THE RODENTS FROM THE HAGERMAN LOCAL FAUNA, UPPER PLIOCENE OF IDAHO

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CONTRIBUTIONS FROM THE MUSEUM OF PALEONTOLOGY

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ABSTRACT—The Hagerman local fauna is known from deposits of the Glenns Ferry Formation exposed west of the town of Hagerman in Twin Falls County, Idaho. Approximately 300 localities are known over an area of six square miles through 500 feet of beds (elevation 2900 to 3400 feet above sea level). Rodents are represented in the fauna by at least 14 genera and 19 species. These include five species from the family Sciuridae, two from the Geomyidae, three from the Heteromyidae, two from the Castoridae, and seven from the Cricetidae. Five of the species are described as new: *Pliogeomys parvus, Perognathus magnus, P. maldei, Dipoides intermedius,* and *Baiomys aquilonius.*

The beaver *Castor* and the microtines *Cosomys* and *Pliopotamys* are the most abundant mammalian forms in the fauna. This fact suggests a marsh-meadow habitat near the depositional area. Upland forms, though rare in the fauna, become relatively more abundant above 3100 feet.

Changes in the population structure of the microtines are demonstrated as one goes higher in the section. These changes include a slight increase in size for *Cosomys* and *Pliopotamys* and an increase in the number of triangles on the M_1 in *Cosomys* and *Ophiomys.* There is also a gradual replacement of *Cosomys* by *Pliopotamys* and *Ophiomys,* which apparently becomes complete above the elevation of 3265 feet.

On the basis of the fauna and a potassium-argon date of $3.48 \pm 0.27 \times 10^6$ years on a basalt which has been correlated with the basalt approximately 150 feet below the Horse Quarry, the Hagerman local fauna is considered to be Upper Pliocene in age. Comparison with other Upper Pliocene local faunas in regard to the stage of evolution of the rodents suggests a post-Rexroad age for the Hagerman local fauna.

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INTRODUCTION

The Hagerman local fauna is known from flood plain and stream deposits of the Glenns Ferry Formation (Malde & Powers, 1962) exposed west of the town of Hagerman in Twin Falls County, Idaho. Approximately 300 localities are known over an area of six square miles through 500 feet of beds. The fauna has been known since the late 1920's when Elmer Cook, a local rancher, created enough interest in his fossil finds to warrant a field party from the United States National Museum. The party opened the now world famous Horse Quarry (Gazin, 1936).

The fauna has been considered as one of the classic Upper Pliocene faunas of North America and was thought to be well known. However, collections of fossils by field parties from The University of Michigan, Museum of Paleontology, under Claude W. Hibbard in the summers of 1956, 1962, 1964–1966, and by

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[1] This paper is a revision of the thesis submitted in a partial fulfillment of the requirements for the degree Doctor of Philosophy at The University of Michigan.
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Philip R. Bjork and Richard J. Zakrzewski in 1967 have more than doubled the fauna. The presence of radiometrically dated horizons, the best of which is a basalt dated at $3.48 \pm 0.27 \times 10^6$ years which has been correlated with the basalt 150 feet below the Horse Quarry (Evernden, *et al.*, 1964) has placed the Hagerman local fauna in a critical position for the interpretation of late Cenozoic history.

Of great importance in placing the Hagerman local fauna in its proper perspective is the rodent portion of the fauna. Rodents, especially microtines, are very abundant throughout the section. Because of the rapid evolution which microtines have undergone (Zakrzewski, 1967) they are valuable for correlative purposes. The microtines, as well as the other rodents, are limited in their habitat preferences and are, therefore, good indicators of the ecology. Changes in the population structure of the microtines have also been demonstrated (Hibbard, 1959; Hibbard & Zakrzewski, 1967). The combination of these factors makes the study of the rodents of great interest.

PREVIOUS WORK

The first description of rodents from the Hagerman local fauna was by Wilson (1933). He also described and discussed rodents from the younger Grand View local fauna. From the Hagerman local fauna he described *Citellus* ? sp., *Thomomys gidleyi*, *Mimomys (Cosomys) primus*, and *Ondatra idahoensis minor*. Wilson (1933) discussed the beaver from the Grand View local fauna and questionably placed the Hagerman beaver in the same species. Stirton (1935) after cursory examination referred the beaver to another species.

Most references to Hagerman rodents after Stirton were simply in faunal lists. These included Wilson (1937), Schultz (1937), and Hibbard (1941, 1958). Davis (1939) utilized the then known fossil fauna to discuss the possible origins of the extant fauna of Idaho and the changes which had taken place since Pliocene times. Bryant (1945) listed the Hagerman ground squirrel in his discussion of the phylogeny of nearctic Sciuridae, placing it definitely in the genus *Citellus*.

No further studies were made until Hibbard undertook the study of the small mammals at the request of Dwight W. Taylor of the United States Geological Survey in 1956. A preliminary report on the microtines was published by him (Hibbard, 1959). Subsequently *Prodipodomys idahoensis* and *Peromyscus hagermanensis* were described (Hibbard, 1962). Taylor (1966) presented a list of the Hagerman local fauna based principally on personal communication with Hibbard. The most recent study involved the microtine genus *Ophiomys* (Hibbard & Zakrzewski, 1967).

MATERIALS AND METHODS

The materials discussed in this report consist of maxillaries and jaws, with and without teeth, plus numerous isolated teeth of rodents from the Hagerman local fauna. Post-cranial material was considered only in the discussion of *Paenemarmota* and *Dipoides*. Measurements were made to the nearest 0.01 mm, using a Gaertner Measuring Microscope. Statistical analyses were made using The University of Michigan IBM 7090 computer.

The specimens are listed under the various taxa, except in the case of *Citellus* cf. *C. howelli*, *Thomomys*, and the microtines, which are too numerous to list individually. The terminology used in the discussion of the various groups is defined under the specific group in question. The majority of the specimens are in the collection of The University of Michigan, Museum of Paleontology. The others are to be found in the United States National Museum. The specimens found in the former are prefixed by a V; those in the latter by USNM. Recent forms used for comparison are in The University of Michigan, Museum of Zoology (UMMZ).

The specimens and the localities at which they are found are listed in stratigraphic order. This is not necessarily in topographic order, as Bjork (pers. comm.) has demonstrated a vertical displacement of 160 feet between some of the marker horizons in the Glenns Ferry Formation. Localities affected by this displacement are followed by an asterisk. One hundred and sixty feet should be subtracted from the given elevation so that the locality can be placed in proper stratigraphic position. The University of Michigan, Museum of Paleontology fossil localities in Idaho are listed as UM–Ida. 0–00. The number before the dash represents the locality number. The number after the dash is the year of discovery. United States Geological Survey Cenozoic localities are prefixed by USGS Cen. Loc. The University of Kansas Museum of Natural History localities are prefixed by KU. Text-figure 1 gives the location and elevation of some of the important localities and horizons referred to in this report, as well as an index map of Idaho showing the area under consideration. Elevations were determined from air photos and a USGS topographic map (7.5 minute series) of the Hagerman Quadrangle.
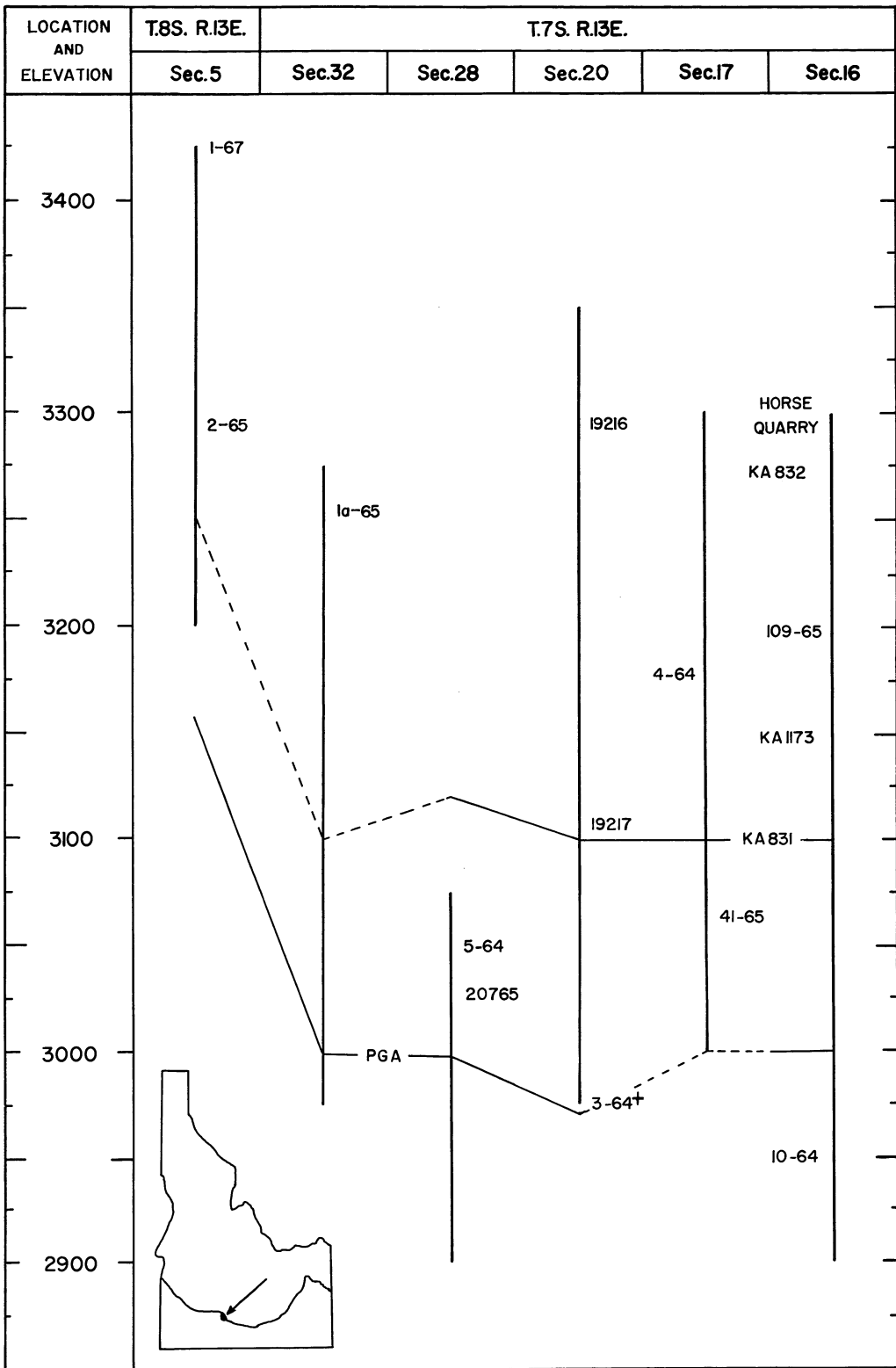
TEXT-FIG. 1—Topographic position of frequently discussed localities and marker horizons in the Hagerman area. Vertical lines represent the topographic range of fossil localities. Elevations from USGS Topographic Map of Hagerman Quadrangle 7.5 Minute Series. Marker horizons modified from Bjork (pers. comm.). KA, radiometrically dated level (Evernden, et al., 1964). PGA, Peters Gulch Ash. 1–67, The University of Michigan, Museum of Paleontology fossil locality. 20765, United States Geological Survey Cenozoic fossil locality. +, Locality 3–64 in sec. 21. Index map of Idaho shows area under consideration by black dot and arrow.

SYSTEMATIC PALEONTOLOGY

Family SCIURIDAE

Remains of the family Sciuridae are represented by at least two genera and five species in the Hagerman local fauna. *Paenemarmota*, a large marmot-like form is found from an elevation of 3075 to 3200 feet. *Citellus* cf. *C. howelli* Hibbard is the most abundant of the ground squirrels. It is known from 3000 to 3295 feet, but is more common above 3100 feet. A large *Citellus* is found from 3050 through 3260 feet. A medium-sized *Citellus* is known at 3295 feet, while a small *Citellus* or *Ammospermophilus* is found at 3025 feet.

The terminology used in the discussion of the teeth is basically that of Bryant (1945) with some additions from Repenning (1962) and Black (1963).

PAENEMARMOTA BARBOURI Hibbard & Schultz
Text-fig. 2H

Marmot sp., Gazin, 1936, p. 285.

Referred material.—USNM 24937, part of left lower toothless jaw, Loc. unknown; V54298, part of right maxillary with P³, P⁴, and M² with alveolus for M¹, UM–Ida. 52–64, elev. 3075 feet; V51017, RM¹, USGS Cen. Loc. 19123, elev. 3135 feet; V56173, LM¹, UM–Ida. 109–65, elev. 3200 feet.

Description of material.—This material appears to be indistinguishable from specimens considered as *Paenemarmota barbouri* from the Fox Canyon local fauna, Meade County, Kansas. The P³ has the double cusped "protoloph" followed by a distinct valley and loph-like posterior cingulum (text-fig. 2H). These characters were considered diagnostic in the P³ of *Paenemarmota* by Repenning (1962) in his revision of the genus. One slight difference in the teeth is that the metaconule of P⁴ does not appear as well developed as in the isolated P⁴'s from the Fox Canyon local fauna.

The jaw is similar to the jaws in The University of Michigan collection, though it is broken and only the alveoli for the P₄ and the labial roots for the M₁ and M₂ are present.

Remarks.—*Paenemarmota barbouri* was apparently a very wide-ranging form during the Hemphillian and Blancan. The Hagerman finds are the most northern and western record. The previous records were the Broadwater-Lisco local fauna (Nebraska) for the north and the Comosi local fauna (Arizona) for the west.

Repenning (1962) placed all specimens of *Paenemarmota* into *P. barbouri*. Differences of the P₄ in the development of the trigonid area can be seen between the Rexroad and Yepomera specimens (Repenning, 1962, text-fig. 2). There are also some differences in the size of the teeth. A specimen of *Paenemarmota*, (V47126), which was not available to Repenning, from the Rexroad Formation taken east of Gas Well Canyon, Meade County, Kansas, has a P₄ which resembles *Marmota* in the closeness of the metaconid and protoconid and the more labially directed hypoconid. In this respect it also resembles *M. nevadensis* (Kellogg). The size of the P₄ with respect to the M₁ and development of the "basin trench" of Repenning (1962) in the Gas Well Canyon specimen is like that in other specimens of *Paenemarmota*. All three of the *Paenemarmota* forms could be considered as distinct species. While there is some variation in the development of the protolophid and trigonid basin of the P₄ in Recent *Marmota*, there is a consistent separation between the three species in the development of the trigonid area.

Associated with one of the *Paenemarmota* specimens (V42127) from Kansas are parts of a skeleton. These remains include part of a humerus, astragalus, and calcaneum as well as other elements. The humerus possesses an entepicondylar foramen. Bryant (1945) showed that this foramen was variable in the Sciuridae. In the few skeletons of *Marmota* in The University of Michigan Museum of Zoology collection available for study, the foramen was found to be absent in *M. monax* (Linnaeus) but present in *M. caligata* (Eschscholtz) and *M. flaviventris* (Audubon and Bachman). The features of the astragalus and calcaneum appear to align *Paenemarmota* closer to *Marmota* than to *Citellus* or *Cynomys*.

Marmota sawrockensis Hibbard, *M. oregonensis* Shotwell, and *M. nevadensis*, known from deposits of Hemphillian age, are also characterized by the "basin trench." Except in size and in the relative proportion of P₄ to M₁, *M. sawrockensis* is indistinguishable from *Paenemarmota*. I believe there is a closer relationship between *Paenemarmota*, *M. sawrockensis*, *M. oregonensis*, and *M. nevadensis*, than there is between the three latter species and *Marmota*. The exact nature of this relationship is still a moot point. Only additional specimens will enable us to know their true relationship to Recent *Marmota*. It is equally possible that one or all are ancestral to species of *Paenemarmota*; or their similar features represent a divergence from a common ancestor.

CITELLUS cf. C. HOWELLI Hibbard
Text-figs. 2B, D, F–G

Citellus ? sp., Wilson, 1933, p. 122; 1937, p. 38.
Citellid sp., Gazin, 1936, p. 285; Schultz, 1937, p. 84.
Citellus sp., Bryant, 1945, p. 357.

Referred material.—Remains of this ground squirrel include maxillaries, lower jaws, with and without teeth, as well as isolated teeth representing at least 32 individuals from 21 localities ranging in elevation from 3000 to 3295 feet.

Description of material.—Among the specimens referred to *Citellus* cf. *C. howelli* are parts of three maxillaries. These are indistinguishable from maxillaries referred to the same species from the Fox Canyon local fauna. One of the maxillaries (V54502) contains a P^3. This is the only P^3 known from either of the faunas. The P^3 is characterized by a cone which slopes lingually to the edge of the tooth, where it merges with a cingulum which continues posteriorly and labially. The area between the cone and the cingulum is a basin rather than a shelf (text-fig. 2F). In this respect it most closely resembles the subgenus *Callospermophilus* among the Recent forms. The remaining upper teeth are those of a generalized ground squirrel. The presence of metastyles on M^1 and M^2 is variable. An incipient metaconule is present on the M^3, but no M^3 was found where the metaconule was developed as well as in *Citellus* sp. (large) from the Hagerman local fauna (text-fig. 2A). The development of the infraorbital foramen and masseteric tubercle is closer to that of *C. rexroadensis* Hibbard than to the Recent specimens of *Callospermophilus* or *Otospermophilus* examined.

The lower dentitions also resemble those of *Otospermophilus* or *Callospermophilus*. The development of the trigonid basin or pit is extremely variable, especially on the P_4. Some of the Hagerman specimens, though not approaching the amount of development observed in the subgenus *Citellus*, appear more advanced in this character than *Otospermophilus*, *Callospermophilus*, or the fossil population from the Fox Canyon local fauna (text-fig. 2D). The DP_4 (USNM 24936, text-fig. 2B) cannot be distinguished from a small sample of DP_4s from the Fox Canyon local fauna. Measurements of the specimens are given in table 1.

Remarks.—With a few exceptions most fossil ground squirrels have been placed in the subgenus *Otospermophilus* (Black, 1963; Hazard, 1961). These assignments have been based primarily on the generalized nature of

the dentitions and size relationships of P^3 to P^4. Specimens of *Citellus* cf. *C. howelli* appear to have a closer resemblance to *Callospermophilus* than to *Otospermophilus*. It may be that *Citellus* cf. *C. howelli* is near the point where these two subgenera became separated. Hazard (1961) considered a similar phylogenetic relationship for *C. rexroadensis*, though he placed *C. rexroadensis* in *Otospermophilus*. In some respects *C. rexroadensis* and *C.* cf. *C. howelli* are closer to each other than either is to Recent forms. I, therefore, agree with Wilson (1949) that placing fossil forms from the late Tertiary into Recent subgenera may be somewhat premature until more and better specimens become available.

TABLE 1—ALVEOLAR LENGTH OF P_4-M_3 (mm) OF FOSSIL *Citellus*.

Specimen	C. cf. *howelli* (Hagerman)	C. sp. (medium) (Hagerman)	C. cf. *howelli* (Fox Canyon)
V49902	8.94		
V50645	8.48		
V52737	9.05		
V53561	8.78		
V54604	8.83		
V55225	8.63		
V56228	8.54		
V55056		10.08	
V55265		9.83	
V28387			8.84
V28388			8.68
V28389			8.55

CITELLUS sp. (large)
Text-fig. 2A

Referred material.—V54367, RM^3, UM–Ida. 5–64, elev. 3050 feet; V56229, LM^3, UM–Ida. 2–65*, elev. 3280–3300 feet; V55956, LM^1 or M^2, UM–Ida. 1a–65, elev. 3260 feet.

Description of material.—The teeth are those of a large ground squirrel near the size of the *Citellus parryi* (= *undulatus*) group. The shape of the M^3 (text-fig. 2A) is as in *C. rexroadensis* but the tooth is larger. The teeth appear to be larger than any known fossil *Citellus* except *C. pattersoni* Wilson from which *C.* sp. (large) can be distinguished by the absence of a metaloph. The M^3s are characterized by the presence of a metaconule with a pit developed posterior to it. The development of the metaconule and pit was found to be variable in a small sample of M^3s from *C. rexroadensis* available for study. The molar from UM–Ida. 1a–65 is worn and is referred to this species on the basis of size.

Remarks.—*Citellus* sp. (large) is probably closely related to *C. rexroadensis*, but the exact
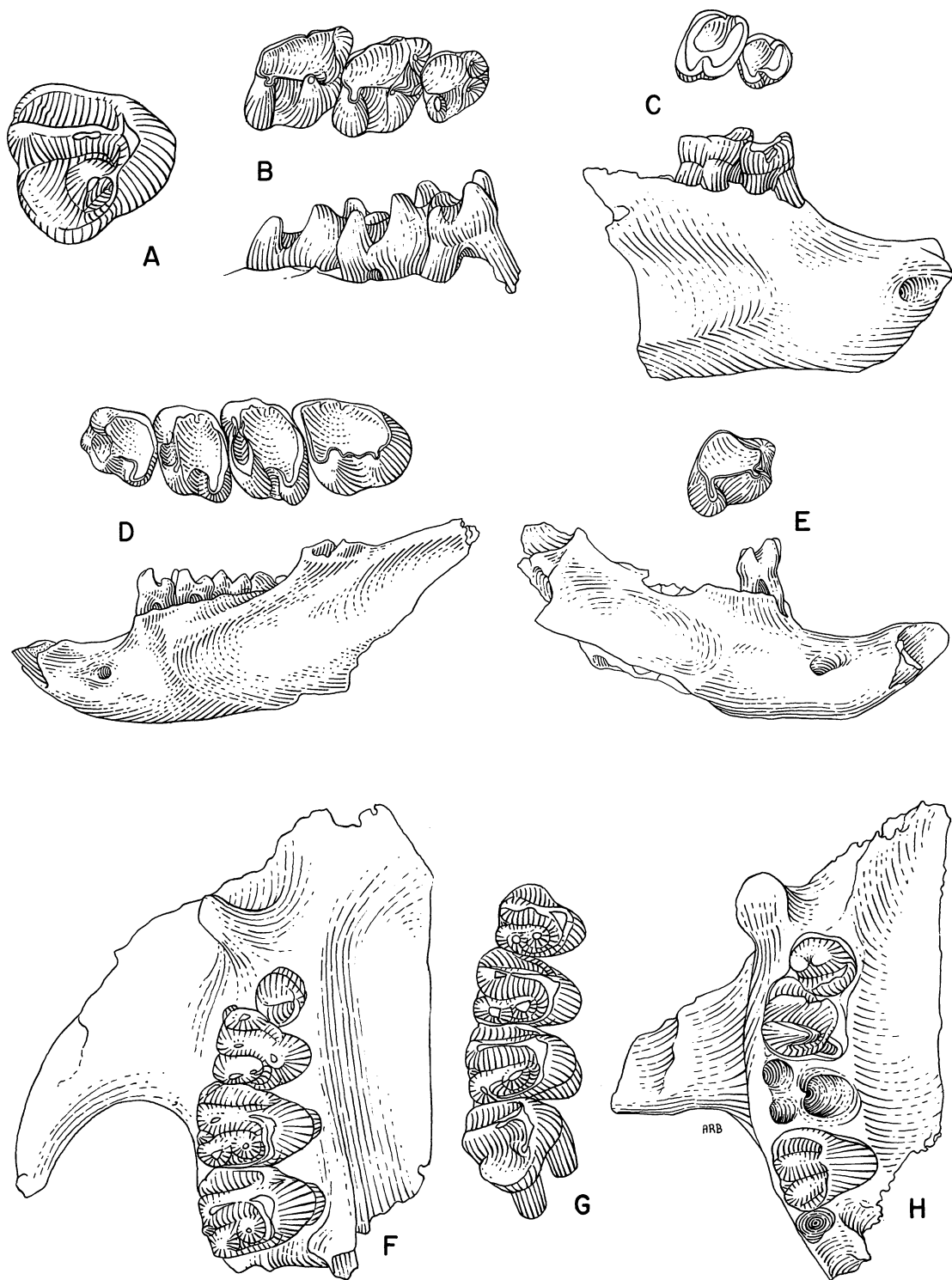
TEXT-FIG. *2*—Squirrels from the Hagerman local fauna. A, *Citellus* sp. (large), V54367, RM^3, occlusal view × 6. B, *C*. cf. *C. howelli,* USNM 24936, RDP$_4$-M$_2$, labial and occlusal views ×6. C, *Ammospermophilus* or *Citellus* sp. (small), V56074, right lower jaw with P$_4$-M$_1$, labial and occlusal views ×6. D, *C*. cf. *C. howelli,* V55225, left lower jaw with P$_4$-M$_3$, labial view ×3, occlusal view ×6. E, *C*. sp. (medium), V55056, right lower jaw with P$_4$, labial view ×3, occlusal view ×6. F–G, *C*. cf. *C. howelli,* F, V54502, right maxillary with P^3-M^2; G, V55955, right maxillary with P^4-M^3; occlusal views ×6. H, *Paenemarmota barbouri,* V54298, right maxillary with P^3-P^4, M^2, occlusal view ×1.5.

relationship cannot be determined with the small sample. The larger and more advanced ground squirrels are found in the northern regions today. This relationship could have been the same in Upper Pliocene time.

CITELLUS sp. (medium)
Text-fig. 2E

Referred material.—V55056, part of right lower jaw with P_4 and alveoli for M_1–M_3, V55265, part of right lower jaw with alveoli for P_4–M_3, USGS Cen. Loc. 19216, elev. 3295 feet.

Description of material.—A medium-sized ground squirrel is represented by these specimens. It is distinguished from *Citellus* cf. *C. howelli* by its larger tooth-row measurement (table 1). The P_4 of *C.* sp. (medium) is characterized by the metaconid being closer to the protoconid, lack of a well-developed trigonid pit and a more expanded hypoconid than in *C.* cf. *C. howelli* (text-fig. 2E).

AMMOSPERMOPHILUS or CITELLUS sp. (small)
Text-fig. 2C

Referred material.—V56074, part of right lower jaw with P_4–M_1, USGS Cen. Loc. 20765, elev. 3025 feet.

Description of material.—This specimen represents a small ground squirrel near the size of *Ammospermophilus leucurus* (Merriam). The teeth are very worn (text-fig. 2C). The length of P_4–M_1 is 2.77 mm. The shape of the teeth approaches those seen in some specimens of *A. leucurus* and *Citellus lateralis* (Say) at an equivalent stage of wear. The position of the mental foramen with respect to the P_4 is similar to that of *C. lateralis*.

Remarks.—Black (1963) lists a combination of characters in the dentition by which *Ammospermophilus* can be distinguished from *Citellus*. Unfortunately, the condition of this specimen prevents their use.

Both *Ammospermophilus leucurus* and *Citellus lateralis* are found in Idaho today, but not in the Hagerman area (Davis, 1939). It is possible that the Hagerman species could be ancestral to one or both of the Recent forms.

Family GEOMYIDAE

Gophers are represented in the Hagerman local fauna by the extant genus *Thomomys* and the extinct genus *Pliogeomys*. *Thomomys* is the most abundant of the two genera and is found from an elevation of 2950 through 3295 feet. *Pliogeomys* is known only from elevations

above 3050 feet. The highest occurrence of *Pliogeomys* is at 3300 feet.

Terminology employed in the discussion of the gopher material follows that of White & Downs (1961) and Hibbard (1967).

THOMOMYS GIDLEYI Wilson
Text-figs. 3A–C

Thomomys gidleyi Wilson, 1933, p. 122–123.

Holotype.—USNM 12651, part of left lower jaw with P_4–M_1. Collected by Elmer Cook, fall of 1930.

Horizon and type locality.—Upper Pliocene, Glenns Ferry Formation; Loc. unknown, Twin Falls County, Idaho.

Referred material.—The material consists of jaws and maxillaries with and without teeth, the anterior part of a skull, and isolated teeth representing at least 70 individuals from 39 localities ranging in elevation from 2950 to 3295 feet.

Emended diagnosis.—A small pocket gopher near the size of *Thomomys talpoides quadratus* Merriam. This small size distinguishes *T. gidleyi* from the other fossil species of *Thomomys* so far known. *T. gidleyi* is distinguished from Recent species of *Thomomys* by a shallower development of the temporal fossa and a better development of the valley between the ascending ramus and the capsular process.

Description of material.—Wilson (1933) separated *Thomomys gidleyi* from other members of the genus principally on the fact that the lower molar came to a gradual termination lingually rather than being constricted as in Recent *Thomomys*. Lingual constriction of the molar was found to be variable both in Recent *Thomomys* and *T. gidleyi*. The greater percentage of *T. gidleyi* molars, however, are not constricted (text-figs. 3A, C) while the opposite is true for Recent species. All of the teeth are rootless. The enamel pattern of the teeth is interrupted after a little wear. Measurements of some specimens are given in table 2.

The jaw of *Thomomys gidleyi* is characterized by a shallow temporal fossa and a well-developed valley between the ascending ramus and the capsular process (text-fig. 3C). The development of the valley is similar to that described in *Pliogeomys buisi* Hibbard (1954a). Some specimens of *T. bottae* (Eydoux & Gervais) also have this valley fairly well developed. The capsular process appears to be more perpendicular with respect to the angle of the jaw and better developed for the size of the gopher than in Recent species of *Thomomys*.

TABLE 2—LOWER JAW MEASUREMENTS[1](mm) OF *Thomomys* AND *Pliogeomys*.

	T. gidleyi				P. parvus			
	V34829	V52741	V52743	V45312	V55185[b]	V55957	V53562	V54366
Length of P_4-M_3	—	5.73	8.17[a]	8.96[a]	—	—	—	4.76[a]
Length of P_4-M_2	4.90	4.62	4.12	4.65	3.08	—	3.27	—
Length of P_4-M_1	3.23	3.30	2.68	3.24	2.22	2.32	2.28	—
Length of P_4	1.93	2.02	1.69	1.87	1.51	1.60	1.11	—
Width of al of P_4	0.99	0.98	—	0.81	0.86	0.93	0.81	—
Width of pl of P_4	1.60	1.43	—	1.56	1.23	1.10	0.97	—
Length of M_1	1.28	1.16	—	1.29	0.79	0.68	0.90	—
Width of M_1	2.05	1.82	—	1.84	1.38	1.19	1.28	—
Length of M_2	1.29	1.27	—	1.36	0.89	—	1.01	0.80
Width of M_2	1.97	1.87	—	1.81	1.51	—	1.39	1.37
Length of M_3	—	1.12	—	—	—	—	—	0.81
Width of M_3	—	1.52	—	—	—	—	—	1.12
Diastemal length	5.55	5.12	4.75	5.82	3.54	3.09	3.26	—
Depth of jaw below M_1	6.44	6.85	—	6.02	5.43	4.46	5.39	—

1, Measurements of teeth along occlusal surface except for those marked "a," which are alveolar measurements. b, holotype. Abbreviations: al, anterolophid; pl, posterolophid.

The anterior part of the skull of *Thomomys gidleyi* most closely resembles that of the *T. talpoides* (Richardson) complex among the Recent gophers. The infraorbital foramen is shaped as in *T. talpoides*. The dorsal posterior edges of the premaxillary extend beyond the nasals as in *T. bottae* (text-fig. 3B). The frontal in the region of the orbits appears to be more constricted than in Recent forms examined. The median ridge of the palate is strongly developed in the diastemal region. The degree of development of this ridge was found to be variable in Recent species. There is a slight groove on the incisors. Measurements of the skull were made as in White & Downs (1961). These are listed in table 3.

Thomomys gidleyi is smaller than *T. scudderi* Hay, which I examined, and *T. microdon* Sinclair, from Sinclair's (1905) measurements. The latter forms, likewise, more closely resemble Recent *Thomomys* than does *T. gidleyi*.

TABLE 3—SKULL MEASUREMENTS (mm) OF *Thomomys* AND *Pliogeomys*.

	T. gidleyi	P. parvus
Alveolar length of P^4-M^3	6.75	
Alveolar length of P^4-M^2		2.80
Diastemal length	10.91	3.09
Least interorbital constriction	5.46	
Least depth of rostrum	5.47	3.24
Palatofrontal depth of skull	11.82	

Remarks.—There appears to be no significant difference between the Hagerman specimens of *Thomomys gidleyi* from any part of the section. *Thomomys gidleyi* is the earliest record of the genus *Thomomys* as a fossil. From the description of the dentition and mandibles

of *Parapliosaccomys oregonensis* Shotwell (1967b), it appears that *P. oregonensis* could be ancestral to *T. gidleyi*. The exact relationships of these two forms, as well as their relationship to *Pliosaccomys* Wilson, await the recovery of more material.

Davis (1939) thought that *T. gidleyi* was directly ancestral to *T. quadratus* (now a subspecies of *T. talpoides*, Miller & Kellogg, 1955). *T. t. quadratus* is found in the Hagerman area today (Davis, 1939). It appears, however, that *T. gidleyi* possesses just as many characters in common with *T. bottae* as it does with *T. talpoides*. *T. gidleyi* could be the ancestral stock for either one or both of these species.

PLIOGEOMYS PARVUS n. sp.
Text-figs. 4A–D

Holotype.—V55185, part of a right lower jaw with incisor and P_4-M_2. Collected by Claude W. Hibbard and party, summer of 1965.

Horizon and type locality.—Upper Pliocene, Glenns Ferry Formation; UM–Ida. 1a–65, elev. 3260 feet, Twin Falls County, Idaho.

Paratypes.—V54366, part of a left lower jaw with M_2-M_3, UM–Ida. 5–64, elev. 3050 feet; V53450, LM_2, UM–Ida. 41–65, elev. 3050–3075 feet; V51578, LP_4, UM–Ida. 65–64, elev. 3100 feet; V56017, LP_4, UM–Ida. 4–64, elev. 3150 feet; V55184, part of skull with LI, P^4-M^2 and RP^4, V53562, part of left lower jaw I-M_2, V55957, part of left lower jaw I-M_1, part of right lower jaw P_4-M_1, part of right lower jaw with P_4, UM–Ida. 1a–65, elev. 3260 feet; V53495, upper RI, USGS Cen. Loc. 19216, elev. 3295 feet; V55031, LP^4, USNM Horse Quarry, elev. 3300 feet.
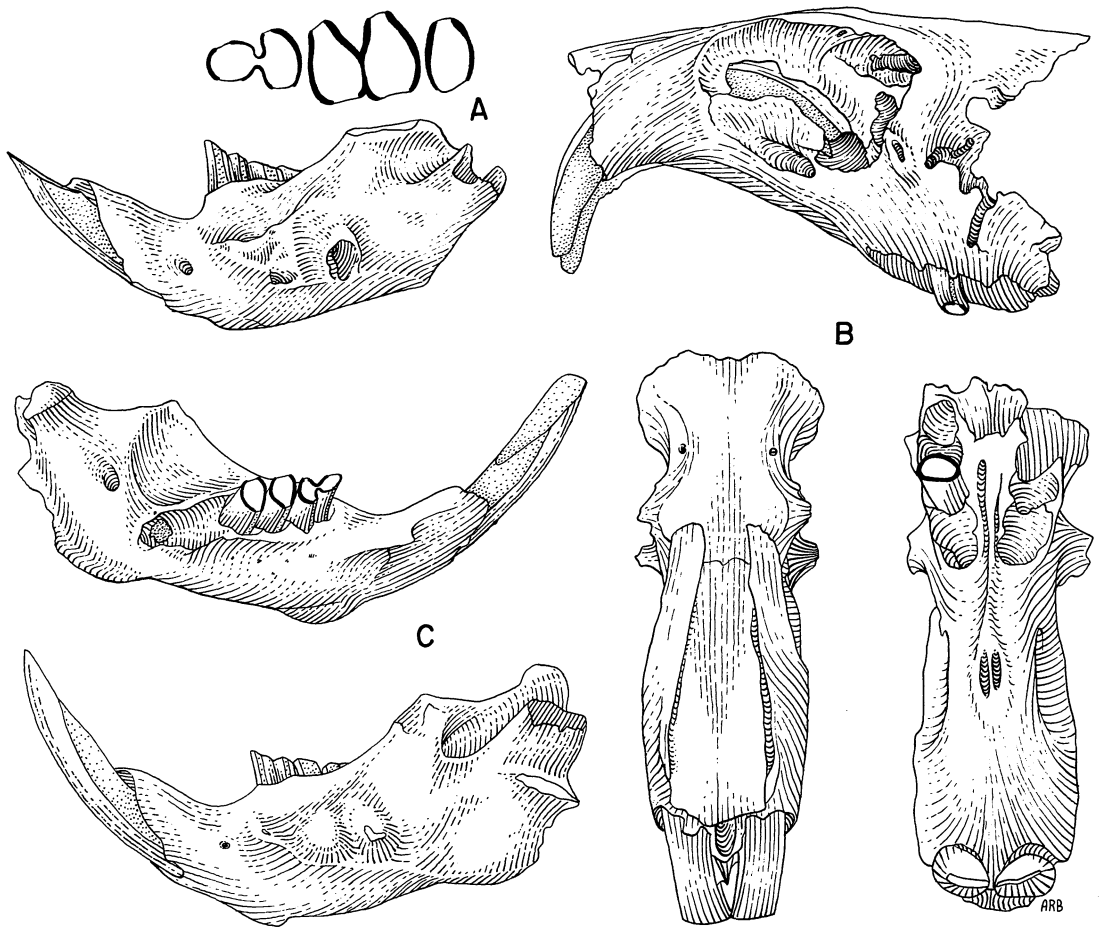
TEXT-FIG. *3—Thomomys gidleyi* from the Hagerman local fauna. A, V52741, left lower jaw with P₄-M₃, labial view ×3, occlusal view ×6. B, V44319, part of skull, all views ×3. C, V50539, left lower jaw with P₄-M₂, both views ×3.

Diagnosis.—A pocket gopher about the size of *Perognathus hispidus* Baird. The upper incisors are bisulcate. The teeth are rooted.

Description of holotype.—The holotype is an adult jaw, the posterior portion of which is broken. The diastemal region is short and not as robust as in *Pliogeomys buisi*. The masseteric crest is well developed as in *P. buisi* and *Geomys smithi* Hibbard, but it ends in more of a knob than in the latter two species. The mental foramen is ventral to the masseteric crest as in the subgenus *Nerterogeomys* (Hibbard, 1967). The foramen is closer to the crest than in *Geomys (N.) smithi* (text-fig. 4D). There appears to have been a slight temporal fossa but its extent cannot be determined because of damage to the jaw in this area.

The occlusal length of P₄-M₂ is 3.08 mm. Other measurements are given in table 2. Dentine tracts are better developed on the labial side of the teeth than on the lingual. The anterolophid of the P₄ is narrower in proportion than in *P. buisi*. The labial edge of the M₁ is wider in *P. parvus* than in *P. buisi*. There is no enamel on the anterior edge of the molars. The species takes its name from the Latin meaning "little" in allusion to its size.

Description of paratypes.—The lower jaws all have the mental foramen under the masseteric crest. A left lower jaw (V53562) is that of a young adult. Enamel is present on the anterior edge of the molars. The labial sides of the molars are wider than the lingual, approaching the condition observed in *Thomomys* (text-fig. 4C). The other four lower jaws are similar to the type or V53562.

Among the isolated teeth are a P₄ (V56017) and an M₂ (V53450) that are immature. The P₄ possesses the typical geomyid pattern on its occlusal surface. The dentine tracts are better
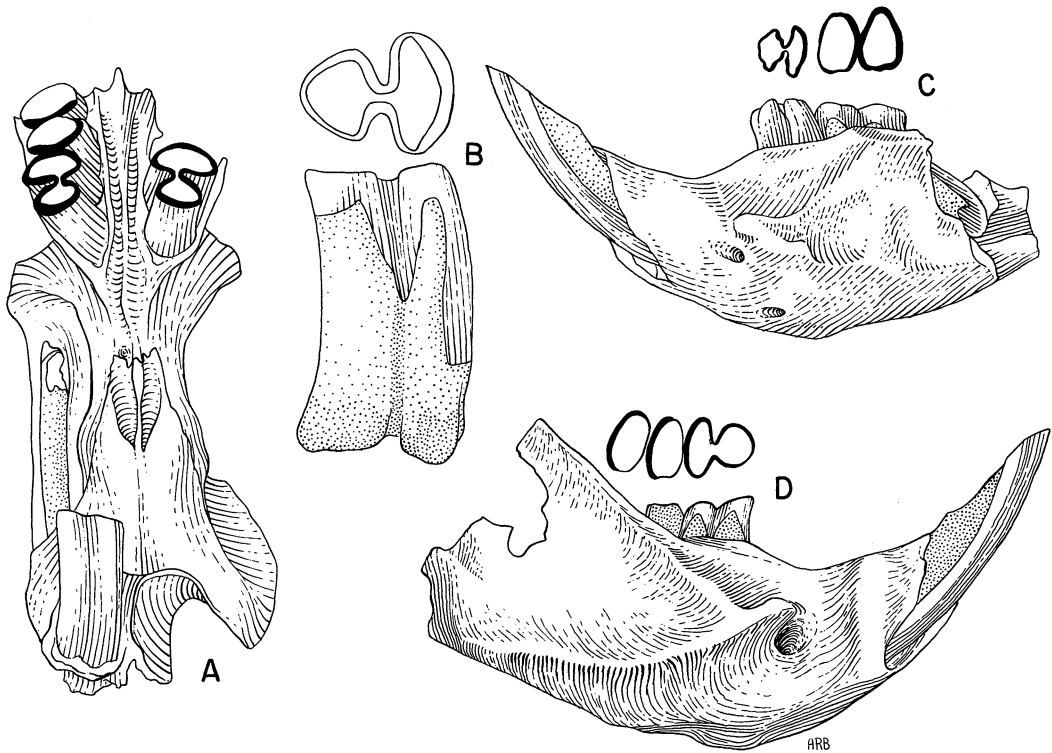
TEXT-FIG. 4—*Pliogeomys parvus* from the Hagerman local fauna. A, V55184, part of skull, ventral view ×6. B, V51578, LP$_4$, labial and occlusal views ×12.5. C, V53562, left lower jaw with P$_4$-M$_2$, labial and occlusal views ×6. D, V55185, *holotype,* right lower jaw with P$_4$-M$_2$, labial and occlusal views ×8.

developed on the labial side than on the lingual side of the tooth. There is no evidence of root development at this stage of wear. The M$_2$ has two lophids on the occlusal surface. The lophids are joined on the labial side to give a C-shape to the occlusal pattern. Enamel is present on the anterior face approximately $\frac{1}{3}$ of the way down from the occlusal surface. The base of the tooth is still open. It would have become single rooted. An adult P$_4$ (V51578) shows the development of dentine tracts and two roots (text-fig. 4B). The roots are not as well developed as those of *Pliogeomys buisi.* An isolated P^4 (V55031) from the Horse Quarry has the lophs attached lingually more like *Thomomys.* The dentine tracts are approximately equal on the anteroloph. There is no tract on the labial side of the posteroloph. However, a large percentage of the enamel is gone from the posterior surface of the tooth except where a thin wedge is present on the lingual edge. The dentine extends up the posterior face to a point approximate to the lingual dentine tract. The lophs fuse at the base of the tooth into a single root.

The premaxillary, maxillary, and palatine are present in the partial skull of *Pliogeomys*

parvus. The area behind the incisive foramina appears to be more constricted than in any of the Recent species of *Geomys, Thomomys,* or *T. gidleyi.* The palatine is fused to the maxillary. The posterior edge of the palate terminates opposite the posterior surface of the M^2 (text-fig. 4A). The P^{4}s with their narrower anterolophs and labial connection with the posteroloph are like *Thomomys.* The molars are like those of *Geomys.* The incisor is bisulcate as in *Geomys* and more opisthodont than in *Geomys* or *Thomomys.* Opisthodont incisors in geomyids are considered to be the primitive condition (White & Downs, 1961) and should be expected in *Pliogeomys.* The skull may represent the same individual as the holotype, but the two specimens were not found in definite association.

Remarks.—The size, characteristics of the upper molars and the position of the mental foramen suggest that *Pliogeomys parvus* is closely related to the subgenus *Nerterogeomys.* Hibbard (1967) redefined *Nerterogeomys* Gazin (1942) as "gophers with the mental foramen beneath the masseteric crest" and considered *Nerterogeomys* as a subgenus of *Geomys.* The

exact taxonomic importance of the position of the foramen is difficult to determine.

The position of the mental foramen is variable in *P. buisi,* though it too is more ventral and closer to the masseteric crest than in Recent species of *Geomys.* Variability in the position of the foramen has also been pointed out by White & Downs (1961) in *G. garbanni.* They considered the position of the foramen to be of little or no taxonomic significance. The differences in the position of the foramen, as well as other characters, suggest that two lines of gophers could be represented, which separated some time in the Hemphillian or Clarendonian. *P. parvus* is a representative of the line which gave rise to the subgenus *Nerterogeomys,* while *P. buisi* could be a representative of the line from which the subgenus *Geomys* was derived. *G. garbanni* could be a primitive member of *Geomys,* in which the forward shift of the foramen had not completely occurred, or a later branching off from the *Nerterogeomys* line.

Pliogeomys parvus is the latest representative known of the Geomyidae with rooted teeth. *Pliogeomys buisi, Pliosaccomys* Wilson, and *Parapliosaccomys* Shotwell are so far not known from deposits younger than Hemphillian. Some isolated rooted gopher teeth are present in the Fox Canyon local fauna (Hibbard, pers. comm.), but it cannot be determined at this time whether they belong to one of the species already described (Hibbard, 1967) or whether another genus is represented.

The presence of a *Geomys* type of gopher well out of the range of Recent *Geomys* indicates that this group possessed a wider geographical distribution in earlier times. The occurrence of *Pliogeomys parvus* in the Hagerman local fauna represents another example of the situation observed by Matthew (1939) that the species on the periphery of the range in many groups tend to retain more primitive characteristics than the central population.

Family HETEROMYIDAE

The remains of pocket mice and kangaroo rats in the Hagerman local fauna are extremely rare. The pocket mice are represented by two species of *Perognathus.* A large species is found only at an elevation of 3260 feet. A medium-sized species is found from an elevation of 3025 to 3295 feet. The kangaroo rat, *Prodipodomys,* also is known from 3025 to 3295 feet.

The terminology employed in the discussion of the teeth is based on the geographic position of cusps and lophs.

Subfamily PEROGNATHINAE
PEROGNATHUS MAGNUS n. sp.
Text-fig. 5C

Holotype.—V55958, right maxillary P⁴–M³. Collected by Philip R. Bjork and Richard J. Zakrzewski, summer of 1967.

Horizon and type locality.—Upper Pliocene, Glenns Ferry Formation; UM–Ida. 1a–65, elev. 3260 feet, Twin Falls County, Idaho.

Paratype.—V53563, part of left lower jaw with incisor and P₄–M₂, UM–Ida. 1a–65, elev. 3260 feet.

Diagnosis.—A large pocket mouse near the size of *Perognathus hispidus* Baird, from which it is distinguished by the shape of M³. The M³ of *P. magnus* is a complete circle, while *P. hispidus* has a C-shaped M³.

Description of holotype.—The teeth are in an adult stage of wear (text-fig. 5C). The occlusal length of P⁴–M³ is 4.56 mm. P⁴ is the largest tooth, M³ the smallest, and M¹ is slightly larger than M². The anterior cone of the P⁴ joins the posteroloph lingually rather than medially. This character was found in no other specimen examined, but Wood (1935) pointed out a tendency for a lingual joining of the lophs in specimens of *Perognathus flavus* Baird. In the M¹, the two lophs first unite medially and in the M² this juncture occurs farther labially, but still not at the labial edge. The M³ is a complete circle with an enamel island rather than a C-pattern as in *P. hispidus.* The labial grooves between the lophs on the P⁴–M² are fairly deep. The species derives its name from the Latin "magnus" in allusion to its large size.

Description of paratype.—The paratype is from the same locality as the holotype and is referred to *Perognathus magnus* on the basis of its large size. The occlusal length of the P₄–M₂ is 3.57 mm. The cusps are completely obliterated. M₁ is the largest tooth. P₄ is slightly smaller than M₁. The grooves between the lophids were probably deeper on the lingual side, since they are still visible.

Remarks.—The relationship of *Perognathus magnus* is difficult to determine. It does not appear close to any extant or extinct form examined. Other large fossil pocket mice have been described, *P. sargenti* Shotwell (1956) from the Hemphillian of Oregon and *P. coquorum* Wood (1935) from the Pliocene of Nebraska. These latter specimens are known from lower jaws only. *P. sargenti* differs from *P. magnus* by the relative sizes of the teeth and its highly molariform P₄. Shotwell (1956,

1967b) thinks *P. sargenti* may be a different genus. *P. coquorum* appears to be shorter crowned and slightly larger from Wood's description. More specimens are needed before any relationships can be established.

PEROGNATHUS MALDEI n. sp.
Text-fig. 5B

Holotype.—V55183, part of right lower jaw bearing incisor and P_4–M_3. Collected by Claude W. Hibbard and party, summer of 1966.

Horizon and type locality.—Upper Pliocene, Glenns Ferry Formation; UM Ida. 1a–65, elev. 3260 feet, Twin Falls County, Idaho.

Paratypes.—V55100, part of right lower jaw with I, P_4, M_2–M_3, USGS Cen. Loc. 20765, elev. 3025 feet; V53541, part of left lower jaw with P_4–M_3, UM–Ida. 32–65, elev. 3033 feet; V45257, part of right lower jaw with P_4, USGS Cen. Loc. 19216, elev. 3295 feet.

Diagnosis.—A medium-sized pocket mouse the size of *Perognathus parvus* (Peale) and *P. gidleyi* Hibbard. *P. maldei* differs from *P. parvus* by a larger and more quadrate P_4. *P. gidleyi* has a heavier jaw and the H-pattern of the molars (Wood, 1935) is not as strongly developed as in *P. maldei*.

Description of holotype.—The P_4–M_3 of the holotype are in an adult stage of wear. The occlusal length of P_4–M_3 is 3.70 mm. M_1 is the largest tooth, M_2 the next largest and the P_4 is larger than the M_3. The median cusp of the posterolophid of the molars extends deeply into the median valley, which would give the teeth a strong H-pattern upon subsequent wear (text-fig. 5B). The P_4 has an X-pattern and is more quadrate than in Recent species of *Perognathus*. The lophids of the molars are wider than *P. parvus* or *P. gidleyi* for equivalent stages of wear.

The masseteric crest is not as heavy nor as high on the jaw of *Perognathus maldei* as in *P. parvus* or *P. gidleyi*. The mental foramen is located as in *P. gidleyi*. The back end of the jaw is broken. The incisor is narrower than in *P. gidleyi*. The species is named for Harold E. Malde of the United States Geological Survey for his aid in various aspects of this project.

Description of paratypes.—The paratypes, though at different stages of wear, have the characteristics of the type. The length of the P_4–M_3 in the paratypes is 3.58 mm and 3.27 mm.

Remarks.—*Perognathus maldei* closely resembles the extant *P. parvus* found in Idaho today. I can find no reason why *P. maldei*

could not be ancestral to *P. parvus*. Shotwell (1967b) discusses some pocket mice from the Hemphillian of Oregon, which he considers close to *P. parvus*. From his description it appears that there are slight differences in the P_4 between the Oregon and Idaho fossil specimens, but a close phylogenetic relationship between the species could be possible.

Subfamily DIPODOMYINAE
PRODIPODOMYS IDAHOENSIS Hibbard
Text-fig. 5A, D

Prodipodomys idahoensis Hibbard, 1962, p. 482–484.

Holotype.—USNM 22754, part of a left lower jaw with incisor, P_4–M_1, and the alveoli of M_2–M_3. Collected by Dwight W. Taylor, September, 1957.

Horizon and type locality.—Upper Pliocene, Glenns Ferry Formation; USGS Cen. Loc. 20475, Elmore County, Idaho.

Referred material.—V50220, part of left lower jaw with P_4–M_2, V50221, part of left lower jaw with P_4 and M_2 and the alveolus for M_1, USGS Cen. Loc. 20765, elev. 3025 feet; V53449, part of left lower jaw with P_4, UM–Ida. 41–65, elev. 3050–3075 feet; V50074, LP^4, V50079, RDP^4, V52740, $2LM_1$s, USGS Cen. Loc. 19216, elev. 3295 feet.

Emended diagnosis.—A kangaroo rat with rooted premolars and molars. Slight dentine tracts are developed along the sides of the teeth. It is the size of *Prodipodomys rexroadensis* Hibbard, but the teeth are more hypsodont and the roots of the teeth are not as well developed.

Description of material.—The additional material of *Prodipodomys idahoensis* possesses no features which would separate it from the type specimen. The posterior portion of the lower jaw is missing in all the new finds, so there is no additional information regarding the development of the mandibular foramen.

Wedge-shaped dentine tracts are present on the sides of the teeth. The tracts are better developed on the molars than on the premolars. The height of the tracts on the labial side of the isolated M_1s from USGS Cen. Loc. 19216 are 1.59 and 1.38 mm, respectively, from the base of the tooth. The tracts are equally developed on both sides of the teeth. The enamel is not interrupted on any of the specimens, but one jaw (text-fig. 5A) would show an interrupted pattern on the M_1 and M_2, with a little more wear. Dentine tracts are just barely observable above the edge of the ramus in the holotype.

The DP^4 of *Prodipodomys idahoensis* (text-fig. 5D) is characterized by an anteroloph, in contrast to a single cusp present in Recent *Dipodomys* (text-fig. 5E). Shotwell (1967b) assigned a calcaneum from the Hagerman local fauna to ?*Dipodomys* sp. suggesting it may be *P. idahoensis*. No post-cranial material of *Prodipodomys* was identified.

Remarks.—There appears to be no change in the dentition of *Prodipodomys idahoensis* through the geological section, though the holotype occurs more than 900 feet higher in the section (Malde, pers. comm.) than the highest specimens taken at Hagerman.

The presence of slightly developed dentine tracts makes *Prodipodomys idahoensis* the most advanced of any species assigned to *Prodipodomys*. The development of the roots of the teeth is similar to that observed in *Etadonomys tiheni* Hibbard from the Borchers local fauna (Yarmouth of Kansas). Shotwell (1967b) has reported *Dipodomys* sp. from the Krebs Ranch II local fauna of Hemphillian age in Oregon because of an incipient dentine tract on an isolated lower molar. A form such as this could have been ancestral to *P. idahoensis*. It would appear that an advanced group of kangaroo rats was present in the northwest during Pliocene time.

Outside of specimens assigned to Recent species, the only fossil specimen of a kangaroo rat with well-developed dentine tracts is "Dipodomyine (?), n. gen. and sp." reported by Wilson (1939) from the Avawatz local fauna of Clarendonian age in California. From Wilson's figure, I agree with Downs (1956) that the Avawatz specimen appears closer to the Recent species of *Dipodomys* than to any *Prodipodomys* so far known.

The presence of dentine tracts alone does not separate *Dipodomys* from *Prodipodomys;* but the two genera can be separated by the proper combination in the development of dentine tracts, roots, and the depression between the ascending ramus and the M$_3$ in the lower jaw.

The development of dentine tracts is variable in the Recent species of *Dipodomys*. Hibbard (1954b) stated that the tracts of *D. compactus* True and *D. sennetti* (J. A. Allen) were less developed than in *D. ordii richardsoni* (J. A. Allen). Wood (1935) pointed out that the development of the tracts in some species of *Dipodomys* was variable between the upper and lower teeth as to whether the labial or lingual side of the tooth had the tracts better developed. Wilson (1939) stated that not all species of living kangaroo rats possess dentine tracts. Shotwell (1967b) stated that not all *specimens* of living kangaroo rats possess dentine tracts.

Recent kangaroo rats in The University of Michigan Museum of Zoology were examined for the presence of dentine tracts. Thirteen of the 21 species of *Dipodomys* listed in Miller & Kellogg (1955) were available for study. *D. compactus* and *D. sennetti* were examined at the United States National Museum. All the species examined possessed dentine tracts. The following generalizations can be made concerning dentine tracts: The tracts are better developed on the M$\frac{1}{1}$ and the M$\frac{2}{2}$ than on the P$\frac{4}{4}$ or M$\frac{3}{3}$; they are better developed on the M$_3$ than on P$_4$ and better on P^4 than on M^3; better developed on the posteroloph(id) of the P$\frac{4}{4}$ than on the anteroloph (id); in some species there is a posterior tract on the M^3. If there is a difference in the development of the tracts between the sides of the teeth, it appears that the tracts are better developed on the lingual side of the uppers and the labial side of the lowers; though Wood (1935) cites some evidence to the contrary. The tracts are not always visible on the teeth of young specimens in the jaws. This fact may account for Shotwell's (1967b) statement. Dentine tracts were found on all species of *Dipodomys* at the United States National Museum by Charles O. Handley, Jr., (letter of Jan. 29, 1968).

> I found dentine tracts on the exterior surface on the teeth of all species of *Dipodomys* represented at the U. S. National Museum. In my examination I did not go beyond a single specimen in a given species if it displayed dentine tracts on any tooth. Therefore, I do not know what kind of individual, geographic, or age variation there may be in this characteristic.

The detailed differences between the various species both inter- and intraspecifically would require the measuring of large samples of isolated teeth and is beyond the scope of this study.

Family CASTORIDAE

Beavers are represented by two genera, *Castor* and *Dipoides*, in the Hagerman local fauna, one from each of two subfamilies. *Castor* is one of the more common elements in the fauna and occurs throughout the section. *Dipoides* is rare. Its stratigraphic range cannot be definitely documented, since the exact position of the United States National Museum finds are unknown. The specimens in The University of Michigan Museum of Paleontology collection were found in an interval from 2950 to 3050 feet.

The terminology employed for the teeth is that of Woodburne (1961), which was modified

from Shotwell (1955) and Stirton (1935). The terminology of the foot elements is modified from Stains (1959).

Subfamily CASTORINAE
Castor cf. C. CALIFORNICUS Kellogg

Castor accessor ? Hay, Wilson, 1933, p. 119, 124; Gazin, 1936, p. 285; Schultz, 1937, p. 84.
Castor cf. *C. californicus* Kellogg, Stirton, 1935, p. 446–447; Taylor, 1966, p. 75.
Castor sp., Wilson, 1937, p. 38.

Remarks.—Remains of the genus *Castor* are very abundant in the Hagerman local fauna. A fine suite of specimens has been obtained from all parts of the section to supplement the material on hand at the United States National Museum. No detailed study of the material was attempted at this time.

The genus is listed to note its presence and it will be considered in the discussion of the correlation and paleoecology of the fauna. I agree with Stirton (1935) that the Hagerman specimens of *Castor* appear to be slightly larger than the Recent species.

Subfamily CASTOROIDINAE
DIPOIDES INTERMEDIUS n. sp.
Text-figs. 5F–I, 6D

Procastoroides sp., Taylor, 1966, p. 75.

Holotype.—USNM 24933, isolated RP_4. Collected by C. Lewis Gazin, summer of 1934.

Horizon and type locality.—Upper Pliocene, Glenns Ferry Formation, 4–5 miles south of Horse Quarry, Twin Falls County, Idaho.

Paratypes.—USNM 24934, LM^1, USNM 24935, RM^1, Loc. unknown; V50237, astragalus and calcaneum, V50282, 5 isolated teeth, V53117, RM^3, V53118, RM^3, UM–Ida. 10–64, elev. 2950 feet; V55487, RP_4, UM–Ida. 9–66, elev. 2950 feet; V56093, LM_2, UM–Ida. 13–67, elev. 2980 feet; V51630, LM_1, UM–Ida.

97–64, elev. 2980 feet; V53780, articular portion of calcaneum, UM–Ida. 36–65, elev. 3050 feet.

Diagnosis.—*Dipoides intermedius* is distinguished from all other species of *Dipoides* by its large size. The M^3 possesses a complete metastria.

Description of holotype.—The holotype is an isolated RP_4. The tooth lacks a parastriid and has the S-shape pattern typical of *Dipoides* (text-fig. 6D). The length of the P_4 is 9.3 mm, the width 8.8 mm, and the height 26.7 mm. Some cement is present on the anterior and posterior faces of the tooth. The lophids are uninflated. The flexids are parallel to the lophids. The mesoflexid is slightly crescentic near its termination. The terminations of the mesoflexid and hypoflexid abut but no pseudostriids are present. The abutting of the mesoflexid is not apparent on the occlusal surface of the holotype because of slight erosion in this area. It is readily visible at the base of the tooth (text-fig. 6D). The species receives its name because of its size relationship, which is approximately intermediate between *D. rexroadensis* Hibbard and both *Procastoroides sweeti* Barbour & Schultz and *Paradipoides stovalli* Rinker & Hibbard.

Description of paratypes.—Two additional P_4s are known. They are similar to the holotype in size and shape, but no cement is present on the anterior or posterior face. The measurements of these teeth as well as the remaining specimens are given in table 4.

The two M^3s are characterized by a metaflexus which bifurcates the posterior loph into the first and second posterior lophs of Woodburne (1961) (text-figs. 5F–G). The metastria is complete in both teeth. A complete metastria has not been previously reported in *Dipoides*. It is, however, common in *Procastoroides* (Woodburne, 1961). The first posterior loph

TABLE 4—MEASUREMENTS (mm) OF TEETH OF *Dipoides, Paradipoides,* AND *Procastoroides.*

	D. rexroadensis (Woodburne, 1961)			D. intermedius			P. stovalli			P. sweeti (Woodburne, 1961)		
	N	$\overline{x}$L	$\overline{x}$W	N	$\overline{x}$L	$\overline{x}$W	N	$\overline{x}$L	$\overline{x}$W	N	$\overline{x}$L	$\overline{x}$W
P^4	6	5.7	4.4	1	—	8.1	1	11.4	11.8	5	11.3	10.7
M^1	4	5.8	4.7	2	8.3	8.3				2	9.3	8.7
M^2	3	5.2	4.5	2	6.3	6.9				2	8.8	8.3
M^3				2	8.0	5.5				4	9.3	6.9
P_4				3	9.5	8.7				13	12.3	9.0
M_1				1	7.4	8.4	1	8.3	8.0*	7	11.4	9.3
M_2				2	7.1	7.3	1	8.1	8.4*	9	11.1	8.9
M_3										5	9.8	8.2

* From Rinker & Hibbard, 1952.
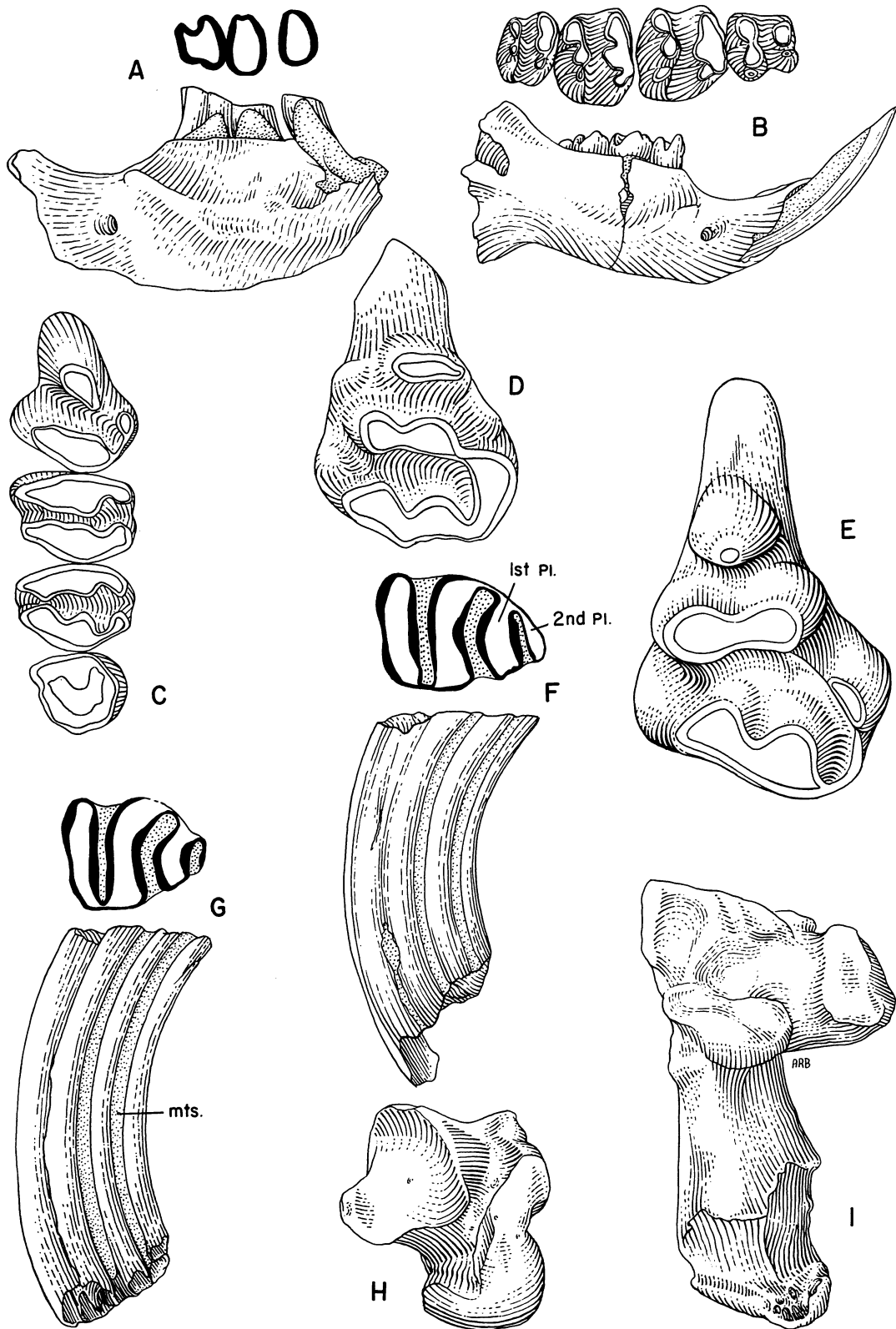
TEXT-FIG. 5—Heteromyids and beaver. A, *Prodipodomys idahoensis*, V50220, left lower jaw with P₄-M₂, labial and occlusal views ×6. B, *Perognathus maldei*, V55183, *holotype*, right lower jaw with P₄-M₃, labial view ×6, occlusal view ×12.5. C, *P. magnus*, V55958, *holotype*, RP⁴M³, occlusal view ×12.5. D, *Prodipodomys idahoensis*, V50079, RDP⁴, occlusal view ×25. E, *Dipodomys ordii luteolus*, UMMZ 87491, RDP⁴, occlusal view ×25. F-I, *Dipoides intermedius*, F, V53117, G, V53118, F-G, RM³s, labial and occlusal views ×3; H-I, V50237, H, calcaneum, ventral view ×1.5, I, astragalus dorsal view ×1.5. Abbreviations: mts = metastria, Pl = posterior loph.

is slightly inflated. The other lophs are not. The mesoflexus is slightly crescentic. The remaining teeth possess the S-shape pattern characteristic of *Dipoides*.

The one astragalus and two calcanea are typical of the subfamily Castoroidinae (text-figs. 5H-I) and can easily be distinguished from *Castor*. The three specimens were compared with an astragalus of *Castoroides,* an astragalus and calcaneum of *Procastoroides* and a small series of the same foot elements from *Dipoides wilsoni* Hibbard. While there are some obvious differences, besides size, between the four beavers, the Hagerman elements more closely resemble those of *D. wilsoni*. This is especially evident in the astragalus, where the groove between the lateral and sustentacular facets is better developed and the trochlear surface is not as well developed on the ventral surface as in *Procastoroides*. The body of the calcaneum of *Procastoroides* is much stouter than in *Dipoides*. A better sample is needed of *D. intermedius* and *Procastoroides* to show if the differences are real or fortuitous. The variation observed in the *D. wilsoni* sample may preclude the use of foot elements below the subfamily level except for difference in size.

Remarks.—Dipoides intermedius is the largest known member of the genus. *D. intermedius* is approximately intermediate in size between *D. rexroadensis* and *Paradipoides stovalli* (table 4). The possibility exists that *D. intermedius* could have given rise to the latter form.

The systematic position of *Paradipoides* is, however, in some doubt. There is a strong possibility it may be congeneric with *Dipoides*. The type specimen of *Paradipoides* is that of an immature, or at least a very young individual. The position of the incisor with respect to the tooth row, and the degree of development of the coronoid fossa, characters which are diagnostic for the genus, are characters which can be shown to vary with the ontogenetic age of an individual. An immature specimen of *Dipoides wilsoni* (V24338) shows the end of the incisor slightly more posterior than in *Paradipoides*. It cannot be determined whether these specimens are of the same ontogenetic age; nor is a large enough sample available to determine the amount of variation which might exist in this character. Until these factors are resolved, it may be best to consider *Paradipoides* as a distinct genus.

Dipoides intermedius is likewise intermediate in size between *D. rexroadensis* and *Procastoroides sweeti*. It is like *P. sweeti* in the possession of a complete metastria on the M^3.

D. intermedius lacks a complete parastriid on the P_4 as well as pseudostriids on it and the remaining molars, features which are characteristic of *Procastoroides*. Whether a parastriid is present in *D. intermedius* on the P_4 or the molars at a younger ontogenetic age is not known. The characteristics of the teeth and the similarity of the foot elements denote a form which could be very close to the stock of *Dipoides* which gave rise to *Procastoroides*.

Family Cricetidae

The family Cricetidae is represented by six genera in the Hagerman local fauna. *Peromyscus, Baiomys,* and *Neotoma* are members of the subfamily Cricetinae. Remains of these forms are rare in the fauna. *Peromyscus* and *Baiomys* are found from 3025 to 3295 feet while *Neotoma* is known from 3025 to 3150 feet. *Pliopotamys, Ophiomys,* and *Cosomys* are representatives of the subfamily Microtinae. These forms are the most abundant in the fauna. *Ophiomys* is known only from localities above 3100 feet. *Cosomys* is found only below 3265 feet while *Pliopotamys* is found from 2950 to 3300 feet.

The terminology employed in the discussion of the Cricetidae is that of Hershkovitz (1962) for the Cricetinae and Zakrzewski (1967) for the Microtinae, which was modified from Hinton (1926).

Subfamily Cricetinae
Peromyscus hagermanensis Hibbard
Text-figs. 6A-B

Peromyscus ?, Hibbard, 1959, p. 11.
Peromyscus hagermanensis Hibbard, 1962, p. 484.

Holotype.—V34441, part of right lower jaw with M_2 and alveoli for M_1 & M_3. Collected by Claude W. Hibbard, August, 1956.

Horizon and type locality.—Upper Pliocene, Glenns Ferry Formation, USGS Cen. Loc. 20765, elev. 3025 feet.

Referred material.—V50658, part of toothless left lower jaw, USGS Cen. Loc. 20765, elev. 3025 feet; V49990, part of left lower jaw with parts of M_1 & M_2, V55023, LM_1, UM–Ida. 2–64, elev. 3025–3050 feet; V53448, part of left maxillary with M^1-M^2, UM–Ida. 41–65, elev. 3050–3075 feet; V53296, 2 toothless jaws, UM–Ida. 3–65, elev. 3110 feet; V56013, part of left toothless lower jaw, USGS Cen. Loc. 19217, elev. 3115 feet; V55981, part of left lower jaw with M_2, V50659, part of right lower jaw with M_1 and lower toothless left jaw, UM–Ida. 2–65, elev. 3280–3300* feet; V52739, LM^1, USGS Cen. Loc. 19216, elev. 3295 feet.

Emended diagnosis.—A *Peromyscus* near the size of *P. dentalis* Hall from which it is distinguished by the lack of the deep fossa between the coronoid process and M₃. The development of accessory lophs and styles(ids) on the teeth is variable. Differential wear (i.e., labial cusps not as high as lingual cusps) is exhibited on some specimens.

Description of material.—The maxillary of *Peromyscus hagermanensis* is that of an old adult. Comparing it with a maxillary of *P. crinitus* (Merriam) (UMMZ 59251), in an approximately equivalent stage of wear, shows that the length for the M¹-M² is the same. *P. hagermanensis*, however, is slightly narrower. The M² of *P. hagermanensis* is more quadrate, does not narrow posteriorly, and lacks a well-developed anteroloph and mesostyle. The M¹, likewise, does not possess a mesostyle.

The isolated M¹ (text-fig. 6B) is characterized by a mesoloph and paralophule which join at the mesostyle. The anterolabial style is strongly developed. The metacone is joined to the hypocone by the posteroloph.

Two M₁s are known. The one from UM–Ida. 2–64 (V55023) appears to be slightly narrower, possesses a very shallow anterior groove and lacks the labial stylids and differential wear shown in the M₁ from UM–Ida. 2–65 (V50659).

Differential wear is also found on the M₂ from UM–Ida. 2–65. This specimen (V55981, text-fig. 6A) is slightly shorter and wider than the holotype. It lacks the labial stylids and the major fold appears to be somewhat broader than in the holotype. The jaw from UM–Ida. 2–64 is that of an old adult with badly worn and broken teeth. Seven M₁-M₃ alveolar measurements for *Peromyscus hagermanensis* range from 3.46 to 3.92 mm with a mean of 3.82 mm.

Remarks.—The teeth which show differential wear could well represent a species different from *Peromyscus hagermanensis*. These teeth are found higher in the section than most of the other specimens. Only the isolated M¹ is found higher but it shows no wear. Differential wear, however, was found to be variable in specimens of *P. crinitus*. Variability of the accessory cuspules and lophs in *Peromyscus* has been well demonstrated (Hooper, 1957; Hibbard & Taylor, 1960; Shotwell, 1967a), so that separation of the specimens is not valid on this basis with the present sample. It is interesting to note that none of the *Peromyscus* from the Rexroad local fauna possess accessory lophs (ids) or styles(ids). Because of the small sample of *Peromyscus* from the Hagerman local fauna and the variation which has been shown

to exist in the genus, I feel that it is best to consider all specimens from the fauna as belonging to *P. hagermanensis*.

BAIOMYS AQUILONIUS n. sp.
Text-figs. 6E-F

Holotype.—V55055, part of left lower jaw with M₁-M₃. Collected by Claude W. Hibbard and party, summer of 1966.

Horizon and type locality.—Upper Pliocene, Glenns Ferry Formation, USGS Cen. Loc. 19216, elev. 3295 feet.

Paratypes.—V56075, part of left lower jaw with incisor, M₂ and alveoli for M₁ & M₃, part of right lower jaw with incisor, M₂ and alveoli for M₁, upper incisor, USGS Cen. Loc. 20765, elev. 3025 feet; V54929, part of right lower jaw with incisor and M₁-M₂, UM–Ida. 112–65, elev. 3150 feet; V52738, part of right lower jaw with incisor, M₁, and alveoli for M₂-M₃, V55959, part of right lower jaw with incisor and alveoli for M₁-M₃, USGS Cen. Loc. 19216, elev. 3295 feet.

Diagnosis.—A pygmy mouse near the size of *Baiomys taylori* (Thomas) with an expanded procingular area and a small anteromedian stylid developed on M₁. The M₃ is reduced.

Description of holotype.—The holotype is in an adult stage of wear. The occlusal length of the M₁-M₃ is 2.52 mm. The cingula of all the molars are weakly developed. In this respect *B. aquilonius* bears a close resemblance to *B. rexroadi* Hibbard. The mesoloph of the M₁ in *B. aquilonius* is farther from the procingulum than in *B. rexroadi* or *B. taylori*. The anteromedian stylid is still visible on the procingulum of the M₁ (text-fig. 6E). The procingulum of the M₁ is wider than in *B. taylori* or *B. rexroadi*. There is a small ectostylid developed on the M₁. The M₃ is 0.54 mm, making it the most reduced of any of the M₃s of *Baiomys* examined. The major fold and first primary fold of the M₃ do not appear as well developed as in the other members of the genus, but this may be due to wear. The incisor and ascending ramus are missing. This species takes its name from the Latin for "northern" to note its geographic occurrence.

Description of paratypes.—The right lower jaw with M₁ (V52738) is considered a young adult. There is little or no wear on the cusps (text-fig. 6F). The anteromedian stylid is well developed. The procingular area is larger than in other species of *Baiomys*. The incisor is more proödont than in *B. brachygnathus* (Gidley) but less than in *B. minimus* (Gidley). This is
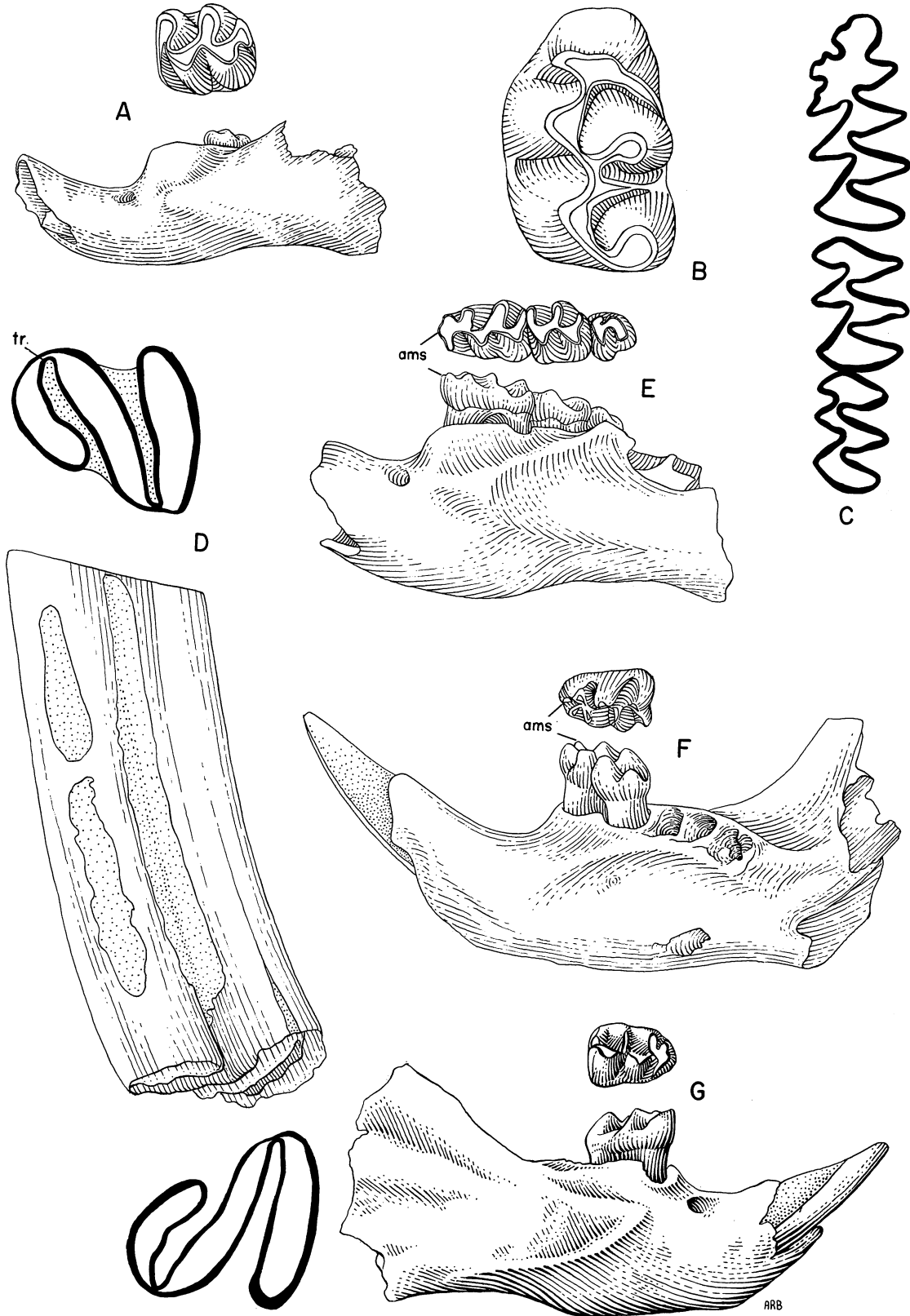
TEXT-FIG. 6—Beaver, cricetines, and microtine from the Hagerman local fauna. A–B, *Peromyscus hagermanensis*, A, V55981, left lower jaw with M_2, labial view ×6, occlusal view ×12.5; B, V52739, LM^1, occlusal view ×25. C, *Ophiomys taylori*, V55983, LM_1-M_3, occlusal view ×12.5. D, *Dipoides intermedius*, USNM 24933, *holotype*, RP_4, occlusal, lingual, and ventral views ×3. E–F, *Baiomys aquilonius*, E, V55055, *holotype*, left lower jaw with M_1-M_3; F, V52738, right lower jaw with M_1, labial and occlusal views ×12.5. G, *B.* sp., V53192, right lower jaw with M_1, labial and occlusal views ×12.5. Abbreviations: tr = termination, ams = anteromedian stylid.

the same relationship as is found in *B. rexroadi*. The width of the incisor is likewise the same as in *B. rexroadi*.

The right lower jaw with M_1-M_2 (V54929) is an old adult. The cusps are well worn. No anteromedian stylid is present. The cingula of the molars are poorly developed. The mental foramen in the latter two paratypes is more dorsal than in the holotype.

The two jaws (V56075) from USGS Cen. Loc. 20765 both contain M_2s. One of the specimens has the anteroloph similarly developed as in *Baiomys rexroadi*. This is the lowest occurence of the species in the section. The upper incisor is the size and shape of *Baiomys*. It is asulcate.

Remarks.—*Baiomys aquilonius* represents the most northern known occurrence of the genus. The presence of *Baiomys* so far north of its present range is not really striking. Other mammals with southern affinities, such as *Cryptotis* (Hibbard, pers. comm.), are also known from the fauna. These groups could have moved northward by population spread. However, it is just as logical to assume, maybe more so, that *Baiomys* was originally a widespread form and its range has since retracted. Faunas of Upper Pliocene age are poorly known. Valid comparisons can be made only between the Rexroad and the Hagerman local faunas. The microfauna of the Benson local fauna is also fairly well known and in all three of these local faunas *Baiomys* is present.

Lack of well-developed stylids, other than the anteromedian stylid, places *Baiomys aquilonius* in the *B. rexroadi*-*B. taylori* grouping of Packard (1960). An expanded procingular area and reduced M_3 would appear to set *B. aquilonius* off as a specialized member of the genus. *B. aquilonius* most closely resembles *B. rexroadi;* whether it was directly derived from the latter or the similarities are a reflection of a common ancestry cannot be satisfactorily determined with the specimens on hand.

BAIOMYS sp.
Text-fig. 6G

Referred material.—V53192, right lower jaw with I, M_1 and alveoli for M_2-M_3, UM–Ida. 4–65, elev. 3170 feet.

Description of material.—The specimen represents a tooth of a pygmy mouse in a young adult stage of wear. The alveolar length of M_1-M_3 is 2.85 mm. The M_1 differs from M_1s of *Baiomys aquilonius* by the absence of an anteromedian stylid and an unexpanded procingular area (text-fig. 6G). The M_1 also appears to be slightly more triangular in outline than other specimens of *Baiomys* examined. The procingular area is relatively narrow and there is a slight groove on the anterior face of the M_1. The incisor is 0.38 mm wide and more proödont than in *B. aquilonius*. Stylids and lophids are absent.

Remarks.—*Baiomys* sp. can be readily distinguished from *B. aquilonius* by the characters of the M_1. Its relationship to other members of the genus is not as obvious. The determination of the relationship awaits the recovery of additional material.

NEOTOMA cf. N. QUADRIPLICATUS Hibbard

Referred material.—V50229, 2 RM_1s, LM_1, and RM^1, USGS Cen. Loc. 20765, elev. 3025 feet; V53462, LM^1, UM–Ida. 41–65, elev. 3050–3075 feet; V54754, part of right maxillary M^1-M^2, and RM_1, UM–Ida. 54–65, elev. 3100 feet; V56063, part of left lower jaw with incisor and alveoli for M_1-M_3, UM–Ida. 63–65, elev. 3130 feet; V49727, same as V56063, UM–Ida. 4–64, elev. 3150 feet.

Description of material.—The isolated molars compare favorably in all characteristics with *Neotoma quadriplicatus* (Hibbard) from the Rexroad local fauna. The same is true of the partial maxillary and lower jaws. However, some slight differences are apparent. The capsular process for the reception of the incisor appears to be less developed in the two jaws from the Hagerman than in the Rexroad specimens. Development of the capsular process is a character which is known to vary with the ontogenetic age of the individual. Since the Hagerman specimens lack teeth, no age determination can be made.

Eighty-one percent (56/69) of the *Neotoma* M^1s from the Rexroad local fauna have a remnant of a fourth root located medially on the dorsal surface of the tooth approximately equidistant from the three main roots. This fourth root was not in evidence on the two isolated M^1s from the Hagerman.

Remarks.—No third molars, either upper or lower are known. These teeth are critical for specific assignment. Because of the absence of any diagnostic criteria and the similarity of the isolated molars, the Hagerman specimens are referred to the Rexroad species.

OPHIOMYS TAYLORI (Hibbard)
Text-fig. 6C

Nebraskomys ? *taylori* Hibbard, 1959, p. 12–15.
Pliophenacomys idahoensis Hibbard, 1959, p. 15–19.
Nebraskomys ? *taylori* Hibbard, Taylor, 1966, p. 75.
Ophiomys taylori (Hibbard), Hibbard & Zakrzewski, 1967, p. 262–268.

Referred material.—Maxillaries and jaws with and without teeth, plus isolated teeth representing at least 165 individuals from 11 localities ranging from 3100–3295 feet in elevation.

Remarks.—The systematic position of this species has been recently discussed (Hibbard & Zakrzewski, 1967). It was demonstrated that the M_1 was highly variable in populations of *Ophiomys taylori,* but a trend could be established from a predominance of three-triangled forms through four-triangled forms to five-

M^3s possessed enamel pits. At the USNM Horse Quarry a complete lower jaw was recovered *in situ* during quarrying operations by John A. White of Idaho State University.

Additional material was also recovered at UM–Ida. 1a–65 and USGS Cen. Loc. 19216. The new samples show that there is little or no difference between the populations at the two localities (table 5). No collections were made at the Sand Point local fauna. At USGS Cen. Loc. 20475, where the associated lower jaws with five-triangled M_1s were recovered, one M_1 was found. It, too, has five triangles. *Ophiomys* appears to be most closely related to *Cosomys.* The exact nature of the relationship is indeterminable at this time. *Ophiomys* receives its name from the Greek "Ophis" meaning snake in allusion to its presence along the Snake River.

TABLE 5—SUMMARY OF VARIATION IN M_1s OF *Ophiomys taylori.*

Character	Hagerman UM–Ida. 1a–65		Hagerman USGS Cen. Loc. 19216		Sand Point USGS Cen. Locs. 19128–29		USGS Cen. Loc. 20475	
	N	%	N	%	N	%	N	%
Number of M_1s	84	—	66	—	18	—	3	—
Three triangles	57	68.0	45	68.2	6	33.3	0	—
Four triangles	26	30.9	21	31.8	11	61.2	0	—
Five triangles	1	1.1	0	—	1	5.5	3	100
Enamel pits	50	59.5	38	57.6	7	39.0	0	—
Prism folds	13	15.5	8	12.2	3	16.7	0	—
Enamel ridges	16	19.0	14	21.2	7	39.0	0	—
Three lobed	25	28.1	28	42.5	9	50.0	0	—

triangled forms as one proceeded higher in the Glenns Ferry Formation. A reduction through time in the presence of prism folds and enamel pits on the M_1 was also documented.

A suggestion was made that Loc. UM–Ida. 1a–65 might be slightly younger than USGS Cen. Loc. 19216, even though it was lower topographically, because of the higher percentage of four-triangled and one five-triangled form at the former locality. The lowest known occurrence of *O. taylori* was at an elevation of 3110 feet and three localities had only one or two specimens.

Collections made in the summer of 1967 by Philip R. Bjork and R. J. Zakrzewski have slightly altered this picture. Six additional localities have been added from which *Ophiomys* is now known. Two of these localities are at an elevation of 3100 feet. These are now the lowest known occurrence of *O. taylori.* At the localities where few specimens were known such as UM–Ida. 2–65 a lower jaw with M_1-M_3 was recovered (text-fig. 6C), also three M^3s. None of the

COSOMYS PRIMUS Wilson
Text-figs. 7B–C, E; 8K–T

Cosomys primus Wilson, 1932, p. 150–154; Hibbard, 1964, p. 123; Taylor, 1966, p. 75; Hibbard & Zakrzewski, 1967, p. 255–271.
Mimomys primus (Wilson), Hinton, 1932, p. 280–281.
Mimomys (*Cosomys*) *primus* (Wilson), Wilson, 1933, p. 126–128; Hibbard, 1959, p. 9–12; Thaler, 1966, p. 158.

Referred material.—Numerous maxillaries and jaws, with and without teeth, also numerous isolated teeth representing at least 1,473 individuals from 130 localities ranging in elevation from 2900–3265 feet.

Description of material.—The palate of *Cosomys primus* (text-fig. 7B) has the lateral palatal grooves moderately developed. The maxillary walls which make up the border of these grooves are vertical at the anterior end. Posteriorly, the walls begin to slope outward and upward toward the alveolar plane from a point approximate with the anterior end of the maxillopalatine suture. This sloping character

appears to increase with age. The opposing maxillary walls are equidistant throughout the length of the palate. The development of these grooves most closely approaches that of *Ophiomys taylori* and seems to be intermediate in development between *Ogmodontomys sawrockensis* Hibbard and *O. poaphagus* Hibbard (Hibbard & Zakrzewski, 1967). The grooves of *Pliophenacomys primaevus* Hibbard are similarly developed but shallower. The maxillary borders of the grooves appear to narrow anteriorly in *Ogmodontomys* and *Pliophenacomys*. In *C. primus* the median ridge of Miller (1896) is wide and depressed. A similar condition is found in *O. taylori*, and *P. primaevus*. In *Ogmodontomys* the median ridge is narrow and elevated throughout its length.

The anterior edge of the palatine in *Cosomys primus* reaches a point approximately at a line drawn between the alveolar border of the M^{1}s and M^{2}s. The palate terminates posteriorly at a line drawn between the midpoints of the anterior root of the M^{3}s. The palate terminates more anteriorly in *Ogmodontomys* and *Pliophenacomys*. In *C. primus* the posterior palatine foramina are situated more posteriorly with respect to the maxillopalatine boundary than in *Ogmodontomys* and *Pliophenacomys*. The incisive foramina of *C. primus* vary with age (Hibbard & Zakrzewski, 1967). The posterior edge of the incisive foramina becomes more anteriorly situated in older specimens. Reduction in size of the incisive foramina with age in Recent microtines was pointed out by Quay (1954).

The upper incisor of *Cosomys* is asulcate while that of *Ogmodontomys* is faintly grooved (Hibbard, 1956). The occlusal pattern of the upper molars of *C. primus* is typical of primitive microtines in the number of loops and triangles present. *C. primus*, however, can be readily distinguished much of the time from *Ophiomys* and *Pliopotamys* by size and from *Ogmodontomys* and *Pliophenacomys* by occlusal pattern. The M^1 and M^2 are basically three rooted. The M^3 is principally two rooted. There was some variation found in the number of roots present on the molars, however. Less than 2% (12/700) of the M^{1}s were four rooted and one M^1 was two rooted (Hibbard, 1959, p. 11). Slightly more than 7% (35/486) of the M^{2}s possessed two roots and slightly more than 3% (16/486) had four roots. Less than 8% (15/-183) of the M^{3}s were three rooted. Three per cent (21/700) of the M^{1}s have a slight anterior cingulum at the base of the crown. The specimen with the best development of this feature is shown in text-figure 7C. The anterior cingulum is moderately developed on four of 10 M^{1}s

of *Ogmodontomys sawrockensis*. It is slightly developed on less than 10% of the M^{1}s of *O. poaphagus*. Four M^{1}s possess a small depression near the base of the crown on the posterior internal surface (text-fig. 7C). This depression occurs in a position where a re-entrant angle would start to form. The term "re-entrant pit" is here proposed for this depression. The best development of the pit can be seen in the Recent *Phenacomys intermedius* Merriam. The pit can also be found moderately developed in *Pliophenacomys* and can be considered incipient in *Cosomys*. Three of the M^{1}s with re-entrant pits were found at UM–Ida. 1a–65. The other tooth was from UM–Ida. 9–66, elev. 2950 feet. Only one M^3 was found which had an enamel pit (text-fig. 8T).

The capsular process for the reception of the incisor in the lower jaw is well developed. The process is better developed, in equivalent stages of wear, than in any other of the fossil genera examined. The dental foramen is ventral to or at approximately the same height as the capsular process. There is no well-developed fossa between the tooth row and the ascending ramus.

The M$_1$ of *Cosomys* as in all microtine genera, is the most variable of the teeth. The M$_1$ is characterized by a posterior loop, three or four alternating triangles, and a complex anterior loop. The anterior loop can possess (1) an enamel pit (text-fig. 8L), (2) a prism fold (text-fig. 8M), or (3) enamel ridge (text-fig. 8R), and (4) can be trilobed, or any combination of 1, 2, 4 or 1, 3, 4 (text-figs. 8N–Q).

The enamel pit is present in most specimens considered immature and young adult. In some immature and young adult specimens the pit has not yet formed. The pit is formed by an isolation of the tip of the third outer re-entrant angle (Wilson, 1933). Text-figure 8K shows the pit starting to form. Hibbard (1949, fig. 2D) shows the pit in *Ogmodontomys sawrockensis* starting to form from the fourth inner re-entrant angle. No specimens of *O. poaphagus* were found which showed the pit starting to form. Therefore, it cannot be definitely stated whether the formation of the pit in *O. sawrockensis* is an exception to the rule observed in *Cosomys* and *Pliopotamys*, or it is diagnostic for that genus. The pit is developed in the majority of adult specimens. The depth of pit development is variable. The highest crowned adult specimen in which no pit was found measured 2.21 mm. The shortest-crowned adult specimen in which a pit was present measured 1.00 mm. No pits were found in specimens considered old adults. The prism fold, or some evidence of it, was found on the majority of
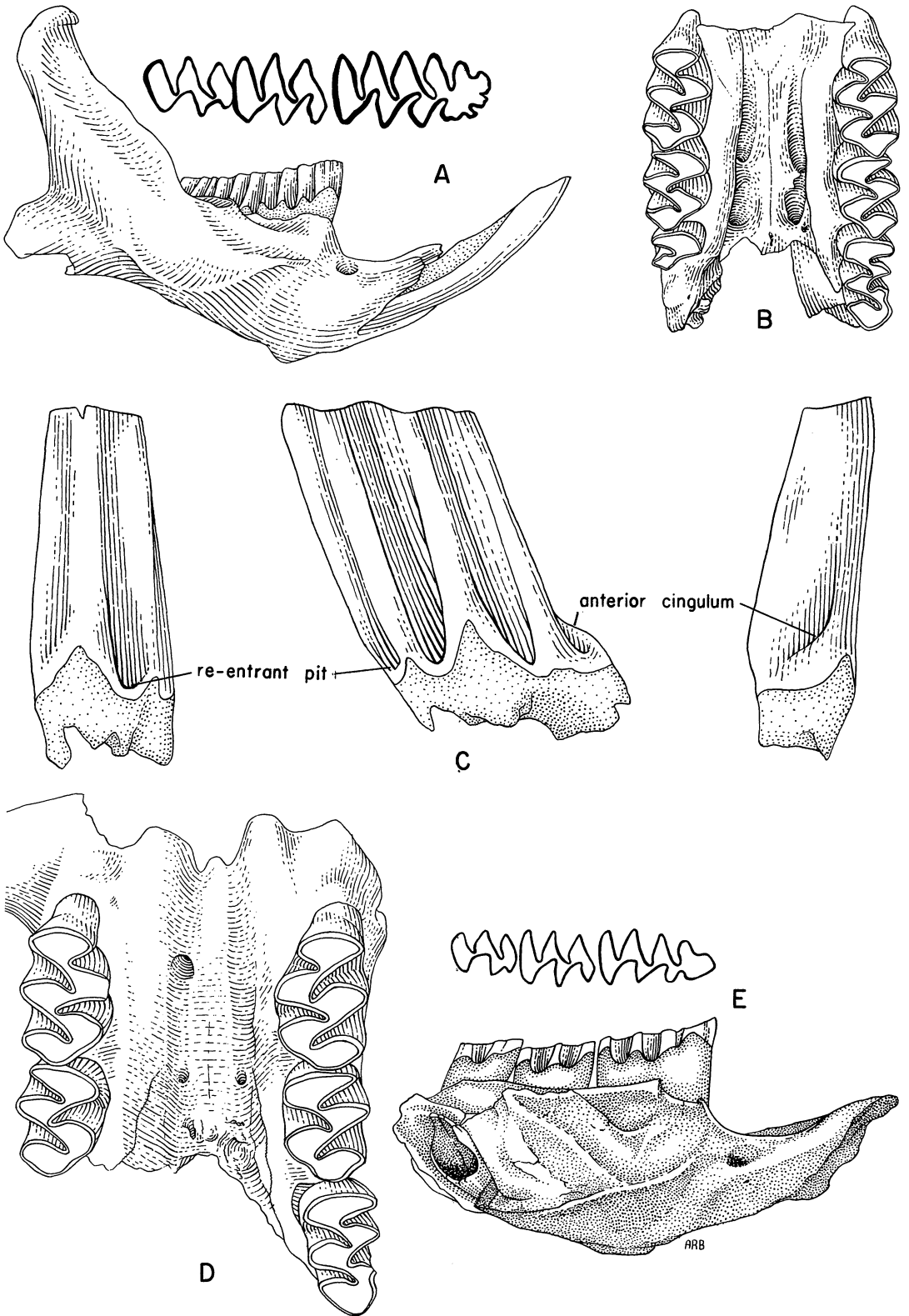
TEXT-FIG. 7—*Pliopotamys* and *Cosomys* from the Hagerman local fauna. A, *P. minor,* V49831, right lower jaw with M_1-M_3, labial view ×3, occlusal view ×6. B–C, *C. primus,* B, V50081, palate and maxillary with LM^1-M^3 and RM^1-M^2, occlusal view ×6; C, V55488, RM^1, posterior, lingual and anterior views ×12.5. D, *P. minor,* V50082, palate and maxillary with LM^1-M^3 and RM^1-M^2, occlusal view ×6. E, *C. primus,* V55177, right lower jaw with M_1-M_3, labial and occlusal views ×6.
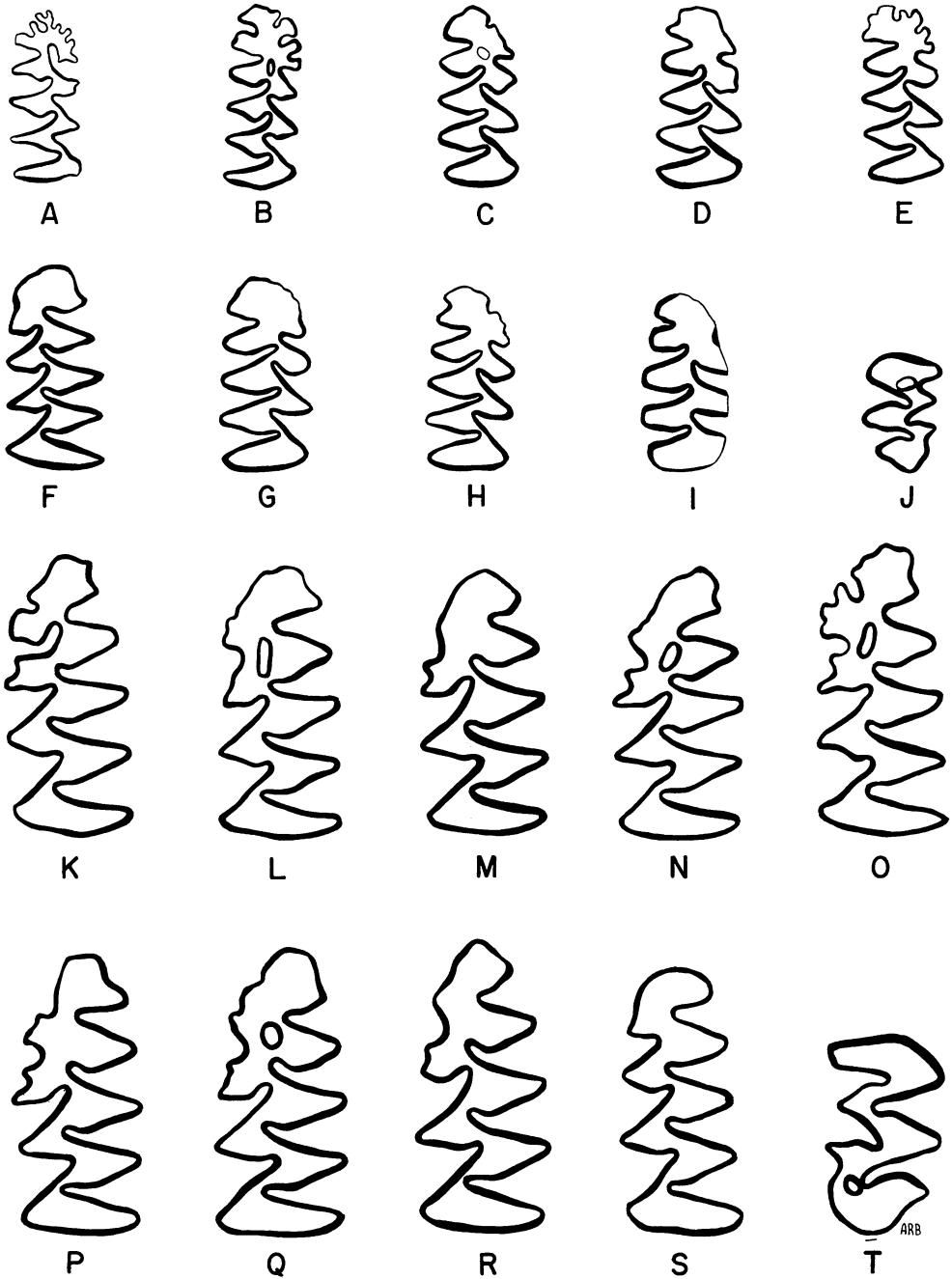
TEXT-FIG. 8—*Pliopotamys* and *Cosomys*, occlusal views of teeth. A–E, *P. minor;* A, V54095, B–E, V50969; A–E, RM$_1$s; ×6. F, *P. meadensis*, V32055, LM$_1$, ×6. G–J, *P. minor;* G–H, V55220, I, V54095, RM$_1$s; J, V54410, LM^3; ×6. K–T, *C. primus;* K, O, V50967, L–N, Q–R, V54416, P, V55239, S, V54417, T, V50218; K–S, LM$_1$s, T, RM^3; ×12.5.

M_1s. Variations of the anterior loop of *Cosomys* M_1s are listed in table 6.

The dentine tracts on the labial side of the M_1 are considered to be incipient, or slightly developed. The tract height of the posterior loop in 252 specimens ranged from 0.14 to 0.67 mm (text-fig. 9A). The closure between the loops and the triangles is variable. Conditions of closure can be found in table 6. The re-entrant angles of *Cosomys* are narrower than in *Ogmodontomys*. The angles constrict at their apices before they turn forward. The M_1s are similar to *O. poaphagus transitionalis* Zakrzewski in length and width, but appear to be slightly more hypsodont than any species of *Ogmodontomys*. The majority of M_1s are three-triangled. Four-triangled forms (text-figs. 7E, 8S) are found at only three localities: UM–Ida. 1a–65, UM–Ida. 1–67, and USGS Cen. Loc. 19217. The M_2s and M_3s possess the typical microtine pattern.

Remarks.—*Cosomys primus* is the most abundant of any of the mammals found in the Hagerman local fauna. *Cosomys* is found from 2900–3265 feet in the section. Because of this relatively large stratigraphic range it was thought that some evolutionary trends could be established in *Cosomys*. All of the specimens were examined, but five localities were chosen for detailed study: UM–Ida. 3–64; USGS Cen. Loc. 20765; UM–Ida. 2–65; UM–Ida. 109–65; UM–Ida. 1a–65 (text-fig. 1). Isolated M_1s from these five localities were measured and had their patterns coded as was done for *Ogmodontomys* (Zakrzewski, 1967). The results of this analysis formed the basis for the preceding and following discussion of the M_1s. A summary can be found in table 6 and text-figure 9. There appears to be no significant difference in the size parameters from the five localities. There does, however, seem to be a trend towards a slight increase in the height of crown and the dentine tract height of the posterior loop upward in the section based on the adult specimens. Some discrepancies exist to this general statement because of sampling error.

The most significant difference is that the population of *Cosomys* from UM–Ida. 1a–65 has M_1s which are all four-triangled. This four-triangled condition was found in only two other M_1s, one of 49 from USGS Cen. Loc. 19217, and one of two from UM–Ida. 1–67. At present it cannot be determined with satisfaction whether (1) these four-triangled forms have evolved *in situ* from the three-triangled forms, (2) they represent another stock, or (3) they represent a slightly different ecology.

TABLE 6—SUMMARY OF VARIATION IN MEASURED M_1S OF *Cosomys primus*.

Character	UM–Ida. 3–64 N	%	USGS Cen. Loc. 20765 N	%	UM–Ida. 2–65 N	%	UM–Ida. 109–65 N	%	UM–Ida. 1a–65 N	%
Number	8	—	100	—	100	—	30	—	14	—
Enamel pit	6	75.0	74	74.0	71	71.0	21	70.0	6	42.8
Prism fold	7	87.5	61	61.0	69	69.0	24	80.0	—	—
Enamel ridge	—	—	23	23.0	14	14.0	2	6.67	—	—
Three lobed	2	25.0	27	27.0	12	12.0	5	16.6	—	—
Three triangles	8	100.0	100	100.0	100	100.0	30	100.0	—	—
Four triangles	—	—	—	—	—	—	—	—	14	100.0
P. L. and 1st △ open	—	—	—	—	2	2.0	—	—	—	—
slightly open	6	75.0	85	85.0	95	95.0	22	73.4	12	85.7
closed	2	25.0	15	15.0	3	3.0	8	26.6	2	14.3
1st and 2nd △ open	2	25.0	70	70.0	69	69.0	23	76.7	8	57.2
slightly open	5	62.5	30	30.0	31	31.0	7	23.3	5	35.65
closed	1	12.5	—	—	—	—	—	—	1	7.15
2nd and 3rd △ open	2	25.0	52	52.0	57	57.0	20	66.7	1	7.15
slightly open	6	75.0	48	48.0	43	43.0	9	30.0	12	85.7
closed	—	—	—	—	—	—	1	3.3	1	7.15
3rd △ and A. L. open	1	12.5	3	3.0	4	4.0	—	—	—	—
slightly open	6	75.0	88	88.0	92	92.0	22	73.4	—	—
closed	1	12.5	9	9.0	4	4.0	8	26.6	—	—
3rd and 4th △ open									1	7.15
slightly open									12	85.7
closed									1	7.15
4th △ and A. L. open									8	57.2
slightly open									6	42.8
closed									—	—

Abbreviations: N, number; P. L., posterior loop; A. L., anterior loop; △, triangle.
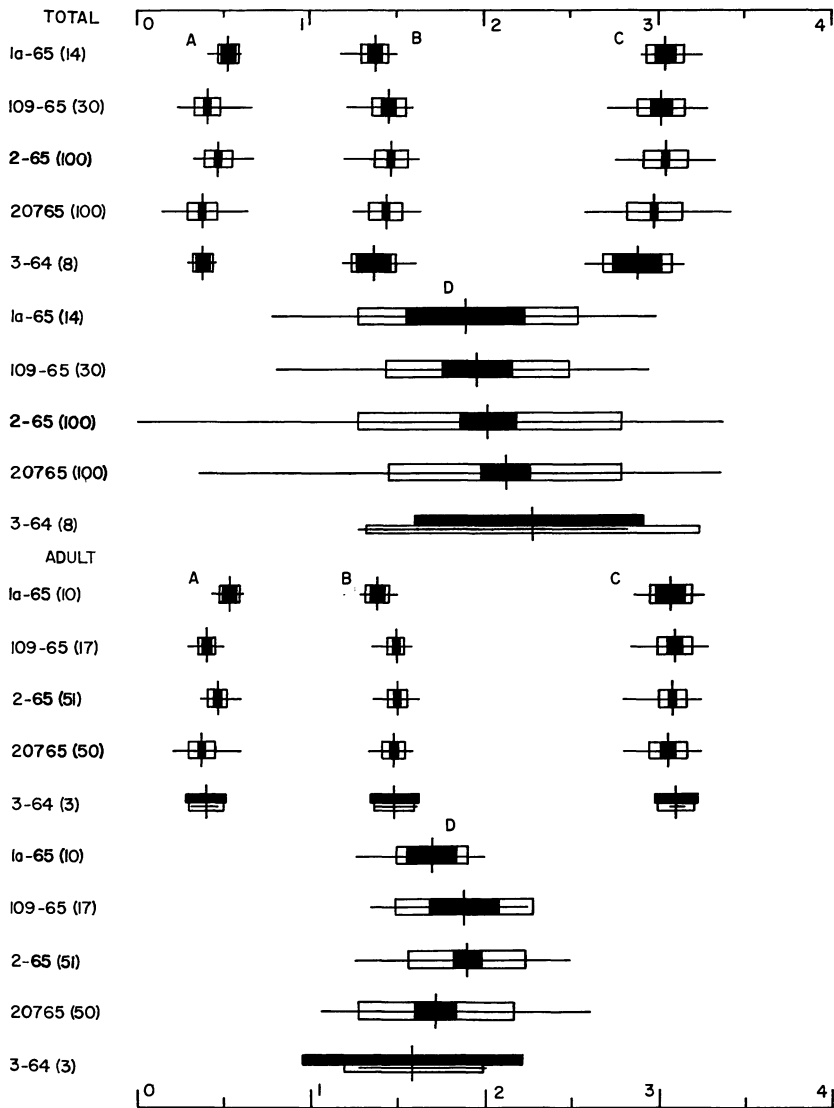
Text-fig. 9—Bar diagrams modified from Dice & Leraas (1936) showing variations in size parameters of *Cosomys primus* M_1s. Vertical line represents the mean of the sample, the darkened area two standard errors of the mean, the white areas a standard deviation on either side of the mean, and the horizontal line the observed range. A, measurements (mm) of the dentine tract height on the labial side of the posterior loop; B, width of occlusal surface; C, length; and D, height of enamel crown. Size of sample is found in parentheses beside locality number. Total is the analysis of all age groups; adult, only that portion of the population.

Semken (1966) has demonstrated an east-west cline of increase in alternating triangles in the M_1s in populations of Recent *Microtus pennsylvanicus* (Ord). Forms with the most triangles are more abundant on the plains. It is interesting that the four-triangled *Cosomys* are found only above 3100 feet and are most abundant at 1a–65. It is approximately at 3100 feet where the rodent species considered to be upland forms start to occur more frequently and percentage-wise they are most abundant at 1a–65. These factors might suggest an ecological control for the presence of the four-triangled form. Additional samples may show that the four-triangled form warrants separation on at least a subspecific level.

It has been previously considered that *Ogmodontomys* gave rise to *Cosomys* (Hibbard, 1964; Hibbard & Zakrzewski, 1967; Zakrzewski, 1967). If this is the case, then the branching off of the *Cosomys* stock must have taken place from a pre-*Ogmodontomys sawrockensis* form. The two genera may have had a common ancestor some time in the Hemphillian or two entirely different stocks are represented. *Cosomys* lived on at least till the Coso Mt. local fauna (2.3×10^6 years; Evernden, *et al.*, 1964), but did not give rise to any other form so far as is known.

In Europe some workers regard *Cosomys* as a subgenus of *Mimomys*. *Cosomys* is generically distinct from *Mimomys* as has been pointed out by Hibbard (1964). *Cosomys* is likewise distinct from *"M." stehlini* Kormos, which Thaler (1966) has placed in the subgenus *Cosomys*. *"M." stehlini*, as well as *Csersia gracilis* Kretzoi, can be distinguished from *Cosomys* and *Ophiomys* by the dominance of one or two deep enamel pits on the M^3 (Hibbard & Zakrzewski, 1967). Apparently these forms represent two parallel lines of development on the two continents. These groups could have had a common ancestor, but this is a moot question.

PLIOPOTAMYS MINOR (Wilson)
Text-figs. 7A, D; 8A–E, G–J

Ondatra idahoensis minor Wilson, 1933, p. 135.
Pliopotamys idahoensis minor (Wilson), Hibbard, 1941, p. 87.
Dolomys minor (Wilson) *non* Hibbard, Kretzoi, 1955, p. 348–355.
Pliopotamys idahoensis (Wilson), Hibbard, 1956, p. 176.
Pliopotamys sp., Hibbard, 1959, p. 25–26.
Pliopotamys minor (Wilson), Hibbard, 1959, p. 26–29.

Referred material.—Numerous maxillaries and jaws, with and without teeth, also numerous isolated teeth representing at least 380 individuals from 77 localities ranging in elevation from 2950 to 3295 feet.

Description of material.—The lateral palatal grooves of *Pliopotamys minor* are better developed than in *Cosomys primus*. The maxillary walls which form the borders of these grooves are vertical throughout; though there is a slight slope with age at the posterior end, where the maxillopalatine suture makes up part of this border (text-fig. 7D). These two characteristics are reminiscent of *Ogmodontomys sawrockensis*. The median ridge of the palate is narrow and elevated anteriorly. The ridge widens and is slightly elevated posteriorly. The widening begins at a point approximate to a line drawn between the median root of the M^1s and continues to the termination of the palate. This condition is intermediate to that observed between *Ogmodontomys* and *Cosomys*. The palatine of *P. minor* terminates anteriorly as in *C. primus* and posteriorly as in *Ogmodontomys*. In *P. minor* the posterior palatine foramina appear to form part of the maxillopalatine boundary as in *Cosomys*. The position of the incisive foramina in *P. minor* varies with age, but the foramina appear to be slightly anterior to the position in *Cosomys* for equivalent age groups.

The upper molars of *Pliopotamys minor* can be distinguished from the other fossil genera examined by their relatively large size. The upper teeth are all basically three rooted, but a variation in root number was observed for the M^2 and M^3. The M^1s (250) were all three rooted. Slightly more than 7% (12/169) of the M^2s and 15% (15/100) of the M^3s were two rooted. Less than 3% (5/169) of the M^2s and 7% (7/100) of the M^3s had a fourth root fused to one of the anterior pair in one fashion or another. A little over 6% (16/250) of the M^1s had a slight trace of an anterior cingulum, but no teeth were found which had any trace of a re-entrant pit. One M^3 was found which had a deep enamel pit on the anterior loop (text-fig. 8J). To my knowledge this is the only M^3 of a North American microtine with the pit in this position.

The lower jaw of *Pliopotamys minor* has the capsular process the least developed of the three Hagerman microtines (text-fig. 7A). The position of the dental foramen with respect to the termination of the incisor is as in *Cosomys primus*.

The M_1 of *Pliopotamys minor* is characterized by a posterior loop, five alternating triangles, and a complex anterior loop. The number of alternating triangles can vary, however, from three to six depending on the ontogenetic age

of the individual (text-figs. 8B, I). A prism fold and/or enamel pit can be present on the anterior loop but they do not occur as frequently as in *Cosomys*. The prism fold when present occurs on the fourth triangle or the sixth triangle (text-figs. 8A–B, E). Sometimes two enamel pits can be found on the anterior loop. All specimens considered immature possess pits; however, only some young adults and adults have pits. No pits were found on M_1s considered old adult. The lowest-crowned specimen in which a pit was found was 1.88 mm. The highest-crowned specimen in which no pit was found was 2.48 mm. The pit forms in a manner similar to that observed for *Cosomys* (text-fig. 8A). The dentine tracts vary from absent to slightly developed. The highest dentine tract from the Hagerman local fauna was 0.41 mm; however, a specimen from USGS Cen. Loc. 20475 had a tract height of 0.76 mm. This latter locality is where the three known M_1s of *Ophiomys taylori* all have five triangles.

The degree of confluency of the alternating triangles in *Pliopotamys minor* varies. The closure between the posterior loop and the first triangle, between the second and third triangle, and between the third and fourth triangle is generally slightly open. The first and second triangles vary from slightly open to open. The relationship of the fourth triangle to the fifth and both triangles to the anterior loop is the most varied. In some specimens both the fourth and fifth triangles opened directly into the anterior loop (text-figs. 8B–E); in others the fourth triangle joined only the fifth and did not open into the anterior loop (text-figs. 8G–H). It was found that the former situation was dominant in the lower part of the section while the latter condition was dominant near the top (table 7). In *P. meadensis* the fifth triangle no longer opens broadly into the anterior loop (text-fig. 8F). The M_2 and M_3 possess the typical microtine pattern.

Remarks.—The same five localities that were studied in detail for *Cosomys* were utilized in analyzing *Pliopotamys*. In addition, a sample higher in the section than 1a–65, USGS Cen. Loc. 19216, was available for study as well as a small sample from the Sand Point local fauna some 900 feet higher in the section. These specimens plus specimens of *P. meadensis* from Late Blancan localities on the High Plains were measured and coded as in *Cosomys*. The results of the analysis can be found in table 7 and text-figure 10.

In addition to the trend in the development of the fourth triangle discussed above, some size clines were found. There is a slight increase in all dimensions through time. Discrepancies from the general trend may be due to sampling error. The size differences between the various samples of *Pliopotamys* from the Hagerman are not as great as those found to exist between *Ogmodontomys poaphagus transitionalis* and *O. p. poaphagus* (Zakrzewski, 1967).

The most striking difference in crown and dentine tract height is found between the Hagerman and Sand Point specimens. The *Pliopotamys* from the Sand Point local fauna was originally considered a distinct species (Hibbard, 1959). Additional specimens may show that this population warrants at least subspecific separation.

Pliopotamys has been considered as ancestral to *Ondatra* (Hibbard & Zakrzewski, 1967). No evidence has been found to the contrary in this study. Semken (1966) has demonstrated a size chronocline in *Ondatra*. Plotting the same parameters used by him (Semken, 1966) this size cline can be carried back through *Pliopotamys* (text-fig. 11). The same is true for the dentine-tract cline (Semken, 1966). Lingual dentine tracts are absent to slightly developed in *P. meadensis*. They are absent in *P. minor*. From the characters of the palate and dentitions it appears that *Pliopotamys* could have been derived from some early member of the *Ogmodontomys* stock or from some common ancestor.

CONCLUSIONS

Paleoecology

Beaver and microtines are the most abundant of the rodents and they suggest a marsh and meadow habitat near the depositional area of the Hagerman local fauna. Numerous bodies of fresh water, both ponds and streams, are also indicated by the large number of fish (Miller & Smith, 1967), frogs, water snakes (Holman, 1968), and water and shore birds (Brodkorb, 1958; Murray, 1967; Feduccia, 1967) present in the fauna. The most abundant of the carnivores is a semi-aquatic otter-like form (Bjork, pers. comm.).

Upland elements are rare among the rodents. Upland types, however, become relatively more abundant near the top of the section. Upland is used here to denote a drier, better drained situation and does not imply a large amount of relief. The increase in the number of upland forms occurs above 3100 feet. At approximately 3100 feet there occurs a small series of thin beds of diatomaceous, ashy silts rich in emergent plant material (Bjork, pers. comm.). Bjork considers these beds to correlate with a high stage of Lake Idaho (Miller & Smith, 1967). After this episode the water table

TABLE 7—SUMMARY OF VARIATION IN THE MEASURED M_1S OF *Pliopotamys*.

Character	USGS Cen. Loc. 20765 N	%	UM–Ida. 2–65 N	%	UM–Ida. 1a–65 N	%	USGS Cen. Loc. 19216 N	%	Sand Point l.f. N	%	Dixon l.f. N	%
Number	43	—	10	—	27	—	51	—	5	—	7	—
Enamel pit	18	42.0	1	10.0	4	14.8	10	19.6	—	—	3	42.9
P. F. on 4th Δ	2	4.7	—	—	—	—	1	2.0	—	—	—	—
P. F. on 6th Δ	7	16.3	2	20.0	2	7.4	2	3.9	—	—	—	—
Enamel ridge	—	—	1	10.0	—	—	—	—	—	—	—	—
P. L. and 1st Δ open	4	9.3	1	10.0	1	3.7	6	11.8	—	—	1	14.3
slightly open	35	81.4	9	90.0	25	92.6	41	80.3	5	100	4	57.1
closed	4	9.3	—	—	1	3.7	4	7.9	—	—	2	28.6
1st and 2nd Δ open	7	16.3	5	50.0	23	85.2	36	70.6	3	60.0	2	28.6
slightly open	33	76.8	5	50.0	4	14.8	15	29.4	2	40.0	5	71.4
closed	3	6.9	—	—	—	—	—	—	—	—	—	—
2nd and 3rd Δ open	5	11.5	3	30.0	3	11.1	11	21.8	1	20.0	1	14.3
slightly open	36	83.8	7	70.0	24	88.9	38	74.3	4	80.0	5	71.4
closed	2	4.7	—	—	—	—	2	3.9	—	—	1	14.3
3rd and 4th Δ open	3	6.9	1	10.0	3	11.1	14	27.5	—	—	—	—
slightly open	37	86.2	9	90.0	24	88.9	35	68.6	5	100	6	85.7
closed	3	6.9	—	—	—	—	2	3.9	—	—	1	14.3
4th Δ and A. L. open	22	51.2	2	20.0	14	51.8	5	9.8	1	20.0	1	14.3
4th and 5th Δ open	19	44.1	6	60.0	13	48.2	25	49.0	3	60.0	5	71.4
slightly open	2	4.7	2	20.0	—	—	20	41.2	1	20.0	1	14.3
closed	—	—	—	—	—	—	1	2.0	—	—	—	—
5th Δ and A. L. open	43	100	10	100	26	96.3	50	98.0	5	100	4	57.1
slightly open	—	—	—	—	1	3.7	1	2.0	—	—	2	28.6
closed	—	—	—	—	—	—	—	—	—	—	1	14.3

Abbreviations: P. F., prism fold; P. L., posterior loop; A. L., anterior loop; Δ, triangle.
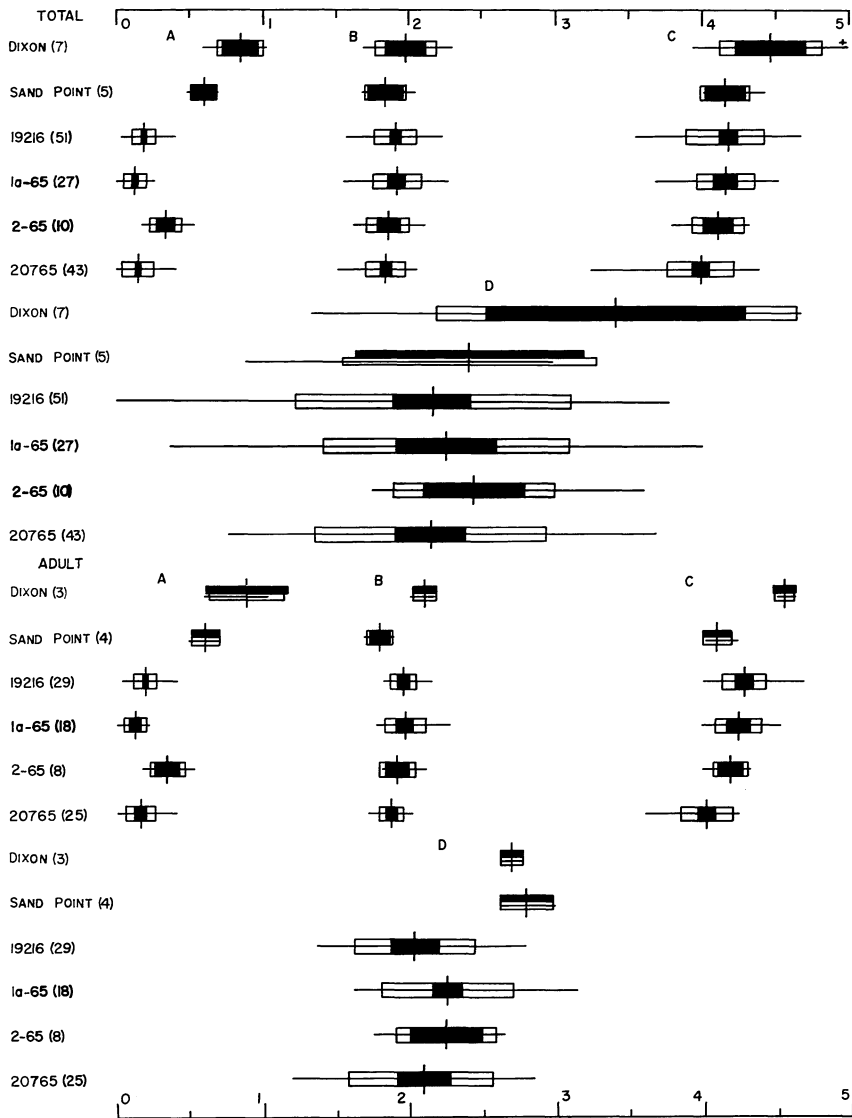
TEXT-FIG. *10*—Bar diagrams modified from Dice & Leraas (1936) showing variations in size parameters of *Plio-potamys* M_1s. + = greatest length of *P. meadensis,* 5.15 mm. For additional explanation see text-figure 9.

became lower and the area was better drained, which would account for the increase in upland forms. Upland genera such as *Prodipodomys, Perognathus,* and *Neotoma* are present at USGS Cen. Loc. 20765, which is the best sampled and most intensively collected of the localities below 3100 feet.

The rodents are placed in a number of habitats or communities. The placement in a community is based upon the adaptive characters of the forms and upon the habits of living genera which have representatives in the fauna (Hibbard, 1941).

The beavers *Dipoides* and *Castor* can be considered as members of the marsh-meadow community, spending a good deal of time in or near water. The presence of *Castor* indicates the proximity of trees, probably as gallery forests along the stream borders. This interpretation is supported by the pollen record which includes *Celtis* and *Populus* in addition to various genera of Pinaceae (Leopold, *in* Weber, 1965). The exact habitat preference of *Dipoides* is unknown. *Dipoides* is rare, but where present it is found in association with *Castor.* It is possible that the two beavers were competing for similar resources and that *Castor* displaced *Dipoides.* An approach to the prob-
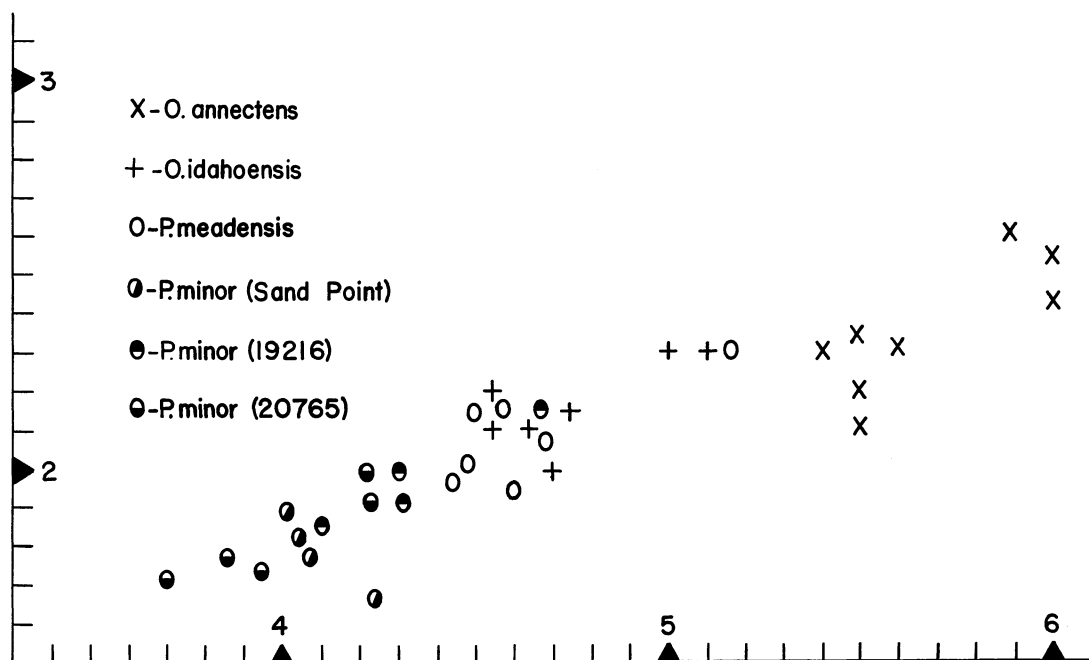
TEXT-FIG. *11*—Scatter diagram of length vs. width of M_1 (mm) in *Pliopotamys* and fossil *Ondatra*. *Ondatra* measurements from Semken (1966). $\times$ = Kansan age; $+$ = Yarmouth age; O = Nebraskan age; other circles = Pliocene age.

lem from the point of view of functional morphology may prove of value. There is no actual evidence that either of the beavers built dams, but there is no reason, especially in the case of *Castor*, to suspect that they did not. *Castor* will build dams and lodges or burrow into the stream bank for a home depending on the conditions of the stream (Burt, 1957).

Cosomys is also thought to have lived in the marsh-meadow community. It is noteworthy that whenever *Cosomys* is abundant at a locality *Pliopotamys* is rare. At the top of the section *Pliopotamys* becomes the dominant microtine and *Cosomys* drops out (text-fig. 12). Because of these facts it is postulated that *Cosomys* and *Pliopotamys* were competing for the same niche, *Pliopotamys* eventually displacing *Cosomys*.

Ophiomys is considered to have inhabited the drier portions of the meadows and the valley slope or upland. This interpretation is based on the fact that *Ophiomys* is known only above 3100 feet and is most abundant at UM–Ida. 1a–65, where it is found with an abundance of ground squirrels, both species of *Perognathus*, and *Pliogeomys*.

It may be of significance that the *Cosomys* that have four triangles on the M_1 follow the same pattern of occurrence as *Ophiomys*. It has been suggested above that these four-triangled *Cosomys* may have represented a different eco-

logic form from the three-triangled individuals. If so, then possibly the four-triangled *Cosomys* were in competition with *Ophiomys*. It may be that increased pressure from *Pliopotamys* led to selection for forms of *Cosomys* with a larger amount of triangles. This change would enable *Cosomys* to shift from the wetter to the drier community. Either this accommodation began too late to make an impact on the already present *Ophiomys*; or if the shift began earlier, *Ophiomys* was still better adapted and replaced *Cosomys*.

Baiomys and *Peromyscus* could have inhabited either the meadows or the valley slope. *Thomomys* could have dwelt in the dry flood plains, the dry regions of the meadows, and the valley slopes where the soil was suitable for burrowing (Davis, 1939). *Pliogeomys*, I believe, was relegated to the upland.

Paenemarmota and *Neotoma* could have lived on the valley slope, a habitat which is similar to that of the extant woodchuck and wood rat. *Citellus* cf. *C. howelli* probably dwelt on both the valley slope and upland. The other species of ground squirrels and the heteromyids were probably limited to the upland area.

Some of the rodents do not have living representatives in the extant fauna of Idaho. The affinities of these forms seem to be southern; or at least a retraction of range has taken place
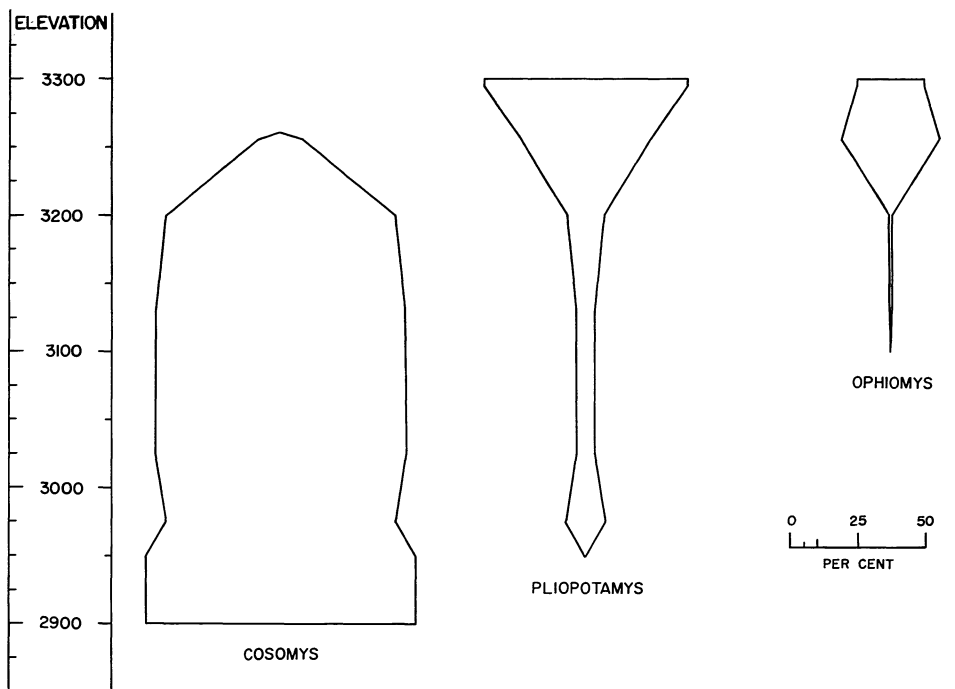
TEXT-FIG. 12—Relative abundance of the Hagerman microtines, expressed in percent of the minimum number of individuals of these genera identified at the key localities.

subsequent to Hagerman time. Included in this group are *Baiomys, Pliogeomys,* and possibly *Paenemarmota.* This change in range is somewhat in contrast to the lower vertebrates in the Hagerman local fauna which no longer have living representatives in the fauna. The lower vertebrates show a close relation to forms now found farther west and in the eastern United States. Among these are a sunfish, *Archoplites taylori,* close to the Recent *A. interruptus* of the Great Valley and adjacent areas of California, and a catfish, *Ictalurus vespertinus,* whose closest relative appears to be *I. catus* of eastern United States (Miller & Smith, 1967); the snakes *Natrix hibbardi* and *Elaphe vulpina,* genera which are now found well to the east of the Hagerman area (Holman, 1968); and some Pacific coast type frogs (Chantell, pers. comm.). These differences are probably due to the fact that mammals would be influenced less than lower vertebrates by changes in the drainage systems which must have occurred (Miller, 1965; Taylor, 1966). The presence of voles, frogs, water snakes, and water birds suggests that the Hagerman area was more humid than it is now. The pollen record also suggests a climate slightly wetter than at present, which allowed low montane vegetation to grow in an area which is now treeless (Leopold *in* Weber, 1965). Mammals with extant southern distri-

butions such as *Baiomys* and *Cryptotis,* indicate that winters must have been milder than at present.

Age and Correlation

The Hagerman local fauna can be definitely placed in the Upper Pliocene on the basis of the fauna and available radiometric dates (Evernden, *et al.,* 1964). However, before an interfaunal correlation is attempted, some intrafaunal aspects will be considered. Since fossils are known through 500 feet of the section, it was thought that some evidence might be found which could suggest that the Hagerman represented more than one fauna. Text-figure 13 shows the stratigraphic occurrence of the rodent species found in the Hagerman local fauna.

Two changes which occur in the fauna are thought worthy of mention. The first is the apparent relegation of *Dipoides* to the basal part of the section. This relegation, however, cannot be definitely documented, since the locations of the United States National Museum finds are unknown. No *Dipoides* are known from USGS Cen. Loc. 20765, which is of some interest because other rare forms are present there. Apparently *Castor* completely replaces *Dipoides* above 3050 feet in the fauna. However, there appears to be no significant differ-
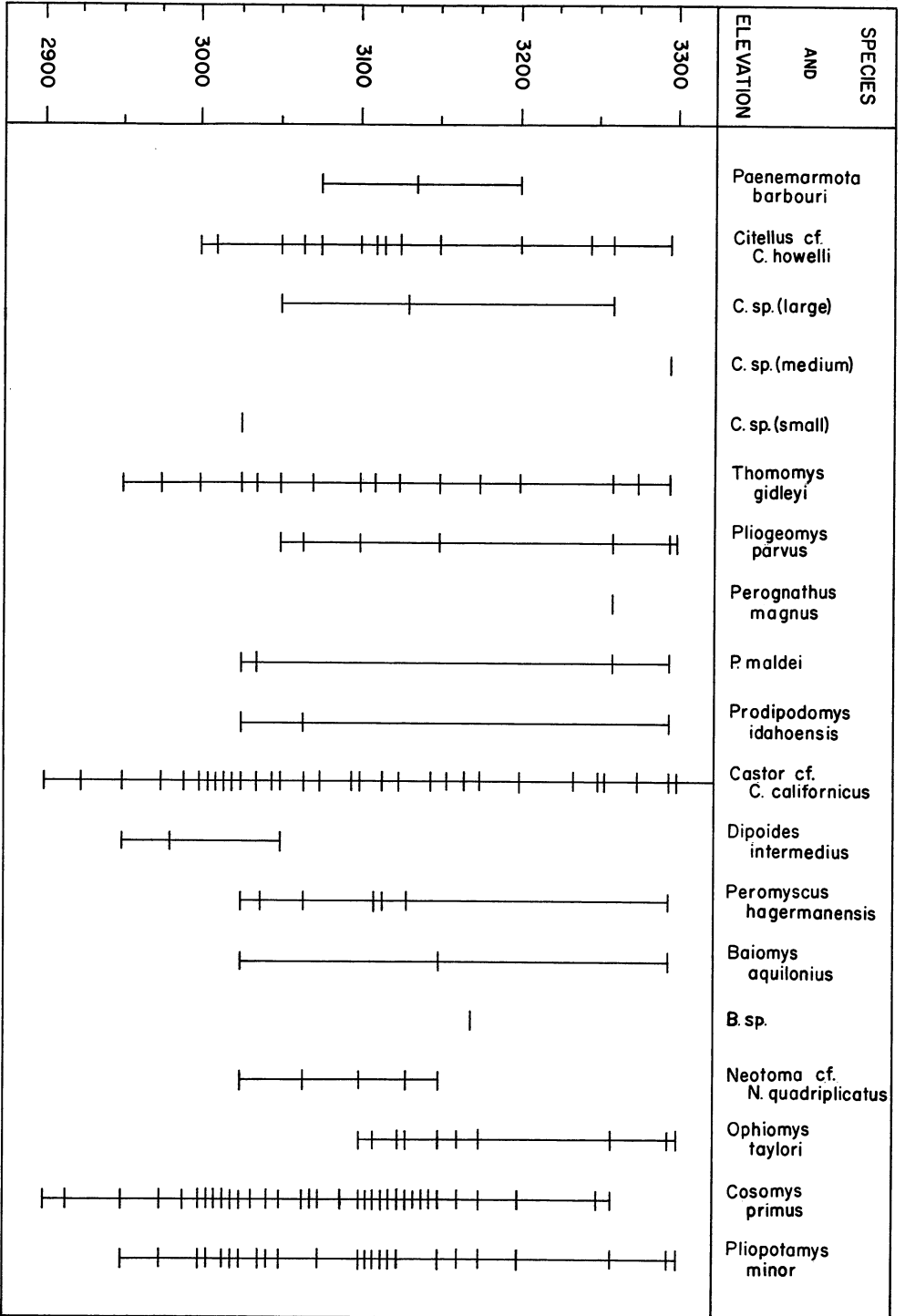
TEXT-FIG. 13—Stratigraphic occurrence (horizontal lines) and range (vertical lines) of rodents within the Hagerman local fauna, corrected for the displacement of 160 feet.

ence between the other rodents in the lower part of the section and the same forms slightly higher. Therefore, separation of the fauna on the basis of this replacement does not seem warranted.

The second change occurs in the population structure of the microtines near the top of the section between 3200 and 3250 feet. Between these two elevations a few localities are known, none of which have microtines present. At 3200 feet and below *Cosomys* is the dominant microtine. At 3250 feet and above, *Pliopotamys* is the dominant microtine along with *Ophiomys* (text-fig. 12). *Cosomys* is rare, and, when it is present, the four-triangled form is dominant. The significance of this change is difficult to determine. If the data regarding the microtines are properly interpreted, *Cosomys* apparently becomes completely replaced in the Hagerman area. The change may be ecological in part, because *Cosomys* evidently did not become extinct at this time. The type specimen of *Cosomys* is known from the Coso Mountain local fauna of California which dates some 1.2×10^6 years younger than the Hagerman local fauna. The type of *C. primus* was indistinguishable from three-triangled specimens of *Cosomys* in the Hagerman local fauna. *C. primus* apparently had a long life as a species. One may not have expected this since the microtines have evolved so rapidly as a whole. This length of time, however, is apparently not contradictory with the average span of a rodent species (Kurtén, 1968); nor is it unique among the microtines. Specimens of *Ogmodontomys poaphagus* from KU Loc. 3 of the Upper Pliocene Rexroad local fauna are apparently indistinguishable from specimens of the Deer Park (Kansas) and Sand Draw (Nebraska) local faunas considered Pleistocene in age (Zakrzewski, 1967), while a more advanced form of *Ogmodontomys,* on the basis of dentine tract development, is present in the Bender local fauna, which is considered post-Rexroad and pre-Pleistocene in age. If additional research demonstrates that the differences are real and a change does occur in the population of the microtines at 3200 to 3250 feet, then possibly the fauna could be split at that level.

It is, likewise, evident that fossils found at the higher elevations must be younger, but how much? Three radiometric dates are available. These are based on two volcanic ashes dated by Evernden, *et al.,* (1964) at 3.2×10^6 years (KA–832) and 3.3×10^6 years (KA–831) and a basalt at $3.48 \pm 0.27 \times 10^6$ years (KA–1173). They consider the latter as the best date for the fauna. Because of the nature of the samples (hydrated glass shards) the ash units

may have been dated too young. The two volcanic ashes are separated by 170 feet stratigraphically. The basalt is found between the ashes, approximately 95 feet below the upper ash and 74 feet above the lower ash (text-fig. 1). The lower ash is the only horizon which is directly associated with the fossil localities. The position of the other horizons is based on correlations of the strata by Harold E. Malde of the United States Geological Survey. It appears that sedimentation must have been fairly continuous and relatively little time is represented. Bjork (pers. comm.) suggests, on the basis of analogy with Recent deposition in the flood plain of the Tigris and Euphrates rivers, 80,000 years as a minimum and 370,000 years as a maximum. These dates are based on the thickness of sediment between the two ashes. Since very little time is suggested by radiometric dates, and there is a paucity of information at critical elevations, it is thought best to consider the fauna as one until more information becomes available.

There are three faunas of Upper Pliocene age with which the Hagerman local fauna can be compared: the Fox Canyon and the Rexroad of southwestern Kansas and the Benson of southern Arizona. The Rexroad is approximately equivalent to the Benson and has been shown to be younger than the Fox Canyon (Hibbard, 1967; Zakrzewski, 1967). The rodents of the Hagerman local fauna appear to be more advanced than the rodents from the Rexroad local fauna with few exceptions. Therefore, comparison need only be made with the Rexroad local fauna.

Paenemarmota and *Neotoma* are at present indistinguishable from similar forms in the Rexroad. *Thomomys gidleyi* may be at a similar stage of development as *Geomys jacobi* Hibbard or slightly more primitive. *Pliogeomys,* though more primitive than even the gophers in the Fox Canyon, is a case of peripheral survival.

Citellus cf. *C. howelli, C.* sp. (large), *Perognathus maldei,* and *P. magnus* appear advanced over similar forms in the Rexroad. However, a similar difference is present between related forms in the extant faunas of the two areas. Because of the small samples and lack of other adequate faunas for comparisons, the differences due to geographic separation are difficult to determine. However, because of the more equable climate of Upper Pliocene time (Hibbard, 1960), one would think that there would have been less geographic variation then.

The remaining elements of the fauna, *Prodipodomys, Dipoides, Baiomys, Peromyscus,* and the microtines, are more advanced than their

Rexroad counterparts. At present *Castor* is not known from the Great Plains earlier than Illinoian time.

On the basis of the evolutionary stage of development of the above forms, the Hagerman is certainly no older than the Rexroad local fauna and is here considered to be post-Rexroad and pre-Pleistocene in age. This agrees with Hibbard's (1956) suggestion that the Hagerman was equivalent in part to the post-Rexroad pre-Ballard unconformity in Meade County. Repenning (1967) also considers the fauna transitional. Younger faunas considered to be pre-Pleistocene are known in both areas, for example, the Sand Point and USGS Cen. Loc. 20475 in Idaho and the Bender in southwestern Kansas. None of these are well enough known, however, to be used for precise correlation. To do so would require many assumptions and would be premature at this time.

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