THE LATE CENOZOIC BENSON AND CURTIS RANCH FAUNAS FROM THE SAN PEDRO VALLEY, COCHISE COUNTY, ARIZONA

by

George Eber Lammers

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GRADUATE COLLEGE

I hereby recommend that this dissertation prepared under my direction by George Eber Lammers entitled The Late Cenozoic Benson and Curtis Ranch Faunas from the San Pedro Valley, Cochise County, Arizona. be accepted as fulfilling the dissertation requirement of the degree of Doctor of Philosophy

Everett Lindsay
Dissertation Director

April 20, 1970
Date

After inspection of the dissertation, the following members of the Final Examination Committee concur in its approval and recommend its acceptance:*

E Lendell Cockrum	April 20, 1970
[illegible]	April 13, 1970
Everett Lindsay	April 13, 1970
P E Pickens	April 9, 1970
R A Thomson	April 8, 1970

*This approval and acceptance is contingent on the candidate's adequate performance and defense of this dissertation at the final oral examination. The inclusion of this sheet bound into the library copy of the dissertation is evidence of satisfactory performance at the final examination.

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SIGNED: George E. Lammers

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TABLE OF CONTENTS

TABLE OF CONTENTS, Continued — Page

TABLE OF CONTENTS, Continued — Page

LIST OF ILLUSTRATIONS

LIST OF TABLES

LIST OF TABLES, Continued

ABSTRACT

Plio-Pleistocene vertebrate faunas were found in the St. David Formation, in the vicinity of Benson and St. David, in the San Pedro River Valley, Cochise County, Arizona. The faunas consist of fish, three amphibians, five reptiles, one insectivore, one chiropteran, one edentate, six lagomorphs, three sciurids, three geomyids, six heteromyids, one castorid, seventeen cricetids, one hydrochoerid, four canids, one mustelid, three felids, two proboscideans, four equids, one tayassuid, two camelids, one cervid and two antilocaprids.

The chronologically older fauna, the Benson fauna, is early Blancan in age and the younger fauna is very early Irvingtonian age. Two new species of rodents, Peromyscus titanomys and Neotoma olseni, and one new species of dog, Borophagus minycyon, are described. The paleoecology of both the Benson and Curtis Ranch faunas are thought to be little different than is the ecology in the same area within historical time (pre-1880).

The major difference is thought to be a higher water table, pre-1880, which supported a more diversified flora and fauna, and the extinction of many of the Plio-Pleistocene fauna, especially the megafauna.

INTRODUCTION

All measurements in the following paper are given in millimeters. Capital letters are used to designate upper teeth and lower case letters refer to the lower teeth.

Abbreviations used in this work to designate institutional collections, measurements, etc., include:

AMNH - American Museum of Natural History

USNM - United States National Museum

A - Localities, University of Arizona

CIT - California Institute of Technology Material now in Los Angeles County Museum

UA - University of Arizona - Vertebrate Paleontology Collection

UAB - University of Arizona - Biology Department Collection

LACM - Los Angeles County Museum

UK - University of Kansas

WTM - West Texas Museum

KU - Kansas University

FAM - Frick American Museum

UM - University of Michigan

mm. - Millimeters

N - Number of specimens

O.R. - Observed range of measurement

$\overline{X}$ - Mean of sample

S - Standard deviation

V - Coefficient of variation

Purpose

Over the years a large number of fossil vertebrates were collected from the St. David Formation and are now in the collections of The University of Arizona. In the summer of 1963 additional prospecting, and many shorter collecting trips since that time, have added materially to the collections. The purpose of this study is to analyze this material, to identify and describe new forms collected, to compare the faunas with other North American Plio-Pleistocene faunas to establish age relationships and by examination of the faunas and lithologies to contribute to the paleoecology of the area during the concerned time.

Materials and Methods

The materials used for this study are the preserved fossil remains of vertebrates, invertebrates and plants collected from the St. David Formation, Cochise County, Arizona. The fossils were collected and are now curated and retained by the Geochronology Department of The University of Arizona.

The lithologies were examined in the field and stratigraphic sections measured to determine relative relationships of the collecting localities.

The fossils were examined in the laboratory, measured, and either compared with the published accounts of related taxa or in some cases with the actual specimens from related fossil faunas. Gross comparisons and identifications were made with specimens in the Department of Biology at the University of Arizona.

Measurements for the family Equidae are taken as though there was a rectangular figure about the maximum limits of the enamel with the long axis of the rectangle parallel to these coordinates to the outer margins of the enamel.

Mammal teeth are designated by upper case letters (e.g. I, C, P, M) for upper dentitions and lower case letters (e.g. i, c, p, m) for lower dentitions.

Previous Work

A fossil vertebrate and invertebrate fauna was first reported about 1920 in the Benson and St. David area by Kirk Bryan and G. E. P. Smith in a U.S.G.S. Water-Supply Report which was never published and has since been lost. At that time they thought the deposits to be Pleistocene, later they changed their opinion to Pliocene. J. W. Gidley collected at the "Benson quarry" during the winter of 1920 and from February to April of 1921. He published two reports the following year (Gidley 1922a, 1922b). C. W. Gilmore the same year, reported a fossil *Kinosternon*

(Gilmore 1922) from Benson. Gidley (1925) considered the Benson and Curtis Flats (now called Curtis Ranch) faunas to be of slightly different ages; he believed the Benson beds slightly older than the Blanco fauna of Texas and the Curtis Flats fauna to be somewhat younger. Gidley recognized no species common to the two Arizona fossil faunas.

Gilmore (1928) described the median portion of a right lizard dentary from Benson as Crotophytus, later corrected by Etheridge (1958) to be Cnemidophorus, and in 1938, Gilmore reported a colubrid snake from Curtis Flats. Frick (1933) gave a brief review of the mastodons from the San Pedro Valley in the Frick collections at the American Museum of Natural History. Further work included a description of a bat, Symonycteris stocki from Curtis Ranch by R. A. Stirton (1931) and a general treatment of the fauna by C. L. Gazin (1942) summarizing the known fauna and reporting new forms.

More recent published work has included J. F. Lance's (1960) consideration of Benson faunas to be late Pliocene and early Pleistocene and the Curtis Ranch to be middle Pleistocene.

Geographic and Geologic Setting

The study area (Fig. 1) is located approximately forty-five miles southeast of Tucson, Arizona in the west central portion of Cochise County. The St. David formation was examined and prospected for fossils over an approximate distance of two and one-half miles on the east and west sides of the north-flowing San Pedro River for a north-south distance of approximately ten miles.

The San Pedro River Valley appears to be a structural trough almost completely circumscribed by mountains, approximately 3750 feet above the lowest part of the river within the study area. These mountains, along with topography of lesser magnitude, define a linear basin oriented north-south. The bordering mountains could well have contributed much of the sediments making up the St. David formation, due to basinward drainage with another major source of sediments from a through-flowing stream, that may have been stopped intermittently during the period of sediment accumulation, due to lateral and vertical structural constrictions in the basin. The constrictions are the Charleston narrows, 25 miles south of Benson, primarily Tertiary-Cretaceous volcanics and the Tres Alamos narrows, 6 miles north of Benson, predominantly formed of a Precambrian granite (Gilluly, 1959).

The mountains to the west, the Whetstones, are composed of Paleozoic and Cretaceous sediments with

Precambrian metamorphic and granitic rocks. To the northwest rise the Rincon Mountains of metamorphics and granite. A composite cluster of hills to the northeast includes the Johnny Lyon Hills and the Little Dragoons, composed of largely Tertiary and Precambrian granites, and sediments deposited during Precambrian, Paleozoic, and Cretaceous intervals. The Dragoon Mountains, lying to the east, consist of granites, Paleozoic, and Cretaceous sediments, the sediments mostly metamorphosed. The southwest is bounded by the Tombstone Hills, composed largely of Tertiary granites, a few Paleozoic and Cretaceous sediments. The major topographic features of the San Pedro Valley were developed during a period of mountain building in the Cretaceous and Tertiary referred to collectively as the Laramide Orogeny.

The lack of data concerning the subsurface structural relationship between the trough form of the valley and the surrounding mountains makes it difficult to even speculate upon the structural nature of the San Pedro basin. However, field evidence indicates that subsidence has kept ahead of sedimentation as shown by the basinward thickening of sediments in the lower part of the St. David Formation which would indicate some structural activity such as faulting along the mountain fronts. The upper sediments lack this thickening toward the valley axis, and thus suggest subsidence had ceased.

Within the study area, the basin-filled deposits may be divided into three units: (a) a pre-St. David unit composed of Pliocene and older sediments; (b) the St. David Formation; and (c) granite wash and recent flood plain deposits. The St. David Formation can be divided into three subunits based on superposition and in a general way upon elevation, the sediments being nearly horizontal. The lower unit is composed mainly of red clays, mudstones with minor sands, followed at about the 3,800' contour (sea level as datum) by the second unit composed of an increase in tuffaceous units, green and red clays, brown silts and limestones. This, in turn grades vertically into coarser brown and gray-orange, silty clay and sand with paleosols and caliche beds. Six hundred feet (the above three units) of the St. David Formation are exposed in the valley. Water-laid tuffs are also common which with their contained plants and invertebrate fauna indicate intermittent damming of the through-drainage deposition of the St. David Formation.

Major folding and associated structures are rare in the St. David Formation with the exception of a monoclinal fold, with 15-30 degree dip, paralleling the axis of the valley on the west side of the valley.

Minor structural features associated with sedimentation, include cross-bedding, scour and fill, slickensides (differential compaction shears), and crumpled and contorted penecontemporaneous deformation, probably in large part due to initial dip (only 2-5 degrees) in most places.

Gray (1967) believes the source of the sediments may have been in highlands areas in Mexico as well as locally derived. He states, "Heavy mineral suites, however, do not record much transportation."

Stratigraphic sections, containing the Benson and Curtis Ranch faunas, cannot be correlated with the present knowledge. The localities (Maps, Figs. 1, 2, and 3) show good correlation from Green Saddle (A-12-1) southward to Rabbit locality (A-47-9) as shown in Fig. 4. The composite section (Fig. 5) illustrates the relative positions of localities within the area of correlation. Correlation further beyond Benson to the north or Curtis Ranch to the south or across the San Pedro River lacks continuous, traceable beds or if such beds exist are concealed by the overlying granite wash.

Fig. 1 Map of collecting sites, from Benson and St. David 15 minute quadrangles, Cochise County, Arizona.

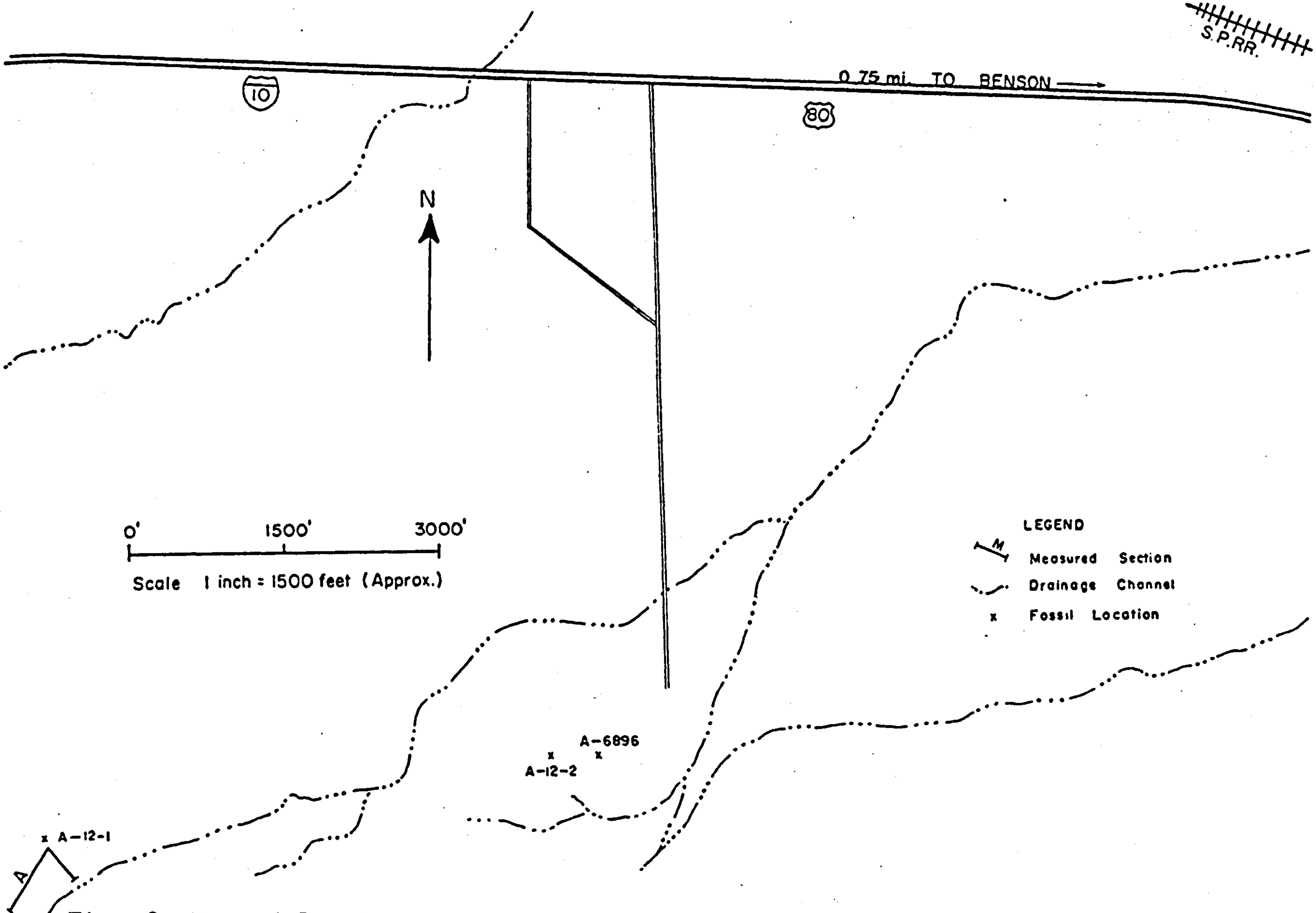


Fig. 2 Map of localities on Mendivil Ranch, sec. 8, T.17S, R.20E.

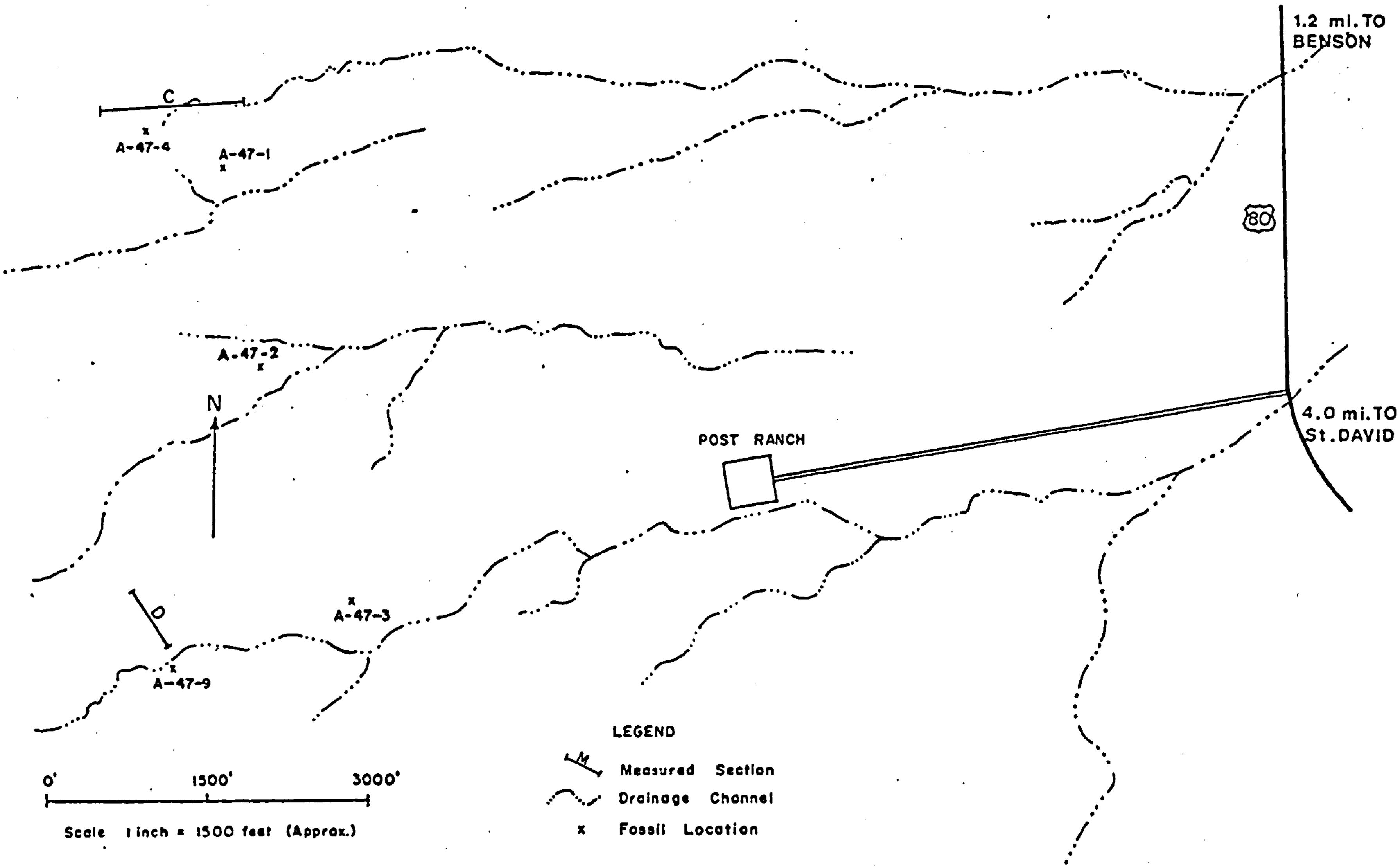


Fig. 3 Map of localities on Post Ranch, secs. 21, 22, 27, T.17S, R.20E.

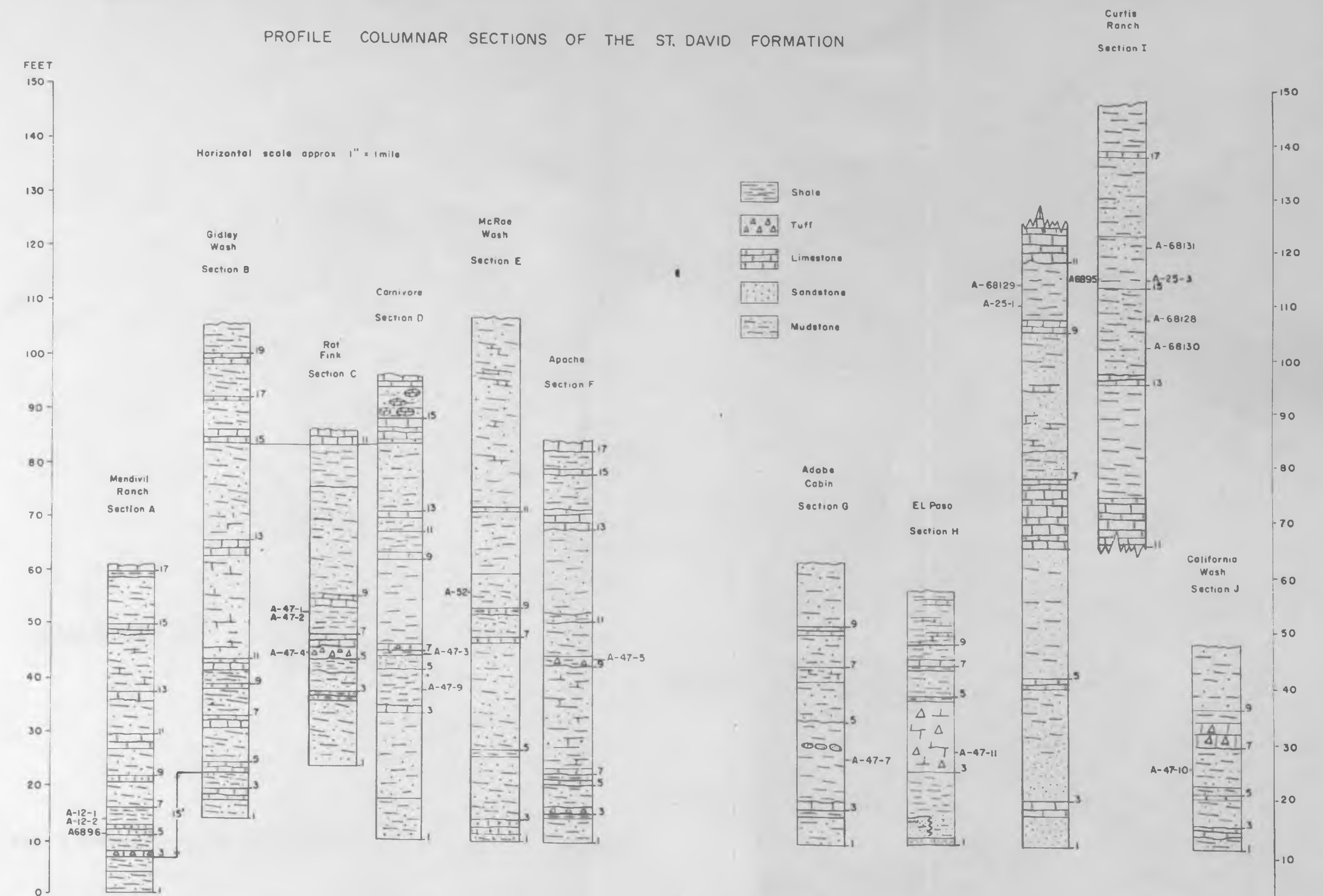
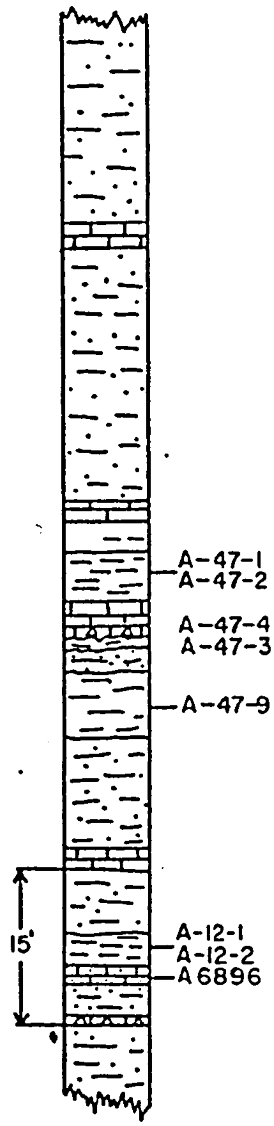


Fig. 4 Columnar Sections as measured on Fig. 1.

COMPOSITE SECTION,

MENDIVIL RANCH TO CARNIVORE LOCALITY



SCALE: 1/2" = 10'

Fig. 5 Composite section of Mendivil Ranch and Post Ranch Localities

Localities in the Benson and St. David Area

The localities are prefixed with A for Arizona. Specimens in the collection of the University of Arizona are written as fractions, the numerator being the locality and the denominator is the specimen's catalog number.

The older literature refers to the Benson and Curtis Flats faunas. In general, the Benson fauna was collected approximately two miles S.S.W. of Benson near the locality presently called Gidley Wash (Fig. 1). The specimens from Curtis Flats were collected approximately twelve miles southeast of Benson (five miles southeast of St. David) and the area is at the present time more frequently called Curtis Ranch.

Numerous vertebrate remains have been collected over the last 20-30 years as surface float without locality data. The localities used for this work (Fig. 1) are listed below with land survey descriptions.

A. A-12-1 Green Saddle, A-12-2 Devil's Lawn, and A-6896 East Side Lime, are located within a radius of one quarter mile in the SW$\frac{1}{4}$SE$\frac{1}{4}$ sec. 8,T. 17S.,R.20E.

B. A-47-1 Gray Point and A-47-4 Rat Fink are located very near to one another in secs. 21 and 22,T.17S.,R.20E., along the sections common boundary in an east-west direction.

C. A-47-2 Bentonite Quarry, A-47-3 Carnivore Local, and A-47-9 Rabbit Site are located in the NW¼, sec.27,T.17S.,R.20E.

D. A-47-5 Apache Site is located in the SE¼ sec. 34,T.17S.,R.20E.

E. A-47-7 Adobe Cabin is located in NE¼ sec. 14, T.18S.,R.20E., about one mile N30E from San Juan.

F. A-47-10 California Wash is located in SE¼ sec. 35,T.18S.,R.20E.

G. A-52 McRae Wash is located in the NE¼ sec. 34, T.17S.,R.21E.

H. A-25-1 Cal Tech is located in SW¼SE¼ sec. 23, T.18S.,R.21E.

I. A-68129 North Slope is located in SE¼SE¼ sec. 23,T.18S.,R.21E.

J. A-25-3 Rat Field (=Gidley Site) is located in NE¼ sec.25,T.18S.,R.21E.

K. A-6895 Ben Smith Site located in NE¼ sec.25, T.18S.,R.21E.

L. A-68131 Edentate Site is located in NW¼NE¼ sec.25,T.18S.,R.21E.

M. A-68128 Gass Camel Site is located in NE¼NW¼ sec.25,T.18S.,R.21E.

N. A-68130 Seff Site is located in NE$\frac{1}{4}$NW$\frac{1}{4}$ sec. 25,T.18S.,R.21E.

SYSTEMATIC DESCRIPTION OF THE FAUNA

Class Osteichthyes

Numerous fragmental bones of the class Osteichthyes were found at Green Saddle locality A-12-1, Ben Smith locality A-6895 and Rat Field A-25-3.

Class Amphibia

Order Anura

Family Bufonidae

Bufo alvarius and *B. woodhousei*

Gazin (1942) mentions amphibians from Benson, believing them to be either *Rana* or *Bufo*. Brattstrom (1955) did a study of the amphibians from both Benson and Curtis Ranch and reported *Ambystoma tigrinum* from both the Benson and Curtis Ranch faunas.

Tihen (1962) referred the Benson *Bufo* to two species, *B.* cf. *alvarius* (AMNH-3256) based on an anterior end of a coccyx and *B. woodhousei* (AMNH-3257) based on ilia and partial frontoparietal.

Class Reptilia

Gidley (1922b) reported *Testudo* and *Kinosternon* from both Benson and Curtis Ranch. Brattstrom (1955) published a comprehensive treatment of the herpetofauna (given in the faunal list) adding several new species of reptiles.

Others have also contributed to the herpetofauna and are listed under the specific subdivisions below, where discussion is warranted.

Order Squamata

Family Teiidae

Cnemidophorus sp. Etheridge 1958

Material. USNM-10690 left dentary with teeth

Gilmore (1928) described a median portion of a left dentary with pleurodont teeth from the Benson beds as the iguanid Croptophytus sp. Etheridge (1958, p. 95) states, "The description and figure of this specimen given by Gilmore indicates that the fragment should not be referred to this genus or even to the family Iguanidae. . . . The specimen may well be referrable to the teiid genus Cnemidophorus in which many species have a long series of bicuspid teeth. Brattstrom (in litt) has informed me that the specimen (USNM-10690) is labeled Cnemidophorus and that he agrees with this determination." I also agree with this interpretation.

Family Colubridae

Coluber constrictor

Gilmore (1938, p. 70) reported vertebrae USNM-13687 and USNM-3251 found at Curtis Flats as a member of the Colubridae stating, "The materials are too fragmentary for closer determination." Brattstrom (1955), with additional vertebrae collected by the California Institute of Technology, identified the vertebrae as Coluber constrictor.

Order Chelonia

Gidley (1922a) in his preliminary fauna list, showed one species of Testudo from both the Benson and Curtis Ranch faunas. He also listed a Kinosternon from each fauna, the Benson form described later by Gilmore (1922). Gidley (ibid.) also mentions a "new species of box turtle" from the Benson fauna and "a small land turtle" at Curtis Flats, which have not been reported further, nor has additional material been found.

Family Chelydridae

Kinosternon flavescens Agassiz

Kinosternon arizonense Gilmore

Materials. USNM-10463, 10462

Stratigraphic and geographic range. St. David Formation, southern Arizona, and recent fauna in Texas, Arizona northward into Colorado and Utah; through Oklahoma and Kansas to Iowa and Illinois.

Age. Blancan - Recent

Discussion. Gilmore (1922) described a new Kinosternon from the Benson locality, two miles south of Benson, collected in the summer of 1921. He felt that the new species, K. arizonense was closer to the species K. flavescens still found in the area today, than to any other living species. Gilmore (ibid., p. 2) based the new species only upon its being larger stating, "The much larger size of the fossil forms at once distinguishes them from any living species, and I therefore propose the name Kinosternon arizonense for their reception." However, I find his measurements of the type, USNM 10463, (carapace length 170 mm., width 118 mm.) within the range of the species living in the area today and therefore propose Gilmore's name be relegated to the nomen dubium and the above specimens be referred to the living species, *K. flavescens*.

Kinosternon cf. sonoriense

Material. UA-1352, portion of carapace and plastron and UA-1625, fragments of carapace and plastron

Stratigraphic and geographic range. The St. David Formation, southern Arizona at locality A-25-3 as float and as an extant species from southeastern California to western Texas in the southwest

Age. Irvingtonian-Recent

Kinosternon remains were also mentioned in a faunal list by Gidley (1922b) from Curtis Ranch; no further report was made in the literature. During the field season in the summer of 1963, diagnostic portions of skeletons of two individuals were obtained from the Curtis Flats area. Measurements of the more complete specimen are here given for comparison and appear to be well within the range of K. sonoriense and the placement and orientation of the ninth and tenth marginals are more nearly like *K. sonoriense* than *K. flavescens*.

The width of the posterior hinge of specimen UA-1352 is 36.3 millimeters in length. Length of the hypoplastral along the medial line is 12-8 millimeters and the length of the xiphiplastral along the medial line is 22.3 millimeters and lacks any indication of a v-shaped medial notch more typical of *K. flavescens*.

Family Testudinidae

Geochelone sp.

Material. UA-2569 - Nearly complete carapace, slightly crushed UA-2570 - greater part of carapace

Stratigraphic and geographic distribution. St. David Formation, southern Arizona

Age. Blancan - Irvingtonian

Examination of the numerous fragments of large turtles found at all of the localities mentioned above suggest that there are at least two forms in the Blancan fauna and perhaps a third in the Irvingtonian fauna of the St. David Formation. However, material sufficient for meaningful identification was collected only at Post Ranch. One almost complete carapace (UA-2569) and a large portion of a second (UA-2570) represent the two Blancan forms.

Description. A large turtle (UA-2569) with a low carapace having a very rugose surface, but absence of true keel. The carapace is slightly crushed dorso-ventrally. The proximal ends of pleurals two, four and probably six (this area being very crushed) are in contact with three neurals each. The peripheral bones, very poorly preserved in this specimen, extend their anterior and posterior borders directly from the edges of the pleurals. Neural four is octagonal, while three, five and seven are quadrilateral, the unmentioned neurals being too damaged to examine. The transverse diameters of the centrals are less than the antero-posterior length of the laterals. This specimen has pleurals whose anterior and posterior margins converge or diverge, depending on their alternate positions in sequence.

Specimen UA-2570, on the other hand is also a large turtle, having a proportionately higher carapace and being entirely disarticulated (with many missing portions). This specimen has heavier shell and pleurals with their anterior and posterior margins parallel.

Discussion. In 1957 Loveridge and Williams gave *Geochelone*, generic rank equal to *Testudo*. Loveridge and Williams (ibid.) as well as Hibbard (1960a) and Auffenberg (1963, 1966) have referred the large fossil land turtles of the Tertiary and the Pleistocene to the genus *Geochelone*, while Brattstrom (1961) retains *Geochelone* as a subgenus. Loveridge (op.cit.) however, in a footnote states that he favors retaining *Geochelone*, as a subgenus of *Testudo* but for the present purpose he deferred to the current trend in herpetology.

The pleurals of the above two specimens possess relative difference that has been used to place North American Cenozoic turtles either in Testudo or Gopherus. However, Hay (1908) early pointed out that in most species of Testudo and Gopherus the proximal ends of the second, fourth and sixth costals are much narrowed, while the distal ends are widened.

Assignment of the above specimens to Geochelone is based on the carapace sulci lacking a ridge, the shell being relatively thick and the transverse diameter of the centrals less than the proximal-distal length of the laterals.

Table 1. Testudinidae carapace measurements UA-2569

Total length carapace	595
Maximum width carapace	550

Table 2. Testudinidae scute measurements UA-2569

Central scute no.	Medial Antero-posterior Length	Medial Lateral Width
1	--	155
2	131	152
3	121	180
4	148	150

Lateral scute no.	Antero-posterior Width	Proximal-distal Length
1	--	157
2	135	180
3	131	193
4	114	--

Table 3. Testudinidae bony plate measurements UA-2569

Neural bone no.	Maximum Antero-posterior Length	Maximum Lateral Width
1	100	63
3	--	75
4	83	109
5	44	81
6	56	85
7	43	73

Pleural bone no.	Antero-posterior Diameter of Distal end	Antero-posterior Diameter of Proximal end	Transverse Diameter Maximum
2	81	69	159
3	67	68	179
4	82	64	178
5	77	68	193
6	--	55	--

Class Aves

Material.

Benson Fauna

Colymbus sp. coracoid

Querquedula sp. two fragmental ulnas + partial metacarpal

Dendrocygna eversa USNM-10547 proximal portion of the right humerus

Branta minuscula USNM-10548 proximal half of right humerus

Anatidae indet. three fragmentary coracoids

Colinus sp. distal end of right tarso-metatarsus

Gallinula sp. distal ends of two tibia

Corvus sp. distal portion of right tibio-tarsus

Micropalama hesternus USNM-10550 head of right humerus

Junco sp. premaxilla

Fringillidae indet. distal end of ulna and portion of another ulna

Agriocharis progenes a right tarso-metatarsus

Curtis Fauna

Odontophoridae indet. head of right humerus

Chloroehas micula USNM-10549 distal part of tarso-metatarsus

Fringillidae indet. partial ulna and proximal end of left tibia

A number of bird bones were found in the Benson-St. David area by Gidley and reported by Wetmore (1924). These birds are particularly interesting for their zoogeographical implications and will be further discussed in this section.

Brodkorb (1964) referred _Agriocharis_ sp. (illustrated) in Wetmore (1924) to _A progenes_ a species that he described from Rexroad locality 3.

A small amount of new material has been collected and is presently being studied by Alexander Wetmore.

Class Mammalia

Order Insectivora

Family Soricidae

Notiosorex crawfordi Coues

Figure 6 A,B

Material. UA-2301 left dentary with i, p4, m1,2,3

Stratigraphic and geographic range. St. David Formation, southern Arizona, locality A-47-11

Age. Blancan - Recent (Southwestern North America)

Description. Left jaw with i, p4, m3 indistinguishable from *N. crawfordi*; mental foramen beneath posterior half of m1 in a shallow depression; pigmentation apparently absent. Incisor with single lobe.

Table 4. *Notiosorex crawfordi*

Length	N	O.R.	Width	N	O.R.
p4	1	0.85		1	0.70
m1	1	1.25		1	0.80
m2	1	1.25		1	0.85
m3	1	1.05		1	0.60
p4-m3	1	4.25			
p4-m2	1	3.30			
m1-m3	1	3.60			

Discussion. _Notiosorex_ _crawfordi_ in the Benson fauna is smaller than the smallest of 66 rami of _N_. _jacksoni_ Hibbard from the Rexroad fauna, Meade County, Kansas (m1-m3 is 3.7 mm. to 4.1 mm.). In addition _N_. _crawfordi_ from Benson has a single lobe on the elongated lower incisor in contrast to two lobes in _N_. _jacksoni_. Hibbard (1950, p. 131) mentions the mental foramen "situated beneath the posterior half of m1; in a few cases the area surrounding the foramen is depressed.... The location of the foramen is as observed in _N_. _crawfordi_." Hibbard (1953, p. 32) states, "The lack of a depression around the mental foramen in _Notiosorex_ is a distinctive character as well as is the muscle attachment on the external tip of the coronoid process." Eight recent specimens of _N_. _crawfordi_ (UAB Collection) show variable development of a depression about the mental foramen. Charles A. Repenning (personal communication) concerning the depression states, "Insofar as I am aware, there is no significance to a depressed area around the mental foramen in _Notiosorex_."

Order Chiroptera

Family Vespertilionidae

cf. Simonycteris stocki Stirton

Type. CIT-394 anterior portion of skull with fragmentary teeth

New Material. UA-3232 left m1

Stratigraphic and geographic range. St. David Formation, southern Arizona, localities 52 and 25-1

Age. Blancan-Irvingtonian

Description of New Material. m1 talonid larger than trigonid; cingular development robust except lingually; protoconid higher apically than paraconid and metaconid, which are subequal; entoconid slightly higher than hypoconid; paralophid and protolophid equal, both larger than metalophid; talonid basin deeper than trigonid; trigonid basin broadly open lingually; slight development of post entoconid, cingular cusp (posteroconid) a slight posterior extension to tooth; length, 1.9 mm, width, 1.3 mm.

Discussion. R. A. Stirton (1931) reported a new genus and species of bat from the Cal Tech locality, 25-1, Curtis Ranch. The description is based upon a palate and rostrum with roots of I2-3, C, P4 minus the protocone and anterior cingulum, M1 without parastyle, M2 with mesostyle and metastyle missing and the alveolus for the M3 on the left side. Stirton (1931) stated Simonycteris stocki is close to Eptesicus, the modern genus.

Specimen UA-3232, a left m1, from locality 52 compares very closely with modern Eptesicus. It is tentatively referred to *S. stocki*, also from the St. David Formation.

Order Edentata

Family Glyptodontidae

Glyptotherium arizonae Gidley

Material. UA-1721 Carapace scutes, UA-1298, carapace scute

Stratigraphic and geographic range. St. David Formation, southern Arizona locality A-68131

Age. Irvingtonian

Gidley (1926) described *Glyptotherium arizonae* as a new species based on three specimens from the Curtis Flats locality now housed in the U. S. National Museum. Additional material includes a few scutes and scute plaques from portions of the carapace apron. A few portions of skeletal material were observed in the matrix, but were too broken for informative data.

Order Lagomorpha

Family Leporidae

Discussion. The rabbits from both the Benson and Curtis Ranch faunas have been studied recently by Joseph Downey with the United States Geological Survey and the following is primarily the results of his study.

Gidley (1922b) originally described three species (No. 1, 2, and 3) and referred one specimen to the genus *Lepus* from the Benson locality. Gazin (1942) referred Gidley's species No. 2 to the genus *Hypolagus*. Species No. 3 of Gidley (ibid.) was identified only as Leporid by Gazin (ibid.). Gazin assigned new material to *Sylvilagus bensonensis*.

The material that Gidley (1922b) had assigned to species No. 3 was referred to *Sylvilagus* sp., near *Sylvilagus floridanus* by Gazin (1942). New material collected in 1936 was placed in the genus *Lepus* sp., near *Lepus californicus* by Gazin (ibid.).

Dawson (1958) in her paper on later Tertiary Leporidae of North America retained the material assigned to *Sylvilagus bensonensis* Gazin, but suggested it was very close to *Pratilepus kansasensis*.

At the present time Joseph Downey (in press) lists the following rabbits from the Benson and Curtis Ranch fauna.

Benson	Curtis Ranch
Auralagus bensonensis	*Lepus*
Nekrolagus sp.	*Aluralagus*
Hypolagus sp.	
Notolagus sp.	

Order Rodentia

Rodents abound in the small mammal fauna of the St. David deposits. In a few places local accumulations appear to be disassociated owl pellets. Six families of rodents are represented, the majority of taxa and specimens being heteromyids and cricetids.

Family Sciuridae

Citellus bensoni Gidley 1922

Type. USNM-10531, right M1 or M2 and left m3

Material. UA-2698 left P4, UA-2699, right M1, UA-3060 left M3, UA1516 left dentary p4-m3, UA-3056 left m2, UA-1520 right m2

Stratigraphic and geographic range. St. David Formation, southern Arizona at localities A-52, A-47-1 and A-47-7, and Irvington fauna, California

Age. Blancan-Irvingtonian

Emended diagnosis. Metastylid absent, depth of labial valley between protoconid and hypoconid deep and with very angular internal corners.

Description. P4 rectangular occlusal outline with parastyle forming noticeable anterior projection in antero-lingual margin; metaconule closely joined to metacone and with distinct break with protocone; posterior cingulum does not reach medial margin; metastyle absent; protoloph lacks well defined cusps; metaloph not connected to protocone.

M1 subtriangular occlusal outline, narrowing lingually; with rounded margin lingual to protocone; metacone slightly larger than paracone; protocone large with gentle sloping medial surface; metaconule near metacone in size, protoconule absent; metaloph with distinct break near protocone, except after extreme wear; parastyle distinct, but not greatly enlarged; posterior cingulum faint lingually; mesostyle small.

M3 similar to M1, small talonid, posterior detail obliterated through wear pattern.

p4 subtriangular in outline; labial valley between protoconid and hypoconid with broad flat face; protoconid relatively lower than the rest of the occlusal surface; protoconid and metaconid close.

m1 subquadrate to rhomboidal occlusal pattern, narrows anteriorly; protoconid and hypoconid subequal; entoconid prominent; mesostylid indistinct; metalophid and posterolophid equally developed; anterior cingulum and metalophid meet midway across occlusal surface; mesoconid absent; labial valley with broad flat medial base.

m2 differs from m1 in larger size, more rhomboidal occlusal pattern due to anterior shift of lingual half; metaconid distinctly higher than other cusps; posterolingual basin deep due to wear and with prominent lingual flexid; labial valley with broad flat base; with excessive wear tooth loses posterolingual corner; poorly developed metalophid.

m3 subtriangular occlusal surface; metaconid high forming angular anterolingual prominence, accentuated due to wear pattern, mesostylid in cingular development with posterolophid; labial valley with broad, flat outline becoming V-shaped with excessive wear; entoconid deemphasized by formation of lingual basin.

Table 5. Citellus bensoni

Length	N	O.R.	$\bar{X}$	Width	N	O.R.	$\bar{X}$
P4	1	2.10			1	2.90	
M1	1	2.50			1	3.10	
M3	1	2.30			1	2.40	
p4	1	2.00			1	2.05	
m1	1	2.25			1	2.65	
m2	3	2.50-2.90	2.77		3	2.50-2.90	2.88
m3	1	3.35			1	3.00	
p4-m3	1	9.20					

Discussion. Citellus bensoni differs from C. dotti Hibbard (1954) from the Rexroad Formation, Beaver County, Oklahoma in being slightly larger and lacks the metastylid and an enamel pit between the protoconid and metaconid of the m1 and m2. The m2 of C. dotti is rectangular as compared to the rhomboidal shape of C. bensoni. In general the cusps of *C. bensoni* are less robust and the lingual valleys are more rectangular than in *C. dotti*.

C. bensoni differs from *C. rexroadensis* Hibbard (1941c) from the Rexroad fauna, Meade County, Kansas, in having the p4 more triangular than rectangular and a de-emphasis of the protoconid. The labial valley of the lower molars of *C. rexroadensis* are more V-shaped.

C. bensoni is slightly larger than *C. howelli* Hibbard (1941a) from the Rexroad fauna, Meade County, Kansas, and the molars are not so quadrate. p4 of *C. bensoni* is less molariform and the labial valleys of all teeth not as broad.

Characters displayed on specimens of *C. bensoni* are very similar to the extant species *C. lateralis* and *C. beecheyi*, being more near the former in size and dental cusp pattern. Except the specimens reported here being smaller, there is close agreement of characters with the paratype of *C. bensoni* as described by Gidley (1922b).

Citellus cochisei Gidley 1922

Figure 6 C

Type. USNM-10490, portion of right maxillary with all cheek teeth

Referred material. UA-1586 left P4, M1, right M1,3, UA-3182 right m1 and UA-1699 left m1-3

Stratigraphic and geographic range. St. David Formation, southern Arizona at localities A-6895 and A-25-3

Age. Irvingtonian

Description. P4 triangular occlusal outline with concave anterolingual border to fit appressed P3; paracone greatly reduced in protoloph; metacone separate from protocone, but contacts posterior cingulum at posterolabial border; anterior cingulum weakly developed with only minor parastyle development; protocone prominent.

M1 triangular occlusal outline with distinct narrowing medially; anterior cingulum low; metacone more cuspate than paracone and subequal in size; protoconule absent; metaconule weakly developed; mesostyle weak; protocone with steep lingual slope.

M3 subtriangular occlusal outline; paracone prominent; parastyle present with thin anterior cingulum connection to protocone; anterior cingulum flexed posteriorly to join protoloph and protocone; metaconule present; metaconule and metastyle present.

m1 rhomboidal occlusal outline; metaconid larger than entoconid, and medial relative to entoconid; protoconid larger than hypoconid; anterior cingulum more prominent than metalophid; posterior cingulum absent; mesostylid present; mesoconid absent; ectolophid straight, forming inner margin of square labial valley.

m2 differs from m1 in larger size; more quadrate occlusal outline.

m3 subtriangular occlusal outline; similar to other lower molars except with deeper basin and more prominent talonid; posterolophid continues from hypoconid to entoconid; ectolophid rounded.

Table 6. Citellus cochisei

Length	N	O.R.	$\bar{X}$	Width	N	O.R.
P4	1	1.50			1	1.90
M1	1	1.70			1	2.40
M3	1	2.20			1	2.40
m1	2	1.90-2.20	2.05		2	2.40
m2	1	2.40			1	2.50
m3	1	3.20			1	2.40
m1-3	1	6.80				

Discussion. Size and cusp positions, especially the lowers, of *Citellus cochisei* are very close to *C. mexicanus*.

Citellus cochisei is slightly larger than *C. bensoni* and has more pronounced anteroposteriorly compressed lophs with reduction of cusps.

Citellus cochisei differs from *C. tuitus* Hay (1921) from Val Verde, Arizona, in that the former's protocone is distinctly less robust. *C. cochisei* also lacks the posterior convergence of the upper teeth displayed in *C. tuitus*.

C. cochisei is very close to C. dotti Hibbard (1954b) from the Rexroad Formation, Beaver County, Oklahoma; however, C. dotti has more square teeth and wider labial valleys between the protoconid and hypoconid according to Hibbard. This similarity suggests close relationship between the two.

Citellus howelli Hibbard (1941a) from the Rexroad faunas may be distinguished on size alone, the former being much smaller, while C. rexroadensis Hibbard (ibid.) from the same deposits is noticeably larger than C. cochisei.

Both Citellus megheei Strain (1966) and C. finlayensis Strain (ibid.) from Hudspeth County, Texas, are much larger than C. cochisei. C. megheei has P4, 2.5 mm. long and 3.0 mm. wide, M1 2.4 mm. long, 3.3 mm. wide, and m3, 3.2 mm. long and 3.7 mm. wide. C. finlayensis has a p4-m3 length of 10.5 mm.

Citellus sp.

One specimen of a large ground squirrel was collected from Curtis Ranch. Dentition, size and cusp arrangement are similar to the living species Citellus variegatus.

Hypodigm. UA-1694, m2, 3 right dentary fragment

Stratigraphic and geographic range. St. David Formation, southern Arizona A-25-3

Age. Hemingfordian-Recent

Description. m2 rhomboidal occlusal outline, wider anteriorly; entoconid and hypoconid relatively low; metalophid and anterior cingulum coalesced; ectolophid thins posteriorly; mesostylid and mesoconid absent; posterior cingulum low, arcuate, and continuous from hypoconid to entoconid; labial valley trapezoidal shaped with medial base.

m3 very similar to m2, with relatively larger basin; basin having posteromedial ridge extending anterolabially and ridge concave medially, transverse thinning results in the appression of the entoconid and hypoconid.

Table 7. Citellus sp.

Length	N	O.R.	Width	N.	O.R.
m2	1	2.70		1	2.90
m3	1	3.70		1	2.90
Alveolar	1	11.70			

Discussion. Citellus bensoni and C. cochisei from the St. David Formation, C. rexroadensis Hibbard (1941a), C. howelli Hibbard, (1941a), and C. meadensis Hibbard, (1941b) from the Rexroad fauna, Meade County, Kansas, C. dotti Hibbard, (1954b)from the upper Pliocene deposits, Beaver County, Oklahoma and C. tuitus Hay, (1921) from the Val Verde Mine, Coconino County, Arizona are significantly smaller than Citellus sp. (UA-1694).

While *Citellus cragini* Hibbard, (1941b) from the Borchers fauna, Meade County, Kansas, is described only from upper molars, the lower dentition from Curtis Ranch seems relatively smaller.

Citellus sp. probably represents a new species, but specific taxonomic assignment is deferred until more material is available.

Family Geomyidae

<u>Geomys</u> (<u>Nerterogeomys</u>) <u>minor</u> (Gidley)

<u>Geomys</u> <u>minor</u> Gidley 1922

<u>Nerterogeomys</u> ? <u>minor</u> Gazin 1942

<u>Type</u>. USNM-10494, fragment of right dentary lacking m3

<u>New Material</u>. UA-1512 2 incisors, UA-1478 left p4, UA-540c left p4, UA-1864 right p4, m1-3, UA-3228 right p4, UA-3227 left p4, UA-3157 left M1, UA-3156 LM1, UA-3058 right M2, UA-3185 LM2, UA-2484 Lp4, UA-1506 right dentary p4-m3

<u>Stratigraphic and geographic range</u>. St. David Formation, southern Arizona at localities A-12-1, A-6896, A-47-1, A-47-4, and A-47-5, and Rexroad fauna, in Meade County, Kansas.

<u>Age</u>. Blancan

<u>Description</u>. P4 protoloph and metaloph flattened ovals; labial and lingual valleys with square corners, containing cement; dentine tracts along lingual and labial borders of column; lateral valley walls converge toward base; posterior enamel plate terminates near base of tooth; roots never close.

M1 or 2 transverse oval in occlusal outline; anterior and posterior enamel plate present; dentine tracts labially and lingually; concave curvature of column lingually and posteriorly.

p4 metalophid elliptical in occlusal outline; protolophid elliptical to round in occlusal outline; protolophid from two-thirds to nearly as wide as metalophid; lingual and labial valleys with square internal corners, filled with cement; anterior enamel plate of protolophid one-third to one-half width of protolophid; dentine tracts labially and lingually on protolophid and metalophid.

m1 elliptical occlusal outline with relatively flatter anterior surface and slightly longer lingually; posterior enamel plate present.

m2 differs from m1 in slightly shorter anteroposterior length.

m3 subquadrate in occlusal outline, with relatively more angular labial corners; posterior enamel plate present; lingual and labial dentine tracts; distinct labial groove persists to base of tooth.

Table 8. Geomys (Nerterogeomys) minor

Length	N	O.R.	$\bar{X}$	Width	N	O.R.	$\bar{X}$
P4	1	2.20			1	2.20	
M1	2	1.10-1.20	1.15		2	2.00-2.20	2.10
M2	2	1.00			2	1.50-1.90	1.70
p4	6	2.20-2.65	2.49		6	2.05-2.50	2.30
m1	2	1.30-1.60	1.45		2	2.30-2.50	2.40
m2	2	1.20-1.50	1.35		2	2.30-2.40	2.35
m3	1	1.30			1	1.90	
p4-m3	1	8.80					

Discussion. Some Geomys minor specimens from the St. David Formation compare specifically with specimens of G. minor as described by Hibbard (1950) from the Fox Canyon fauna. Other specimens do not compare favorably which may be due to age and individual variation as suggested by Hibbard (1950) or different species as recognized by Hibbard (1967). G. minor from the Benson fauna is much larger and has more open valleys than G. adamsi Hibbard (ibid.) and G. jacobi Hibbard (ibid.) both from the Fox Canyon fauna. G. minor is much larger than G. smithi Hibbard (ibid.) from the Fox Canyon local fauna and G. smithi lacks the lingual dentine tract on the protolophid that is present on p4 of G. minor.

Geomys minor differs from G. quinni McGrew (1944) from the Sand Draw fauna of Nebraska, in having more angular medial corners to the lingual and labial valleys in the P4, p4, and an anteroposteriorly much flatter occlusal outline to the protoloph of the P4.

G. minor can be distinguished from G. tobinensis, Hibbard (1944) from the Meade Formation, Kansas, in having proportionally larger reentrant valleys and more angular medial junction with the enamel plates.

G. minor is much larger than Pliogeomys buisi Hibbard (1954b)from the Rexroad Formation in Oklahoma and lacks the roots of p4 which are present in P. buisi. P. buisi has more rounded medial contours to the medial surfaces of the reentrant valleys.

G. garbanii White and Downs (1961) from the Vallecito Creek fauna in California differs from G. minor in having a longer cheek tooth row (average for G. garbanii 10.5 mm.).

Although the range in dental pattern in some of the specimens of G. paenebursarius Strain (1966) from the Ft. Hancock Formation might include some specimens of G. minor the great difference in occlusal length (6.4 mm. in the former and 8.8 mm. in the latter) would prevent their being the same species.

Gidley (1922b)assigned a lower jaw to Geomys on the basis of an associated upper incisor. The new material reported here is referred to the same genus because of its morphologic similarity to modern Geomys. Gazin (1942) assigned Gidley's material to the new genus Nerterogeomys based primarily on enamel being found on the posterior wall of the P4, the protoloph (anterior column) being narrow, both characters being "more as in Thomomys," upper incisors grooved and anterior walls of lower molars without enamel as in Geomys, mental foramen below the anterior extremity of the masseteric crest, and rostrum more depressed anteriorly with respect to plane of the cheek teeth. White and Downs (1961, p. 25) state, "The variability in position of the mental foramen with respect to the anterior extent of the masseteric scar, as well as variability in the presence or absence of enamel on the posterior wall of P4 in G. garbanii, suggests the possibility that Nerterogeomys, like Parageomys (Hibbard), might be considered a subgenus of the genus Geomys." White and Downs also state (ibid.) that in G. garbanii and G. tobinensis there is a delay in interruption of the enamel pattern of P4, p4, but is not known in any specimen of Nerterogeomys. This interruption is noted in some of the St. David Formation specimens.

In the modern genus, Geomys, the unworn cheek teeth are completely enveloped with an enamel cap which wears to four enamel plates of the adult premolar and the single plate of the molars. The height of this cap is unknown as specimens with an unworn enamel cap are rare in collections. Merriam (1895) states that in only four specimens (in excess of 1000 specimens studied) did he observe deciduous premolars and unworn crowns of some of the molars. The fact that Geomys does have an enamel cap on the premolars prior to use, would indicate that at an early stage of ontological development there is a complete encirclement of the premolar by enamel. One specimen, UA-3228, a P4, from the Benson fauna does have a relatively deep posterior enamel band and may well indicate an early growth stage.

Geomys (Nerterogeomys) persimilus (Hay)

Geomys parvidens Gidley 1922b, nec G. parvidens Brown

Geomys persimilus Hay 1927, a renaming of Geomys parvidens Gidley 1922

Nerterogeomys persimilus Gazin 1942

Type. USNM-10492 anterior portion of skull with all teeth except right P4 and M3

New Material. UA-3183 P4, UA-3188 right and left P4 in maxillary fragment, UA-3229 right p4, UA-3183 P4, UA-3230 left dentary with p4-m3

Stratigraphic and geographic range. St. David Formation, southern Arizona localities A-25-3, A-6895, and A-68128

Age. Irvingtonian

Description. P4 protoloph flattened oval with transverse axis concave posteriorly in occlusal outline; metaloph, flattened ellipsoid with transverse axis concave anteriorly; reentrant valleys narrower laterally, filled with cement; isthmus connecting protoloph and metaloph narrow and slightly convergent anteriorly; lateral dentine bands on protoloph; enamel plate on entire anterior surface of protoloph.

p4 protolophid oval in occlusal outline with a flattened posterior margin; metalophid elliptical with transverse axis concave anteriorly; transverse valley closed, filled with cement; metalophid and protolophid with dentine tracts.

m1 oval occlusal outline, slightly straighter anterior and labial margin; enamel plates present on posterior side.

m2 differs from m1 in a more convex anterior occlusal outline.

m3 subtriangular occlusal outline with broad anterior base; enamel band on posterior surface only.

Table 9. Geomys (Nerterogeomys) persimilus

Length	N	O.R.	$\bar{X}$	Width	N	O.R.	$\bar{X}$
P4	2	2.00			2	1.80-2.00	1.90
p4	3	2.00-2.20	2.07		3	1.60-1.90	1.77
m1	1	1.00			1	2.10	
m2	1	1.00			1	2.00	
m3	1	1.00			1	1.70	
p4-m3	1	6.50					

Discussion. *Geomys persimilus* is distinguished from *G. minor* of the Blancan fauna of the St. David Formation in: 1) a smaller P4, 2) more nearly circular outline of the molars, and 3) the molars with flatter external border in occlusal outline.

Enamel on the posterior face of the P4 differentiates *G. persimilus* from *G. paenebursarius* Strain (1966) from the Fort Hancock Formation of Texas.

G. persimilus differs from *Pliogeomys buisi* Hibbard (1954b)from the Rexroad Formation in having shorter occlusal length and closed reentrant valleys in the p4.

G. persimilus differs from *G. tobinensis* Hibbard (1944) from the Meade Formation in having enamel plates subtriangular, closing the reentrant valleys.

G. quinni McGrew (1944) from the Sand Draw, Nebraska fauna has a much wider isthmus in the P4, p4 and open transverse valleys in contrast to closed transverse valleys in *G. persimilus*. The m3 of *G. quinni* is also more oval.

G. adamsi Hibbard (1967) from the Fox Canyon fauna is a much smaller gopher (p4-m3, 5.2 mm.) and the transverse valleys pf P4, p4 are much more open than in *G. persimilus*.

G. jacobi Hibbard (1967) from the Rexroad local fauna has much more open valleys than *G. persimilus* and the protolophid is smaller than the metalophid.

G. smithi Hibbard (1967) from the Fox Canyon local fauna is slightly larger (p4-m3, 6.7 mm.) than *G. persimilus* and the valley of p4 is more open than in *G. persimilus*.

Gidley (1922b) originally assigned specimens from the Curtis Ranch fauna to *Geomys parvidens* a name already occupied by *G. parvidens* Brown. Hay (1927) assigned the new name *G. persimilus*. Gazin (1942) then placed the specimen in his new genus *Nerterogeomys*. *Nerterogeomys* is used as a subgenus for this species for the same reasons given for *Geomys minor*.

In the above description, the P4, p4 was described as having "closed" reentrant valleys or the walls converging laterally. In the type of *Geomys persimilus*, (USNM-10492) and a described lower jaw (USNM-10493), the valleys are open.

Geomys persimilus is closer than *G. minor* to modern species of *Geomys* in the convergence of the reentrant valley walls of the P4, p4 and the proportionally shorter (anteroposteriorly) diameter of the upper and lower molars, suggesting an evolutionary gradation of these characters.

Specimen UA-3229 is included in *Geomys persimilus*, but has the posterior enamel plate of P4 restricted to the inner side. This character would allow its taxonomic placement in the *Ortho*-*Macro*-*Heterogeomys* group.

The morphological character in question may be an advanced wear facet due to abrasion, breakage of a plate as in *Thomomys*, or a diagnostic generic character. If the latter, it is nearer *Heterogeomys*, the geographically closer living genus. If it is a wear facet or breakage feature, the morphological character would suggest *Thomomys* or the remnant of an early stage of the enamel cap, although it appears too symmetrical for this last interpretation.

Cratogeomys bensoni Gidley 1922

Type. USNM-10495 fragmental left dentary with all cheek teeth.

New Material. UA-1613 portion of skull and jaws with teeth.

Stratigraphic and geographic range. St. David Formation, southern Arizona locality A-12-1

Age. Blancan

Description.

I trapezoidal in occlusal outline; enamel plate on anterior surface only; single deep medial sulcus on the anterior face.

P4 lingual valley deeper than labial valley; lingual valleys with rounded labial corners and labial valleys with angular medial corners; metaloph lacks posterior enamel plate; protoloph with dentine tracts.

M1 oval occlusal outline; flattened anteroposteriorly; posterior enamel plate absent.

p4 lingual valley deeper than labial valley, both with rounded corners; labial valley opens with diverging sides; protolophid lacks enamel on anterior face, except possibly some at the very base; talonid with labial and lingual dentine tracts.

m1 flattened oval occlusal outline, flattened anteroposteriorly; anterior enamel plate absent.

m2 same as m1.

m3 differs from m1, 2 in being longer anteroposteriorly and therefore more nearly oval in occlusal outline.

Table 10. Measurements of _Cratogeomys bensoni_

Length	N	O.R.	Width	N	O.R.
P4	1	2.40		1	2.70
M1	1	1.20		1	1.80
M2	1	1.25		1	2.30
M3	1	1.60		1	2.60
p4	1	1.70		1	2.00
m1	1	1.40		1	2.60
m2	1	1.60		1	2.60

Discussion. The p4 of _Cratogeomys_ cf. _tylorhinus_ described by Hibbard (1955a) from the upper Becerra Formation in Mexico, has a more trigonal occlusal outline in addition to the presence of an anterolingual groove or shallow concavity in the metalophid.

Gidley (1922b) named Cratogeomys bensoni on the basis of a portion of a left dentary with all of the cheek teeth and associated upper incisor. Gazin (1942) agrees with this identification and amended the diagnosis by recognizing the slightly more open reentrants in the p4 and the elongate isthmus connecting the protolophid and metalophid (as compared to Geomys). Specimen UA-1613 is very similar to the material assigned by Gidley. Morphologic characters used for this taxonomic assignment, are not very reliable when comparing the recent genera and may not be significant in the fossil record when larger samples are available. On the other hand, post-Blancan convergence could well take place in these two genera.

Gidley (ibid.) did not recognize any taxonomic significance in the distinctive parallel enamel ridges on the posterior face of the m3 in the type (USNM-10495). None of the material later assigned this species, the four jaws assigned by Gazin (ibid.) and UA-1613 have this distinctive feature. The two ridges are bordered laterally by two shallow grooves of about the width of the ridges and the ridges surround a medial dentine tract open to the outside of the tooth.

The specimen described consists of skull and jaws found associated and were separated from the genera Geomys and Thomomys by the unisulcate incisors and the absence of an enamel plate on the M1.

Family Heteromyidae

Perognathus rexroadensis Hibbard 1959

Holotype UM-24793 left ramus, p4-m3, Fox Canyon, Rexroad fauna, Meade County, Kansas.

New Material. UA-2679 right p4, UA-2695 left M1, UA-2696 right M1, UA-2475 left mandibular fragment, p4, UA-3158 left m1, UA-3239 right m1, UA-2680 left m2.

Stratigraphic and geographic range. St. David Formation, southern Arizona, localities A-47-1, A-52, A-47-3, A-6896 and Rexroad Formation, Meade County, Kansas.

Age. Blancan

Description. P4 triangular occlusal outline; slight constriction between protoloph and metaloph; protoloph single cusped; metaloph three cusped; hypocone slightly posterior to metacone and hypostyle, metaloph thus crescentic; hypostyle elongate with an anteroposterior orientation.

M1 occlusal pattern U-shaped open labially; protoloph three cusped; protocone smaller than subequal paracone and parastyle; protolophule absent; metaloph three cusped; with hypostyle to transverse valley completing bottom to U-shaped; metacone and hypocone subequal; posterior cingulum incipient.

M3 smaller than M2; protostyle relatively larger than subequal paracone and protocone; posterior cingulum taper labially, blade like in form; hypocone and metacone absent; transverse valley closed lingually.

p4 two cusps each in protolophid and metalophid; protoconid large and slightly anterior to protostylid; protoconid unites with metaconid by medial lophid; metaconid and hypoconid subequal; protolophid relatively higher than metalophid.

m1 hypolophid thinner than metalophid, both lophids with three cusps; entoconid and hypoconid subequal, both larger than hypostylid; metalophid largest between protoconid and protostylid; metaconid and protoconid subequal, both larger than protostylid; anterior cingulum connects protostylid and stylar cuspid anterolabial to metaconid.

m2 hypolophid lower and thinner than metalophid, both having three cusps; protoconid and metaconid subequal; protostylid elongate anteroposteriorly; anterior cingulum continuous from protostylid to metaconid; entoconid and hypoconid subequal, both larger than hypostylid; posterior cingulum thin and continuous from entoconid to hypostylid.

Table 11. Perognathus rexroadensis

Length	N	O.R.	$\bar{X}$	Width	N	O.R.	$\bar{X}$
P4	1	0.80			1	1.00	
M1	3	0.90-1.15	1.05		3	1.50-1.80	1.67
M3	1	0.50			1	0.65	
p4	1	1.10			1	0.90	
m1	2	0.70-0.80	0.75		2	1.00-1.10	1.05
m2	1	0.80			1	0.85	

Discussion. Perognathus rexroadensis doesn't have the distinct X-pattern of cusps in the p4 mentioned by Hibbard for P. gidleyi Hibbard (1941c) from the Rexroad fauna. The p4 of P. rexroadensis is distinctly smaller and the transverse diameter of the m1 and m2 is smaller than P. gidleyi. The lower molars of P. rexroadensis would form a U-shaped pattern with wear rather than an H-shaped pattern for P. gidleyi.

P. rexroadensis differs from P. pearlettensis Hibbard (1947) from the Sanders fauna, Kansas, Borchers fauna, and the Fox Canyon, Rexroad fauna in a larger size. P. rexroadensis from the Benson fauna also lacks the posteriorly directed protostylid present in P. pearlettensis.

P. mclaughlini Hibbard (1949) from the Saw Rock fauna and the Buis Ranch fauna has a very shallow external reentrant in the p4 which does not separate the anterior lophid from the posterior lophid. In P. rexroadensis from the Benson fauna there is a distinct separation of the protostylid and hypostylid.

The transverse diameter of the lower cheek teeth of P. dunklei Hibbard (1944) from the Edson fauna, Sherman County, Kansas, are much narrower than P. rexroadensis of the Benson fauna in addition to the p4 having an X-pattern of the cusps, not present in the Benson species. The lower molars of P. dunklei wear into an H-pattern and P. rexroadensis develops a U-pattern.

P. rexroadensis from the Benson fauna agrees closely with P. rexroadensis from the Rexroad fauna, especially in characters of the P4, p4 and the size of all the teeth. The slight differences between specimens from the two populations are probably the result of individual variations.

Perognathus sp.

Material. UA-3186 left P4, UA-3199 left p4

Stratigraphic and geographic range. St. David Formation, southern Arizona localities A-6895 and A-68128

Age. Barstovian-Recent

Description. P4 protoloph single cusped, tilted posteriorly; protocone on continuous axis with anterior root; metaloph crescent shaped, concave anteriorly; metacone and hypostyle subequal and larger than hypocone; length 1.0 mm. and width 1.0 mm.

p4 subtriangular in outline; protolophid and metalophid connection slightly labial of median; protoconid and protostylid appressed; posterior cingulum well developed, only slightly narrower than metalophid; lingual cingulum connects protoconid and metaconid; length 1.2 mm. and width 1.1 mm.

Discussion. Wood (1935) first mentioned Perognathus assigning specimen AMNH-27791 to Perognathus sp. indet. based on a small and comparatively recent jaw. The jaw had no teeth. Precise taxonomic assignment is deferred until additional material is known.

Perognathus sp.

Material. UA-3200 right p4

Stratigraphic and geographic range. St. David Formation, southern Arizona locality A-68128

Age. Barstovian-Recent

Description. dp4 tetracuspidate in occlusal outline; two cusps each on protolophid and metalophid, subequal; protoconid highest cusp; slight development of a posteroconid; posterolabial to and appressed to metaconid. Anteroposterior length 0.7 mm., transverse diameter 0.7mm.

Discussion. This specimen is comparable to the modern species of Perognathus merriami in size, but having the unique posteroconid not found on other species in the literature or several recent species examined. Additional material would be needed to see if this was an aberrant morphological character or of taxonomic importance.

Dipodomys minor Gidley 1922

(non) Prodipodomys minor Gazin 1942

Type. USNM-10499, right lower dentary with p4 from the Benson fauna

New Material. UA-3103 right m2, UA-3104 right m1, UA-3063 left p4

Stratigraphic and geographic range. St. David Formation, southern Arizona localities A-12-1, A-52, A-6896

Age. Blancan

Description. P4 slight restriction in occlusal outline between protoloph and metaloph; protoloph single cusped; transverse valley open lingually until extreme wear; base of crown lower in protoloph; cingulum absent; vertical axis of tooth strongly concave anteriorly.

p4 two lophids containing four cusps; slight lingual curvature to protolophid; protolophid thinner than metalophid; protoconid and protostylid subequal, separated by anterior valley; protostylid slightly anterior to protoconid; lingual and labial valleys subequal; metaconid and hypoconid subequal; not rooted.

m1 metalophid and hypolophid form H-pattern in occlusal outline, median union between the protoconid and hypoconid; labial thickness of metalophid greater than lingual; transverse valley deep, open lingually and labially; base of crown lowest at posterior margin of hypolophid; labial and lingual inflection continuous to base of crown; not rooted.

m2 differs from m1 in smaller size; labial and lingual inflection not continuous to base of crown.

Table 12. Dipodomys minor

Length	N	O.R.	Width	N	O.R.	$\bar{X}$
P4	2	0.80		2	1.00-1.20	1.10
p4	1	1.70		1	1.80	
m1	1	1.00		1	1.50	
m2	1	0.90		1	1.40	

Discussion. Hibbard (1952) states that Prodipodomys kansensis Hibbard from the Saw Rock Canyon does not appear as advanced as P. minor (Gidley) which may be true if comparison is made of the Saw Rock and Benson specimens of Prodipodomys, however this comparison was with the specimens assigned to Dipodomys in this study.

Gidley (1922b) described Dipodomys minor from the Benson fauna. Wood (1935) referred specimen AMNH-27790 right lower jaw with p4-m1 from Curtis Ranch to this same species, giving as one of the diagnostic characters, the enamel is "complete on all portions of p4-m1 (p. 156) without any trace of a break....." Wood also states that there are no visible roots in the Curtis Ranch specimen.

Gazin (1942) interpreted the alveolus of m1 to show the m1 rooted and placed Gidley's type in genus Prodipodomys. Gazin (ibid.) also placed specimen AMNH-21835 LP4-M1 (considered Cupidinimus major by Wood) in Prodipodomys ? minor. Hibbard (1954a) concurs with this judgment, but did not comment on rooted or non-rooted condition of the Benson specimens.

Specimen AMNH-27790, probably does not represent Dipodomys in the Benson fauna. To my knowledge this would be the only known locality where Prodipodomys and Dipodomys occur together suggesting their derivation of the latter from the former or the co-occurrence of the two genera for a short time. Gidley's original type does appear rootless and thus Wood's specimen and Gidley's type are probably of different genera. Wood's (1935) description of rooted teeth from Benson, which he placed in Cupidinimus magnus, markedly hypsodont, should probably be in the genus Prodipodomys. Wood (ibid.) does not mention if all of the teeth that he assigned to the genus Cupidinimus are rooted or rootless. Thus, there seems to be two genera of hypsodont heteromyids in the Benson fauna, Dipodomys (non-rooted) and Prodipodomys (rooted). No additional rooted hypsodont heteromyids have been collected.

The genus Dipodomys was differentiated from teeth of Perognathus in the collection primarily on size, the former generally being larger. Perognathus' lophs of lower molars unite at the buccal margin primitively and progress to an H pattern. The lower premolar has an X-pattern to lophs. Upper premolars have an H-pattern, the protoloph being single cusped. *Dipodomys* adult teeth are limited in enamel to anterior and posterior plates soon having a broken oval occlusal pattern. *Dipodomys* teeth are comparatively more hypsodont.

Dipodomys gidleyi Wood

Type. AMNH-21848 right lower jaw, with p4 and m3 in fragmentary condition

Material. UA-3059 right p4, UA-3189 left m1

Stratigraphic and geographic range. St. David Formation, southern Arizona, localities A-25-3 and A-6895.

Age. Irvingtonian

Description. p4 tetralobate in occlusal outline; protolophid higher and narrower than metalophid; protolophid connected medially to metalophid; posteroconid developed posteriorly between metaconid and hypoconid; length 1.3 mm., width 1.6 mm.

m1 oval in occlusal outline; longer anteroposteriorly, labially; transverse lophids of equal width; metalophid and hypolophid joined medially, labial valley deeper and longer anteroposteriorly than lingual valley; dentine tracts on labial and lingual margin extend to height of approximately 7 mm. above base of enamel;

vertical axis with posterolingual flexure, roots absent. Length 1.0 mm., width 1.8 mm.

Discussion. Wood (1935) assigned a fragmentary right lower dentary with teeth to *D. gidleyi*. Gazin (1942) suggested the specimen (AMNH-27790) that Wood assigned to *D. minor* may belong to *D. gidleyi*, the diagnostic grooving of the p4 probably being a condition of wear.

Liomys sp.

Figure 6 D

Material. UA-3105 right m1, UA-3159 right m1

Stratigraphic and geographic range. St. David Formation, southern Arizona localities A-689 and A-12-1

Age. Barstovian-Recent

Description. m1 lophids of relative equal width, with labial corner of the metalophid extending posteriorly; anterior cingulum flexed, making an anterolabial connection of the protostylid to the anterior face of the protoconid; transverse valley remains open until principal cusps effaced, valley deeper lingually; labial cusps of metalophid and hypolophid relative smaller than lingual cusps.

Table 13. *Liomys* sp.

Length	N	O.R.	$\bar{X}$	Width	N	O.R.	$\bar{X}$
m1	2	0.90-1.00	0.95		2	1.10-1.25	1.18

Discussion. *Liomys* sp. from the San Pedro Valley is smaller than *L. centralis* Hibbard (1941a) from the Rexroad fauna, Meade County, Kansas and is less high crowned.

Liomys teeth may be separated from *Dipodomys* on the basis of size and *Liomys* teeth being rooted; *Dipodomys* only being rooted in extreme old age. Fossil *Dipodomys* have relatively higher crowns than contemporaneous forms of *Liomys*. The molars of *Liomys* are decidedly narrower than the premolars, as contrasted to molars and premolars being more equal in *Dipodomys* and *Perognathus*. Lophs of the upper molars and usually those of the lower molars of *Liomys* unite at both ends to enclose a central basin while *Dipodomys* consists of two separate plates surrounding an oval occlusal pattern and form a more U-shaped pattern in *Perognathus*.

Family Castoridae

Castor canadensis

Figure 6 E, F, G

Material. UA-1774 left M3

Stratigraphic and geographic range. St. David Formation, southern Arizona, locality A-68130

Age. Irvingtonian-Recent

Description. M3 hypostria, parastria, mesostria and metastria extend to base; slight posterolingual curvature; paraflexus extends to median plane; mesoflexus extends medially, then posteriorly terminating near the posterolingual margin; metaflexus extends to posteromedial margin; hypoflexus extends anteromedial one-third of the occlusal width; paracone and mesostyle slightly more labial than parastyle and metacone; anteroposterior occlusal length 5.5 mm., occlusal width 4.5 mm. and the basal anteroposterior length 5.85 mm. and basal width is 6.1 mm.

Discussion. Castor from the St. David Formation is very close in detail of tooth morphological characters to Castor cf. accessor Wilson from the Grand View fauna. However the Curtis Ranch specimen appears much smaller.

Castor from the Curtis Ranch fauna is also a much smaller animal than C. californicus Kellogg from the San Joaquin in addition to having striae to the base of the tooth in contrast to the latter species' striae terminating well above the base.

Specimen UA-1774 appears to be a young adult, not having the entire occlusal pattern revealed. The tooth has no indication of roots and is slightly smaller than modern Castor, but in occlusal features is very close to the modern species of Castor canadensis.

Family Cricetidae

Subfamily Cricetinae

Bensonomys arizonae (Gidley)

Figure 7 A, B

Eligmodontia arizonae Gidley 1922b

Bensonomys arizonae Gazin 1942

Type. USNM-10503 left dentary with m1-3

Material. UA-3147 left M1, UA-2658 left M1, UA-3138 left M1, UA-2677 left M1, UA-3142 left M1, UA-2672 right M1, UA-3112 right M2, UA-3139 right M2, UA-2675 left M2, UA-3116 right M2, UA-2651 right M3, UA-2659 left m1, UA-2676 left m1, UA-3678 right m1, UA-2671 right m1, UA-2686 left m1, UA-2673 right m1, UA-3143 right m1, UA-3106 right m2, UA-3145 left m2, UA-3149 left m2, UA-3140 left m2, UA-3136 right m2, UA-3134 right m2, UA-2688 left m2, UA-3137 right m2, UA-3135 left m2, UA-2670 right m2, UA-3113 right m2, UA-3213 right m2, UA-3144 left m2, UA-2674 right m2, UA-3148 left m3, UA-3146 right m3, UA-2660 right m3

Stratigraphic and geographic range. St. David Formation, southern Arizona, localities UA-12-1, UA-12-2, UA-6896, UA-52, and Rexroad Formation, Meade County, Kansas.

Age. Blancan-Irvingtonian

Description. M1 elongate oval in occlusal outline; crown relatively brachyodont; anterior notch in anterocone deep dividing it into subequal cusps; anterolingual valley closed by posterior flexure of anterior cingulum, labial cingulum better developed than lingual cingulum.

M2 obovate in occlusal outline; slight development of anterocone at junction of anterior cingulum and protocone; labial cingulum better developed than lingual cingulum; incipient posterior cingulum.

M3 subtriangular in occlusal outline; crown relatively brachyodont; anterior cingulum well developed labially; metacone and hypocone greatly reduced.

m1 obovate to trapezoidal in occlusal outline; crown relatively brachyodont; anteroconid bicusped of subequal size; anterolabial stylid; anterior cingulum flexes posteriorly and closes anterolabial valley; posterolophid terminates in well developed posterostylid.

m2 subrectangular in occlusal outline; slightly longer than wide; posterolophulid well developed; anterior cingulum reaches labial edge of tooth and closes anterolabial valley; posterolophid terminates in a slightly lingual to median hypoconulid and then continues to lingual edge of the tooth as a posterior cingulum.

m3 subtriangular in occlusal outline; endoconid and hypoconid poorly developed and subequal; anterior cingulum well developed.

Table 14. Bensonomys arizonae

Length	N	O.R.	$\overline{X}$	S.	V.
M1	6	1.30-1.70	1.55		
M2	5	0.90-1.25	1.08		
M3	1	0.80			
m1	7	1.40-1.60	1.45		
m2	13	1.00-1.80	1.23	0.25	20.49
m3	3	0.90-1.30	1.07		
Width					
M1	6	0.80-1.10	0.97		
M2	5	0.75-1.00	0.88		
M3	1	0.90			
m1	7	0.80-1.10	0.91		
m2	13	0.70-1.50	1.02	0.19	18.28
m3	3	0.80-1.00	0.90		

Discussion. Gazin (1942) gave as the dental generic character for Bensonomys: "more brachyodont cheek teeth, notch in anterior lobe of first lower cheek tooth better developed, lower incisor more procumbent," as compared to Eligmodontia. He also stated that the major dental difference between Peromyscus and Bensonomys was Bensonomys having a greater reduction of the m3. The new material supports this diagnosis.

Hibbard (1950) assigned specimen KU-24868 from the Rexroad fauna, Meade County, Kansas to Bensonomys arizonae from *Peromyscus eliasi* Hibbard. Later Hibbard (1956), upon the collection of additional specimens, concluded that *B. eliasi* was a valid species of the genus *Bensonomys*. *B. eliasi* has a more rectangular m1 and the reentrant valleys of m1-2 are broader.

Bensonomys meadensis Hibbard (1956) from Big Springs Ranch, Meade County, Kansas seems to be much smaller (m1-3 is 3.5 mm.) as compared to *B. arizonae* using Gidley's (1922b) measurements. *B. meadensis* lacks the posterostylid present in the m1 of *B. arizonae*.

Peromyscus baumgartneri Hibbard 1954

Type. UM-29677 part of a right dentary with i and m1-3 from the Rexroad fauna, Meade County, Kansas.

Material. UA-3191 left M1, UA-3178 right M1, UA-3190 right m1, 2, UA-3209 left m1, UA-3176 right m3, UA-3177 left m3.

Stratigraphic and geographic range. St. David Formation, southern Arizona, localities A-25-2 and A-6895, and Rexroad fauna of Meade County, Kansas.

Age. Blancan-Irvingtonian

Description. M1 subtriangular in occlusal outline; anterocone consists of a single conule; labial cingulum relatively higher than lingual cingulum; posterior cingulum extends from the base of the hypocone to the labial edge of tooth.

M2 subrectangular in occlusal outline; anterior cingulum extends from protocone nearly to labial edge of tooth; short mesoloph present; metacone located on postero-labial corner of tooth.

m1 subtriangular in occlusal outline; anteroconid consists of a single conule; labial cingulum closes labial reentrant valley; posterior cingulum thick anteroposteriorly and extends from medial side of hypoconid to lingual edge of tooth.

m2 subtriangular in occlusal outline; labial cingulum relatively higher than lingual cingulum; anterior cingulum extends from medial side of metaconid and flexed posteriorly at labial edge of tooth; posterior cingulum very thick anteroposteriorly and extends from hypoconid to lingual edge of tooth; incipient mesostylid present.

m3 subrectangular in occlusal outline; prominent cusps connected in an S-pattern; anterior cingulum extends to labial edge of tooth.

Table 15. Peromyscus baumgartneri

Length	N	O.R.	Width	N	O.R.
M1	1	1.60		1	1.20
M2	1	1.20		1	0.80
m1	1	1.40		1	1.00
m2	1	1.20		1	0.90
m3	1	1.00		1	0.90
m1-m2	1	2.80			

Discussion. *Peromyscus kansasensis* Hibbard (1941a) from the Rexroad fauna, Meade County, Kansas, differs from *P. baumgartneri* in larger size and absence of accessory cusps even in rudimentary stage.

Peromyscus cragini Hibbard (1944c) from the Cudahy fauna, Meade County, Kansas, is a smaller mouse than *P. baumgartneri*; *P. cragini* has a much thinner posterior cingulum, and more rudimentary accessory cusplets.

Peromyscus irvingtonensis Savage (1951) from the Irvington site, California, is a much larger specimen than *P. baumgartneri* from Curtis Ranch and has a much less reduced M3 than the Curtis Ranch specimen.

Peromyscus cochrani Hibbard (1955b) from the Jinglebob fauna, Meade County, Kansas, has more accessory cusps (ectostylid, mesostyle, and enterostyle); it lacks the thick posterior cingulum of the Curtis Ranch m1 and m2.

Peromyscus berendsensis Starrett (1956) from the Berends fauna, Beaver County, Oklahoma, is slightly smaller than the Curtis Ranch specimens and has a small mesolophid not present in *P. baumgartneri*.

Peromyscus progressus Hibbard (1960b) from the Cragin Quarry fauna, Meade County, Kansas, has an ecto-stylid and ectolophid on the m1 not present in the Curtis Ranch species. The posterior cingulum of the m1 and 2 is much thicker in the Curtis Ranch specimens.

Peromyscus hagermanensis Hibbard (1962) from the Hagerman fauna, Twin Falls County, Idaho, is larger than the Curtis Ranch specimen and lacks the mesostylid present in *P. baumgartneri*.

The Curtis Ranch specimens are placed in *Peromyscus baumgartneri* from the Rexroad fauna of Kansas because of the close agreement in size (m1-2 is 2.75 mm.), presence of an incipient mesostyle in the anterointernal reentrant valley, the single cuspule of the anteroconid, and the S-pattern of the m3.

Peromyscus baumgartneri may be separated from *Bensonomys arizonae* by the single cusped anterocone and absence of posterostylid on the m1, M1 subtriangular in outline, presence of metastylid on m2 and S-pattern of occlusal surface on m3.

Peromyscus titanomys n. sp.

Figure 7 C, D

Type. UA-3178 left M1

Hypodigm. UA-3209 right m1

Stratigraphic and geographic range. St. David Formation, southern Arizona, localities A-6895 and A-68129

Age. Irvingtonian

Etymology. titan (Gr.)= gigantic; omys (mys)=mouse

Diagnosis. Relatively large size; M1 with subequal double cusped anterocone; m1 with subequal double cusped anteroconid.

Description. M1 trapezoidal in occlusal outline with the narrower length lingually; labial cingulum higher than lingual; anterocone consists of two subequal conules; anterolingual style posterolabial to the anterolingual conule of the anterocone; low mesoloph extends to labial side of tooth terminating in a mesostyle; posterior cingulum extends from posterolabial corner of hypocone to posterior side of metacone.

m1 sub-triangular in occlusal outline; anteroconid consists of two subequal conules; labial cingulum higher than lingual; incipient ectostylid; posterior cingulum thick anteroposteriorly and extends from hypoconid to lingual side of tooth.

Table 16. Peromyscus titanomys

Length	N	O.R.	Width	N	O.R.
M1	1	2.20		1	1.40
m1	1	2.10		1	1.30

Discussion. Peromyscus kansasensis Hibbard (1941a), from the Rexroad fauna, Meade County, Kansas is smaller than the Curtis Ranch specimens and lacks the ectostylid on m1.

Peromyscus cragini Hibbard (1944) from the Cudahy fauna, Meade County, Kansas is much smaller than the Curtis Ranch specimen and completely lacks accessory cusps in the M1 and m1.

Peromyscus irvingtonensis Savage (1951) from the Irvington fauna, California is a slightly smaller species than P. titanomys and posterior cingulum much reduced when compared with the Curtis Ranch species; P. irvingtonensis also develops a lake between the anteroconid and the metaconid of the m1 that would not develop in the Curtis Ranch species.

P. baumgartneri Hibbard (1954b) from the Rexroad fauna, Meade County, Kansas and from the Curtis Ranch fauna is a much smaller species and lacks the anteromedial groove in the anteroconid, present in the m1 in P. titanomys.

P. cochrani Hibbard (1955b) of the Jinglebob fauna, Meade County, Kansas is a much smaller species and lacks the well developed style and lophs present in P. titanomys.

Peromyscus berendsensis Starrett (1956) from the Berends fauna, Beaver County, Oklahoma is a much smaller species and lacks the divided anterocone present in P. titanomys.

Peromyscus progressus Hibbard (1960) from the Cragin Quarry fauna, Meade County, Kansas is a much smaller species and lacks the divided anterocone present in P. titanomys.

Peromyscus hagermanensis Hibbard (1962) from the Hagerman fauna, Twin Falls County, Idaho, is a smaller species than P. titanomys.

Primarily the large size and the development of the two, subequal anterior cusps distinguish it from contemporaneous and later species. It appears to be the largest species of Peromyscus in the fossil record.

Peromyscus titanomys may be separated from Bensonomys arizonae by its much larger size, presence of mesoloph and mesostylid on M1 and an incipient ectostylid on the m1.

Baiomys minimus (Gidley)

Peromyscus minimus Gidley 1922

Baiomys minimus, Gazin, 1942

Type. USNM-10500, left lower dentary with m1-m3 from the Benson fauna

Material. UA-2663 right M1, UA-2694 right M1, UA-2664 left M1, UA-3111 right M1, UA-2662 right M1, UA-3154 left M1, UA-3152 left M1, UA-3107 right M1, UA-3109 left M2, UA-3108 left M2, UA-3160 right m1, UA-3150 left m1, UA-3151 right m1, UA-2692 right m1, UA-3110 left m2, UA-3091 right m1, UA-3153 left m2, UA-2691 left m2

Geographic and stratigraphic range. St. David Formation, southern Arizona, localities A-12-1, A-47-3, A-47-5, A-52, and A-6896

Age. Blancan

Description. M1 elongate, obovate in occlusal outline; anterocone double cusped; posterior cingulum incipient; cingulum developed in the lingual valley and between cusps of anterocone; anterior arm of protocone unites with anterocone lingual to median axis of tooth.

M2 obovate in occlusal outline; mesoloph weakly developed in 1 of 3 teeth; metacone with incipient development of double cusp; anterior cingulum prominent; posterior cingulum absent.

m1 relatively long sub-oval occlusal outline; anteroconid bifurcate with narrow median anterior valley; anteroconid joins metaconid by median anterolophulid; posterior cingulum terminates in posterolingual stylid.

m2 sub-rectangular in occlusal outline; metaconid continuous with anterior cingulum; anterior cingulum flexes posteriorly at labial border of tooth; posterior cingulum terminates in a median or slightly lingual, posterolingual stylid.

Table 17. Baiomys minimus

Length	N	O.R.	$\bar{X}$	Width	N	O.R.	$\bar{X}$
M1	8	1.20-2.00	1.43		8	0.80-0.90	0.84
M2	2	1.00			2	0.80-0.85	0.83
m1	5	1.10-1.55	1.29		5	0.70-0.85	0.79
m2	3	0.90-1.00	0.93		3	0.70-0.90	0.80

Discussion. Gidley (1922b) described Peromyscus minimus later identified as Baiomys minimus by Gazin (1942) giving no statement for change. B. minimus is slightly smaller than B. brachygnathus from the Curtis Ranch fauna. If the Curtis Ranch species had a bifurcated anterocone it would be indistinguishable from B. brachygnathus after an early stage of wear.

Baiomys rexroadi Hibbard (1941a) from the Rexroad fauna, Meade County, Kansas has a smaller anteroconid on m1 and lacks bifurcation in the anteroconid. Hibbard (ibid.) thought this bifurcation the result of chipped enamel. Additional collecting of topotypic material substantiates Gazin's (ibid.) description. B. rexroadi also lacks the posterolingual stylid present in B. minimus.

Baiomys minimus lacks any "pit" between the anterolabial cingulum and the protoconid (not evident in Hibbard's

(1950) illustration) and has the posterolingual stylid that is absent in the m1 of _B_. _sawrockensis_ Hibbard from the Saw Rock Canyon fauna, Seward County, Kansas.

Baiomys kolbi Hibbard (1952) from the Fox Canyon fauna, Meade County, Kansas, has a more reduced (or absent) anterior groove on the anterocone and is larger than _B. minimus_.

Baiomys may be separated from other members of the Cricetinae of the St. David Formation on size alone; it is much smaller than the other taxa.

Baiomys brachygnathus (Gidley)

Peromyscus brachygnathus Gidley 1922

Type. USNM-10501 right lower dentary with all teeth

Material. UA-3210 right m1, UA-3211 left m1, UA-3212 left m2

Stratigraphic and geographic range. St. David Formation, southern Arizona, locality A-68129

Age. Irvingtonian

Description. m1 relatively long sub-oval occlusal outline; anteroconid single cusped, attached to protoconid by anterolabial cingulum; anteroconid connects with metaconid by short anterolophulid; posterior cingulum reaches lingual border of tooth; labial cingulum connects protoconid with incipient ectostylid.

m2 sub-rectangular in occlusal outline; anterior cingulum continuous lingually to metaconid; anterior cingulum reaches labial border of tooth and flexes posteriorly; posterior cingulum terminates in a posterolingual stylid; crown deeper labially.

Table 18. Baiomys brachygnathus

Length	N	O.R.	$\bar{X}$	Width	N	O.R.	$\bar{X}$
m1	3	1.20-1.30	1.27		3	0.80-0.95	0.85
m2	1	0.90			1	0.80	

Discussion. Baiomys brachygnathus differs from B. minimus in larger size and lacks the bifurcation of the anteroconid of B. minimus.

Baiomys rexroadi Hibbard (1950) from the Rexroad fauna, Meade County, Kansas is smaller and lacks the posterolingual stylid of the m2 present in B. brachygnathus. B. rexroadi has no ectostylid on m1, and m3 is not as reduced as in B. brachygnathus.

Baiomys sawrockensis Hibbard (1953a) from the Saw Rock Canyon fauna, Seward County, Kansas, is smaller than B. brachygnathus and B. sawrockensis differs from B. brachygnathus in a bifurcated anteroconid and absence of an ectostylid on m1.

Baiomys kolbi Hibbard (1952) from the Fox Canyon fauna, Meade County, Kansas has a larger m3 that B. brachygnathus and lacks the ectostylid in the m1.

Baiomys brachygnathus may be separated from the other genera of Cricetinae of the St. David Formation on size alone, it being much smaller.

Onychomys bensoni Gidley 1922

Type. USNM-10509 right lower dentary with complete dentition from the Benson fauna

Material. UA-3155 left M2, UA-3064 right m2

Stratigraphic and geographic range. St. David Formation, southern Arizona, localities A-6896 and A-52

Age. Blancan

Description. M2 obovate in occlusal outline; anterior cingulum continuous from labial to lingual border; posterior cingulum connects hypocone and posterior labial corner of metacone; length 1.35 mm. and width 1.1 mm.

m2 sub-rectangular in occlusal outline, slightly wider anteriorly; anterior cingulum joins medial edge of metaconid, extending to lingual border and labial border where it is flexed posteriorly touching labial border of protoconid; cingulum in reentrant valleys developed on labial and lingual borders; posterolophid connects hypoconid to hypoconulid at extreme posteromedial margin; posterior cingulum extends from hypoconid to lingual border; metaconid relatively higher than other cusps; length 1.3 mm., width 1.0 mm.

Discussion. Onychomys bensoni is much smaller than O. pedroensis from the Curtis Ranch fauna.

Onychomys gidleyi Hibbard (1941c) from the Rexroad fauna, Meade County, Kansas, is slightly larger than O. bensoni and has a larger posterior lobe in the m3 that is absent from O. bensoni.

Onychomys fossilis Hibbard (1941b) from the Borchers fauna, Meade County, Kansas, is a much larger species than O. bensoni and lacks a hypoconulid on the m2, present in the Benson specimens.

Onychomys larrabeei Hibbard (1953a) from the Saw Rock Canyon fauna of Seward County, Kansas, is a much larger species and has broader labial reentrant valleys in the lower molars than O. bensoni.

Onychomys martinii Hibbard (1939) (originally referred to Peromyscus) from Edsen Quarry fauna, Sherman County, Kansas, has less prominent development of the cingulum and lacks the hypoconulid present in O. bensoni.

Onychomys jinglebobensis Hibbard (1955b) from the Jinglebob fauna, Meade County, Kansas, is a much larger species and the posterior cingulum does not reach the lingual border as in O. bensoni.

Onychomys bensoni may be separated from other Cricetinae of the St. David Formation by having much higher cusps relative to the basal part of the crown.

Onychomys pedroensis Gidley 1922

Type. USNM-10506 from the Curtis Ranch fauna

Stratigraphic and geographic range. St. David Formation.

Age. Irvingtonian

Discussion. Gidley (1922b) described a new species of grasshopper mouse from a portion of a left dentary with m1 and m3, USNM-10506. Gazin (1942) notes eight additional specimens commenting that the teeth are "much larger than O. bensoni", and "relatively higher crowned than in O. bensoni." No additional material is presently known.

Onychomys pedroensis may be separated from other Cricetinae of the Irvington fauna by teeth that have relatively higher cusps.

Sigmodon medius Gidley 1922

Type. USNM-10519 right dentary fragment with complete dentition and associated right maxillary fragment with M1-2 possibly of the same individual from the Benson fauna

Referred Material. UA-2636 M1, UA-3082 M1, UA-2644 M1, UA-2630 M1, UA-2651 M1, UA-3117 M1, UA-3078 M1, UA-2643 M1, UA-3069 M1, UA-3090 M1, UA-2693 M1, UA-2690 M1, UA-3070 M2, UA-3067 M2, UA-3087 M2, UA-2689 M2, UA-3066 M2, UA-2642 M2, UA-3077 M2, UA-2681 M2, UA-3126 M2, UA-3068 M2, UA-3065 M2, UA-3073 M2, UA-3075 M3, UA-1510 M3, UA-3118 M3, UA-3121

M3, UA-3096 M3, UA-3129 M3, UA-3089 M3, UA-2616 M3, UA-2646 M3, UA-3093 m1, UA-3128 m1, UA-2635 m1, UA-3086 m1, UA-3130 m1, UA-2625 m1, UA-3081 m1, UA-3083 m1, UA-3101 m1, UA-2637 m1, UA-2654 m1, UA-2640 m1, UA-1518 m1, UA-1516 m2, UA-1514 m2, UA-2645 m2, UA-2620 m2, UA-3124 m2, UA-3079 m2, UA-2656 m2, UA-3119 m2, UA-3127 m2, UA-1515 m2, UA-1517 m2, UA-1518 m2, UA-2485 m3, UA-1519 m3, UA-2687 m3, UA-3123 m3, UA-3094 m3, UA-3100 m3, UA-2685 m3, UA-3120 m3, UA-3132 m3, UA-3131 m3, UA-2613 m3, UA-2634 m3, UA-1515 m3, UA-1517 m3, UA-1518 m3, UA-1518 m1-3, UA-1517 alveolar

Stratigraphic and geographic range. St. David Formation, northern Arizona, localities A-12-1, A-12-2, A-6896, A-47-1, A-47-3, A-47-4, A-47-5, A-47-7, A-47-10, A-52

Age. Blancan

Emended Diagnosis. M1 axis of reentrant valleys relatively vertical; cingulum better developed lingually; posterolabial valley nearly isolates metacone.

M2 axis of reentrant valley relatively vertical; posterolabial reentrant valley nearly isolates metacone slightly lingual to posteromedian border.

M3 axis of renetrant valleys relatively vertical; posterolabial reentrant valley nearly isolates metacone.

m1 anterior cingulum flexes posteriorly almost closing anterolabial reentrant valley.

Description. M1 sub-triangular in occlusal outline; anterocone relatively narrow; axis of reentrant valleys relatively vertical; anterocone bicusped in early stage of wear; valleys open; lophs compressed anteroposteriorly; external reentrant valleys flex posteriorly near median of tooth, brachyodont; crown deeper lingually; cingulum better developed lingually; incipient styles in lingual reentrant valley nearly isolates metacone at its medial margin.

M2 sub-rectangular in occlusal outline; axis of reentrant valleys relatively vertical; valleys open; lophs compressed; exterior reentrant valleys arcuate postero-medially; brachyodont; crown deeper lingually; styles incipient in labial reentrant valleys on 8 of 21 specimens; metacone nearly isolated by posterolabial reentrant valley that terminates slightly lingual to posteromedian border; posterior cingulum extends from posteromedial side of meta-cone to lingual border in 5 of 21 specimens, absent in others.

M3 sub-triangular in occlusal outline; axis of reentrant valleys relatively vertical; valleys open; lophs compressed; exterior reentrant valleys variable; brachyo-dont; crown deeper lingually; incipient styles lacking; posterolabial reentrant valley nearly isolates metacone; anterior and posterior cingula absent.

m1 sub-triangular in occlusal outline; anteroconid bicusped, relatively narrow, arcuate around anterior end of tooth; anterior cingulum flexes posteriorly, almost closing anterolabial reentrant valley; valleys open; lophs compressed; brachyodont; posterior cingulum well developed and reaches lingual edge of tooth; anterointernal reentrant valley transversely wider than the anteroexternal reentrant valley.

m2 sub-quadrangular in occlusal outline; valleys open; lophs compressed; brachyodont; lingual cingulum better developed than labial cingulum; anterior cingulum extends from medial side of metaconid to labial border of tooth; posterior cingulum absent.

m3 sub-triangular in occlusal outline; valleys open; lophs compressed; brachyodont; anterior cingulum extends from lophulid connecting protoconid and metaconid to labial edge of tooth; posterior cingulum absent; clear sigmoid pattern.

Table 19. Sigmodon medius

Length	N	O.R.	$\bar{X}$	S	V
M1	20	2.00-2.30	2.16	0.10	4.57
M2	37	1.40-1.90	1.61	0.15	8.99
M3	10	1.40-1.60	1.48	0.09	5.82
m1	14	1.90-2.50	2.11	0.18	8.42
m2	6	1.50-1.90	1.70	0.14	8.32
m3	20	1.50-2.00	1.77	0.15	8.22
m1-3	1	5.95			
Width					
M1	20	1.50-1.90	1.64	0.12	7.44
M2	37	1.30-1.70	1.51	0.09	6.02
M3	10	1.30-1.60	1.43	0.11	7.62
m1	14	1.30-1.55	1.41	0.08	5.89
m2	6	1.50-1.70	1.60	0.06	3.95
m3	20	1.30-1.70	1.49	0.11	7.43

Discussion. Gidley (1922) first described Sigmodon medius from the Benson fauna. Hibbard (1938) stated that S. intermedius Hibbard from the Rexroad fauna, Meade County, Kansas, is intermediate between S. curtisi from the Curtis Ranch fauna and S. medius from the Benson fauna. Actually the m1-3 length given by Hibbard for S. intermedius is the same as Gidley's for S. medius, and is smaller than recently collected specimens of S. medius. S. intermedius can be separated from S. medius in the entoconid being larger in

S. intermedius and it lacks the well developed anterior cingulum of S. medius. S. intermedius also has many small accessory stylar cusps that are lacking in S. medius.

Sigmodon hilli Hibbard (1941b) from the Borchers fauna, Meade County, Kansas, is slightly smaller than S. medius, the anterocone is not bicusped and the anteroconid is narrower than S. medius. The external reentrant valleys of S. hilli do not flex posteriorly as much as in S. medius.

Sigmodon hudspethensis Strain (1966) from the Fort Hancock Formation, Hudspeth County, Texas, is a much larger species. In S. medius the anterointernal reentrant valley of m1 is transversely wider than the outer one, but in S. hudspethensis just the opposite is true.

Sigmodon medius may be separated from the other genera of Cricetinae from the St. David Formation by the anteroposterior compression of the folds in the teeth and the very high cusps exposing dentine early in the individual's life.

Sigmodon minor Gidley 1922

Type. USNM-10512, portion of left dentary with the complete dentition from the Curtis Ranch fauna

Referred Material. UA-3204 M1, UA-3201 M1, UA-3207 M1, UA-3225 M1, UA-3218 M1, UA-3197 M1, UA-3219 M1, UA-3195 M1, UA-1584 M1, UA-3194 M2, UA-3164 M2, UA-3166 M2, UA-3171 M2, UA-3225 M2, UA-3218 M2, UA-3197 M2, UA-3219 M2, UA-3195

M2, UA-3162 M3, UA-3174 M3, UA-3203 M3, UA-3218 M3, UA-3197 M3, UA-3175 m1, UA-3196 m1, UA-1693 m1, UA-3226 m1, UA-1581 m1, UA-3179 m1, UA-1581 m2, UA-3172 m2, UA-3169 m2, UA-3193 m2, UA-3173 m2, UA-3168 m2, UA-3202 m2, UA-1594 m2, UA-3226 m2, UA-3192 m2, UA-1693 m2, UA-3196 m2, UA-3196 m3, UA-3226 m3, UA-3170 m3, UA-3165 m3, UA-3208 m3, UA-3167 m3, UA-3197 M1-M3, UA-1581 m1-m3, UA-3196 m1-m3, UA-3226 m1-m3

Stratigraphic and geographic range. St. David Formation, southern Arizona, localities A-25-3, A-6895, A-68128 and A-68129

Age. Irvingtonian

Description. M1 sub-triangular in occlusal outline; slightly brachyodont; anterocone relatively narrow and single cusped; open valleys; lophs compressed anteroposteriorly; crown deeper lingually; posterolabial reentrant valley nearly isolates metacone medially.

M2 sub-quadrate in occlusal outline; slightly brachyodont; valleys relatively open; lophs compressed anteroposteriorly; crown deeper lingually; protocone tapers to a thin loph labially; posterolabial reentrant valley nearly isolates metacone medially; teeth commonly wider than long.

M3 sub-triangular in occlusal outline; valleys open; lophs compressed anteroposteriorly; slightly brachyodont; crown deeper lingually.

Table 20. Sigmodon minor

Length	N	O.R.	$\bar{X}$	S	V
M1	10	1.80-2.50	2.08	0.19	9.01
M2	14	1.20-1.85	1.42	0.19	13.64
M3	5	1.10-1.50	1.35		
m1	6	1.80-2.20	2.05		
m2	7	1.20-1.70	1.48		
m3	7	1.40-1.70	1.53		
M1-M3	1	5.20			
m1-m3	3	4.20-5.20	5.00		
Width					
M1	10	1.30-2.10	1.54	0.22	14.09
M2	14	1.20-1.80	1.48	0.20	13.53
M3	5	1.20-1.40	1.34		
m1	6	1.20-1.70	1.40		
m2	7	1.35-1.60	1.47		
m3	7	1.30-1.40	1.37		

m1 triangular in occlusal outline; anteroconid relatively small; valley open; lophs compressed anteroposteriorly; brachyodont.

m2 sub-quadrate in occlusal outline; valleys open; lophs compressed; brachyodont; anterior cingulum extends from junction of metaconid and protoconid to labial border of tooth.

m3 sub-triangular in occlusal outline; valleys open; lophs compressed anteroposteriorly; brachyodont; anterior cingulum extends from anterior border of protoconid to labial border of tooth.

Discussion. *Sigmodon minor* from the Curtis Ranch fauna was described by Gidley (1922), noting that *S. minor* differs from *S. medius* of the Benson fauna in being, on the average, slightly smaller. *S. minor* is intermediate between *S. medius* and the modern species of *Sigmodon* in degree of brachyodonty.

Sigmodon intermedius Hibbard (1938) from the Rexroad fauna, Meade County, Kansas, lacks anterior cingula on m2 and m3 and has greater posterior development of the anterior cingulum (tending to close the anterolabial valley) on the m1, than in *S. minor*.

Sigmodon hilli Hibbard (1941) from the Borchers fauna, Meade County, Kansas, is slightly smaller than *S. minor* (Hibbard, ibid., says slightly larger) and the lophs are more oblique to the long axis of the tooth than in *S. minor*. The metacone tends to be more isolated in the molars of *S. minor* than in *S. hilli*.

Sigmodon hudspethensis Strain (1966) from the Fort Hancock Formation, Hudspeth County, Texas, is much larger than S. minor and doesn't have the near isolation of the metacone in upper cheek teeth.

Sigmodon minor may be separated from other genera of Cricetinae by the anteroposterior compression of the folds in the teeth and the very high cusps, exposing dentine early in the individual's life.

Sigmodon curtisi Gidley 1922

Type. USNM-10510, the lower jaw with complete dentition in each dentary from Curtis Ranch fauna

New Material. UA-3224 M1, UA-3206 M2, UA-3224 M2, UA-3163 M3, UA-3205 M3, UA-3224 M3, UA-3220 m1, UA-3220 m2, UA-3223 m2, UA-3221 m2, UA-1700 m2, UA-3220 m3, UA-3223 m3, UA-3220 m1-3

Stratigraphic and geographic range. St. David Formation, southern Arizona at localities A-25-3, A-6895 and A-68128

Age. Irvingtonian

Description. M2 sub-quadrate in occlusal outline; crown deeper lingually; slightly brachyodont; valleys oblique to long axis of tooth.

M3 sub-triangular in occlusal outline; crown deeper lingually; slightly brachyodont; axis of reentrant valleys oblique to long axis of tooth.

m1 sub-triangular in occlusal outline; slightly brachyodont; anteroconid broad; reentrant valley almost perpendicular to long axis of tooth.

m2 sub-rectangular in occlusal outline; slightly brachyodont; anterior cingulum extends completely across anterior border of tooth; reentrant valleys fairly oblique to long axis of tooth.

m3 sub-triangular in occlusal outline; slightly brachyodont; anterior cingulum extends from labial to lingual margin of tooth; reentrant valleys fairly perpendicular to long axis of tooth; typical sigmoid pattern to occlusal surface.

Table 21. _Sigmodon_ _curtisi_

Length	N	O.R.	$\bar{X}$	Width	N	O.R.	$\bar{X}$
M1	1	2.60			1	2.10	
M2	2	1.90			2	2.10-2.20	2.15
M3	3	1.85-2.10	1.95		3	1.70-2.00	1.83
m1	1	3.00			1	1.90	
m2	4	1.85-2.40	2.09		4	1.80-2.20	1.98
m3	2	2.00-2.40	2.20		2	1.80	
m1-3	1	7.30					

Discussion. _Sigmodon_ _curtisi_ can be differentiated from all known fossil and modern species of _Sigmodon_ on the basis of size alone, _S_. _curtisi_ being much larger. In difference to Gidley (1922b) and Gazin (1942), _S_. _curtisi_ is much larger than recent specimens of S. hispidus, (University of Arizona, Department of Biology mammal collection).

Sigmodon curtisi may be separated from all other genera of Cricetinae from the St. David Formation by the anteroposterior compression of the folds in the teeth and the very high cusps, exposing dentine early in the individual's life.

Neotoma fossilis Gidley 1922

Figure 7 G

Type. USNM-10524, portion of a right maxillary with m1 from Benson fauna

New Material. UA-1509 left M1, 2, UA-3102 left M3, UA-3133 left M3, UA-2476 left m1, UA-2666 left m1, UA-2668 right m1, UA-2473 right m1, UA-2473 right m1, UA-2682 left m1, UA-1525 left m2, UA-2669 right m2, UA-2667 right m2, UA-3215 right m2

Stratigraphic and geographic range. St. David Formation, southern Arizona, localities A-12-1, A-6896, A-47-1, A-47-4, A-52

Age. Blancan

Description. M1 anterior loop followed by two alternating salient angles and a posterior loop; antero-internal groove of the anterior loop shallow; reentrant valleys oblique to longitudinal axis of tooth; three roots.

M2 anterior loop followed by two alternating salient angles and a posterior loop; anterointernal groove very shallow in anterior loop; reentrant valleys oblique to longitudinal axis of tooth; three roots.

m1 anterior loop followed by two alternating salient angles (1 of 4 specimens have salient angles opposite each other) and a posterior loop; anterointernal groove of anterior loop shallow extending only one third the distance to base of crown in little worn teeth; reentrant valleys oblique to longitudinal axis of tooth; two roots.

m2 anterior loop followed by two alternating salient angles (1 of 5 specimens have salient angles opposite each other); reentrant valleys oblique to longitudinal axis of tooth; two roots.

Table 22. Neotoma fossilis

Length	N	O.R.	$\bar{X}$	Width	N	O.R.	$\bar{X}$
M1	1	3.00			1	2.50	
M2	1	2.50			1	1.90	
M3	2	2.45-2.60	2.53		2	2.00-2.20	2.10
m1	5	2.80-3.45	3.09		5	1.50-2.05	1.85
m2	5	2.80-3.00	2.92		5	1.80-2.30	2.12
M1-2	1	5.50					

Discussion. Gidley (1922b) described Neotoma fossilis, giving as a diagnostic feature, the m1 (Gidley referred to it as a p4) entirely devoid of an anterior reentrant valley. I believe Gidley (ibid.) was referring to the lack of a groove in the anterior loop (from his illustration) and this condition exists after extreme wear (see description of m1).

Gidley and Gazin (1933) defined the genus *Parahodomys* on the species *P. spelaeus* from Cumberland Cave, Maryland, stating the cheek teeth were similar to *Hodomys* (now considered a subgenus of *Neotoma*), but with the following differences: in *Parahodomys* the reentrant valleys are directed nearly perpendicular to the long axis of the tooth, while in *Hodomys* (and other subgenera of *Neotoma*) the valleys are directed forward more obliquely; *Parahodomys* has an additional short reentrant valley on the posterior internal lobe of m3 and on the anterior external lobe of m3 in *Hodomys*. Therefore, as indicated in the description, the Benson material is excluded from the genus *Parahodomys*.

The subgenus *Paraneotoma* Hibbard (1967) from the Saw Rock Canyon fauna, Seward County, Kansas, had shorter crowned teeth, thicker enamel, the anterocone of M1 narrower, upper molars had better developed roots, and the paracone, hypocone and metacone of M1 and M2 are more distinct than in recent species of *Neotoma*. *N. fossilis* differs from *Neotoma* (*Paraneotoma*) in lacking these diagnostic features, being more similar to the living species and subgenera.

Neotoma fossilis may be separated from the other genera of the Cricetinae of the St. David Formation by its generally larger size and the upper molars consisting of sub-triangular cusps projecting labially and lower cusps projecting lingually.

Neotoma (Hodomys) olseni n. sp.

Figure 7 E, F, H

Type. UA-3234, right dentary m1-3

Etymology. Patronym for S. J. Olsen for his contributions to vertebrate paleontology in Florida

Hypodigm. UA-1701, palate with right and left M1-2, UA-3222, left dentary with m2 and UA-3235 left dentary with m1-3

Stratigraphic and geographic range. St. David Formation, southern Arizona at locality A-25-3

Age. Irvingtonian

Diagnosis. M1 labial reentrant valleys oblique to the long axis of the occlusal surface and the lingual reentrant valleys perpendicular.

M2 same as for M1.

m1 labial reentrant valleys perpendicular to the long axis of the occlusal surface and the lingual reentrant valley oblique.

m2 same as for m1.

m3 same as for m1 in combination with the distinct S-pattern of the occlusal surface.

Description. M1 trapezoidal in occlusal outline; anterior loop followed by two alternating salient angles and a posterior loop; labial reentrant valleys longer than the lingual reentrant valley and oblique to the long axis of the tooth; anterointernal groove of the anterior loop broad and very shallow.

M2 sub-rectangular in occlusal outline; anterior loop followed by two alternating salient angles and a posterior loop; labial reentrant valleys longer than the lingual reentrant valley and oblique to the long axis of the tooth; lingual reentrant perpendicular to the long axis of the tooth.

m1 anterior loop followed by two alternating salient angles and a posterior loop; anterointernal groove of anterior loops very shallow, terminating near base of crown; external valleys more perpendicular to the long axis than the internal reentrants.

m2 sub-rectangular in occlusal outline; anterior loop followed by two alternating salient angles and a posterior loop; labial reentrant valleys more perpendicular to the long axis than the internal reentrants.

m3 sub-quadrate in occlusal outline; distinct S-pattern to occlusal surface; lingual corner of metaconid flexes posteriorly, not closing internal valley.

Table 23. Neotoma olseni

Length	N	O.R.	$\bar{X}$	Width	N	O.R.	$\bar{X}$
M1	1	3.00			1	2.20	
M2	1	2.40			1	2.10	
m1	3	2.90-3.10	2.97		3	1.90-2.00	1.95
m2	4	2.70-2.90	2.78		4	1.80-2.50	2.15
m3	3	2.00-2.20	2.10		3	1.50-1.90	1.73
M1-2	1	5.80					
m1-3	1	8.00					

Discussion. Neotoma olseni differs from N. fossilis from the Benson fauna in slightly smaller size and the labial reentrant valleys are perpendicular to the longitudinal occlusal axis.

Neotoma olseni is assigned to the subgenus Hodomys because the m3 has a distinct S-shaped occlusal pattern (Hall and Kelson, 1959). N. olseni lacks a reentrant valley in the posterior internal lobe of m3 as found in the genus Parahodomys (Gidley and Gazin, 1933).

Neotoma olseni may be separated from the other genera of the Cricetinae of the St. David Formation by its generally larger size and the upper molars consisting of sub-triangular cusps projecting labially in the upper cheek teeth and lingually in the lower cheek teeth.

Subfamily Microtinae

Pliopotamys meadensis Hibbard

Type. UK-3846, portion of right mandible with i, m1-2 from Ogallala Formation, Meade County, Kansas

Material. UA-1570 mandible with fragmentary teeth

Stratigraphic and geographic range. St. David Formation, southern Arizona, locality A-25-3 and the Rexroad fauna, Ogallala Formation, Meade County, Kansas

Age. Blancan-Irvingtonian

Diagnosis. (Hibbard, 1938, p. 249) For the diagnosis of *Pliopotamys*, Hibbard states,

> "A medium sized vole slightly smaller than *Neofiber*. Molars brachyodont; cement absent in reentrant folds; m1 and m2 each having two well-developed roots. m1 with posterior loop, five alternating triangles and anterior loop of simple structure. The triangles are closed with the exception of the anterior which is nearly closed. Outer diameter of crown, 4.5 mm. m2 with posterior loop and four alternating triangles, with third and fourth nearly separated by the enamel of the reentrant angle; anteroposterior diameter of the crown, 2.5 mm. The base of the lower incisor crosses under the roots of m3 from the lingual to the labial side of the jaw. Anteroposterior alveolar diameter of m1-m3, 10 mm. The mandible distinctly lacks the well-developed ridge for the attachment of *masseter medialis* muscle. Attachment as poorly developed as in *Evotomys*."

Description. m1 posterior loop, five alternating triangles and an anterior loop; enamel complete and of constant thickness; lacks cement; length 5.5 mm., width 2.6 mm. at alveolus, slight increase in transverse diameter of occlusal surface with wear.

m2 three alternating triangles with an anterior and posterior loop; posterior loop labial and lingual to median of tooth; anterior loop labial only; enamel complete and of constant thickness; lacks cement; length 3.6 mm., width 2.2 mm. at alveolus; slight increase in transverse diameter of occlusal surface with wear.

Discussion. Pliopotamys minor Wilson (1934) from the Hagerman Formation, Idaho is a smaller species and the fifth triangle of m1 opens broadly into the anterior loop. P. meadensis of the Curtis Ranch fauna is a much larger species than P. minor (m1, 4.3 mm. x 1.9 mm.; m2, 2.6 mm. x 1.8 mm.).

This is the first occurrence of Pliopotamys at Curtis Ranch.

Mimomys (Cosomys) primus (Wilson)

Figure 7 I, J, K

Cosomys primus Wilson, 1932

Mimomys (Cosomys) primus (Wilson), Wilson, 1934

Type. CIT 500, skull from Coso Mt. fauna of California

Material. UA-2600 left M1, UA-2603 right M1, UA-2605 right M1, UA-2602 left m2, UA-2604 left m2, UA-2606 left m2, UA-2601 right m3

Stratigraphic and geographic range. St. David Formation, southern Arizona, locality A-6896; Coso Mountain fauna, California; Saw Rock Canyon fauna, Kansas; and the Hagerman fauna, Idaho.

Age. Blancan

Description. M1 anterior loop, four almost closed alternating triangles; labial triangles with sharper apices; posterior loop with small posterior projection slightly labial to anteroposterior midline; cement absent; three roots.

m2 anterior loop small, triangular; four almost closed alternating triangles; lingual triangles larger and with sharper apices; posterior loop large; cement absent; two roots.

m3 three alternating triangles; posterior loop large; anterior loop small with an anterolabial extension; concave anterior curvature to prisms; lingual triangles larger and with sharper apices; cement absent; two roots.

Table 24. *Mimomys primus*

Length	N	O.R.	$\bar{X}$	Width	N	O.R.	$\bar{X}$
M1	3	2.40-2.60	2.50		3	1.50-1.80	1.63
m2	3	1.80-1.90	1.83		3	1.20-1.30	1.27
m3	1	1.50			1	0.95	

Discussion. The above specimens lack cement thus belonging to the subgenus *Cosomys* as redefined by Wilson (1934).

Wilson (1934) described a new species *Mimomys ? parvus* from the Grand View fauna, Idaho, the specific diagnosis being primarily based upon m1 and M3, none of which are included in our material. On size alone, *Mimomys parvus* is a slightly smaller species.

The Benson specimens are indistinguishable from *Mimomys primus* from the Coso Mountains, California, the Hagerman fauna, Idaho, and the Saw Rock Canyon fauna, Kansas.

Mimomys primus may be separated from *Pliopotamys meadensis* in the St. David Formation by triangles of teeth not closed and smaller in size.

Ondatra kansasensis Hibbard 1944

Figure 8 C, D

Ondatra sp. Gazin 1942

Neofiber sp. Gidley 1922

Type. KU-6656 left m1, from Cudahy fauna, Meade Formation, Kansas

Material. UA-3233 right dentary m2-3, UA-1703 partial right m2, UA-3217 left M1, UA-1698 left M2, UA-1772 left M1

Stratigraphic and geographic range. St. David Formation, southern Arizona locality 25-3 and Cudahy Formation, Kansas

Age. Irvingtonian

Description. M1 anterior loop triangular in occlusal outline with base anterior, three alternating triangles; posterior loop triangular; three well developed roots.

M2 anterior column diamond-shaped in occlusal pattern, two alternating closed triangles; posterior column large; two well developed roots.

m2 posterior loop triangular with base posterior, preceded by three alternating triangular columns; anterior loop diamond-shaped in occlusal pattern; two well developed roots.

m3 anterior loop oval; two alternating triangles; first triangle smaller than second triangle; posterior loop flattened oval with concave side anterior; two well developed roots.

Table 25. Ondatra kansasensis

Length	N	O.R.	$\bar{X}$	Width	N	O.R.	$\bar{X}$
M1	3	3.10-3.90	3.63		3	2.30-2.90	2.67
m2	1	2.90			1	2.10	
m3	1	3.00			1	1.80	

Discussion. Ondatra nebrascensis Hollister (1911) from the "Equus Beds" near Hay Springs, Sheridan County, Nebraska (not figured) is a much larger species (average length of 7 is 6.57 mm.) than the Curtis Ranch species.

Ondatra oregonus Hollister (1911) from the "Equus Beds" Lake County, Oregon, also not figured, is a larger species (a.p. length of m1 is 517 mm.). Hollister uses the morphological character of open triangles as a diagnostic character.

Ondatra annectens Brown (1908) from Conard Fissure, Newton County, Arkansas is close in size to the Curtis Ranch form (a.p. length of m1 is 5.7 mm.); however not being figured and no specimen observed, no direct comparison can be made.

Ondatra hiatidens Cope (1871) from Port Kennedy is a smaller species than *O. kansasensis* from the Curtis Ranch fauna and has a sharp inflection anterior to the interior reentrant valleys not present in the Curtis Ranch specimens.

O. triradieatus Starrett (1956) from the Berens local fauna, Oklahoma is a much larger species (a.p. length of M1 is 4.7 mm. and width is 3.2 mm.). Like *O. kansasensis* from the Curtis Ranch fauna the M1 also has three well developed roots. *O. zibethicus* normally has only two roots.

Ondatra kansasensis from Curtis Ranch is larger than *O. idahoensis* Wilson (1934) from Grand View, Idaho, and does not possess the intricate crenulations of the enamel possessed by specimens of *O. idahoensis*.

Ondatra kansasensis from Curtis Ranch is different than *O.* sp. Hibbard (1942) from the Borchers fauna an m2, in having the last triangular loop as wide as the entire tooth, while in the Borchers specimen it is only half as wide as the tooth and only projects lingually.

O. kansasensis is much smaller than *O. zibethica* Hibbard (1943) from the Rezabek fauna (a.p. dia. of M1 = 4.5 mm.) and the modern species which Hibbard's specimen matches well in both size and occlusal pattern.

Gidley (1922b) originally described a left M2 (USNM-10527) from the Curtis locality as *Neofiber* sp. Gazin (1942) referred the same tooth to *Ondatra* sp. in view of the tooth having roots, and thought except for its smaller size it could represent the modern species, *O. zibethica*. In addition the m3 having three labial salients instead of two, absence of cement, and the persistent pulp cavity remove the Curtis Ranch material from *Neofiber*.

Ondatra kansasensis may be separated from other genera of Cricetidae in the St. David Formation by its much larger size.

Microtus (?) sp.

Material. UA-3214, posterior fragment of left m1

Stratigraphic and geographic range. St. David Formation, southern Arizona, locality 47-1

Age. Blancan-Recent

Discussion. *Microtus* sp. is represented by a fragment of a left m1 containing a portion of the posterior loop and the first two alternating triangles (closed) The fragment bears cement and shows no evidence of roots. The width of the fragment is 1.5 mm.

Microtus may be separated from the genera of Microtine rodents in the St. David Formation by the triangles of the teeth closed and the teeth rootless. This is the earliest record of the genus *Microtus* in North America.

Family Hydrochoeridae

<u>Neochoerus</u> sp.

<u>Material</u>. UA-56 portion of left M3

<u>Stratigraphic and geographic range</u>. St. David Formation, southern Arizona, A-25-1

<u>Age</u>. Irvingtonian-Rancholabrean

<u>Description</u>. M3 fragment with dimensions of 10.9 mm. in length, 19.5 mm. in width, and 24.0 mm. in height; ten enamel plates surround dentine, alternating with cement.

<u>Discussion</u>. This specimen is larger than the M3 of the modern genus <u>Hydrochoerus</u> and is in the size range of <u>Neochoerus</u> specimens from the 111 Ranch fauna near Safford, Arizona. This is the first report of <u>Neochoerus</u> from the Curtis Ranch fauna.

Order Carnivora

Family Canidae

Canis sp.

Material. USNM-12859, metatarsal

Stratigraphic and geographic range. St. David Formation

Age. Hemphillian-Recent

Discussion. Gazin (1942) reports an incomplete third metatarsal "proportioned about as in material of *Aenocyon dirus* (*Canis dirus*) from Rancho La Brea" and "In robustness it compares favorably with a third metatarsal from the Pliocene at Long Island, Kans., referred to *Aelurodon*..." No additional material is presently known.

Canis edwardii Gazin 1942

Material. USNM-12862 skull and mandible

Stratigraphic and geographic range. St. David Formation, Curtis Ranch

Age. Irvingtonian

Discussion. Gazin (1942) described a new species of dog, *Canis edwardii* from a fairly complete skull and mandible from Curtis Ranch. No additional material is known from the St. David Formation. The canid metatarsal described above could well belong to *C. edwardii*.

Canis latrans Say 1823

Material. UA-1632 left ramus with p2-m2, UA-1313 p3, 4, in ramus fragment, and UA-3231 ramus fragment with m1-3

Stratigraphic and geographic range. St. David Formation, southern Arizona, locality A-68131, the upper Becerra fauna of Mexico, the Rancho La Brea fauna of California, the Sand Draw fauna of Nebraska, numerous widespread late Pleistocene faunas over North America and widespread as a living species

Age. Irvingtonian to Recent

Description.

Table 26. Maximum measurements of lower dentition of Canis latrans and an extant species from the Biology Department collection, University of Arizona.

	UA-1632	UA-1313	UA-3231	UAB-586
Ant-post. length p3	----	12.6	----	12.5
Transv. width p3	----	4.9	----	5.35
Ant-post. length m1	25.0	----	----	23.2
Transv. width m1	8.5	----	8.8	9.5
Ant-post. length m2	9.9	----	9.8	10.6
Transv. width m2	7.2	----	6.7	7.2
Ant-post. length m3	----	----	4.6	5.1
Transv. width m3	----	----	4.1	4.3

Discussion. Three poorly preserved lower rami are referred to the modern species, *Canis latrans*. No morphological differences are recognized between the Curtis Ranch and modern *Canis latrans*.

Canis sp. Hibbard (1955a) from the Upper Becerra of Mexico (early Pleistocene) is comparable size of the above specimen of *C. latrans*. This material represents part of the earliest record of *Canis latrans*.

The metatarsal described from the Blancan fauna could well belong to *C. latrans*, but more probably to a canid closer to *C. edwardii*. *C. edwardii* may be separated from *C. latrans* in its large size and more wolf-like proportions of the dentary.

Subfamily Borophaginae

Borophagus minycyon n. sp.

Figure 8 A, B

Holotype. UA-1466 fragmental ramus with three incisors, a left canine, right p2, p3, right and left p4, and right m1

Hypodigm. Type only

Stratigraphic and geographic range. St. David Formation, southern Arizona, locality A-47-3

Age. Blancan

Etymology. *minys* (Gr.)= little, small; *kyon* (Gr.)= dog.

Diagnosis. p2 and p3 reduced; p4 with only one stepped cusp posteriorly; m1 lacks metaconid while *Osteoborus* has two stepped cusps on the p4 and presence of a metaconid on the m1; m1 does have stylar development in place of metaconid.

Description. p2 and p3 are two rooted without apparent accessory cusps. The p4 has a lingual-curved simple protocone and one posterior cusp developed from an extension of the cingulum, giving the tooth an anteroposterior compressed appearance. The m1 has a relatively high trenchant crown with an overall posterior pitch. The entoconid and hypoconid are equal in development. The m1 lacks the metaconid as a cusp, but does show a definite stylar development.

Table 27. Measurements of mandible and teeth taken at base of enamel. Borophagus minycyon, B. diversidens Vanderhoof (1936) and B. pachyodon.

	B. minycyon	*B. diversidens*	*B. pachyodon*
Length of canine (ant-post)	15.2		16.0
Width of canine	12.2		
Depth of dentary below center of p4	27.7		
Max. width of dentary below center of p4	17.9		
Ant. post. diam. of p3	9.0	11.5	10.0
Max width of p3	6.3	8.0	8.5
Ant. post. diam. of p4	19.0	22.0	22.0
Max. width of p4	14.5		17.0
Ant. post. diam. of m1	32.3		30.5
Max. width of m1	12.8		16.0

Discussion. *Borophagus minycyon* is smaller than *B. diversidens* (Cope) from the Blanco fauna. Although *B. solus* Stock (1932) was described from a palate only, the Benson specimen would appear to be a smaller animal. The Benson specimen is also smaller than *B. pachyodon* Merriam (1903) from Asphalto, Kern County, California.

Family Mustelidae

Spilogale pedroensis Gazin 1942

Stratigraphic and geographic range. St. David Formation, southern Arizona

Age. Blancan

Discussion. Gazin (1942) described a new species of skunk from a right ramus, USNM-14682 and a left maxillary portion USNM-12869. Gazin states the skunk was about the size of male *Spilogale gracilus* or *S. ambigua* living in Arizona today. No additional mustelid specimens are presently known from the St. David Formation.

Family Felidae

Felis sp.

Stratigraphic and geographic range. St. David Formation, southern Arizona.

Age. Hemphillian-Recent

Discussion. A distal portion of a humerus and three incomplete toe bones of a large cat were reported by Gazin (1942) from the Benson Fauna. Gazin (ibid., p. 485) states, "the humerus exceeds in size corresponding material of *Felis concolor* in the National Museum collections but can be closely matched in one of the jaguar (*Felis onca*) skeletons." Modern *F. onca* is measurably larger than *F. concolor*, however if the humerus is comparable to a large jaguar, then on size alone it possibly could be referred to *F. atrox*. No additional material is presently known from the St. David Formation.

Felis sp., near *Felis lacustris* Gazin

Stratigraphic and geographic range. St. David Formation, southern Arizona; Hagerman fauna, Idaho; and Rexroad fauna, Kansas

Age. Irvingtonian

Discussion. Gazin (1942, p. 504) described a left humerus, USNM-16618, from the Curtis Ranch fauna that "compares favorably with those of *Felis lacustris* from the Hagerman lake beds of Idaho." Gazin (1933) based his original description of *F. lacustris* on two lower jaws, the type comparable to *F. concolor* in size and the paratype "suggestive of *Lynx*..." in size. At that time (1933) limb material was available, but not used in the description of the species. Considering the wide range in size it is possible that the humerus Gazin used could belong to a large cat, the size of his type or to a smaller cat, the size of the modern *Lynx*. No additional material is presently known from the St. David Formation.

Felis sp. near *Felis atrox* Leidy

Stratigraphic and geographic range. St. David Formation, southern Arizona

Age. Irvingtonian-Rancholabrean

Discussion. Included in the Curtis Ranch material of the National Museum are an unassociated p4, calcaneum, and fragment of a third metatarsal. These specimens were noted for their similarity to *Felis atrox* material from Cumberland Cave by Gazin (1942). *F. atrox* is very similar to the recent *F. onca* and is considered a closely related species (Simpson, 1941, McCrady, *et al.*, 1951) differing primarily in being larger. No additional material is presently known from the St. David Formation.

Order Proboscidea

Family Gomphotheriidae

Cuvieronius ? bensonensis (Gidley)

Anancus bensonensis Gidley 1926

Cordillerion bensonensis (Gidley) Osborn 1936

Cordillerion bensonensis (Gidley) Gazin 1942

Stegomastodon Savage 1955

Haplomastodon waringi Simpson and Couto 1957

Type. USNM-10538 greater part of basal portion of skull with both M3's and only the left M2

New Material. UA-1436 partial right dp2, UA-1496 well worn right dp3, UA-1672 partial m2, UA-1890 partial m2, UA-539 partial molar?, UA-1410 right M3

Stratigraphic and geographic range. St. David Formation, southern Arizona, localities A-12-1, A-47-2, A-47-5, and A-47-10

Age. Blancan

Description. Additional description is given here only for specimen UA-1410, a right M3, considering the fragmentary condition of the other teeth.

M3 tetralophodont, with heel consisting of two half lophs; high degree of choerodonty; slight retroversion of lophs (Gidley 1922 states lophs at right angle); double trefoil pattern better defined on the lingual side; numerous median and lateral conules developed in transverse valleys;

median sulci present on protoloph and metaloph; serrate spur on metaloph.

Table 28. Cuvieronius bensonensis

		Length	Width
M3	UA-1410	180.0	69.5
dp2	UA-1436	-	25.5
dp3	UA-1496	72.5	52.0
m2	UA-1672	111.0	69.5

Discussion. Gidley (1922) originally assigned specimen USNM-10538 from the Benson fauna to the old world genus Anancus commenting that it was considered provisional. Osborn (1936) assigned the species to Cordillerion based on an associated tusk of Cordillerion from Benson. A footnote in the original description caused some confusion concerning the association of tusks (with enamel band or not) and other elements assigned to this species. In the text Gidley (ibid., p. 85) states that it was not known if the tusks of A. bensonensis were twisted and possessed an enamel band or not. In a following footnote he comments that a tusk in the American Museum of Natural History is a "nearly straight, twisted variety and possesses a wide band of enamel extending along its entire length." Gidley felt that this tusk could belong to A. bensonensis. He also mentions a few feet away from the skull of A. bensonensis in the Benson beds and "at somewhat lower level" was another tusk, "of the short, thick, much curved, and rapidly tapering variety" with no evidence of an enamel band. Further he mentions two juvenile tusks from the Benson beds, one about 10 inches long with a well developed enamel band and one somewhat larger, more curved and with no enamel band.

Gazin (1942) retained Gidley's type in the genus Cordillerion and then referred the short, much curved tusks lacking the enamel band, to Mastodon sp. Simpson and Couto (1957) believed the M2-3 to be very close to Haplomastodon waringi and stated the short, much curved, rapidly tapering tusk with no evidence of an enamel band could be an adult tusk of Haplomastodon. Simpson and Couto (ibid.) then state that the Benson material includes a skull that could be either Haplomastodon or Cuvieronius, closer to the former, a tusk that is probably Cuvieronius and a tusk that could be either Haplomastodon or some other genus other than Cuvieronius. Savage (1955) states that the mandible from the Benson fauna (FAM-23333) identified by Frick (1933) as A. bensonensis, appears to belong to the small Rexroad type of Stegomastodon. From only this well worn occlusal view of a single m3 (5+ lophs) even a generic placement would be difficult.

I concur basically with Simpson and Couto (1957) in considering that Haplomastodon and Cuvieronius are indistinguishable on the basis of cheek teeth, and choose the conservative line of retaining Gidley's type of *Cuvieronius* until better association of teeth and tusk are found in the Benson fauna.

Stegomastodon arizonae Gidley

Type. USNM-10707 portion of a skeleton, skull with tusks, cheek teeth, and lower jaw

New Material. UA-3236 well worn left m2, UA-1553 partial left m3, UA-3237 partial molar, and UA-3238 partial molar

Stratigraphic and geographic range. St. David Formation, southern Arizona, locality A-25-1

Age. Irvingtonian

Description.

Table 29. *Stegomastodon arizonae*

		Length	Width
m2	UA-3236	73.6	57.0
m3	UA-1553	160.5	78.5

Discussion. Three species of *Stegomastodon* are recognized in North America. They are *S. mirificus* (Leidy) Pohlig (1912), *S. rexroadensis* Woodburne (1961), and *S. arizonae* Gidley (1926). These species are distinguished primarily on size, and corresponding increase in length of m3. *S. mirificus* from the Blanco and Cita Canyon faunas is intermediate in size (5-6½ lophids on m3) and chronology (late Blancan) between S. rexroadensis from the early Blancan Rexroad fauna with 5+ lophids on m3, and S. arizonae from the early Irvingtonian Curtis Ranch fauna with 7½ lophids on m3. As pointed out by Savage (1955) the Curtis Ranch Stegomastodon may prove to fit within the range of the individual variation from the Blanco and Cita Canyon populations.

The fragmentary teeth examined of Cuvieronius bensonensis and Stegomastodon arizonae from the St. David Formation differ in the former species having a higher degree of choerodonty, less cement, and the development of a double trefoil in contrast to the later species having incipient quadruple trefoils on the protolophs and metalophs of the type specimen.

Order Perissodactyla

Family Equidae

Measurements for the family Equidae are taken in the following manner.

<u>Uppers</u>. Length - anteroposterior diameter taken through the center of the tooth

Width - maximum diameter across the protocone and mesostyle

Protocone length - (abbr. P.C.) maximum anteroposterior diameter of protocone

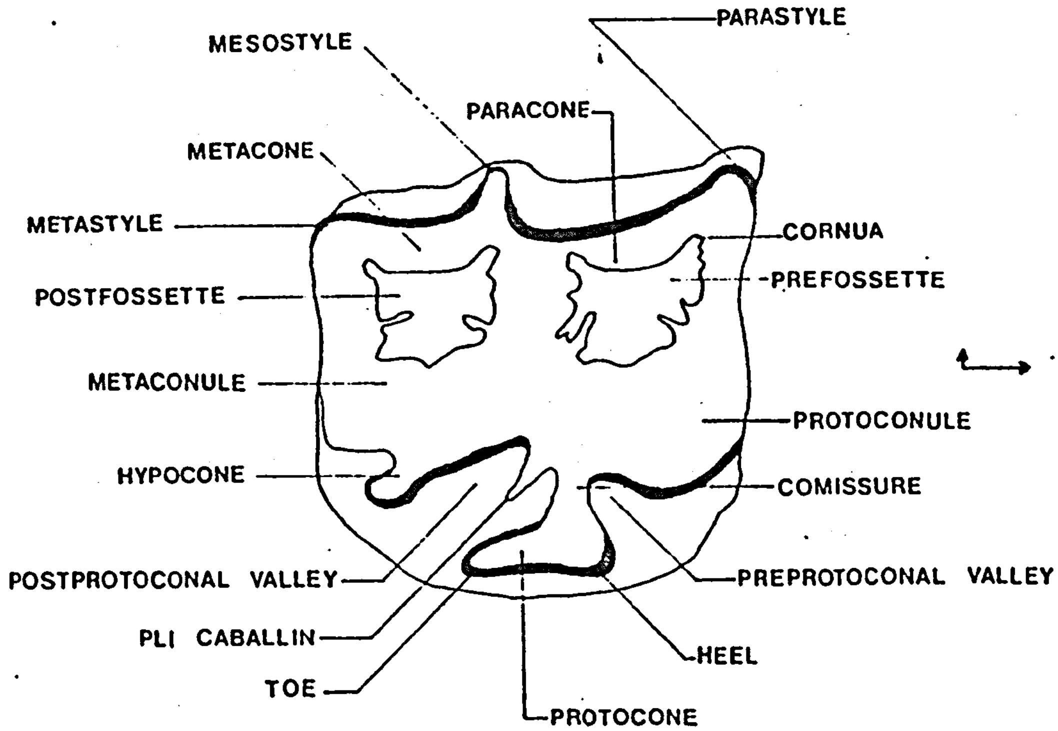
Protocone width - maximum diameter across anteroposterior center

<u>Lowers</u>. Length - anteroposterior diameter taken through the center of the tooth

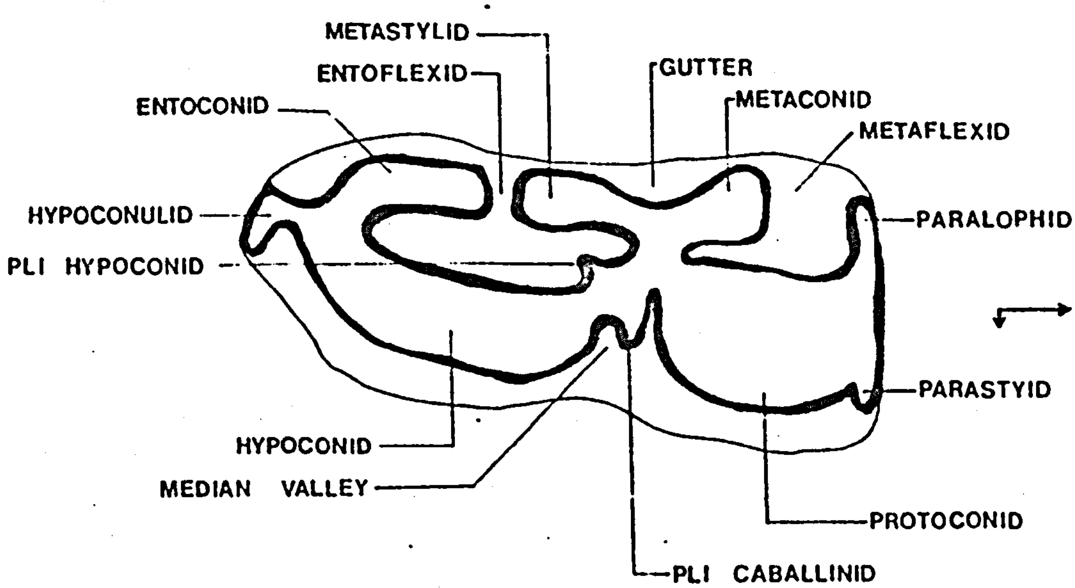
Anterior width - maximum diameter across the metaconid-protoconid

Posterior width - maximum diameter across the metastylid-hypoconid

Metastylid-metaconid length - (abbr. M.M.) maximum anteroposterior length of two conids



UPPER CHEEK TOOTH



LOWER CHEEK TOOTH

Nannippus phlegon (Hay)

Figure 9 C, D, E, F

Equus minutus Cope 1892

Equus phlegon Hay 1899

Hipparian phlegon Gidley 1922

Hipparion (Nannippus) phlegon Matthew 1926

Nannippus phlegon Gazin 1942

Material. UA-1406a P2, UA-1406b P2, UA-1406d P3, UA-2534 P3, UA-1482 P3, UA-1958 P3, UA-1406c P3, UA-1296 P3, UA-1406c P4, UA-1487 P4, UA-1370 P4, UA-533 P4, UA-1291 P4, UA-1538 M1, UA-1540 M1, UA-1353 M2, UA-1522 M2, UA-1595 M2, UA-2520 M2, UA-2522 M2, UA-2523 M2, UA-1501 M2, UA-1502 M2, UA-1542 M2, UA-1540 M2, UA-2241 M3, UA-1462 M3, UA-2521 M3, UA-2481 M3, UA-1542 M3, UA-1540 M3, UA-1480 p2, UA-2482 p3, UA-2491 p4, UA-1488 p4, UA-2467 p4, UA-1356 m1, UA-1417 m1, UA-1357 m1, UA-1484 m2, UA-1469 m2, UA-1295 m2, UA-1539 m2, UA-1370 m3, UA-1481 m3, UA-2238 m3, UA-1469 m3, UA-1416 m3, UA-1539 m3

Stratigraphic and geographic range. St. David Formation, southern Arizona at localities A-12-1, A-12-2, A-47-1, A-47-3, A-47-5, A-47-7, and A-52; Blanco Formation of Texas; the Rexroad fauna of Kansas; the Meade Formation, Clark County, Kansas; the Deer Park fauna, Kansas; the Camp Rice Formation, Texas; and the Sanders fauna, Kansas.

Age. Blancan

Description. The teeth are described collectively as there is little variation in pattern due to position in the series. The uppers and lowers have a relatively small occlusal surface and are very hypsodont.

The upper cheek teeth have a marked lingual curvature, increasing anteriorly and posteriorly. Enamel folding is moderately complex, with adjacent borders of the fossettes very complex. The protocone shape is variable from smooth ovals to quite elongate. The lingual border of the protocone is slightly concave in a few specimens.

Lower cheek teeth show some curvature in the anteroposterior plane. The enamel pattern lacks complexity. The median valley is broadly U-shaped, with a well developed pli caballid noted on a few specimens. The metaconid-metastylid gutter is broadly open, and U-shaped.

Table 30. Nannipus phlegon

Length	N	O.R.	$\bar{X}$	Width N.	O.R.	$\bar{X}$
P2	2	21.70-24.30	23.00	2	14.40-14.60	14.50
P3	5	18.20-22.60	20.14	5	13.80-17.50	15.90
P4	4	16.10-21.90	19.70	4	10.90-14.50	13.30
M1	2	13.40-15.50	14.45	2	14.00-16.80	15.40
M2	8	15.10-20.00	18.79	9	12.90-16.60	14.88
M3	6	15.00-18.60	16.52	5	13.00-15.40	13.84

Table 30. (<u>Continued</u>)

P.C.	N	O.R.	$\bar{X}$
P2	2	5.70-5.80	5.60
P3	5	5.70-5.80	6.64
P4	4	5.40-5.90	5.65
M1	2	5.50	
M2	9	5.80-8.60	7.30
M3	5	6.60-7.80	7.38

Length	N	O.R.	$\bar{X}$	Ant. Width	N	O.R.	$\bar{X}$
p2	1	21.60			1	5.20	
p3	1	18.70			1	8.90	
p4	3	16.90-22.00	18.83		2	3.60	
m1	3	15.60-22.30	18.53		3	7.20-9.70	8.80
m2	4	16.50-18.00	17.00		3	7.60-9.90	8.37
m3	4	18.90-21.40	20.10		6	6.40-8.50	7.28

Post. Width	N	O.R.	$\bar{X}$	M.M. Length	N	O.R.	$\bar{X}$
p2	1	6.30			1	10.60	
p3	1	9.10			1	12.00	
p4	3	6.70-10.00	8.77		3	11.40-12.40	11.90
m1	3	7.90-9.40	8.40		3	10.20-11.80	10.77
m2	3	7.00-9.40	7.80		4	11.00-11.80	11.25
m3	6	6.00-9.00	7.17		6	9.70-10.40	10.10

Discussion. Gidley (1922b) reported *Nannippus* from the Benson beds referring the material to *Hipparion*. Gazin (1942) correctly referred the material to *Nannippus phlegon* on the basis of its isolated smooth, oval protocone, small size and three toed feet.

Equus (*Plesippus*) cf. *shoshonensis*

Figure 9, A, B

Type. USNM-11986 a complete skull and other parts of the skeleton from the Hagerman fauna, Idaho.

Referred material. UA-1602 P2, UA-525 P2, UA-2480 P2, UA-2427 P2, UA-1880 P2, UA-1879 P2, UA-1500 P2, UA-1601 P3, UA-2480 P3, UA-1880 P3, UA-1879 P3, UA-48 P4, UA-45 P4, UA-526 P4, UA-1684 P4, UA-1601 P4, UA-1425 P4, UA-569 P4, UA-2480 P4, UA-1483 P4, UA-1604 P4, UA-1425 P4, UA-1423 M1, UA-525 M1, UA-570 M1, UA-538 M1, UA-2480 M1, UA-1411 M1, UA-569 M1, UA-1605 M1, UA-2518 M1, UA-567 M2, UA-1685 M2, UA-586 M2, UA-575 M2, UA-566a M2, UA-2480 M2, UA-1464 M2, UA-566b M2, UA-575 M2, UA-1683 M3, UA-525 M3, UA-1682 M3, UA-2486 M3, UA-1686 M3, UA-44a M3, UA-2480 M3, UA-1464 M3, UA-1686 M3, UA-44b M3, UA-80 p2, UA-1677 p3, UA-572 p3, UA-584 p3, UA-1465 p3, UA-1603 p4, UA-574 p4, UA-39 p4, UA-42 p4, UA-78 p4, UA-41 p4, UA-526 p4, UA-1608 p4, UA-6 p4, UA-1465 p4, UA-1418 p4, UA-1465 m1, UA-1463 m1, UA-577 m2, UA-1443 m2, UA-82 m2, UA-87 m2, UA-1465 m2, UA-43 m3, UA-83 m3, UA-1679 m3, UA-1678 m3, UA-526 m3, UA-575 m3, UA-14 m3, UA-1465 m3, UA-1486 m3

Stratigraphic and geographic range. St. David Formation, southern Arizona at localities A-12-1, A-47-1, A-47-2, A-47-3, A-47-7 and Hagerman fauna, Idaho

Age. Blancan

Description. The teeth are described collectively. Upper and lower teeth are relatively large and very hypsodont.

The upper teeth have a slight lingual curvature. Adjacent borders of the fossettes are finely crenulate and show well developed labial cornua. The pli caballin is well developed, almost reaching the protocone. The protocone has a slight projection anterior to the commissure and has a slightly concave lingual border in most specimens.

Lower cheek teeth have no noticeable curvature, except the terminal cheek teeth are curved in an anteroposterior plane. The enamel pattern is simple. The pli caballinid varies from absent to well developed. The labial borders of the protoconid and hypoconid are flat and enclose a deep median valley which penetrates the metaconid and metastylid in variable degree. The paralophid is well developed. The metaconid-metastylid gutter has a relatively sharp V-shape. The entoconid, metaconid, and metastylid are round to oval in shape and subequal in size.

Table 31. <u>Equus</u> (<u>Plesippus</u>) cf. <u>shoshonensis</u>

Length	N	O.R.	$\bar{X}$	Width	N	O.R.	$\bar{X}$
P2	4	31.70-42.80	36.28		6	14.10-31.70	26.20
P3	4	27.50-34.70	31.50		3	21.60-29.80	26.85
P4	11	28.60-37.00	31.29		7	14.10-35.70	25.80
M1	7	27.40-31.50	29.44		7	24.30-34.30	28.51
M2	9	25.30-29.50	27.69		9	24.40-29.40	27.06
M3	8	25.50-35.00	29.71		10	20.60-27.60	25.52

P.C. Length	N	O.R.	$\bar{X}$
P2	6	6.30-18.80	11.43
P3	4	8.80-13.50	10.95
P4	9	11.90-15.80	14.22
M1	9	11.20-16.00	14.34
M2	9	11.60-15.30	13.31
M3	10	13.50-17.00	15.13

Length	N	O.R.	$\bar{X}$	Ant. Width	N	O.R.	$\bar{X}$
p2	1	35.50			1	11.50	
p3	3	27.40-29.20	28.33		3	13.90-16.40	14.97
p4	9	26.00-33.10	30.48		10	13.70-19.70	16.63
m1	2	30-60-31.40	31.00		2	12.20-16.40	14.30
m2	4	26.80-35.00	30.83		5	11.50-15.10	13.62
m3	8	30.00-37.80	34.71		8	10.80-14.20	12.60

Table 31. (Continued)

Post. Width	N	O.R.	$\bar{X}$	M.M. Length	N	O.R.	$\bar{X}$
p2	1	15.10			1	14.20	
p3	3	13.10-16.90	14.37		3	14.90-17.70	16.23
p4	10	13.40-17.50	15.86		10	14.50-21.00	17.57
m1	2	12.60-15.60	14.10		2	16.00-17.60	16.80
m2	5	10.40-15.10	12.62		5	14.00-16.50	13.26
m3	8	10.70-12.90	11.64		8	14.10-16.00	14.64

Discussion. Gidley (1922b) described Pliohippus from the Benson fauna. Gazin (1942) referred the same material to Plesippus sp., however did recognize their similarity to P. shoshonensis. The material now available is indistinguishable from P. shoshonensis of the Hagerman fauna, Idaho. Nannippus phlegon is not found with P. shoshonensis in the Hagerman fauna.

The upper teeth of Equus (Plesippus) shoshonensis may be separated from Nannippus phlegon by their much larger size, being relatively less hypsodont, having a more lingual curve to the teeth, and the protocone connected to the enamel pattern of the tooth while in N. phlegon the protocone is completely isolated. The lower teeth of E. (P.) shoshonensis are of a much larger size, relatively less hypsodont, the metaconid-metastylid gutter being more sharply V-shaped than N. phlegon and the labial borders of the protoconid and hypoconid flat while in *N. phlegon* they are relatively more rounded.

Equus (*Equus*) sp.

Figure 9 G

Material. UA-1399 right P3, UA-2562 right DP4 and RM2, UA-1568 left M1, UA-1401 left P3, UA-1566 left M2, UA-1629 left M3, UA-1319 left DP4, UA-1348 right M1, UA-1559 left m1, UA-3240 right m1 and UA-1576 left m3.

Stratigraphic and geographic range. St. David Formation, southern Arizona at localities A-25-3 and A-68130 and widespread throughout the world

Age. Irvingtonian-Recent

Description. The teeth are described collectively. Both the upper and lower dentition are large and hypsodont.

The upper teeth have complex enamel patterns with the fossette borders especially crinkled. The cornua extend to near labial border. The parastyle and mesostyle are very pronounced, the metastyle less so; the pli caballin is well developed. The protocone extends anteriorly about one third of its length and is straight or concave lingually. There is a slight lingual curvature to the long axis of the teeth.

Lower teeth have a very simple enamel pattern. The protoconid and hypoconid are straight labially with a narrow, flat-floored, U-shaped median valley. The metaconid and metastylid are oval to quite angular and enclose an open V-shaped gutter. Entoconid and hypoconulid are well developed. Pli caballinid is absent to incipient in development. The paralophid is moderately developed. Pli hypoconid incipient.

Table 32. Equus (Equus)

Length	N	O.R.	$\bar{X}$	Width	N	O.R.	$\bar{X}$
P3	2	25.20-32.00	28.60		2	28.30-28.50	28.40
P4	2	25.30-31.40	28.35		2	21.90-28.60	25.25
M1	1	33.20			2	23.50-28.90	26.20
M2	2	28.80-33.30	31.50		2	21.20-26.50	23.85
M3	1	31.50			1	22.20	

P.C. Length	N	O.R.	$\bar{X}$
P3	2	13.60-16.70	15.15
P4	2	9.90-13.60	11.75
M1	1	11.90	
M2	2	14.00-16.00	15.00
M3	1	13.50	

Length	N	O.R.	$\bar{X}$	Ant. Width	N	O.R.	$\bar{X}$
p2	1	28.70			1	11.50	
p3	1	26.80			1	15.40	
p4	1	25.20			1	15.20	
m1	2	23.80-27.80	25.80		2	14.00-14.30	14.15
m2	1	24.50			1	13.70	
m3	2	26.00-27.50	26.75		2	10.90-12.00	11.45

Table 32. (Continued)

Post. Width	N	O.R.	$\bar{X}$	M.M. Length	N	O.R.	$\bar{X}$
p2	1	14.50			1	15.00	
p3	1	16.30			1	16.80	
p4	1	15.30			1	15.60	
m1	2	13.20-13.80	13.50		2	14.00-14.90	14.45
m2	1	12.60			1	14.40	
m3	2	9.70-12.00	10.85		2	12.10-13.60	12.85

Discussion. Equus (Equus) was reported from the Curtis Ranch fauna by Gazin (1942) who expressed the opinion that the Curtis Ranch Equus was not far removed from Plesippus. The Curtis Ranch specimens of Equus show primitive characteristics such as the protocones not very elongate and the narrow V-shaped valley between the protoconid and hypoconid.

The upper cheek teeth of Equus (Equus) may be separated from those of E. (Plesippus) by the more pronounced development of the parastyle, mesostyle and the pli caballin. The protocone of E. (Equus) has a proportionally longer heel on the protocone and a straighter lingual border when compared to the more concave lingual margin of the protocone of E. (Plesippus) shoshonensis. E. (Equus) may be separated from Nannippus phlegon by its much larger size, proportionally less hypsodont and a connected protocone while N. phlegon is smaller, very hypsodont, and has an isolated protocone.

The lower cheek teeth of Equus (Equus) may be separated from those of E. (Plesippus) by the metaconid-metastylid gutter more U-shaped and ending short of the metaconid-metastylid and is relatively V-shaped in E. (Plesippus) penetrating the metaconid-metastylid. E. (Equus) may be separated from Nannippus phlegon by its much larger size, relatively less hypsodont, and lacking the penetration of the metaconid-metastylid by the median valley.

Equus (Asinus) sp.

Figure 9 H, I

Material. UA-1630 right P4-M3, UA-1403 right P3, UA-1349 right m3, UA-1321 right m2, UA-1552 right dp2-4, m1 and metatarsals UA-1318, UA-1554 (partial) and UA-1343

Stratigraphic and geographic range. St. David Formation, southern Arizona at localities A-25-3, A-68130, Sanders fauna, Kansas, and recently widespread throughout the world.

Age. Irvingtonian-Recent

Description. The teeth are described collectively. Both the upper and lower dentition are large and hypsodont.

The upper teeth have a slight lingual curvature. The parastyle and mesostyle are very large and the metastyle greatly reduced. The enamel pattern is moderately complex, especially the fossettes. The protocone is straight or only slightly concave lingually. The heel of the protocone projects anteriorly less than one third the protoconal length. Pli caballin is well developed.

The lower teeth have a simple enamel pattern and little vertical curvature. The metaconid and metastylid are sub-angular with flat lingual walls. The gutter is broadly V-shaped. The metaconid, metastylid, and entoconid are subequal in development. The protoconid and hypoconid are moderately flat labially, enclosing a V-shaped median valley.

The pli caballinid is well developed in deciduous teeth, and lacking in adults. The hypoconulid and paralophid are well developed. Parastylid is well developed in deciduous teeth.

The metatarsals are extremely long and slender, a complete one (UA-1343) measuring: length (long axis) 342.7 mm., proximal length (anteroposterior) 51.8 mm., proximal width 44.8 mm., distal length (anteroposterior) 44.1 mm., and distal width 37.2 mm.

Table 33. Equus (Asinus)

Length	N	O.R.	$\bar{X}$	Width	N	O.R.	$\bar{X}$
P4	2	29.10-30.00	29.55		2	29.00-29.20	29.10
M1	2	26.40			2	28.00-28.10	28.05
M2	2	27.30-28.20	27.55		2	26.70-27.00	26.85
M3	1	26.00			2	19.60-21.2-	20.40

P.C. Length	N	O.R.	$\bar{X}$
P3	1	16.90	
P4	2	14.40-15.00	14.70
M1	2	11.40-11.60	11.50
M2	2	13.80-14.20	14.00
M3	2	12.30-12.70	12.50

Length	N	O.R.	Ant. Width	N	O.R.
p2	1	38.10		1	11.90
p3	1	32.20		1	12.20
p4	1	32.70		1	12.20
m1	1	30.80			
m2	1	23.90		1	13.40
m3	1	31.50		1	13.00

Post. Width	N	O.R.	M.M. Length	N	O.R.
p2	1	12.70		1	19.20
p3	1	12.90		1	17.90
p4	1	11.70		1	16.90
m1					
m2	1	12.20		1	13.40
m3	1	11.60		1	13.80

Discussion. The teeth and metatarsals were not found in association and are treated together as they are individually characterized in _Equus_ (_Asinus_). Variation in the known material from these deposits does not support separate taxonomic treatment of teeth and metatarsals; that is, known material suggests but a single equid (_Asinus_) from the deposits in question. The teeth are assigned to _Equus_ (_Asinus_) because of the slight projection of the heel of the protocone, the well developed parastylid on the deciduous teeth, and the broad V-shaped, metaconid-metastylid gutter. The presence of the pli caballin has been used to separate _Equus sensu stricto_ from _E_. (_Asinus_) and _E_. (_Plesippus_), however McGrew (1944) refers to the invalidity of this characteristic.

The metatarsal from the Curtis Ranch is much longer than _Equus_ (_Asinus_) _pons_ Quinn (1958) from the Comosi fauna, Santa Cruz County, Arizona. The metatarsal is slimmer and longer than the _Equus calobatus_ Troxell (1915), from Rock Creek, Texas. Metatarsals reported by Hibbard (1953b) as _Equus_ (_Asinus_) _calobatus_ Troxell from the Arkalon fauna, Seward County, Kansas, are much longer than Troxell's (ibid.) specimen and narrower at the distal and proximal end, and are thus intermediate in size between Troxell's metatarsal and the Curtis Ranch specimen. Because of the similarity of the metatarsal to the specimens discussed above, the Curtis Ranch specimens are assigned to the same subgenus.

The upper cheek teeth of Equus (Asinus) may be separated from Equus (Equus) by the enamel patterns of the fossettes relatively more complex and the lingual margin of the protocone less concave. E. (Asinus) may be separated from E. (Plesippus) shoshonensis by its greater elongation of the protocone and more hypsodont. E. (Asinus) may be separated from Nannippus phlegon by the protocone attached to the remaining enamel pattern rather than isolated and the tooth is much larger.

The lower cheek teeth of Equus (Asinus) may be separated from E. (Equus) by its V-shaped median valley (E. (Equus) has a more U-shaped valley) and the presence of the parastylid. E. (Asinus) may be separated from E. (Plesippus) by the lack of penetration of the metaconid-metastylid by the median valley and the relatively narrower width. E. (Asinus) may be separated from Nannippus phlegon by its larger size and lesser hypsodonty.

Order Artiodactyla

Family Tayassuidae

Platygonus texanus Gidley 1903

Figure 10 A, B

Type. AMNH-10702, palate with upper dentition from the Blanco fauna, Texas

Material. UA-585 right M3, UA-1671 right m3, UA-1607 right m3, UA-19 right dentary with p3-m3, UA-20 left ramus with p3, m1, UA-1360 p3-m1, UA-17 right upper canine, UA-15 right lower canine, UA-18 left lower canine, UA-21 left i1, UA-16 left i2, UA-22 right i1, UA-23 right i2

Stratigraphic and geographic range. Blanco local fauna, Texas and St. David Formation, southern Arizona

Age. Blancan

Description. p3 quadrate in occlusal outline with heavy cingulum labially; protoconid heavier than metaconid; protoconid and metaconid relatively high to talonid; slight stylar development anterior and posterior to protoconid.

p4 differs from p3 in rectangular occlusal outline; styles not as well developed and a much heavier postero-labial cingulum; wider than p3.

m1 rectangular in occlusal outline, the four cusps of equal development soon wearing to transverse lophs and posterolingual and labial development of cingulum; larger than p4.

m2 rectangular occlusal outline with cingular development around tooth; stylar development along median of tooth forms "ridge"; all cusps of about equal development; lingual cusp slightly higher.

m3 differs from m2 in development of fifth terminal cusp posteromedially, only slightly smaller than four main cusps.

Table 34. Platygonus texanus

Length	N.	O.R.	$\bar{X}$	Ant. Width	N.	O.R.	$\bar{X}$
p3	2	11.60-13.20	12.40		2	8.20-10.80	9.50
p4	2	13.60-14.00	13.90		2	12.10-12.40	12.25
m1	2	16.80			2	12.40-12.50	12.45
m2	2	19.50-19.70	19.60		2	15.20-15.40	15.30
m3	4	18-30-27.30	23.08		5	13.90-16.30	13.78

Post. Width	N	O.R.	$\bar{X}$
p3	2	9.30-10.60	9.95
p4	2	12.30-12.60	12.45
m1	2	13.00-13.20	13.10
m2	2	15.20-15.50	15.35
m3	4	11.30-14.90	13.25

Discussion. Gidley (1922b) reported Platygonus remains from the "Benson Beds" referring it to P. vetus or a new species. Gazin (1938) mentioned Platygonus being found near Benson, later (1942) suggesting that the teeth were near P. pearci from Hagerman, but not assigning the remains to that species.

Specimens figured in Hibbard (1937) of Platygonus material from Rexroad appear close in form to P. texanus from the St. David formation but are slightly larger. The St. David form can be readily separated from P. vetus of the Hagerman and Coso Mountain deposits on having the more typical Platygonus number of incisors (two in each lower jaw as opposed to three teeth in the latter two) and a slightly larger size. These could well be synomynized following the collection of more material.

Platygonus specimens from the St. David formation can be better compared with Meade's (1945) description of additional P. texanus material from the Blanco formation, Texas (includes inferior dentition) than in Gidley's (1903) original description (superior dentition only) as the St. David material is practically limited to lowers. The St. David material appears closer to P. texanus than other species in the linear and transverse measurements, development of cingulum and number of accessory styles.

A full complement of lower incisors (UA-16, 21, 22, 23) from Mendivil Ranch show there were two incisors in either half of the mandible rather than three as in Mylohylus.

Family Camelidae

Camelops sp.

Referred specimen. UA-1317 right M3, UA-1316 left i2

Stratigraphic and geographic range. St. David Formation, southern Arizona, locality A-6895; Meade Formation, Kansas; Sand Draw fauna, Nebraska; Borchers fauna, Meade County, Kansas; and the upper Becerra Formation, Mexico

Age. Blancan-Rancholabrean

Description. i2 spatulate shaped; subtriangular cross section; blunt internally, tapering to sharper edge externally.

M3 two selenes; mesostyle prominent, projecting anteroexternally; very hypsodont; approximate length 60.0 mm., approximate width 37.0 mm.

Discussion. The above specimens are assigned to Camelops on the basis of their large size and lack of ribs and styles, typical in Titanotylopus. This is the first reporting of Camelops from the Curtis Ranch fauna.

Tanupolama sp.

Referred specimens. UA-1951 portion of left maxillary with P4, M1, UA-1565 left M2-3, UA-1713 left M1, right dp4, left m2, UA-1303 right m1, 2, UA-1315 left m3.

Stratigraphic and geographic range. St. David Formation, southern Arizona, localities A-25-3 and A-6895; Camp Rice Formation, Texas; Irvington fauna, California

Age. Blancan-Rancholabrean

Description. The teeth are very poorly preserved and only those listed are adequate for measurement and description.

dp4 very hypsodont; three selenes; parastyle larger than mesostyle; incipient, lingual styles between anterior and center selene; occlusal length 34.0 mm., occlusal width 9.4 mm.

M3 very hypsodont; two selenes; fossettes triangular; mesostyle larger and extending more labially than parastyle; occlusal length 27.0 mm., occlusal width 14.2 mm.

m3 very hypsodont, three selenes; posterior selene much reduced; fossettes centrally constricted; enamel island at junction of central and posterior selene; well developed "llama buttress"; occlusal length 36.8 mm., occlusal width 13.2 mm.

Discussion. Gazin (1942) referred to Tanupolama cf. longurio Hay a fairly complete lower jaw with a full dentition and fragments of the jaws and right maxilla of a second, immature individual with poorly preserved teeth. Specific taxonomic reference was made by Hay (1921) to a species from a Pleistocene fissure deposit near Anita, Arizona. Hay (ibid.) based his new species on a cannon bone, a cervical vertebra, foot material, and the distal portion of a radius-ulna. The Curtis Ranch material is placed in Tanupolama on the basis of upper molars having strong styles, the presence of the "llama buttress" on the m3, and the teeth are smaller than Camelops.

Family Cervidae

cf. Odocoileus sp.

Stratigraphic and geographic range. St. David Formation, southern Arizona and widespread as a recent genus.

Age. Blancan to Recent

Discussion. Gazin (1942) reported a large deer in the Curtis Ranch fauna including a right lower jaw portion, USNM-12872, with dp2-dp4 and m1-m2, fragment of a jaw with p4-m1, limb fragments and portions of antlers. Gazin states it represents a larger, more robust species than the extant species of Odocoileus. No additional material is presently known from the St. David Formation.

Family Antilocapridae

Texoceros sp. Frick

Stratigraphic and geographic range. Benson fauna, southern Arizona; upper Snake Creek Formation, Sioux County, Nebraska; Guyman fauna, Texas County, Oklahoma, Hemphill County, Texas; Wray fauna, Yuma County, Colorado; Eden beds, California

Age. Hemphillian-Blancan

Gidley (1922b) ascribed to *Merycodus* fragments of the right and left rami of an immature mandible that Gazin (1942) suggested could be either *Texoceros* or *Capromeryx*. Frick (1937) tentatively assigned additional material, consisting of horn cores from the Benson area to the genus *Texoceros*.

Horn cores of *Texoceros* have subequal, nonparallel tines as compared to *Capromeryx* (Matthew) with the anterior tine much smaller than the posterior tine, and the two tines parallel.

Capromeryx gidleyi Frick 1937

Figure 10 C, D

Capromeryx arizonensis Skinner 1942

Type. FAM-23324 an incomplete horn core from Curtis Ranch

Material. UA-1556, left (m1-m3) in fragment of dentary; UA-1347, lower portion of left horn core on base including upper half of orbit; and UA-1558, right posterior prong of horn core

Stratigraphic and geographic range. Curtis Ranch fauna, southern Arizona and Dry Mountain, southern Arizona.

Age. Irvingtonian

Diagnosis (of Frick, 1937). Prongs of horn core sub-parallel on high base directly above orbit. Anterior tine shorter than posterior tine.

Description. Prongs of horn cores on common base which bifurcates approximately 15 to 20 mm. above orbit. Posterior prong one and one half diameters larger than the anterior prong in each horizontal dimension, with prominent vertical sulcus along extero-lateral surface of posterior tine. Anterior tine has sub-triangular cross-section with wide shallow sulcus posteriorly and shallow sulcus along anterolateral face of tine. Posterior tine sub-quadrate.

The teeth of the Curtis Ranch specimen (m1-m3) are not distinctive compared to teeth of other Antilocaprids and are of less value than the horn cores in the present classification. The metastylid and entostylid are weakly developed; pillars are relatively high crowned.

Table 35. Maximum measurements at point of bifurcation of horn cores of <u>Capromeryx gidleyi</u>

	UA-1556	UA-1558
ant-post. diam. of post. prong	16.5	17.6
transverse diam. of post. prong	16.6	17.4
ant-post. diam. of ant. prong	14.4	-
transverse diam. of ant. prong	13.6	-

<u>Discussion</u>. A portion of a right maxillary (USNM-12873) and part of a right lower jaw (USNM-12874) from Curtis Ranch were referred by Gidley (ibid.) to <u>Merycodus</u>. Frick (ibid.) proposed the name <u>Capromeryx gidleyi</u> for an incomplete horn core (FAM-23324) collected at Curtis Ranch. Gazin (1942) was uncertain that the teeth collected by Gidley belong with the taxon based on horn cores by Frick, but referred the teeth to <u>Capromeryx</u>.

<u>Capromeryx gidleyi</u> differs mainly from <u>C</u>. <u>mexicana</u> from near Tequixquiac, Mexico, <u>C</u>. <u>furcifer</u> from Hay Springs, Nebraska, and <u>C</u>. <u>minor</u> from Rancho la Brea, California in having an anterior tine nearly as large as the posterior tine and a higher core base. <u>C</u>. <u>minimus</u> Meade (1942) from Pleistocene deposits of West Texas has a higher core base than <u>C</u>. <u>gidleyi</u>, but the posterior tine is much heavier than the anterior.

The measurements and general appearance of the horn core fragments from Curtis Ranch are indistinguishable from *Capromeryx arizonensis* Skinner (1942) from Dry Mountain, Arizona. Comparison with a similar horn core fragment from the Vallecito Creek fauna indicates their very close relationship. *C. gidleyi* has priority over *C. arizonensis* and though there is a lack of complete material for the type, reference to this species is necessary by rule of priority.

Stock (1930, p. 16) in considering species of *Texoceras* stated, "In the light of the variation in structure of horn core of the modern pronghorn, some of the more striking characters which distinguish *T. conklingi* from *T. shuleri*, and which may be regarded as of generic value, are attributed to a difference in age and sex." Along the same line Furlong (1946, p. 139) said, "Horn cores of recent *Antilocapra americana* show diversity in their shape. Some cores are modified to an extreme degree from the norm, and if found fossil unassociated with skeletal parts might be considered as presenting structural evidence of specific or even generic value." After comparison of variation in approximately a dozen specimens of recent *Antilocapra*, consideration of figure 14 by Skinner (1942), and evaluating the slight differences of placement of sulci and relative sizes of prongs in *Capromeryx*, I believe the variation in all the described fossil *Capromeryx* could be contained in the expected variation of a single population and will later be synonymized when represented by more material. The only criteria that satisfactorily separate presently recognized species of *Capromeryx* are time and geography. In light of the limited knowledge of *Capromeryx* and the known geographic range and morphological variation of extant *Antilocapra*, it is unrealistic to describe new taxa of Antilocapridae.

Table 36. Maximum measurements of molars of *Capromeryx gidleyi* compared with other *Capromeryx*.

	UA-1556	[1]No. 4943	[1]No. 4542	[2]CIT-15	[2]LACM-Z8501	[3]UK-3480	[4]WTM-19
Occlusal length m1	9.8					10.3	6.8
Transverse width m1	5.2					5.5	
Dorso-ventral height m2	30.7			31.7	30.3		
Occlusal length m2	11.7			10.8	10.0	12.0	8.2
Transverse width m2	5.7			4.7	4.8	5.8	
Dorso-ventral height m3	27.6	28.8	22.8	28.3	26.3		
Occlusal length m3	19.4	18.0	17.6	13.3	12.2		15.7
Transverse width m3	6.4	6.0	5.7	4.3	4.4		
Length of m1-m3	42.4			47.0	47.0		

[1]*Capromeryx* Hibbard 1941c

[2]*C. minor* Furlong 1930

[3]*C. texanus* Hesse 1935

[4]*C. minimus* Meade 1942

DISCUSSION

Paleoccology of the Benson and Curtis Ranch Faunas

The paleoecology of the Benson and Curtis Ranch faunas is based upon the assumptions that: (1) the ecological requirements of fossil genera fall within the range of variation exhibited by the extant genus, (2) uniformitarian interpretation of adaptation to an ecological situation may be inferred from morphological similarity to extant genera, (3) interpretation of environment from lithologies represented, and (4) relative degree of representation of taxa in the fossil assemblage. The weaknesses inherent in such assumptions are realized, but provide a framework for interpreting paleoecology.

The Benson and Curtis Ranch show no major replacements of any taxon beyond the error inherent in the preservation and applied method of collection. Half of the mammalian genera are common to both faunas. The changes in the taxa representative of the two faunas either represent evolution in the area or replacement of taxa from outside the area. The most noticeable change was the introduction into the Curtis Ranch fauna of several genera from South America and does not have to represent an ecological change. (Fig. 6)

Benson or Curtis	Fauna	A-12-1	A-12-2	A-6896	A-47-1	A-47-4	A-47-2	A-47-3	A-47-9	A-47-5	A-47-7	A-47-11	A-47-10	A-52	A-25-1	A-68129	A-68130	A-68128	A-25-3	A-68131	A-6895
Gramineae	B										x										
Sedge	B/C										x				x						
Celtis	B					x	x			x											
Gastropoda	B/C	x		x				x						x				x	x		
Ostracoda	B/C									x	x				x				x		
Pisces	B/C																		x		x
Reptilia /Amphibia	B/C							x		x				x				x	x		
Aves	B/C																	x			
Notiosorex crawfordi	B											x									
Simonycteris stocki	B/C													x	x						
Glyptotherium arizonae	C																			x	
Auralagus bensonensis	B				x				x												
Nekrolagus sp.	B																				
Hypolagus sp.	B				x																
Notolagus sp.	B																				
Lepus	C																				
Aluralagus	C																				
Citellus bensoni	B				x						x			x							
Citellus cochisei	C																		x		x
Citellus sp.	C																		x		
Geomys minor	B	x		x	x	x				x											
Geomys persimilus	C																	x	x		x
Cratogeomys bensoni	B	x																			
Perognathus rexroadensis	B			x	x			x						x							
Perognathus sp.	C																	x			x
Dipodomys minor	B	x		x										x							
Dipodomys gidleyi	C																		x		x
Liomys sp.	B	x		x																	
Castor canadensis	C																x				
Bensonomys arizonae	B/C	x	x	x	x		x							x							x
Peromyscus titanomys	C															x					x
Peromyscus baumgartneri	C																		x		x
Baiomys minimus	B	x		x				x		x				x							
Baiomys brachygnathus	C															x					
Onychomys bensoni	B																				
Onychomys pedroensis	C			x										x							
Sigmodon medius	B	x	x	x	x	x		x		x	x		x	x							
Sigmodon minor	C															x		x	x		x
Sigmodon curtisi	C																	x	x		x
Neotoma fossilis	B	x		x	x	x								x							
Neotoma olseni	C																		x		
Mimomys primus	B			x																	
Pliopotamys meadensis	C																		x		
Ondatra kansasensis	C																		x		
Microtus	B				x																
Neochoerus	C														x						
Borophagus minicyon	B							x													
Canis sp.	B																				
Canis edwardii	C																				
Canis latrans	C																			x	
Spilogale pedroensis	B																				
Felis sp.	B/C																				
Cuvieronius ? bensonensis	B	x					x			x			x								
Stegomastodon arizonae	C														x						
Nannipus phlegon	B	x	x		x			x		x	x		x								
Equus (Plesippus) shoshonensis	B	x			x	x	x	x													
Equus (Equus)	C														x		x		x		
Equus (Asinus)	C																x		x		
Tanupolama sp.	C																		x		x
? Camelops	C																				x
Platygonus texanus	B	x																			
Odocoileus sp.	C																				
Texoceros	B																				
Capromeryx gidleyi	C																x				

Figure 6 FAUNAL DISTRIBUTION IN THE ST. DAVID FORMATION

The birds reported from the Benson and Curtis Ranch faunas are of little help in determination of a change in the ecology because of their previous habitation in the area within historical times or are migratory forms. Two exceptions would be Odonotophorus and Agriocharis which are now restricted to southern Mexico and parts of Central America.

Because of the similarity between the Benson and Curtis Ranch fauna, their paleoecology can best be considered by the significance of their shared taxa, only discussing their differences where paleoecologically significant.

The presence of large turtles (e.g. Geochelone) in both faunas suggests that (Hibbard 1960), "large Pliocene and Pleistocene land tortoises could not stand freezing, but they may have existed in an area where very few light frosts occurred at night but with temperatures during the day warmed to 60° or more Fahrenheit." Brattstrom (1961), states that large tortoises are probably indicators of tropical or subtropical, feeling that they could not burrow to escape the cold or absorb enough heat during the day to endure cold nights. Brattstrom (ibid.) largely based his conclusions upon the distribution and ecology of extant forms, which would exclude Geochelone, but turtles of probable similar adaptations. Though large species of Geochelone such as found in the Benson and Curtis Ranch faunas may well have been limited by their temperature extremes, it is then difficult to explain why the smaller species of *Geochelone* also became extinct at the time of the Wisconsin glaciation, as pointed out by Auffenberg (1962).

The presence of *Kinosternon*, *Citellus*, *Perognathus*, *Dipodomys*, *Peromyscus*, *Baiomys*, *Onychomys*, *Sigmodon*, *Neotoma* and *Canis* in both the Benson, Curtis Ranch, and extant faunas in the same area today, suggests that the paleoecological diversity of habitats were quite similar to the present time. The presence of *Cnemidophorus*, *Bufo*, *Liomys* and *Microtus* in the Benson fauna and their absence from the Curtis Ranch fauna has little ecological significance, but could probably represent sampling error.

The presence of *Castor* in the Curtis Ranch fauna is not surprising since *Castor* was trapped in the San Pedro River drainage within historical times. *Castor* may have been an ecological competitor with *Ondatra* or *Neochoerus*, however only very few specimens of each of the three genera were found, suggesting a limited habitat for these more aquatic mammals.

Some of the mammal genera have paleoecological significance and bear special mention in the overall historical development of the respective faunas. Kennerly (1959, p. 253) for example reports that *Geomys* is "partial to sandy friable soils, (Merriam, 1895, Davis, 1940) and that areas of indurate, nonfriable soils, abundant vegetation.... act as usually effective barriers or deterrants to its distribution." At the present time Geomys occurs within two hundred miles to the east in similar environments and is now replaced in the San Pedro Valley by Thomomys.

Near Benson and St. David Thomomys lives in the same soil types and thus the change in taxon doesn't seem to be in response to an apparent ecological change.

Perognathus has clearly adapted to a wide range of temperature and moisture conditions as evidenced by its present distribution, however Hall and Kelson (1959, p. 473) state that, "most pocket mice live in semi-arid situations." Osgood (1900, p. 58) states, "pocket mice usually choose plains and deserts for their habitat." Hibbard (1941d) concluded that Perognathus in the Rexroad fauna was a member of the "upland grass community" which here would be interpreted as a desert grassland.

Grinnell (1922) states that the genus Dipodomys is "...emphatically Austral in its life zonal occurrence", however in the southern end of the humid coastal belt of California many do occur in moderately heavy rainfall if the soil has a loose texture for burrowing. He further states that most prefer a loose soil such as normally associated with lack of rainfall.

Dale (1939, p. 728) agrees with Grinnell's observations, but adds: "another factor ordinarily associated with the habit of *Dipodomys* is sparseness of vegetation. *D. venustus* is said to be an exception to this general rule, and to occur in quite dense chaparral." Dale also stressed the fact that moisture is a definite limiting factor in restricting the range of *Dipodomys* and that a habitat of adequate drainage is preferred in their available range. Howell (1932) agreed with the above, however described in greater detail, the habitat of *Dipodomys* in more humid and vegetated areas as short grass lands, often devoid of brush in prairie country and is never found in low, swampy areas amid lush vegetation.

The above authorities conclude that *Dipodomys* inhabited the desert grasslands adjacent to the riparian woodland.

Sigmodon is primarily a southern form and is quite variable, but according to Hall and Kelson (1959, p. 671) the habitat of *Sigmodon* "usually includes tall weeds and grass."

Shotwell (1961) states that the habitat of *Nannippus* was savanna and *Equus* lived in open grasslands. It is difficult to distinguish between these two habitats in the fossil record.

The diatomite, cherts, and limestone in the St. David formation are clearly indicative of the former presence of subaqueous deposition. Large numbers of gastropod, ostracods, pelecypod, and fish remains are present in the above sediments in addition to occurring in numerous green beds. This suggests the presence of a great number of ponds and cienagas. In several sites examined (e.g. A-47-10, a tuffaceous limestone) sedges, and undistorted horsetails occur in their growing position. The high number of diatoms and Characeae also indicate the presence of bodies of water. Much of the plant material occurs as a compressed fibrous mat of the horestails and sedges intermingled with a limy clay sediment. According to Wendorf (1961) the above flora indicates shallow water, quiet or slow moving, slightly alkaline (pH 7.0 to pH 9.5), with an appreciable amount of carbonate, an excess of silica, and water depth 1/2 to 9 meters.

Dominance of fine clastics in the St. David Formation suggest these sediments were deposited by a slow meandering stream, with low competence but high capacity. The sediment transport orientation shows the major vector to have been from south to north with a smaller contribution from the lateral mountains, basinward. Low angle cross bedding, scourfill structures, ripple marks and mud cracks occur rarely in the St. David Formation suggesting slight axial changes in flow direction and intermittent periods of drying.

The preponderance of primary or secondary red clays and red silts indicate a relatively semi-arid, oxidizing environment. Gray (1967) prefers a secondary or post-depositional origin for the red beds. The increase of caliche (commonly found in arid soils) toward the top of the section would support this conclusion. Gypsum in the form of selenite in many of the red beds also would suggest an arid, oxidizing environment. The presence of green beds, more abundant in the middle third of the Formation are probably the result of large bodies of water which would provide a more reduced environment, or more probably the fluctuation of the ancestral San Pedro regimen and the consequent changes in the water table.

I find nothing in either the lithologies represented or the Benson and Curtis Ranch faunas that would necessitate a significant deviation from the present climate except possibly the cold tolerance of the large turtles. Much of fauna is represented by genera living in the area or similar habitats within historical times. I suggest the St. David Formation deposited in the ancestral San Pedro Valley was comparable to the pre-1880 condition in the semiarid Southwest as described by Antevs (1952). Before the recent cycle of stream channelling the water table was much nearer the surface with frequent cienagas, ponds and backed up ephemeral bodies of water that would have provided the comparative lush riparian woodlands for the woodland element of the fauna. There is good reason to believe that there may have been greater rainfall during the interval of time represented by the deposition of the St. David Formation, but probably not to the extent of pluvial conditions often attributed to the glacial maxima of the Pleistocene.

The habitat of the Benson and St. David Formation faunas, as indicated by the sediments and fossils, appears to have been a broad aggrading flood plain with a scattered dendritic artesian spring system similar to the St. David area pre-1880. The areas of spring discharge and the temporary impondments of streams choked with sedges, horse-tails and associated tule would provide the necessary environment for the preservation of the fossil fauna found today. Around these ponds and along the streams grew the riparian woodland habitat for the rodents, shrews and large browsers as well as a watering and feeding place for the larger grazers and carnivores. The surrounding slopes quite likely supported a grasslands and associated lower Sonoran desert scrub typical of the Chihuahuan desert today. The climate might have been more equable than at present, without extremely cold winters or severely hot summers and the more prevalent open water may well have provided a greater degree of humidity in the region than there is now.

Age of the Benson Fauna

The presence of *Nannippus phlegon*, *Equus* (*Plesippus*), *Borophagus*, and *Mimomys* (*Cosomys*) indicate a Blancan age for this fauna. The primitive dental characteristics of *Borophagus* and *Equus* (*Plesippus*) and the presence of *Bensonomys* indicate very early Blancan and in my opinion would be pre-Nebraskan or a warm dry climatic interval as suggested by the many genera still living in the area such as *Notiosorex*, *Neotoma*, *Dipodomys*, *Perognathus*, and *Baiomys*. This same fauna could well suggest Aftonian except for the early aspect of the fauna in general.

Based on comparison of faunas (see appendix B), the Benson fauna approximates the Blanco (in part), Hagerman (in part), Coso Mountain, Sanders, and the Rexroad faunas, possibly later than Rexroad and is slightly earlier than the Hagerman (in part), and Blanco faunas (in part).

Age of the Curtis Ranch Fauna

The presence of Ondatra, Neochoerus, Lepus, and Equus (Equus) along with the absence of Nannippus, Bensonomys, Equus (Plesippus), Mimomys (Cosomys), and Borophagus suggest the Curtis Ranch fauna to be Irvingtonian. The absence of such forms as Tapirus, Tetrameryx and Mammuthus suggest very early Irvingtonian or possibly very latest Blancan.

The resemblance of the Curtis Ranch fauna to animals living in the area today or further south suggests that the effects of the Kansan glacial were not too great in this area. Savage (1955) states that Stegomastodon extends into only the very earliest post-Blancan in North America and considers the Curtis Ranch form synonymous with S. mirificus. Hibbard (1958) lists Stegomastodon in the Hallman and Seger faunas in Kansas. Thus while S. arizonae doesn't rule out a Blancan age, it does suggest the Curtis Ranch fauna is not younger than early Irvingtonian.

By comparison of faunas, the Curtis Ranch fauna approximates the Seger fauna (in part) and equates with most of the Cudahy fauna. It equates well with many elements in the Irvington fauna of California and appears to be earlier in part.

SUMMARY AND CONCLUSIONS

It is concluded that two North American Land Mammal Ages, as defined by Wood *et al.* (1941) and as extended into the Pleistocene by Savage (1951), are represented by the fossil faunas of the St. David Formation, Cochise County, Arizona. What has been referred to in the literature and in this study as the Benson fauna is assigned to early Blancan and the Curtis Ranch fauna is referred to the Irvingtonian. Certain elements of the Benson fauna suggest that it could be very late Blancan in which case this may represent an early occurrence for several taxa (e.g. *Ondatra*, *Lepus*, *Neochoerus* and *Equus* s.s.). Following is an age comparison of selected Pleistocene faunas.

Epochs	North American Land-Mammal Ages	Approximate correlative glacial stage	Faunas
Recent		Post Glacial	
Pleistocene		Wisconsin	Jones
	Rancholabrean	Sangamon	Jinglebob Cragin Quarry
		Illinoian	Mt. Scott Butler Spring
	Irvingtonian	Yarmouth	Borchers
		Kansan	Cudahy
		Curtis Ranch	
	Blancan	Kansan	Seger
		Aftonian	Sanders Deer Park
		Nebraskan	Unnamed
Pliocene		Benson	
			Bender Rexroad

As a result of this study the chronological range of several of the taxa have been extended when compared to the range of the same taxon as given in a recent summary by Hibbard (1965). The genera _Cratogeomys_, _Liomys_, and _Microtus_ have been extended to include Blancan. Hibbard (ibid.) replaces _Prodipodomys_ with _Dipodomys_ near the Blancan-Irvingtonian boundary, however I would agree with Gidley (1922) that the material from the Benson fauna does represent _Dipodomys_. _Neotoma_ should also be shown in the Blancan (ibid.) however _Neotoma_ had been reported by Gidley (1922b) and Gazin (1942) in Blancan deposits. In Hibbard's listing, _Neochoerus_ would now be extended to the Irvingtonian.

From the sediments and the taxa represented I would conclude that the environment during the time of the deposition of the St. David Formation, was little different than the area just prior to its development by man pre-1880. Before the present cycle of stream cutting, the water table was higher, thus contributing to the comparative lush fauna that too frequently is attributed to pluvials. The climate was more equable than at the present time with higher humidity due to the presence of more open water and the relative mesic vegetational cover.

Two new species of rodents, *Peromyscus titanomys* and *Neotoma olseni*, have been named in the Curtis Ranch fauna and *Borophagus minycyon*, a new species of dog, has been added to the Benson fauna.

The location of additional collecting sites may define a good separation of the two chronologic faunas or demonstrate that a continuum exists in the area, between the Benson and Curtis Ranch faunas.

Fig. 7 Soricidae, Sciuridae, Heteromyidae, Castoridae

A. *Notiosorex crawfordi*, UA-2301, lateral view left dentary i-m3 (6.5x).

B. *Notiosorex crawfordi*, UA-2301, occlusal view left dentary i-m3 (6.5x).

C. *Citellus cochisei*, UA-1699, occlusal view left m1-3 (9x).

D. *Liomys* sp., UA-3105, occlusal view right m1 (8x).

E. *Castor canadensis*, UA-1774, lateral view left M3 (5x).

F. *Castor canadensis*, UA-1774, occlusal view left M3 (5x).

G. *Castor canadensis*, UA-1774, medial view left M3 (5x).

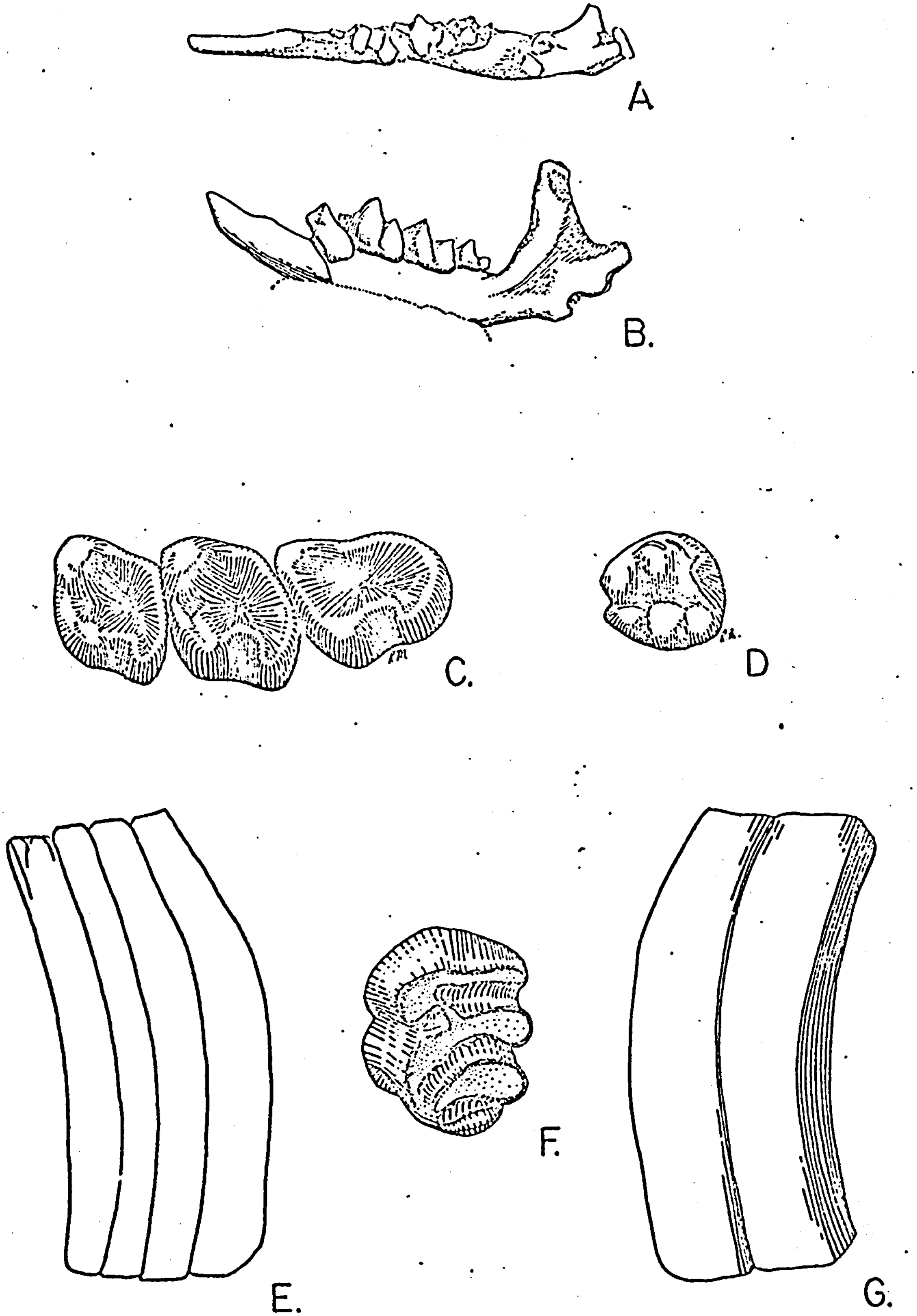


Figure 7 Soricidae, Sciuidae, Heteromyidae, Castoridae

Fig. 8 Cricetidae

A. *Bensonomys arizonae*, UA-2677, occlusal view left M1 (10x).

B. *Bensonomys arizonae*, UA-2671, occlusal view right m1 (9.3x).

C. *Peromyscus titanomys*, UA-3209, occlusal view right m1 (12x).

D. *Peromyscus titanomys*, UA-3178, occlusal view left M1 (10x).

E. *Neotoma olseni*, UA-1773, occlusal view right m1-m3 (10x).

F. *Neotoma olseni*, UA-3234, occlusal view right m1-m3 (5x).

G. *Neotoma fossilis*, UA-1509, occlusal view left M1-2 (10x).

H. *Neotoma olseni*, UA-3234, lateral view right dentary m1-3 (5x).

I. *Mimomys primus*, UA-2605, occlusal view right M1 (9x).

J. *Mimomys primus*, UA-2606, occlusal view left m2 (8.5x).

K. *Mimomys primus*, UA-2601, occlusal view right m3 (8x).

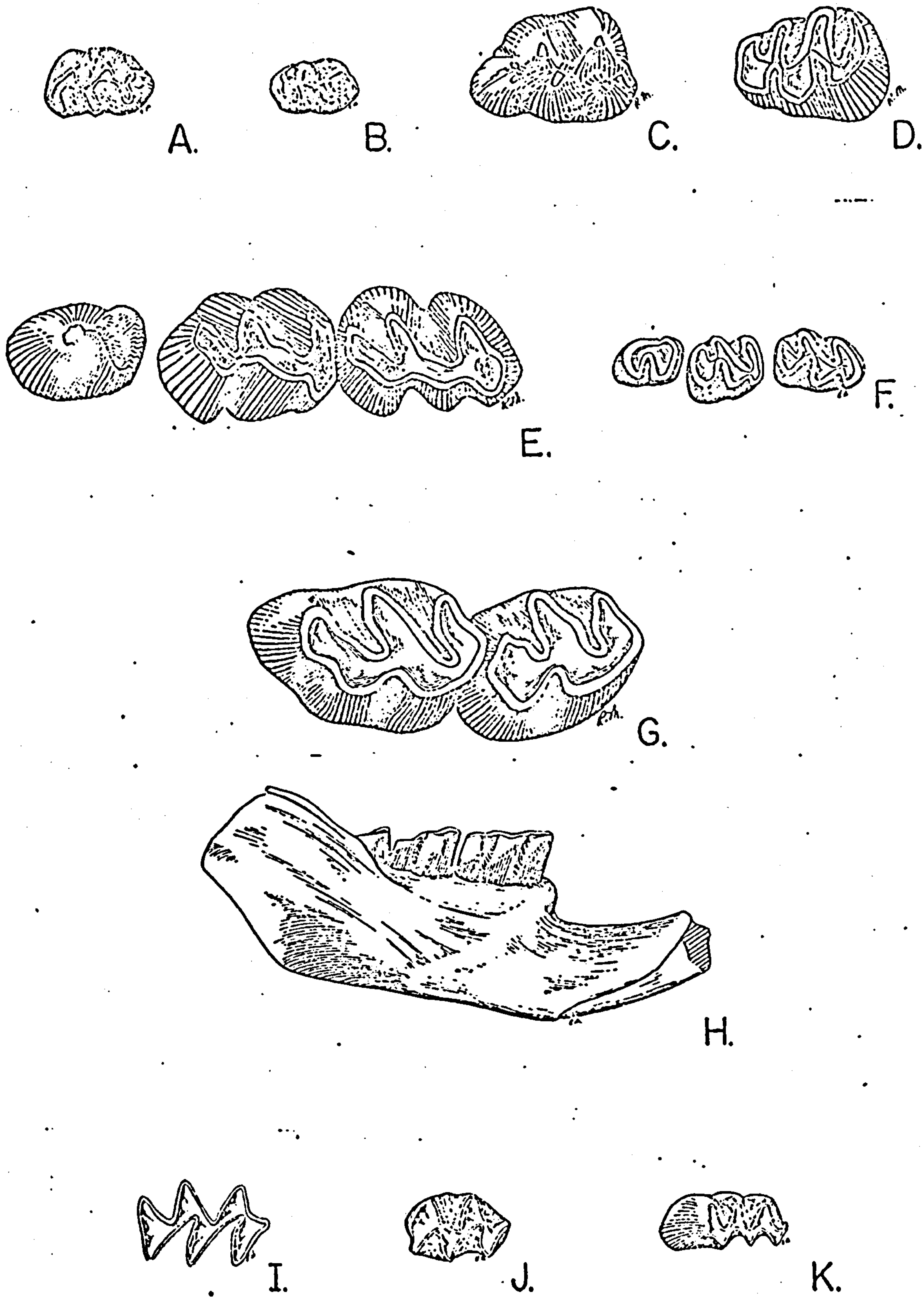


Figure 8 Cricetidae

Fig. 9 Cricetidae, Canidae

A. *Borophagus minycyon*, UA-1466, occlusal view right p2-m1, p2-p3 (1.8x), p4-m1 (1x).

B. *Borophagus minycyon*, UA-1466, medial view right p4-m1 (1x).

C. *Ondatra kansasensis*, UA-3233, occlusal view right m2-3 (8.6x).

D. *Ondatra kansasensis*, UA-3233, lateral view right m2-3 (7x).

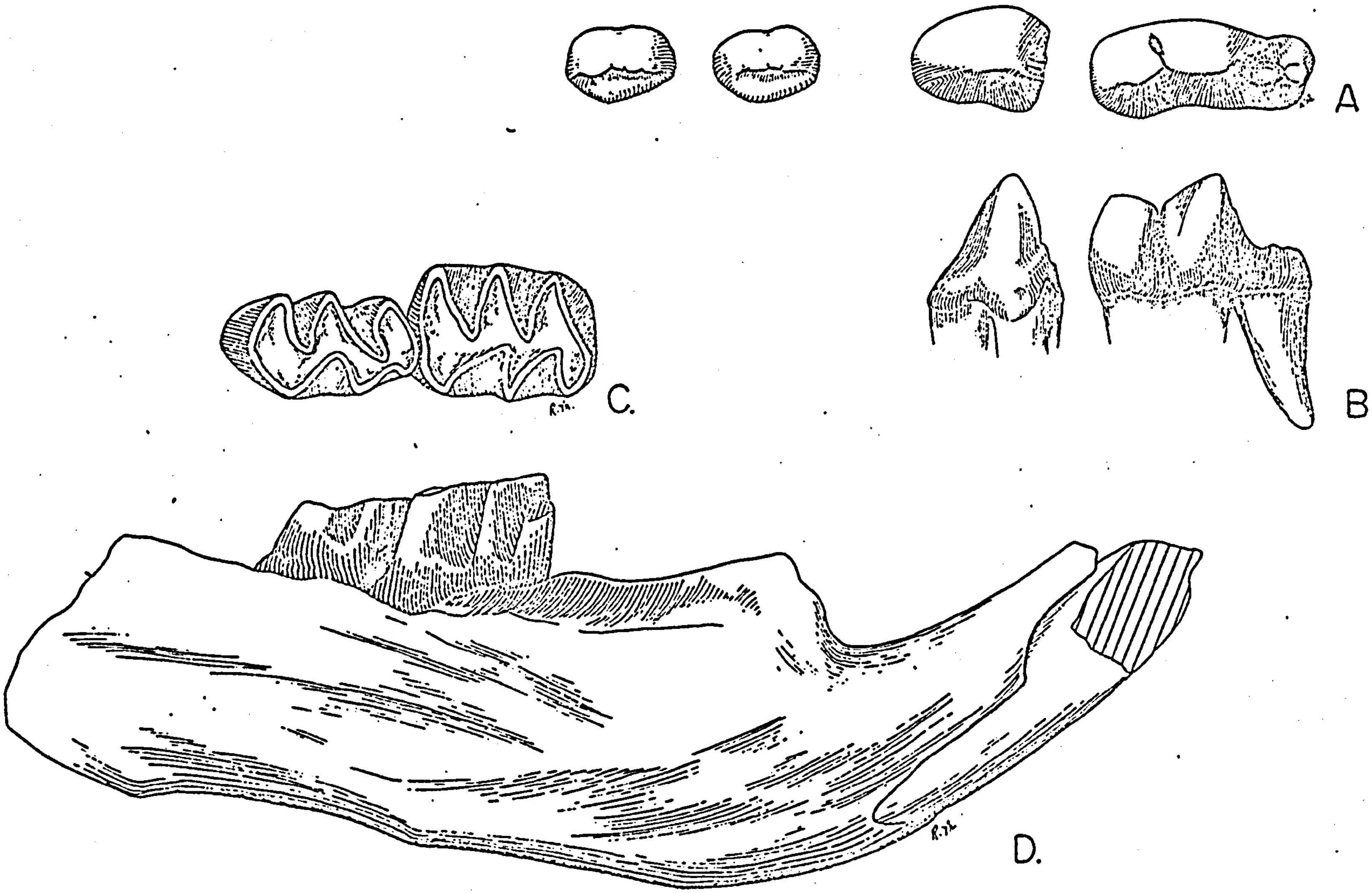


Figure 9 Cricetidae, Canidae

Fig. 10 Equidae

A. *Equus* (*Plesippus*) cf. *shoshonensis*, UA-2480, occlusal view right P2-M3 (0.5x).

B. *Equus* (*Plesippus*) cf. *shoshonensis*, UA-45 occlusal view right P4 (1,1x).

C. *Nannippus phlegon*, UA-1271, occlusal view right P4 (1.0x).

D. *Nannippus phlegon*, UA-1540, occlusal view right M2 (1.0x).

E. *Nannippus phlegon*, UA-1417, occlusal view left m1 (0.8x).

F. *Nannippus phlegon*, UA-1469, occlusal view right m2-3 (10x).

G. *Equus* (*Equus*) sp., UA-2562, occlusal view right p2-m3 (0.5x).

H. *Equus* (*Asinus*) sp., UA-1552, occlusal view right Dp2-4, m1 (1.0x).

I. *Equus* (*Asinus*) sp., UA-1343, anterior view metatarsal (0.26x).

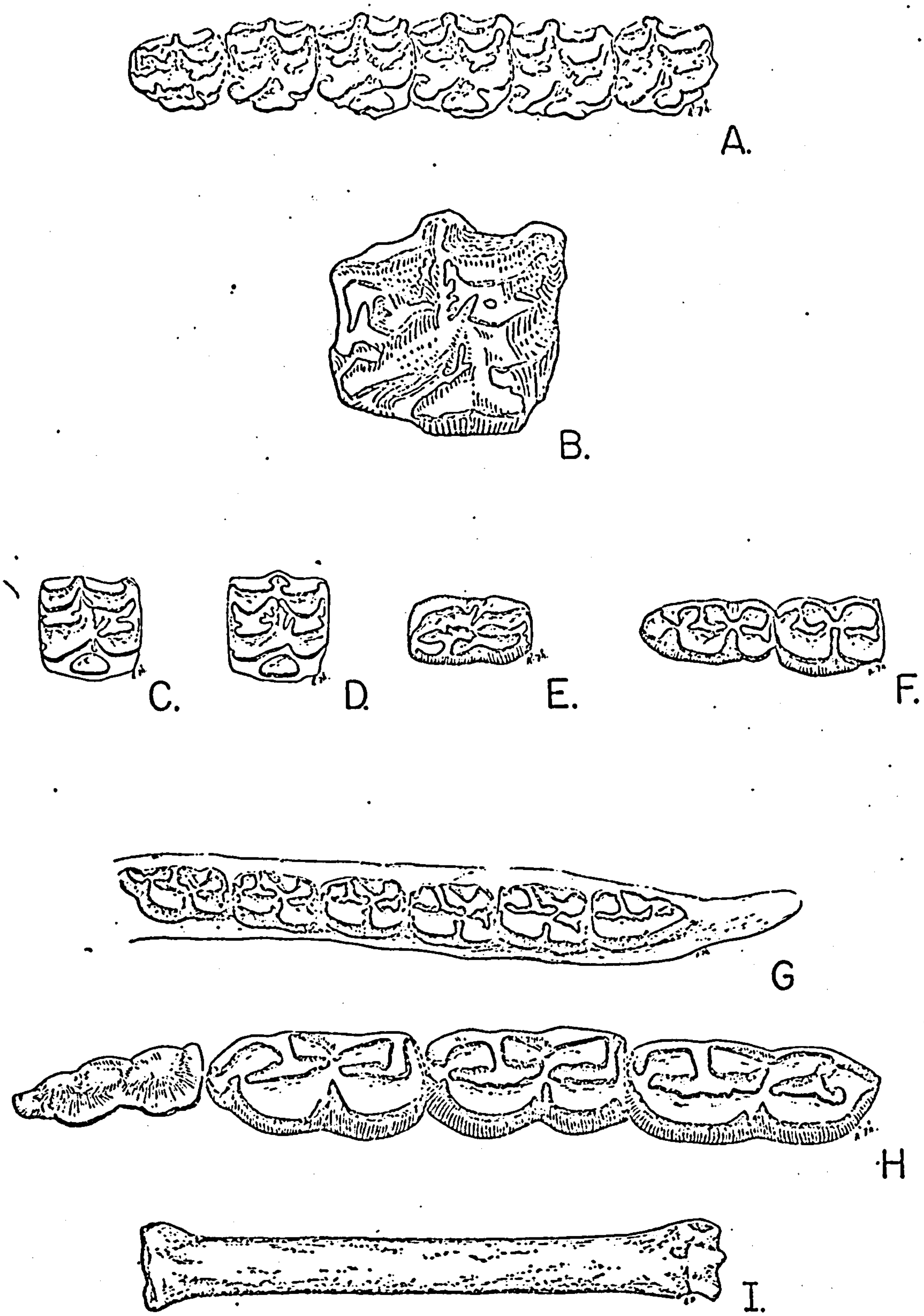


Figure 10 Equidae

Fig. 11 Tayasuidae, Antilocapridae

A. *Platygonus texanus*, UA-19, occlusal view right dentary p3-m3 (1.0x).

B. *Platygonus texanus*, UA-19, medial view right dentary (1.0x).

C. *Capromeryx gidleyi*, UA-1347, x-section left horn core (1.0x).

D. *Capromeryx gidleyi*, UA-1347, lateral view left horn core (1.0x).

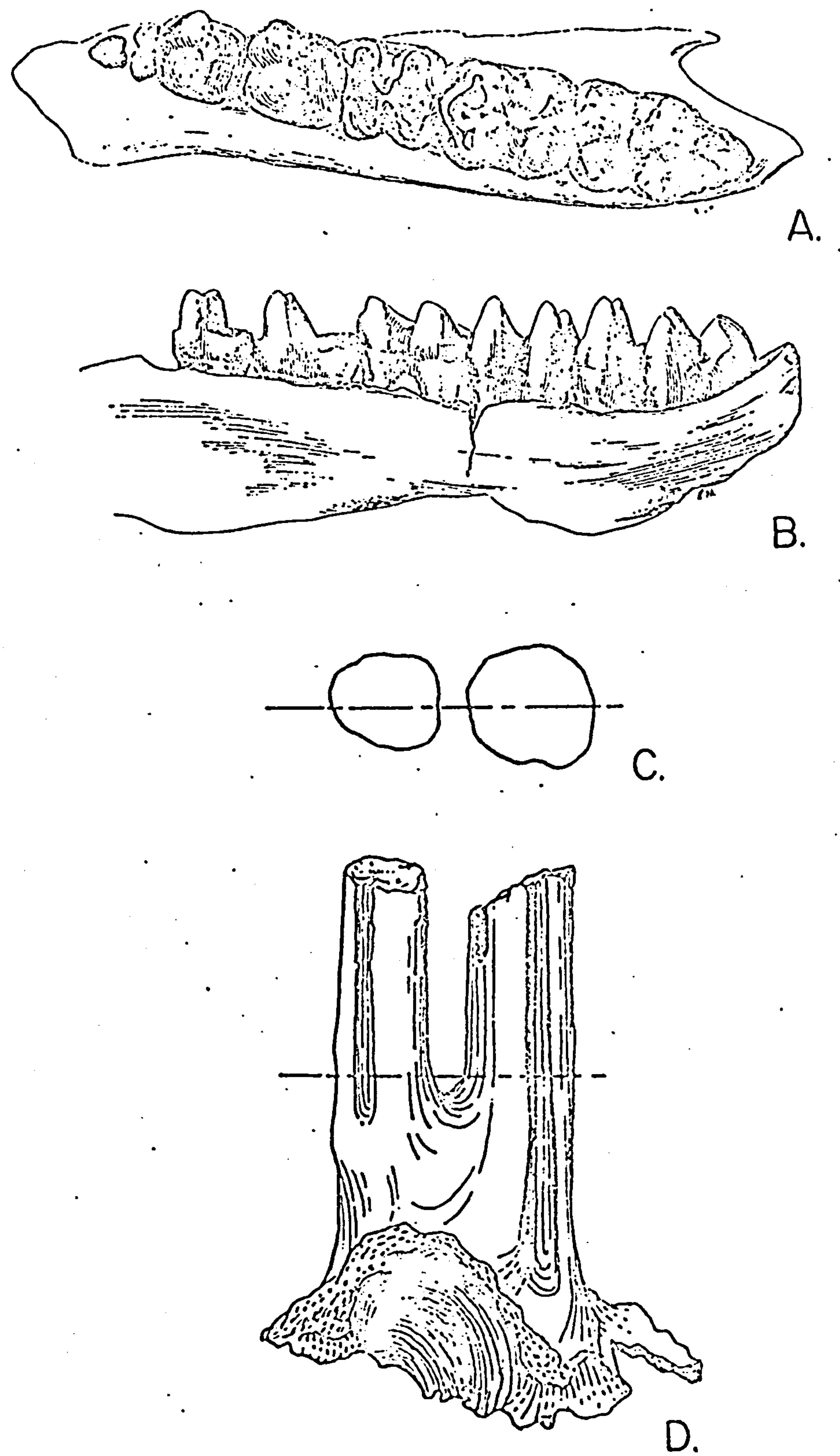


Figure 11 Tayassvidae, Antilocapridae

APPENDIX A

MEASURED SECTIONS

Section A. Mendivil Ranch

		Thickness
17.	Cream silty limestone	0.6
16.	Green mudstone	1.0
15.	Maroon siltstone	9.6
14.	Cream limestone	1.8
13.	Tan silty caliche	10.8
12.	Cream limestone	1.5
11.	Tan mudstone	6.1
10.	White limestone	2.5
9.	Brown mudstone	5.0
8.	Calcareous mudstone	0.9
7.	Brown mudstone	4.6
6.	Green mudstone containing locality A-12-1 and A-12-2	3.3
5.	Silty limestone with locality A-6896	1.6
4.	White tuffaceous limestone	3.7
2.	Tan siltstone	3.0
1.	Maroon siltstone (exposed)	7.0
	Total	66.6 Feet

Section 3. Gidley Wash

		Thickness
19.	Tan siltstone	5.0
18.	Tan silty limestone	2.0
17.	Brown siltstone	6.2
16.	Tan limestone	0.5
15.	Brown siltstone	5.4
14.	White limestone	2.5
13.	Brown siltstone	18.0
12.	Tan silty limestone	4.0
11.	Brown siltstone with limestone lenses	19.8
10.	White limestone	2.0
9.	Brown siltstone	3.2
8.	Brown limestone	0.8
7.	Brown siltstone	5.7
6.	Tan limy siltstone	2.5
5.	Brown siltstone	7.0
4.	Brown limestone	1.5
3.	Brown siltstone	3.7
2.	White tuffaceous limestone	2.0
1.	Brown siltstone	3.0
	Total	94.8 Feet

Section C. Rat Fink

		Thickness
11.	Tan silty limestone	1.6
10.	Maroon shale	8.0
9.	Brown mudstone	27.6
8.	Cream limestone	2.0
7.	Green mudstone with some calcareous lenses containing localities A-47-1, A-47-2 and A-47-4	4.3
6.	Green calcareous mudstone	3.0
5.	White calcareous tuff	1.6
4.	Green mudstone	2.0
3.	Brown calcareous siltstone	5.6
2.	Gray silty limestone	1.7
1.	Brown calcareous siltstone	12.0
	Total	69.4 Feet

Section D. Carnivore

		Thickness
16.	White limestone	1.1
15.	Brown silt with caliche	5.3
14.	Brown silty limestone	4.6
13.	Brown siltstone	12.6
12.	Cream limestone	1.0
11.	Brown siltstone	2.3
10.	Green mudstone	4.0
9.	Tan limestone	0.6
8.	Green mudstone	16.0

7.	Gray tuff	1.3
6.	Green mudstone with locality A-47-3	1.0
5.	Brown siltstone	3.5
4.	Brown & red mudstone with locality A-47-9	6.1
3.	Tan limestone	1.0
2.	Brown siltstone	15.6
1.	Maroon mudstone	7.3
	Total	83.3 Feet

Section E. McRae Wash

		Thickness
12.	Red and green mudstone with calcareous lenses	34.7
11.	White limestone	0.5
10.	Red, brown siltstone	11.0
9.	Green, brown mudstone containing locality A-52 in lower half of unit	6.3
8.	Tan calcareous siltstone	1.1
7.	Tan siltstone	4.2
6.	White limestone	0.7
5.	Brown siltstone	19.9
4.	Red, brown mudstone with vertical jointing	1.1
3.	Brown siltstone	11.7
2.	White limestone	3.0
1.	Chocolate brown siltstone	1.0
	Total	95.2 Feet

Section F. Apache Site

		Thickness
17.	White limestone	1.8
16.	Brown siltstone	3.0
15.	Tan limestone	0.6
14.	Brown siltstone	6.3
13.	White silty limestone	4.0
12.	Red siltstone and claystone	15.3
11.	Well consolidated brown calcareous siltstone	1.3
10.	Brown siltstone	6.3
9.	Green tuffaceous siltstone with calcareous nodules, with locality A-47-5	2.0
8.	Brown calcareous siltstone	19.3
7.	White limestone	1.0
6.	Brown siltstone	1.0
5.	White limestone	0.6
4.	Brown siltstone	4.9
3.	White tuff	1.0
2.	Green mudstone	0.3
1.	Brown siltstone	4.7
	Total	73.4 Feet

Section G. Adobe Cabin

		Thickness
9.	Brown siltstone	12.0
8.	White limestone	1.5
7.	Brown siltstone	5.6
6.	Well consolidated tan calcareous siltstone	2.5
5.	Brown siltstone	6.9
4.	Green mudstone with 6" calcareous nodules 5'2" below top contact and containing locality A-47-7	15.6
3.	White limestone	1.5
2.	Green silty mudstone	1.0
1.	Brown siltstone	5.5
	Total	52.1 Feet

Section H. El Paso

		Thickness
9.	Greenbeds with thinly laminated carbonates	9.8
8.	Green mudstone	3.0
7.	White limestone	0.8
6.	Green mudstone	0.3
5.	Brown siltstone	4.8
4.	Green mudstone	0.8
3.	Tuffs with some calcareous lenses containing locality A-47-11	12.5
2.	Brown silts and green mudstone	12.0
1.	Tan, cross-bedded, well indurated sandstone	1.5
	Total	35.5 Feet

Section I. Curtis Ranch

		Thickness
17.	White limestone	0.6
16.	Tan sandy mudstone	14.7
15.	Brown mudstone with caliche nodules: locality A-68131, 2' from top of unit and localities A-6895 and A-25-3 2' above base	10.0
14.	Green mudstone with brown sandy lenses locality A-68130 about 10.5' above base of unit A-68128, 10' higher	16.0
13.	Tan silty limestone	2.0
12.	Tan siltstone with calcareous beds	10.5
11.	Tan silty limestone	16.5
10.	Green calcareous mudstone with locality A-25-1 about 3' above base and A-62429 in middle of unit	11.5
9.	White limestone	2.0
8.	Tan calcareous siltstone	22.0
7.	Brown siltstone	5.3
6.	Tan limestone	11.5
5.	Brown mudstone with sand increasing upward	13.7
4.	White limestone	1.8
3.	White limestone	3.0
1.	Tan sandstone with thin mudstones	32.0
	Total	183.6 Feet

Section J. California Wash

		Thickness
9.	Brown siltstone	11.0
8.	Green mudstone	2.0
7.	White tuff with root and stem casts	4.2
6.	Green mudstone with locality A-47-10 near tuff contact	7.5
5.	Brown siltstone	1.6
4.	Tan calcareous siltstone	0.3
3.	Brown siltstone	5.7
2.	Cream limestone	1.7
1.	Brown siltstone	2.5
	Total	36.5 Feet

APPENDIX B

SELECTED TAXA FOR CHAPTER ON AGE

Benson

Blanco	Hagerman
Megalonyx leptostomas	Blarina gidleyi
Glyptotherium texanum	Castor californicus
Hypolagus sp.	Castor cf. accessor
Paenemarmota barbouri	Marmota sp.
Procastoroides sp.	Citellus sp.
Canimartes cumminsii	Thomomys gidleyi
Canis cf. dirus	Prodipodomys idahoensis
Osteoborus hillanus	Peromyscus hagermanensis
Borophagus diversidens	Mimomys (Cosomys) primus
Felis palaeoonca	Pliopotamys idahoensis
Serbelodon ? praecursor	Pliopotamys minor
Stegomastodon mirificus	Nebraskomys ? taylori
Rhyncotherium falconeri	Ondatra idahoensis
Nannippus phlegon	Mustela gazini
Equus (Plesippus) simplicidens	Borophagus sp.
Equus (Plesippus) cumminsii	Lutra piscinaria
Platygonus bicalcaratus	Lutravus ? idahoensis
Platygonus texanus	Lutravus ? cookii
Pliauchenia spatula	Machairodus ? hesperus
Gigantocamelus spatulus	Felis lacustris
Camelops sp.	Equus (Plesippus) shoshonensis
Tanupolama blancoensis	

Sanders

Sorex sandersi

Geomys (*Parageomys*) *tobinensis*

Perognathus cf. *pearlettensis*

Prodipodomys sp.

Prodipodomys sp.

Bensonomys meadensis

Sigmodon cf. *intermedius*

Pliolemmus antiquus

Pliophenacomys meadensis

Zapus sandersi

Mustela sp.

Nannippus phlegon

Equus (*Plesippus*) *simplicidens*

Camelidae

Coso Mtn.

Hypolagus

Mimomys (*Cosomys*) *primus*

Borophagus solus

Mamut cosoensis

Equus (*Plesippus*) *francescana*

Platygonus sp.

Tanupolama ? sp.

Rexroad

Sorex rexroadensis

Sorex taylori

Blarina adamsi

Cryptotis ? *meadensis*

Paracryptotis rex

Notiosorex jacksoni

Scalpus

Hesperoscalops rexroadi

Lasiurus fossilis

Dicea lepuscula

Praticlepus kansasensis

Nekrolagus progressus

Hypolagus regalis

Paenemarmota barbouri

Cynomys

Citellus howelli

Citellus rexroadensis

Geomys jacobi

Geomys (*Nerterogeomys*) cf. *minor*

Thomomys

Perognathus gidleyi

Perognathus pearlettensis

Perognathus rexroadensis

Rexroad (cont'd)

Liomys centralis

Dipodes rexroadensis

Procastoroides lanei

Reithrodontomys wetmorei

Reithrodontomys rexroadensis

Peromyscus baumgartneri

Peromyscus kansasensis

Peromyscus eliasi

Bensonomys arizonae

Baiomys kolbi

Baiomys rexroadi

Onychomys gidleyi

Symmetrodontomys simplicidens

Sigmodon intermedius

Parahodomys quadriplicatus

Pliolemmus antiquus

Ogmodontomys poaphagus

Neondatra kansasensis

Phenacomys primaevus

Canis lepophagus

Borophagus diversidens

Bassariscus rexroadensis

Procyon rexroadensis

Trigonictis kansasensis

Rexroad (cont'd)

Mustela rexroadensis

Taxidea taxus

Brachyprotoma breviramus

Brachyopsigale dubius

Mephitus ? *rexroadensis*

Spilogale rexroadi

Lutra cf. *piscinaria*

Felis lacustris

Smilodon sp.

Stegomastodon rexroadensis

Nannippus phlegon

Equus (*Plesippus*) *licidens*

Platygonus sp.

Camelops sp.

Capromeryx sp.

Odocoileus brachyodontus

Curtis

Cudahy

Sorex cinereus

Sorex cudahyensis

Neosorex lacustris

Microsorex pratensis

Sciuridae

Geomys sp.

Reithrodontomys cf. *pratincola*

Peromyscus cragini

Cudahomys moorei

Synaptomys borealis

Ondatra kansasensis

Pitymys meadensis

Microtus paroperarius

Microtus llanensis

Mustela

Grand View

Castor cf. *accessor*

Hypolagus furlongi

Synaptomys vetus

Mimomys (*Cosomys*) *primus*

Mimomys (*Cosomys*) *parvus*

Ondatra idahoensis

Pliopotamys minor

Grand View (cont'd)

Pliophenacomys parvus

Erethizon bathygnathus

Lutra ingens

Equus (*Plesippus*) *idahoensis*

Hudspeth

Scalopus

Megalonyx

Glyptotherium

Leporidae

Geomys paenebursarius

Citellus mcgheei

Citellus finlayensis

Sigmodon hudspethensis

Equus sp.

Equus (*Plesippus*) *idahoensis*

Equus (*Plesippus*) *simplicidens*

Equus (*Asinus*) *cumminsii*

Tapirus cf. *copei*

Gigantocamelus sp.

Tanupolama sp.

Odocoileus sp.

Borchers	Berends
Sorex taylori	*Sorex* cf. *cinereus*
Lepus cf. *californicus*	*Blarina brevicauda*
Hypolagus	Leporidae
Nekrolagus	*Castoroides* sp.
Citellus meadensis	*Paradipodes stovalli*
Citellus cragini	*Burosor effossorius*
Geomys	*Geomys* sp.
Perognathus gidleyi	*Perognathus* cf. *hispidus*
Perognathus pearlettensis	*Peromyscus berendsensis*
Reithrodontomys pratincola	*Ondatra triradicatus*
Onychomys fossilis	*Microtus pennsylvanicus*
Sigmodon hilli	*Pedomys* cf. *ochrogaster*
Neotoma (*Parneotoma*) *taylori*	*Canis latrans*
Parahodomys sp.	*Mammuthus* cf. *columbi*
Synaptomys cf. *vetus*	*Equus* (*Equus*) sp.
Ondatra sp.	
Zapus burti	
Canis sp.	
Felis ? sp.	
Spilogale cf. *leucoparia*	
Mustela	
Equus sp.	
Camelops	

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