BUREAU OF ECONOMIC GEOLOGY
The University of Texas
Austin 12, Texas

Peter T. Flawn, Director

Report of Investigations—No. 48

The Hill-Shuler Local Faunas of the Upper Trinity River, Dallas and Denton Counties, Texas

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BOB H. SLAUGHTER, WILSON W. CROOK, JR., R. K. HARRIS,
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The Hill-Shuler Local Faunas of the Upper Trinity River, Dallas and Denton Counties, Texas

BOB H. SLAUGHTER, WILSON W. CROOK, JR., R. K. HARRIS,
D. C. ALLEN, AND MARTIN SEIFERT[1]

ABSTRACT

The Pemberton Hill-Lewisville (T-2) terrace deposits of the Trinity River in Dallas and Denton counties are divided into four consecutive members. Sixty-three vertebrates, thirty-two mollusks, and several insects and plants have been collected from three members and are discussed. Fluorine-uranium-nitrogen (F-U-N) tests on fossil material from each member indicate that the entire unit is a single depositional sequence with a short time span. During this period there were local extinctions and new arrivals which probably reflect change of climate from more humid to more arid than is present in the area today. The terrace deposits are tentatively referred to the Sangamon interglacial on the basis of two radiocarbon dates in excess of 37,000 years and on the association of the giant bison, *Bison alleni,* with a typical interglacial fauna. Other Trinity River terraces and local archeology are described, and stratigraphic and faunal relationships with other well-known fossil localities in Texas, Oklahoma, and Kansas are suggested.

INTRODUCTION

Shuler (1918, pp. 25–26, 28, 47) first alluded to the fossil-rich alluvial terrace deposits along the Trinity River near Dallas, Texas (fig. 2) ; Lull (1921) published the first study of these deposits. Stovall and McAnulty (1941) described a similar occurrence at Trinidad, Henderson County, Texas, about 80 miles downstream from Dallas (fig. 1).

Most of the fossils have been discovered during large-scale economic exploitation for sand and gravel of the 50-foot thick Pemberton Hill-Lewisville (T-2) terrace deposits of the Trinity River. Because so much new material has been added to the older Pemberton Hill-Lewisville fossil collections and because there has been a general increase in knowledge over the years of ancient animals, plants, and climates, a more accurate interpretation of the fossils is now possible.

Recent study shows the Pemberton Hill-Lewisville (T-2) terrace deposits to be late Pleistocene. Because recently determined radiocarbon dates of the surface of the Beaumont clay off the Texas coast indicate the Wisconsin to have begun about 25,000 years BP[2] and because two radiocarbon dates of fossil material from the Pemberton Hill-Lewisville (T-2) terrace deposits at Dallas indicate their age to be in excess of 37,000 years BP, the Pemberton Hill-Lewisville (T-2) terrace deposits are allocated to the last interglacial or Sangamon.

Although this paper is jointly authored, the authors assume individual responsibility for certain sections. These sections and their authors are: Geology of the Terrace Deposits, Wilson W. Crook, Jr.; Vertebrate Fossils from the T-2 Deposits, Bob H. Slaughter; Molluscan Fauna from the Lower Shuler Member, T-2 Deposits,

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[1] Dallas, Texas.

[2] Abbreviation used throughout paper to indicate "years before present."

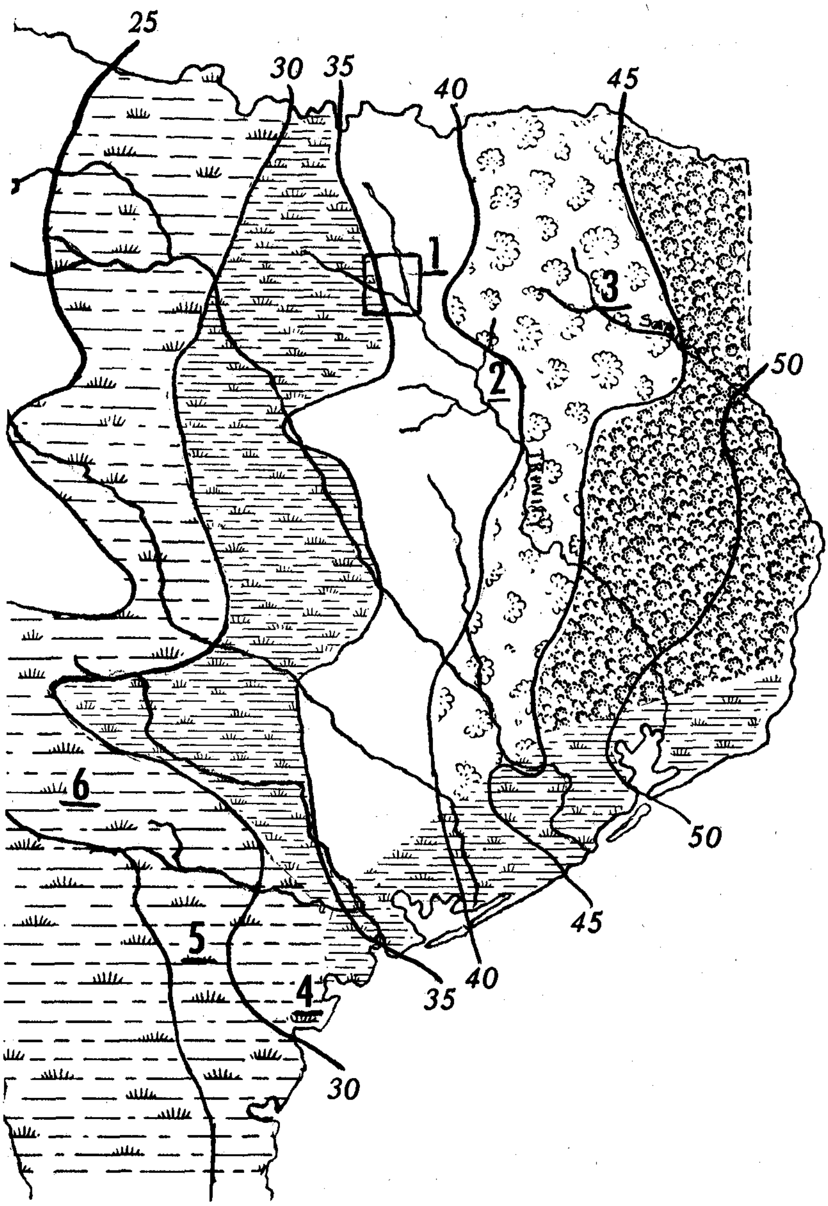

FIG. 1. Index and rainfall map: (1) Area of the Hill-Shuler local faunas: (2) Trinity terrace (Boatwright pit, etc.), Trinidad, Texas; (3) Iron Bridge local fauna; (4) Ingleside local fauna; (5) Berclair local fauna; (6) Friesenhahn Cavern local fauna.

Dallas occupies a position between forested areas to the east and prairie-plains to the west; upstream and downstream migration of fauna and flora, therefore, may occur with relatively small increase or decrease in rainfall.

Numbers on the rainfall lines indicate inches of precipitation annually.

D. C. Allen and Martin Seifert; and Fossil Man in the Alluvial Terraces of the Upper Trinity River, R. K. Harris.

The writers are indebted to the following workers for their help in making and preparing the collections: J. L. Connolly, Virgil Hudson, Theodore Saldivar, and L. P. Starrett, Jr. Pit operators Roy Moore

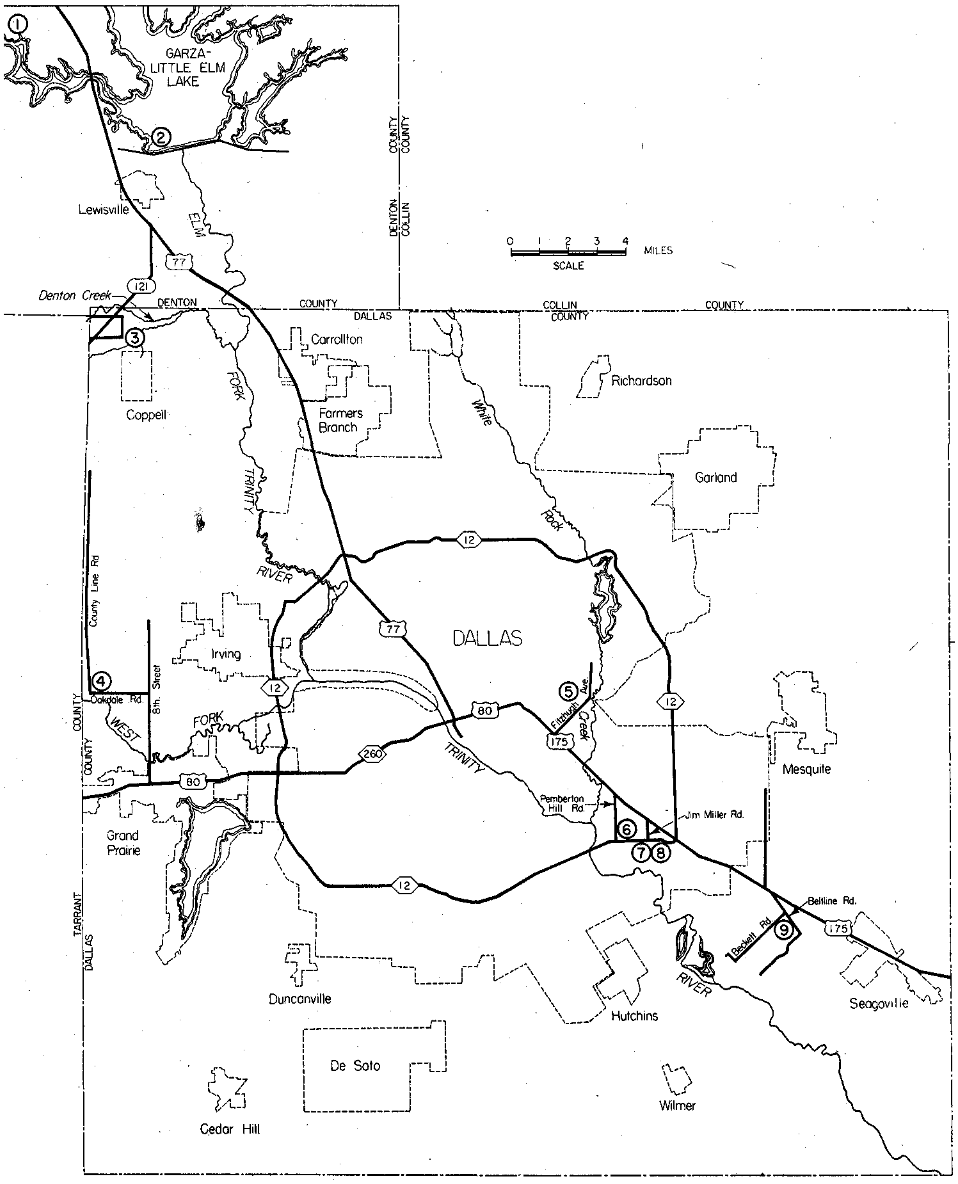

FIG. 2. Location map for Hill-Shuler fossil localities, region of Dallas, Texas. (1) Hickory Creek locality. (2) Lewisville site. (3) Coppel locality. (4) Seale pit. (5) Lagow pit. (6) Pemberton Hill. (7) Moore pit. (8) Wood pit. (9) Gifford-Hill pit.

and Charles Scott gave permission to excavate certain fossiliferous zones, and this help is gratefully acknowledged.

Appreciation is also expressed to Dr. A. Byron Leonard, University of Kansas, for reading and criticizing the molluscan portion of the manuscript; to the late Dr. John T. Lonsdale, former Director of the Bureau of Economic Geology; and to Dr. E. L. Lundelius, Assistant Professor of Geology, The University of Texas, for offering suggestions and for permission to examine fossil and recent material in the collections at Austin.

The authors are most grateful to Mr. Harry W. Elliott for the drawings of the specimens, exclusive of the equine tooth patterns.

ABBREVIATIONS AND TERMS

The following abbreviations are used in the text and tables of measurements:

AMNH	American Museum of Natural History, New York, New York.
BEG	Bureau of Economic Geology, The University of Texas, Austin, Texas.
CITVPC	California Institute of Technology Vertebrate Paleontology Collection, Pasadena, California.
DPSC	Dallas Prehistorical Society Collections. Deposited jointly at Southern Methodist University, Dallas, Texas (bulk of study collection) and at Dallas Museum of Natural History (display specimens).
SMUMP	Southern Methodist University Museum of Paleontology, Dallas, Texas.
SMUP	Southern Methodist University Biology Department (Pleistocene mollusks).
SMUR	Southern Methodist University Biology Department (Recent mollusks).
LSM	Los Angeles County Museum, Los Angeles, California.
TMM	Texas Memorial Museum, Austin, Texas.
UC	University of California, Los Angeles, California.
WFIS	Wagner Free Institute of Science, Philadelphia, Pennsylvania.
BP	Years before present.

Sand and gravel size terms are according to the grain size classification of Wentworth.

GEOLOGY OF THE TERRACE DEPOSITS

Alluvial terrace deposits of the Trinity River are well defined, easily recognized, and remarkably consistent in content and sequence from 40 or more miles upstream from Dallas to at least 80 miles downstream. The writers have investigated and studied these terrace deposits from Tarrant and Denton counties, west and northwest of Dallas, to Henderson County, southeast of Dallas.

Shuler (1935) first described the Trinity terrace deposits at Dallas; Pattillo (1940) described those of the Elm Fork of the Trinity River near Carrollton, traced this sequence to its junction with the Trinity River sequence described by Shuler, and established a lithologic correlation between the two. The present writers have confirmed this correlation and have further refined the sequence and definition of the terrace deposits, including the recognition of two additional terraces. The current binomial nomenclature, used locally, emphasizes the relation of the Trinity and Elm Fork type localities for the several terrace deposits (Crook and Harris, 1957, p. 37). In the binomial system, the first name indicates the Trinity River terrace deposits at Dallas; the second indicates the comparable terrace deposits upstream on Elm Fork.

The following Trinity River terrace deposits, in order from highest to lowest, occur in the Dallas area (fig. 3):

Designation	Feet above present stream grade
Cretaceous uplands	195–425
T-5, Buckner Home—Hackberry Creek	165
T-4, Love Field—Bethel	120
T-3, Travis School—Farmers Branch	90
T-2, Pemberton Hill—Lewisville	70
T-1, Union Terminal—Carrollton	50
T-0, Flood plain (approx.)	20

The Hill-Shuler local faunas described in this paper are from Pemberton Hill-Lewisville (T-2) terrace deposits (fig. 3) in Dallas, Denton, and Tarrant counties (fig. 2); these terraces lie along the Trinity River and its tributaries, Elm Fork, West Fork, and Hickory Creek. Uniformity of age of the terrace deposits and the fossil bone within them was proven by fluorine-uranium-nitrogen (F-U-N) tests on bone samples submitted to the Univer-

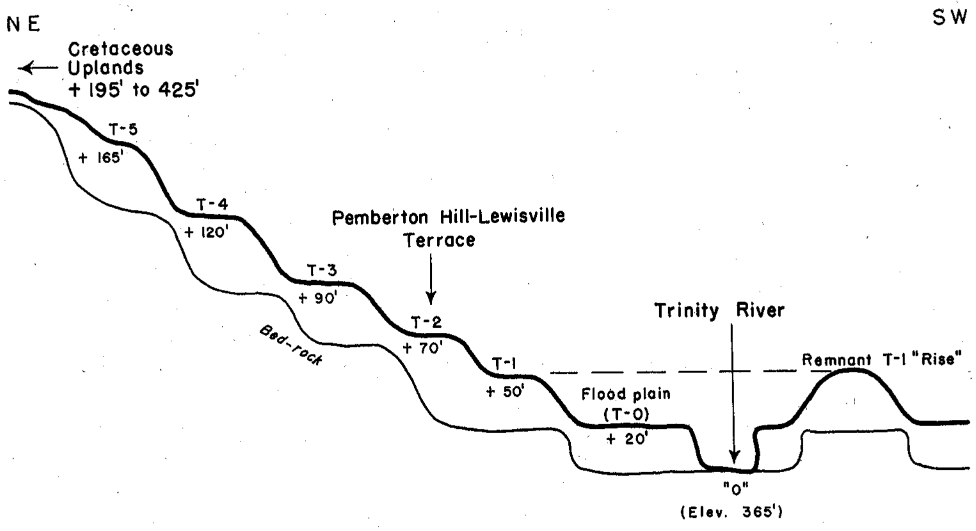

FIG. 3. Schematic section showing Trinity River alluvial terraces, Dallas, Texas. Numbers indicate elevation above present stream grade of top of present terrace surface.

sity of London (Oakley and Howells, 1961).

There were only minor differences in fluorine, uranium, and nitrogen content of bone from four different localities as much as 40 miles apart; four species of animals were represented and bone was analyzed from each of the three lowest members of the Pemberton Hill-Lewisville (T-2) terrace fill. Uniformity in age of the three lowest members of the terrace deposits both geographically and stratigraphically is thus demonstrated. Because the difference in age between the three lowest members of the Pemberton Hill-Lewisville (T-2) fill is so small, they must have been deposited within a brief period despite the pronounced erosional break that occurs in places between members and despite the change from gravel to sand, to clay, and so on.

Individual members of the Pemberton Hill-Lewisville (T-2) terrace fill vary in thickness from exposure to exposure, depending upon the amount of erosion at a given locality during any of the erosion intervals separating the different members. This variation in thickness is typical of the meandering cut-and-fill deposits of low-gradient coastal plain streams. Despite its distance of nearly 250 miles from the Gulf Coast, the gradient of the Trinity River at Dallas is only approximately 0.7 foot per mile.

Hereinafter, the terms "T-2 deposits" and "T-2 fill" designate the Pemberton Hill-Lewisville (T-2) terrace deposits. Similar terms are used to designate other terrace deposits of the Trinity River System.

A typical section of T-2 deposits in the Dallas area is as follows, beginning at the base (fig. 4):

(1) At Dallas bedrock is Cretaceous, either Eagle Ford shale or Austin chalk.

(2) A marked angular unconformity separates the Cretaceous and Quaternary deposits. Its last refinement was the valley trenching which established relief on T-3 deposits and produced the cut into which the T-2 fill was deposited.

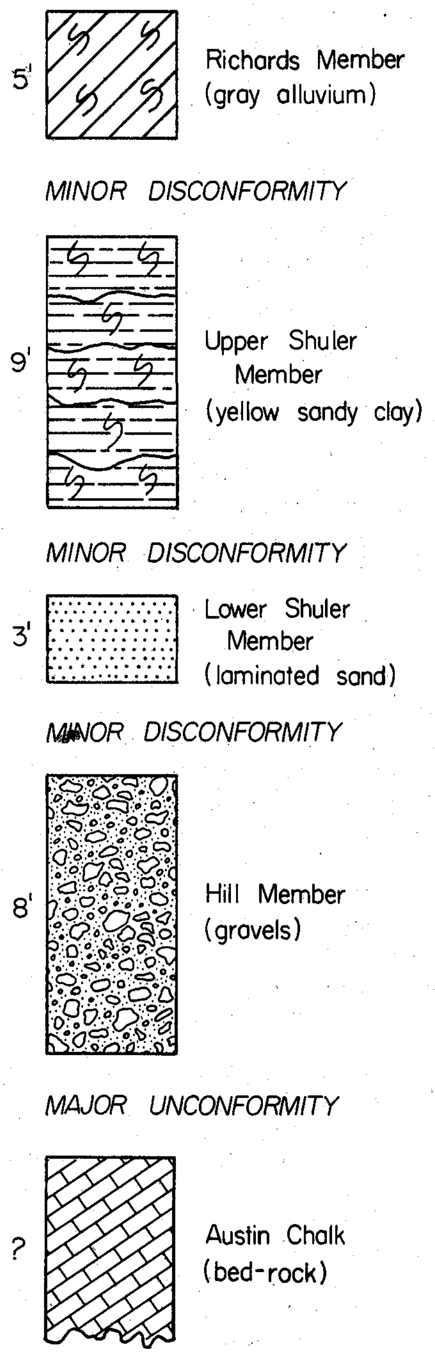

FIG. 4. Typical section, Pemberton Hill-Lewisville (T-2) terrace deposits.

(3) A deposit of gravel with much included sand overlies the bedrock and is called locally the Hill member. The gravels range in size from very large pebbles at the base to small pebbles at the top. Thickness varies from section to section, from a minimum of about 3 feet to an observed maximum of 20 feet, and averages about 10 to 12 feet. In many exposures, the topmost foot or so is cemented by iron oxide to form a brownish, rust-colored conglomerate. Fossil bone is heavily mineralized, is usually stream abraded, and has small pebbles and sand grains firmly cemented to it.

(4) A minor disconformity separates the Hill member from the next higher member.

(5) Clean, finely laminated yellow sands comprise the Lower Shuler member. The laminae are approximately 2 mm thick. The yellow color is limonite stain, and in places there are narrow bands of manganese stain. Many calcareous root molds occur throughout at various levels which must have been surfaces at the time the roots were emplaced. Layers of calcareously cemented sand as much as 6 inches thick also occur at certain localities. Occasional lenses of small pebbles interspersed with layers of laminated sand occur near the base.

Average thickness of the member is approximately 5 feet, although it may be as much as 10 feet. At many localities succeeding erosion has completely removed the yellow laminated sand; here, higher members rest directly upon the eroded Hill gravels below. Included fossil bones are well mineralized, unabraded, and commonly complete; a few small logs also occur. Some bones and logs are encrusted with iron oxide. In places near the top of the member a thin (5-mm thick) layer of ironstone has formed beneath the buried erosion surface which separates the Lower Shuler from the Upper Shuler.

(6) The yellow sands of the Lower Shuler member are separated from the overlying Upper Shuler by a minor disconformity, the formation of which, in places probably close to the stream channel, resulted in the removal of all of the Lower Shuler sands.

(7) Yellow sandy clay, often massive and indurated, comprises the next higher member, the Upper Shuler member, which is 3 to 20 feet thick and averages about 12 feet. Although this fill is relatively homogeneous, it does contain five to seven depositional units which vary in thickness. The upper layer of each of these units was a surface long enough for minor erosional features to develop thereon and for a subsurface zone of caliche to form; it is the caliche that delineates each of these minor erosional surfaces. The caliche is composed of popcorn-like nodules and concretions which are progressively larger and more abundant upward. A number of calcareous root fillings, caliche-filled crotovinas (presumably prairie-dog holes judging from the size of the holes and the presence of fossilized remains of these animals), and smaller, filled crayfish holes identical to filled holes in present creek beds occur at each of the successive unit surfaces; there are also vague, whitish, limy zones. Fossil bones are mineralized, primarily by calcium carbonate, and are usually heavily encrusted by caliche. They show no evidence of stream abrasion and are commonly cracked and fragmentary, although the fragments are recemented, usually by calcium carbonate.

(8) Another minor disconformity occurs above the yellow sandy clays of the Upper Shuler member. In places, 3- to 8-foot deep stream channels have been cut in the Upper Shuler, then filled by the overlying member.

(9) The Richards, locally derived gray alluvium, is the uppermost member of the T-2 depositional sequence. It averages 5 feet thick, excluding the deeper channel fills in the underlying Upper Shuler member; in places the Richards has been almost totally removed by subsequent erosional periods. The Richards has remained the exposed surface of the T-2 fill essen-

tially ever since it was laid down as the uppermost member of the T-2 deposits. The member contains numerous small calcareous nodules and concretions throughout, but no fossils have yet been found. It is possible that leaching, during the long period that the Richards has comprised the T-2 surface, may have removed fossil bone and caused the small size of the caliche nodules.

(10) A major episode of valley cutting created the T-2 relief.

(11) Another depositional cycle partially filled the valleys cut in the T-2 deposits; this fill is the T-1 deposit. Thickness of the T-1 fill does not equal that of the T-2 deposits (50 feet above present stream grade as compared to 70 feet). The T-1 deposits, red Albritton clay and overlying gray Pattillo sand, do form a veneer in places on the eroded slopes of the T-2 fill. Especially near the present valley, typical red sandy clay and gray sand members of the T-1 fill commonly rest directly on truncated sections of T-2 fill.

(12) Another major valley cutting established the present relief on the T-1 deposits. This was followed by deposition of the present flood plain (T-0) deposits to a height of some 20 feet above present stream grade (fig. 3).

(13) The present channels were incised to bedrock.

COMPARISONS AND INTERPRETATIONS

The sequence of alluvial terrace deposits of the Trinity River has been tentatively correlated by Crook and Harris (1957, p. 53; 1958, p. 237) with those of the neighboring reaches of the Red, Sulphur, Sabine, Brazos, and Leon Rivers.

Crook and Harris' conclusions agree essentially with those of Fisk (1938, pp. 169–172; 1940, p. 58; and revised by Doering, 1956, pp. 1832–1837) concerning Fisk's investigations of the Red River in northern Louisiana.

Briefly, these investigators allocated the terrace fills to non-glacial periods of high sea stand and allocated the cuts and trenches to glacial maxima of low sea level. Thus, the T-2 fill is related, depending upon recent interpretation and revisions, either to the last interglacial or to a major interstadial within the last glacial.

Two radiocarbon dates from the lower part of the Upper Shuler member at Lewisville, near the junction of Hickory Creek and Elm Fork in Denton County, are "more than 37,000 years BP" (Brannon et al., 1957, p. 149).

Numerous radiocarbon assays from glacial tills in the Midwest have established that the standard Wisconsin, or Fourth Glaciation as it has been previously considered, encompasses the period roughly from 25,000 to 10,000 BP. These dates are substantiated by Magnolia Petroleum Company (a division of Socony Mobil) which has obtained radiocarbon dates of samples from submerged offshore deposits in the Gulf of Mexico that can be correlated with sea-level fluctuations. One sample from the surface of the Beaumont clay, a marine deposit presumably of the last interglacial, was from the subaerially weathered zone exposed by the last major regression of the sea—assumed to have occurred during the last glacial or Wisconsin. Certainly the sea had to be lowered considerably for this surface to be exposed. The oldest sample measured some 28,000 BP (Bray and Nelson, 1956, p. 173). On the other hand, the radiocarbon dates of offshore borings by Magnolia, from the base of Recent marine deposits laid down during the transgression related to modern high sea stand, range from 9,000 to 12,000 BP.

In Germany, recent radiocarbon measurements have dated the Masurian Interstadial deposits at Rixdorf, near Berlin, as 28,000 to 42,000 BP (DeVries, 1958, p. 15), presumably that interval between the early and late phases of the Wurm or Fourth Glacial. In more southerly climatic areas, such as at Dallas, this non-glacial period may have begun somewhat earlier and lasted somewhat later, perhaps covering the period 25,000 to 45,000 BP.

There is also some recent evidence from the Midwest that there an early Wisconsin predates standard Wisconsin, but this is not yet widely accepted.

Based on radiocarbon dates the T-2 fill must pertain to a non-glacial period, either major instadial in the last glacial or the last interglacial. Climatic implications based upon the fossil fauna and flora definitely allow this interpretation; it is also in agreement with conclusions of Fisk (1938, pp. 169–172; 1940, p. 58) and Doering (1956, pp. 1832–1837) concerning correlation of river terraces and coastal deposits with glacial and non-glacial periods.

Further confirmation is supplied by the next-younger (or T-1) fill, which should in theory be related to the Recent post-glacial period characterized by high sea stand. One unpublished radiocarbon date from near the mid-point of T-1 deposits just southeast of Dallas is approximately 6,000 BP.

Archeological materials of the Archaic Stage, in place and undisturbed, are common throughout the T-1 deposits. The Archaic Stage in the United States, based on radiocarbon dates, ranges from 4,000 to 10,000 BP. As yet only a modern vertebrate fauna has been recovered from the T-1 deposits on the Trinity River system, and the snail assemblage of the T-1 deposits appears to be modern in contrast to that of the T-2 deposits.

The present flood plain (T-0) deposits have yielded, appropriately, inclusions of late pottery-and-agriculture Indians, scant evidences of possible Spanish explorations, a surficial capping of Anglo-American materials, plus a totally modern fauna. It is obviously but yesterday in origin.

The writers have visited and studied the downstream terrace evidence near Trinidad and Malakoff, Henderson County (fig. 1, no. 2). The Trinity terrace deposits described by Stovall and McAnulty (1941) are directly correlated with those of the T-2 at Dallas on the basis of the elevation above stream grade, lithology, and the included fauna.

Exposures near Iron Bridge Dam (fig. 1, no. 3) on the upper Sabine River in Van Zandt and Hunt counties east of Dallas exhibit a sequence of units almost identical to those at Dallas and Trinidad (Peterson and Slaughter (MS). T-0 deposits are composed of locally derived alluvium, with one historic Indian village site upon its surface—the Tawakoni Village of 1759–1767. The T-1 fill is the same red clay-gray sand sequence as at Dallas, containing in-place Archaic archeological artifacts also directly related to those of the Dallas area. The T-2 deposits of the two areas exhibit the same general lithologic sequence, including the most recent caliche zone, and extinct faunal species are also similar (*Tetrameryx shuleri* is known only from these two localities). Higher terraces, not yet intensively studied, are capped, as at Dallas, by a remnant of the typical Dallas area T-5 cobble fields of quartzite and petrified wood. Similarities of the terrace deposits and faunas of the Iron Bridge and Dallas areas are striking.

Other Texas late Pleistocene areas paleontologically, geologically, and archeologically described in the literature—the Ingleside pond fill, the Berclair terrace deposits, and the Friesenhahn Cavern deposits of south Texas (fig. 1, nos. 4, 5, 6) are related in varying degrees. Berclair terrace deposits (Sellards, 1940), Bee County, which have been directly correlated with the Beaumont clay shore line and its non-contradictory fossils, seem to be a direct correlative of the T-2 terrace deposits at Dallas. Ingleside pond deposits in San Patricio County (studied by the writers) have a fauna similar to the fauna of the T-2 deposits at Dallas, but the stratigraphic position of the Ingleside atop the Beaumont clay (implying considerable regression of sea level) suggests the Ingleside fill was deposited during late, last interglacial interstadial, and early last glacial time. This is apparently slightly later than the T-2 deposits at Dallas. Friesenhahn Cavern local fauna (Bexar County), for various reasons, may be somewhat later, perhaps early-to-late last glacial.

A last glacial fauna of pluvial deposits, such as the late deposits of west Texas, has not been found in the Dallas area, perhaps because of the excessive local downcutting occurring at that time.

In summary, the fauna of the T-2 deposits along the Trinity River and its tributaries near Dallas probably pertains to the last interglacial or a major interstadial of the last glacial. These deposits and their faunas, far south of the actively glaciated regions, are directly related to the Gulf Coastal Plain alluvial deposits which can be correlated over wide areas with fluctuating sea levels of the late Quaternary. There is little doubt, however, that these obvious fluctuations of sea level can be directly correlated with major cycles of glaciation and deglaciation, and because of this the abundant fossils in the terrace deposits are most useful and instructive.

HILL-SHULER LOCAL FAUNAS

Fossils comprising the Hill-Shuler local faunas were collected from commercial excavations and one natural exposure of the T-2 fill along Trinity River from southern Denton County to southern Dallas County, Texas. These specimens, almost without exception, were *in situ* and therefore can be assigned to one of three members of the T-2 fill. Specimens found without an overlying soil profile have been omitted to avoid the possibility of mixed faunas. With the exception of a small collection made in the early twenties by the late Dr. Ellis W. Shuler, all material was collected by the writers and their colleagues.

LOCATION AND DISCUSSION OF SITES

Lagow pit.—In 1920, Shuler collected fossils from the Lagow sand and gravel pit (fig. 2, no. 5) in the T-2 fill. The pit, located just east of Fitzhugh Street and south of East Grand Avenue in Dallas, Texas, has since been refilled, and the site is now occupied by the locomotive roundhouse of the Texas and Pacific Railroad. The site and general area have been visited by the writers, and their observations, added to Shuler's (1923) study, definitely correlate these deposits with other T-2 deposits along the Trinity River. One side of the original pit displayed an almost complete section of the terrace deposit while the opposite side sloped to the river. The Richards and part of the Upper Shuler were removed and red Albritton clay of the T-1 terrace fill was deposited on the cut surface.

Gifford-Hill pit.—In 1961, this pit (fig. 2, no. 9), exposed only clay, sand, and gravel of the lowest terrace section. In 1955, however, there was an island remnant of T-2 deposits near the middle of the Gifford-Hill properties. Hill-Shuler fossils from the Gifford-Hill pit were collected from this island remnant, which had the same elevation and lithology as better preserved exposures of the T-2 deposits. This pit is just east of Beckett Road, 0.6 mile south of Belt Line Railroad and 3 miles northeast of Seagoville, Dallas County.

Pemberton Hill.—Excavations for sand and gravel have almost completely destroyed Pemberton Hill, which stood on the northeast corner of Pemberton Hill Road and Loop 12 in the Dallas City limits (fig. 2, no. 6). Early excavations into this portion of the T-2 fill exposed a complete section, with all members present in maximum thickness. The Pemberton Hill location will be covered with a housing project within a year. This site is an excellent example of the amount of erosion that has taken place between the deposition of the T-2 and T-1 deposits; road cuts just to the south and west and an excavation immediately to the east display eroded sections in which the Richards and Upper Shuler members are missing.

Moore pit.—Moore pit (fig. 2, no. 7) is on the south side of Loop 12 just 400 yards southeast of Pemberton Hill. The pit walls opposite the river display all members of the T-2 deposits except the Richards. On the river side, however, both the Richards member and the Upper Shuler member have been removed along with some of the Lower Shuler member, and there is a cover of T-1 deposits. There are several ancient channel fills *within* the Lower Shuler of this pit, and these have produced most of the fossils.

Wood pit.—Wood pit (fig. 2, no. 8), 700 yards downstream from Moore pit, is at the south end of Deepwood Street. Rapid expansion of excavation has joined Wood and Milton pits making it practical to combine Milton and Wood pit collections. As in Moore pit, Upper Shuler is present only in the wall opposite the river.

Coppel locality.—This site (fig. 2, no. 3) is on Grapevine Creek where it has cut into a terrace of Denton Creek near where Denton Creek joins the Trinity River. The site is on the Good farm, 100 yards upstream from Coppel Road bridge over Grapevine Creek, half a mile southeast of the town of Coppel in Dallas County. Although this deposit was too far upstream from the main river to be affected by backwash from the river and although the alluvial material is all locally derived, the sequence is the same as that of the Trinity River—gravel capped by sand which is, in turn, capped by clay charged with caliche nodules. The fossils and the 70-foot elevation of the location above Denton Creek indicate a direct correlation with T-2 deposits of the Trinity River.

Hickory Creek locality.—Fossils were collected from this site (fig. 2, no. 1) subsequent to erosion of a large excavation made to obtain material to build the dump of the Santa Fe Railroad, which crosses Hickory Hill Road 150 yards west of the site. The locality, the Ernest D. Calvert farm, is on Hickory Hill Road, 1.4 miles west of the junction with Farm-to-Market Road 2181. This terrace deposit of Hickory Creek has been traced 5 miles downstream where it merges with T-2 terrace deposits of Trinity River. The Hickory terrace sequence has a slightly different composition because of a slightly more westerly source; the Hill gravel equivalent, Upper Shuler, and Richards are well preserved. Lower Shuler is either missing or represented by a 4-foot clay bed above the gravel; this clay bed is more sandy than the Upper Shuler clay and lacks its massive caliche.

Lewisville site.—A barrow pit (fig. 2, no. 2), from which material was excavated to build the Garza-Little Elm Dam, is immediately northeast of the west end of the dam. Fossils from this pit were discovered by Theodore White and later described by Crook and Harris (1957, p. 54). All fossils recovered from this site are from the Upper Shuler member, although a complete section is present. Lewisville site was designated as the Elm Fork type locality of the T-2 deposits; this locality has since been inundated by waters of the reservoir.

Seale pit.—This pit, an excavation for sand, is on property of Mr. W. Q. Seale and is located at the south end of County Line Road and the west end of Oakdale Road, approximately 4 miles north of Grand Prairie, Texas (fig. 2, no. 4). Unlike the other localities, the Seale pit is on the T-2 terrace of the West Fork of Trinity River, near its junction with the main river.

Haymarket pit.—Because of the close proximity of this pit to the Wood-Milton pit complex and also because only a single specimen was recovered from it, the Haymarket pit is considered part of the Wood pit local fauna.

VERTEBRATE FOSSILS FROM THE T-2 DEPOSITS

The specimens collected from the T-2 deposits and described in the following pages are listed below so that their member and site location may be readily at hand.

Chart showing distribution of vertebrate fossils from T-2 deposits.

Locality designations: C, Coppel locality; G, Gifford-Hill pit; Ha, Haymarket pit; H, Hickory Creek locality; La, Lagow pit; Le, Lewisville site; M, Moore pit; S, Seale pit; P, Pemberton Hill; W, Wood pit.

	Member		
	Hill	Lower Shuler	Upper Shuler
Mammalia			
Marsupialia			
Didelphis cf. *D. marsupialis* Linnaeus		M	....
Insectivora			
Scalopus aquaticus (Linnaeus)	....	....	Le
Edentata			
?Glyptodon sp.	....	....	Le
?Paramylodon sp.	....	La	....
Megalonyx cf. *M. brachycephalus* McAnulty	G	M, W	....
Holmesina septentrionalis (Leidy)	....	M, C	....
Dasypus bellus (Simpson)	....	M	H
Rodentia			
Cynomys ludovicianus (Ord)	....	....	Le, H
Sciurus cf. *S. carolinensis* Gmelin	....	M, C	....
Sciurus niger Ord	....	M	Le
Spermophilus cf. *S. tridecemlineatus* (Mitchell)	....	C	....
Peromyscus gossipinus (Le Conte)	....	....	Le
Peromyscus leucopus (Rafinesque) or *P. maniculatus* (Wagner)	....	M, C	Le, H
Neotoma sp.	....	M, C	Le, H
Sigmodon hispidus Say and Ord	....	M, C	H
Synaptomys sp.	....	C	H
Microtus cf. *M. (Pitymys)* sp.	....	M, C	Le, H
Ondatra cf. *O. zibethicus* (Linnaeus)	....	....	H
Geomys cf. *G. bursarius* (Shaw)	....	M, C	Le, H
Castor cf. *C. canadensis* Kuhl	....	M	H
Carnivora			
Canis sp. (coyote)	....	M	Le
Canis sp. (wolf)	....	....	Le
Aenocyon sp.	....	P, M	....
Arctodus cf. *A. simus* (Cope)	....	S	....
Ursus americanus Pallas	....	....	Le
Procyon lotor (Linnaeus)	....	M	Le, H
Mustela cf. *M. vison* (Bangs)	....	M	....
Mephitis mephitis (Schreber)	....	M	Le
Smilodon trinitiensis Slaughter	M,La	M, W, P	....
Lynx cf. *L. rufus* (Schreber)	....	M	....
Proboscidea			
Mammut americanus (Kerr)	W, G	M	H
Elephas columbi Falconer	W, G, S, P	W, M, C, P, H, S	P, Le, H
Langomorpha			
Sylvilagus cf. *S. floridanus* (Allen)	....	M, C	Le, H
Lepus sp.	....	W	Le
Artiodactyla			
Platygonus sp.	....	....	Le
**Dama virginianus aplodon,* n. subsp.		M, W	....
**Dama* sp.	La, W	M, W, C, P	Le, H
Breameryx sp.	....	P, C	....
Tetrameryx shuleri Lull	....	La, M	....
Camelops huerfanensis dallasi Lull	....	La, P	....
?Camelops sp.	W, G, M	M, W, C, H	Le
Tanupolama sp.	....	M, La, W	....
Bison alleni Marsh	....	La, G, M, S	....
Bison sp.	W, G	C, M, W, P	Le, H

*** Since this paper was written and in type the International Congress of Zoological Nomenclature recommended the use of *Odocoileus* in place of *Dama*.**

	Member		
	Hill	**Lower Shuler**	**Upper Shuler**
Perrisodactyla			
Equus midlandensis Quinn	W	M, W	....
Equus cf. *E. fraternus* (Leidy)	W	M, W	....
Equus sp.	W, M, P	C, M, P, W	....
Asinus conversidens (Owen)	W, M	M, W, C	....
Equus? quinni Slaughter, n. sp.	W, M	W, M	....
Equus cf. *E. caballus* Linnaeus	....	....	Le, P
Tapirus sp.	W, M	M, W	....
Reptilia			
Testudinata			
Graptemys geographica (Le Sueur)	....	M	....
Terrapene canaliculata Hay	....	....	Le, H
Terrapene cf. *T. carolina* (Linnaeus)	....	W, M, C	....
Geochelone sp.	W, G	W, M, C, P	Le
Alligator mississippiensis (Daudin)	C	M	....
Squamata			
?Coluber constrictor Linnaeus	....	....	Le
Amphibia			
Anura	....	M, C	Le, H
Aves			
Falconiformes			
Aquila chrysaetos (Linnaeus)	....	W	....
Galliformes			
Tympanuchus cf. *T. pallidicinctus* (Ridgeway)	....	C	....
Passeriformes			
Corvus brachyrhynchos Brehm	....	M	....
Stringiformes			
Tyto alba (Scopoli)	....	C	....
Pisces			
Lepisosteiformes			
Lepisosteus cf. *L. spatula* (Lacepede)	....	M	....

SYSTEMATIC PALEONTOLOGY

Most of the specimens upon which this study is based were originally in the collections of the Dallas Prehistorical Society. These have now been transferred to Southern Methodist University Museum of Paleontology, and most of the specimen numbers reflect that change. Specimens on loan to other universities, however, still carry the number of the Dallas Prehistorical Society; both numbers are given for specimens that have been previously reported and described in the literature.

Phylum VERTEBRATA

Class MAMMALIA

Order MARSUPIALIA

Family DIDELPHIDAE

DIDELPHIS cf. D. MARSUPIALIS Linnaeus

Referred specimen.—Right M3 (SMU-MP 60152); Lower Shuler, Moore pit.

Discussion.—This is a single tooth; reference identification is provisional. It is identical to several Recent specimens except for its slightly smaller size, which is certainly within individual size range.

Stovall and McAnulty (1941, p. 242) state that their record of the opossum in the Trinity terrace at Trinidad, just 80 miles downstream from Dallas, is the second Pleistocene report of the form. If this is so, the Dallas occurrence is apparently the third.

Order INSECTIVORA

Family TALPIDAE

SCALOPUS AQUATICUS (Linnaeus)

Referred specimen.—Humerus (DPSC 1060); Upper Shuler, Lewisville site.

Discussion.—This specimen was identified in 1956 by Dr. Claude Hibbard when he examined material from the Lewisville site.

Order EDENTATA

Family GLYPTODONTIDAE

?GLYPTODON sp.

Theodore E. White, a salvage paleontologist for the River Basin Survey Party which conducted operations in the Garza-Little Elm reservoir, reported (personal communication to W. W. Crook, Jr., 1955) *"Glyptodon scutes"* from the Upper Shuler at the Lewisville site. It is possible to identify scutes of various members of Edentata even specifically, but apparently these particular specimens, now in the U. S. National Museum, have not been studied; *Glyptodon* scutes do not occur in Dallas site collections available to the writers.

Family MYLODONTIDAE

?PARAMYLODON sp.

Shuler (1918, p. 26) stated that dermal scutes of ground sloths were collected at the Lagow sand pit. These specimens were not used in this study, but because *Paramylodon* is the only sloth genus that had such scutes, the genus is added provisionally to the Hill-Shuler faunal list.

Family MEGALONYCHIDAE

MEGALONYX cf. M. BRACHYCEPHALUS McAnulty

Referred specimens.—Second upper cheek tooth (SMUMP 60046) ; Lower Shuler, Moore pit. Third upper cheek tooth (SMUMP 60058) ; Lower Shuler, Moore pit. Fused first and second phalange of the third pes digit (SMUMP 60023); Hill member, Gifford-Hill pit.

Discussion.—Isolated sloth teeth are not easily identified specifically, but these specimens are almost identical in size and form to *M. brachycephalus,* which is smaller than other species of the genus. It is on this basis that the Dallas specimens are referred provisionally (table 1).

TABLE 1. *Measurements of sloth teeth* (in mm).

	Upper cheek teeth		*M. brachycephalus* (BEG 30907-60)
	(SMUMP 60046)	(SMUMP 60058)	
Antero-posterior diameter of 2nd tooth	15	......	16
Transverse diameter of 2nd tooth	22.5	......	23
Antero-posterior diameter of 3rd tooth	......	16.5	15.3
Transverse diameter of 3rd tooth	......	23	24

The writers visited the pit near Trinidad, Texas, where the holotype of this species was collected, and they are convinced that the deposits of this type locality are a Henderson County equivalent of the T-2 deposits at Dallas.

Family DASYPODIDAE

HOLMESINA SEPTENTRIONALIS (Leidy)

Referred specimens.—Cheek tooth (SMUMP 60068); Lower Shuler, Moore pit. Buckler scutes (SMUMP 60092); Lower Shuler, Moore pit. Casque scute (SMUMP 60267); Lower Shuler, Coppel locality.

Discussion.—The cheek tooth (SMUMP 60068) was compared with the dentition of a mandible of *H. septentrionalis,* in the collection at the Bureau of Economic Geology, The University of Texas, which came from a terrace of the Brazos River. The same specimen was sent to Mr. Walter Auffenburg, University of Florida, for comparison with material from that State. The Dallas specimen is somewhat smaller than both. Auffenburg felt, however, that size is not an important specific characteristic of this animal.

The buckler scutes are similar to scutes found at other localities in Texas and Florida. They are 8 to 10 mm in thickness and 30 to 40 mm in diameter.

The casque scute (SMUMP 60267) is very thin and kite-shaped; dimensions are 5 × 37 mm.

DASYPUS BELLUS (Simpson)

Referred specimen.—Over one hundred buckler, movable ring, and leg scutes plus three thoracic vertebrae belonging to a single individual (SMUMP 60297; DPSC 705). Upper Shuler, Hickory Creek locality.

Discussion.—This individual has been described by Slaughter (1959) and is the first record of this species in Texas.

Order RODENTIA

Family SCIURIDAE

CYNOMYS LUDOVICIANUS (Ord)

Referred specimens.—Six lower jaws (SMUMP 60668); Upper Shuler, Lewisville site. Lower jaw (SMUMP 60296); Upper Shuler, Hickory Creek locality.

Discussion.—In addition to the six jaws (SMUMP 60668), post-cranial elements have been collected from the Lewisville site and Hickory Creek and Coppel localities. Although fairly abundant prairie-dog material occurs in the Upper Shuler, not a single specimen has been recovered from the Hill or Lower Shuler members. This is an indication of more arid conditions during Upper Shuler deposition than during that of the Hill and Lower Shuler members.

There are no reliable records of the occurrence of prairie dogs within a hundred miles of Dallas during Recent time. The Upper Shuler specimens do not appear to be intrusive because they were collected from a depth of over 20 feet, and several were encrusted with caliche.

SCIURUS cf. S. CAROLINENSIS Gmelin

Referred specimens.—Lower jaw (SMUMP 60117); Lower Shuler, Moore pit. M1 (SMUMP 60283); Lower Shuler, Coppel locality.

Discussion.—These specimens were compared with *S. carolinensis* and *S. niger* and the size of both matches that of *S. carolinensis* more closely. Gray squirrels are not present in the area today but are found east of Dallas in the pine-hardwood forests. This is an indication of the existence in the Dallas area of a humid climate, with accompanying fauna and flora, during Lower Shuler deposition.

SCIURUS NIGER Ord

Referred specimen.—Lower jaw (DPSC 1061); Upper Shuler, Lewisville site.

Discussion.—This species is abundant today both east and west of Dallas.

SPERMOPHILUS cf. S. TRIDECEMLINEATUS (Mitchill)

Referred specimens.—Partial jaw (DPSC 1034); Upper Shuler, Lewisville site. Single tooth (SMUMP 60286); Lower Shuler, Coppel locality.

Discussion.—Dallas is near the eastern edge of the range of this species. Because the species ranges west and slightly east, it cannot be used to infer climate.

Family CRICETIDAE

PEROMYSCUS GOSSIPINUS (Le Conte)

Referred specimens.—Lower jaws (DPSC 1013, 1069) ; Upper Shuler, Lewisville site.

Discussion.—The presence of this species in the Upper Shuler member is a paradox. Because it is a species whose normal habitat is somewhat farther east, it does not conform with the previously suggested climate for this member.

The climate of earliest Upper Shuler times may have been much like that of Lower Shuler time, and perhaps it was not until well into Upper Shuler time that arid conditions began to affect the fauna.

PEROMYSCUS LEUCOPUS (Rafinesque)
or
PEROMYSCUS MANICULATUS (Wagner)

Referred specimens.—Lower jaw (DPSC 1070) ; Upper Shuler, Lewisville site. Tooth (provisional reference) (SMUMP 60287); Lower Shuler, Coppel locality.

Discussion.—Both species are present in the area today.

NEOTOMA sp.

Referred specimens.—Isolated teeth (SMUMP 60122) of this genus are abundant in the Lower Shuler at the Moore pit and Coppel locality and in the Upper Shuler at the Hickory Creek locality and Lewisville site.

Discussion.—*N. floridanus* occurs in the Dallas area today.

SIGMODON HISPIDUS Say and Ord

Referred specimens.—Lower jaw fragment containing $\overline{M3}$ (SMUMP 60150); Lower Shuler, Moore pit. Maxilla fragment containing $\underline{M3}$ (SMUMP 60158) ; Lower Shuler, Moore pit. $\overline{M3}$ (SMUMP 60307); Upper Shuler, Hickory Creek locality.

Discussion.—Although *S. hispidus* ranges throughout most of southern United States today, *Sigmodon's* center of distribution is definitely south of the United States border. Although currently abundant within its range, this species has not been previously collected from any of the well known Sangamon localities. Its occurrence in the Upper Shuler at Dallas may indicate that at least this member of the T-2 terrace sequence is younger than the Kansas and Oklahoma local faunas referred to the Sangamon.

Family MICROTINAE

SYNAPTOMYS sp.

Referred specimen.—$\overline{\text{M1}}$ (SMUMP 60306); Upper Shuler, Hickory Creek locality.

Discussion.—Fossil *Synaptomys* from Pleistocene deposits of approximately the same age as those of the T-2 are usually referred to *S. australis* Simpson, whose larger size distinguishes it from the living form *S. cooperi.* The small size (2.6 mm) of the Dallas specimen makes it impossible to refer it with confidence to the fossil species, although the Dallas form could represent a young individual. On the other hand, if it belongs to the Recent species, there is the subtle suggestion that Upper Shuler time was getting cooler as well as drier.

MICROTUS cf. M. (PITYMYS) sp.

Referred specimens.—Isolated teeth (SMUMP 60277); Lower Shuler at the Coppel locality and Moore pit; Upper Shuler at Hickory Creek locality and Lewisville site.

Discussion.—Single teeth are difficult to identify, even subgenerically, but *M. (Pitymys) pinetorum* (Le Conte) is present today in east Texas. There is one report of *M. (Pitymys)* sp. near Kerrville, Texas, but this subspecies is considered primarily a deep east Texas type.

ONDATRA cf. O. ZIBETHICUS (Linnaeus)

Referred specimen.—$\overline{\text{M1}}$ (SMUMP 60556); Upper Shuler (?), Hickory Creek locality.

Discussion.—This specimen was collected in the lowest portion of the Upper Shuler where that member is very sandy and almost free of caliche nodules. Although indicative of a marsh condition, *O. zibethicus* is not a good climate marker because its present range includes most of the arid and semi-arid areas of the Southwest. A steady supply of ground water is all that is necessary for its existence.

Family GEOMYIDAE

GEOMYS cf. G. BURSARIUS (Shaw)

Referred specimens.—Isolated teeth (SMUMP 60307) ; Upper Shuler, Hickory Creek locality.

Discussion.—These cheek teeth were compared with Recent specimens of this species and no important differences were seen. Specific identification is provisional, however, because of the fragmentary nature of the specimens.

Family CASTORIDAE

CASTOR cf. C. CANADENSIS Kuhl

Referred specimens.—Incisor (SMUMP 60567); Lower Shuler, Moore pit. Molar (SMUMP 60294) ; Upper Shuler, Hickory Creek locality.

Discussion.—The incisor is slightly larger than Recent specimens with which it has been compared; it is, no doubt, within the size range of the modern species.

The molar was collected from the same zone in the basal Upper Shuler at Hickory Creek that produced the muskrat and other evidence of marsh conditions.

Order CARNIVORA

Family CANIDAE

CANIS sp. (coyote)

Referred specimen.—Left lower jaw with complete dentition except incisors (SMUMP 60315); Upper Shuler, Lewisville site.

Discussion.—Although this specimen is coyote size, comparison with numerous Recent specimens of *C. latrans* and *C. niger* indicate that it is distinct from these forms. Because of certain wolf-like characteristics, such as the presence of an additional posterior cusp on $\overline{\text{P2}}$, further study and additional material may prove that this specimen (SMUMP 60315) from the Lewisville site is a new type. It is also possible that the specimen will prove to belong to *C.*

caneloensis Skinner (1942), the type of which is a skull and therefore not directly comparable. *C. caneloensis* also is very wolf-like (Skinner, 1942, p. 164).

CANIS sp. (wolf)

Referred specimen. — Claw (DPSC 1001); Upper Shuler, Lewisville site.

Discussion.—This claw seems to be slightly larger than claws of *C. latrans* or *C. niger* but is hardly large enough to be considered *Aenocyon.* It is possible that it belonged to a small individual of *C. lupus.*

AENOCYON sp.

Referred specimens.—Left ulna (SMUMP 60037); Lower Shuler, Pemberton Hill. Phalanx (SMUMP 60103); Lower Shuler, Moore pit.

Discussion.—Although these specimens are not adequate for specific identification, they were compared with Recent specimens of *Canis latrans* and *C. niger* (fig. 5) and found to be almost one-third longer and twice as robust. The referred specimens are, however, comparable in size with three ulnas of *Aenocyon,* one from California and two from Texas. The ulna from California, with which the Dallas specimen was compared, is referred to *A. dirus. A. ayersi* is more commonly known from Texas, but only the tooth row is diagnostic. Table 2 compares measurements of several *Aenocyon* ulnas.

Family URSIDAE

ARCTODUS cf. A. SIMUS (Cope)

Fig. 6

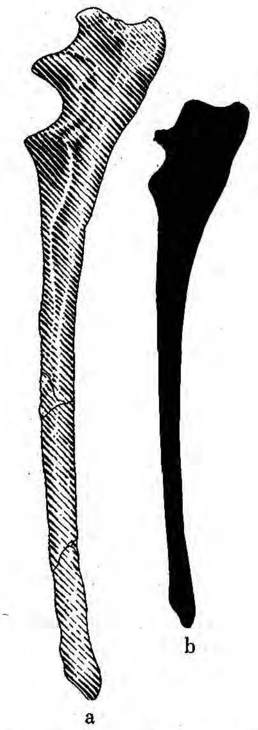

FIG. 5. Comparison of left ulna of (a) *Aenocyon* sp. (SMUMP 60037) and of (b) *Canis niger.* × $^1/_3$

Referred specimen.—Fragmentary maxilla and complete pre-maxilla containing the canine and P4, plus the alveoli of the left incisors and one premolar anterior to P4 (BEG 40442–1); Lower Shuler, Seale pit.

This specimen, collected several years ago by W. Q. Seale and submitted to Dr. J. H. Quinn, formerly with the Bureau of Economic Geology, was made available to the authors by Quinn.

Discussion.—The maxilla and pre-maxilla are fused. I1 and I2 are equal size and flattened transversely, as indicated by the alveoli. I3 is larger, with only the inner side flattened. There is no diastema between I3 and the canine. The canine is large and the crown is relatively short,

TABLE 2. *Comparative measurements of* Aenocyon *ulnas* (in mm).

	Aenocyon sp. (SMUMP 60037)	*Aenocyon* sp. Friesenhahn Cavern (TMM 933–1847)	*Aenocyon* sp. Ingleside Terrace (BEG 30967–172)	*Aenocyon dirus* Rancho La Brea (TMM 31021)
Over-all length	267	......	......	260
Greatest width of olecranon process	40	41.6	43.7	38.6
Greatest diameter at distal end	13	......	......	15.8

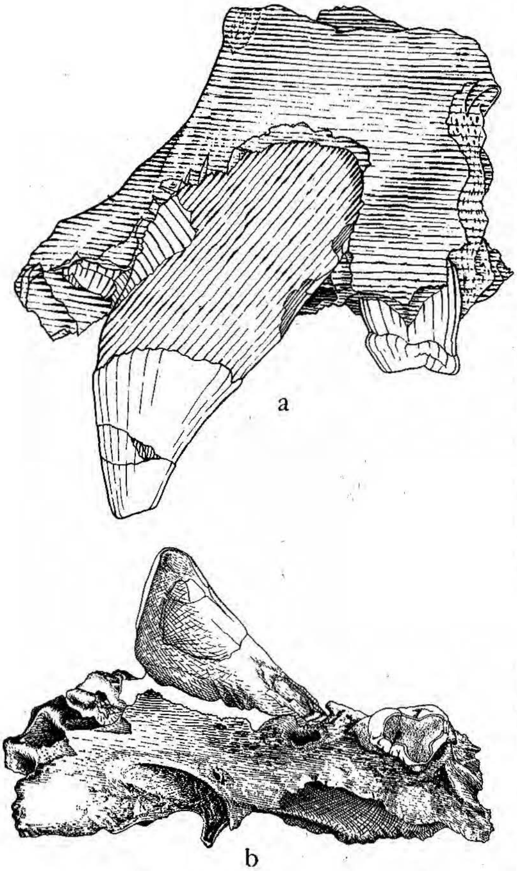

FIG. 6. Upper jaw fragment of *Arctodus* cf. *A. simus* (Cope) (BEG 40442–1). (a) Lateral view. (b) Occlusal view. ×½

comprising less than one-third of the tooth's total length. The anterior premolar is directly behind the canine but inside a line drawn from the canine to $\underline{P4}$. Although a portion of bone is broken away at this point, it is not enough to remove a possible alveoli of an additional premolar. Therefore, the number of premolars appears to have been reduced to two. The number of premolars in Recent bears and described species of *Arctodus* varies, but the space between the canine and $\underline{P4}$ is not reduced accordingly.

$\underline{P4}$ has three roots. The protocone is opposite the notch between the paracone and metacone, as in other described material referred to *Arctodus*. This gives the crown a more or less triangular shape with the protocone less prominent than the paracone or the metacone. This tooth is in an advanced stage of wear in the Dallas specimen, but a rather sharp ridge on the anterior inner edge indicates a tendency for the paracone to form a shearing blade instead of the conical cusp present in species of *Ursus*. It is unfortunate that this specimen is not comparable with an *Arctodus* cranium from the Jinglebob occurrence described by Rinker (1949). The Kansas skull is 18 mm wider at the orbits than either *A. simus* or *A. californicum*. The Dallas specimen is almost 18 mm wider at the incisors than are these species. It is possible that the extra width at the muzzle extended the length of the skull, and that the material from Texas is more closely related to the Kansas specimen than to the two well-known species. The Jinglebob local fauna is certainly more closely related to the Hill-Shuler faunas, both geographically and geologically, than to Rancho La Brea.

The wider and shorter muzzle, plus the reduction of the number of premolars to two, accompanied by the crowding of the anterior premolar out of line, strongly suggests that this material represents an undescribed form. The proposal of another "short-faced" bear must, however, await the recovery of additional material.

Comparison of three specimens of *Arctodus* is given in table 3 (p. 19).

URSUS AMERICANUS Pallas

Referred specimen.—Single superior canine (DPSC 1023) ; Upper Shuler, Lewisville site.

Discussion.—This tooth is small, reminiscent of the small black bears found in extreme west Texas and in contrast to the huge *Arctodus* collected from the Lower Shuler member.

Family MUSTELIDAE

PROCYON LOTOR (Linnaeus)

Referred specimens.—Maxilla (DPSC 1021); Upper Shuler, Lewisville site. Fragment of lower jaw (DPSC 1026); Upper

TABLE 3. *Comparative measurements of species of* Arctodus (in mm).

	A. cf. simus **(BEG 40442-1)**	***A. simus*** **(UC 3001)**	***A. californicum*** **(LAM Z-1)**
Greatest transverse diameter of the incisor series	74*	57.2	64.2
Length from posterior edge of canine to *anterior edge of* $\underline{P4}$	20	27	30
Antero-posterior diameter of canine	34	27.9	29.3
Antero-posterior diameter of anterior premolar	7†	8.5	7.9
Antero-posterior diameter of $\underline{P4}$	22	20.5	20.5
Transverse diameter of $\underline{P4}$	17.5	15	15.8

* Measurement made from inner border of $\underline{I1}$ alveoli to outer edge of $\underline{I3}$ and doubled.

† Measurement taken from alveoli.

Shuler, Lewisville site. Right lower jaw (SMUMP 60202) ; Lower Shuler, Moore pit.

Discussion.—All three specimens are just within the extreme upper size range of this species. While it is possible that only large males have been collected, this series of specimens suggest that this species may have averaged somewhat larger in the area during the Pleistocene.

MUSTELA cf. M. VISON (Bangs)

Referred specimen.—Fragment of left lower jaw containing M1 and the alveoli of P3, P4, and M2 (SMUMP 60047); Lower Shuler, Moore pit.

Discussion.—This specimen is referred provisionally because of its fragmentary nature. Because Dallas today is on the extreme western range line of this species at this latitude, a Lower Shuler climate at least as moist as present is indicated.

MEPHITIS MEPHITIS (Schreber)

Referred specimens.—Fragment of lower jaw (DPSC 1032); Upper Shuler, Lewisville site. Fragment of lower jaw (SMUMP 60139); Lower Shuler, Moore pit.

Discussion.—Little can be learned about Shuler climate by the presence of this animal in the fauna. *M. mephitis* is present today in almost all parts of Texas—moist and arid sections, woodlands and plains.

Family FELIDAE

SMILODON TRINITIENSIS Slaughter

A cranium (SMUMP 60006; DPSC 152) from the Hill gravel of the Lagow pit was collected by the late E. W. Shuler and described by Lull (1921, p. 160) as *S.* cf. *S. fatalis.* A re-evaluation was undertaken when a right mandible (SMUMP 60030; DPSC 304) was recovered from the Lower Shuler member at Pemberton Hill; a new species was proposed, with the mandible as the holotype and the cranium as the paratype (Slaughter, 1960).

Large antero-posterior diameter of the cheek teeth, relative to the mandibular measurements, plus an extremely short post-canine diastema are the specific characters. Although the mandibular measurements of the Dallas specimen compare with the smallest 20 percent of the mandibular measurements of twenty-five described specimens of *S. californicus* from Rancho La Brea, only five of the California jaws contain $\overline{M1}$ with antero-posterior diameter as large as that found in the Dallas specimen and only one of the California jaws contains a $\overline{P4}$ of equal size. Furthermore, these teeth, approaching the size of the teeth of the Dallas specimen, are much larger and longer. Still further comparison with the specimens from California shows that the $\overline{P4}$ of the Dallas specimen is thinner transversely, relative to the antero-posterior diameter, and the inferior canine is smaller, relative to $\overline{P4}$, than that of the California specimens.

The larger size of the cheek teeth and the lack of $\overline{P3}$ in *S. trinitiensis* are suggested differences between it and *S. troglodytes* and *S. gracilis.*

The cranium of *S. trinitiensis* (SMUMP 60006) is comparable with that of *S. floridanus,* but the Hill gravel cranium of Dallas was so closely associated geographically and stratigraphically with the mandible of *S. trinitiensis* that the cranium was referred to the new species and used to distinguish *S. trinitiensis* from *S. floridanus.* The occiput of the Dallas cranium is much narrower and more triangular than the occiput of *S. floridanus,* and the mastoid-postglenoid processes are more forwardly directed in the Dallas specimen.

The recent recovery, from lower in the T-2 deposits, of two additional lower jaws that may be more closely related to *S. troglodytes* than to *S. trinitiensis* creates doubt concerning the reference of the cranium from the Hill gravel to *S. trinitiensis.* Although *S. trinitiensis* now is considered distinct from *S. floridanus,* this hardly seems sufficient reason to refer the Hill gravel cranium to *S. trinitiensis.* This problem is discussed more fully in a paper by Slaughter (in preparation).

LYNX cf. L. RUFUS (Schreber)

Referred specimen. — Metacarpal (SMUMP 60145); Lower Shuler, Moore pit.

Discussion.—This metacarpal is identical to that of *L. rufus,* which species is occasionally reported in the area today. The specimen may also be within the size range of *L. canadensis* but is slightly smaller than the average individual of that species.

Order PROBOSCIDEA

Family MASTODONTIDAE

MAMMUT AMERICANUS (Kerr)

Referred specimens.—Maxilla fragment with two teeth (SMUMP 60256); Hill, Wood pit. Isolated tooth (SMUMP 60018); Lower Shuler, Gifford-Hill pit.

Discussion.—The American mastodon is present in all three members of the T-2 terrace, although very rare. Three specimens from the Wood and Moore pits and a single tooth fragment from Hickory Creek are all that are available to the writers. The ratio of mastodon to mammoth in the T-2 fill is less than one to fifty, while the ratio in a seemingly equivalent terrace east of Dallas on the Sabine River is one to two or three. No doubt the Sabine drainage offered a more wooded environment, as it does today, and the difference in these proboscidean faunas is probably ecological.

Family ELEPHANTIDAE

ELEPHAS COLUMBI Falconer

Referred specimens.—Skull, complete except for cranium and lower jaws (SMUMP 60817); Lower Shuler, Pemberton Hill. Two lower jaws (SMUMP 60027); Lower Shuler, Pemberton Hill. Three lower jaws (SMUMP 60063); Lower Shuler, Moore pit. Three lower jaws (SMUMP 60016); Hill, Gifford-Hill pit. Ninety-four isolated teeth from Hill, Lower Shuler, and Upper Shuler at all localities under discussion.

Discussion.—There has been some discussion as to whether *E. imperator* and *E. columbi* are truly distinct. All studied localities have produced elephant teeth, and there is a rather wide variation displayed in the spacing of the enamel plates. If lowers and uppers are grouped together, they range from $3^3/4$ to $8^1/2$ plates in a 100-mm line. Several of the specimens with widest spacing are from deep in the Hill gravel and could possibly have been redeposited from older formations. The vast majority, however, most certainly belong to the T-2 deposits. These could be divided into *E. columbi* and *E. imperator* according to the tooth measurements for these species as given by Osburn (1942, pp. 1001, 1002, 1075). There, if these species are distinct, it appears that characters other than enamel plate spacing should be considered for the separation.

Semi-articulated skeletons occur in some quantity; often two or more are intermixed. One tusk at the Moore pit was measured in excess of 13 feet.

Order LAGOMORPHA

Family LEPORIDAE

SYLVILAGUS cf. S. FLORIDANUS (Allen)

Referred specimens.—Maxilla (DPSC 1010) ; Upper Shuler, Lewisville site. Tooth (SMUMP 60264); Lower Shuler, Coppel locality.

Discussion.—This species has a wide habit-range and is not a useful climatic indicator.

LEPUS sp.

Referred specimens.—Single tooth (SMUMP 60231); Lower Shuler, Wood pit. Lower jaw (DPSC 1038); Upper Shuler, Lewisville sites. Lower jaw (DPSC 1042); Upper Shuler, Lewisville site.

Discussion.—C. W. Hibbard examined the two mandibles from the Lewisville site and remarked (personal communication to Crook, 1956) that if more complete material could be found, the Dallas jack rabbit might prove to be a new species.

Although the jack rabbit inhabits plains and open fields in the arid and semi-arid west, it also inhabits areas more moist than Dallas today.

Order ARTIODACTYLA

Family TAYASSUIDAE

PLATYGONUS sp.

Referred specimen.—$\underline{\mathrm{P4}}$ and $\underline{\mathrm{M1}}$ of a single individual (DPSC 1025) ; Upper Shuler, Lewisville site.

Discussion.—$\underline{\mathrm{P4}}$ in *Mylohyus* sp. and *Tayassu* sp. contains two pairs of cusps; the Dallas specimen has only one pair. $\underline{\mathrm{M1}}$ in these genera also has two pairs of cusps, each pair of which retains its identity throughout life; each pair in the Dallas $\underline{\mathrm{M1}}$ forms a continuous ridge because of the worn state of the tooth. Because of these differences, the Dallas teeth are referred to *Platygonus.*

Teeth are not the diagnostic features which separate valid species; therefore, the Dallas material is not identified specifically. As shown in table 4, the antero-posterior diameter of $\underline{\mathrm{P4}}$ is slightly less than the observed range of the specimens of *P. compressus* described by Simpson (1949, p. 29), but all other measurements fall within the ranges of his measurements. The small difference in $\underline{\mathrm{P4}}$ diameters is not important, because Simpson has shown that this species is quite variable. The Dallas material may possibly represent a population of slightly smaller individuals in Texas during the last interglacial.

TABLE 4. *Measurements of* Platygonus (in mm).

	Platygonus sp. (DPSC 1025)	*Platygonus compressus* Observed range after Simpson (1949, p. 30)
Antero-posterior diameter of $\underline{\mathrm{P4}}$	8.5	9.3–12.7
Transverse diameter of $\underline{\mathrm{P4}}$	14.5	12.3–14.8
Antero-posterior diameter of $\underline{\mathrm{M1}}$	14	13.3–15.4
Transverse diameter of $\underline{\mathrm{M1}}$	12.4	11.9–16.0

DAMA VIRGINIANUS APLODON Slaughter, n. subsp.

Fig. 7

Holotype.—Right mandible containing P2 through $\overline{\mathrm{M3}}$ (SMUMP 60077).

Referred specimen.—Right mandible fragment containing $\overline{\mathrm{M2}}$-$\overline{\mathrm{M3}}$ (SMUMP 60060); Lower Shuler, Moore pit.

Type locality.—Lower Shuler, Moore pit, one-fourth mile northeast of Pemberton Hill Road and Loop 12, Dallas, Texas.

Diagnosis of subspecific characters.—Third or posterior lobe of $\overline{\mathrm{M3}}$ is represented by a simple loop without suggestion of the internal enamel fold or fossette prescent in all living subspecies of *D. virginianus;* shorter diastema relative to length of the cheek tooth series; more nearly vertical ascending ramus.

Discussion.—The third or posterior lobe of $\overline{\mathrm{M3}}$ is a simple loop without internal enamel fold representing the fossette present in the anterior lobes of the fossils and in all three lobes of other described species and subspecies of *Dama.* In the Dallas specimens this lobe has the same antero-posterior and transverse diameters for the

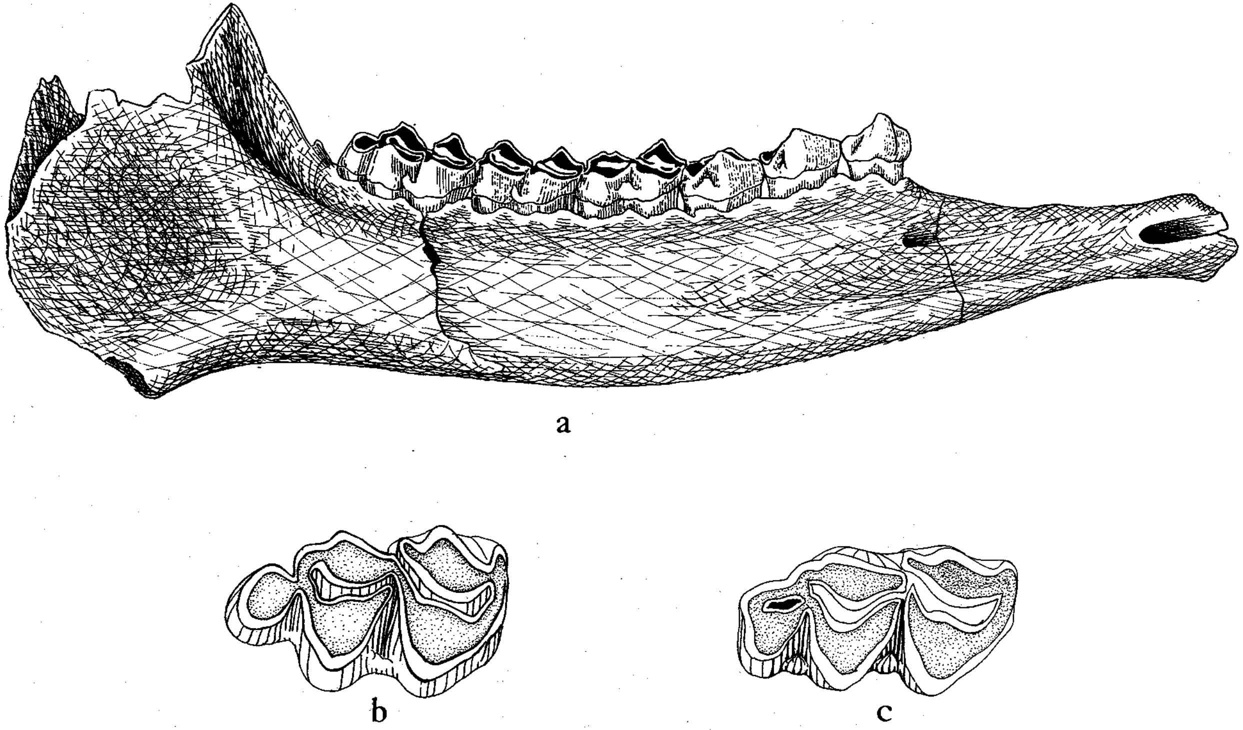

FIG. 7. *Dama virginianus aplodon* Slaughter, n. subsp. (SMUMP 60077). (a) Right lower jaw, x1. (b) M$\overline{3}$, occlusal view, x2. (c) *Dama virginianus texanus,* occlusal view of M$\overline{3}$, x2.

entire height, whereas in other forms it tapers from bottom to top. This feature is identical in the only two Dallas specimens which contain this tooth.

There are also two specimens in the Ingleside assemblage (Sellards, 1940, p. 1650) that match these characters and seemingly should be referred to this race. These specimens are the only ones from that fauna that are comparable to *D. virginianus aplodon.*

Another specimen collected from the Seymour (late Kansan) beds of west Texas was examined through the courtesy of Dr. Walter Dalquest, Midwestern University. Its diastema index and general size seem to exclude this specimen from the new race, but it shares with the material from Dallas and Ingleside the simple loop feature of the third lobe of $\overline{\text{M3}}$.

Because the diastema is not complete in the Dallas specimens, measurements demonstrating this feature were taken from the anterior edge of $\overline{\text{P2}}$ to the posterior edge of the symphysis in fossil and Recent specimens alike. The position of the mental foramen relative to both points gives assurance that a possible long symphysis is not creating the illusion of a short diastem. The diastema index was calculated as follows:

$$\frac{\text{Length of entire cheek tooth series}}{\text{Length from anterior edge of P}\overline{2}\text{ to posterior edge of symphysis}} = \text{diastema index}$$

$$\frac{\textit{Dama virginianus aplodon}}{} = \frac{74\text{ mm}}{29\text{ mm}} = 2.55$$

Seventeen lower jaws of Recent Florida white-tail deer and twenty-seven lower jaws of Recent Texas white-tail deer were measured and compared. The diastema index of these specimens ranged from 1.54 to 2.46 with all but one less than 2.28 and all but seven less than 2.23. This feature is reminiscent of the shorter diastema of the more primitive *Stockoceras* rather than that of the Recent form *Antilocapra.*

The ascending ramus is more nearly vertical in the black-tail and mule deer than in all white-tail deer other than *Dama virginianus couesi.* None of these, however, is as nearly vertical as the ramus in the Dallas specimen. This near-vertical ramus together with the shorter diastema would certainly shorten the profile of the living animal.

There can be no doubt that the Dallas form is subspecifically distinct from other described forms, although antler fragments from the same stratum affiliate the Dallas deer with white-tail deer.

D. virginianus aplodon and *D. virginianus texanus* are compared in table 5.

TABLE 5. *Measurements of* Dama virginianus (in mm).

	Dama virginianus aplodon		*Dama virginianus texanus*	
	(SMUMP 60077)	(SMUMP 60060)	Average	Range observed
Length of cheek tooth series: P$\overline{2}$–M$\overline{3}$	75	......	77	65–89
Length from anterior edge of P$\overline{2}$ to posterior edge of symphysis	31	......	38.5	32–46
Diastema index	2.55	......	1.98	1.54–2.46
Antero-posterior diameter of—				
P$\overline{2}$	10	......	......	....
P$\overline{3}$	11	......	......	....
P$\overline{4}$	11	......	......	....
M$\overline{1}$	13	......	......	....
M$\overline{2}$	15	14.5	......	....
M$\overline{3}$	17.5	19	......	....

It is probable that the numerous antler fragments and post-cranial elements collected at all levels and localities belong to the same species and race, but there is no positive assurance that another species is present, so most are referred to *Dama* sp.

Family ANTILOCAPRIDAE

BREAMERYX sp.

Referred specimens.—$\overline{M2}$ (SMUMP 60034); Lower Shuler, Pemberton Hill. $\overline{P4}$ (SMUMP 60262); Lower Shuler, Coppel locality.

Discussion.—There are no important differences between the Dallas specimens and California material referred to *B. minimus* Meade. Comparative measurements of the Dallas teeth are in table 6.

TABLE 6. *Measurements of teeth referred to* Breameryx sp. (in mm).

	(SMUMP 60034)	(SMUMP 60262)
Antero-posterior diameter	9.5	7.5
Transverse diameter	4.5	3
Vertical diameter	28	13

TETRAMERYX SHULERI Lull

Holotype.—Skull cap with horn cores and left maxilla with complete cheek tooth series (SMUMP 60006; DPSC 152). Lower Shuler, Lagow pit.

Referred specimen.—Left $\underline{M2}$ (SMUMP 60134). Lower Shuler, Moore pit.

Discussion. — Specimen (SMUMP 60006) was collected from the Lagow pit by the late E. W. Shuler and described by Lull (1921, p. 163) as the holotype of the genotypic species. The exact horizon from which the specimen was collected is not known, but the preservation indicates it may have been Lower Shuler.

Family CAMELIDAE

CAMELOPS HUERFANENSIS DALLASI Lull

Pl. I, figs. 1, 2

Holotype.—Partial skull and superior dentition (SMUMP 60005; DPSC 151); Lower Shuler, Lagow pit; collected by the late E. W. Shuler.

Referred specimens.—Skull, complete except for premaxilla (SMUMP 60029; DPSC 303); Lower Shuler, Pemberton Hill.

Discussion.—Hay (1914b) described the occiput of *C. huerfanensis* as follows: "The occipital surface bears a median descending ridge, rough and rounded, separating two deep excavations, on each side of which is another deep excavation at the bottom of which is placed the lateral foramen." Lull (1921, p. 169) commented on this: "In the Dallas specimen the median ridge is of less vertical extent, so that the deep excavations on either side are confluent below, while in *C. huerfanensis* they are entirely separate." The occipital characters of the new skull (SMUMP 60029) are identical to those of the holotype described by Lull. This further substantiates the difference between *C. huerfanensis* and *C. huerfanensis dallasi* as stated by Lull. Merriam (1913, p. 311), speaking of the median ridge, stated: "In the Rancho La Brea specimens [*C. hesternus*] there is a short low median crest at the upper end of the occiput in no. 20028 and no. 20040; in 20049 it is scarcely visible."

This ridge, therefore, is longer if not stronger in *C. huerfanensis* than in the Dallas subspecies, whereas the same element is decidedly weaker in the California specimens referred to *C. hesternus*. *C. huerfanensis dallasi* is thus intermediate between *C. huerfanensis* and *C. hesternus* on the basis of the median ridge.

In his discussion of the diastema between $\overline{I3}$ and the superior canine in *C. huerfanensis,* Hay (1914b, p. 269) said: "The canine must have emerged immediately behind the incisor, just as it does in the Bactrian camel." This diastema is 45 mm in *C. kansanus* and this, according to Merriam (1913, p. 318), agrees with the California specimens referred to *C. hesternus.* This same measurement taken from the type of *C. huerfanensis dallasi* is 17 mm. The length of the diastema is another character in which the Dallas subspecies is intermediate between C. *huerfanensis* and C. *hesternus.*

A large deep fossa near the upper margin of the maxillary above P4 was mentioned by Merriam (1913, p. 308) as being present in C. *hesternus.* This fossa is identical in the skull (SMUMP 60029) from Dallas and may be another correlation between the Dallas material and C. *hesternus.* Because the fossa is not known for the other species in the genus, however, it is possible that the large deep fossa is not indicative.

The posterior palatine foramen occupies a position opposite P3 or P4 in C. *hesternus* from California, while in both C. *huerfanensis* and C. *huerfanensis dallasi,* the former is opposite M1. The foramen lies at the anterior edge of M1 in the new skull (SMUMP 60029) referred to C. *huerfanensis dallasi.* This is posterior to the position occupied in C. *huerfanensis dallasi* or C. *huerfanensis.* The first two cheek teeth in this specimen are deciduous, however, and may allow the foramen to appear farther forward than it would be in adulthood.

Perhaps the fact that C. *huerfanensis dallasi* has features of both C. *huerfanensis* and C. *hesternus* suggests that all three are so closely related that they are the same species and are no more than racial variants.

In table 7, the holotype and newly referred specimen of C. *huerfanensis dallasi* are compared to C. *hesternus.*

?CAMELOPS sp.

Pl. I, fig. 3; text fig. 8

Referred specimens.—Cranium posterior to the orbits (SMUMP 60237) ; Lower Shuler, Haymarket pit. Metatarsal (SMUMP 60570) ; Hill gravel, Moore pit.

Discussion.—The third camelid skull collected from T-2 deposits at Dallas differs in several respects from other skulls referred to C. *huerfanensis dallasi.* The sagittal crest is very weak and the brain case itself much less vaulted than any of the species referred to the genus *Camelops* with which it has been compared. The lamboidal crest overhangs the occiput more than in C. *hesternus,* C. *huerfanensis,* or the

TABLE 7. *Skull and dentition measurements of* C. huerfanensis dallasi, *Dallas, and* C. hesternus, *Rancho La Brea* (in mm).

	C. huerfanensis dallasi		***C. hesternus***	
	(SMUMP 60005; DPSC 151)	**(SMUMP 60029)**	**(UC 20028)**	**(UC 20040)**
Greatest skull width posterior to orbits	195	......	245	251
Greatest height of orbits	50	......	63.3	61
Least width of brain case immediately behind orbits	83	80*	77	83
Length from anterior edge of P4 to posterior edge of M3	123	127	141.9	......
Antero-posterior diameter of P3	8†	23	......	18.8
Transverse diameter of P3	6†	12	......	11
Antero-posterior diameter of P4	35†	26	23.5	28
Transverse diameter of P4	22†	23	25	22.5
Antero-posterior diameter of M1	40	35	24.4	42
Transverse diameter of M1	21	29.5	31	33.6
Antero-posterior diameter of M2	49	44	42.1	52
Transverse diameter of M2	20	29	31.6	32.8
Antero-posterior diameter of M3	50‡	51.5	49.5	45.8
Transverse diameter of M3	......	26	31.4	27.2

* Estimated.
† Deciduous.
‡ Unerupted.

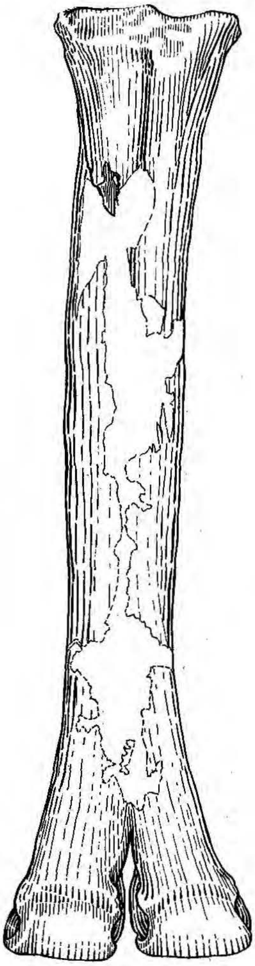

FIG. 8. Metatarsal of *?Camelops* sp. (SMUMP 60570). ×1/3

C. huerfanensis dallasi skulls. The occiput is almost completely smooth without a trace of the excavations present in the occiputs of the skulls of *C. huerfanensis dallasi* and possesses only a hint of a descending median ridge. Even the lateral foramen are abrupt holes without the slightest indentation around them. The brain case is considerably wider relative to its length than the types mentioned above, including the Dallas subspecies.

The first cervical vertebra, the ulna, and a metatarsal of *C. huerfanensis dallasi* were directly associated with the skull designated as the holotype, and a few fragments of post-cranial skeletons have been collected from both Upper and Lower Shuler which match very closely the material associated with the holotype skull. There are, however, some elements of the skeleton fragments from the Shuler that are a little larger than the same elements known to belong to *C. huerfanensis dallasi*. This is not attributed to age because the type specimen represents a very old individual. There is much variation in the limb bones of Recent camels, and this may account for these fossil differences. On the basis of the strange cranium (SMUMP 60237) and the large metatarsal (SMUMP 60570), there may be two large camels in the fauna. Metapodial measurements of *?Camelops* sp. compared with those of *C. huerfanensi dallasi* (table 8) show the distinctly larger size of *?Camelops* sp.

TABLE 8. *Measurements of camel metapodials from T-2 deposits* (in mm).

	C. huerfanensis dallasi (SMUMP 60014) Belongs to type	(SMUMP 60011) Referred	*?Camelops* sp. (SMUMP 60570)
Width at proximal end	60	66	75
Width at mid-shaft	36	39	47
Width at distal end	....	....	97
Over-all length	....	....	381

TANUPOLAMA sp.

Fig. 9

Referred specimens.—Fragment of left lower jaw containing $\overline{\text{P4}}$, $\overline{\text{M1}}$, and $\overline{\text{M2}}$ (SMUMP 60015) ; Lower Shuler, Lagow pit. Upper left $\overline{\text{M2}}$ (SMUMP 60195); Hill gravel, Milton pit. Metatarsal (SMUMP 60239); Lower Shuler, Wood pit.

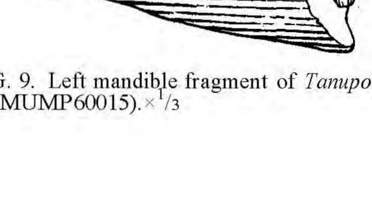

FIG. 9. Left mandible fragment of *Tanupolama* sp.(SMUMP60015). ×1/3

Discussion.—The lower jaw (SMUMP 60015) referred to this genus, like the Dallas *Camelops* material, contains features of several described species and is exactly like none. The Dallas jaw lacks $\overline{P3}$, which is said to be variable in *T. stevensi,* absent in *T. americana,* and consistently present in *T. mirifica* (Simpson, 1929, p. 595). The lower molars are similar in size to both *T. stevensi* and *T. mirifica,* except for their shorter transverse diameter, which may be attributed to adolescence. $\overline{M1}$ in *T. stevensi* contains a median external style not present in the Dallas specimen or in *T. mirifica.*

The isolated $\overline{M2}$ in the Dallas collection also resembles more closely the same tooth in *T. mirifica* than in *T. stevensi,* in that the anterior lobe is considerably broader transversely than the posterior lobe.

The Dallas metatarsal agrees almost perfectly with two metatarsals of *T. stevensi* with which it was compared.

Dentition measurements of several specimens of *Tanupolama* are given in table 9.

Family BOVIDAE

BISON ALLENI Marsh

Pl. I, figs. 5–8; text fig. 10

Referred specimens. — Horn core (SMUMP 60317); probably Lower Shuler, Seale pit. Horn core (SMUMP 60003); Hill or Lower Shuler, Lagow pit. Pair of horn cores (SMUMP 60019); Lower Shuler, Gifford-Hill pit. Female horn core (SMUMP 60067); Lower Shuler, Moore pit. Metacarpal (SMUMP 60249); Lower Shuler, Wood pit. Metacarpal (SMUMP 60248); Lower Shuler, Moore pit. Metatarsal (SMUMP 60266); Upper Shuler, Coppel locality. Metatarsal (SMUMP 60186); Lower Shuler, Moore pit.

Discussion.—Post-cranial elements unidentifiable to species occur at every locality and in all three members. These are referred to *Bison* sp. but no doubt belong to the same species as represented by the identifiable material. If size alone were considered, the only complete horn core (SMUMP 60067) would fall within the range of *B. antiquus* as outlined by Skinner and Kaisen (1947, p. 178). Although the burr of this specimen suggests the horn core is that of a male, the relatively smooth surface indicates that it may be immature. Horn cores (SMUMP 60003) and (SMUMP 60317) are the proper size and proportion to be *B. alleni.* Post-cranial elements from the terrace deposits vary in size from small to very large, with metacarpals and metatarsals in the upper 20 percent of the size range of the thousands of elements measured by Skinner and Kaisen (1947, pp. 135, 136). Their measurements of several species even included the gigantic *B. latifrons.* Horn cores of *B. alleni* from the Lower Shuler member of the T-2 deposits are compared in table 10 with the range of measurements of *B. alleni* as given by Skinner and Kaisen (1947, p. 184).

TABLE 9. *Measurements of* Tanupolama *dentition* (in mm).

			T. stevensi CITVPC		
	Tanupolama sp. (SMUMP 60015)	*T. mirifica* (AMNH 23487)	4	5	7
Antero-posterior diameter of $\overline{P4}$	12	18	15.2	14	17.8
Transverse diameter of $\overline{P4}$	6	8	8.7	7.7	8.8
Antero-posterior diameter of $\overline{M1}$	22	23	21.2	......	21
Transverse diameter of $\overline{M1}$	11	15	14.4	......	14.9
Antero-posterior diameter of $\overline{M2}$	27.5	27	25.3	24	29.4
Transverse diameter of $\overline{M2}$	11	15	14.1	16.6	16.8
Antero-posterior diameter of $\underline{M2}$	25	24	29.7	28.7	23.9
Transverse diameter of $\underline{M2}$	22	23	17	19	25.3

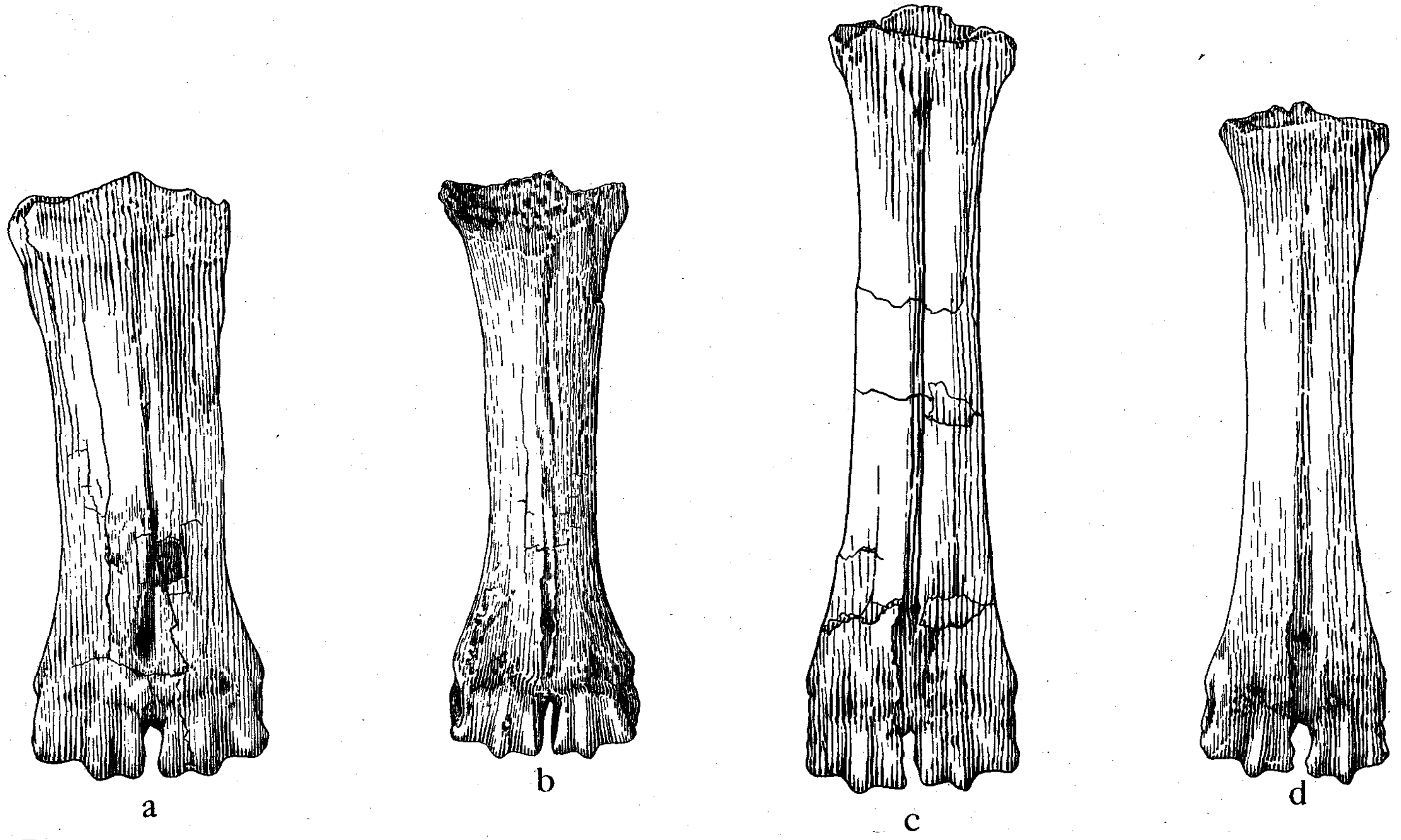

FIG. 10. Metapodials of *Bison alleni* Marsh. (a) Metacarpal (male) (SMUMP 60249). (b) Metacarpal (female) (SMUMP 60281). (c) Metatarsal (male) (SMUMP 60266). (d) Metatarsal (female) (SMUMP 60186). All x⅓

TABLE 10. *Measurements of* B. alleni *horn cores* (in mm).

	60317 SMUMP	60003 SMUMP	60019 SMUMP	SMUMP 60067 (Female)	***B. alleni* range Skinner and Kaisen (1947, p. 184)**		
					Minimum	Average	Maximum
Core length on upper curve, tip to burr	540*–750†	400‡	305	275	400	561	720
Core length on lower curve, tip to burr	710*–900†	450‡	357	330	480	647	890
Transverse diameter at base	110*	128	112	75	133	151	169
Vertical diameter at base	110*	100	97	66	107	124	145
Circumference at base	340*	360	325	240	378	434	495
Tip to burr, straight line	440*	350‡	280	250	355	471	575
Index of curvature	......	128‡	123	132	121	135	155
Index of compression	....	78	86	77	72	82	91

* Exact measurement of fragment.
† Estimated minimum according to solidness of fragment.
‡ Measurement taken from reconstruction; must be considered approximate.

Skinner and Kaisen's (1947, pp. 142–143) method for determining indices of horn cores is as follows:

$$\frac{\text{Horn-core length on lower curve}}{\text{Distance, core tip to upper base of burr}} = \text{index of curvature}$$

$$\frac{\text{Vertical diameter of core at base}}{\text{Transverse diameter of core at base}} = \text{index of compression}$$

Table 11 is included for comparison of measurements of bison metapodials collected from the Hill-Shuler local fauna.

It is concluded that the smaller elements represent females and the larger, males; therefore, it is unlikely that one can rule out the possibility of the larger bison forms being present in an assemblage where only post-cranial elements are known.

Order PERRISSODACTYLA

Family EQUIDAE

Vertical ranges after Quinn (1957)

Discussion. — Specific identifications based on single teeth are unreliable because of the unknown range of variation possible within a single fossil species. Because most of the Dallas specimens are isolated teeth and the enamel patterns suggest a seemingly excessive number of species, a thorough study of other collections was undertaken to prove or disprove preliminary identifications. After reviewing the literature and examining numerous Texas collections, the writers were unable to reduce the number of species in the Hill-Shuler local faunas. J. H. Quinn (oral communication at site, 1958) suggested that the North American equine faunas of the Pleistocene may have been almost as diversified as the present-day antelope of Africa, with size which ranged from quite large to very small, and with equally varied habits. The ranges of eastern types, such as *Equus fraternus,* may have overlapped with southwestern types, such as *Asinus*

TABLE 11. *Measurements of Dallas bison metapodials* (in mm).

	Metacarpals		Metatarsals	
	Male (SMUMP 60249)	Female (SMUMP 60281)	Male (SMUMP 60266)	Female (SMUMP 60186)
Over-all length	229	224	298.5	264.9
Transverse diameter at proximal end	85.8	74.8	66.9	65.5
Transverse diameter at mid-shaft	65.4	42.4	47.5	40
Transverse diameter at distal end	91.3	74.6	80.8	72.6

conversidens, only where optimum conditions existed. Such conditions in the form of ample rainfall and an equable climate are suggested for Hill and Lower Shuler time at Dallas. A similar situation may not have existed to the east or west; consequently; the horse faunas may have been more restricted in number of species. An equable climate is demonstrated at Dallas in the lower members of the T-2 fill by the association of such animals as *Synaptomys* and *Sigmodon* plus certain snails.

Quinn (1957, p. 10) proposed the use of the generic name *Onager* for several Pleistocene forms from North America and Asia; among the diagnostic characters, he listed complex enamel patterns of upper cheek teeth, elongate protocones, and unusually long, slender metapodials. Hibbard and Taylor (1960, p. 192) did not follow Quinn's use of *Onager* but instead preferred *Hemionus* and quoted Ellerman and Morris-Scott's statement that Brisson used *Onager* for *Equus asinus.* Quinn (personal correspondence with the writers, citing several references) has demonstrated, rather convincingly, that the terms onager, *Asinus onager, Equus onager,* and *Onager* have rather consistently been used in connection with the Persian ass. If, then, all Asiatic asses are grouped together, it seems proper to include them under the name *Onager,* whether it proves to be of generic or simply subgeneric rank, and *Hemionus* could be used only in a lesser capacity to include Mongolian and Tibetan asses.

The writer's reasons for not using *Onager* as generic rank in this paper, therefore, are somewhat different from those of Hibbard and Taylor. If one adheres strictly to the diagnosis of *Onager* as outlined by Quinn, each group of horse material from Dallas offers something of a paradox. The teeth referred provisionally to *E. fraternus* do not have elongated protocones nor is the similar-size metacarpal particularly long or slender. The metapodials of the new species are quite long and slender, but the similar-size teeth do not have especially long protocones and the enamel patterns are not complicated. The writer agrees with Quinn that horses will be much more helpful when they can be separated into groups, which no doubt exist, but the Dallas material is not referable to such groups with confidence.

EQUUS MIDLANDENSIS Quinn

(Wisconsin?)

Figs. 11, 12(a)

Referred specimens.—Right metacarpal (SMUMP 60079); Hill-Lower Shuler contact, Moore pit. Isolated teeth, Hill and Lower Shuler members, Wood and Moore pits.

Discussion.—The only difference between teeth referred to *E. midlandensis* and those referred to *E. scotti,* which the writer has examined, is a slight tendency for the mesostyle in teeth of *E. midlandensis* to be more nearly perpendicular to the antero-posterior midline of the tooth. This slight difference might vary if numerous specimens were available. The Dallas teeth are referred to *E. midlandensis* provisionally because this species is generally considered a late Pleistocene type, whereas

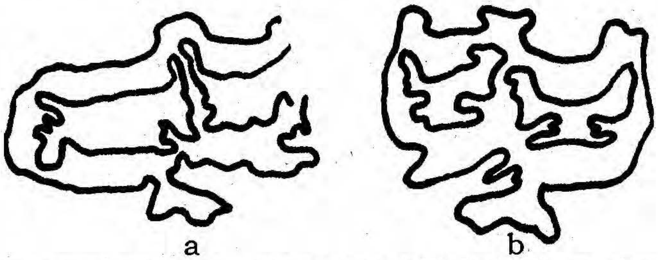

FIG. 11. *Equus midlandensis* Quinn. (a) Left P2 (SMUMP 60233). (b) Right P3 (SMUMP 60225). ×1

E. scotti is found in middle Pleistocene deposits.

Although the metacarpal (SMUMP 60079) has a mid-shaft transverse diameter slightly greater, relative to the proximal and distal transverse diameters, than the Recent horse material at hand, the metacarpal probably could be duplicated in some specimens of *E. caballus*. This is said to be true in both *E. midlandensis* and *E. scotti* (Gidley, 1901, p. 116; Quinn, 1957, p. 26).

EQUUS cf. E. FRATERNUS (Leidy)

(Post-Illinoian to post-Wisconsin)

Figs. 12(b), 13

Referred specimens.—Left metacarpal (SMUMP 60238) ; Lower Shuler, Wood pit. Isolated teeth from Hill and Lower Shuler members, Pemberton Hill, Wood, and Moore pits.

Discussion.—Medium-size teeth with strongly folded enamel patterns collected from the Hill and Lower Shuler members have been referred provisionally to *E. fraternus*.

Four sizes of metapodials from the T-2 deposits are in the Dallas collection. These were placed with teeth of corresponding size: the largest teeth with the largest metapodial, the smallest teeth with the smallest metapodial, and so on. The two smallest sizes and the largest may be grouped with some confidence, but there are two types of teeth that would fit metacarpal (SMUMP 60238) very nicely—those referred to *E. fraternus* and those referred to *Equus* sp. Because this metacarpal is very horse-

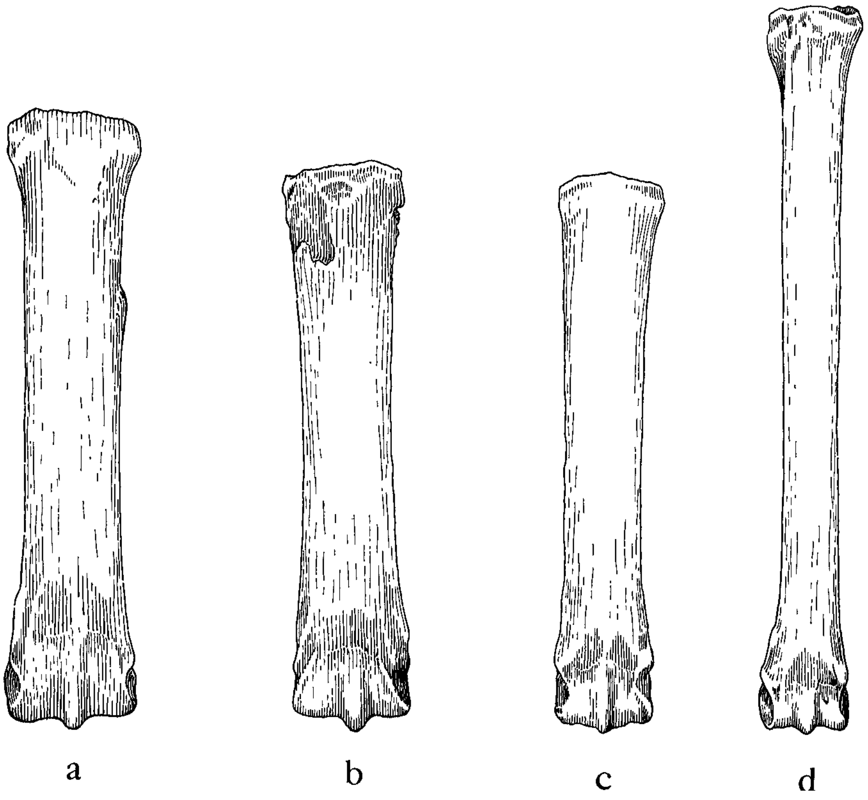

FIG. 12. Equine metapodials. (a) Metacarpal of *Equus midlandensis* Quinn (SMUMP 60079). (b) Metacarpal of *Equus* cf. *E. fraternus* (Leidy) (SMUMP 60238). (c) Metacarpal of *Asinus conversidens* (Owen) (SMUMP 60013). (d) Metatarsal of *Equus? quinni* Slaughter, n.sp. (SMUMP 60228). All × 1/3.

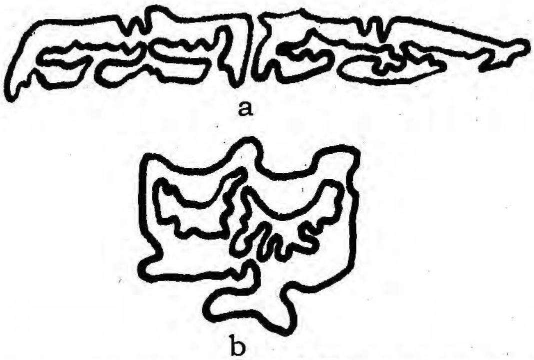

FIG. 13. *Equus* cf. *E. fraternus* (Leidy). (a) Right $\overline{P2}$-$\overline{P3}$ (SMUMP 60135). (b) Right $\underline{M2}$ (SMUMP 60234). ×1

like (*Equus* s.s.) and because the protocones of the teeth referred to *Equus* sp. are extremely long (a character attributed to *Onager*), the metacarpal is referred provisionally to *E. fraternus* along with the Dallas teeth which do not have exceptionally long protocones.

If this reference is proven by the future recovery of a like metapodial in association with *E. fraternus* teeth, Quinn's reference of this species to the *Onager* group may be questioned.

EQUUS sp.

Fig. 14

Referred specimens.—Isolated teeth from the Hill and Lower Shuler members.

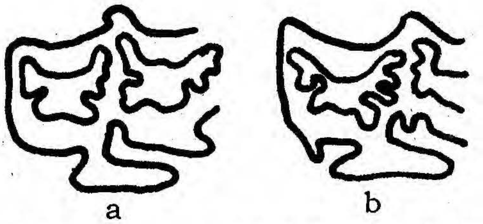

FIG. 14. *Equus* sp. (a) Left $\underline{M1}$ (SMUMP 60197). (b) Left $\underline{M1}$ (SMUMP 60223). ×1

Discussion.—There are a number of teeth in the Dallas collections that are similar to those of *E.* cf. *E. fraternus* but which have protocones ranging up to three-fifths of the total antero-posterior length. This character is attributed to *E. lambei,* but the writer is hesitant to refer the Dallas specimens to that species because the enamel folds of the Hill-Lower Shuler teeth are much stronger than in the holotype of *E. lambei.* According to Hay's figures and text (1917, p. 435), simplicity of the enamel pattern is one of the characters of the *E. lambei.*

ASINUS CONVERSIDENS (Owen)

(Sangamon? to late Wisconsin)

Figs. 12(c), 15

Referred specimens.—Right metacarpal (SMUMP 60013); Lower Shuler, Lagow pit. Left metacarpal (SMUMP 60194); Lower Shuler, Wood pit. Isolated teeth.

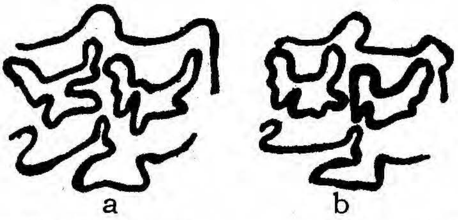

FIG. 15. *Asinus conversidens* (Owen). (a) Right P4 (SMUMP 60272). (b) Right $\underline{M2}$ (SMUMP 60196). ×1

Discussion.—Some of the teeth from the T-2 deposits referred to *A. conversidens* are similar to those referred to *E.? quinni* except that they are larger than those of *E.? quinni.* The Lower Shuler teeth average slightly larger than the same teeth of the holotype as given by Hibbard (1955a, p. 59).

Although the two Lower Shuler metacarpals are larger than the metacarpal from Papago Springs referred to this species by Skinner (1942, p. 171), their ass-like character was used in their reference to *A. conversidens*. Thus Skinner agreed with Quinn that *A. conversidens* is an ass, though not of the *Onager* type. The larger size of the Lower Shuler metacarpals and the referred teeth from the T-2 deposits suggest that the species averaged somewhat larger at Dallas than farther to the southwest. Both metacarpals can be duplicated in the European ass, *A. hydruntius*.

EQUUS? QUINNI SLAUGHTER, n.sp

Figs. 12(d), 16

Specific dedication of the new form is made, with pleasure and appreciation, to Dr. James H. Quinn.

Holotype.—Right metatarsal (SMUMP 60578); Lower Shuler, Moore pit.

Paratype.—Left metacarpal (SMUMP 60578; Lower Shuler, Moore pit.

Referred specimens.—Left metatarsal (SMUMP 60174) ; Hill, Moore pit. $\underline{M2}$ (SMUMP 60101); Lower Shuler, Moore pit. $\underline{M1}$ (SMUMP 60146); Lower Shuler, Moore pit. $\overline{M2}$ (SMUMP 60467); Lower Shuler, Moore pit. Distal end of metapodial (SMUMP 60045) ; Lower Shuler, Moore pit. Distal end of metapodial (SMUMP 60208); Lower Shuler, Wood pit. Proximal end of metatarsal, (SMUMP 60165); Lower Shuler, Moore pit.

Type locality.—Lower Shuler, Wood pit.

Diagnosis of specific characters.—Metapodials are extremely long and slender, with diameters smaller than any specimens previously described from the late Pleistocene (table 12). Referred teeth smaller than other late Pleistocene species.

Discussion and comparisons.—Hibbard (1955a, pp. 56–62; Hibbard and Taylor, 1960, pp. 189–193) concluded that the late Pleistocene types—*Asinus francesi, Equus littoralis,* and *Equus tau*—are synonyms of *A. conversidens*. Based on differences between the small metatarsals from the Hill and Lower Shuler members at Dallas and the same element of *A. francesi,* it is now evident that there are at least two small equine types in the late Pleistocene of North America. Although the writer is not suggesting that Hibbard's supposition of the synonymity of *A. francesi, E. littoralis,* and *E. tau,* is incorrect, he is comparing *E.? quinni* with these species separately to show that the new material does not fall within a range of variation represented by material referred to all of these species.

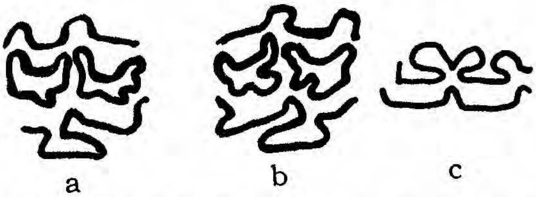

FIG. 16. *Equus? quinni* Slaughter, n.sp. (a) $\underline{M2}$ (SMUMP 60101). (b) $\underline{M1}$ (SMUMP 60146). (c) $\overline{M2}$ (SMUMP 60467). ×1

TABLE 12. *Measurements of Hill and Lower Shuler equine metapodials* (in mm).

	E. midlandensis	*E. fraternus*	*A. conversidens*	*Equus? quinni*, n.sp.		
		Metacarpals		Metacarpal (Paratype)	Metatarsals (Holotype)	
	(SMUMP 60079)	(SMUMP 60238)	(SMUMP 60013)	(SMUMP 60578)	(SMUMP 60228)	(SMUMP 60174)
Over-all length	245	219	221	235	287	277
Transverse diameter at proximal end	53	48.8	42	31.4	35	32.2
Transverse diameter at mid-shaft	40.5	36	30	23.4	22	23.5
Antero-posterior diameter at mid-shaft	27.5	27	24	21.4	25	25.5
Transverse diameter at distal end	51	43	39	31.6	30.9	29

Quinn (1957, p. 13) stated that *Onager littoralis* (Hay) is the "smallest of the Equini, teeth slightly larger than those of *Nannippus phlegon.*" The measurements of *E. littoralis,* as given by Hay (1913, p. 575), are almost identical to those of *A. conversidens.* In addition, the very simple enamel patterns of tiny teeth from Dallas referred to *E.? quinni* are in direct contrast with Hay's (1915, p. 575) statement: "Enamel surrounding the lakes [in *E. littoralis*] rather strongly folded." It has been pointed out by Quinn (personal communication, 1959) that the length of upper teeth of horses plays an important role in determining tooth diameters and the complexity of enamel patterns. This point is well taken; it can be demonstrated that the antero-posterior and transverse tooth diameters are reduced as the crown is shortened through wear. $\underline{\text{M1}}$'s in the holotypes of the other species under discussion, however, are as short as or even shorter than the Dallas $\underline{\text{M1}}$. The diameters of the teeth of *E. ? quinni* should thus be as large or larger, but they are not.

The size of *E. tau* has been somewhat confused in the literature. When Owen (1869, p. 565) proposed the species, he stated that it was much smaller than *A. conversidens.* Cope (1884, p. 12) considered the two synonymous but later (1893, p. 80), in discussing *E. semiplicatus,* said: "Teeth indicate a species of about the same dimensions of the *E. tau.*" He thus suggested a larger size for *E. tau.* Hibbard (1955a, p. 60) stated:

> "In *Equus tau* this molar ($\underline{\text{M3}}$) has a greater relative size [than the same tooth in *Asinus conversidens*], especially in antero-posterior length. Because the figure of *Equus conversidens* is distorted, that of *Equus tau* probably is also. [The holotype of *E. tau* is lost.] Measurement of the illustration published by Owen of *Equus tau* establishes a greater antero-posterior length of $\underline{\text{P3}}$-$\underline{\text{M3}}$ series than for the same series in the illustration of *Equus conversidens.* If, however, the illustration by Owen of *Equus tau* is correct, the length for the $\underline{\text{P3}}$-$\underline{\text{M3}}$ series is the same as that in the type specimen of *Equus conversidens* (measured from the type). According to the measurements *Equus tau* was not a smaller horse than *Equus conversidens.* . . . The name *Equus tau* is probably a synonym of *Equus conversidens.*"

Although smaller, the simple enamel folds of the small Dallas teeth, both upper and lower, are very nearly like those of *A. francesi* and *E. tau.* Quinn (personal communication, 1959) has pointed out, however, that enamel patterns tend to become simpler and the characters less certain with excessive wear. Therefore, if the teeth referred to *E.? quinni* are not of maximum size for this species and the teeth of the *A. francesi* holotype are not of minimum size, it would be difficult, if not impossible, to refer isolated teeth of intermediate size to either. Excessive wear also tends to reduce the diameters of check teeth, and this may account for the size differences between the horses compared. The length of the Dallas teeth ($\underline{\text{M1}}$, 75 mm; $\underline{\text{M2}}$, 67.4 mm) is greater than that of any of the specimens here compared; therefore, larger, instead of smaller, diameters should be expected. Although the diameters of the *E.? quinni* metatarsals are but 2 to 3 mm less than those of *A. francesi,* the metatarsal lengths of 277 and 287 mm are striking when compared with the over-all length of 225 mm for the metatarsal of *A. francesi.*

Comparison between the metacarpal of *E.? quinni* and the same elements of *A. conversidens* and *A. francesi* is equally striking. The diameters of *E. ? quinni* range from 2.6 to 10.6 mm less than those of either *A. conversidens* and *A. francesi,* and the over-all length of the metacarpal of *E.? quinni* is 14 and 15 mm greater respectively than the metacarpals of the other two species. In fact, the *E.? quinni* metacarpal is longer than the metatarsal of *A. francesi.*

Quinn (1957, p. 12) referred a metatarsal from the Holloman gravel pit in Oklahoma (late Kansan) to *Onager semiplicatus.* The Holloman metatarsal, although much larger than those of *E.? quinni,* is also quite long relative to its diameters. The same is true of *E. calobatus* from the late Kansan of Kansas. *E.? quinni* is most certainly closely related to these earlier equine types.

Although the Dallas teeth referred to *E.? quinni* were not collected in direct association with the five metapodials, these teeth are referred with some confidence as both the teeth and the metapodials have smaller diameters than any described from the late Pleistocene. To say that the teeth and the metapodials may not belong to the same species would necessitate suggesting that there are two equine types in the Lower Shuler member that are smaller than any described heretofore from the late Pleistocene.

Reference of the new species to *Equus* is rather doubtful. The splint bone scars on the complete metatarsals are very long and are quite like metapodials of the three-toed genus *Nannippus,* which is known to have survived into the early Pleistocene. The protocones of *Nannippus* are isolated, however; in the small Dallas teeth they are not.

In a small collection at the Bureau of Economic Geology, The University of Texas, there are teeth of two distinct horses from an unknown locality in northwest Texas. One is *N. phlegon*; the other is slightly larger and, based on teeth, cannot be distinguished from *E.? quinni.* Associated with these specimens is a complete metatarsal of the proper size for *Nannippus* teeth and a broken metatarsal exactly like the holotype of the new species from Dallas.

Barbour and Schultz (1937, p. 4) list an "Equid (very light-limbed form; known only from a single metapodial)" from Broadwater, Nebraska, in association with *Stegomastodon.*

It is also noteworthy that Skinner (1942, p. 170) described a first phalanx from the Papago Springs Cave, Arizona, as too small to belong to *A. conversidens.* He referred this specimen to *Equus tau,* saying : "The single specimen of *Equus tau* is very different from the larger *Equus conversidens* of the cave fauna. The phalanx is slender proportioned and resembles some of the large Pliocene Equidae." The Arizona phalanx of *E. tau* is 14 percent longer than the same element of *A. francesi,* with an over-all length of 78.5 mm compared to 69 mm for *A. francesi,* and is 30 percent narrower with a proximal transverse diameter of 25 mm compared to 36 mm for *A. francesi.* The comparison of this longer, more slender Arizona phalanx with the phalanx of *A. francesi* is reminiscent of the comparison between the metatarsals of *E.? quinni* and *A. francesi.* It is probable, therefore, that *E.? quinni* is associated with *A. conversidens* in the Papago Springs Cave, as it is in the Lower Shuler at Dallas.

Considering the possible association of *E.? quinni* with (1) *Nannippus* in the unknown northwest Texas locality, (2) *Stegomastodon* at Broadwater, Nebraska, and (3) a typical Wisconsin fauna at Papago Springs, Arizona, *E.? quinni* may have been a rather long-ranging species. Why, then, should it be so rare elsewhere and yet one of the most abundant forms in the Lower Shuler at Dallas? Perhaps, being a southern form, it moved north from Mexico only during interglacials. Yarmouth deposits are practically unknown in Texas, and reported Sangamon deposits are very rare south of Kansas. Both size and form of the M3 figured by Hibbard (1955a, fig. 4-d, p. 63) from Mexico compare well with the Dallas teeth referred to *E.? quinni* thus strengthening the supposition that *E.? quinni* found refuge in Mexico during glacial periods.

Table 13 (p. 36) compares teeth measurements of *E.? quinni* with other small Pleistocene Equidae.

EQUUS cf. E. CABALLUS Linnaeus

(Wisconsin to Recent)

Fig. 17

Referred specimens. — Left P2-M3 (SMUMP 60036); Upper Shuler, Pemberton Hill. Isolated teeth (SMUMP 60490); Upper Shuler, Lewisville site.

Discussion.—When M. F. Skinner examined the collection from the Lewisville site in 1956, he discovered that two sizes of caballine-type horses were represented.

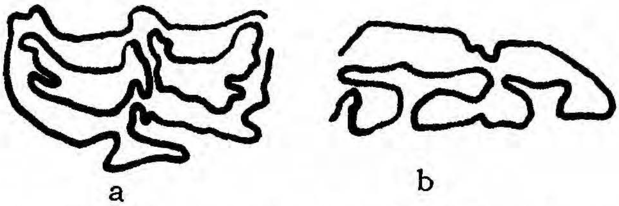

FIG. 17. *Equus* cf. *E. caballus* Linnaeus. (a) Left $P\underline{4}$ (SMUMP 60036). (b) Right $P\overline{2}$ (SMUMP 60490). ×1

Skinner did not attempt to make specific identification because of the fragmentary nature of the specimens. Better material since collected from the Lewisville site and Pemberton Hill cannot be separated from the modern form.

Because radiocarbon dates indicate an age in excess of 37,000 BP for the Lewisville site, this is a very early report for this species in America. With minor discrepancies, the ranges given for the other equine species are in line with the age allocation of the T-2 deposits.

Family TAPIRIDAE

TAPIRUS sp.

Referred specimens.—Right metacarpal III (SMUMP 60093); Hill, Moore pit. Left mandible fragment less teeth (SMUMP 60110); Lower Shuler, Moore pit. Right mandible fragment less teeth (SMUMP 60572); Lower Shuler, Wood pit.

Discussion.—The Dallas tapir material is very fragmentary and is referred to this genus on the basis of age of the deposits. The tapir cannot be separated from earlier genera by size or form. Tooth measurements used in comparisons were taken from alveoli and could be misleading, but at least a rather general size can be determined. All described species from the Pleistocene of North America are near the upper size range of the Recent species *T. terrestris,* or larger. Because the three Dallas specimens are quite small, al-

TABLE 13. *Measurements of teeth of small Pleistocene Eqiddae* (in mm).

		***Equus? quinni,* n.sp.**		***Equus littoralis***
	(SMUMP 60146)	**(SMUMP 60101)**	**(SMUMP 60467)**	**(WFIS 4086) (Holotype)**
Antero-posterior diameter of $M\underline{1}$	18.7	....	....	21.5
Transverse diameter of $M\underline{1}$	18.5	....	....	22
Length of protocone	10.9	....	....	12
Antero-posterior diameter of $M\underline{2}$	....	17.2	....	21
Transverse diameter of $M\underline{2}$	....	17.9	....	20
Length of protocone	....	10	....	11
Antero-posterior diameter of $M\overline{2}$	....	....	18.5	....
Transverse diameter of $M\overline{2}$	....	....	11.8	....

	Asinus conversidens **(UNAM 403) (holotype) (After Hibbard, 1955a, p. 56)**		***Asinus francesi*** **(TAM; no number)**	***Equus tau*** **(UNAM; lost) (After Hay, 1915, p. 539)**
	Right	***Left***		
Antero-posterior diameter of $M\underline{1}$	21.7	22	19.5	21
Transverse diameter of $M\underline{1}$	22	21.7	22	20
Length of protocone	10.5	11.1	11	11
Antero-posterior diameter of $M\underline{2}$	21.7	21.9	20	22
Transverse diameter of $M\underline{2}$	20.8	19.8	21	18.5
Length of protocone	11.3	11	12	11.5
Antero-posterior diameter of $M\overline{2}$	....	....	20	....
Transverse diameter of $M\overline{2}$	....	....	12.5	....

though perhaps within the lower range of *T. terrestris,* the Dallas tapir is closer to *T. terrestris* than to the fossil species described from the Pleistocene.

Until quite recently, tropical, rain-forest climate has been associated with the presence of tapir in fossil faunas, based on the habitat of the living Central American species. Martin (1958, p. 412) suggested that the presence range of *T. terrestris* may represent a refuge from early man and not a climatic preference. Also, one must consider the possibility that a fossil species may not be closely related to the geographically nearest living representative. The recent species *T. roulini* dwells in the mountain forest of Ecuador and Central America at elevations up to 8,000 feet. Desire Roulin, while accompanying Boussingault on his 1824 Andean expedition, came across a strange animal in the bare mountain heights of the Andes in Colombia, "resembling the typical South American tapir but has long, thick hair like a bear's" (Goodwin, 1954, p. 669).

Various elements of the Dallas tapir material are compared (table 14) with those of the Recent tapir, *T. terrestris.*

Class REPITILIA

Order TESTUDINATA

Single carapace plates of turtles are abundant in the T-2 deposits but seldom is more than one plate of a single individual recovered. A more detailed study may make specific identification possible, but the present writers have attempted to make only generic identifications based on single plates.

Family EMYDIDAE

GRAPTEMYS GEOGRAPHICA (Le Sueur)

Referred specimens.—Third, 4th, and 5th nuchals; right 3rd, 4th, and 5th pleurals (SMUMP 60109); Lower Shuler, Moore pit.

Discussion.—It is evident that the carapace of this turtle was somewhat more flattened than that of the sawback turtle (*G. pseudographica*) present today in the area, and the tubercles on the nuchals were less well developed. These are both characters of *G. geographica.* The present range of this species is no closer than 150 miles northeast of Dallas. Collection of this specimen and other single plates from the Lower Shuler member indicates that the climate during deposition of the Lower Shuler was more like that of deep east Texas today. The antero-posterior diameter of a 5th nuchal of a Recent specimen with an over-all carapace length of 176 mm is only 18 mm. Because the largest reported Recent specimen has an over-all length of 253 mm, the turtle to which the Lower Shuler 5th nuchal belonged was probably equal to or slightly larger than the maximum size of recent forms.

TABLE 14. *Measurements of Dallas* Tapirus *material and observed size ranges of* T. terrestris (in mm).

	***Tapirus* sp.**			***T. terrestris***
	(SMUMP 60110)	**(SMUMP 60572)**	**(SMUMP 60093)**	**Observed range (Simpson, 1945, p. 44)**
Antero-posterior diameter of P$\overline{4}$	20*	......	......	18.7–21.9
Transverse diameter of P$\overline{4}$, anterior lobe	13*	......	......	16.0–18.5
Transverse diameter of P$\overline{4}$, posterior lobe	13.4*	......	......	16.5–19.1
Antero-posterior diameter of M$\overline{1}$	......	21	......	19.5–24.0
Transverse diameter of M$\overline{1}$, anterior lobe	......	14	......	14.8–17.9
Transverse diameter of M$\overline{1}$, posterior lobe	......	15	......	14.5–17.0
Length of metacarpal III	......	......	1114.5	126
Transverse diameter of metacarpal III at mid-shaft	......	......	22	29.5

* Measurement made from alveoli.

TERRAPENE CANALICULATA Hay

Referred specimens.—Half carapace and complete plastron (DPSC 1063); Upper Shuler, Lewisville site. Almost complete carapace (SMUMP 60310); Upper Shuler, Hickory Creek locality.

Discussion.—Holman (1958 p. 277) and others have considered *T. canaliculata* a synonym of *T. carolina,* but the specimens of the T-2 deposits are so much larger than the Recent specimens reported that the T-2 specimens are referred to the fossil species. Milstead (1956, p. 164) referred a number of specimens collected from the Friesenhahn Cavern in Bexar County to *T. canaliculata,* saying: "The largest *T. carolina* carapace examined was 162.0 mm in length; the largest fossil carapace was 208.0 mm." Both specimens collected from the Upper Shuler are almost 300 mm in length.

TERRAPENE cf. T. CAROLINA (Linnaeus)

Referred specimens.——Complete carapace (SMUMP 60112); Lower Shuler, Moore pit. Isolated single plates.

Discussion.—The material provisionally referred to this species falls within the size range of the living form, commonly very near the maximum. It is particularly noteworthy that not a single specimen of the extremely large size that occurs in the Upper Shuler has been recovered from the Hill or Lower Shuler members. Because this is the most northern report of *T. canaliculata,* it may be that this species moved into the Dallas area from the south only after the Dallas area became relatively arid, a condition already suggested for Upper Shuler time.

Family TESTUDINIDAE

GEOCHELONE sp.

Pl. I, fig. 4

Although fragments of *Geochelone* carapace are found in the three lower members of the T-2 fill, the fragments are much less abundant in the Upper Shuler, only two specimens having been collected therefrom. These Upper Shuler fragments are somewhat smaller than the very large fragments found in the Hill and Lower Shuler. Unfortunately, these fragments are useless for specific identification. There is, however, one well-preserved specimen in the Dallas collection (SMUMP 60028) consisting of almost half of the plastron and one-fourth of the carapace. An attempt was made to compare the Dallas specimen with the *Geochelone* material from the Ingleside occurrence, described by Pyburn (1956). The measurements considered diagnostic by Pyburn are not available for the Dallas specimen, but over-all size of the Dallas and Ingleside specimens is comparable. Pyburn assigned the Ingleside material to *G. crassiscutata* Leidy.

A complete specimen was collected several years ago by Mr. Thomas Williams from the Hill-Shuler contact and sent to Dr. Thomas Oelrich, University of Michigan. This specimen has not been identified, but after examining photographs and measurements of the Dallas specimen (SMUMP 60028), Oelrich stated that apparently both belong to the same species. Both specimens are almost 4 feet long.

Order CROCODILIA

Family CROCODYLIDAE

ALLIGATOR MISSISSIPPIENSIS (Daudin)

Referred specimens.—Fragment of left maxilla with four teeth and alveoli of three more (SMUMP 60059); Lower Shuler, Moore pit. Single tooth (SMUMP 60276); Hill, Coppel locality.

Discussion. — Specimen (SMUMP 60059) was found to be identical in size with the skull of a Recent specimen whose body length was almost 10 feet. Specimen (SMUMP 60276) is considerably larger and, according to Dr. Walter Auffenburg (personal communication to Slaughter, 1959), could have belonged to an individual perhaps 13 feet long.

The association of the aquatic snail *Physa* with specimen (SMUMP 60059) indicates that the part of the Lower Shuler in which these specimens were found was deposited in a pond on the flood plain of the ancient Trinity River system.

Order SQUAMATA

Family COLUBRIDAE

?COLUBER CONSTRICTOR Linnaeus

Referred specimens.—Vertebrae (DPSC 1020). Upper Shuler, Lewisville site.

Discussion.—These specimens were submitted for identification to Dr. H. G. Dowling, University of Arkansas. Dowling stated (personal communication to Slaughter, 1959) that because the vertebrae were somewhat damaged he could not say positively whether they belonged to *Coluber constrictor* or to *Masticophis flagellum.*

Class AMPHIBIA

Order ANURA

Unidentifiable frog bones have been collected from the Lower Shuler of the Moore pit and the Upper Shuler of the Lewisville site and Hickory Creek locality.

Class AVES

Only four identifiable specimens of birds have been recovered from the T-2 deposits; all are from the Lower Shuler member. Crow and prairie chicken were identified by Mr. Norman Ford under the direction of Dr. H. B. Tordoff, University of Michigan, barn owl by Dr. Tordoff, and eagle by Dr. Pierce Brodkorb, University of Florida.

The presence of a turkey- or crane-size bird in the Upper Shuler of the Lewisville site was indicated by burned egg shell adhering to fossil bone.

Order FALCONIFORMES

Family ACCIPITRIDAE

AQUILA CHRYSAETOS (Linnaeus)

Referred specimen.—Tarsal-metatarsal (SMUMP 60293) ; Lower Shuler, Wood pit.

Discussion.—This eagle is very rare in the area today.

Order GALLIFORMES

Family TETRAONIDAE

TYMPANUCHUS cf. T. PALLIDICINCTUS (Ridgeway)

Referred specimen.—Distal end of tarsal-metatarsal (SMUMP 60294); Lower Shuler, Coppel locality.

Discussion.—Although this species is not found in the area today, its local extinction was probably caused by hunting pressure of man. It has been recorded historically less than 150 miles west of Dallas.

Order PASSERIFORMES

Family CORVIDAE

CORVUS BRACHYRHNCHOS Brehm

Referred specimen.—Tarsal-metatarsal (DPSC 475); Lower Shuler, Moore pit.

Discussion.—The common crow is abundant in the area today.

Order STRIGIFORMES

Family TYTONIDAE

TYTO ALBA (Scopoli)

Referred specimen.—Distal end of tarsal-metatarsal (DPSC 620); Lower Shuler, Coppel locality.

Discussion.—This species is present in the area today.

Class PISCES

Order LEPISOSTEIFORMES

Family LEPISOSTEIDAE

LEPISOSTEUS cf. L. SPATULA (Lacepede)

A number of scales of this genus were collected from the Lower Shuler member in the Moore pit. Perhaps more than one species is represented, but only one specimen is identified specifically. This was done on the basis of size, because the referred specimen is beyond the size range of all but *L. spatula.*

A report has been made by Uyeno and Miller (1962) on Lower Shuler fish material submitted to them for detailed study.

INVERTEBRATE FOSSILS FROM THE T-2 DEPOSITS

Phylum ARTHROPODA

Class INSECTA

One of the many clay balls in the sand of the Lower Shuler member at the Roy Moore pit was sliced quite by accident during excavation of a fossiliferous zone; it contained a coprolite as a nucleus. The clay ball was *in situ* and the material within did not smoke or char upon ignition. The coprolite appears to have been replaced by non-organic material except for hard parts of insects. The specimen was submitted to Dr. J. F. Gates Clark of the Division of Insects, Smithsonian Institution. Because of the fragmentary condition of the individual insect specimens, identifications were necessarily rather general and therefore offer no help in deducing climatic conditions. The occurrence is quite interesting, however, because Pleistocene fossil insects are rare.

Dr. Clark's identifications follow:

- Class Insecta
  - Order Coleoptera
    - Family Carabidae
    - Family Elateridae
      - Beetles
    - Family Chrysomelidae
  - Order Hymenoptera
    - Ants, bees, wasps, etc.
  - Order Hemiptera
    - Stink bugs, leaf bugs, etc.
  - Order Orthoptera
    - Cockroaches, crickets, etc.
- Class Myriapoda
  - Order Diplopoda
    - Millipedes, centipedes

Because millipedes contain stink glands, many Insectivora do not eat them. Millipedes are often included, however, in the diet of the armadillo. The apparent size of the coprolite suggests that it belonged to one of the large fossil armadillos in the terrace deposits.

In addition to its occurrence in the coprolite, the order Coleoptera also occurs in the Upper Shuler in a dirt dauber nest found *in situ* at the Lewisville site. The nest was collected from a burned area at a depth of over 20 feet. The nest was burned, as were associated bones of several extinct vertebrates.

PLANT FOSSILS FROM THE T-2 DEPOSITS

Sincere gratitude is expressed to Dr. John Grayson, Socony Mobil Research Laboratory, Dallas, Texas, for his patience in running four samples for pollen before a satisfactory sample was found. Unfortunately, Dr. Grayson has not yet made a detailed analysis, but the general identifications are most interesting. Pine pollen is by far the most abundant, but hickory, oak, and evening primrose are also represented. Pine trees are not native to the area today, and one would have to travel approximately 100 miles downstream to encounter native stands. These closest pines are located in an area averaging over 5 inches more annual rainfall than the Dallas area. The sample was collected from the Lower Shuler (Wood pit); this reinforces the hypothesis that Lower Shuler climate was more moist than the climate today. It is doubly significant that the pine spores dominate the sample and therefore probably do not represent remnant stands of pine. The reference of some spores to the "hickory family" may also be indicative, because these trees have not been observed in the Dallas area by the writers, but they do occur in some abundance east of Dallas in the pine-hardwood forests. Dr. Grayson stated (personal communication to Slaughter, 1959) that he also observed in the sample the representatives of grass families and Compositae (daisy), which make up the bulk of the diet of grazers.

This flora, especially the pine, is similar to that of the Jinglebob flora in Kansas. Pine trees are not present in the area of the Jinglebob local fauna today but are found in the Sangamon deposits.

The Upper Shuler flora is represented by numerous fossilized hackberry seeds collected at the Lewisville site and Hickory Creek locality. Part of a pecan shell was found at Hickory Creek beneath an excavated carapace of *Terrapene canaliculata*. Because hackberry trees are very hardy and are able to survive long periods of drouth along draws and other waterways, the presence of this element does not negate the indicated arid climate for the Upper Shuler.

MOLLUSCAN FAUNA FROM THE LOWER SHULER MEMBER, T-2 DEPOSITS

Prior to 1959, little was known of the molluscan fauna of the T-2 deposits. A small collection from the Lewisville site (Upper Shuler) was identified as follows by Dr. Elmer P. Cheatum, Southern Methodist University (Crook and Harris, 1957, pp. 57–58):

Class Gastropoda—
  Stenotrema monodon (Rockett)—abundant
  Stenotrema monodon aliciae (Pilsbry) =
    Stenotrema leai (Binney)—abundant
  Anguispira alternata (Say)—abundant
  Polygyra cf. *texasiana* (Moricand)—rare
  Mesomphix sp.—abundant
Class Pelecypoda—
  Fusconia cf. *undata* (Barnes)
  Quadrula frustulosa (Lea)
  Amblema [=*Crenodonta*] *plicata* (Ortmann and Walker)

In 1957, several pelecypods collected by Slaughter from the Lower Shuler of the Moore pit were submitted for identification to Dr. Joseph P. E. Morrison, Smithsonian Institution. He identified the following:

Crenodonta perplicata (Conrad)
Quadrula speciosa (Lea)
Truncilla truncata (Rafinesque)

WOOD PIT POND DEPOSIT

Early in 1959, an ancient pond clay fill containing fossil snails was located in the T-2 deposits at Wood pit. Fortunately, several feet of the typical laminated sands of the Lower Shuler are displayed both above and below the snail-bearing clay fill. The pond-fill matrix, averaging 6 feet in thickness, lacks stratification in its complete exposure. It has vertical and horizontal continuity with little variation in lithology and faunal distribution. The light gray, highly calcareous fill is slightly indurated and is very fine sand, silt, and clay. Calcium carbonate amounts to approximately 10 percent by volume. Much of the calcium carbonate is contributed by minute particles of snail tests and calcium precipitates, no doubt partially derived from calcium-charged water from nearby native limestone. In screenings, organic debris was meager and consisted primarily of small plant rootlets.

The contact between the snail-bearing clay fill and the laminated sands is quite sharp, both above and below the fill, with little intergradation. There is some local discoloring caused by precipitation of iron compounds. Lack of stratification can be attributed to several causes, wave action and reworking by organisms probably being primary ones.

Although the fossils contained in the snail-bearing clay fill are abundant, their tests are very fragile and many were destroyed in collecting. In order to make the faunal list as complete as possible, samples of the matrix were taken from all parts of the exposure and were repeatedly washed and sifted. Only two vertebrate fossils appeared in the collection: one tooth of *Lepus* sp. and one of *Asinus conversidens* (Owen).

In listing the molluscan fauna, an attempt has been made to shorten and simplify descriptions, yet to retain as much pertinent information as is readily available. Descriptions include the following reference points:

(1) Habitat, aquatic or terrestrial.
(2) Relative abundance of species, indicated by *rare, sparse, average,* or *abundant.* Because quantitative analysis has not been made, these indications must be considered truly general.
(3) Stratigraphic range.
(4) Present distribution (North America).
(5) Ecology.
(6) Remarks.

Phylum MOLLUSCA

Class GASTROPODA

Family PLANORBIDAE

GYRAULUS PARVUS (Say)

Habitat and relative abundance.—Aquatic, average.

Stratigraphic range.—Middle Pliocene to Recent.

Present distribution.—"Eastern North America east of the Rocky Mountains from Florida north to Alaska and northern British America" (Baker, 1928, p. 377). As pointed out by Taylor (*in* Hibbard and Taylor, 1960, p. 100), this distribution given by Baker is based upon a relatively narrow concept of the species. Taylor also stated: "Probably other forms are identical with *G. parvus* and the distribution includes almost all North America." This species is abundant in Dallas County today.

Ecology.—*G. parvus* commonly lives in quiet pools and stream beds and also in larger lakes on partly water-logged pieces of driftwood that have been washed up along shore (Leonard, 1959, p. 61).

Material.—SMUP 469.[3]

GYRAULUS CIRCUMSTRIATUS (Tryon)

Habitat and relative abundance.—Aquatic, more abundant than *G. parvus.*

Stratigraphic range.—Kansan to Recent.

Present distribution.—"*G. circumstriatus* is found in a broad belt across central North America, in southern Canada and the northern United States between the Atlantic and Pacific Oceans, southward in the Rocky Mountains to northern Arizona" (Hibbard and Taylor, 1960, pp. 96–97). Because of its confusion with similar species, such as *G. parvus,* the exact northern and southern limits are not known.

Ecology.—*G. circumstriatus* is more limited in distribution and environment than *G. parvus; in* places they are associated. *G. circumstriatus* is more common in small seasonable bodies of water whereas *G. parvus* prefers rivers and lakes. An excellent description of the two species and a comparison of their differences in ecological preference are given by Hibbard and Taylor (1960, pp. 96–101).

Material.—SMUP 474.

HELISOMA ANCEPS (Menke)

Habitat and relative abundance.—Aquatic, sparse.

Stratigraphic range.—Lower Pliocene to Recent. *Helisoma anceps* [=*H. antrosa* (Conrad)] is wide-ranging and has been identified in Lower Pliocene (Laverne formation, Kansas), Aftonian, and Yarmouth deposits and, rarely, in Illinoian (Crete-Loveland, Kansas) sediments (Leonard, 1952, p. 21).

Present distribution.—Maine to Oregon and from Hudson's Bay to Mexico. This is a prominent species in the Dallas County Recent fauna.

Ecology.—*Helisoma anceps* inhabits streams, ponds, and short-lived pools. This species commonly does not live in large lakes.

Material.—SMUP 460.

HELISOMA TRIVOLVIS (Say)

Habitat and relative abundance.—Aquatic, more abundant than *H. anceps.*

Stratigraphic range.—Nebraskan or Aftonian (Dixon local fauna, Kingman County, Kansas) to Recent.

Present distribution.—Atlantic Coast and Mississippi River drainages, north to Arctic British America, south to Tennessee, Missouri, and Kansas. The southern and western limits of distribution are not clear because of uncertain systematic status of the species with respect to its races (Leonard, 1950, p. 16). *Helisoma trivolvis lentum* (Say) is a prominent member of Dallas County Recent fauna. The relatively small number and fragile condition of T-2 deposit specimens prevent a positive comparison with Recent specimens.

Ecology.—*Helisoma trivolvis* inhabits quiet, somewhat stagnant waters. Although it does live in permanent bodies of water, it flourishes in ponds or sloughs, even though they may be choked with vegetation or polluted with decaying organic materials. It is invariably absent in flowing streams (Leonard, 1950, p. 16).

Material.—SMUP 472.

PLANORBULA ARMIGERA (Say)

Habitat and relative abundance.—Aquatic, average.

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[3] Catalog numbers in this section of the paper are those of Southern Methodist University Biology Department, where the T-2 molluscan collections are housed.

Stratigraphic range.—Pleistocene to Recent; not perfectly known.

Present distribution.—"New England west to Nebraska, south to Georgia and Louisiana, north to Great Slave Lake" (Baker, 1928, p. 359).

Ecology.—*Planorbula armigera* lives in small stagnant bodies of water.

Material.—SMUP 470.

Family LYMNAEIDAE

LYMNAEA CAPERATA Say

Habitat and relative abundance.—Aquatic, sparse.

Stratigraphic range.—Middle Pliocene to Recent.

Present distribution.—"From Quebec and Massachusetts west to California; Yukon Territory and James Bay south to Maryland, Indiana, Colorado and California" (Baker, 1928, p. 263).

Ecology.—*Lymnaea caperata* lives in intermittent streams or small ponds which often become seasonably dry. The living species is probably restricted to a northern distribution because of the species' apparent inability to withstand southern temperature highs.

Material.—SMUP 480.

LYMNAEA DALLI Baker

Habitat and relative abundance.—Aquatic, rare.

Stratigraphic range.—Early Pliocene to Recent.

Present distribution.—"Ohio to northern Michigan and Montana, south to Kansas and Arizona" (Baker, 1928, p. 288).

Ecology.—"*Lymnaea dalli* is often found in moist shaded places or a few centimeters away from the edge of water on wet surfaces of mud, stones or sticks" (Leonard, 1959, p. 56).

Material.—SMUP 481.

LYMNAEA HUMILIS MODICELLA (Say)

Habitat and relative abundance.—Aquatic, average.

Stratigraphic range.—Pleistocene to Recent. This species has been observed in Pleistocene deposits in Hardeman, Howard, Hall, and Wichita counties, Texas.

Present distribution.—Eastern Quebec, Nova Scotia, and New Jersey, west to Vancouver Island; Manitoba, south to Alabama and Texas and west to Arizona and southern California.

Ecology.—This species lives in quiet ponds and ephemeral pools.

Material.—SMUP 465.

LYMNAEA OBRUSSA Say

Habitat and relative abundance.—Aquatic, average.

Stratigraphic range.—Nebraskan to Recent.

Present distribution.—"From the Atlantic to the Pacific oceans, and from Mackenzie Territory, Canada, south to Arizona and northern Mexico" (Baker, 1928, p. 296).

Ecology.—*Lymnaea obrussa* lives in shallow water on mud bottoms and among lake and pond vegetation.

Material.—SMUP 479.

Family PHYSIDAE

APLEXA HYPNORUM (Linnaeus)

Habitat and relative abundance.—Aquatic, sparse.

Stratigraphic range.—Nebraskan to Recent.

Present distribution.—". . . from east of the Cascade Mountains to the Atlantic and from Alaska and Hudson Bay south to the vicinity of the Ohio River" (Baker, 1928, p. 474).

Ecology.—"It is especially abundant in woodland pools which become dry in summer . . ." (Baker, 1928, p. 474).

Material.—SMUP 482.

PHYSA GYRINA Say

Habitat and relative abundance.—Aquatic, most abundant species in the pond site.

Stratigraphic range.—Yarmouth to Recent. *Physa gyrina* lives in large numbers in sinkhole deposits of southwestern Kansas and northwestern Oklahoma. The sediments, while not accurately dated, are obviously younger than Yarmouth (Leonard, 1950, p.22).

Present distribution.—*P. gyrina,* according to Baker (1928, p. 452), ranges from the Arctic region south to Alabama and Texas. A study of Recent collections in Texas (Cheatum, MS) has failed to identify living specimens of *P. gyrina,* and it is quite possible that Baker's Texas shells came from Pleistocene deposits. Many north-central Texas river-terrace deposits ranging in age from Kansan to Sangamon, which are now being studied by the authors, contain fossil shells of *P. gyrina* or *P. gyrina* form *hildrethiana.* Taylor *(in* Hibbard and Taylor, 1960, p. 118) reported: "The species [*P. gyrina* form *hildrethiana*] has not been found living in Meade County and may not occur in the southern Great Plains except as fossils." The distribution of this species today may likely be east of the Mississippi River, north and east of the mid-continent region, and as far south as Alabama.

Ecology.—*P. gyrina* inhabits stagnant, ephemeral pools and also lives on mud or among stones in a stream. In the Wood pit pond deposit, *P. gyrina* appears in such concentrated numbers that a shallow-pond environment can easily be visualized.

Remarks.—There is an unusual variety of sizes in the T-2 deposit specimens, which range in length from 4 to 17 mm. Although the shells are very fragile, the luster of the surface is well preserved; most of the specimens resemble polished ivory in texture. Among individual specimens there is some variation in length of the spire, but most of the spires are very short, the sutures are not deeply impressed, and all of the specimens have the typical elliptical shape.

Material.—SMUP 459.

Family SUCCINEIDAE

SUCCINEA cf. S. AVARA Say

Habitat and relative abundance.—Terrestrial, average.

Stratigraphic range.—Yarmouth to Recent. Shells referred to this species are abundant in lower zones of the Peoria silt in Kansas (Leonard, 1950, p. 23).

Present distribution.—*S. avara* has been reported from every State in the continental United States (excluding Alaska), but in view of the difficulty of identifying species of *Succinea* from shells alone, many records are undoubtedly erroneous.

Ecology.—Habitat preferences of small succineids vary from lowland swampy areas to well-drained forest areas where they live under leaves, logs, and debris.

Material.—SMUP 458.

Family BULIMULIDAE

BULIMULUS DEALBATUS (Say)

Habitat and relative abundance.—Terrestrial, rare, one specimen.

Stratigraphic range.—Unknown.

Present distribution.—Illinois, Tennessee, Alabama, Kentucky, Missouri, Arkansas, Texas, Oklahoma, and Louisiana. This is one of the most abundant species in Dallas County today.

Ecology.—This hardy species lives in bushes and grass and can prosper in arid regions. It often hibernates a few inches beneath ground surface.

Material.—SMUP 451.

Family CARYCHIIDAE

CARYCHIUM EXILE H. C. Lea

Habitat and relative abundance.—Terrestrial, sparse.

Stratigraphic range.—Pleistocene to Recent.

Present distribution.—Maine and Ontario to Manitoba, south to Mobile, Alabama, and Texas (Leonard, 1959, p. 195).

Ecology.—This species has a preference for marshy areas around ponds and creeks and lives under logs or sticks or partially submerged in water.

Remarks.—Taylor (*in* Hibbard and Taylor, 1960, p. 85) has suggested that *C. exile* is a synonym of *C. exiguum.* The specimens of *C. exile* from the T-2 deposits, which are few in number probably because the minute size of the shell causes its loss through screen processes, have radial striae.

Material.—SMUP 468.

Family ZONITIDAE

HAWAIIA MINUSCULA (Binney)

Habitat and relative abundance.—Terrestrial, sparse.

Stratigraphic range.—Lower Pliocene to Recent.

Present distribution.—From Alaska to Maine, Costa Rica, Cuba, Santo Domingo, Puerto Rico, Bermuda, and Japan. In the United States, this species is found from Maine to Florida and Texas, west to the Rocky Mountains.

Ecology.—*H. minuscula* lives in leaf mold and under logs, stones, and the loose bark of trees. In spite of its preferred habitat, this species can withstand drouth and high temperatures.

Material.—SMUP 461.

RETINELLA cf. R. IDENTATA (Say)

Habitat and relative abundance.—Terrestrial, rare.

Stratigraphic range.—Unknown.

Present distribution.—"North America from Canada (46° N. Lat.) south to northern Alabama; from Maine west to Kansas" (Leonard, 1959, p. 113).

Ecology.—This species lives under and in rotting logs, leaves, and other forest debris in both upland and flood plain situations (Leonard, 1959, p. 114).

Remarks.—The smaller size and more narrow umbilicus of the T-2 species were used to distinguish it from the locally abundant Recent subspecies *Retinella identata paucilirata.* Too few specimens were recovered for positive identification.

Material.—SMUP 477.

ZONITOIDES ARBOREUS (Say)

Habitat and relative abundance.—Terrestrial, sparse.

Stratigraphic range.—Early Pliocene to Recent.

Present distribution.—*Z. arboreus* is widely distributed over the North American continent from northern Canada to Mexico and in Central America (Leonard, 1959, p. 122).

Ecology.—This is a woodland species and although it is widely distributed throughout the United States, it is absent from large areas not having protective timber. *Z. arboreus* prefers moist situations and lives under logs or among dead leaves.

Material.—SMUP 475.

Family PUPILLIDAE

GASTROCOPTA ARMIFERA (Say)

Habitat and relative abundance.—Terrestrial, rare.

Stratigraphic range.—Lower Pliocene (Laverne, Kansas) to Recent (Taylor, 1954, p. 4).

Present distribution.—Eastern United States and Canada: Quebec to northern Florida, west to Red Deer, Alberta, the Dakotas, Boulder, Colorado, Lincoln County, New Mexico, and the mouth of the Pecos River, Texas (Pilsbry, 1948, p. 875).

Ecology.—*G. armifera* "is limited to timber or brushy situations along stream courses or thick grasses nearby. It thrives best in limestone districts, where it may occur in dense populations. The species is found in leaf mold, dead leaves and grass, or beneath stones" (Leonard, 1950, p. 29).

Material.—SMUP 466.

CASTROCOPTA CONTRACTA (Say)

Habitat and relative abundance.—Terrestrial, rare.

Stratigraphic range.—Yarmouth to Recent (Leonard, 1950, p. 30).

Present distribution.—Northern United States, Ontario, Canada, and eastern Mexico.

Ecology.—*Gastrocopta contracta* lives in large numbers under chips and stones and in rotting logs and debris on the edge of forests (Baker, 1902, p. 236).

Material.—SMUP 473.

GASTROCOPTA PENTODON (Say)

Habitat and relative abundance.—Terrestrial, abundant.

Stratigraphic range.—Unknown.

Present distribution.—Eastern United States and Canada, west to New Mexico and Arizona, south to Texas, and Florida.

Ecology.—This species lives on wooded hillsides, in well-drained groves, and among leaves and grass in underbrush.

Remarks.—The specimens of *G. pentodon* from the T-2 deposits measure almost uniformly 1.8 mm in length.

Material.—SMUP 457.

GASTROCOPTA PROCERA (Gould)

Habitat and relative abundance.—Terrestrial, sparse.

Stratigraphic range.—Early Pleistocene to Recent. The geologically oldest occurrence is in the Nebraskan or Aftonian Dixon local fauna, Kingman County, Kansas (Hibbard and Taylor, 1960, p. 123).

Present distribution.—Eastern United States from Maryland to South Carolina, west to Kansas, and east Texas (Leonard, 1959, p. 179).

Ecology.—This species lives near streams, under the loose bark of trees, and under logs and stones, and can withstand periods of drouth.

Material.—SMUP 476.

PUPOIDES ALBILABRIS (C. B. Adams)

Habitat and relative abundance.—Terrestrial, sparse.

Stratigraphic range.—Lower Pliocene to Recent (Leonard, 1950, p. 29); throughout the late Kansan of the mid-continent region, Kansas, Oklahoma, Texas, and Nebraska.

Present distribution.—Maine to Ontario, Canada, south to the Gulf of Mexico, west to the Dakotas and Arizona; West Indies (Leonard, 1950, p. 29).

Ecology.—This hardy species thrives in woodlands, under leaf mold, or in the loose bark of trees, but it also inhabits unshaded fields of short grass.

Material.—SMUP 453.

Family STROBILOPSIDAE

STROBILOPS cf. S. TEXASIANA (Pilsbry and Ferris)

Habitat and relative abundance.—Terrestrial, sparse.

Stratigraphic range.—Unknown.

Present distribution.—East Texas, Oklahoma, Louisiana, and Arkansas.

Ecology.—This species lives among leaf mold and on decaying logs and thrives in moderately humid forest environment.

Remarks.—The first specimens collected from the Wood pit pond site are difficult to distinguish from *Strobilops sparsicosta* Baker. The bases of the shells are nearly smooth, with but few faint riblets. The parietal lamella emerge to the edge of the callus and extend far into the shell, where there are other complex lamella. The *Strobilops* collected from the stream site (p. 48) bear the typical lamella and oblique ribbing of *S. texasiana.*

Material.—SMUP 456.

Family ENDODONTIDAE

HELICODISCUS PARALLELUS (Say)

Habitat and relative abundance.—Terrestrial, average.

Stratigraphic range.—Kansan (Cudahy) to Recent (Taylor, 1954, p. 5).

Present distribution.—Eastern Mexico to Newfoundland.

Ecology.—*H. parallelus* lives upon decaying wood in shady or humid places and among damp leaves (Pilsbry, 1948, p. 627).

Remarks.—The distribution in Texas of *H. parallelus* is not perfectly known. Sub-Recent shells have been collected from Foard County by Dr. Walter Dalquest, Midwestern University. The species occurs sparsely in a sub-Recent deposit in Dallas County.

Material.—SMUP 464.

Family HELICINIDAE

HELICINA ORBICULATA TROPICA Pfeiffer

Habitat and relative abundance.—Terrestrial, rare, two specimens.

Stratigraphic range.—Unknown. This is an abundant species in east Texas today and was reported by Sellards (1940, p. 1637) from the Berclair terrace deposit in Bee County.

Present distribution.—Arkansas, Oklahoma, Texas, and Mexico.

Ecology.—*Helicina orbiculata tropica* apparently has great resistance to drouth, for it lives at great distance from water. It has been observed on trees at heights of 5 to 6 feet (Cheatum, MS; Pilsbry, 1948, pp. 1084, 1085). This is one of the most abundant species of the Dallas area today; it thrives in open fields among sparse vegetation.

Material.—SMUP 452.

Family POLYGYRIDAE

MESODON THYROIDUS (Say)

Habitat and relative abundance.—Terrestrial, sparse.

Stratigraphic range.—Unknown.

Present distribution.—Eastern United States and Canada, west to eastern Nebraska and Texas; distributed throughout the wooded areas of Dallas County.

Ecology.—*Mesodon thyroidus* is a true woodland species, which prefers humid localities.

Material.—SMUP 455.

POLYGYRA TEXASIANA (Moricand)

Habitat and relative abundance.—Terrestrial, rare, only two specimens.

Stratigraphic range.—Yarmouth to Recent.

Present distribution.—Illinois, Tennessee, Alabama, Kentucky, Missouri, Arkansas, Texas, Oklahoma, and Louisiana. This is one of the most abundant species of Dallas County today.

Ecology.—This hardy species lives in bushes and grass and can prosper in arid areas. It often hibernates a few inches deep in the ground.

Material.—SMUP 463.

STENOTREMA LEAI (Binney)

Habitat and relative abundance.—Terrestrial, abundant.

Stratigraphic range. — Middle Pleistocene (Kansan) to Recent. The first recorded appearance is in the Cudahy fauna, Kansas and Oklahoma (Hibbard and Taylor, 1960, p. 150).

Present distribution.—Iowa, Kansas, Missouri, Arkansas, Oklahoma, Texas, Louisiana, Mississippi, Alabama, Tennessee, Illinois, Indiana, Virginia, Maryland, District of Columbia (Pilsbry, 1940, p. 680).

Ecology.—*Stenotrema leai* is a woodland or woodland border species; it thrives under leaf mold, fallen trees, and stones.

Material.—SMUP 454.

Class PELECYPODA

Family SPHAERIIDAE

SPHAERIUM STRIATINUM (Lamarck)

Habitat and relative abundance.—Aquatic, sparse.

Stratigraphic range.—Middle Pliocene to Recent.

Present distribution.—New England west to California, Canada south to Louisiana, and Florida.

Ecology.—*S. striatinum* inhabits small creeks, ponds, and rivers where it may be buried in black slimy mud to a depth of several inches (Baker, 1928, p. 115). Taylor (*in* Hibbard and Taylor, 1960, p. 76) stated: "Perennial water bodies with some current action are suitable habitats. The species lives in large lakes or small ones, in rivers or small streams, in a bottom of gravel, sand or mud."

Material.—SMUP 467.

WOOD PIT CHANNEL DEPOSIT

Late in 1959, a second area, apparently an ancient stream bed, was excavated approximately 200 yards to the northwest of the first locality. Although the new area is vertically aligned with the pond deposit and displays the same laminated sands of the Lower Shuler above and below the newly exposed clay, at no place is the snail-bearing clay fill thicker than 18 inches. The exposure was made by commercial gravel companies and is very irregular; the over-all dimensions cannot be determined at this time. At one place, 20+ feet exposure with little variation in thickness of the clay can be seen. The silty and sandy clay is gray and highly calcareous. The snail fauna of the Wood pit channel deposit, collected by bulk sampling and washing, is as follows:

Gastrocopta procera (Gould)—rare, two specimens (SMUP 208)
Bulimulus dealbatus (Say)—sparse, more abundant than at pond site (SMUP 201)
Hawaiia minuscula (Binney)—more abundant than at pond site (SMUP 202)
Pupoides albilabris (C. B. Adams) (SMUP 203)
Polygyra texasiana (Moricand)—rare, three specimens (SMUP 204)
Strobilops cf. *S. texasiana* (Pilsbry and Ferris) (SMUP 205)
Retinella cf. *R. identata* (Say)—rare, one specimen (SMUP 207)
Helicina orbiculata tropica (Pfeiffer)—rare, one specimen (SMUP 206)
Pupisoma cf. *P. dioscoricola* (C. B. Adams)—rare (SMUP 209)

The only species that occurs in the channel but not the pond deposit is described below.

Family PUPILLIDAE

PUPISOMA cf. P. DIOSCORICOLA (C. B. Adams)

Vertical range.—Unknown.

Present distribution.—Florida, south Texas (Brownsville), West Indies, Central and South America (Pilsbry, 1948, p. 1008).

Ecology.—*P. dioscoricola* lives on the bark of trees and on plants. Its tropical habitat today denotes its preference for humid environment.

Material.—SMUP 209.

DISCUSSION OF MOLLUSCA FROM T-2 DEPOSITS

Most of the molluscs collected from the T-2 deposits were species normally found in ponds and streams in moist, woodland areas. The variation of the collections from the two Wood pit sites, only 200 yards apart, is an excellent demonstration of the importance of considering the ecology of any fossil locality. The channel deposit contained one species not found in the pond site; relative abundance of species was markedly different in the two sites. Screenings from the channel deposit yielded many fewer specimens. The presence in the pond of permanent water species, such as *Gyraulus parvus, Planorbula armigera, Aplexa hypnorum, Lymnaea caperata, L. humilis modicella, Physa gyrina,* and *Helisoma trivolvis,* suggests that they lived in a flood-plain pond, near a wooded area, which was temporarily out of reach of river deposition. *Physa gyrina* is found abundantly in stagnant-water environments. The heavy concentration of this species in the pond deposit along with the supporting species that thrive under semi-stagnant water conditions, indicates that the pond at times was reduced to a shallow pool which may have become dry seasonally. Although the pond was short lived, or at least did not last long enough to become a swamp or marsh, it was in existence long enough for many generations of snails to accumulate. The sand, silt, and land-snail tests that are a large part of the pond-clay deposit probably were brought in by surface runoff from higher ground and by small streams.

The narrow band of clay comprising the channel deposit contains much more sand and silt than does the pond fill and contains none of the aquatic Mollusca. The channel deposit is the record of a stream that apparently supplied the pond with runoff water only during moist seasons.

The shifting meander belt of the Trinity River eventually filled the pond and buried it beneath flood-plain deposits of sand and silt.

SUB-RECENT COMPARATIVE MOLLUSCAN FAUNA

To illustrate the difference in climate between sub-Recent time (deposition of the last 6,000 years) and the time of deposition of the T-2 deposits, a faunal comparison is made with sub-Recent small creek terrace (p. 51) molluscan fauna in Dallas County.

The small creek terrace molluscan fauna of Dallas is as follows:

Gyraulus parvus (Say) (SMUR 113)
Helisoma anceps (Menke)—abundant (SMUR 101)

Helisoma trivolvis (Say) (SMUR 102)
Lymnaea bulimoides (Lea) (SMUR 110)
Amnicola intrega (Say)—abundant (SMUR 112)
Physa anatina (Lea)—abundant (SMUR 109)
Ferrissia rivularis (Say) (SMUR 120)
Bulimulus dealbatus (Say)—abundant (SMUR 104)
Hawaiia minuscula (Binney) (SMUR 118)
Succinea cf. *S. grosvenori* (Lea) (SMUR 117)
Gastrocopta procera cf. *G. p. sterkiana* (Pilsbry) (SMUR 111)
Gastrocopta contracta (Say) (SMUR 114)
Pupoides albilabris (C. B. Adams) (SMUR 107)
Strobilops texasiana (Pilsbry and Ferris) (SMUR 106)
Euconulus fulvus (Müller) (SMUR 116)
Helicodiscus parallelus (Say) (SMUR 115)
Helicina orbiculata tropica Pfeiffer—abundant (SMUR 105)
Mesodon thyroidus (Say) (SMUR 103)
Polygyra texasiana (Moricand)—abundant (SMUR 100)
Pisidium nitidum Jenyns (SMUR 119)
Sphaerium striatinum (Lamarck)—abundant (SMUR 108)

Wherever the sub-Recent and Recent Dallas County molluscan faunas are encountered, by far the most abundant terrestrial species are *Bulimulus dealbatus, Polygyra texasiana, Helicina orbiculata,* and *Mesodon thyroidus.* These species are among the most rare in the T-2 deposits; because they are hardy species, it is quite easy to see how they could have become relatively more abundant in Recent time as summer temperatures became more severe and the climate less stable.

The climatic interval between the Sangamon (last major interglacial) and the Early Wisconsin must have been more stable than, and lacked the extreme highs in temperature of, the climate of north-central Texas today. The Sangamon interval of the Great Plains region was described by Frye and Leonard (1957, p. 10) as more moist than at present in that region. Faunal evidence shows this to be equally true during the deposition of at least the first part of the T-2 deposits at Dallas, because the T-2 molluscan fauna indicates a more moist climate at the time of deposition.

Frye and Leonard also pointed out that many molluscan species found today at higher and cooler latitudes or altitudes were widespread throughout the Great Plains regions and in the southern High Plains from Kansan to Early Wisconsin, only to disappear from these regions during Late Wisconsin and Recent. Many of the wide-ranging species identified from the T-2 deposits live today in north-central Texas under varied ecological conditions. Some, however, are Recent inhabitants of areas quite distinct from the area under study. *Physa gyrina, Planorbula armigera, Lymnaea caperata,* and *Aplexa hypnorum* are now confined to an area north and east of the mid-continent region. *Pupisoma dioscoricola* has been recorded in Texas in Recent time only from the Brownsville area at the mouth of the Rio Grande, where the relative humidity exceeds that of Dallas County.

This section summarizes evidence of ancient man associated with the various terrace deposits of the Trinity River at Dallas; most of the attention is focused on the Pemberton Hill-Lewisville, or T-2, deposits.

All small creeks in the Dallas area that are currently flowing on Austin chalk display evidence of two earlier fills. The youngest and lowest of these is generally called simply the "small creek" terrace. The older and higher has not been dated with any confidence and remains unnamed.

The small creek terrace materials were locally derived from the Cretaceous formations and are lithologically different from those of the main river terraces. Archeological correlation is possible, however, between the T-1 deposits of the Trinity River and the small creek terrace deposits. Fortunately, the small creek terrace deposits are not acidic as are those of the T-1 terrace and therefore better preserve shell and bone.

T-0 DEPOSITS

A modern fauna occurs in the T-0 deposits which also contain Neo-American Stage materials (pottery, agriculture, and arrow points) at the base of the alluvium and Historic Stage artifacts in the uppermost 6 inches. The same cultures are found on the surface of the T-1 deposits.

T-1 DEPOSITS

The T-1 deposits are rises or natural levees on the Recent flood plain and veneers upon the eroded slopes of the next higher terrace deposits near stream valleys. Three cultural stages are associated with these deposits: Archaic Stage, Neo-American Stage, and Historic Stage.

Archaic Stage.—This Stage is divided into the Carrollton focus and the Elam focus (Crook, 1952; Crook and Harris, 1952).

The Carrollton focus is in the top 24 to 30 inches of the red Albritton clay and the basal 6 to 8 inches of the overlying Pattillo sand. Artifacts collected from this focus are dart points, about 5 percent of which are Paleo-American types: Plainview, Meserve, Dalton, Scottsbluff, and Angostura. The rest are stemmed or shouldered dart points of the Carrollton, Trinity, Edgewood, Yarbrough, and Wells types and a few central Texas Archaic types. About 70 percent of the scrapers collected are gouges of the Clear Fork type, although somewhat smaller; the remainder are side, flake, and end scrapers. Other types of tools found include drills, choppers, knives, gravers, the Carrollton axe, and the so-called net sinkers, which are probably actually atl-atl weights. A few small manos and milling stones were also collected. The Wheeler site, near Carrollton, has produced two rather fragmentary Carrollton focus skulls. Both are keel-vaulted.

In June 1959 a mussel shell collected from a Carrollton midden was radiocarbon dated at 5945±200 BP. The writers are indebted to Dr. C. I. Alexander, Socony Mobil Research Laboratory, Dallas, Texas, fer determination of this date.

The Elam focus usually occurs at depths ranging from 15 to 30 inches below the surface of the Pattillo sand (Crook and Harris, 1952, p. 24). This focus is wholly Archaic. The artifacts resemble those of the Carrollton focus except for their smaller size. The net sinkers and Paleo-American points which occur in the Carrollton focus have not been found in the later Elam focus.

Neo-American Stage.—Sites of this Stage are usually found within the top 6 to 8 inches of the T-1 deposits as well as on the T-0 terrace. The sites are divided into pre-Gibson, Gibson, and Fulton aspects and in turn into Alto, Sanders, Wylie, and Henrietta foci. This sequence is estimated to have begun approximately 1,000 A.D.

Historic Stage.—Historic sites are uncommon in the Dallas area. One interesting find, however, was a relatively small battle-axe discovered on a bluff in southern Dallas County. After the rust was removed, the blade was found to be covered with a very ornate design of silver inlays. The handle concealed another weapon, a screw-out dagger. Another interesting find, made after a flood had scoured the low-lying, locally derived alluvium of the T-0 terrace near Carrollton, was a silver chain-mail gauntlet. European gun-flints and a few lead balls have also been collected from Dallas County sites. One site near Kaufman, 30 miles south of Dallas, produced a dress ornament of tinkler made from sheet copper.

T-2 DEPOSITS

The T-2 deposits, the primary concern of this paper, contain a few traces of early man which have been uncovered during excavation for building materials such as gravel, sand, and clay. These Paleo-American Stage sites are usually in the Upper Shuler about 15 to 20 feet below the surface of the terrace.

Lewisville site.—The remains of early man were uncovered after about 20 feet of T-2 deposits had been removed for fill for Garza Dam. Twenty-one hearths and hearth areas were located and excavated by the Dallas Archeological Society before the new lake covered the site. A Clovis point, a scraper, a chopper, a hammer stone, a few flint flakes, and a large faunal collection were obtained. This apparently represents a camp site of the Llano Culture. A complete description of this site is given by Crook and Harris (1957).

The Lewisville site has been known primarily as an archeological locality; radiocarbon dating gives its age as more than 37,000 BP (Brannon et al., 1957, p. 149).

It is also one of the major concentrations of faunal material known from the T-2 deposits. It is noteworthy that while most exposures of the Upper Shuler portion of the T-2 deposits lack fossil remains, where fossils do occur they are in great numbers in local areas, such as the Lewisville site. Interestingly enough, all material at Lewisville appears to be confined to the general hearth area of presumed human habitation.

The Lewisville site hearths, artifacts, and fossil faunal materials occur only in the Upper Shuler yellow sandy clay and are well encrusted with caliche. Heaviest concentration of caliche is in the lower zones.

Large numbers of hackberry seeds, both burned and unburned, occur within the hearths. The charcoal from Hearth 1 used for radiocarbon dating was described (Crook and Harris, 1957, p. 69) as "charred, fibrous, vegetable material"—probably grass or sedges of some type. Also radiocarbon dated, the charcoal from Hearth 8 was so degenerated that the cellular structure necessary for identification was obscured. The charcoal gave the impression of possibly having been cedar.

Hickory Creek.—This site was discovered after a large pit was opened for fill and gravel. Although to date no artifacts have been found, two flint flakes and a large collection of faunal material, including some burned bone, have been collected. The site, 10 miles upstream on Hickory Creek from the Lewisville site, is in the same stratum of the T-2 deposits as that site. Evidence of human activity is scanty, yet the concentration of faunal material around such evidence is reminiscent of Lewisville; no fossils have been found in the remainder of the pit.

The specimen of *Elephas columbi* excavated from the Upper Shuler of this site by North Texas State College personnel is intriguing in that the skull with tusks was found lying *upside down,* although associated with the remainder of the skeleton which was lying on its side. Many split bone fragments, teeth, and even mussel shell appear to be burned—as do a few caliche nodules—even though no definite hearths, like those at the Lewisville site, have yet appeared.

In addition, a carbonized, possibly burned, pecan was found immediately beneath a carapace fragment of *Terrapene canaliculata* which, in turn, had an apparently burned hackberry seed cemented to it by caliche.

Lagow pit.—A small faunal collection including part of a human skeleton was obtained from this pit. The human and other animal bones are mineralized. The T-2 deposits of the Lagow pit are practically identical with those of the Lewisville site, although the two localities are 25 miles apart.

Unfortunately, in Lagow pit no artifacts were found, and the skeletal remains are incomplete. Results of a recent study, made by Harvard University and the British Museum Fluorine Laboratory, on the Lagow pit human and animal remains are contained in a paper by Oakley and Howells (1961). It is demonstrated that the Lagow pit man is not the same age as the animals found in the T-2 deposits; however, the human remains are somewhat mineralized and seem to be old. The Lagow pit human remains are fragmentary but do not differ from remains of American Indians, except for a very thick skull and thick walls of the long bones. Certainly there is every evidence that this is *Homo sapiens.*

The thickness of the skull of Lagow man is similar to that of a fragmentary, mineralized human skull found in 1959 by Tom Padgitt and Richard Johnson of the Tarrant County Archeological Society in a site near Eagle Mountain Lake, Tarrant County, Texas.

Shuler (1923, p. 334) described his fruitless search of the Lagow pit walls for signs of a burial pit. Certainly any burial or intrusion from an overlying surface, once the Albritton red sandy clays were present, should be obvious. Any admixture of these red sandy clays and the yellow sandy clays of the Upper Shuler would be most striking. Therefore, it seems that the bones of Lagow man must have reached their discovery position *after* the T-2 fill was deposited but *before* deposition of the veneer of Albritton red sandy clay. Whether this occurred by gully cutting or intentional burial into the exposed and eroded-off slope of the T-2 fill, then composed of residual Upper Shuler yellow sandy clays, is immaterial; a yellow sandy clay fill might easily escape detection after some thousands of years.

The age of Lagow man, therefore, must be between 28,000 and 10,000 BP or prior to the commencement of deposition of the Albritton. Most probably the age is closer to 10,000 BP because the erosion and slope-off must have been essentially completed before emplacement of the remains. This is corroborated by the remains of Archaic man that have been recovered elsewhere from the Albritton clay. It is the opinion of Crook (1961) that the remains of some type of pre-Archaic Man, accidentally or intentionally, were buried in a residual surface of eroded Upper Shuler about 10,000 years ago.

Seagoville site.—What appeared to be a large Plainview point was discovered in the Richards formation exposed in a garden in the city of Seagoville. The point was about 8 inches below the surface and partly covered by a thin caliche coating. No other artifacts have been found at this place; this is the only known possible evidence of man in the Richards.

Pemberton Hill site.—The mid-section of a projectile point and a blade or knife have been collected from the Upper Shuler member of this exposure, which is but 4 miles downstream from the Lagow pit. Provenance of the two sites is identical and geology and paleontology of the two sites are similar.

Human evidence is very scarce, but it seems indisputably associated with the other faunal materials. The broken mid-section of a projectile point could well be from a typical Clovis-type point, based on technique, size, and flaking. The flint blade, or knife, was found *in situ* very close to caliche-encrusted fossil remains of *Elephas columbi* and *Equus caballus.*

Boatwright pit.—Sellards (1952, pp. 99–105) described the remarkable occurrence of crudely carved stone heads in human image from near Trinidad, Texas, about 80 miles downstream from the Dallas sites. These stones apparently were collected from the "Trinity terrace" of Stovall and McAnulty (1941, pp. 216–217) which is correlated in this paper with the T-2 deposits at Dallas. The stones were collected at the contact of the basal gravels and the clean cross-bedded sands. Three carved stone heads were found; these are at the Texas Memorial Museum, Austin. A fossilized human femur, of disputable origin, is also known from this same area.

Althugh few artifacts have been found in the T-2 deposits, the artifacts that have been recovered from the several sites investigated indicate that the T-2 deposits offer possibilities where they are exposed to a considerable depth.

T-3 AND T-4 DEPOSITS

T-3 and T-4 deposits have produced no artifacts; a few flint flakes, no doubt dropped by man on his way to the T-4 terrace to obtain material for artifacts, have been found relatively recently.

T-5 DEPOSITS

T-5 deposits have a capping of cobbles of quartzite, petrified wood, ferruginous sandstone, and some flint. Early man made trips to these cobble fields to obtain material for tools. Because all local cultures used these materials, one may find in the T-5 deposits small sites of most of the ages represented on lower terraces.

CRETACEOUS UPLANDS

Carrollton focus artifacts are found *in situ* in shallow alluvial deposits accompanying small tributary creeks of the Trinity River, which have their headwaters on the Cretaceous uplands. Through these artifacts, these deposits are correlated with T-1 terrace of the main river where the Carrollton focus is also found. *Bison bison* predominates in this essentially modern fauna.

COMPARISON WITH OTHER LOCALITIES AND LOCAL FAUNAS

TRINIDAD, TEXAS, LOCALITY

Comparison between the Dallas terrace deposits and those at Trinidad, Texas, described by Stovall and McAnulty (1941) deserves serious attention, because the terraces in the two areas were deposited by the same river and are but 80 miles apart.

The authors correlate the Trinidad fossil material, and the Trinity terrace deposits of Stovall and McAnulty (1941) in which it occurred, with the Dallas discoveries and the T-2 deposits. This correlation is based on independent paleontologic study of the Trinidad region.

Although Stovall and McAnulty (1941, p. 216) designated the Trinity terrace deposits as T-3, this merely reflects the individual expression at Trinidad of the dual nature of the T-1 deposits at Dallas. At Dallas, the T-1 deposits are composed of the basal red sandy Albritton clay and overlain by the gray Pattillo sand. The Trinidad T-2, or Trinidad terrace, deposits are almost lithologically identical to the Albritton red sandy clay which is capped by a thin layer of what appears to be gray Pattillo sand; the Trinidad T-1, or Power Plant terrace, deposits are composed essentially of gray Pattillo sand. Trinidad is only 80 miles downstream from Dallas, and such lithologic continuity is very possible.

At Dallas, Trinity aspect Archaic archeological materials occur in place in the upper zone of the Albritton, along the Albritton-Pattillo contact line, and in the lower half of the Pattillo; Neo-American archeological remains commonly occur as surface deposits on top of the Pattillo. This sequence is repeated perfectly in the corresponding members at Trinidad.

Thus, the Trinidad T-1 and T-2 fill was deposited within the last 10,000 years, or essentially within the Recent epoch, based on correlation with Dallas deposits, on the presence of modern fauna, and on radiocarbon dates. The Trinidad T-3 deposits, like the Dallas T-2 deposits, are the youngest terrace deposits that contain extinct fauna. Because the contained faunas are similar and the lithologic composition of these two terraces is nearly identical, direct correlation is probably between the paleontologic materials studied for this paper and those studied by Stovall and McAnulty (1941).

It is very probable that the variation between the two areas in *numbers* of terraces is a result of geography. Dallas lies in the Cretaceous upland zone where the river gradient today is still 12 inches per mile. Trinidad lies below the contact line with the Gulf Coastal Plain Tertiary surface; the gradient there is 8 inches per mile. In addition, Dallas lies in the constricted zone where the Trinity River has cut a notch through the resistant Austin chalk; Trinidad lies below the point of debouchment into the wide, low-lying Tertiary plain. Relatively minor alluvial events of late date might, therefore, have expressed themselves topographically in a slightly different manner in the two areas, whereas topographic expressions of earlier, major events would be essentially the same.

In 1941, before the advent of radiocarbon datings, Stovall and McAnulty tentatively assigned their T-3 deposits to an interstade of the last glaciation. Thus, they recognized the salient point: the T-3 deposits are *non-glacial*, i.e., interglacial or interstadial. This agrees with the authors' views on the age of the Dallas terraces. In light of recent radiocarbon dates for the interglacial Beaumont formation offshore (C. I. Alexander, personal communication, 1959) and the T-2 deposits at Dallas, Stovall and McAnulty's possible correlation of their T-3 deposits at Trinidad with the Lissie is subject to revision. The T-2 deposits at Dallas and the T-3 deposits at Trinidad appear to be correlative with the Beaumont.

Although the Dallas area fossil material is far more extensive than that described from Trinidad, exposures at the two localities are greatly disproportionate. The Dallas pits are a result of much greater economic exploitation of sand and gravel. Those fossils present at Trinidad are, in the main, almost directly comparable to the Dallas specimens.

It is perhaps noteworthy that the new species *Megalonyx brachycephalus* (McAnulty) from Trinidad may be present in the Dallas collection. This cannot be demonstrated positively because of the fragmentary nature of the Dallas specimens, but the size range is similar. Likewise, examination of the deer jaw in the Trinidad collection proved that the jaw belongs to the new subspecies from Dallas, *Dama virginianus aplodon* (Slaughter).

The only problem that arose in the comparison of contained materials was the identification in the Trinidad collection of a nearly complete skull of *Bison occidentalis.*

According to measurements published by Stovall and McAnulty (1941, p. 241), this specimen's horn-core length is well beyond the maximum for this species as given in Skinner and Kaisen's (1947, p. 170) definitive work on the *Bison.* Thus, despite the configuration, the *B. occidentalis* assignment is somewhat in question. Added to this is the lack of positive geologic provenance for this particular specimen at Trinidad. Unlike the other described fossils, this specimen is attributed ". . . from near Cayuga, Anderson County ..." It may or may not be an example from the T-3 deposits at Trinidad. The measurements of this specimen seem closer to those of *B. alleni,* the species to which the Dallas bison material is assigned.

IRON BRIDGE DAM LOCALITY

At Iron Bridge Dam, approximately 50 miles east of Dallas on the Sabine River drainage in Van Zandt and Hunt counties, earth-fill excavations exposed another interesting bone bed that bears comparison with the bones from the T-2 deposits at Dallas.

A probable and paleontologic correlation exists between this late Pleistocene terrace fill and the T-2 deposits on the Trinity River at Dallas. Allowing for the difference in upstream drainage, lithologic similarities are notable. An excess of calcium carbonate in the terrace materials is responsible for the good preservation of the Iron Bridge fossils, which occur in the most extensive vertebrate fossil bed in Texas that is near the moist, destructive humid climate of the wide Mississippi basin.

Miss Hazel Peterson, East Texas State College; Dr. E. L. Lundelius, The University of Texas; and the writers collected the following Pleistocene fossils: *Mammut americanus, Elephas columbi, Camelops* sp. (although not directly comparable with the Dallas specimens, the size is similar), *Bison alleni* or *B. latifrons, Tetrameryx shuleri, Breameryx* sp., *Equus complicatus* or *E. fraternus, Holmesina septentrionalis,* and *Alligator mississippiensis.* All of these types are represented in the Dallas collections; there seems to be nothing to negate the proposed correlation with the Hill-Shuler local faunas. The presence of *T. shuleri* at Iron Bridge may be most significant, because the holotype of this genus and species is from the Dallas occurrence.

The predominance of mastodon at Iron Bridge is in strong contrast to the approximately 50 to 1 ratio of mammoth-mastodon at Dallas. This is easily explained by the grazing habits inferred from tooth structure and geographic distribution of *Elephas* and by the browsing-tooth structure of *Mammut.* Even today the delineation is fairly sharp between west Texas grasslands and east Texas timber. The town of Edgewood, 90 miles east of Dallas, is well named. This grassland-forest boundary most certainly existed in the past and fluctuated east and west, with climatic changes. In upper Pleistocene time, Dallas was in grassland country and mammoth predominated; Iron Bridge was in a forested area and mastodon was the more prominent. Other forms of animal life intermingled between the grassland and forest habitats.

Even today, relict pines can be found on the upper Sabine River drainage in southwest Hunt County, and relict palmetto and swamp birch can be found on the middle Sabine near Mineola. These are indicative of a past climate similar to the more humid, sub-tropical climate now existing east and southeastward toward Louisiana. The Dallas area of the upper Trinity River supports a sub-arid flora of pecan and hackberry and other hardwoods in the bottoms and draws, whereas the uplands basically are grasslands.

Because the upper Sabine River and the Elm Fork of Trinity River are so close, both must have reacted to the same climatic stimuli even in ancient times.

INGLESIDE AND BERCLAIR LOCALITIES

The famous Ingleside fauna from the Texas Coastal Plain has not been thoroughly described in the literature; results of future studies will be important for comparison with the results of study of the Dallas material.

The Ingleside deposits were considered by Sellards (1940, p. 1651) to be contemporary with the Berclair terrace deposits. Descriptions by Sellards and subsequent references by other writers to unpublished knowledge of the collections have been largely in terms of genera rather than species. Despite this handicap, it is obvious that the fauna is late Pleistocene. Stovall and McAnulty (1941, p. 247) after comparing the Ingleside local fauna to the Trinidad fauna, concluded that the Trinidad material was slightly older than that of Ingleside-Berclair; certainly no younger. The absence of a number of genera at Trinidad may not be significant because of the wider variety of faunal material found in Ingleside and Berclair terrace deposits. This is especially true because the Dallas and Trinidad faunas are equated herein, and the Dallas T-2 deposits have a greater total of forms over Ingleside-Berclair than Ingleside-Berclair in turn have over Trinidad. Stovall and McAnulty (1941, p. 247) also considered the age of the Ingleside-Berclair faunas to be similar to that of Rancho La Brea; they considered Trinidad and McKittrick local faunas to be slightly older. No further faunal comparison can be made with the Ingleside-Berclair deposits until material from them has been identified to the specific level.

Sellards (1940, p. 1646) related the Berclair terrace formation to the period of high sea stand during which the marine Beaumont formation was deposited. In the Berclair area, the Beaumont is recognizable near Refugio, some 80 miles inland and at an elevation at least 80 feet above sea level. The flood-plain alluvium that later became the Berclair terrace merges with delta and beach deposits of this high sea stand. It is believed that the Beaumont was deposited during a late interglaciation and probably the last interglaciation or Sangamon. Radiocarbon dates indicate that the now-submerged offshore Beaumont formation was subjected to subaerial weathering and erosion between about 28,000 and 10,000 BP. The latter date was the beginning of the present transgression and the deposition of Recent marine sediments. This suggests that the Berclair terrace deposits are roughly contemporary with the T-3 deposits at Trinidad. These deposits all seem to be last interglacial alluvial equivalents of the marine Beaumont formation.

On the other hand, as described by Sellards (1940, p. 1651) and confirmed by the writers' studies of the site, the Ingeside pit was a lake deposit, *situated on the exposed surface of the Beaumont*. Thus, at the time of the Ingleside lake fossil accumulation, the sea had withdrawn at least as far as it is today and perhaps farther. There are shallow somewhat brackish lakes immediately adjacent to the Ingleside site, but the water in these lakes is not too brackish for frogs to live in and cattle to drink. The present vegetation is being overrun by scrub live-oak, but some sixty years ago, according to the memory of local residents, the area was coastal prairie, perhaps as it was in the day of Ingleside's fossil lake. It is suggested that the Ingleside deposits must be somewhat later than those of Berclair, perhaps laid down during the early stages of the last glaciation. The Ingleside fauna, however, cannot have been greatly different from that of the immediately preceding interglaciation, because interglacial forms may have lingered on even after a new glacial advance had commenced in the north and had lowered sea level 80 feet or more.

The age of the Ingleside-Berclair faunas, therefore, should be between the last interglaciation and early last glaciation. Because most of this material occurs in the Ingleside lake bed, much of the material may be slightly later than the Trinidad and Dallas faunas.

FRIESENHAHN CAVERN LOCALITY

Friesenhahn Cavern, Bexar County, is another famous and important but not fully described late Pleistocene locality. This site is in the Edwards Plateau region of Texas, which is higher today than either the Coastal Plain or the Dallas-Trinidad region and characterized by dissected limestone hills covered with brush and cedar. Publication of more complete studies of this material will be most welcome.

The only detailed publication on this site is by Milstead (1956), who described numerous turtle specimens. Prior to the discovery of fauna from the Upper Shuler member of the Lewisville T-2 deposits, the most prolific and northernmost occurrence of *Terrapene canaliculata* was probably in Friesenhahn Cavern. In addition, Friesenhahn contained a good bit of *Geochelone* material, including a new species not yet recognized elsewhere in Texas. These excavations also produced a complete skeleton on the great cat *Dinobastis serus*; a complete skeleton of the peccary *Mylohyus;* and remains of *Mammut, Elephas, Panthera,* and many other genera. A flint scraper, indicative of early man, was found beneath the *Dinobastis* skeleton.

The fauna is not nearly as similar to the Dallas material as are the Trinidad, Iron Bridge, and Berclair faunas. Age and probably climatic differences are suggested. Even today the areas are different physiographically.

Pending possible radiocarbon dating of the Friesenhahn charcoal, the writers suggest that the cavern deposits may represent early last glaciation. Perhaps the turtles were hibernating regularly in this favorable underground retreat as the weather in the area cooled. As winter cold periods lengthened, fewer and fewer turtles would survive, which would account for the large collection of fossil turtles. This could also explain the presence of *Geochelone* (restricted in its final appearence to the Sangamon interglaciation) and the large numbers of *Terrapene canaliculata* which, to date, have not been reported north of the Lewisville site (T-2, Upper Shuler) in Denton County.

It has also been suggested that the extinction of these turtles was caused by increasing aridity. If so, the cave deposits must necessarily be allocated to an interstadial within the last glaciation or the glaciation itself must be considered arid. Because glaciations are generally believed to be accompanied by pluvials, only the first possibility will be considered. Arid conditions seem unlikely, however, because of the large number of mastodon remains found at Friesenhahn Cavern. The browsing tooth structure of the mastodon is indicative of forested conditions which would hardly be available during times arid enough to annihilate the vast numbers of turtles.

The presence of *Sigmodon hispidus* at Friesenhahn seemingly would negate the possibility of this local fauna representing the next earlier glacial stage (Illinoian) because the earliest reported occurrence of this species in the United States is from the Lower Shuler member of the T-2 deposits.

If, then, the Friesenhahn assemblage generally suggests a glaciation, the scanty but definite evidence of human presence almost certainly places the period in the *last* glaciation of circa 25,000 to 10,000 BP. Turtle remains suggest that the Friesenhahn fauna should be assigned to the earlier half of this period.

JINGLEBOB LOCALITY

Hibbard's (1955b) Jinglebob local fauna of interglacial (Sangamon?) age in south-central Kansas, just north of the Oklahoma border, resembles a slightly more northern version of the Dallas collection. The question mark following Sangamon indicates the problem in referring to the last interglaciation, whatever it may eventually be named or numbered.

Hibbard (1955b) interpreted the Jinglebob local fauna as *non-glacial.* Combining material from several localities, he was handicapped by the preponderance of small vertebrate forms over the more definitive larger species; the Dallas collections offer no such handicap. Hibbard is the outstanding advocate of the idea that *Bison* arrived in America during the Illinoian glacial and the presence of *B. latifrons* in an interglacial fauna suggests Sangamon age. Also indicative of an interglacial age is the presence of *Terrapene llanensis,* related to *T. canaliculata,* which is the turtle present in the Dallas T-2 deposits. Obviously, giant bison and *T. canaliculata* in the Hill-Shuler local faunas, although slightly different from those in the Jinglebob, suggest a general correlation with it. Additional correlation is indicated by the similarities of *Arctodus* collected from the different faunas.

The land snails of Hill-Shuler and Jinglebob faunas offer suggestive comparisons, and the identification of pine pollen in the deposits at both localities is significant.

Considering the semi-arid climate current in the Jinglebob area (Meade County, Kansas), it is surprising to think of an upstream advance of a flora containing pine along that Arkansas drainage from eastern Oklahoma, especially when interglacials are normally considered as having been drier. Now, however, a somewhat comparable situation is known on the upper Trinity River near Dallas. Here the upstream advance of native pine from the vicinity of Anderson County is a minimum of 100 miles. Further, because the Dallas region has blackland on the divides and uplands, in which pines cannot grow and propagate, the fossil pine flora could only have existed in the sand and sandy clay deposits along the stream valley.

This may suggest the cause of some of the heavy iron cementation at the top of the Hill gravels and of the yellow limonite in the Lower Shuler sand at Dallas. Conifers concentrate iron in the soil, whereas oaks concentrate calcium carbonate.

During the earlier phases of the Dallas T-2 deposition, the climate appears to have been more moist than that characteristic of the area today; during later phases of T-2 deposition progressive drying-up occurred, culminating in greater aridity than today. The evidence from Jinglebob agrees with this sequence of events.

RANCHO LA BREA LOCALITY

The term "Rancholabrean" is the descriptive name of the general late Pleistocene fauna of North America, based upon the magnificent collections from Rancho La Brea tar pits in California. The faunas of the T-2 deposits at Dallas and all other faunas which are discussed herein are quite similar in a rather general way with the Rancho La Brea local fauna; therefore, all of the above mentioned fossil faunas should be correlated with the "Rancholabrean."

Superb as the California material is, it does occur at the far western edge of a vast continent and possibly may be incomplete or not entirely representative of forms present elsewhere, especially those at considerable distance. Such discrepancies, however, should not distort the basic premise of a generally similar, widely distributed late Pleistocene fauna.

Again, although upper Pleistocene roughly includes the Illinoian-Sangamon-Wisconsin (certainly at least the last two glaciations and the intervening interglaciation), it is not certain that all of the Rancho La Brea materials represent this span. The period of accumulation involved is not positively known, nor, for that matter, is the precise provenance of any given specimen from the various tar deposits. Several clues suggest, however, that perhaps the bulk of the fossil material from the California tar pits is last glacial-pluvial in age. The Rancho La Brea local fauna would, therefore, belong to *late* upper Pleistocene.

The fantastic but easily explainable concentration of carnivores in the tar pits implies an even more vast population of herbivores in the immediate area to support these predators. Observing the Los Angeles basin today, with its aridity and brush fires, it is difficult to imagine the presence there of the forage necessary to support herds of such large animals, unless it were during a pluvial period connected with glaciation. During such glacio-pluvial times, even the desert country of the interior portions of southern California, Arizona, Nevada, and Utah contained large lakes and enough vegetation to support a great Pleistocene fauna.

A few radiocarbon tests have been run on wood and plant material from the tar pits, and although there are many uncertainties concerning contamination by the tar, these tests are certainly worth considering. The radiocarbon tests indicate ages of about 14,000 to 17,000 BP, which fall near the middle of the last glaciation.

The Rancho La Brea fauna is somewhat late, e.g., the *Bison* present is *antiquus* rather than the giant species (*B. latifrons, B. alleni*) currently thought to be representative of the last interglaciation. The horse fauna is rather small, with but one species, *Equus occidentalis,* in contrast to the several equine groups in the terrace deposits at Dallas. *Breameryx* is the extinct antilocaprid present, rather than *Tetrameryx, Stockoceras,* etc.; from the Scharbauer archeological site near Midland, Texas, it is known from radiocarbon dating that this tiny antelope lasted until 12,000 to 20,000 BP. The absence of large land tortoises may not be significant because of geography, but southern California enjoys a very mild climate today and has ecological contact with Mexico. Because *Tapirus* is present at Rancho La Brea, the absence of turtle may indicate a time slightly later than the last interglaciation, and from the presence of sub-Recent and Recent fauna in the tar pits, it is apparent that accumulation continued into post-glacial time.

While definitely correlative with the "Rancholabrean" fauna of the upper Pleistocene, the Dallas T-2 assemblage is considered to be somewhat earlier in age and regionally different in a number of species and even genera.

CONCLUSIONS

In summing up the Pemberton Hill-Lewisville (or T-2) terrace deposits and the faunal, floral, and archeological material contained therein, it is concluded that they belong to a non-glacial period of the Upper Pleistocene. Whether this is ultimately correlated with an interglaciation today called Sangamon, or a new interglaciation which may become the last interglaciation, or be assigned to a pronounced and major interstade yet to be established within the last or Wisconsin glaciation, remains to be seen.

Radiocarbon dates now indicate that the classic concept of the Wisconsin glaciation encompasses approximately the period 25,000 to 10,000 BP, a period during which sea level was significantly lowered. Along the Texas coast, the Beaumont formation is the product of late interglacial high sea stand, during which the rise in sea level was as much as 80 feet above present sea level and the coastline advanced about 30 miles inland from today's coastline. Radiocarbon dates of offshore cores taken from the Beaumont formation have shown that the sea had withdrawn and subjected portions of today's Continental Shelf to subaerial weathering by about 28,000 BP when deposition of Recent marine deposits commenced. These events agree rather closely with the radiocarbon brackets (25,000 to 10,000 BP), mentioned at the beginning of this paragraph, placed upon the classic Wisconsin.

The interglacial and related high sea stand during which the Beaumont formation was deposited should, therefore, be earlier than about 28,000 BP. The two radiocarbon dates from different samples at the Lewisville site in the Dallas T-2 deposits indicate an age greater than 37,000 BP for these deposits. These deposits apparently pre-date the classic Wisconsin and may some day be shown to correspond with the Beaumont marine deposits.

A number of climatic implications regarding this non-glacial period of the upper Pleistocene are of interest. Two basic circumstances must be understood. First, if valley cutting is correlated with glacial periods and valley filling with interglacial periods for Gulf Coastal Plain streams (Fisk, 1938, 1940) the following may be visualized. The maximum glacial advance was attained during lowest sea level. As the glaciers retreated and sea level rose, river flow and cutting action slowed. Filling began, at first with coarser material, then as stream flow was further reduced (and sea level rose higher and higher), progressively finer sands and silts were deposited until the flood plain reached its highest level. Equilibrium was achieved sometime during the ensuing interglaciation. As a new glaciation began, sea level fell, stream flow increased, and valley cutting began again, eventually leaving the former flood plain as remnants and terraces. Thus, a terrace fill should represent a period extending from a glacial retreat into the following interglaciation, until either equilibrium is reached or cutting is renewed.

Second, the Dallas region is an area of overlap between the east Texas-Mississippi Valley timbered country and the grassland prairies to the west. Timber occurs in the draws and stream valleys, whereas adjacent divides and uplands are prairies. As climate varies between moist and dry, the timbered bottoms and grassy uplands wax and wane, relative to each other, up and downstream. This is caused by the drainage heading in more arid areas to the northwest but flowing southeastward into more moist zones. Presumably, flora and fauna of these two different environments would fluctuate in like manner.

The beginning of deposition of the Dallas T-2 fill presumably took place in a period of greater annual rainfall, and certainly stream flow, than today. The basal

Hill gravels represent the strongest flow; these gravels are followed by the overlying Lower Shuler sand, the Upper Shuler sandy clay, and the locally derived blackland alluvium of the Richards, all of which appear to represent progressively reduced carrying power. Iron cement and deposits of limonite, present respectively in the Hill gravel near the top and in the immediately overlying Lower Shuler sand, suggest a more humid climate than exists today in the region. The pine pollen from the Lower Shuler implies upstream migration of flora; it indicates an annual rainfall, or a continuous water equivalent in the flood plain, of 40 or more inches as compared with today's 36-inch average at Dallas. The snail fauna in particular, both from the Lower Shuler and even from the lower part of the Upper Shuler, strongly indicates a heavily timbered environment, at least in the bottoms of the flood plain at the time.

The presence of alligator, beaver, muskrat, vole, and a number of other forms which live in timber and in moist climate reinforce this assumption.

On the other hand, the presence of calcareous nodules, such as those found in the Upper Shuler, is often considered indicative of aridity. These concretions increase in size from bottom to top of this member. The sharp reduction in number of species of large animals and the presence of prairie animals, such as prairie dogs and the turtle *Gopherus,* lend support to the hypothesis of an increasingly arid climate.

The existence of timbered valleys surrounded by grassy uplands, however, made it possible for both woodland and prairie animals to exist contemporaneously within a short distance of each other. It appears that conditions were more favorable to the woodland, moist climate biota in the earlier phases of terrace deposition, and less so in the latter phases.

None of the fossils, with the possible exception of *Synatomys* from the Upper Shuler, indicates a cold climate by today's standards. The vast majority are temperate climate types. A few—perhaps the large alligator, the giant *Geochelone,* the tapir, the peccary, and the armadillos—suggest a slightly warmer climate than today. Certainly winters could have been no colder than those occurring in the area today and possibly were milder, with resultant cooler summers; in other words, a more equable year-round climate must have existed. If the interglacial high sea stand extended the shoreline 50 miles inland from the present coastline, that may have contributed both to a milder climate and an increased rainfall in the earlier stages, having the comparable climatic effect of moving the region that distance southeast today.

Most of the fossils are directly comparable with material described from other localities. Differences, such as noted herein for new forms, are no more than regional variations to be expected in thorough investigations of an area not previously studied in detail.

Certain evolutionary trends exist which may have some bearing on extinctions or faunal changes, at least in the Dallas region. At Dallas, mastodon fossils are virtually unknown above the Hill gravels, whereas mammoth bones are abundant. Giant land tortoises are common in the Hill and Lower Shuler members but are extremely rare above these members. *Terrapene canaliculata* seems to replace a smaller *carolina*-like *Terrapene* near the Lower Shuler-Upper Shuler contact. In the lower members, fossils of the equine group are abundant and varied, with bones of horses, onagers, and asses present; in the Upper Shuler bones of caballine horses appear and are, to date, the sole representatives. There are at least two caballine types, one draft-horse size and one pony size. Remains of the large carnivores are, so far, restricted mostly to the Hill and Lower Shuler; only the bones of coyote and a small black bear have been found in the Upper Shuler.

Some of these apparent faunal changes, especially the absences, could be the result of chance collecting. Many or all could be connected with the change to a drier climate. Allowing for all of these, there still remains a subtle suggestion of faunal change, perhaps not extinction of types but reduction in numbers so that the fauna may have become highly vulnerable to climatic change during the last glacial advance.

Many of these animals lived on into the last glaciation and some even into early post-glacial time. Based upon the southern High Plains archeological sites, however, it is known that by essentially the close of the last glaciation, in Folsom-Yuma time of about 8,000 to 11,000 BP, the bison remained in extinct form but in smaller species. A few remnant camels, sloth, and horses lingered in the west and the last of the mastodons in the east.

The period of the classic Wisconsin, of circa 25,000 to 10,000 BP, is not well represented in the terrace deposits at Dallas because the river was cutting rather than depositing. After this period of valley cutting, the T-1 fill of Recent age was deposited, and it contains a modern mammalian fauna, including *Bison bison,* and a modern snail fauna. Radiocarbon dates suggest that deposition of these deposits began at least 6,000 BP and possibly one or two thousand years earlier. While the smaller forms continued into the upper Pleistocene, the larger ones, such as the deer and excepting possibly the black bear, had almost completely changed. Man was common in the Archaic Stage, which began as early as 10,000 BP and lasted until about 2,000 to 4,000 BP.

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Plate I

PLATE I

Vertebrate fossils from T-2 terrace deposits

FIGURES— PAGE

1, 2. Occiput of *Camelops huerfanensis dallasi* Lull. x⅛ 24

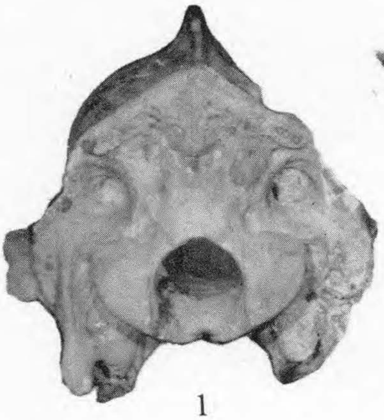
  1. Holotype (SMUMP 60005).
  2. Referred paratype (SMUMP 60029).

3. Occiput of *?Camelops* sp. (SMUMP 60237). x⅛ 25

4. Fragmentary carapace of *Geochelone* sp. (SMUMP 60028). x1/14 38

5–8. *Bison alleni* Marsh. x¼ 27

  5. Horn core (SMUMP 60003).
  6. Horn core (SMUMP 60019).
  7. Female horn core (SMUMP 60067).
  8. Horn core (SMUMP 60317) (approximately ¼).



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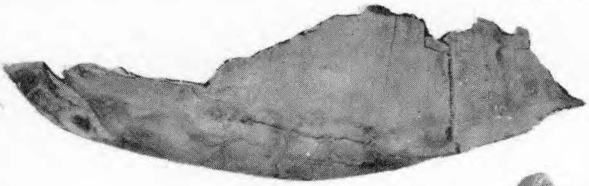

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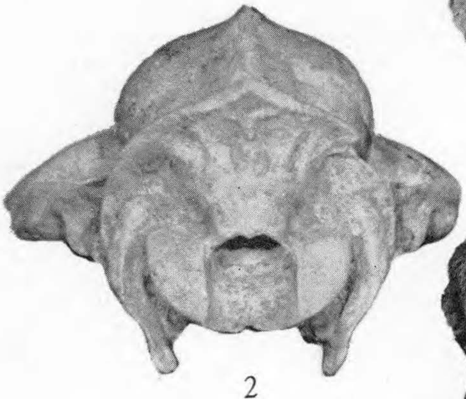

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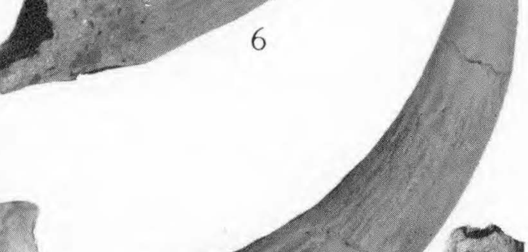

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