utahensis* (new comb.) were found in the northeast part of the Big Bend National Park, Brewster County, Texas (Text-fig. 1). These specimens were recovered from multidepositional floodplain splay or small stream channel sandstones within the Tornillo Group (*sensu* Maxwell et al., 1967, p. 88). These sandstone lenses lie approximately 350 meters below the base of the Eocene Canoe Formation and approximately 100 meters above the subjacent Campanian Aguja Formation.

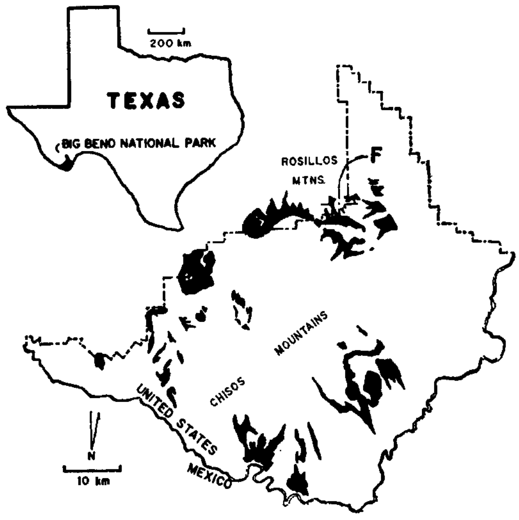
The genus *Tyrannosaurus*, represented by a single known species *T. rex* was, until its discovery in Texas, thought to have a geographic range including only Alberta, Wyoming, Montana, and South Dakota. The geographic range of *Torosaurus*, heretofore recognized only in Wyoming and South Dakota (Hatcher, Marsh, and Lull, 1907; Colbert and Bump, 1947), has likewise been extended by the assignment of *Arrhinoceratops? utahensis* Gilmore to that genus, and the recognition of the taxon in Texas.

AGE AND CORRELATION

Until the discovery of the specimens discussed here, a Maestrichtian age for the lower third of the Tornillo Group was based on the presence of the sauropod dinosaur *Alamosaurus* (see Maxwell et al., 1967, p. 96). *Alamosaurus sanjuanensis* Gilmore (1922) was known elsewhere in the Ojo Alamo Formation (*sensu* Fassett and Hinds, 1971) of New Mexico and the North Horn Formation of Utah (Gilmore, 1946). The correlation of these formations with the Maestrichtian Stage is rather tenuous, for neither formation intertongues with a marine equivalent. The discovery of *Tyrannosaurus rex* and *Torosaurus* provides a better basis for determining the age of the lower third of the Tornillo Group and together with *Alamosaurus* adds strength to the Maestrichtian assignment of the North Horn and Ojo Alamo formations.

Based on the vertebrates from Texas and the invertebrate faunas of Northern Mexico and Texas, the lower part of the Tornillo Group can be correlated with coeval formations of the Western Interior of North America. *Tyrannosaurus rex* and *Torosaurus latus*, found in the Hell Creek Formation of Montana and South Dakota, lie above the *Cucullaea* Assemblage Zone which overlies the *Sphenodiscus* Zone in the Fox Hills Formation. *Tyrannosaurus* and *Torosaurus* at Lance Creek, Wyoming occur above the *Sphenodiscus lenticularis* Zone of the Fox Hills. Thus the type Fox Hills is Maestrichtian, as must be the overlying Hell Creek and Lance formations (Waage, 1968, p. 144; Gill and Cobban, 1973). *Gryphaea vesicularis* and *Exogyra costata* of Texas and Northern Mexico are found below *Sphenodiscus intermedius* and *S. pluerisepta* which are characteristic of the Maestrichtian Escondido Formation of the Navarro Group in Texas (Böse and Cavin, 1927, p. 102; Cooper, 1973). These mollusks are found above the Campanian Taylor Formation cephalopod *Monticeras* cf. *M. delawarense*, which occurs with *Exogyra cancellata* in the lower part of the deltaic Aguja Formation (Adkins, 1932, p. 507). Therefore, correlation of the marine mollusks indicates that *Tyrannosaurus* and *Torosaurus* are Late Maestrichtian and the Tornillo Group and the upper part of the subjacent Aguja Formation are younger than Campanian.

Torosaurus utahensis has been found in the lower half of the North Horn Formation (Gilmore, 1946). Spieker (1946) and Young (1955)



TEXT-FIG. *1*—Index map of Tornillo outcrop pattern and fossil locality (F).

placed the lower, dinosaur-bearing, part of the North Horn in the Maestrichtian Stage and the upper part in the Paleocene.

A microflora consisting of thirty-seven species was recovered from a lignite bed 184 meters above the base of the Tornillo in the western part of the Big Bend National Park. Of these taxa, twelve have affinities with ferns, five with gymnosperms and 15 with angiosperms. The angiosperms include; *Alnipollenites trina, Betulaceoipollenites infrequens, Faguspollenites granulatus*, and *Bombacacipites nacimientoensis* (Lawson, Univ. Texas, Master's thesis, 1972). This flora is similar to that of the Fort Union (Oltz, 1969), Nacimiento (Anderson, 1960) and Brazeau formations (Radforth and Rouse, 1954), which are totally or partially Paleocene in age. In an uninterrupted section of the Tornillo Group, this Paleocene microflora lies 80 meters above the highest occurrence of *Alamosaurus sanjuanensis*. The fossil evidence thus indicates that the lower third of the Tornillo Group was deposited during the last eight million years of the Cretaceous.

ACRONYMS

The following acronyms are used for institution names:

AMNH—American Museum of Natural History, Department of Vertebrate Paleontology.
ANSP—Academy of Natural Science, Philadelphia.
LACM—Los Angeles County Museum.
ROM—Royal Ontario Museum, Toronto.
TMM—Texas Memorial Museum, The University of Texas at Austin.
USNM—United States National Museum of Natural History.
YPM—Peabody Museum, Yale University.

SYSTEMATIC PALEONTOLOGY

Order SAURISCHIA
Suborder THEROPODA
Family TYRANNOSAURIDAE
Genus TYRANNOSAURUS Osborn, 1905
TYRANNOSAURUS REX Osborn, 1905
Text-fig. 2 a, b

Material.—TMM 41436-1, left maxilla with teeth.

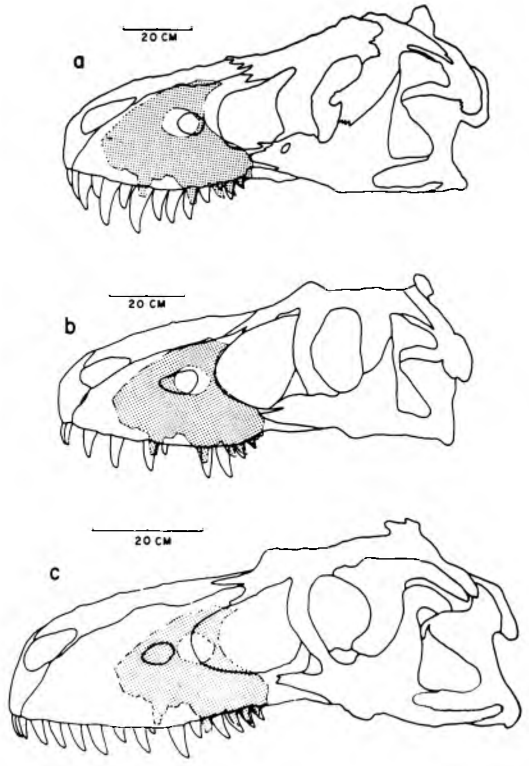
Locality.—Tornillo Flat, Big Bend National Park, Brewster County, Texas.

Horizon.—Within the lower third of the Tornillo Group (base of the Group faulted out); Maestrichtian Age.

Description.—The anterior tip, lower edge, and anterior teeth of the specimen have been broken away exposing the aveoli and the roots of the anterior teeth. The maxilla is triangular in lateral outline, with a height of 228 mm measured at the anterior edge of the first antorbital fenestra. The estimated length of the bone from its anterior edge to the posterior blade of the last tooth is 390 mm. The greatest diameter of the second antorbital fenestra is 96 mm and the least diameter is 69 mm. This fenestra lies at the anterior margin of a lateral depression which also contains the first antorbital fenestra and is separated from the latter by a slender bar 24 mm across at its narrowest point. The anteriormost antorbital fossa lies at the anterior edge of the second antorbital fenestra and is not visible in lateral aspect. The transversely rounded anterodorsal edge of the bone indicates that the maxilla took part in forming the external nares. The palatal flange of the maxilla is a triangular prism that runs the length of the maxilla, decreasing in height posteriorly. The dorsal surface of the flange is nearly horizontal, sloping downward toward the inner surface of the maxilla. The last three teeth decrease gradually in length posteriorly and are sharply recurved. The interdental plates are not present (the burial of this specimen in a conglomeratic sandstone, suggests that the plates were lost during stream transport).

Discussion.—The general proportions of the Texas specimen are much like those of *Tyran-*

TEXT-FIG. 2—*Tyrannosaurus rex* Osborn, TMM 41436–1, left maxilla. a, lateral view. b, medial view. ×¼.



TEXT-FIG. 3—Maxilla, TMM 41436–1 (stippled) compared with other tyrannosaurs (*sensu* Russell, 1970). The height of TMM 41436–1 is used as a standard. a, *Tyrannosaurus rex*, AMNH 5027, from photograph in Osborn (1912). b, *Daspletosaurus torosus*, NMC 8506, modified from Russell (1970). c, *Albertosaurus libratus*, FMNH PR 308, from AMNH negative No. 39113.

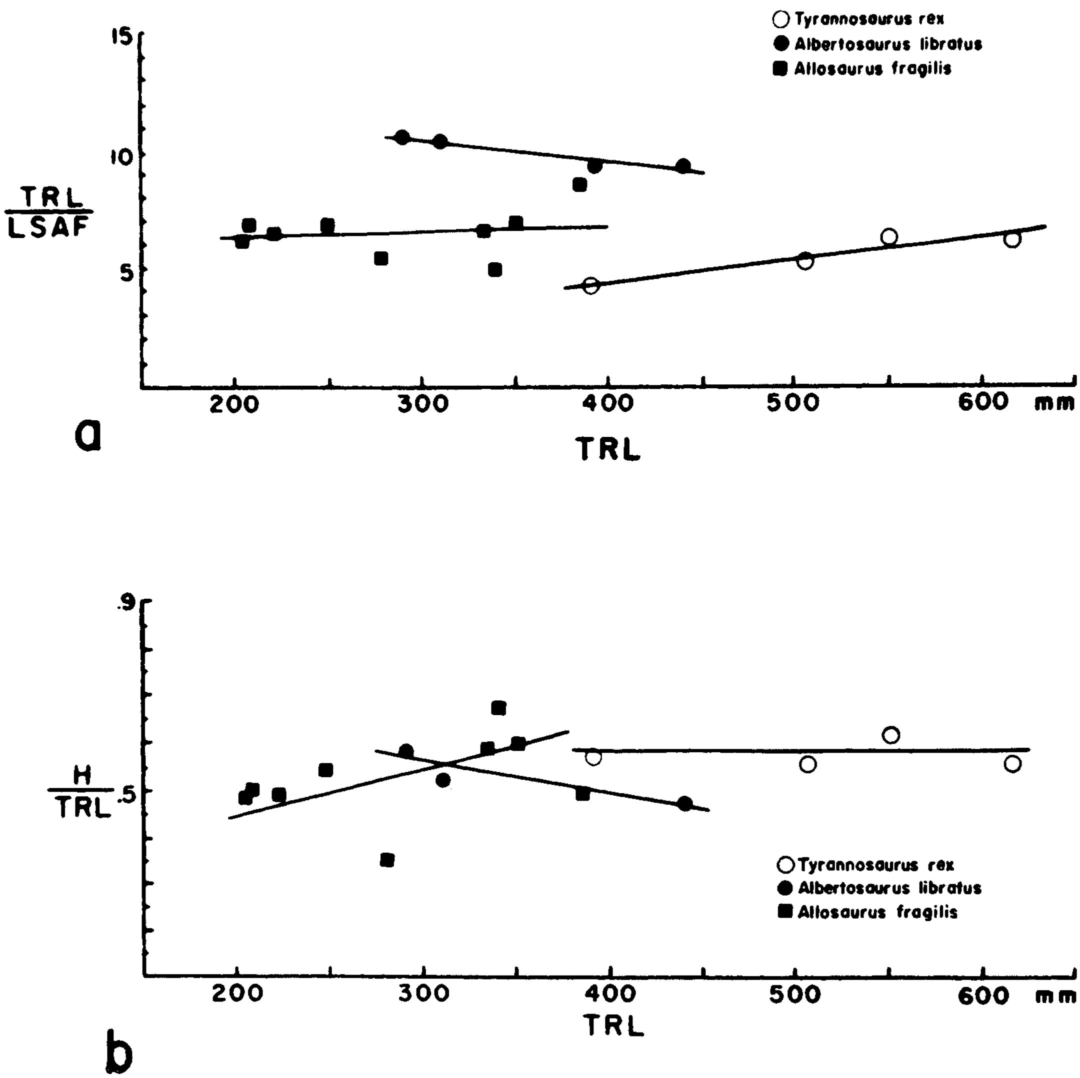
nosaurus rex (AMNH 973; AMNH 5027: Table 1). The maxilla of *Tyrannosaurus* is higher than long; in *Daspletosaurus* it is equidimensional; in *Albertosaurus* is longer than high (Text-fig. 3). As in *Tyrannosaurus*, but unlike *Daspletosaurus* or *Albertosaurus*, the second antorbital fenestra lies at the anterior edge of the well defined lateral depression which contains the first antorbital fenestra (Osborn, 1912; Matthew and Brown, 1923). Unlike *Albertosaurus* and *Daspletosaurus*, but like *Tyrannosaurus*, the anteriormost antorbital fossa of the Texas specimen is not visible in lateral aspect, and the first and second antorbital fenestrae are separated by a narrow bar as in *Tyrannosaurus rex*. The anterodorsal edge of this specimen takes part in the border of the external nares as in *Albertosaurus* and *Tyrannosaurus* (Russell, 1970).

The small size of TMM 41436–1 and the

TABLE 1—Comparative measurements (in mm) of the maxillae of three specimens of *Tyrannosaurus rex*.

	TMM 41436–1	AMNH 5027*	AMNH 973*	LACM 23844
height	228	290	342	343
tooth row length	390 est.	505	550	615
length of second antorbital fenestra	96	100	90	105

* from Osborn (1912).

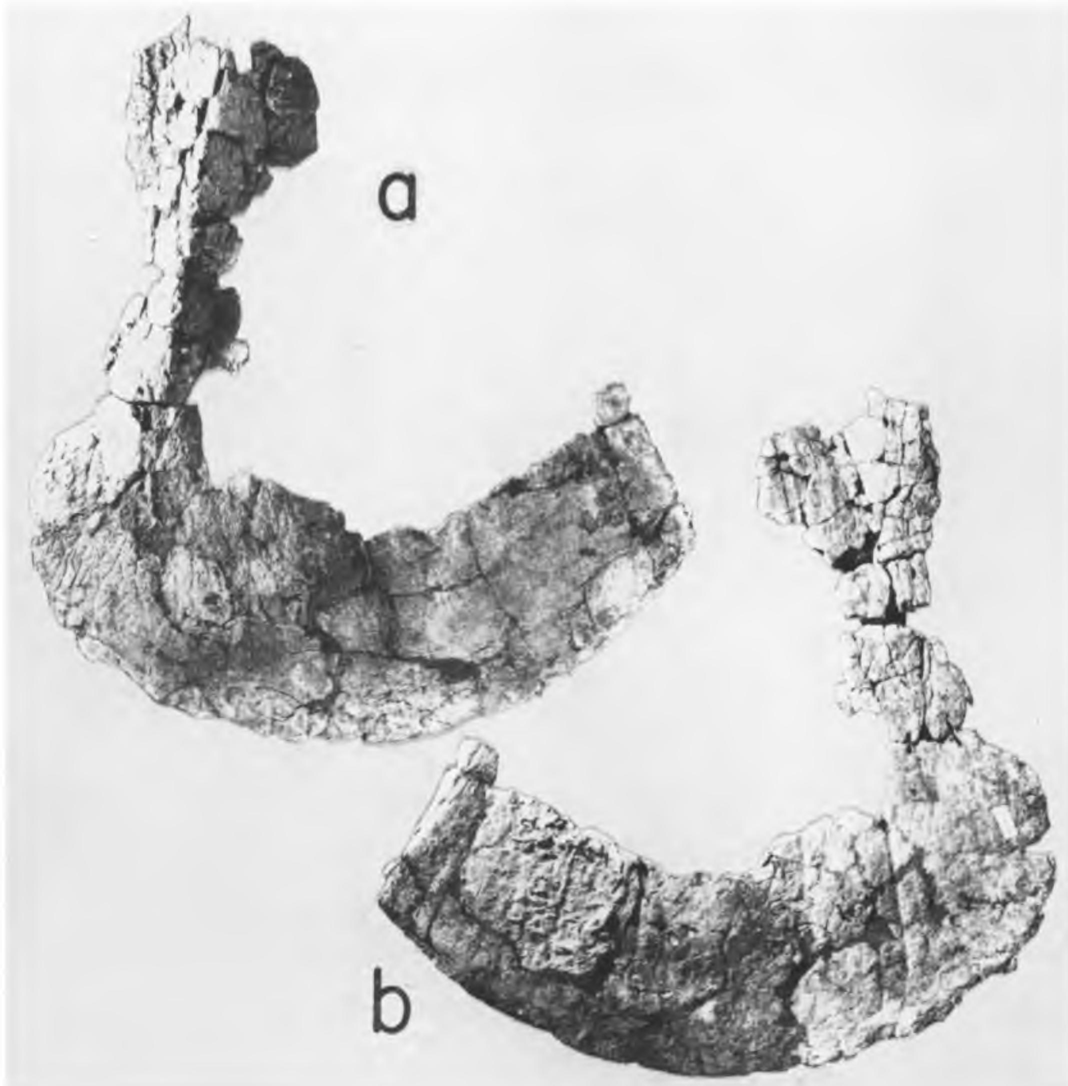


TEXT-FIG. 4—Growth changes in the maxilla of three species of carnivorous dinosaurs. Acronyms: H, height of the maxilla at the anterior edge of the first antorbital fenestra; LSAF, length of the second antorbital fenestra; TRL, tooth row length. a, size of the second antorbital fenestra relative to the size of the maxilla. b, rectangularity of the maxilla relative to size.

large diameter of the second antorbital fenestra might have distinguished this specimen from other maxillae of larger members of the species. Text-figure 4 shows the characteristic relationships between fenestra size and tooth row length in three species of carnivorous dinosaurs. In *Albertosaurus libratus* the second antorbital fenestra appears to increase in diameter more rapidly than the maxilla does in length; in *Allosaurus fragilis* there appears to be no growth differential; and in *Tyrannosaurus rex* the length of the maxilla increases faster than that of the second antorbital fenestra. Thus, TMM 41436-1 probably exhibits the characteristics of a young adult *Tyrannosaurus rex.*

Order ORNITHISCHIA
Suborder CERATOPSIA
Family CERATOPSIDAE
Genus TOROSAURUS Marsh, 1891

Remarks.—There are three shapes to the frills of ceratopsia with fenestrated parietals, 1) triangular, found in *Protoceratops, Chasmosaurus,* and *Pentaceratops,* 2) figure-8, found



TEXT-FIG. 5—*Torosaurus utahensis* (Gilmore) n. comb., TMM 41480–1, right parietal. a, dorsal view. b, ventral view. ×⅛.

in *Brachyceratops, Monoclonius, Styracosaurus* and presumably *Pachyrhinosaurus,* 3) broad frill with elliptical or circular fenestrae, found in *Anchiceratops, Arrhinoceratops,* and *Torosaurus. Triceratops,* except for a few "sports," lacks fenestrae but is related to the last group. Considering the third group, in dorsal view *Anchiceratops* and *Arrhinoceratops* have rectangular frills with well developed epoccipitals. *Torosaurus* has a cardioid frill, has weakly developed epoccipitals, thinner parietals, and reduced vascular sulci. Since *Torosaurus* arose from an *Arrhinoceratops*-like form, a complete fossil record would show a gradation between forms and primitive torosaurs should be intermediate in character. Such a situation seems to exist in the case of *Torosaurus utahensis.*

TOROSAURUS UTAHENSIS (Gilmore)
new comb.
Text-fig. 5 a, b

Arrhinoceratops? utahensis Gilmore, 1946, U. S. Geol. Survey Prof. Paper 210-C, p. 42, Pl. II, fig. 1.

Holotype.—USNM 15583. A right squamosal, quadrate, quadratojugal, postorbital, supraorbital horn core, postfrontal, lacrimal, jugal, and epijugal.

Type locality.—West side of North Horn Mountain, Manti National Forest, Emery County, Utah.

Referred material.—USNM 15875 (Paratype), a right squamosal and the posterior part of a parietal; USNM 16573, part of a left parietal; TMM 41480–1, posterior part of right parietal.

Horizon.—Lower half of the North Horn Formation; lower third of the Tornillo Group; Maestrichtian Age.

Revised diagnosis.—*Torosaurus utahensis* can be distinguished from *T. latus* by the more anteriorly placed supraorbital horns, and the presence of straight, diagonal and longitudinal vascular sulci on the parietals. Distinct epoccipitals are present only on the anterolateral edge of the squamosal. The squamosal of *T. utahensis* is proportionally shorter than in *T. latus*.

Description.—The right parietal, TMM 41480–1, is extremely thin, reaching a thickness of 24 mm at the midline of the frill, and in a zone within 150 mm of the posterior edge. The bone thins gradually toward the posterior margin of the frill and 166 mm from the parietal-squamosal suture. The frill thins to a broken edge only 5 mm thick approximately 280 mm from the midline. There is a sharp sagittal ridge running along the interparietal bar. The bar has a triangular cross-section; its ventral surface is flat. Subdued undulations are present along the curved posterior edge of the frill, but distinct epoccipitals are lacking. Vascular sulci are developed on the posteromedial area on the dorsal surface of the frill. The remaining surfaces appear relatively smooth, exhibiting broadly separated, straight, diagonal and longitudinal, wide and deep vascular sulci on the dorsal and ventral surfaces.

Discussion.—The squamosal of the type of *Torosaurus utahensis* (USNM 15583) and the parietal and squamosal of USNM 15785 possess shallow vascular sulci on the dorsal surface. Both the Texas and Utah specimens exhibit a few straight, diagonal and longitudinal, broad and deep vascular sulci on an otherwise relatively smooth parietal. Both specimens have a slightly undulating posterior border that lacks distinct epoccipitals. The greatest thickness of the frill of the North Horn specimen (USNM 15583) is 18 mm approximately 40 mm anterior to the posterior edge. From there, the frill thins to 30 mm at the posterior border of the fenestra (Gilmore, 1946). The parietal thickens slightly within 25 mm of its posterior edge. The similarity in the topology of these parietals leaves little doubt that they are from members of the same species.

Although Gilmore questionably assigned the Utah ceratopsian to the genus *Arrhinoceratops*, close examination of the type *A. brachyops* (ROM 5135; Parks, 1925) shows a number of differences. Unlike *Torosaurus utahensis, Arrhinoceratops brachyops* possesses deep reticulate sculpturing of the frill. Unlike the parietal of *A. brachyops* which thickens to 30 mm about 40 mm from the posterior edge, the parietal of *Torosaurus utahensis* does not exceed 17 mm in a comparable zone. The ornamentation on the posterior edge of the frill of *Arrhinoceratops* is much exaggerated compared to that of *Torosaurus utahensis*. In dorsal view, the outline of the frill in the two genera is quite different—rectangular in *Arrhinoceratops* and cardioid in *Torosaurus*.

The frill of *Torosaurus latus* is fairly smooth on both the dorsal and ventral surfaces and has small marginal undulations as in *Torosaurus utahensis*. The vascular sulci, less than 2 mm in diameter on the dorsal surface of the frill in *T. latus* (YPM 1830), are more pronounced in the area near the midline. The ventral surface of *Torosaurus latus* (ANSP 15192) exhibits a significantly deep and extensive network of vascular sulci as does the paratype of *Torosaurus utahensis*. The squamosal of *T. utahensis* (USNM 15583) is proportionally shorter than that of *T. latus*.

The supraorbital horns of *T. utahensis* (USNM 15583) arise directly in front of the anterior edge of the orbits, but the greater part of the horn arises behind the posterior edge of the orbit as in *T. latus*. The horns of *Torosaurus* give an appearance of being extensions of the skull because the dorsal edge of the horns may continue up from the squamosals with little change in slope. The anterior edge of the horns may lie in front of or above the posterior edge of the orbits (Colbert and Bump, 1947). The rapidly tapering horns of *Torosaurus* curve dorsally at the tip, whereas the relatively blunt horns of *Arrhinoceratops* taper more gradually, starting from a base which lies over the orbits.

It should be pointed out that the characteristics used to distinguish *T. utahensis* from *T. latus* might actually be those that separate young and old of the same species. In USNM 15583 all the bones of the skull were unfused as in young individuals. The frill is thinner in the Texas and Utah specimens than in those from Wyoming and South Dakota. The distance between parietal-squamosal sutures at the posterior edge of the frill is smallest in the two southern specimens. Even though the squamosal of *T. utahensis* is proportionally shorter than *T. latus*, it is approximately 945 mm long in USNM 15583 compared to 790 mm (ANSP 15192), 1240 mm (YPM 1830), and 1430 mm (YPM 1831) in *T. latus* (Colbert and Bump, 1947). But geographic distribution and lithologic association of the *Torosaurus* specimens adds credence to the recognition of two species; *T. utahensis* being the southern species that lived hundreds of kilometers from the coast and *T. latus* the northern species that lived near the coast.

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