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A Unique Cricetid (Rodentia, Mammalia) from the Early Oligocene of Natrona County, Wyoming

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ABSTRACT

Two specimens, a partial right mandibular ramus with M_1 - M_3 and an isolated left M_2 , represent a new genus and species of rodent, *Nanomys simplicidens*. The teeth of this rodent are so lacking in special characters that its phylogenetic position is difficult to interpret, but seems best referred to the Cricetidae.

INTRODUCTION

In the Frick Collection, Department of Vertebrate Paleontology, the American Museum of Natural History, are several hundred specimens of fossil rodents from the early Oligocene of the Flagstaff Rim area, Natrona County, Wyoming. Within this collection, the rodent described here is represented by a single lower jaw. An additional isolated molar was found by the senior author in the same area during the summer of 1971. These two specimens are unique among the known fossil rodents. Following is a description of this form as a new genus and species and a discussion of its possible relationships.

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specimen. It was collected in 1959 by a Frick Laboratory field party under the joint leadership of Messrs. Morris F. Skinner and Ted Galusha, both of whom we thank for providing the stratigraphic and geographic data without which the specimen would be of less value. Helpful discussions (with the junior author) of the possible relationships of this rodent were provided by Drs. H. de Bruijn, V. Fahlbusch, O. Fejfar, and M. Freudenthal. The pencil drawings are by Miss Jennifer Perrott and the stereo photographs were taken by means of the scanning electron microscope by Mr. Walter Brown of the Smithsonian Institution.

The initials FAM and NMNH, as prefixes to the specimen catalogue numbers stand for Frick American Mammals, Department of Vertebrate Paleontology, the American Museum of Natural History, and the National Museum of Natural History, Smithsonian Institution, respectively.

FAMILY CRICETIDAE ROCHEBRUNE, 1883

NANOMYS,¹ NEW GENUS

DIAGNOSIS: Very small, M_1 largest of molars, M_3 smallest; teeth low crowned; no mesolophid nor mesoconid; other connecting crests very low; well-developed buccal cingula; distinct hypoconulid on M_1 and M_2 ; entoconid of M_3 absent or barely indicated.

Nanomys simplicidens,² NEW SPECIES

TYPE: FAM 79304, a partial right mandibular ramus with slightly worn M_1 - M_3 and part of I_1 .

TYPE LOCALITY AND HORIZON: From the outcrops near the base of Flagstaff Rim, in the North Fork of Lone Tree Gulch, in the SE 1/4, sect. 22, T. 31 N, R. 83 W, Natrona County, Wyoming. The type specimen was included in a package containing 21 rodent rami (mostly *Cylindrodon*), all under one field number, and all of which were collected from the interval between 10 and 15 ft. (3.05-4.6 m.) above ash D. This ash is 285 ft. (87 m.) above the base of the generalized zonation section which is about 720 ft. (219 m.) in total thickness, all of Chadronian (early Oligocene) sediments. A description of the section will be published in a report dealing with the stratigraphy of the Flagstaff Rim area.

REFERRED SPECIMEN: NMNH 175638, an isolated left M_2 , from the same general area as the type specimen, except in the South Fork of Lone

¹ From Greek *Nanos*, a dwarf, and *mys*, mouse.

² From Latin *simplex*, *icis*, simple, simplicity, and *dens*, tooth.

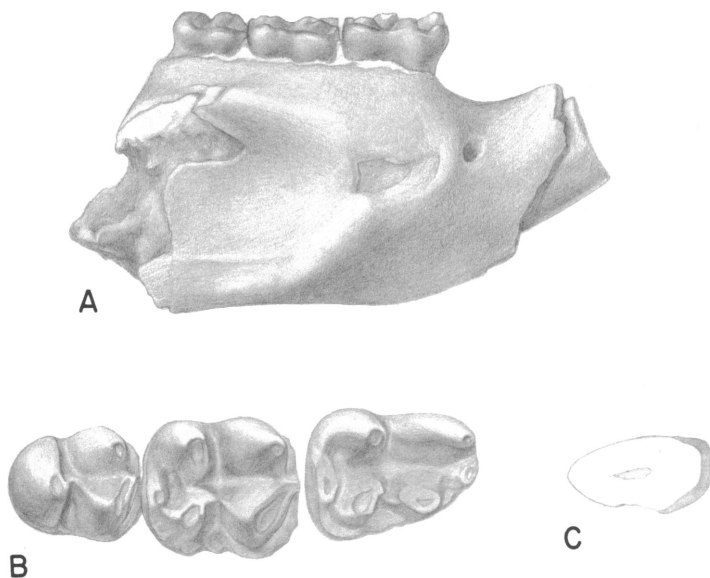


FIG. 1. *Nanomys simplicidens*, type, FAM 79304. A. Lateral view of right mandibular ramus. Approximately $\times 10$. B. Occlusal view of right M_1 – M_3 . Approximately $\times 16.7$. C. Cross-sectional view of right incisor. Approximately $\times 16.7$.

Tree Gulch, in about the center of the NW 1/4, SE 1/4, SE 1/4, sect. 27, T. 31 N, R. 83 W, Natrona County, Wyoming. This tooth was found in a rich concentration of vertebrate remains at 60 ft. (18.3 m.) below Ash F, or at 315 ft. (96 m.) above the base of the generalized zonation section, or from 15 to 20 ft. (4.6–6.1 m.) stratigraphically above the type specimen.

DIAGNOSIS: Same as for the genus.

DESCRIPTION: The ramus of *Nanomys* is relatively lighter than that of *Eumys*, more nearly of the proportions of that of *Copemys*. The ramus is rather thin transversely. If a "chin" process was present it was anterior to the point of breakage; the ventral border of the jaw beneath the molars is quite straight and nearly parallel to the tooth row or alveolar border. The masseteric fossa is defined by rather thick ridges, lacking the sharp crests seen in some of the later cricetids. The ventral margin of the fossa descends almost to the ventral border of the ramus and probably continued backward near or at the ventral border of the angular process. The main part of the fossa apparently ended beneath the posterior part of M_1 . The surface has been broken just anterior to this, but there was apparently an elevated area ("masseteric knob") beneath M_1 . This forward position of

the fossa suggests masseteric muscle specialization as in cricetids. The mental foramen is anterior to M_1 and about one-third the distance from the dorsal border of the jaw to the ventral border. The dorsal border of the ramus is depressed between the incisor and M_1 , but not nearly so much as in *Eumys* or *Copemys*. The coronoid process is missing, but the leading edge would have passed the alveolar border at least as far posteriorly as the middle of M_3 . The inner surface of the ramus is concave and has a series of small vascular foramina beneath the cheek teeth, about halfway down the inner surface of the ramus. No part of the symphysis is preserved; its posterior limit was some distance anterior to M_1 .

The lower incisor is much narrower and more procumbent than that of *Eumys*. In cross section (see fig. 1C), the anteroposterior dimension is about twice the transverse. The enamel is carried around onto the inner and outer surfaces so that it covers approximately the anterior third of the tooth. The anterior surface is quite evenly rounded except for a very narrow flat surface, much narrower than the widest part of the tooth.

As in most cricetid rodents, M_1 is the longest of the lower cheek teeth, anteroposteriorly, and M_3 is the shortest. The crowns are very low, the inner cusps of M_1 and M_2 somewhat higher than the outer cusps, the connecting crests very low, and none of the teeth have a mesoconid or mesolophid.

The apex of the metaconid of M_1 is near the anteroconid, considerably farther forward than that of the protoconid. The anteroconid is conical, relatively smaller than in most cricetids, somewhat flattened anteroposteriorly, and is buccal to the midline of the tooth row. A short crest connects the anterior end of the metaconid to the anterolingual part of the anteroconid. Another low crest connects the posterobuccal part of the anteroconid to the anterobuccal part of the protoconid. This latter crest is almost, but not quite, continuous with the buccal cingulum. The buccal cingulum is a broad low shelf connecting to the buccal side of the protoconid, continuing lateral and posterior to the hypoconid and continuous with the posterior cingulum. Along the buccal margin of the tooth, opposite the valley between the protoconid and hypoconid, the buccal cingulum is raised into a low cusp that probably represents the ectostylid. The hypoconulid of M_1 is a broadened and raised part of the posterior cingulum. The posterior cingulum lingual to the hypoconulid is a low crest that turns slightly upward at its lingual end and merges with the posterior surface of the entoconid. There is no mesoconid or mesolophid. The protoconid and hypoconid are somewhat elongated posteromedially and anteromedially, respectively, and are joined by a low crest, forming a mure (in the sense of Hooper, 1957, p. 9, fig. 1; or James, 1963, p. 112,

fig. 46) or ectolophid (in the sense of Wood and Wilson, 1936, p. 390, fig. 2). The anteromedial extension of the hypoconid is slightly swollen, but one would certainly hesitate to term this feature the mesoconid, or even to suggest that it may be an incipient mesoconid. The apex of the entoconid is slightly ahead of that of the hypoconid.

The second molar of *Nanomys* has the appearance of being rectangular in outline, but measurements including the buccal cingulum show that the transverse dimension is very nearly as great as the anteroposterior. The referred isolated M_2 , NMNH 175638, is so similar to that of the type that one description suffices for both, except for minor differences as noted

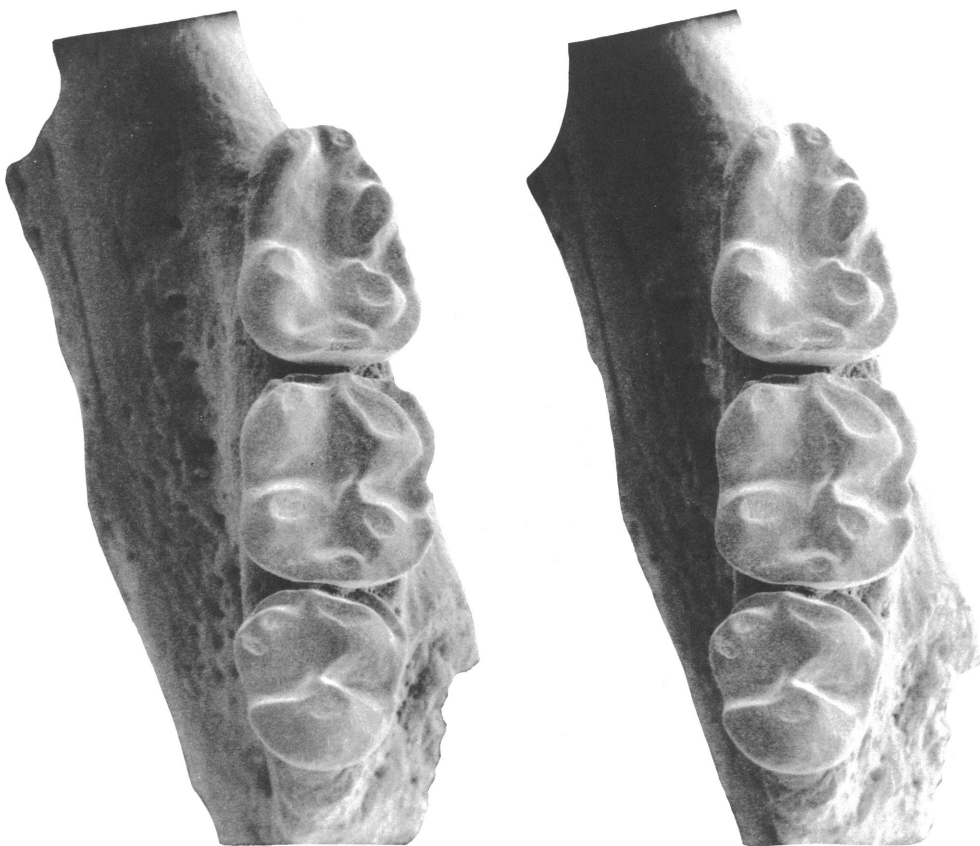


FIG. 2. *Nanomys simplicidens*, type, FAM 79304. Occlusal view of right M_1 - M_3 , stereogram. Approximately $\times 22$.

below. The anterior, buccal, and posterior cingula are continuous, being interrupted only by the anteroconid and hypoconulid, which seem to be merely raised parts of the cingula. The anteroconid is very small and so intimately connected to the anterior arm of the protoconid that it is impossible to distinguish the division of these two cusps. The lingual portion of the anterior cingulum is a low shelf that almost reaches the lingual margin of the tooth. The buccal cingulum is a broad low shelf; in the type, but not in the referred specimen, there is a slightly enlarged area in the center that probably represents the ectostylid. There is a distinct hypoconulid on this tooth, and, as in M_1 , it is apparently developed as a raised part of the posterior cingulum. The lingual portion of the posterior cingulum is a low crest that merges with the posterior surface of the entoconid. The apexes of the metaconid and entoconid are slightly ahead of those of the protoconid and hypoconid, respectively. M_2 , like the other cheek teeth, has no mesoconid or mesolophid. The posterior arm of the protoconid and the anterior arm of the hypoconid are joined into a low but distinct mure (in the sense of James, 1963, fig. 46); this is somewhat more distinct in the referred specimen than in the type. The posterior arm of the hypoconid has a low connection to the hypoconulid. A low crest from the metaconid joins the anterior arm of the protoconid very near its junction with the anterior cingulum or very near the anteroconid. The entoconid is elongated buccally as a low ridge that joins the portion of the mure formed of the anteromedial part of the hypoconid. This connection is low yet distinct (even more distinct in the referred specimen), so that the median valley is separated from the small posterior basin.

The last molar is the smallest of the cheek teeth, and the posterior half of this tooth is narrower than the anterior half. The buccal cingulum is weaker than on the other molars, being faint but discernible buccal to the protoconid. It merges posteriorly with the buccal surface of the hypoconid and anteriorly is continuous with the anterior cingulum. The anterior arm of the protoconid extends to the raised part of the anterior cingulum that is considered to represent the anteroconid. The lingual part of the anterior cingulum descends as a shelf from the apex of the anteroconid and continues around to the lingual side of the metaconid. The buccal part of the anterior cingulum is a low shelf that does not rise up to the apex of the anteroconid as it does in M_2 . The metaconid of M_3 is relatively smaller than in M_2 , but the connection to the anterior protoconid arm near the anteroconid is the same on the two teeth. The posterior arm of the protoconid joins the anterior surface of the hypoconid so that a mure is also present in this tooth. The posterior part of the tooth appears to be composed of one single large cusp, the hypoconid. The hypoconid has a



FIG. 3. *Nanomys simplicidens*, referred specimen, NMNH 175368. Occlusal view of left M_2 , stereogram. Approximately $\times 55$.

rounded crest however, that extends to the lingual margin of the tooth, and is slightly swollen or bulbous at its lingual end. Just posterior to this is a shallow indentation in the posterolingual surface, which, if it were deeper, would more clearly separate the entoconid, and the relationship between this cusp and the hypoconid would be much like that in many of the later cricetids.

DISCUSSION: The known teeth of *Nanomys* are so simple in character and lacking in most special features usually used in determining relation-

TABLE 1
MEASUREMENTS (IN MILLIMETERS) OF *Nanomys simplicidens*

	TYPE, FAM 79304	Referred Specimen NMNH 175638
M ₁ -M ₃ , anteroposterior	3.62	—
M ₁ , anteroposterior	1.33	—
M ₁ , transverse	1.06	—
M ₂ , anteroposterior	1.23	1.21
M ₂ , transverse	1.13	1.14
M ₃ , anteroposterior	1.06	—
M ₃ , transverse	0.96	—
I ₁ , anteroposterior, cross section	1.13	—
I ₁ , transverse, cross section	0.63	—
Depth of ramus beneath M ₁	3.00	—

ships that its phylogenetic position is difficult to interpret. Absence of upper jaws and teeth compounds the problem. It lived at a time when North American rodent faunas characteristically were shifting from dominance of protrogomorphs, such as ischyromyids, sciuravids, and cylirodontids, toward prominence and radiation of more advanced types, such as eomyids and heteromyids among the geomorphs and cricetids among the myomorphs. *Nanomys* is here interpreted as one of the early products of the myomorph radiation.

Characters indicating that *Nanomys* has myomorph affinities are reduction of the lower cheek teeth to three molars and a relatively anterior position of the masseteric fossa, which suggests progressive development of the masseter muscles. The oldest known myomorph, *Simimys* from the North American late Eocene, has an interesting combination of muroid-like zygomaseteric structure and dental formula, and dipodoid-like tooth pattern (Wilson, 1949, pp. 22-23). Nothing is known of the zygomaseteric structure of *Nanomys*, but in lower tooth pattern it is very different

from *Simimys*, in which the teeth are generally more lophate, M_{1-3} have well-developed mesolophids, and M_1 lacks a distinct anteroconid. Although older and a myomorph, *Simimys* does not appear to be close to *Nanomys*.

The rodent family that appears most likely to be ancestral to the myomorphs is the Sciuravidae (Wilson, 1949, p. 23). The steps leading from these primitive protrogomorphs, still retaining one or two upper and one lower premolar, to myomorphs are still undocumented. Thus, it is not known whether the ancestral sciuravids and oldest myomorphs were lophate like *Simimys* in molar development, as suggested by Wilson (1949, p. 23), or more cusate like *Nanomys*, or even whether myomorphs might have originated from more than one sciuravid line. If descended from sciuravids, the ancestors of *Nanomys* probably went through a somewhat more lophate stage than in *Nanomys*, but perhaps the earliest myomorphs were less so than *Simimys*. If descended from a line near *Sciuravus powayensis*, for example, the ancestors of *Nanomys* might have had less well-developed lophs than those of *Simimys*.

Two myomorph families are known from the Oligocene: the Zapodidae appeared in the middle Oligocene in Eurasia (and in the early Miocene in North America, if *Simimys* is not a zapodid); the Cricetidae appeared in the early Oligocene in Eurasia and North America. Compared with early zapodids, *Nanomys* has a better developed anteroconid on M_1 , simpler, less lophate teeth without a mesolophid, and lacks an entoconid on M_3 . *Nanomys* tends also to be less lophate than Oligocene cricetids. In European and Asian Oligocene cricetodontines (*sensu lato*, not in the restricted sense of Mein and Freudenthal, 1971) as well as in the North American eumyines, there is some development of the posterior protoconid arm and of a mesoconid and/or mesolophid, and M_3 has an entoconid. But some eumyines and such a form as "*Cricetodon*" *atavus* (Misonne, 1957, pp. 7-8) have less development of lophs than in zapodids. Further, *Nanomys* has a well-developed anteroconid as do these cricetids. In total, *Nanomys* shows a few indications of affinity with the Cricetidae among the myomorphs, and it is thus referred to that family. Another line of evidence, discussed more fully below, that lends weight to this assignment is morphological resemblance to some later cricetids.

The oldest previously recognized Cricetidae in North America are specimens of *Eumys* from the early Oligocene of northwestern Nebraska. Wood (1969, p. 4) referred three jaws from Harold Cook's "*Chadronia* pocket" to *Eumys* cf. *elegans* and noted that they could be referred either to *E. elegans* or to *E. obliquidens*. Wood also referred to a study by Rice (ms) of 178 specimens of *Eumys* from the same general area and equivalent age, which Rice concluded were best referred to *E. elegans*. Hough and Alf

(1956, p. 133) reported the occurrence of 267 teeth of cricetid rodents, including *Eumys elegans*, *E. exiguus*, and *E. planidens*, from the Chadronian of northwestern Nebraska. These specimens were from an ant hill, however, and the authors suggested that they may have been accumulated from a wider vertical range. Wood (1969, p. 17) concluded that the rodents from *Chadronia* pocket occurred a very short time interval before middle Oligocene time, and that the Pipestone Springs (Main Pocket) fauna of Montana, which lacks *Eumys*, is probably considerably older. We concur in this opinion. The part of the Flagstaff Rim sequence from which *Nanomys* was collected is, on a faunal basis, a very near temporal equivalent of the "Main Pocket" at Pipestone Springs, and, based on other evidence, also seems to be older than "*Chadronia* Pocket" and other Chadronian localities of northwest Nebraska. If these opinions are correct, *Nanomys* is older than any other recognized North American cricetid.

Compared with *Eumys* and other eumyines, *Nanomys* shows little resemblance other than in general cricetid characters. The teeth of *Eumys*, for example, have a long posterior protoconid arm, a mesoconid and a mesolophid, although the mesolophid may be short. The connecting lophs of the teeth of *Eumys* are more strongly developed, generally almost as high as the four primary cusps. *Scottimus* is very much like *Eumys* in these respects, but the anteroposterior crests are more strongly emphasized.

Nanomys has some similarity to certain later Tertiary hesperomyines and other cricetids. Included within the hesperomyine genus *Copemys* is an array of late Miocene and early Pliocene species at different levels of development (Clark, Dawson, and Wood, 1964, pp. 44–56; James, 1963, pp. 113–129). *Copemys* has been considered to be descended from eumyine cricetids, but this transition is not well documented, as few cricetids are known from the critical Miocene time interval (Clark, Dawson, and Wood, 1964, p. 42). Although the dental pattern of *Nanomys* is simpler than that of most species of *Copemys*, in some features there is similarity. *Copemys* is a smaller rodent than *Eumys*, some of the species being about the size of *Nanomys*. *Nanomys* and *Copemys* are also similar to each other and differ from *Eumys* in having: jaw relatively lighter; incisors narrower and more procumbent; connecting crests lower, considerably lower than primary cusps; masseteric fossa farther forward. The mental foramen of *Nanomys* is beneath the diastema, as in most species of *Copemys*.¹

¹ A contradiction regarding this feature, in Clark, Dawson, and Wood (1964) needs clarification. On page 47, they gave the position of the mental foramen of *Copemys dentalis* as "below the diastema as in *C. loxodon*," but on page 55, they stated that, in *C. esmeraldensis*, "the prominent mental foramen lies beneath the anterior root of M₁,

The metaconid of M_2 and M_3 of *Nanomys* is very near the anterior margin of the tooth, although there is a narrow lingual part of the anterior cingulum anterior to it. In *Copemys*, the metaconids of M_2 and M_3 are also near the anterior margin of the tooth, this also being a diagnostic character (Clark, Dawson, and Wood, 1964, p. 41). Their diagnosis of *Copemys* goes on to say, however, that the anterior cingulum is absent or restricted to the buccal margin of the tooth. In the type of *C. loxodon*, however, there is a very narrow, low shelf anterior to the metaconid of M_2 , less well developed than the same part of the anterior cingulum of *Nanomys*, but distinctly discernible. *Nanomys* has also some more detailed similarities to various species of *Copemys*. For example, it resembles *C. dentalis* in proximity of metaconid to anteroconid on M_1 , and resembles most known specimens of that species in lacking a mesolophid; *C. loxodon*² and *C. russelli* have some development of anterobuccal and buccal cingula although these are not so well developed as in *Nanomys*. *Nanomys* is, however, much less advanced than *Copemys* in having little or no alternation of outer and inner cusps and more emphasis on cusps, less on connecting crests or lophids.

The morphological similarities between *Nanomys* and the late Miocene and early Pliocene *Copemys* suggests some relationship between this simple, cusped early Oligocene rodent or closely allied forms and the hesper-

as in *C. loxodon*, instead of beneath the diastema as in the other species." The mental foramen of *C. loxodon* is just in front of the anterior root of M_1 as the authors stated in their description of this species (p. 46).

² Wood, in his original diagnosis of *Copemys loxodon*, stated that there is no hypoconulid on M_2 and that the posterior cingulum arises from the external border of the hypoconid, as shown in his illustration (1936, p. 2, fig. 5; and again in Clark, Dawson, and Wood, 1964, p. 48, fig. 7A). This statement and the figures mentioned are incorrect. M_2 of the type of *Copemys loxodon* has a rather large, matrix-filled fracture running through the hypoconulid, but it can be clearly seen that there is a distinct hypoconulid and further that the hypoconulid connects directly to the hypoconid. This can be seen in the stereogram and drawing of the type of *C. loxodon* in Fahlbusch (1967, pl. 15, figs. 1, 2). An additional low crest runs directly from the hypoconulid to the posterior surface of the entoconid. This short crest is quite distinct on the specimen and can also be clearly seen in the stereogram mentioned above, but not in the drawing (fig. 2 of the same plate). There is only a faint ridge suggesting the part of the posterior cingulum buccal to the hypoconulid, and this does not reach as far as the buccal part of the hypoconid.

In the emended specific diagnosis of *Copemys loxodon* (Clark, Dawson, and Wood, 1964, p. 44), the masseteric fossa is characterized as having an everted, overhanging dorsal margin. This is, in the opinion of the senior author who has checked the specimen, nothing more than an artifact of preservation, resulting from breakage and crushing in of the central part of the fossa.

omyines. Perhaps rather than known euomyines, the ancestors of hesperomyines were cricetids with relatively simple teeth and the hesperomyine pattern developed by increase in crests rather than by their reduction. As now known, *Nanomys* is a rare form, seemingly inhabiting areas not usually represented in the fossil record. If this habitat preference also characterized closely related forms that might lead toward hesperomyines, it might explain the absence of a good record of hesperomyine ancestors in the North American Miocene.

These are, however, speculations, and possibly hazardous speculations, in view of the time interval between *Nanomys* and the hesperomyines and especially of parallelism in rodents. Various characters can also be selected in which *Nanomys* resembles other later cricetids: in the Miocene cricetodontine *Fahlbuschia*, for example, the mesolophid is frequently reduced and buccal cingulum may be present; in Recent *Cricetus* the teeth are moderately cuspsate and lack a mesolophid. Even more striking is similarity to *Macrotarsomys*, a sub-Recent and Recent nesomyine in which the teeth are basically cuspsate, have a buccal cingulum, and lack mesolophids. But aside from these selected points of resemblance *Nanomys* differs from these cricetids in development of M_1 and M_3 , near absence of alternation of outer and inner cusps, and proportions of teeth. The resemblance is interpreted here as being due to parallel development of a relatively simple cricetid pattern.

Finally and even more speculatively, two features of *Nanomys*, the well-developed buccal cingulum of the lower molars and the essentially cuspsate development of the conids might be suggestive of relationship to the family Muridae. This family appears to be a development from the Cricetidae but no definite ancestral forms are known. The murids first appear in the fossil record, already well developed as murids, in the late Miocene or early Pliocene of the Old World. It has been suggested that the third buccal row of cusps of the murid lower molar is derived from a cingulum; such a cingulum is present in *Nanomys* and its cuspsate teeth are also somewhat reminiscent of those of murids. The evidence is tenuous at best, and perhaps this is only one more case (others being *Diplolophus*, of uncertain relationships, and the geomyid *Palustrinus*, North American Tertiary rodents for which murid affinities have been suggested but never determined) in which a rather enigmatic rodent, *Nanomys* in this case, has been suggested to have affinities with an enigmatic family, the Muridae.

In summary, *Nanomys simplicidens* is an early Oligocene rodent that was rare in the habitats usually preserved in the North American record of that time interval. It is characterized by relatively simple, cuspsate molars that are specialized mainly in their development of anterior and especially

buccal cingula. It is considered a myomorph, closest to the Cricetidae and here referred to that family. The relatively simple teeth, similar in several ways to those of some late Miocene and later hesperomyines, and some other characters in common suggest that *Nanomys* might have been near the hesperomyine ancestral group. However, *Nanomys* shares some of its simple characters also with various other later myomorphs, similarities that may be expected between a relatively simple older form and other simple later forms, no matter how these features were derived. *Nanomys* may then have been only an early experiment at simplification in the cricetids. It does, however, indicate more variety in early cricetids than was previously known.

LITERATURE CITED

BLACK, CRAIG C.

- 1961a. Fossil mammals from Montana. Pt. I. Additions to the late Miocene Flint Creek Local Fauna. Ann. Carnegie Mus., vol. 36, pp. 69-76.
- 1961b. New rodents from the early Miocene deposits of Sixty-six Mountain, Wyoming. Breviora, Mus. Comp. Zool., no. 146, pp. 1-7.
- 1961c. Rodents and lagomorphs from the Miocene Fort Logan and Deep River formations of Montana. Postilla, Yale Peabody Mus., no. 48, pp. 1-20.

CLARK, J. B., M. R. DAWSON, AND A. E. WOOD

- 1964. Fossil mammals from the lower Pliocene of Fish Lake Valley, Nevada. Bull. Mus. Comp. Zool., Harvard Univ., vol. 131, no. 2, pp. 29-63, 11 figs.

FAHLBUSCH, VOLKER

- 1967. Die Beziehungen zwischen einigen Cricetiden (Mamm., Rodentia) des Nordamerikanischen und Europäischen Jungtertiärs. Paläont. Zeitschr., vol. 41, no. 3-4, pp. 154-164.

GALBREATH, E. C.

- 1966. A record of *Democricetodon* (Order Rodentia) from the late Tertiary of northeastern Colorado. Trans. Illinois State Acad. Sci., vol. 59, no. 3, pp. 212-213.

HALL, E. RAYMOND

- 1930a. Rodents and lagomorphs from the later Tertiary of Fish Lake Valley, Nevada. Univ. California Publ., Bull. Dept. Geol. Sci., vol. 19, pp. 295-312.
- 1930b. Rodents and lagomorphs from the Barstow beds of southern California. *Ibid.*, vol. 19, pp. 313-318.

HOFFMEISTER, D. F.

- 1959. New cricetid rodents from the Niobrara River Fauna, Nebraska. Jour. Paleont., vol. 33, pp. 696-699.

HOOPER, E. T.

- 1957. Dental patterns in mice of the genus *Peromyscus*. Misc. Publ. Mus. Zool., Univ. Michigan, no. 99, pp. 1-59.

HOUGH, JEAN, AND RAYMOND ALF

- 1956. A Chadron mammalian fauna from Nebraska. Jour. Paleont., vol. 30, no. 1, pp. 132-140.

JAMES, G. T.

1963. Paleontology and nonmarine stratigraphy of the Cuyama Valley Badlands, California, Part I. Geology, faunal interpretations, and systematic descriptions of Chiroptera, Insectivora, and Rodentia. Univ. California Publ. Geol. Sci., vol. 45, pp. 1-154, 53 figs., 8 pls.

MACDONALD, J. R.

1963. The Miocene faunas from the Wounded Knee area of western South Dakota. Bull. Amer. Mus. Nat. Hist., vol. 125, pp. 139-238.

MEIN, PIERRE, AND M. FREUDENTHAL

1971. Une nouvelle classification des Cricetidae (Mammalia, Rodentia) du Tertiaire de l'Europe. Scripta Geol., no. 2, pp. 1-37.

MISONNE, XAVIER

1957. Mammifères Oligocènes de Hoogbutsel et de Hoelden. I. Rongeurs et Ongulés. Inst. Roy. Sci. Nat. Belgique, Bull., vol. 33, no. 51, pp. 1-16.

RICE, E. R.

- [MS.] Early Oligocene cricetid rodents from Nebraska. Amherst, Mass., Amherst College, Masters Thesis.

ROCHEBRUNE, ALPHONSE TRÉMEAU DE

1883. Faune de la Sénégambie. Mammifères. Actes Soc. Linnéenne Bordeaux, vol. 37 (ser. 4, vol. 7), pp. 49-203, pls. 4-12.

SCHAUB, S.

1925. Die hamsterartigen Nagetiere des Tertiärs und ihre lebenden Verwandten. Abhandl. Schweizerischen Paläont. Gesell., vol. 45, pp. 1-112, 15 figs., 5 pls.

STEHLIN, H. G., AND S. SCHAUB

1951. Die trigonodontie der simplicidentaten Nager Schweizerische Paläont. Abhandl., vol. 67, pp. 1-385, 620 figs.

WHITE, THEODORE E.

1954. Preliminary analysis of the fossil vertebrates of the Canyon Ferry Reservoir area. Proc. U. S. Natl. Mus., vol. 103, no. 3326, pp. 395-438.

WILSON, R. W.

1949. Additional Eocene rodent material from southern California. Carnegie Inst. Washington, Publ. 584, pp. 1-25.
1960. Early Miocene rodents and insectivores from northeastern Colorado. Univ. Kansas Paleont. Contrib., Vertebrata, no. 7, pp. 1-92.

WOOD, A. E.

1935. Two new genera of cricetid rodents from the Miocene of western United States., Amer. Mus. Novitates, no. 789, pp. 1-3.
1936. The cricetid rodents described by Leidy and Cope from the Tertiary of North America. Amer. Mus. Novitates, no. 822, pp. 1-8, 5 figs.
1937. Rodentia, Part II. In Scott, W. B., and G. L. Jepsen, The mammalian fauna of the White River Oligocene. Trans. Amer. Phil. Soc., new ser., vol. 28, no. 2, pp. 153-269, 70 figs., 11 pls.
1969. Rodents and lagomorphs from the "*Chadronia* Pocket," early Oligocene of Nebraska. Amer. Mus. Novitates, no. 2366, pp. 1-18, 2 figs.

WOOD, A. E., AND R. W. WILSON

1936. A suggested nomenclature for the cusps of the cheek teeth of rodents. Jour. Paleont., vol. 10, pp. 388-391.