

THE NORTH AMERICAN *PROMIMOMYS* IMMIGRATION EVENT

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ABSTRACT

Explosive radiation of the mammalian rodent family Arvicolidae (muskrats, voles and lemmings) at the end of the Miocene and throughout the remaining late Neogene provided an ideal group for biochronological correlations. Consecutive waves of arvicolid immigration into North America, plus some autochthonous cladogenesis, allows the development of a faunal chronology based almost exclusively on these animals. One thorny problem has been the relatively early appearance of *Promimomys* (= *Prosomys*) in North America, leaving the distinct possibility that arvicolids first evolved in the New World. A summary of biochronological and radioisotopic information shows that *Promimomys* dispersed to North America from Asia subsequent to about 5.5 Ma and gave rise to the Pliophenacomyinae between 5.5-5.0 Ma.

INTRODUCTION

Our understanding of the origin of the cosmopolitan family Arvicolidae has been complicated by the occasional assumption that *Promimomys mimus* (= *Prosomys mimus* Shotwell, 1956) appeared earlier in North America than it did elsewhere, despite the fact that a host of arvicolid-like cricetids (e.g., *Baranarviomys*, *Microtodon* [= *Baranomys*, *Bjornkurtenia*], *Celadensia*) are found in Europe and Asia but not in North America. Indeed, Repenning's (1987) biochronology of arvicolid rodents began with the immigration of *Promimomys* to the United States at 6.7 ± 0.5 Ma, his "Event 1" (Repenning, 1987, p. 239), leaving open the possibility that Eurasian *Promimomys* is the result of an as yet undiscovered early radiation of North American proto-arvicolids. In subsequent treatments, Repenning et al. (1990) and Bell (2000) placed the immigration of *Promimomys* (and Dispersal Event 1) between 5.5-4.8 Ma, but provided no substantiating evidence. In possible support of the older dispersal scenario, Zakrzewski and Harington (2001) reported a mandible of cf *Baranomys* from a locality on Ellesmere Island, high in the Canadian Arctic. The associated mammalian fauna pointed to an "early Pliocene" age, too late for ancestry to *Promimomys*, but suggestive nonetheless of a previously unknown high arctic dispersal and possible radiation of arvicolid-like taxa. Compounding the problem is the fact that the late Hemphillian localities with *Promimomys*, Christmas Valley and McKay Reservoir, Oregon, and Mailbox, Nebraska, lack

external age control (Repenning, 1987; Bell et al., 2004), and therefore establishing their approximate chronological position must be done with biostratigraphic information. In this essay I examine a series of North American mammalian assemblages ranging in age from about 7-4.9 Ma. The results support the revised immigration timing for *Promimomys* suggested by Repenning (1990) and Bell (2000); *Proimimomys* is absent from fossil assemblages older than about 5.5 Ma, and apparently gave rise to the North American endemic subfamily Pliophenacomyinae between about 5.5-5.0 Ma.

METHODS

Table 1 was constructed from a variety of late Hemphillian and early Blancan local faunas. The information was taken from published sources (Shotwell, 1956, 1970; Jacobs, 1977; Baskin, 1979; May, 1981; Dalquest, 1983; Tedford et al., 2004; White, 1987, 1991; Voorhies, 1990), on-line museum collection databases (Pinole assemblage; Museum of Paleontology, University of California, Berkeley) and John Alroy's on-line compilation of mammalian records known as *The Paleobiology Database* (<http://paleodb.org>). Radiosotopic calibration points were as follows: A fission-track date of 6.8 ± 0.2 and an Ar/Ar date of 6.8 ± 0.03 Ma were reported from an ash just above the Coffee Ranch l.f. of Texas (Tedford et al., 2004). A range of K/Ar dates from the Quiburis Formation of 5.21-6.25 Ma within which the Redington l.f. is found was given by Jacobs (1977). A fission-

track glass date for an ash above the Santee l.f. of Nebraska with *Protopliophenacomys parkeri* was reported by Boellstorf (1976) as 5.0 ± 0.2 Ma. A fossiliferous Blancan sequence from the Panaca Formation of Nevada was reported by Lindsay et al. (2002) in their redefinition of the Hemphillian-Blancan boundary. An Ar/Ar date of 4.69 Ma was derived from pumice tuff materials overlying sediments from which *Ophiomys panacaensis* was collected. The lowest record of *O. panacaensis* is from a level in the sequence just above a pumice with two Ar/Ar dates at 4.96 ± 0.01 and 4.96 ± 0.02 Ma. A tuff overlying the Pinole assemblage from the San Francisco Bay area of California is dated at 5.5 ± 0.2 Ma (Tedford et al., 2004).

RESULTS AND DISCUSSION

The database in Table 1 is separated into those mammalian assemblages with and without arvicolid rodents. None of the assemblages >5.5 Ma contains arvicolids (*Goniodontomys* and *Paramicroscoptes* are not now considered to be arvicolids, based on characters of the mandible outlined by Repenning [1968]), and this difference conveniently basically correlates in time with the Miocene/Pliocene boundary (about 5.3 Ma). Nevertheless, the relatively dense mammalian record for the late Miocene does not demonstrate an obvious schism that could separate a more ancient "fauna" from one with arvicolids. Rather, each assemblage in Table 1 includes a few unique species that likely represent a combination of immigration and autochthonous cladogenetic events. Some small mammals, such as *Lemoynea*, *Aneuroneomys*, the eomyid rodent *Kansasimys*, and *Paramicroscoptes* and *Goniodontomys* are restricted to older local faunas, but many genera have species that range from the Hemphillian through the Blancan (e.g., *Hypolagus*, *Nekrolagus*, *Spermophilus*, *Bensonmys*, *Perognathus*, *Onychomys*, *Repomys*, *Bensonmys*, etc.). I am hesitant to use the large mammals for detailed biochronological purposes because their fossilization probability, and therefore their potential representation in fossil assemblages, is so much lower than with small mammals. Still, pre-arvicolid assemblages include the large mammals *Aphelops*, *Dinohippus*, *Pliohippus*, *Astrohippus*, *Alforjas*, *Pediomyx*, *Texoceras*, *Nimravides*, and *Barbourofelis*. The rhinoceros *Teleoceras*, once considered to be a Hemphillian indicator, extends to the early Blancan, as it has been recovered with *Ogmodontomys* from the Pipe Creek Sinkhole of Indiana (Martin et al., 2002). Mylagaulid rodents remain as good Hemphillian indicators, as they are last seen in the Santee l. f. (Voorhies, 1990).

This information suggests that the North American *Promimomys* (= *Prosomys*) immigration event occurred between 5.5-5.0 Ma, considerably later than the original proposal of 6.67 Ma. Although more in line with European records of *Promimomys*, dispersal of this genus to the New World still seems early compared to the earliest records of *Promimomys* in Europe, which had been set at about 4.9 Ma, at the base of MN (European Mammal Neogene zone) 14 (Fejfar et al., 1998). However, Hordijk and de Bruijn (2009) recently established the occurrence of *Promimomys cor* in the Ptolemais lacustrine-lignitic sequence of Greece at a level in excess of 5.0 million years. As *Promimomys cor* appears to be somewhat morphologically advanced over *P. insuliferus* (Fejfar et al., 1998), we can look to an earlier date in Eurasia for the origination of *Promimomys* from its cricetid ancestor.

Changzhu and Yingqi (2005) described a species of *Promimomys*, *P. asiaticus*, from a cave deposit in Dajushan Hill, Anhui Province, China, which they considered to exhibit the most primitive dental features of the genus. They concluded, based on the associated fauna, that the Dajushan Hill assemblage was deposited in early MN 14 which, with the new Ptolemais *Promimomys* records, should likely be pushed back from its current position at about 4.9 Ma (Fejfar et al., 1998) to at least 5.3 Ma. Despite the independent age assessment, these considerations collectively support the proposition of Repenning et al. (1990) and Bell (2000) that *Promimomys* originated in Asia subsequent to 5.5 Ma and dispersed soon after to both Europe and North America.

Chaline et al. (1999) suggested that *Ogmodontomys* evolved from North American *Promimomys mimus*, but intermediates are not known from the North American fossil record, whereas they are between North American *Promimomys* and the Pliophenacomyinae (Martin et al., 2002; Martin, 2007). *Ophiomys* and *Ogmodontomys* are closely related and diverged rapidly after they appeared in North America. The first appearance datum of an *Ophiomys*-like m1 dental morphology (e.g., *O. panacaensis*; Mou, 1997) is used to define the Hemphillian/Blancan boundary (Lindsay et al., 2002) at approximately 4.98 Ma. A potential ancestor, *Promimomys antiquus*, has been described from Siberia (Zazhigin, 1980) and, at least for now, the Blancan presence of *Ophiomys* seems likely to represent a second dispersal event a few hundred thousand years after *Promimomys* entered the continent.

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LITERATURE CITED

- Baskin, J. A. 1979. Small mammals of the Hemphillian age White Cone local fauna, northeastern Arizona. *Journal of Paleontology* 53:695-708.
- Bell, C. J. 2000. Biochronology of North American microtine rodents. Pp. 379-406 in J. S. Noller, J. M. Sowers and W. R. Lettis (eds.), *Quaternary Geology Methods and Applications*. American Geophysical Union, Washington, D. C.
- Bell, C. J., Lundelius Jr., E. L., Barnosky, A. D., Graham, R. W., Lindsay, E. H., Ruez Jr., D. R., Semken Jr., H. A., Webb, S. D., Zakrzewski, R. J. 2004. The Blancan, Irvingtonian, and RanchoLabrean Mammal Ages. Pp.232-314 in M. O. Woodburne (ed.), *Late Cretaceous and Cenozoic Mammals of North America: Biostratigraphy and Geochronology*. Columbia University Press, New York. Pp. 232-314.
- Boellstorff, J. 1976. The succession of late Cenozoic volcanic ashes in the Great Plains: a progress report. Pp. 37-71 in C. K. Bayne (ed.), *Guidebook 24th Annual Meeting Midwestern Friends of the Pleistocene*. Kansas Geological Survey, University of Kansas. Guidebook Series 1.
- Chaline, J., P. Brunet-Lecomte, S. Montuire, L. Viriot and F. Courant. 1999. Anatomy of the arvicoline radiation (Rodentia): palaeogeographical, palaeoecological history and evolutionary data. *Annals Zoologica Fennici* 36:239-267.
- Changzhu, J. and Y. Zhang. 2005. First discovery of *Promimomys* (Arvicolidae) in east Asia. *Chinese Science Bulletin* 50:327-332.
- Dalquest, W. W. 1983. Mammals of the Coffee Ranch local fauna Hemphillian of Texas. The Pearce-Sellards Series. No. 38:1-41.
- Fejfar, O., W.-D. Heinrich, and E. H. Lindsay. 1998. Updating the Neogene rodent biochronology in Europe. Pp. 533-553 in T. Van Kolfschoten and P. Gibbard (eds.), *The Dawn of the Quaternary*. Mededelingen Netherlands Institute voor Toogepaste. Geowetenschappen TNO, 60.
- Hordijk, K. and H. de Bruijn. 2009. The succession of rodent faunas from the Mio/Pliocene lacustrine deposits of the Florina-Ptolemais-Servia Basin (Greece). *Hellenic Journal of Geosciences* 44:21-103.
- Jacobs, L. L. 1977. Rodents of the Hemphillian age Redington local fauna, San Pedro Valley, Arizona. *Journal of Paleontology* 51:505-519.
- Lindsay, E. H. , Mou, Y. and Downs, W. 2002. Recognition of the Hemphillian/Blancan boundary in Nevada. *Journal of Vertebrate Paleontology* 22:429-442.
- Martin, R. A. 2007. Arvicolidae. Pp. 480-497 in C. M. Janis, G. F. Gunnell and M. D. Uhen (eds.), *Evolution of Tertiary Mammals of North America*, Vol. 2. Cambridge University Press, New York.
- Martin, R. A., H. T. Goodwin, and J. O. Farlow. 2002. Late Neogene (late Hemphillian) rodents from the Pipe Creek Sinkhole, Grant County, Indiana. *Journal of Vertebrate Paleontology* 22:137-151.
- May, S. R. 1981. *Repomys* (Mammalia: Rodentia gen. nov.) from the late Neogene of California and Nevada. *Journal of Vertebrate Paleontology* 1:219-230.
- Mou, Y. 1998. Schmelzmuster of *Mimomys panacaensis*. Pp. 79-90 in Y. Tomida, L. J. Flynn and L. L. Jacobs (eds.), *Advances in Vertebrate Paleontology and Geochronology*. National Science Museum Monograph 14, Tokyo.
- Repenning, C. A. 1968. Mandibular musculature and the origin of the subfamily Arvicolinae (Rodentia). *Acta Zoologica Cracoviensia* 13:29-72.
- Repenning, C. A. 1987. Biochronology of the microtine rodents of the United States. Pp. 236-268 in M. O. Woodburne (ed.) *Cenozoic Mammals of North America*. University of California Press, Berkeley.
- Repenning, C. A., Fejfar, O. and Heinrich, W.-D. 1990. Arvicolid rodent biochronology of the northern hemisphere. Pp. 385-418 in O. Fejfar and W.-D. Heinrich (eds.); *International Symposium Evolution, Phylogeny and Biostratigraphy of Arvicolids (Rodentia, Mammalia)*. Geological Survey, Prague.
- Shotwell, J. A. 1956. Hemphillian mammalian assemblage from northeastern Oregon. *Bulletin of the Geological Society of America* 67:717-738.
- Shotwell, J. A. 1970. Pliocene mammals of southeast Oregon and adjacent Idaho. *Bulletin Museum of Natural History, University of Oregon*. 17:1-103.
- Tedford, R. H., et al. 2004. Mammalian biochronology of the Arikarean through Hemphillian interval (late Oligocene through early Pliocene epochs). Pp. 169-231 in M. O. Woodburne (ed.), *Late*

- Cretaceous and Cenozoic Mammals of North America: Biostratigraphy and Geochronology. Columbia University Press, New York.
- Voorhies, M. R. 1990. Vertebrate biostratigraphy of the Ogallala Group in Nebraska. Pp. 115-151 in T. C. Gustavson (ed.), Geological Framework and Regional Hydrology: Upper Cenozoic Blackwater Draw and Ogallala Formations, Great Plains. Bureau of Economic Geology, University of Texas, Austin.
- White, J. A. 1987. The Archaeolaginae (Mammalia, Lagomorpha) of North America, excluding *Archaeolagus* and *Panolax*. Journal of Vertebrate Paleontology 7:425-450.
- White, J. A. 1991. North American Leporinae (Mammalia: Lagomorpha) from late Miocene (Clarendonian) to latest Pliocene (Blancan). Journal of Vertebrate Paleontology 11:67-89.
- Zakrzewski, R. J. and C. R. Harington, 2001. Unusual Pliocene rodent from the Canadian arctic islands. Journal of Vertebrate Paleontology, 21 (suppl. To no. 3):116A-117A.
- Zazhigin, V. 1980. Late Pliocene and Anthropogene rodents of the south of western Siberia. Academy of Sciences USSR, Geological Institute, Moscow, Transaction 339:1-156.

TABLE 1. Mammal species lists for select assemblages between about 7-4.6 million years ago. NALMA = North American Land Mammal Age, Ma = millions of years ago, sp. = referable to the genus, species unknown, cf = compares favorably with; roughly equivalent to “aff,” = has affinities with. Radioisotope dates are from the literature (see text).

Epoch					Miocene	Pliocene			
NALMA								Hemphillian	Blanca
Arvicolids					absent	present			
Age (Ma)	?>6.0	6.69	6.25-5.21	6.5-6.8	5.5	?	?	5.0	4.96-4.69
Local faunas	Cambridge	White Cone	Redington	Coffee Ranch	Pinole	McKay Reservoir	Mailbox	Santee	Panaca
Mammal taxa									
<i>Domninoidea</i>		?							
<i>Notiosorex</i>		sp.							sp.
<i>Meterix</i>	x						x	x	
<i>Aneuroneomys magnus</i>	x								
<i>Paracryptotis</i>							x	x	
<i>Scalopus (Hesperoscalops)</i>							x	x	
<i>Scalopus (Hesperoscalops) reficervus</i>				x					
<i>Scapanus</i>					x	x			
<i>Lemoynea biradicularis</i>	cf								
<i>Eptesicus hemphillensis</i>				x					
<i>Eptesicus</i>			x						
<i>Myotis</i>			x						
<i>Pliometanastes</i>	x								
<i>Megalonyx curvidens</i>								cf	
<i>Megalonyx leptostomus</i>					x				
<i>Thinobadistes</i>	x								
<i>Ochotona spanglei</i>						x	cf		
<i>Hypolagus ringoldensis</i>	x	x						x	x
<i>Hypolagus tedfordi</i>			x						
<i>Hypolagus vetus</i>		x	x	cf			x		
<i>Hypolagus edensis</i>			x		x				x
<i>Hypolagus oregonensis</i>						x			
<i>Hypolagus regalis</i>								x	
<i>Hypolagus</i>	x								
<i>Alilepus vagus</i>								x	
<i>Lepoides lepoides</i>								x	x
<i>Pewelagus dawsoni</i>									x
<i>Nekrolagus progressus</i>									x
<i>Mylagaulus monodon</i>	sp.	cf		cf		sp.			
<i>Ceratogaulus hatcheri</i>							x	cf	
<i>Paenemarmota cf nevadensis</i>							x		
<i>Paenemarmota sawrockensis</i>								x	
<i>Marmota vetus</i>								x	
<i>Marmota oregonensis</i>						x			
<i>Spermophilus wilsoni</i>						x			
<i>Spermophilus mckayensis</i>						x			

Local faunas	Cambridge	White Cone	Redington	Coffee Ranch	Pinole	McKay Reservoir	Mailbox	Santee	Panaca
<i>Pliohippus interpolatus</i>				x	x				
<i>Astrohippus ansae</i>				x					
<i>Equus simplicidens</i>									cf
<i>Equus (Hemionus)</i>									x
<i>Aphelops kimballensis</i>	x			cf					
<i>Aphelops mutilis</i>								x	
<i>Teleoceras schultzi</i>	x								
<i>Teleoceras</i>				x		x	x	x	
<i>Prosthenops brachirostris</i>						x			
<i>Prosthenops graffhami</i>	x								
<i>Prosthenops</i>							x		
<i>Platygonus</i>								x	x
<i>Peudoceras</i>	x								
<i>Hemiauchenia vera</i>	cf			x			cf	cf	sp.
<i>Megatylopus matthewi</i>				x					
<i>Megatylopus gigas</i>	cf		cf				x		sp.
<i>Megacamelus merriami</i>								cf	
<i>Alforjas taylori</i>						x			
<i>Pediomeryx figginsi</i>	x								
<i>Pediomeryx hemphillensis</i>				cf					
<i>Pediomeryx</i>					x			x	
<i>Sinocapra willdownsi</i>							x	x	
<i>Capromeryx</i>					x				
<i>Texoceras guymonensis</i>	x								
<i>Texoceras altidens</i>			sp.	cf					