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THE JINGLEBOB INTERGLACIAL (SANGAMON?) FAUNA FROM KANSAS AND ITS CLIMATIC SIGNIFICANCE

BY
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Vols. II–XI. Parts of volumes may be obtained if available.

Volume XII

PLATE I

Southwestern Kansas during Sangamon ? time.

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INTRODUCTION

In the summer of 1947 Francis Cochran, foreman of the XI Ranch, told me of an elephant skull in the bed of Shorts Creek (Lone Tree Arroyo), an intermittent stream in the Jinglebob pasture on the ranch in Meade County, Kansas. The skull had been found by Charley Oates, a rider for the ranch, who took us to visit the site in the SW.¼ sec. 32, T.33 S., R.29 W. The elephant skull was removed July 28, 1947. Upstream in the same deposit along the bank of the arroyo the base of a skull of the large short-faced bear (*Tremarctotherium*) was found in association with numerous shells of pelecypods and gastropods. This bear skull was described by George C. Rinker (1949). The deposit was revisited in September, 1948 and 1949, when isolated bones of the large bear and of a large sloth were taken.

In the summer of 1950 at the close of the field season, three sacks of matrix were removed from the deposit for washing. From these were recovered, by the washing technique described by Hibbard (1949*c*), two lower jaws of *Oryzomys,* two lower jaws of *Peromyscus,* one lower jaw of *Zapus,* and hundreds of pelecypod and gastropod shells. Occurrence of *Oryzomys* in Pleistocene deposits in the High Plains at such an elevation (approximately 2600 feet) and in an area that is now semiarid with vegetation consisting of sage brush and short grass, indicates that the climatic conditions in the past differed from those of today. A field party from the Museum of Paleontology of the University of Michigan began a study of the deposit in the summer of 1951. Every effort was made to secure as representative a collection of fossil remains as possible. An excessively and unusually rainy season that summer greatly handicapped our work. The mammalian remains that we recovered form the basis for this report. The other fossils are mentioned.

Acknowledgments

I am greatly indebted to the members of the 1951 field party for their careful handling of the matrix removed from the quarry and, also, for their enthusiastic and painstaking search of the washed and dried residue. Members of the party were Thomas M. Oelrich, University of Michigan; Clyde O. Priddy, Kansas State College; Alex F. Ricciardelli, University of Pennsylvania; John C. Wagner, University of Michigan; and Faye Ganfield Hibbard and Claude W. Hibbard.

I am grateful to Dave Leahy, Director of the Kansas Forestry, Fish, and Game Commission, and to Harry Smith, Superintendent of Meade

County State Park, for permission to live at the park and to wash the fossil-bearing matrix there. I owe sincere thanks to Horace G. Adams II and Horace G. Adams III, for allowing us to work on their ranch and for the help they have given me during the past nineteen years in the study of Pliocene and Pleistocene deposits on their property.

This study was aided by permission to examine specimens under the care of Dr. Rollin H. Baker and Dr. Robert W. Wilson, of the Kansas University Museum of Natural History; Dr. W. H. Burt, of the University of Michigan Museum of Zoology; and Dr. George G. Simpson, of the American Museum of Natural History. I am grateful to Dr. E. Lendell Cockrum, Museum of Natural History, University of Kansas, for providing me with a map showing marginal trapping records of *Blarina* in Kansas; to Dr. W. B. Davis, Department of Wildlife Management, Agricultural and Mechanical College of Texas, for permission to quote him on the distribution and habitat of *Oryzomys couesi;* and to W. H. Burt and R. P. Grossenheider (1952) for the use of distributional maps from their book, *A Field Guide to the Mammals.*

Financial support for the field work in Meade County, Kansas, and for the services of Thomas M. Oelrich, Research Assistant, who helped in the collecting, preparation, and cataloging of the specimens, was provided by the Board of Governors of the Horace H. Rackham School of Graduate Studies of the University of Michigan. The illustrations were made possible by a grant from the Faculty Research Fund of the University of Michigan. The drawings for the figures were made by Jane S. Mengel (JSM) and Jean Libby (JL). A scene during Sangamon? time (Pl. I) in southwestern Kansas is portrayed by Carleton W. Angell, Museums artist.

GENERAL FEATURES OF THE MEADE BASIN

The region under discussion is on the eastern edge of the High Plains section of the Great Plains physiographic province (Fenneman, and others, 1930). Elevation of the region is about 2600 feet above sea level. The surface is a plain of deposition and distribution formed by the top of the Ogallala, Meade, and Crooked Creek formations. Owing to the development of the Meade Basin (Frye and Hibbard, 1941), this, unlike other parts of the High Plains which were stable or subjected to slight subaerial erosion, was an area of deposition during the Upper Pliocene and early Pleistocene. The late Cenozoic section is nearly complete here, which allows the dating of many events, but only those of the Pleistocene that are related to the history of the deposit from which the fauna was taken are discussed.

Toward the end of Yarmouth? time the streams in southwestern Kansas, western Oklahoma, and northern Texas began to rapidly entrench themselves. The present drainage systems and terraces in this area are post-Yarmouth in age. Byrne and McLaughlin (1948, p. 35) noted the geological evidence that supports the very recent development of the Cimarron River and its High Terrace deposits. Hibbard (1948, p. 595; 1949*a*, p. 77) presented evidence to show that the Cimarron River and its tributaries (including Crooked Creek) and the terraces along them were post-Crooked Creek formation.

The early Cimarron River was a large stream carrying sizable cobbles (Smith, 1940, p. 126; McLaughlin, 1946, pp. 132–34; Byrne and McLaughlin, 1948, p. 84). It shifted back and forth between the low divides before becoming entrenched in its present channel. Consequently, the large cobbles, some as long as 12 inches (Smith, 1940, p. 126), together with pieces of vesicular basalt which are as much as 20 inches long, (Hibbard, 1944, Pl. 2, Fig. 2), are found stranded far from the present river, high up on the side of the valley, nearer to the elevation of the present divides than to stream level. These thin deposits are known as the High Terrace gravels. In Seward County, at the Arkalon sand and gravel pit in sec. 35, T.33 S., R.32 W., one finds cobbles up to 12 inches long and 5½ inches in diameter. They lie unconformably upon the Crooked Creek formation, 125 feet above the bed of the Cimarron River. Soon after these gravels were deposited a tremendous entrenchment of the river took place. As the river entrenched its bed through the Crooked Creek formation and well into the underlying sediments a thick deposit of sand and gravel was laid down. The lower sand and gravel of this cycle of stream development in this region is often called the Second Terrace. It is 55 feet below the large-cobble zone.

After the Cimarron River started to cut its present channel, the Crooked Creek formation was down-faulted on the west side of Crooked Creek in Meade County. Crooked Creek, which is a tributary of the Cimarron River, developed along the fault zone, and its own tributaries rapidly began a headward erosion into the surrounding territory to the west. One tributary, in the area in which Shorts Creek now flows, cut deeply headward into the High Plains surface, through the Crooked Creek and Meade formations and into the top of the Rexroad formation. In this stream deposition took place during part of Sangamon? time and these deposits contain the Jinglebob local fauna of interglacial age described in this report. The stream flowed at approximately the same level as the present Shorts Creek, which has exposed the sediments containing the fossils.

The Rexroad formation into which the interglacial stream was entrenched and into which the present drainage system has cut, dips slightly eastward toward Crooked Creek. Some of the dip must have developed after the interglacial deposits were laid down, for the present drainage lacks about 5 feet of cutting through these sediments.

Only tentative correlation exists at the present time in North America between the glacial and interglacial deposits of the glacial region and the nonglacial deposits of Ice Age (Pleistocene) outside of the glaciated regions. If only four major glaciations and three major interglacial intervals occurred in North America, then a direct correlation can be made between the nonglacial Pleistocene deposits in southwestern Kansas, and the known glacial section, on the basis of cyclic erosion, deposition, and successive Pleistocene faunas. Until more detailed work is done and a better correlation exists between these regions it is considered best to treat the assignment of Pleistocene faunas from southwestern Kansas to definite glacial or interglacial ages as only tentative. The interglacial Jinglebob fauna is assigned questionably to the Sangamon? (which explains the use of the query).

The deposit from which the Jinglebob fauna was recovered is in the Kingsdown formation. Frye and Leonard (1952) introduced new definitions for formations and different stratigraphic terms for the Pliocene and Pleistocene deposits in southwestern Kansas which were adopted by the Kansas State Geological Survey. Since my interpretation of the deposits in this region and the faunas recovered from them differs from that of Frye and Leonard, I include a discussion of the stratigraphic terminology to show why I have not used the term (Sanborn formation) proposed by them for the Kingsdown formation in southwestern Kansas.

PLEISTOCENE STRATIGRAPHIC TERMS APPLIED TO THE KINGSDOWN FORMATION OF SOUTHWESTERN KANSAS

Since 1940 many names have been used in a variety of ways in southwestern Kansas for stratigraphic units, which are, or are presumed to be, of Pleistocene age. Chart 1 shows how these terms have been applied by different workers at different times. To understand the present confusion it is necessary to go back to the first study of Pleistocene deposits in this region. Cragin (1896) named three formations, the Meade Gravels or Meade formation, the Pearlette Ash, and the Kingsdown Marls. He (p. 53) described them thus:

At several localities in Kansas, typically on Bluff Creek, in Clark County, in the immediate vicinity of the old Vanhem postoffice, occurs a succession of three terranes: (1) [Meade Gravels or Meade formation] the lowest, consisting of gravels and sands laid down in deep and broad valleys; (2) [Pearlette Ash] the middle, consisting of a widespread horizon of white to brownish (rarely greenish) volcanic ash; and (3) [Kingsdown Marls] the highest, consisting of yellowish-brown lacustrine or slack-water marls, containing variously shaped concretions of carbonate and silicate of lime (the former called 'native plaster').

In a summary Cragin added (p. 54):

All three of the terranes here described are supposed to be formations of the *Tule division* of Cummins (Equus beds of Cope), and to represent late Pliocene time. They are conformable with each other, and unconformably overlaid with local beds of marl, sand, diatomaceous earth, etc., of supposed Quaternary age.

The local beds recognized by Cragin above the unconformity are referred to in this discussion as Cragin's younger beds.

Cragin did not designate a type section for any of the formations he named, but his statement that the three terranes occur in a succession typically on Bluff Creek, in Clark County, in the immediate vicinity of the old Vanhem post office (N.½ sec. 13, T.30 S., R.23 W.; Hibbard 1949*a*, p. 84), signifies that he assumed this to be a type area in which all three formations were exposed. This locality must be considered whenever the names proposed by Cragin are used. Note his comment (1896, p. 54):

The name *Kingsdown marls* is proposed, after the station of that name west of Bucklin on the Rock Island railway, between which and the upper part of Bluff creek, Clark county, they are finely exposed in deep ravines. . . . They are typically developed in Meade county also.

Smith (1940, p. 119) in a discussion of the Kingsdown formation of Cragin, remarked that "The ash [Pearlette] deposits of northern Clark County are the same in age as the Kingsdown formation." Unfortunately, Smith had not recognized the unconformity that exists between the Pearlette Ash and the Kingsdown formation nor the one between the Kingsdown and Cragin's younger beds. He, therefore, included the younger beds in the Kingsdown formation. The "typical" section Smith measured and published (p. 112) as the Kingsdown formation of Cragin is in sec. 13, T.30 S., R.23 W., in the immediate vicinity of the old Vanhem post office. It is, in fact, an exposure of Cragin's younger beds. I later made this exposure the type section of the Vanhem formation (Hibbard, 1949*a*). After Smith's study of the area, members of the Kansas Geological Survey considered the exposure described by him as typical Kingsdown, and therefore Cragin's younger beds were mapped along with the overlying

CHART SHOWING RELATIONSHIP OF STRATIGRAPHIC TERMS USED IN VARIOUS REPORTS ON SOUTHWESTERN KANSAS

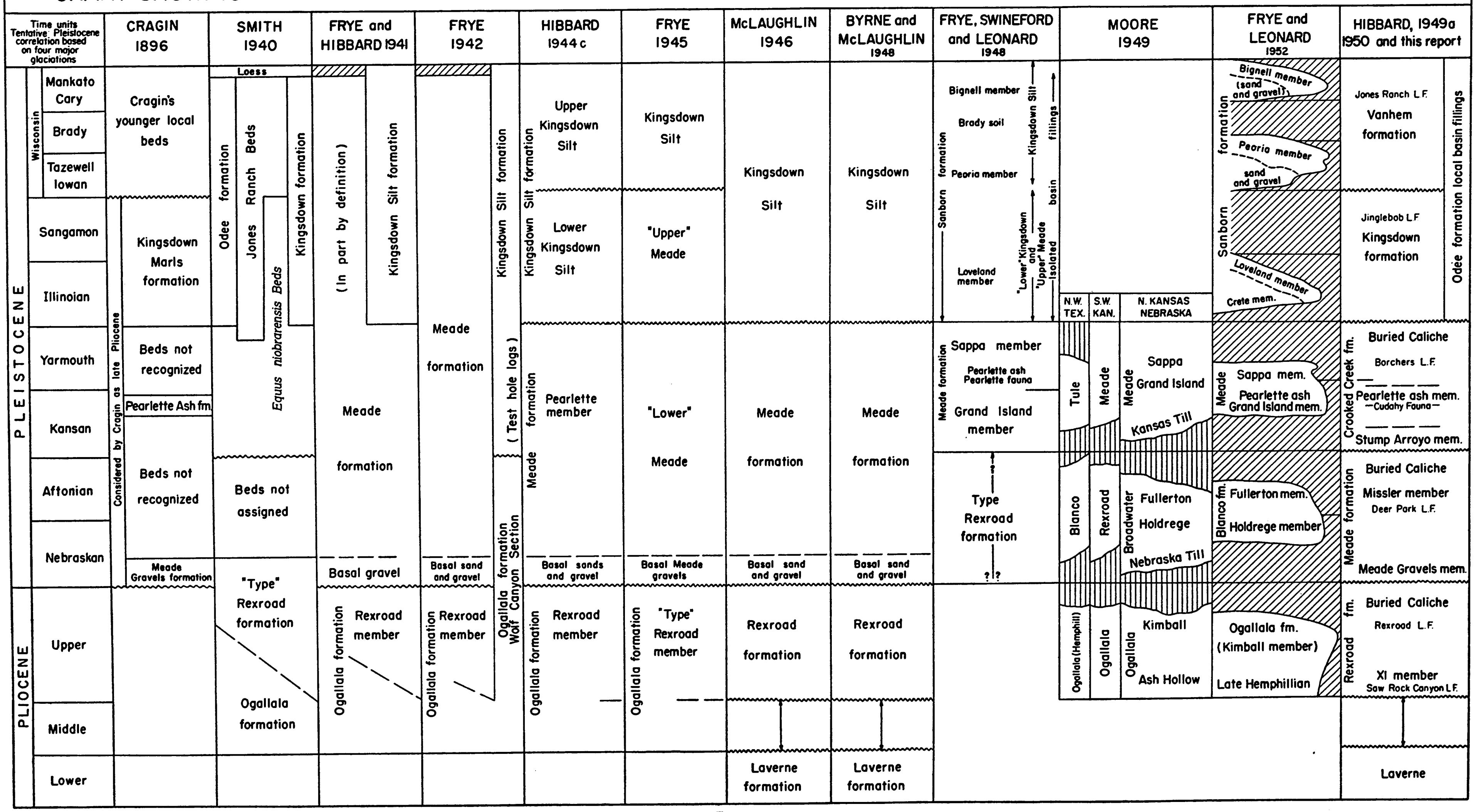

CHART 1

loess as part of the Kingsdown formation. In consequence, their term Kingsdown does not include Cragin's Kingsdown formation.

Of Smith's work, Frye (1942, p. 109) wrote:

Smith (1940, pp. 111–116) revived the name, as the Kingsdown formation, redefined it to include only beds of Pleistocene age, and described the occurrence of this formation in southwestern Kansas. He did not specifically include the overlying loess. The Kingsdown silt as used in this report includes the loess which locally overlies the waterlaid beds and in many places cannot be sharply distinguished from them (Frye and Hibbard, 1941, p. 420).

It is evident from this statement of Frye's that he considered the younger beds overlying Cragin's Kingsdown Marls to be part of the Kingsdown Silt formation. But the beds listed by Frye (1942) as Kingsdown Silt in the logs of his test holes, Nos. 18, 19, and 20 in Meade County, are in reality beds of the Crooked Creek formation (Hibbard, 1949*a*)—the Meade formation of Frye and Leonard (1952). These beds (Crooked Creek formation) crop out along the valleys of headwater tributaries of Stump Arroyo just northeast of these test holes. Frye (1942) did not recognize the age and stratigraphic significance of these deposits on the west side of Crooked Creek, which allowed him to correlate the older Meade formation of Cragin (which overlies the Rexroad formation) with the younger Pleistocene deposits on the east side of Crooked Creek. As a result of this the Kansas State Geological Survey uses the name Meade formation for these younger beds.

In attempting to reach a compromise, I proposed a term, Kingsdown Silt formation, to include both Cragin's Kingsdown Marls and Cragin's younger beds, which the Kansas Geological Survey had mapped as part of the Kingsdown formation (Hibbard, 1944). I further suggested that the Kingsdown Silt be divided into the Lower Kingsdown Silt, which would include Cragin's Kingsdown Marls and related deposits, and the Upper Kingsdown Silt, which would include Cragin's younger beds.

Frye (1945, p. 91) commented on my proposal:

Hibbard (1944) has subdivided the formation in northern Clark County into the Upper and Lower Kingsdown. The beds that he calls 'Lower Kingsdown' lie unconformably below the more extensive Upper Kingsdown and are known only from northern Clark County and Comanche County. The lower Kingsdown deposits are dominantly massive light-buff to tan silt. They differ lithologically from the beds outcropping west of Clark County which are considered 'Upper' Meade, but their stratigraphic occurrence indicates that they may be equivalent in age to some of the beds that have been placed in the Meade formation.

From this it seems clear that Frye recognized the unconformity mentioned by Cragin (1896), which separates Cragin's younger beds from the

Kingsdown Marls formation, for he here restricts the use of the term Kingsdown formation to the younger beds overlying Cragin's Kingsdown formation. The Kansas Geological Survey, however, continued to use the term Kingsdown formation for the younger beds in southern Kansas, until Frye and Fent (1947) assigned the name Sanborn formation (Elias, 1931) to deposits in Rice and McPherson counties, Kansas. They wrote (pp. 41 and 42):

During the May, 1947, field conference, the loesses and buried soils were traced by outcrops and auger holes southward from Jewell County across the uplands of Mitchell and Lincoln Counties to Rice and McPherson Counties.

In view of these various facts, it is proposed that the late Pleistocene loesses, associated deposits, and lateral facies generally occurring in northern and central Kansas, be classed as the Sanborn formation.

Elias (1931, p. 163) stated:

The name Sanborn formation is proposed for the loess, with some gravel and sand at the base, which is widely distributed on the divides in western Kansas. The name is intended as a substitute for the old terms 'Tertiary marl' or 'Plains marl' introduced for this formation by Robert Hay. The new name is derived from Sanborn, Neb., which is the nearest town to a locality of the formation in the northwestern corner of Cheyenne County, Kansas, where loess attains a thickness of 180 feet.

Six years later (1937, p. 7) he wrote:

In the northeastern quarter of Decatur County there is a darker brownish ('red') loess that underlies the light yellowish buff Sanborn loess with distinct erosional unconformity but without any trace of ancient soil between. The 'red' loess is provisionally classed as equivalent to the Loveland formation of Iowa and Nebraska. This loess is from 20 to 30 feet thick.

Leonard and Frye (1943, p. 454) commented:

The Sanborn consists predominantly of dirty yellow to gray-tan loess, but in some places it is very sandy and, locally, contains coarse sand and gravel at the base. In most exposures it is impossible to recognize any distinct bedding or zoning of the formation. It is gradational from top to bottom. Elias [1937] has distinguished Loveland loess in northern Decatur county, and Smith (personal communication) has stated that it can be subdivided in Cheyenne county. In the areas studied by the writers, however, no vertical subdivision, except for snail zones, could be recognized. [On page 461] Correlation of the Sanborn formation of northwestern Kansas with the much better known Pleistocene section in southwestern Kansas (Frye and Hibbard, 1941) is not so obvious. Few vertebrate fossils (Williston, 1894) have as yet been collected from the Sanborn, and the snail assemblages are not diagnostic enough to attempt such a detailed correlation. The Kingsdown silt may be equivalent in age to the upper part of the loess, and the lower part of the Sanborn formation may be equivalent in age to the middle and upper part of the Meade formation.

Because Leonard and Frye did not recognize the two divisions observed by Elias and Smith, they combined the Loveland(?) of Elias with his

Sanborn formation. The usage of the term Sanborn formation by the Kansas Geological Survey, since the paper by Leonard and Frye (1943), includes the Loveland(?) of Elias (1937) in the Sanborn formation.

After the publication of Frye and Fent's study, Frye, Swineford, and Leonard (1948, p. 523) wrote:

> In 1947 Frye and Fent reviewed usage of the Sanborn formation and expanded its geographic application to cover all of northern and central Kansas. It represents the time span of the Kingsdown silt of southwestern Kansas and correlative deposits of the panhandle regions of Oklahoma and Texas.

Frye's statement (1945, p. 91) definitely correlates the Sanborn formation with Cragin's younger beds and the Upper Kingsdown Silt (Hibbard, 1944). If one looks at their Figure 3 (Frye, Swineford, and Leonard (1948, p. 520) under Kansas, it will be seen, however, that the Sanborn formation is made equal to the Lower Kingsdown of Hibbard (1944), the Kingsdown Marls of Cragin (1896), and the Upper Meade of Frye (1945) without explanation.

I have redefined (1949*a*, p. 81) the Kingsdown formation to include the sand and gravel at the base of the silt. It was not recognized by Cragin but I included it (1944) in the Lower Kingsdown Silt. The term Kingsdown formation is preferred to Cragin's term Kingsdown Marls, because the unit defined as a formation consists both of channel sand and gravel and flood-plain silts.

Frye and Leonard (1951, p. 293) had this to say in regard to the Sanborn formation:

> The Crete member is known to occur prominently in Kansas only in the north-central area (Frye and Fent, 1947; Frye and A. R. Leonard, 1949), although scattered deposits in southeastern, central, and southwestern Kansas are judged to be assignable to the member. . . . [p. 296:] In southwestern Kansas eolian silts equivalent to the Loveland member are rare to non-existent. . . . [p. 297:] The profile morphologies in southwestern Kansas present a marked contrast to those of northwestern and northcentral Kansas. Eolian silts of the Loveland member have not been identified in southwestern Kansas, but Peoria loess containing a diagnostic fauna has been traced extensively over the area (Fig. 1).

Frye and Leonard (1952, p. 106) stated:

> The Sanborn formation, unlike all other stratigraphic units of formational rank in the Kansas Pleistocene, includes deposits of two stages (Illinoian and Wisconsinan) and the several substages of the Wisconsinan. Furthermore, it includes two unconformities, defined by the Sangamon and Brady buried soils, and represents three distinct cycles of deposition. . . . [p. 115:] In southwestern Kansas the Crete member has been recognized with certainty at very few places and it seems evident that it is quantitatively not important in that area. . . . [p. 118:] In the southwestern corner of the state Loveland loess has not been recognized although sands have been

observed in its stratigraphic position. Eastward in southwestern Kansas, relatively thick Loveland loess is exposed in Clark (NW.¼ sec. 3, T.30 S., R.24 W.) and Ford (sec. 22, H.29 S., R.23 W.) Counties where it is overlain by thin fossiliferous Peoria loess.

The locality in Clark County bounds Meade County on the east. It should be noted (1) that Frye and Leonard state (1951, p. 296) that this Loveland loess is "rare to nonexistent" in southwestern Kansas; (2) the above Clark locality they cited in 1952 (p. 118) is in the type area of Cragin's Kingsdown marls (see Hibbard, 1949*a*, p. 82), and (3) that they (1952, p. 118) give no geographical location for the sands they consider to occupy the stratigraphic position of the Loveland loess.

The so-called "Loveland loess," cited by Frye and Leonard as a new discovery in Clark County, is the Kingsdown Marls of Cragin (1896) and the Lower Kingsdown Silt of Hibbard (1944). Frye (1945, p. 91) made this statement about these beds:

> The lower Kingsdown deposits are dominantly massive light-buff to tan silt. They differ lithologically from the beds outcropping west of Clark County which are considered 'Upper' Meade, but their stratigraphic occurrence indicates that they may be equivalent in age to some of the beds that have been placed in the Meade formation.

Frye stated (p. 90):

> In every exposure where 'Upper' Meade deposits have been observed in contact with the 'Lower' Meade, they are separated by a prominent unconformity which may represent an erosion interval as long or longer than that represented by the unconformity between the Meade and Kingsdown.

It must be clearly understood that Frye, although using the term Kingsdown here, is talking about Cragin's younger beds. Frye went on to say:

> Two major stratigraphic problems are presented by the Meade formation: (1) the proper delineation and disposition of the beds that have been considered as the Upper Meade and (2) the accurate delineation of the Pliocene-Pleistocene boundary line in the Meade basin.
>
> The retention of these younger Pleistocene beds within the Meade formation seems justified only because of the inadequacy of field data and convenience in mapping. Stratigraphically, they are distinct from the underlying deposits, and they have yielded a younger fauna at several localities.

Frye has never acknowledged the fact that Cragin recognized the Meade Gravels in Clark County (Vanhem post office site) and the Kingsdown Marls in Meade County. Cragin (1896, p. 54) stated in regard to the Kingsdown Marls: "They are typically developed in Meade County also."

O. P. Hay described the fossils collected by Cragin in Meade and Clark counties. He reported (1917, p. 39):

> In the sixth volume of the Colorado College Studies, on pages 53 and 54, issued at Colorado Springs, Colo., March, 1896, Dr. F. W. Cragin made a brief report on some vertebrate fossils which he had discovered in 1891, in Meade and Clark counties, Kansas. . . . All of the materials of the collection made by Cragin which have been studied by the writer belong to the lowest terrane, the Meade gravels.

Of the Cragin specimens described by Hay the following are listed as having been found either on Spring Creek in Meade County or at a locality four miles southwest of Meade, Kansas. Both sites are on the Big Springs Ranch and I consider them to be one and the same locality. Smith (1940, p. 108) gave the location of the quarry as the SW.¼ sec. 17, T. 32 S., R.28 W.

Testudo equicomes Hay	*Camelops huerfanensis* (Cragin)
Mylodon harlani Owen	*Canis occidentalis?* Richardson
Equus complicatus Leidy	Undetermined Felid

In the summer of 1936 Mr. Jerry D. Golliher, of Meade County, told me of an old bone quarry on the Big Springs Ranch. He took me to meet an old gentleman who lived at the ranch and who had worked there for many years. Through him I learned that years ago Dr. Cragin stayed at the ranch and had dug bones out of the point of a hill less than a quarter of a mile from the ranch house. The quarry is located in buff silts with fine sandy pockets and lenses. Fossils listed by Hay as occurring in the Meade Gravels of Meade County and as taken on Spring Creek without question are, in part, fossils from this quarry. The vertebrates reported by Hay as a unit fauna from the Spring Creek area are unknown from either the Meade gravels of Cragin or the next younger sand and gravel, the Stump Arroyo member of Hibbard (1949*a*).

The quarry worked by Cragin is in the Kingsdown Marls of Cragin. The silt contains some bones but most of them occurred in sand pockets in the silt. I named (1939) this quarry the Cragin Quarry and I reported a list of fossils collected from there (1949*a*). The Cragin Quarry fauna is the only one in the region that can be considered to comprise the majority of vertebrates that were reported by Hay (1917) from the Spring Creek localities in Meade County.

Except for terrace deposits along the Cimarron River, this one on the Big Springs Ranch is the best deposit of the Kingsdown formation in Meade County. It extends along the west and north bank of Spring Creek for over 3 miles. In a few places such as Mount Scott, a hill about half a mile south of Cragin Quarry, there is an exposure of 60 feet. The lower part of the exposed beds consists of sand and gravel reworked locally from the Meade and Crooked Creek formations. The sand grades upward into a dark-gray sandy silt and blue-gray clay which contain a large molluscan fauna. Above these beds are buff silts that are also rich in mollusks. The buff silts are capped by a well-developed "pseudo-mortar" bed. The base of the Kingsdown formation is not exposed either because there was a slump or because it lies below the bed of the present stream. From a distance the formation looks like a typical outcrop of the Ogallala. The development of a calcium carbonate zone in the surface silt is in part due to the down-faulting of the region toward Crooked Creek on the east. The caliche up-dip to the west in the Crooked Creek and Meade formations has provided some if not all of the calcium carbonate for the development of this feature in the Kingsdown formation. The same type of mortar-like bed caps the deposits of this age on the north side of the Cimarron River on the XI Ranch in the vicinity of Butler Spring in secs. 32 and 33, T.34 S., R.29 W. The Kingsdown formation is not so widespread and continuous as are the older Pleistocene beds but occurs as isolated valley or basin fills or as terrace deposits.

Frye and Leonard (1952, p. 122) stated that "South of Arkansas River in southwestern Kansas exposures of Sangamon soil are rare." Frye and Leonard do not recognize any deposition as having taken place during Sangamon time. They added (p. 123):

> The character of the Sangamon soil shows that the distribution of climate and floral zones in Kansas during Sangamonian time was similar to that of the present, although the present boundary lines may have been displaced toward the east.

The name Sanborn as used by Frye and Leonard (1951 and 1952) cannot include the Kingsdown formation of Cragin, the Kingsdown formation, as I have redefined it (1949*a*), or Cragin's younger beds, or any combination of these. The Sanborn formation of Frye and Leonard may in part be equivalent in age to some of these deposits, but any beds in southern and southwestern Kansas that can be shown to be stratigraphically equivalent to the Kingsdown Marls of Cragin (1896) should retain the name Kingsdown by prior usage on the basis of distinct lithology. Frye and Leonard (1952, p. 106) stated that "It is judged to be advisable to retain the broadly inclusive Sanborn as the unit of formation rank as an expedient to mapping." But this does not justify the use of the term Sanborn in an area where detailed stratigraphic work is being done. Frye (1945) admitted that the Kingsdown formation as used by him for Cragin's younger beds was distinct from his Upper Meade, which is Lower Kingsdown of Hibbard or the Kingsdown Marls formation of Cragin. If it is impossible to correlate the Lower Kingsdown (Hibbard, 1944), of Clark

County to adjoining Meade County, with Upper Meade and maybe part of the Middle Meade (Frye, 1945), it is impossible to consider the Kingsdown formation as part of the Sanborn. The Kingsdown formation of Cragin has never been proved to be a part, either stratigraphically, lithologically, or faunally, of the Sanborn formation of Elias (1931). Elias's formation is 200 miles to the northwest. The correlation of the Sanborn with the Kingsdown deposits has been by definition and not by stratigraphic method. To overextend the name Sanborn formation, so as to make it an all inclusive term for two distinct formations in southwestern Kansas, in an area already studied and partly mapped, is unwise, for it will only lead to further confusion.

I have previously shown (1949*a*, p. 81) that the Kingsdown formation is (1) distinct lithologically and faunally from Cragin's younger and overlying beds (the Vanhem formation, Hibbard, 1949*a*); (2) in the type area of the Kingsdown formation, in Clark County, it is a mappable unit, as are the equivalent beds in Meade County; (3) these equivalent beds were deposited under different physiographic conditions than the younger unconformably overlying beds of Cragin; (4) the areal extent of deposits of the two formations (Kingsdown and Vanhem) are not the same; (5) the two formations were laid down under two distinct erosional and depositional cycles, which is admitted by Frye (1945); (6) the younger deposits were excluded by definition by Cragin at the time he named the Kingsdown Marls formation; and (7) the Kingsdown deposits were laid down during interglacial as well as glacial time. For the above reasons I use the name Kingsdown formation for deposits of this cycle of deposition (as defined by me, 1949*a*) in southwestern Kansas.

SHORTS CREEK SECTION

The Shorts Creek section is located on the XI Ranch along the valley and in the bed of Shorts Creek where part of the Kingsdown formation is exposed (see Oelrich, 1953, Pl. II). The Pleistocene stream that laid down these deposits headed a short distance, not more than 2 or 3 miles, to the west and southwest, in the upland surface, which in this area (see Fig. 1) is formed by the Crooked Creek formation. The ancient stream was local and the deposit with its contained fossils was local in origin. A tributary of Crooked Creek, it became entrenched headward through the Crooked Creek and Meade formations into the top of the Rexroad formation (see Pl. II, Fig. 1). Shorts Creek does not follow the meanders of the old stream but cuts across the old channel here and there. The outcrops of the Kingsdown formation in the banks and bed

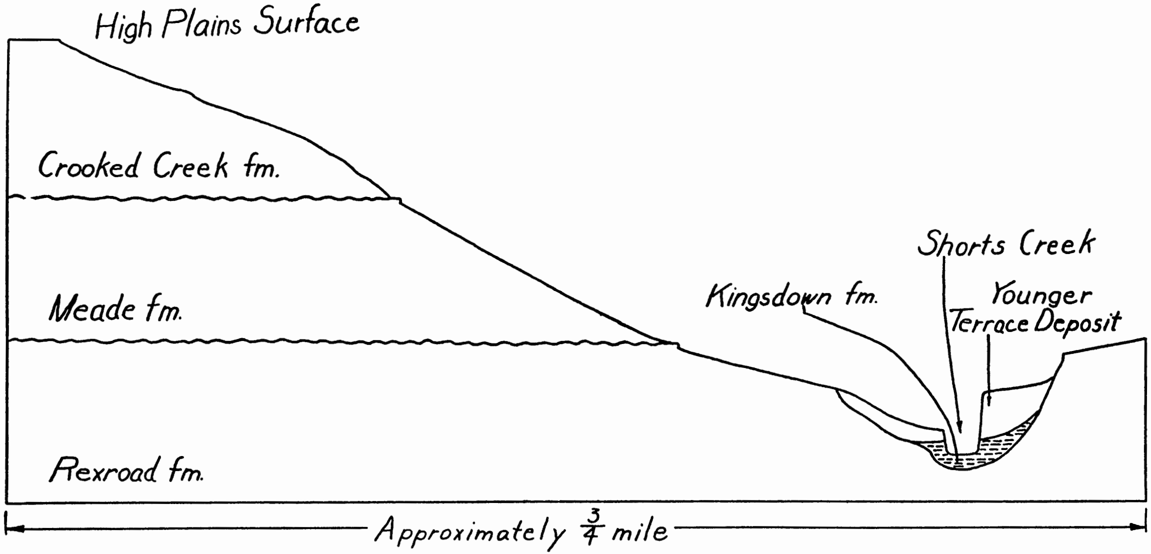

Fig. 1. Diagrammatic cross section through the terrace deposit (Kingsdown formation) containing the Jinglebob fauna, from the north side of Shorts Creek Valley southward to the High Plains surface.

consist of dark-colored, dark-gray to black when wet, sandy silts which contain abundant shells of mollusks and some remains of vertebrates. The silts vary from 3 to 5 feet in thickness. They grade downward below the bed of the present stream into dark-gray sandy silts, becoming increasingly sandier downward until they grade into a fine sand. From 4 to 6 feet of deposits lie below the present stream bed at the site of the Jinglebob Quarry. The sediments appear to have been deposited in a broad slough fed by local springs that issued at the bases of the dissected Meade Gravels member and the Stump Arroyo sand and gravel member.

Assignment of the beds containing the Jinglebob fauna to the Kingsdown formation is based on their stratigraphic position in relationship to the other Pleistocene beds of the region and on contained fossils.

Section along Shorts Creek including the Jinglebob Quarry

In the SW.¼ sec. 32, T.33 S., R. 29 W. and south into sec. 5, T.34 S., R.29 W. to the upland surface capped by the Crooked Creek caliche. (Pl. II, Fig. 2).

	Thickness feet
Top soil	
Crooked Creek formation	
7. Residual sand and gravel (Stump Arroyo member) at base. Grassed interval along a northward slope to upland caliche surface	30.0
Meade formation	
6. Missler member, Sandy silt and clay with caliche zone at top. Weathers to ash gray	16.0
5. Meade gravels member. Sand and gravel, grading to fine rusty yellow sand at top	11.0
Rexroad formation	
4. Gray clay	3.0
3. Sandy silt, light-gray to reddish-buff. Upper 3 feet chiefly nodules of caliche in light reddish silt (base not exposed)	33.0
Kingsdown formation (Terrace deposit)	
2. Light to dark-gray sandy silts exposed along banks and bed of Shorts Creek. Contains Jinglebob fauna	5.5
1. Test hole in stream bed. Dark-gray sandy silt grading into fine sand (resting on Rexroad formation)	5.0

AGE OF KINGSDOWN FORMATION

Pleistocene deposits, and their contained fossils, from southwestern Kansas, cannot be assigned unquestionably to definite glacial and interglacial stages in a glaciated region. Past attempts by workers in Pleistocene stratigraphy and paleontology to make positive correlations between glaciated and nonglaciated regions have led to serious errors. It is, however, generally accepted that only four major continental glaciations and three interglacial intervals existed during the Pleistocene in North America. If only four major continental glaciations existed, the Kingsdown formation can be correlated, in part, with the glacial Illinoian and the interglacial Sangamon stages (see Chart 1). Both the correlation and references, throughout the paper, to deposits and faunas from Meade County in relation to time units based on the events in the glaciated section are tentative.

JINGLEBOB FAUNA

The Jinglebob local fauna is named for the Jinglebob pasture of the XI Ranch, Meade County, Kansas, in which it was found (Hibbard, 1952). The pasture got its name from the "mark" of the first range cattle to be grazed in this area.

The fauna comprised of mollusks and vertebrates was taken, with the remains of plants, from a very limited area along the banks and bed of Shorts Creek (locally known as Lone Tree Arroyo) in SW.¼ sec. 32, T.33 S., R.29 W.

Mollusca

Mollusks are plentiful in the deposit, which disproves a statement by A. B. Leonard (1952) regarding the absence of Sangamon fossils. Forty-nine species of mollusks that were found associated with the vertebrates were reported by van der Schalie (1953). Additional forms have since been recovered. All material has been studied by Dwight W. Taylor, who said in *litt.* (December 5, 1954) "the molluscan fauna to date consists of 57 species."

Vertebrata

FAUNAL LIST

Class Pisces
- *Semotilus atromaculatus?* (Mitchell)
- *Ameiurus* sp., bullhead

Class Amphibia
- Caudata
  - *Ambystoma* sp.
- Salientia
  - *Scaphiopus* (*Spea*) *bombifrons* (Cope), spadefoot toad
  - *Bufo woodhousei woodhousei* Girard, Woodhouse toad
  - *Acris*(?) sp.
  - *Rana catesbeiana* Shaw, bullfrog
  - *Rana pipiens* Schreber, leopard frog

Class Reptilia
- Chelonia
  - *Terrapene llanensis* Oelrich, Plains box turtle (extinct)

Sauria
- *Holbrookia?* sp.
- *Sceloporus?* sp.
- *Eumeces* sp.

Class Mammalia

Insectivora
- *Sorex* cf. *cinereus* Kerr, masked shrew
- *Blarina* cf. *brevicauda* (Say), shorttail shrew

Edentata
- †*Paramylodon harlani* (Owen), Harlan ground sloth

Rodentia
- *Citellus* sp., ground squirrel
- *Geomys* sp., pocket gopher
- *Perognathus hispidus* Baird, hispid pocket mouse
- *Perognathus* sp., pocket mouse
- *Dipodomys* cf. *ordi* Woodhouse, Ord kangaroo rat
- **Onychomys jinglebobensis,* sp. nov., grasshopper mouse
- *Reithrodontomys* cf. *montanus* (Baird), Plains harvest mouse
- **Peromyscus cochrani,* sp. nov., Cochran white-footed mouse
- *Peromyscus* sp., white-footed mouse
- *Neotoma* sp., wood rat
- **Oryzomys fossilis,* sp. nov., fossil rice rat
- **Synaptomys australis* Simpson, southern bog lemming
- *Microtus* (*Pedomys*) *ochrogaster* (Wagner), prairie vole
- *Microtus* (*Microtus*) cf. *pennsylvanicus* (Ord), meadow vole
- *Ondatra zibethica* (Linnaeus), muskrat
- **Zapus adamsi,* sp. nov., Adams jumping mouse

Carnivora
- †*Tremarctotherium simus* (Cope), short-faced bear
- *Spilogale interrupta* (Rafinesque), little spotted skunk

Proboscidea
- †*Mammuthus columbi* (Falconer), Columbian mammoth

Lagomorpha
- Leporid sp., rabbit

Artiodactyla
- **Bison latifrons* (Harlan), giant bison

Relationship of Jinglebob Fauna to Other Vertebrate Faunas of Southwestern Kansas.—The Jinglebob interglacial fauna is younger than the Borchers interglacial fauna (Hibbard, 1941) and older than the Jones Ranch glacial (Wisconsin) fauna (Hibbard, 1940) from Meade County. Stratigraphically, the Jinglebob fauna lies above an undescribed vertebrate and invertebrate glacial fauna (Illinoian?), which occurs at the type locality of *Emys twentei* Taylor, in Meade County. This undescribed glacial fauna is equivalent to the Berends local fauna of Beaver County, Oklahoma (D. W. Taylor, 1954; C. L. Smith, 1954). The Jinglebob

* Species extinct. † Genus extinct.

vertebrate fauna is closely related to the Cragin Quarry interglacial fauna from the Big Springs Ranch in Meade County. The Cragin Quarry fauna occurs in the upper part of the Kingsdown formation and consists chiefly of macrovertebrates, whereas the Jinglebob fauna is made up for the most part of microvertebrates. The two lived during the same interglacial interval. Whether they were contemporaneous or whether one lived slightly in advance of the other is not known.

Mammals reported from the Cragin Quarry local fauna (Hibbard, 1939; 1949*a*; 1949*b*):

Aenocyon dirus (Leidy), dire wolf (extinct)
Smilodon sp., saber-toothed cat (extinct)
Panthera atrox (Leidy), giant jaguar (extinct)
Felis cf. *oregonensis* Rafinesque, mountain lion
Geomys sp., Plains pocket gopher
Lepus sp., rabbit
Mammuthus columbi (Falconer), Columbian mammoth (extinct)
Paramylodon harlani (Owen), Harlan ground sloth (extinct)
Equus francisci Hay, Francis horse (extinct)
Equus niobrarensis Hay, Niobrara horse (extinct)
Camelops kansanus Leidy, Kansas camel (extinct)
Tanupolama sp., llama-like camel (extinct)
Breameryx minimus (Meade), Meade antelope (extinct)

Distinctive Vertebrate Elements of Jinglebob Fauna.—In comparison with the present-day fauna of the region, the distinctive elements are the Plains box turtle (*Terrapene llanensis,* of the *carolina* group), masked shrew (*Sorex* cf. *cinereus*), shorttail shrew (*Blarina* cf. *brevicauda*), Harlan ground sloth (*Paramylodon harlani*), rice rat (*Oryzomys fossilis*), meadow vole (*Microtus* cf. *pennsylvanicus*), Adams jumping mouse (*Zapus adamsi*), short-faced bear (*Tremarctotherium simus*), Columbian mammoth (*Mammuthus columbi*), and giant bison (*Bison latifrons*).

As a unit this local fauna is unlike any known from the Pleistocene of Meade County. Certain elements, such as *Terrapene, Blarina, Geomys, Perognathus, Dipodomys, Onychomys, Reithrodontomys, Peromyscus, Neotoma, Oryzomys, Spilogale* and *Mammuthus columbi,* belonged to a southern faunal unit. Although absent from this area during the preceding glacial time, they were part of a glacial fauna to the south. Other elements, now associated with a northern faunal unit, such as *Sorex, Synaptomys, Microtus* (*Microtus*), *Ondatra,* and *Zapus,* were without doubt members of the glacial fauna that inhabited the Meade County region just prior to the approaching interglacial interval in which the Jinglebob fauna lived. The stratigraphic occurrence of *Paramylodon, Tremarctotherium,* and

Bison latifrons is not well enough known to assign any of them definitely to a northern or southern faunal unit. The genus *Citellus* has a wide range of tolerance and seems to belong to both faunal units.

Climatic Significance of Faunal Elements.—Present distribution patterns for Recent relatives of the distinctive fossil forms of the Jinglebob fauna follow:

Terrapene llanensis Oelrich. The closest living relative of the Plains box turtle is *T. major* Agassiz, whose geographical range is restricted to the Gulf coastal plain from eastern Texas to western Florida (Oelrich, 1953).

Sorex cinereus Kerr. The masked shrew is chiefly northern in distribution and is found in a moist habitat (see range map, Burt and Grossenheider, 1952, p. 5). Hamilton (1939, p. 292) said of this small shrew:

> Some mammals are much more adaptable than others. . . . Such is the masked shrew (*Sorex cinereus cinereus*), whose range encompasses an area in excess of two million square miles, extending from central Alaska and all northern Canada south to North Carolina in the east and New Mexico in the west. Within its range, this mammal mite . . . occupies diverse ecologic niches, from the driftwood-lined beaches of the Atlantic Coast to the coniferous forests and Arctic Barren Grounds of northern Canada.

Blarina brevicauda (Say). The genus *Blarina* is restricted to the eastern part of the United States. It ranges westward along moist stream valleys which support moderate amounts of trees and shrubs. Cockrum (1952, pp. 42–43) gives the following marginal records for the western extension of the range of the shorttail shrew (*Blarina*) in Kansas. The southeastern record nearest to Meade County is in Cowley County, 175 miles east of Meade County, where it has been taken along the wooded Arkansas River. *Blarina* has been collected approximately 150 miles to the northeast of Meade County, along the valley of the little Arkansas River, and at Hays, Kansas, approximately 120 miles to the north and a little east, along the valley of Big Creek.

Oryzomys palustris and *O. couesi*. The rice rat is a southern element of our Recent fauna and is confined chiefly to a marsh habitat (Fig. 2). The Recent specimens of *Oryzomys palustris* (Goldman, 1918) from Kansas came from Neosho Falls, along the valley of the Neosho River at an elevation between 900 and 950 feet. No others have been taken in Kansas. This colony was probably a marginal population, the same as that reported by Guilday and Mayer-Oakes (1952, pp. 253–55). According to Goldman (1918, p. 21) the geographical distribution of *O. palustris* is:

> Atlantic and Gulf coastal areas from southern New Jersey, . . . to southern Texas and north through the Mississippi Valley to southern Kentucky, southern Illinois, and eastern Kansas. Altitudinal range from sea level up along streams to

about 500 feet altitude (rarely to 1,000 feet), mainly in the Lower Austral Zone, but reaching into the upper Austral Zone in the more northerly localities, and into the Tropical Zone in southern Florida.

Hamilton (1946, p. 732) said of the habits of the rice rat:

In the southern states, rice rats and cotton rats (*Sigmodon*) are frequently found in the same association. In coastal Virginia, in the same habitat they are outnumbered only by *Microtus* [*pennsylvanicus*]. The little short-tailed shrew, *Cryptotis,* is also an inhabitant of the same marsh.

W. B. Davis has furnished me with the following data on *Oryzomys couesi*:

We have captured specimens from near sea-level at Brownsville, Texas, at one extreme, to near 7,500 feet near Mexico City, at the other extreme, in altitudinal range. All specimens were taken in marshy situations, except for one individual that was captured in a brushy habitat some 30 feet from a stream. In Morelos, Mexico, rice fields seem to support the heaviest populations.

Microtus (*Microtus*) *pennsylvanicus* (Ord). Distribution of the meadow vole is in the northern part of the Temperate Zone. Its range extends from southern Nebraska to Hudson Bay and from Alaska to New York (Fig. 3). The meadow vole requires a more moist and slightly cooler habitat, with a more dense cover of heavy grass, than does the prairie vole. Whenever the two species occur in the same vicinity the prairie vole will be found higher on valley slopes and on flat upland grassland.

Zapus. The jumping mouse's present distribution in North America nearly coincides with that of the meadow vole, *Microtus* (*M.*) *pennsylvanicus,* except that it ranges slightly farther south, especially in eastern Kansas. This mouse frequents the tall-grass areas along brush-covered and woodland slopes and ranges south into northeastern Oklahoma.

The following genera are common elements of the present-day fauna of western Kansas: *Citellus, Geomys, Perognathus, Dipodomys, Onychomys, Reithrodontomys, Peromyscus, Neotoma, Microtus* (*Pedomys*), *Ondatra,* and *Spilogale.*

Synaptomys. The bog lemming is now only an isolated ecological island form in a few of the bog habitats around artesian springs in Crooked Creek Valley.

Dipodomys and *Microtus* (*Pedomys*) require special comment, since their ranges overlap, to the south, the range of the rice rat (*Oryzomys*).

Dipodomys ordi Woodhouse. The Ord kangaroo rat ranges from the edge of southern Canada throughout the western United States to the northeastern edge of Mexico (Fig. 2). It lives chiefly in arid and semiarid regions wherever there is sand or sandy soils. In the southern tip of Texas, in the vicinity of Brownsville, the ranges of *Dipodomys* and *Oryzomys* overlap. Here the kangaroo rat is confined to sandy and well-drained soils or sand dunes; the rice rat, to intermarsh areas.

Microtus (*Pedomys*) *ochrogaster* (Wagner). The prairie vole frequents tall-grass and mixed-grass land throughout the upper Missouri and Mississippi valleys and south in the Plains region to northern Oklahoma. Two isolated colonies of *M.* (*Pedomys*) *ludovicianus* Bailey occur, or did occur, in coastal-plain areas; one in southeastern Texas and the other in southwestern Louisiana (Lowery, 1943, p. 247).

The environmental requirements of the following extinct forms can only be inferred from the scanty knowledge of the fossil record. They are believed to be as indicated below.

Paramylodon harlani (Owen). All evidence indicates that this large ground sloth ranged in regions of permanent water, since it could not easily travel such great distances as were possible for the horse, pronghorn, camel, and bison. Although food preferences are unknown, its presence suggests that shrubs, trees, and tall grasses grew on the stream banks or in the valleys and provided them with browse.

Tremarctotherium simus (Cope). The climatic tolerance of the large short-faced bear is not known. It had a wide geographical range and was later replaced in the North American fauna by the more progressive grizzly bear.

Mammuthus columbi (Falconer). Fossil evidence indicates that the Columbian mammoth (elephant) belonged to the southern fauna. This is also supported by the fact that a more northern species, the Jefferson mammoth, ranged in the area between the tundra-dwelling woolly mammoth and the Columbian mammoth. This mammoth required a habitat with permanent water in the streams and vegetation of shrubs, trees, and tall grasses for food.

Bison latifrons (Harlan). The giant bison ranged from California to Florida, Nebraska to Texas, and Kentucky to the Gulf of Mexico. The kind of deposits from which remains are recovered in North America indicate that this long horned bison either lived along permanent streams, which supported shrubs and some trees, or in well-wooded stream valleys, in which there were intermittent areas of tall-grass land (meadow). The large size of its horns is also an indication of such a habitat. In horned mammals in general, size of horn or antler is, in most instances, correlated with the type of habitat, whether open terrain, shrubbed, or timbered, in which a form lives.

Environmental Conditions at the Time the Jinglebob Fauna Lived.— The deposit from which this local fauna was taken represents but a small part of an interglacial stage. The climatic conditions under which the animals lived cannot be assumed to be the same throughout the interglacial time (Sangamon?). Any inference in regard to past conditions is based upon the fossils recovered and the sediments in which they occurred, and for the time during which the animals lived and were being buried. It is assumed (1) that the mollusks and vertebrates of the Jinglebob fauna chiefly possessed the habitat preferences of living members of their species group, and (2) that the smaller vertebrates had rather restricted habitats and, therefore, best serve as indices to climatic conditions. If it is not possible to make such assumptions, few if any, interpretations of past conditions can be made and all that would be available for any region and for a given time would be floral and faunal lists.

Since floral remains contain important clues to vegetative surroundings, samples of the matrix which contain hackberry seeds (*Celtis*), mollusks, and vertebrate remains were sent to Kathryn H. Clisby, Research Associate, Department of Geology and Geography, Oberlin College, for pollen analysis. Mrs. Clisby recovered pollen of *Pinus* (pine) and *Maclura* (Osage orange) from the matrix. In a letter of November 27, 1953, she states, "The Jinglebob flora seems to be a grassland with scattered pine and Osage orange trees." Neither of the trees she reported is native to the contemporary flora of southwestern Kansas. The presence of pine indicates that there must have been a greater rainfall for the Plains region at that time than at the present. The Osage orange (*Maclura pomifera* Rafinesque) now growing there was introduced from the south by the early settlers. It is one of the hardiest trees in the area and withstands dust-bowl conditions better than native species. That it is no longer indigenous is probably due to the extinction of the horse (*Equus*) during Wisconsin glaciation, since the horse was one of the greatest means of dispersal of the seed in North America. If the Osage orange was a food of the mammoth as well, the extinction of the southern mammoth would help account for the limited range of *Maclura* before North America was settled by the white man.

A large molluscan fauna was associated with the fossil mammals. Some species of mollusks have different ecological requirements. From the kinds that are found as fossils in a locality, the nature of the habitat may be inferred. Henry van der Schalie (1953, p. 85) said of the molluscan fauna:

> Some of the land shells in the Jinglebob fauna are now more southern in distribution. . . . *Strobilops texasiana* and *Gastrocopta cristata* are at the present time farther south in range. . . . *Vallonia pulchella* and *Pupilla muscorum*, which now occupy a more northern range, are conspicuously absent. The land and fresh-water

forms suggest a warm and moist climate in a wooded region containing temporary woods pools.

The opinion of H. B. Herrington, who interpreted the Sphaeriidae of the deposit (van der Schalie, 1953, p. 85–86), is that:

> There seems to have been two related kinds of habitats contiguous—running water where larger and heavier specimens of *Pisidium casertanum, Pisidium compressum* and *Sphaerium sulcatum* lived. The other habitat seems to have been something of the nature of a pond or lagoon where the water pretty well dries up for part of the year.

Dwight W. Taylor, who studied the Jinglebob mollusks so far recovered said in litt. (December 5, 1954):

> The mollusks of the Jinglebob local fauna show five general types of distribution: widespread, including the area of the Jinglebob occurrence; northern; southern; Rocky Mountain; and eastern. It is inferred from these different types of distribution that the Jinglebob local fauna lived in a moist, temperate climate, more equable than that of southwestern Kansas at the present. Rainfall was greater, summers were cooler and less dry, and winters were no colder, if not milder, than those of today. Mean annual temperature may have been no different, but the conditions for molluscan life were certainly more favorable. This is clearly shown by the fact that there are 57 species in the Jinglebob local fauna, from a single locality, whereas A. E. Leonard (1943) reports only 27 species living in Meade and Clark counties, Kansas, from several localities.

Forms with affinities to present-day southern or northern species groups help to evaluate conditions in Jinglebob time. Oelrich (1953, p. 38) made the following statement regarding the Plains box turtle (*Terrapene llanensis*) which is related to the Recent *Terrapene carolina:*

> The Recent forms of the *Terrapene carolina* group (Fig. 2) occupy a temperate woodland habitat which may vary as to humidity. This habitat is significant of the climate indicated by the presence of *T. llanensis* in southwestern Kansas during the middle or late Pleistocene.

Tihen (1954, p. 221) commented on the strong similarity of this herpetofauna to the living assemblage of amphibians and lizards of the region. With the exception of *T. llanensis,* he said:

> There is not a single specimen in the entire collection which can definitely be referred to some form not now inhabiting this area. . . . The range of most of these forms is so wide-spread that their presence here provides little information concerning climatic conditions at the time of deposition of the fossiliferous deposits. In general, they at least do not conflict with the evidence presented by the mammalian and molluscan faunae that the climate at that time was warmer and more humid than at present.

Occurrence of the Plains box turtle, *Terrapene llanensis,* and the rice rat (*Oryzomys*) in the Jinglebob fauna is a strong indication that a moist uniform environment existed along the major stream valley that led to the gulf. This valley provided not only a suitable habitat but a northern pathway for these two essentially southern faunal elements to reach southwestern Kansas (Figs. 2 and 3). Their ability to live there suggests a

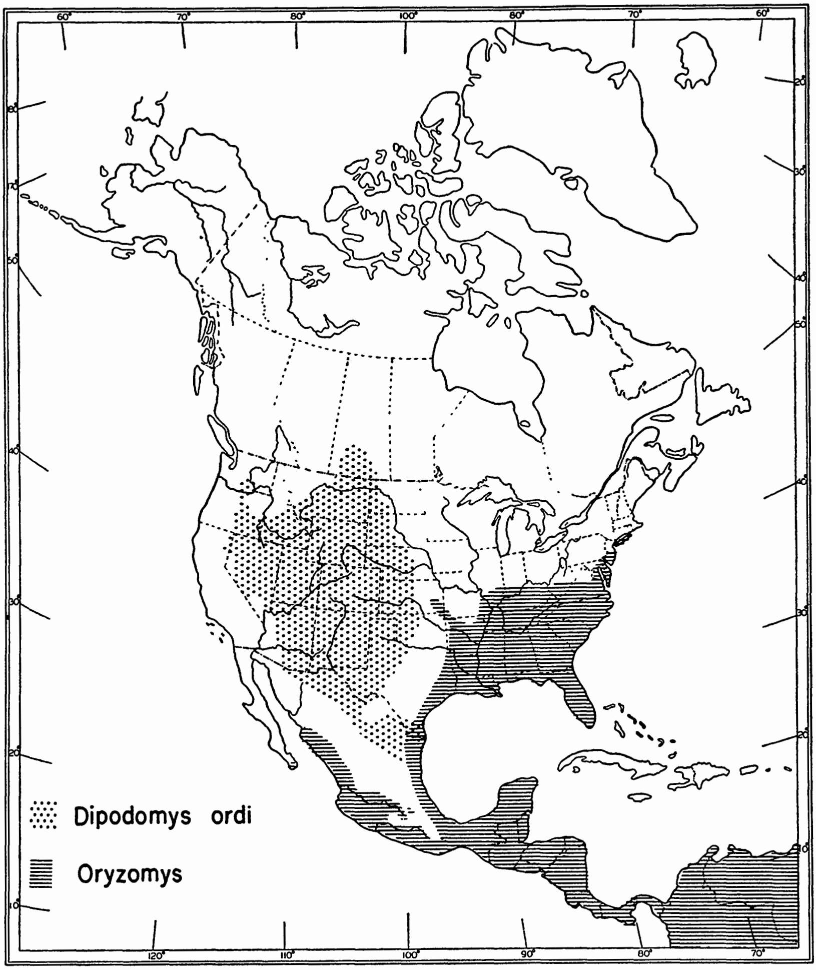

FIG. 2. Present distribution of *Dipodomys ordi,* kangaroo rat, and *Oryzomys,* rice rat. Note slight distributional overlap of their geographical ranges. After Burt and Grossenheider, Goldman, and Setzer.

milder winter than now occurs. Moreover, presence of two northern forms, the masked shrew (*Sorex cinereus*) and meadow vole (*Microtus* cf. *pennsylvanicus*) is added evidence that the region had a more moist and equable summer climate than occurs at the present.

From the floral and faunal evidence the landscape at the time the Jinglebob fauna lived in southwestern Kansas was one of broad braided stream valleys having a savanna-type vegetation, permanent pools along

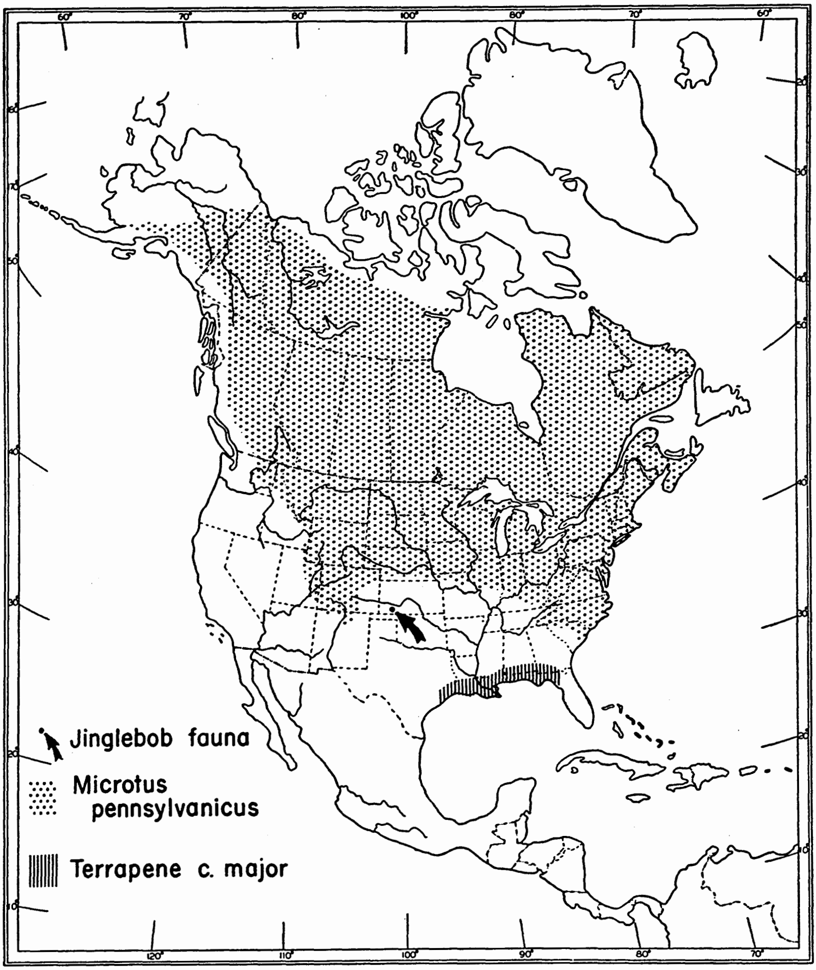

FIG. 3. Present distribution of *Microtus pennsylvanicus,* meadow vole, and *Terrapene c. major,* Gulf Coast box turtle. Note how geographical range of the meadow vole overlaps that of the rice rat (Fig. 2). Black dot marks location of Jinglebob local fauna, Meade County, Kansas.

the valley floor, and permanent streams with low gradients (Plate I). Some parts of the lowland were marshy with heavy vegetational cover. Other parts were meadow covered with tall grasses. Trees and shrubs grew in the valleys and on part of the valley slopes. Short grasses were confined to uplands, especially where the soil was sandy. Mixed grasses grew on some valley walls and on some uplands. A rainfall of 40 to 45 inches, comparable to that of the Ozark area of eastern Kansas, would have allowed pine to grow. If the tolerance of the rice rat was the same then as now, summers were cooler, without drought; winters were milder, without severely low temperatures. Winters would have been as warm or slightly warmer than those of the coastal area of Virginia. At the time the Jinglebob fauna lived in the area optimal conditions may have contributed to the large size of the box turtle, grasshopper mouse, southern bog lemming, short-faced bear, and the giant bison.

Observations made elsewhere in North America confirm the evidence for such a description of the paleoclimatic conditions in southwestern Kansas during part of the Sangamon(?). For instance, the interglacial Don beds in the Toronto area can be tentatively correlated, on the basis of *Bison,* with the deposits containing the Jinglebob fauna. Coleman (1933, p. 10) listed the species of trees found in the Don beds and stated that "It is agreed by botanists and foresters that the interglacial forest indicates a climate 4 to 5 degrees warmer than at present, about like that of Ohio and Pennsylvania."

There is also evidence of a milder and slightly more moist climate in Pennsylvania during the Sangamon than at present. Peltier (1949, p. 138) stated:

> The red soils developed upon the Illinoian glacial deposits in the Susquehanna Valley are more similar to the red and yellow soils of North Carolina and Virginia than to the brown earths which have developed on the adjacent Wisconsin deposits. This scanty evidence indicates that the climate of Pennsylvania was, during the interglacial period, similar to that of Virginia today.

The pronounced soil profile on the Loveland loess in Nebraska and northern Kansas contrasts with the soil profile of the earlier Pleistocene formations in southwestern Kansas. The latter are represented chiefly by a caliche horizon. None comparable to that at the top of the Loveland has been found in the Kingsdown formation. There is a dark silt (mud) zone which occurs locally in the area that appears to be equivalent to the deposit from which the Jinglebob fauna was recovered. No buried caliche zone is present in the Kingsdown formation. The lack of such a zone is in decided contrast to the pronounced development of it in the older Pleistocene Meade and Crooked Creek formations. Furthermore, the absence of the buried caliche zone may indicate a continuously moist climate (not a long dry, semiarid, interval) during Sangamon? time.

DESCRIPTION OF VERTEBRATE FOSSILS

A systematic description is given for each member of the mammalian fauna. Occurrence of the other vertebrates in the deposit is noted. Catalog numbers, if not otherwise identified, refer to specimens in the University of Michigan Museum of Paleontology. Those in the Kansas University Museum of Natural History are designated K.U.

Class Pisces

Family Cyprinidae

The occurrence of minnows in the Pleistocene stream is shown by several pharyngeal bones with teeth, No. 28100. A pharyngeal bone, No. 28101, has been identified by Robert Rush Miller, Associate Curator of Fishes in the Museum of Zoology, University of Michigan, as questionably belonging to the creek chub, *Semotilus atromaculatus?* (Mitchell).

Family Ameiuridae

Remains of a bullhead, *Ameiurus* sp., No. 28102, were common.

Class Amphibia

J. A. Tihen (1954) reported the amphibians. The forms are given in the Faunal List, page 194.

Class Reptilia

Oelrich (1953) and Tihen (1954) recorded the reptiles. The forms recovered are given in the Faunal List, pages 194–95. The snake remains have not been studied.

Class Aves

The few fragmentary bird bones recovered have not been studied.

Class Mammalia

Order Insectivora

Family Soricidae

Sorex cf. *cinereus* Kerr

Part of a left jaw with P_4-M_2, No. 29263, is the size of the jaw of the masked shrew, *Sorex cinereus*. The characters of the teeth are also like those of *S. cinereus.*

Blarina cf. *brevicauda* (Say)

(Fig. 4B, D, E)

The shorttail shrew is represented by parts of three right maxillaries and one left maxillary, and parts of three right and three left jaws. The specimens are smaller than the specimen of *B. fossilis* Hibbard (6675

K.U.) from the Rezabek fauna of Lincoln County, Kansas. No complete jaws were recovered. The anteroposterior length of M^1-M^2 in one of the right maxillaries is 3.48 mm. In the left maxillary, No. 29265, which contains I^2-M^1 (Fig. 4B), the anteroposterior length of these teeth is 5.7 mm. In two of the right jaws, Nos. 29268 (Fig. 4D) and 29269, each containing M_1-M_3, the anteroposterior lengths of these teeth are 4.8 mm. and 4.6 mm., respectively.

ORDER EDENTATA
Family Mylodontidae
Paramylodon harlani (Owen)
(Fig. 8A, B)

Two right tibiae and an ungula of this large ground sloth were picked up in the bed of the stream. The ungula, No. 25614 (Fig. 8A), was recovered in the spring of 1948 by Francis Cochran. It is 183.0 mm. long. One of the tibiae, No. 26369, taken in September, 1949, is 233.0 mm. long, and the other, No. 26960 (Fig. 8B), taken in the summer of 1950, is 240.0 mm.

ORDER RODENTIA
Family Sciuridae
Citellus sp.

In the collection is part of a right maxillary with P^4-M^2, No. 29274, of a small ground squirrel. Another specimen, No. 29275, is part of a large left jaw, without teeth, of a ground squirrel the size of *Citellus variegatus* (Erxleben).

Family Geomyidae
Geomys sp.

The pocket gopher of the genus *Geomys* is known in this fauna by a few isolated upper incisors and molar teeth.

Family Heteromyidae
Perognathus hispidus Baird
(Fig. 4A)

The hispid pocket mouse is known from a nearly complete right lower jaw with P_4-M_3, No. 31389. Associated were four jaws with one or two teeth each and parts of two maxillaries. The nearly complete jaw compares in size with those of the largest individuals of Recent specimens of *Perognathus hispidus*. The anteroposterior length of the P_4-M_3 is 4.2 mm. In the fossil specimen a deep excavation (broad pit) is situated between

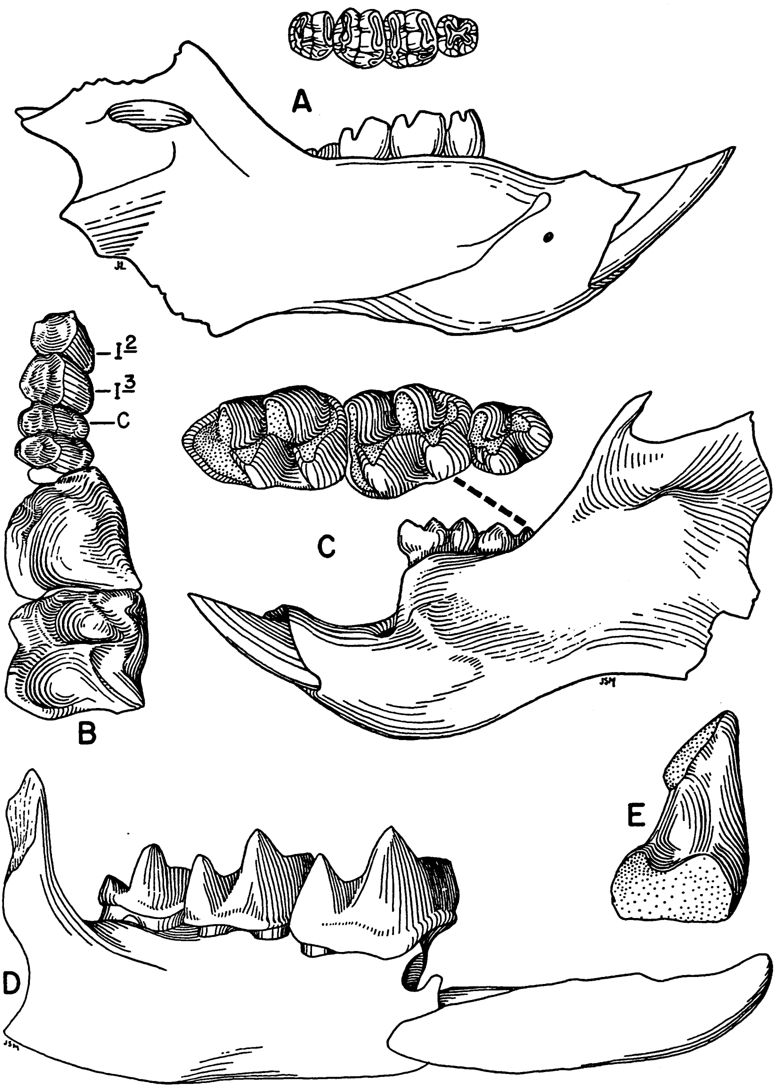

FIG. 4. Interglacial Pleistocene mammals. (A) *Perognathus hispidus* Baird, U.M.M.P. 31389, right ramus, P_4–M_3. Lateral and occlusal views. × 6. (B) *Blarina* cf. *brevicauda* (Say), U.M.M.P. 29265, LI^2–M^1. Occlusal view. × 10. (C) *Reithrodontomys* cf. *montanus* (Baird), U.M.M.P. 29287, left ramus, M_1–M_3. Lateral view, × 8. Occlusal view. × 16. (D) *Blarina* cf. *brevicauda* (Say), U.M.M.P. 29268, right ramus, I, M_1–M_3. Lateral view. × 10. (E) *Blarina fossilis* Hibbard, K.U. 6675, holotype, articular condyles of right ramus. Posterior view. × 10.

the M_3 and the ascending ramus. This is a condition that has been observed in only one Recent specimen (No. 68318, Univ. Mich. Mus. Zool.) from Valentine, Cherry County, Nebraska. In the Recent specimen, the pit was not so deep as in the fossil. This is the second record of *P. hispidus* from the Pleistocene of Kansas. The other record was a specimen taken with the Kentuck assemblage in McPherson County.

Perognathus sp.

A small pocket mouse occurred in the fauna. Parts of three jaws with P_4, No. 29300, and parts of four maxillaries the size of those of the small *Perognathus flavus* Baird were recovered.

Dipodomys cf. *ordi* Woodhouse

(Figs. 6H, K)

A baculum, No. 29261 (Fig. 6H) of a kangaroo rat has the general shape and size of that of *Dipodomys ordi* (Burt, 1936). Found with the baculum were two teeth, the right P_4 and an M_1 of an adult kangaroo rat. The P_4, No. 29262, is worn down to the narrow dentine tract on the labial side of the crown and the enamel is separated (Fig. 6K). The dentine tract on the lingual side is slightly lower, but with a little more wear the enamel on that side would also have become separated. The occlusal pattern of the tooth is very like that of *Dipodomys ordi,* except that the infolding of the enamel between the anterior lophid and the posterior lophid is deeper, especially on the lingual side, than in Recent specimens of *D. ordi* examined.

The P_4 has two well-developed roots which are grown together and closed at the base. The anterior root is narrow transversely and supports the anterolophid. The posterior root extends across the base of the tooth and is narrow anteroposteriorly (Fig. 6K). It joins the anterior root. This condition of the roots on the permanent P_4 was present in every Recent old adult specimen of *Dipodomys ordi* examined. The M_1 has started to close off at the base to form a single root. Recent workers have followed Coues (1875, p. 306) in considering the permanent cheek teeth of *Dipodomys* ever growing. In old adults of *Dipodomys ordi* the base of the molars is closed.

Family Cricetidae

Onychomys jinglebobensis, sp. nov.

(Fig. 5F)

Holotype.—No. 29254, University of Michigan Museum of Paleontology, a right jaw with incisor and M_1–M_3. Paratype: No. 29255, part of a right maxillary with M^1–M^2. Collected in the summer of 1951 by the University of Michigan Museum of Paleontology field party.

Horizon and type locality.—Late Pleistocene (interglacial), Kingsdown formation, Jinglebob local fauna. Locality UM-K2-47, Jinglebob pasture, XI Ranch, SW.¼ sec. 32, T.33 S., R.29 W., Meade County, Kansas.

Diagnosis.—A large grasshopper mouse which belongs to the *Onychomys leucogaster* group. The diastemal region is wider, the jaw deeper, and the M_3 not as reduced, however, as in Recent specimens of *O. leucogaster*. The jaw is slightly larger and the M_3 is definitely larger than in *O. pedroensis* Gidley from the Curtis Ranch fauna of Arizona.

Description of holotype.—No. 29254 is a right jaw with the tip of the angular process and the coronoid process missing. The mental foramen is situated on the side of the jaw as in *O. leucogaster,* though it is more anterior in relation to the anterior root of M_1. The masseteric ridge is well developed, but it does not extend as far forward on the jaw as in *O. pedroensis* or in the majority of Recent specimens of *O. leucogaster* examined. The capsular process for the reception of the base of the incisor is as large as in *O. leucogaster*. The mandibular foramen is situated as in *O. leucogaster*. The greatest transverse width of M_3 is 1.1 mm. The anteroposterior length of M_1–M_3 is 4.5 mm.

Discussion.—*Onychomys jinglebobensis* has a much heavier and deeper jaw, with a larger M_3, than do any Recent specimens of *O. leucogaster* examined from Kansas, or from elsewhere in its range. *O. fossilis* Hibbard of the Pleistocene interglacial Borchers fauna from the Crooked Creek formation, Meade County, Kansas, is smaller and has a more slender jaw like that of the Recent specimens of *O. leucogaster*.

Reithrodontomys cf. *montanus* (Baird)

(Fig. 4C)

Parts of five left jaws, three right jaws, and two left maxillaries are similar to the Plains harvest mouse. The heavy, broad, diastemal region and the shape of the coronoid process is like that of *Reithrodontomys montanus*. In *R. megalotis* (Baird) the diastemal region is narrower and the coronoid process broader. No ectostylid is present on the M_1, between the protoconid and hypoconid, as is often the case in *R. megalotis*. In five specimens the anteroposterior length of M_1–M_3 is 3.0, 2.98, 3.1, 3.1, and 2.9 mm. The anteroposterior length of M^1–M^3 in one maxillary, No. 29295 is 3.05 mm. One of the left lower jaws, No. 29287, is nearly complete. It lacks only the articular process (Fig. 4C). The base of the capsular process is developed as in *R. montanus,* but the mandibular foramen is separated from the pterygoid fossa by a larger and broader ridge of bone than observed in Recent specimens of this species.

Peromyscus cochrani, sp. nov.

(Fig. 5A)

Holotype.—No. 27542, University of Michigan Museum of Paleontology, a right jaw with incisor and M_1–M_3. The coronoid and angular processes are lacking. Collected in the summer of 1950 by the University of Michigan Museum of Paleontology field party. Paratypes: Nos. 29304 and 29305, two left jaws, and No. 29753, a right jaw with M_1–M_3. Collected during the summers of 1951 and 1952.

Horizon and type locality.—Late Pleistocene (interglacial), Kingsdown formation, Jinglebob local fauna. Locality UM-K2-47, Jinglebob pasture, SW.¼ sec. 32, T.33 S., R.29 W., XI Ranch, Meade County, Kansas.

Diagnosis.—A mouse belonging to the subgenus *Peromyscus* the size of *P. leucopus noveboracensis* (Fischer). The dental characters are intermediate between *Peromyscus cragini* Hibbard, from the Cudahy fauna of Meade County, Kansas, and the Recent species *P. leucopus* and *P. maniculatus.* Internal and external re-entrant valleys between the cusps are broader in *P. cochrani* than in *P. leucopus* and *P. maniculatus.* Mesostylid, ectostylid, mesostyle, and enterostyle are not as well developed as in Recent species of the subgenus *Peromyscus.* No lophids are present on the lower teeth, and the mesolophs on the upper molars are either only slightly developed or absent.

Description of holotype.—No. 27542 is a right jaw, which lacks the coronoid and angular processes, of an adult animal (Fig. 5A). The re-entrant valleys between the cusps are broader than in specimens of *P. maniculatus* and *P. leucopus.* There is no median groove on the anterior face of the anteroconid of the M_1. A low rudimentary ectostylid is present between the protoconid and hypoconid. There is no ectolophid. On the lingual side between the metaconid and entoconid is a mesostylid smaller than the ectostylid. The mesolophid is absent. Only rudimentary ectostylid and mesostylid are present on the M_2. The pit formed between the anterior cingulum (anterolophid) and the protoconid on M_2 and M_3 is shallower than in the Recent species with which the type has been compared. The anteroposterior length of the M_1–M_3 series is 3.76 mm.

The species is named for Francis Cochran, of Meade, Kansas, who kindly helped us with our work in that area.

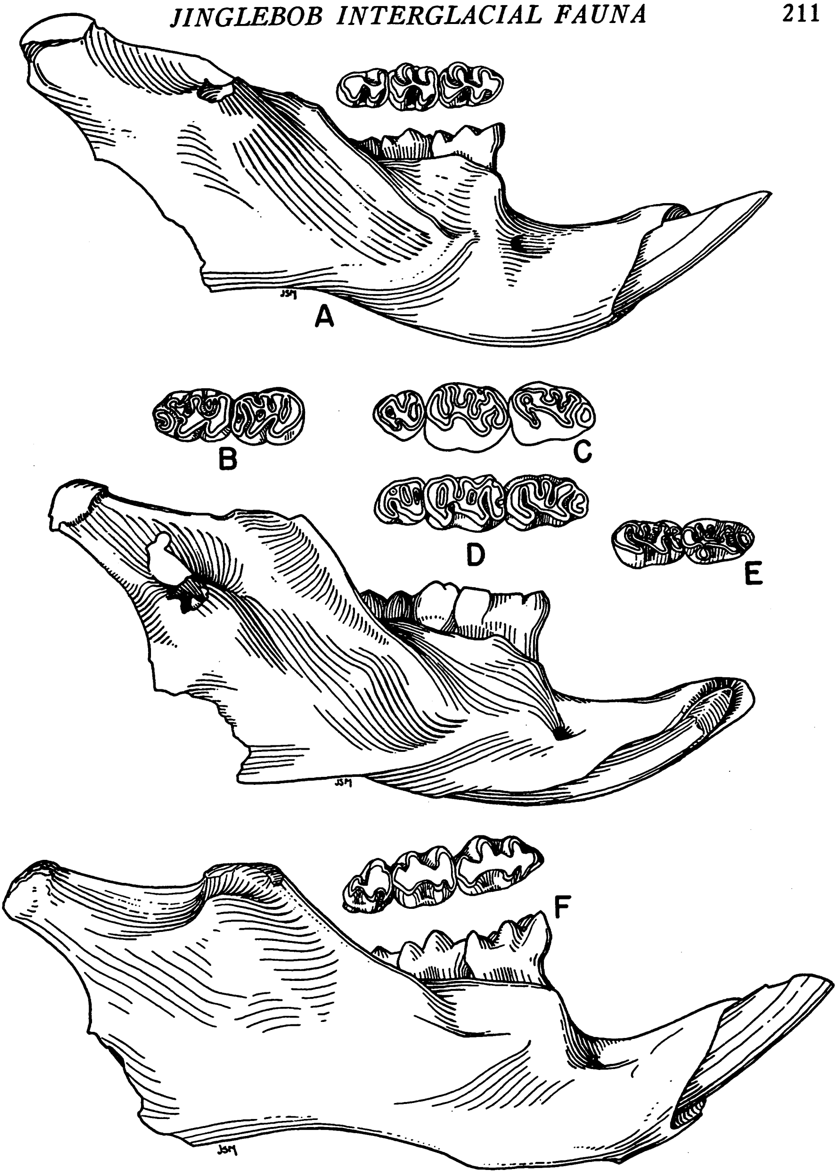

FIG. 5. Interglacial Pleistocene rodents. (A) *Peromyscus cochrani,* sp. nov., holotype, U.M.M.P. 27542, right ramus, M_1–M_3. Lateral and occlusal views. × 6. (B) *Zapus burti* Hibbard, K.U. 7604, LM_1 and M_2. Occlusal view. × 8. (C) *Zapus burti* Hibbard, holotype, K.U. 6152, RM_1–M_3. Occlusal view. × 8. (D) *Zapus adamsi,* sp. nov., holotype, U.M.M.P. 29260, right ramus, M_1–M_3. Occlusal and lateral views. × 8. (E) *Zapus adamsi,* sp. nov., paratype, U.M.M.P. 29259, RM_1–M_2. Occlusal view. × 8. (F) *Onychomys jinglebobensis,* sp. nov., holotype, U.M.M.P. 29254, right ramus, M_1–M_3. Lateral and occlusal views. × 6.

Description of paratypes.—Paratypes, Nos. 29304, 29305, and 29753 are also jaws of adult mice. They lack an anteromedian groove on the anteroconid of the M_1. Stylids are developed as in the holotype and lophids are absent. The anteroposterior lengths of M_1–M_3 are 3.7 mm., 3.75 mm., and 3.6 mm. Associated with the paratypes were five left and three right jaws each containing one or more teeth. In these specimens the cusp development is the same as in the holotype.

Parts of seven maxillaries were recovered. There is a greater difference between the upper dentitions of *Peromyscus cochrani* and *P. maniculatus* and *P. leucopus* than there is between the lower dentitions of the fossil and Recent forms. For example, the upper dentition of *P. cochrani* shows the beginning of the development of the mesoloph, characteristic of the subgenus *Peromyscus*. Specimen No. 29315 is part of a left maxillary with M^1. In this M^1 the anteroloph (anterior cingulum of some authors) has joined the style at the mouth of the re-entrant valley between the anterocone and the paracone. There is no mesostyle or mesoloph between the paracone and hypocone. Specimen No. 29316 is part of a right maxillary with M^1 and M^2. The loph and style had developed between the anterocone and the paracone of the M^1 as in the other specimen. A short mesoloph is present, but there is no mesostyle between the paracone and metacone. The M^2 has broader re-entrant valleys between the cusps than in *P. maniculatus* and *P. leucopus*. The anterior cingulum is not so large or so distinctly separated from the paracone as in the Recent species. A very narrow mesoloph has joined the small mesostyle between the paracone and metacone.

Discussion.—*Peromyscus cochrani* is distinguished from *P. cragini* by its slightly larger size and by the more prominent although still rudimentary styles and stylids. In development of accessory cusps *P. cochrani* had reached what can be considered an early stage in the development of the characters which distinguish the subgenus *Peromyscus*. Either the development of lophs, lophids, styles, and stylids on the teeth of *Peromyscus* is very recent or there were waves of more progressive species of *Peromyscus,* which invaded much of the United States from the south after each glacial recession.

There is no proof that *Peromyscus kansasensis* Hibbard from the Upper Pliocene of Meade County, Kansas, which seems to belong to the subgenus *Haplomylomys,* is ancestral to the forms of *Peromyscus* that now live in that region. But *P. kansasensis* could be ancestral to some species group of the subgenus *Peromyscus*. *Peromyscus* has not been found to be a common fossil in the late Pliocene or early Pleistocene of that region.

Peromyscus sp.

A right lower jaw with M_1 and M_3, No. 29302, of a mouse, which is slightly smaller than *Peromyscus cochrani,* that appears to belong to either the *truei* or *boylei* group of *Peromyscus.*

Neotoma sp.

There are three isolated teeth, No. 29319, of a wood rat of the genus *Neotoma.* One RM^1 is from an adult animal. The others, a RM^1 and an LM^2, are from a younger wood rat.

Oryzomys fossilis, sp. nov.

(Figs. 6I, J)

Holotype.—No. 29271, University of Michigan Museum of Paleontology, a right jaw with the incisor and M_1–M_3 (Fig. 6I). The tip of M_1 is broken and the angle, condyle, and coronoid are missing. Collected in the summer of 1950 by the University of Michigan Museum of Paleontology field party. Paratypes: No. 29272, part of a left ramus with incisor and M_1 (Fig. 6J), and No. 29273, part of a right maxillary with M^1.

Horizon and type locality.—Late Pleistocene (interglacial), Kingsdown formation, Jinglebob local fauna. Locality UM-K2-47, Jinglebob pasture, SW.¼ sec. 32, T.33 S., R.29 W., XI Ranch, Meade County, Kansas.

Diagnosis.—A rice rat the size of *Oryzomys palustris texensis* Allen but with broader re-entrant valleys between the cusps. The stylids are not as well developed as in Recent specimens of *O. palustris* and *O. couesi.* The crescentic anterocentral enamel islands of M_2 and M_3 are decidedly larger and deeper than in *O. palustris.* These enamel islands were not observed on the M_2 and M_3 in *Oryzomys couesi* (Alston).

Description of holotype.—No. 29271 is the right jaw of an adult animal. The mental foramen is situated as in *O. palustris.* The masseteric ridge ends near the anterior edge of the anterior root of M_1. The capsular process for the base of the incisor is developed as in *O. palustris.* The mandibular foramen is separated from the pterygoid fossa by a broader ridge of bone than in *O. palustris.* The external re-entrant valleys between the cusps of M_1, M_2, and M_3 are broader than in either *O. palustris* or *O. couesi.* In comparable stages of wear the re-entrant valleys extend farther across the crowns of the teeth, especially on the M_3. The anteromedian crescentic enamel islands are large and deep. M_2 is about th same size as in *O. palustris.* M_3 is larger than either the M_3 of *O. palustris* or of

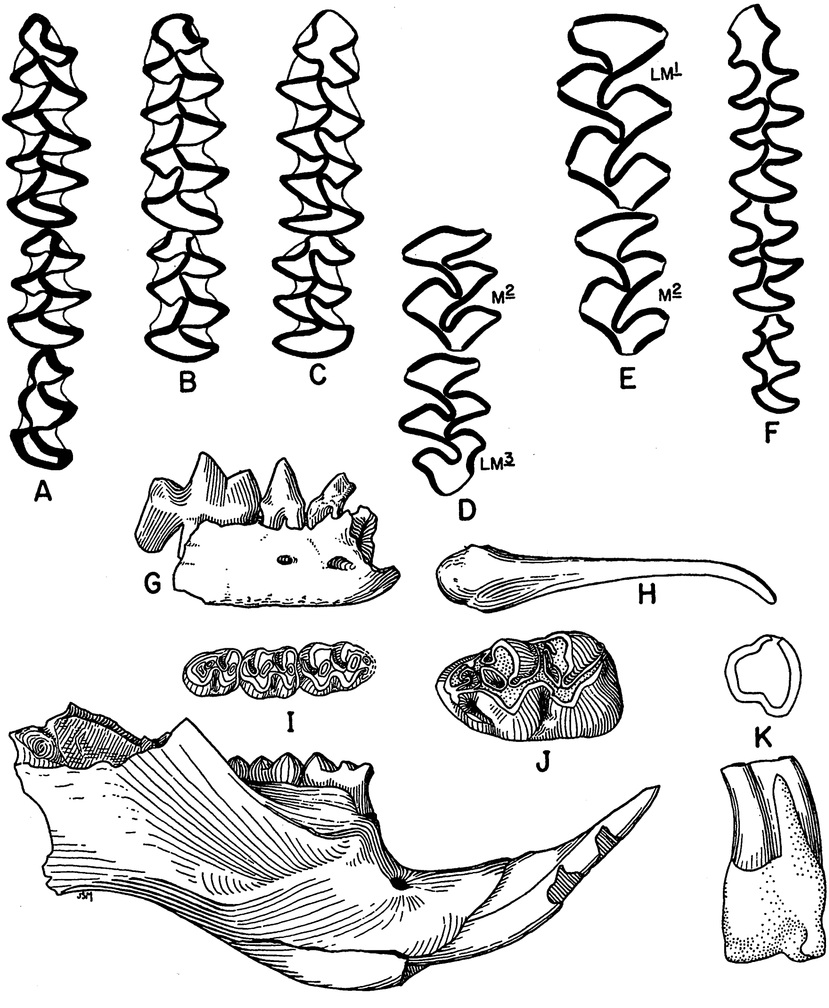

FIG. 6. Interglacial Pleistocene mammals. (A–C) *Microtus* (*Microtus*) cf. *pennsylvanicus* (Ord). (A) U.M.M.P. 29333, LM_1–M_3. (B) U.M.M.P. 29332, LM_1–M_2. (C) U.M.M.P. 29334, RM_1–M_2. Occlusal views. All × 10. (D–E) *Ondatra zibethica* (Linnaeus). (D) U.M.M.P. 29299, LM^2–M^3. (E) U.M.M.P. 29298, LM^1–M^2. Occlusal views. All × 5. (F) *Microtus* (*Pedomys*) cf. *ochrogaster* (*Wagner*), U.M.M.P. 29320, LM_1–M_3. Occlusal view. × 10. (G) *Spilogale interrupta* (Rafinesque), U.M.M.P. 29297, part of right ramus, P_3–M_1. Lateral view. × 2. (H) *Dipodomys* cf. *ordi,* Woodhouse, U.M.M.P. 29261, baculum. Lateral view. × 4. (I) *Oryzomys fossilis* sp. nov., holotype, U.M.M.P. 29271, right ramus, M_1–M_3. Lateral and occlusal views. × 6. (J) *Oryzomys fossilis,* sp. nov., paratype, U.M.M.P. 29272, LM_1. Occlusal view. × 12. (K) *Dipodomys* cf. *ordi* Woodhouse, U.M.M.P. 29262, RP_4. Labial and occlusal views. × 8.

O. couesi. M_1 has the tip broken (Fig. 6I). Alveolar length of M_1–M_3 is 4.8 mm.

Description of paratypes.—No. 29272 is part of a left ramus of an adult. The M_1 agrees with that of the holotype in dental characters (Fig. 6J). There is no median groove on the anterior part of M_1. The anterolabial conulid of the anterocone of M_1 is smaller than the anterolingual conulid (see Hooper, 1952, for dental nomenclature). Its anteroposterior length is 2.1 mm. The greatest transverse width is 1.3 mm. The alveolar length of M_1–M_3 is 5.3 mm.

No. 29273, a right maxillary fragment with M^1, is of an adult animal. The anterior palatine foramen extends posteriorly past the anterior edge of M^1. The internal re-entrant valleys of M^1 are broader than in *O. palustris.*

Synaptomys australis Simpson
(Fig. 7B)

A nearly perfect left lower jaw, No. 29749, a fragmentary left lower jaw with M_1 and M_2, No. 31862, and some isolated teeth of this large bog

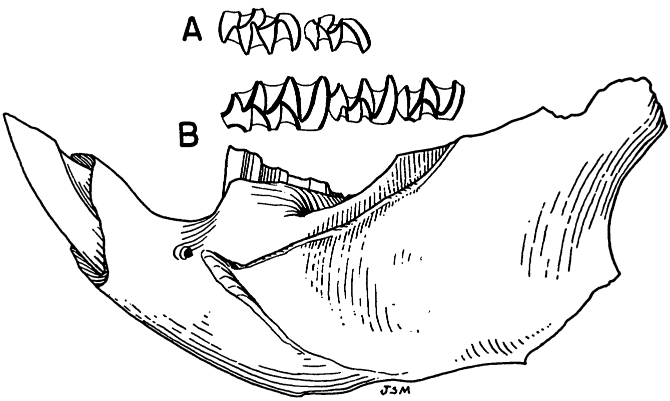

FIG. 7. (A) *Synaptomys bunkeri* Hibbard, holotype K.U. No. 4610, M_1–M_2. Occlusal view, for comparison. (B) *Synaptomys australis* Simpson, U.M.M.P. 29749. Lateral and occlusal views. All × 4.

lemming were recovered from the deposit. In No. 29749 the anteroposterior length of M_1–M_3 is 8.25 mm., which is the same as that in the holotype (No. 23440, American Museum of Natural History) from Florida. The Kansas specimen appears to be from an older individual and its incisor is slightly broader and extends a little farther posterior to M_3 than in the holotype. The fossil lemming is larger than *S. bunkeri* (Fig. 7A) from the late Pleistocene deposits of Beaver County, Oklahoma, and the Recent form (*Synaptomys cooperi paludis* Hibbard and Rinker) that now lives in isolated island bogs around artesian springs in Meade County, Kansas.

Microtus (*Pedomys*) *ochrogaster* (Wagner)
(Fig. 6F)

The prairie vole is represented by a number of isolated teeth, parts of eight lower jaws, and an incomplete maxillary, which are as large as in *Microtus ochrogaster taylori* Hibbard and Rinker. The teeth and occlusal patterns are more like those of *M. ochrogaster,* which lives in the area, than like those of *M. (Pedomys) llanensis* Hibbard, from the Cudahy fauna of Meade County, Kansas. In the adult specimens the M_3 and lower incisor do not appear to be as long as in the Recent specimens of *M. ochrogaster*. The diastemal region in adult jaws is broader than in most of the Recent specimens. In No. 29320 (Fig. 6F), one of the lower jaws, the anteroposterior length of M_1–M_3 is 6.0 mm. In No. 29327, the maxillary, the anteroposterior length of M^1–M^3 is 5.55 mm. Both dentitions are from young adult animals. Remains of this prairie vole are common in the deposit. Parts of 23 individuals were obtained.

Microtus (*Microtus*) cf. *pennsylvanicus* (Ord)
(Figs. 6A, B, C)

Parts of seven lower jaws, maxillary fragments and isolated teeth of a vole of the *pennsylvanicus* group of *Microtus* were recovered. Twenty-seven of the first lower molars have five alternating closed triangles (Fig. 6C) and fifteen have six closed triangles (Fig. 6B). Better material is needed for a comparison with Recent forms. In No. 29333 (Fig. 6A), the anteroposterior length of M_1–M_3 is 6.9 mm. The subgenus *Microtus* does not live in Kansas at the present time, but it does occur to the north in part of Nebraska.

Ondatra zibethica (Linnaeus)
(Figs. 6D, E)

The muskrat is known from isolated teeth, a lower jaw, and maxillary fragments. The most nearly complete specimen, No. 29298 (Fig. 6E) is part of the associated right and left maxillaries with LM^1 and LM^2 and RM^1. The specimen is that of an old adult and the teeth are worn down to the dentine tracts separating the enamel into plates along the sides of the teeth (Fig. 6E). Another specimen, No. 29299 (Fig. 6D), is a broken left maxillary with LM^2 and LM^3 and is from a younger animal than the other. The teeth resemble those of *Ondatra zibethica,* but the fossil ones appear to have slightly better developed roots than do those of Recent specimens showing comparable stages of wear. M^1 has two roots.

Family Zapodidae

Zapus adamsi sp. nov.

(Figs. 5D, E)

Holotype.—No. 29260, University of Michigan Museum of Paleontology, a right jaw with M_1–M_3. The incisor, coronoid process, and tip of the angle are missing. Collected in the summer of 1950. Paratypes: No. 29259, part of a right jaw with M_1 and M_2 (Fig. 5E) of a young adult; No. 29258, part of a right jaw with M_2; No. 29257, part of a left jaw with M_1; and No. 29256, parts of two left jaws of old adults with greatly worn dentitions. Collected in the summer of 1951, by the University of Michigan Museum of Paleontology field party.

Horizon and type locality.—Late Pleistocene (interglacial), Kingsdown formation, Jinglebob local fauna. Locality UM-K2-47, Jinglebob pasture, SW.¼ sec. 32, T.33 S., R.29 W., XI Ranch, Meade County, Kansas.

Diagnosis.—A jumping mouse the size of *Zapus burti* Hibbard of the Borchers fauna but with a narrower tooth row. It is the size of the Recent *Zapus hudsonius* (Zimmermann), but had slightly shorter crowned teeth, with wider re-entrant valleys, and the M_2 broader (in transverse width) anteriorly than posteriorly.

Description of holotype.—No. 29260 (Fig. 5D) is the right jaw of an adult. The mental foramen and masseteric ridge are situated as in *Zapus hudsonius*. The articular condyle and the capsular process for the reception of the base of the incisor are developed as in the Recent *Z. hudsonius*. The approaches to the re-entrant valleys on the sides of the crowns of M_1 and M_2 are more deeply excavated or depressed than in *Z. hudsonius;* in the fossil they are more like the condition observed in *Z. trinotatus* Rhoads. If the front of M_1 ever had an anteromedian groove, it was poorly developed. The first lingual re-entrant valley is very shallow. The other lingual and also the labial re-entrant valleys are not as deeply developed as in the Recent species of *Z. hudsonius* and *Z. trinotatus*. The posterolabial re-entrant valleys of the molars are broader and have a more even depth than in the Recent species. M_2 has a greater transverse width across the anterior part of the crown than across the posterior part, a condition approached in some specimens of *Z. princeps* Allen. The posterior edge of M_1 and M_2 on the labial side is rounded and vertical and does not slope upward toward the occlusal surface as it does in the Recent species.

In the holotype the greatest transverse width of M_1 is 0.8 mm. In a topotype of *Z. burti,* K.U. No. 7604, the width is 0.9 mm. (Fig. 5B). The greatest transverse width of M_2 in the holotype of *Z. adamsi* is 0.88 mm. (Fig. 5D); in the topotype of *Z. burti,* it is 0.98 mm. The anteroposterior length of M_1–M_3 of the holotype of *Z. adamsi* is 3.7 mm. in the holotype (K.U. No. 6152) of *Z. burti,* 3.8 mm. (Fig. 5C).

Zapus adamsi is named for Horace G. Adams II, on whose ranch we have worked for the past sixteen years. Mr. Adams co-operated with us in every way possible to make the field work a pleasure as well as a success.

Description of paratypes.—The characters of the paratypes are like those of the type. None of the first molars possesses an anteromedian groove, a character found on most specimens of *Z. hudsonius.* M_1 of paratype No. 29257 has a small enamel islet on the anteroconid, indicative of the presence of a very shallow groove in the early stage of wear. The M_1 of No. 29259, the right jaw, of a young adult, has a shallow, well-developed, posteroexternal re-entrant valley posterior to the major external re-entrant valley (Fig. 5E). This valley was not seen in any of the immature or young adult dental patterns of the Recent species, nor was it present on the other specimens of *Z. adamsi,* which are in a much later stage of wear.

Discussion.—*Zapus adamsi* is distinguished from *Z. burti,* from the Borchers (interglacial) fauna, by its narrower molar series. On the basis of the width of the molars, *Z. burti* appears to be more like *Z. princeps* and *Z. trinotatus,* although the re-entrant valleys are neither as deep nor as narrow as in these two Recent species. *Zapus adamsi* is distinguished from *Z. hudsonius* by wider re-entrant valleys and shorter crowned teeth and by the fact that the M_2 of *Z. adamsi* has its greatest transverse width across the anterior part of the tooth.

Order Carnivora

Family Ursidae

Tremarctotherium simus (Cope)

(Fig. 8C)

In the summer of 1947 the basal part of the cranium, No. 24380, of a short-faced bear was recovered with the skull of a mammoth. Rinker (1949) reported the bear skull and associated vertebrates and invertebrates. Since the original find, other bones of the bear were obtained. They are all considered parts of a single disarticulated skeleton. The associated elements were two toe bones, an astragalus, a tibia, part of a fibula, a femur, parts of an ulna and radius, and the right lower jaw.

The femur, from the proximal surface of the neck to the distal end, is 494.0 mm. long; the tibia slightly more than 375.0 mm. The lower jaw, No. 26368 (Fig. 8C), is 295.0 mm. from the tip of the angle to the anterior end of the symphysis. The double masseteric fossa is well devel-

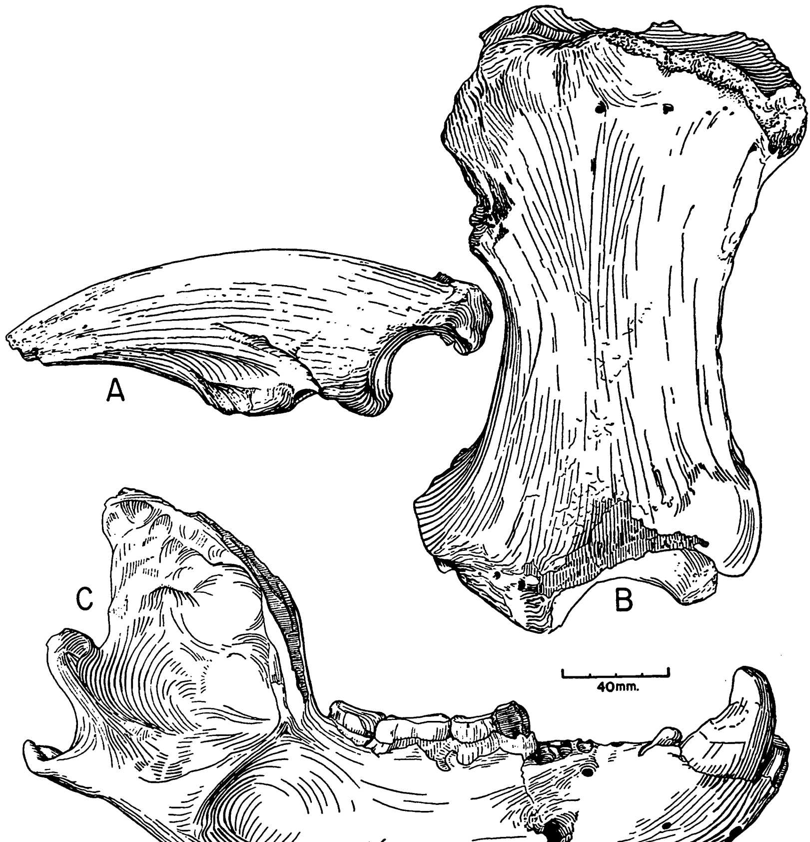

FIG. 8. Interglacial Pleistocene mammals. (A–B) *Paramylodon harlani* (Owen). (A) U.M.M.P. 25614, ungula. Lateral view. (B) U.M.M.P. 26960, right tibia. Anterior view. (C) *Tremarctotherium simus*. U.M.M.P. 26368, right ramus, M_1–M_3. Lateral view. All approximately ⅓ natural size.

oped. It had three incisors, a canine, four premolars, and three molars. The first two incisors are greatly flattened transversely. The antero-posterior diameter of the canine at the base of the enamel is 27.0 mm.; at the alveolar border it is 32.0 mm.

P_1 is single-rooted and lies close to the canine. A diastema of 6.0 mm. separates the alveoli of P_1 and P_2. P_2, P_3, and P_4 are missing, but the alveoli show that the P_2 and P_3 were single-rooted. A diastema of 8.5 mm. separates the alveoli of P_2 and P_3. P_3 was set close to P_4. P_4 had two roots and was close to M_1. The molars are badly worn and have only flat surfaces. The anteroposterior length of M_1–M_3 is 77.0 mm. The ramus has a depth of 62.0 mm., measured between M_1 and M_2. The mental foramen is round with a diameter of 9.5 mm. and is situated 24.0 mm. below the posterior alveolus of P_4. For a good description of the skeleton of this bear, see Merriam and Stock (1925).

Family Mustelidae

Spilogale interrupta (Rafinesque)

(Fig. 6G)

Part of a right jaw with P_3–M_1, No. 29297, of the little spotted skunk was taken. The jaw is indistinguishable from that of *Spilogale interrupta* that now frequents the area. The anteroposterior length of M_1 is 7.2 mm.

Order Proboscidea

Family Elephantidae

Mammuthus columbi (Falconer)

Two limb bones and part of a skull, No. 24381, of an old female elephant were taken in the summer of 1947, from the same deposit from which the small vertebrates and invertebrates were later recovered. The mammoth is considered a female because of the development of the tusks. The left tusk is the larger and has a diameter of 80.0 mm. at the alveolus. The right tusk is slightly longer and extends about 145.0 mm. beyond the alveolus. Ends of both are badly worn. The RM^3 is better preserved than the LM^3. Its grinding surface has 13 ridge plates. Occlusal surfaces of both right and left molars are concave. The teeth are worn down to the edge of the alveoli and the bottom of the concavity of the occlusal surface is below the alveolar border. There are 8 to 8½ ridge plates per 100.0 mm. Osborn (1942, p. 1077) gives the range of ridge plates in *Mammuthus columbi* as 5½ minimum to 8½ maximum per 100.0 mm. The anteroposterior occlusal surface of RM^3 is 164.0 mm. Its greatest width is 90.0 mm. The thickness of the enamel of the plate is approximately 3.0 mm. The specimen is assigned to *Mammuthus columbi* because the thickness of the enamel and the ridge-plate count agree with that species.

Order Lagomorpha
Family Leporidae

Fragments of three rabbit skulls and a few isolated teeth were recovered. Although the fragments comprise those of both a small and a large rabbit, it is impossible to make a positive generic identification of either.

Order Artiodactyla
Family Bovidae
Bison (*Gigantobison*) *latifrons* (Harlan)

In the summer of 1952, part of a horn core, No. 29560, of the giant bison was discovered in place. The base of the horn core was exposed in the bank of the present arroyo. Fragments of bone in the caliche rubble in the bed of the stream indicated that at least part of the skull had been present but had eroded away over a period of years. The horn core is slightly over 490 mm. long, but the extreme tip is missing. Its circumference, taken 185 mm. from the burr, is 331 mm. I am grateful to Morris Skinner of the Frick Laboratory of the American Museum of Natural History for checking the identification of this specimen.

A second phalanx, No. 29997, of the bison was collected with the bones of the short-faced bear. Greatest length of toe bone is 64.0 mm.; greatest depth, 54.0 mm.; and greatest width, 50.0 mm.

This specimen of *Bison latifrons* is the first to be found associated with a fauna. It confirms the earlier finds of this bison in Kansas as being of late Pleistocene age (Hibbard, 1948, p. 625). I know of no large bison taken in Kansas that can be considered older than Illinoian. Furthermore, the age of this specimen agrees with the late Pleistocene age of *Bison latifrons* from California (Vander Hoof, 1942). The giant bison of Mexico (Hibbard and Villa R., 1950) are also of late Pleistocene age. Because previous assignments of *Bison latifrons* in the Plains area are to an older age it was necessary to re-evaluate the sites of these earlier finds. I examined the sand and gravel pits at the west edge of Wellington, Sumner County, Kansas, which the early settlers considered to have yielded Cope's specimens (see Skinner and Kaisen, 1947, p. 209). They are the same age and horizon as the Turner Pit, 1½ miles southeast of Wellington, from which had come a nearly perfect skull of *Bison latifrons*. At this pit I collected a lower jaw of a small horse (*Equus* sp.), K.U. No. 7038. Both deposits are post-Crooked Creek formation in age. A locality 25 miles southeast of Coldwater, Kansas, on the O'Connel ranch I re-examined in the summer of 1953. Associated mollusks were taken where *B. latifrons* had been collected in 1925. The age of this deposit is Sangamon or Wisconsin.

I studied the Geist (Christy) pit, located about 5 miles north and 3.5 miles west of Scott City, Kansas (Waite, 1947, pp. 131–32, Pl. 15). Here a skull and horn cores of this bison were found. The deposit is sand and gravel of post-Crooked Creek age. Schultz and Frankforter (1946, p. 5) made a statement regarding the Geist specimen:

> The University of Nebraska State Museum recently acquired a partial skull with horn cores (U.N.S.M. No. 30361) of *B.* (*Superbison*) *latifrons* from John Newsom of Scott City, Kansas. This specimen came from gravels which are believed to be equivalent to the Grand Island of Nebraska.

Schultz and Frankforter (1946), Schultz and Stout (1948), and Schultz, Lueninghoener, and Frankforter (1948) assigned the stratigraphic occurrence of *Bison latifrons* to deposits of Kansan age in Nebraska. There is neither statigraphic nor faunal evidence to support this assignment.

Prescott (1951, p. 81) followed Schultz and his co-authors in the belief that *Bison latifrons* was an "index fossil" for deposits of assumed Kansan age. He said that

> The evidence of fossils [*B. latifrons* and *Mammuthus columbi*] indicates that at least part of the undifferentiated Pleistocene deposits in Scott County may be properly called Meade. A skull and horns of *Superbison latifrons*, a species commonly found in the lower part of the Meade, were unearthed in a gravel pit in Scott County (Waite, 1947, pp. 132–133; Colbert, 1948, p. 569).

Bison remains have never been taken from the Meade formation of Cragin or from the younger overlying Crooked Creek formation (the Meade formation of the Kansas Geological Survey) in Kansas. Prescott's statement is based on the assumption that (1) the Grand Island sand and gravel in Nebraska has yielded specimens of *B. latifrons* and (2) the Grand Island is equivalent in age to the Stump Arroyo sand and gravel, which underlies the Pearlette ash in southwestern Kansas.

Frye and Leonard (1952) considered the sand and gravel in southwestern Kansas below the Pearlette ash to be the Grand Island member (Kansan age) of their Meade formation. I use the term Stump Arroyo member for this sand and gravel in southwestern Kansas. There is no faunal or stratigraphic evidence that the Grand Island member, as defined by Frye and Leonard for deposits in southwestern Kansas, is equivalent to the Grand Island sand and gravel in Nebraska. Indeed, all evidence is against such a correlation, if *Bison latifrons* actually occurs in deposits in Nebraska equivalent in age to the type section of the Grand Island sand

and gravel. The vertebrate fossils that have been taken from the Stump Arroyo member (Grand Island member of the Kansas Geological Survey) in southwestern Kansas are *Equus* (*Plesippus*) sp., *Nannippus phlegon,* and *Stegomastodon. Mammuthus columbi* has never been found in the Crooked Creek formation, but always in deposits of younger age (Hibbard, 1951 and 1953). It is certain that *B. latifrons* cannot be used in the Plains region as an "index fossil" for deposits of Kansan? age or for the Crooked Creek formation (Meade formation of Frye and Leonard) in Kansas.

SUMMARY

The Jinglebob fauna of Meade County, Kansas, is a local fauna from interglacial (Sangamon?) deposits in the Kingsdown formation. At the time the fauna lived, a moist temperate equable climate must have existed in that part of the Plains region. Moist conditions along the stream valleys allowed a coastal-plain fauna comparable, in part, to the present coastal-plain fauna to live as far north as southwestern Kansas. Due to the presence of pine, the large molluscan fauna, the Plains box turtle, the shorttail shrew, the rice rat, and the meadow vole, it is concluded that the rainfall approximated 40 to 45 inches a year, that the winters were as warm or slightly warmer than they are now along the coastal area of Virginia and that the summers were cooler and more moist in comparison with those of the present. There was probably a complete withdrawal of glacier ice from the polar regions.

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PLATE

PLATE II

FIG. 1. Site of the Jinglebob Quarry. Shorts Creek cuts the Pleistocene stream deposits at a 90° angle. Man is standing at the west edge of the bank of the Pleistocene stream. The white bed in the bottom of the stream is Rexroad silt and caliche into which the old stream channel was cut. The Jinglebob fauna was removed from the dark sandy silt in the bed and along the banks of the stream in the foreground. Arrow marks contact between the Kingsdown formation and the overlying younger terrace.

FIG. 2. Looking south toward the High Plains surface from the site of the Jinglebob Quarry. The geological section was measured along this tributary valley.

PLATE II

Fig. 1

Fig. 2