LATE BLANCAN GAZELLE-HORSE *NANNIPPUS PENINSULATUS* (MAMMALIA, EQUIDAE) FROM SCURRY COUNTY, TEXAS, WITH IMPLICATIONS FOR BIOCHRONOLOGY

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Abstract

Ongoing excavations at Roland Springs Ranch Locality 1 (RSR-1) in Scurry County, Texas, have produced skeletal remains representing a diverse assemblage of vertebrate life. Remains of small, tridactyl equids are common in the stream sediments of RSR-1. As the most common large mammal in the RSR-1 fauna, understanding these diminutive horses is important to determining paleo-community composition. Further, identification of horse remains is biochronologically significant. Lacking numeric age determinations, placing the RSR-1 fauna in time is dependent upon faunal correlation. Ongoing biochronology research is focused on seven taxa, one of which is the small horse. The RSR-1 small horse remains are identified as *Nannippus peninsulatus* based on a combination of cheek tooth crown height, enamel pattern form, and metapodial size. Highly cursorial with strongly hypsodont cheek teeth, *N. peninsulatus* is derived in its adaptations to open grassland. An enigmatic precursor, *N. beckensis*, is known only from the late Pliocene locality of Beck Ranch, also in Scurry County. The RSR-1 sample is distinguished from the slightly less advanced *N. beckensis* by increased crown height, absence of protostylids, and increased metapodial elongation. *Nannippus peninsulatus* is characteristic of the late Pliocene-early Pleistocene (Blancan Land Mammal Age) fauna of North America. The presence of *N. peninsulatus* at RSR-1 provides temporal separation from Beck Ranch, and indicates an age of less than ~3.5 million years ago. Although not conclusive, this age supports the early findings of the biochronology research of an earliest Pleistocene age for the RSR-1 fauna.

Introduction

Systematic excavation of gleyed alluvium at Roland Springs Ranch Locality 1 (RSR-1), on the Rolling Plains of Texas in Scurry County (Figure 1), has produced a rich and diverse assemblage of late Blancan Land Mammal Age vertebrates. The most common large mammal at RSR-1 is a small hipparionine equid (Figure 2). This small tridactyl form co-occurs at RSR-1 with the large monodactyl zebrine *Equus simplicidens*.

The late Pliocene (~3.5 Ma) Beck Ranch fauna is also from Scurry County (Dalquest, 1978). This fauna includes *Equus simplicidens* and a small tridactyl form, *Nannippus beckensis*, known only from Beck Ranch. Identification of the RSR-1 hipparion is important to placing the locality in time as well as clarifying the temporal relationship between RSR-1 and Beck Ranch.

Materials & Methods

The RSR-1 hipparion sample of cheek teeth (n=79), mandibles (n=2), and metapodials (n=6) was analyzed to determine a species identification. Additional samples for this research included: *Nannippus beckensis* (Beck Ranch, TX) cheek teeth (n=83), mandibles (n=6), and metapodials (n=5); *N. peninsulatus* (Rexroad, KS) cheek teeth (n=2); *N. peninsulatus* (Neuse River, NC) cheek teeth (n=19); *N. lenticularis* (Rhino Hill, KS) cheek teeth (n=2), metapodials (n=2); and *N. lenticularis* (Lost Quarry, KS) cheek teeth (n=1), metapodials (n=7). Terminology followed MacFadden (1984). Measurement methodology followed MacFadden (1984) for upper cheek teeth and Hulbert (1987) for lower cheek teeth.

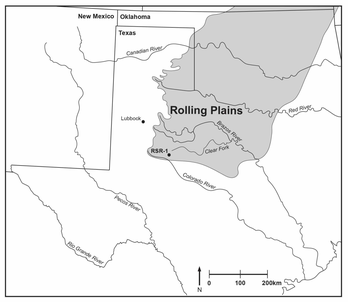

Figure 1. Location of Roland Springs Ranch Locality 1 (RSR-1) within the Rolling Plains (Osage Plains) of West Texas.

Table 1. Adult upper cheek tooth occlusal surface length and width for three species of *Nannippus*.

	N. peninsulatus								*N. beckensis*		*N. lenticularis*	
Sample	RSR-1		Neuse River, NC		Kansas		MacFadden, 1984		Beck Ranch		Kansas	
	AP length	TR width	AP length	TR width	AP length	TR width	AP length	TR width	AP length	TR width	AP length	TR width
n	29	30	19	16	2	2	6	6	56	55	3	3
X	17.2	15.3	16.1	14.3	18.3	15.7	17.9	19.9	17.6	15.4	19.7	17.5
OR	13.8 - 20.8	9.8 - 17.4	12.9 - 18.6	11.9 - 16.3	18.1 - 18.5	14.8 - 16.7	17.0 - 18.5	18.1 - 21.6	13.7 - 21.8	10.3 - 19.7	17.3 - 21.6	17.0 - 17.9

Table 2. *Nannippus peninsulatus* and *N. beckensis* adult cheek tooth crown height.

	N. peninsulatus							*N. beckensis*	
Sample	RSR-1		Neuse River, NC		Kansas		MacFadden, 1984	Beck Ranch	
	Uppers	Lowers	Uppers	Lowers	Uppers	Lowers	Uppers	Uppers	Lowers
n	31	25	14	4	2	8	25	49	21
X	37	53.9	38.3	39.8	55.8	48.4	44.7	41	52.7
OR	12.2 - 56.2	29.8 - 71.8	27.6 - 49.9	25.8 - 55.6	46.0 - 65.6	25.1 - 70.5	25.7 - 66.3	23.3 - 59.4	51.2 - 55.7

Results

The RSR-1 sample included individuals of all ontogenetic stages, represented by deciduous, unworn/unerupted adult, and lightly to heavily worn adult upper and lower cheek teeth (Figures 2-4). A minimum of six individuals, based on M3s, were recorded in the RSR-1 sample.

Adult RSR-1 upper cheek teeth (n=31) exhibited (relative to other equids) small size, tall crowns, moderately to very complex fossette plications, isolated protocones (except in heavily worn P2s), rounded oval to elongate oval protocones, open hypoconal grooves, reduced hypocones, absent hypoconal lakes, strong parastyles and mesostyles, weakly developed metastyles, absent, rudimentary, or single looped pli caballin, and reduced P2 anterostyles (Figure 2, Table 1). Adult lower cheek teeth (n=21) exhibited small size, very tall crowns, widely separated rounded or angular metaconids and metastylids, shallow (not penetrating isthmus) to deep (penetrating isthmus) ectoflexids, protostylids absent, and rudimentary or absent pli caballinids (Figures 3, 4). Metapodials are very small and long with relatively large cuboid and mesoentocuneiform facets on the proximal articular surfaces (Figure 5).

Cheek tooth and metapodial characters distinguish RSR-1 material from the hipparionines *Cormohipparion, Hipparion, Neohipparion, Pseudhipparion*, and are diagnostic of *Nannippus* (Hulbert, 1987; MacFadden, 1984; MacFadden and Waldrop, 1980). Observed characters exclude *N. westoni, N. morgani*, and *N. aztecus* (Hulbert, 1993).

Three characters (cheek tooth crown height, metapodial elongation, presence of protostylids) are significant in distinguishing *Nannippus* species. The development of these characters forms a chronological progression from Hemphillian *N. lenticularis* to medial Blancan *N. beckensis* to early-late Blancan *N. peninsulatus*.

The RSR-1 adult upper cheek teeth do not exhibit greater crown height than *Nannippus beckensis* (Table 2). RSR-1 adult lower cheek teeth, however, achieve a greater maximum crown height than *N. beckensis* (Table 2). The maximum crown height of lightly worn adult lower cheek teeth from RSR-1 is well within the range of variation exclusive to *N. peninsulatus*, and well beyond the maximum observed in *N. beckensis* and *N. lenticularis* (Table 2; Dalquest and Donovan; 1973; MacFadden, 1984). No RSR-1 adult lower cheek teeth exhibit a protostylid (Figures 3, 4). Protostylids are typical of *N. lenticularis* and earlier species, and are present in a minority of *N. beckensis* specimens (Figure 3; Dalquest and Donovan, 1973; Hulbert, 1993; MacFadden, 1984). Protostylids are absent from adult *N. peninsulatus* (MacFadden, 1984). Finally, RSR-1 metapodials exhibit a degree of elongation that is exclusive to *N. peninsulatus* (Figure 5). The suite of observed characters identifies the RSR-1 hipparion as *N. peninsulatus.*

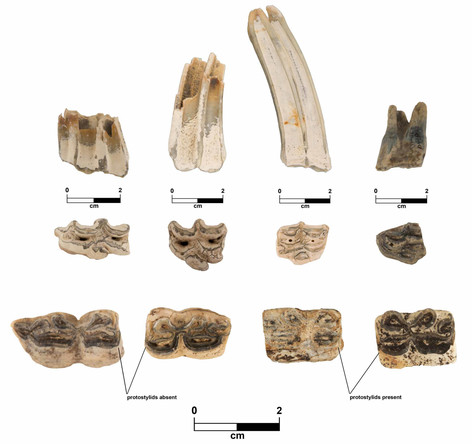

Figure 2. Ontogenetic stages within the RSR-1 sample of *Nannippus peninsulatus* upper cheek teeth (left to right: dP2 – TTU-A7-65120; unerupted P3/4 – TTU-A7-65357; lightly worn adult P3/4 – TTU-A7-67311; heavily worn adult P2 – TTU-A7-49149).

Figure 3. *Nannippus peninsulatus* (RSR-1) and *N. beckensis* lower cheek teeth (left to right: m3 – TTU-A7-49155; m2 – TTU-A7-66218; p4 – TMM41878-8369; m1 – TMM41878-8493).

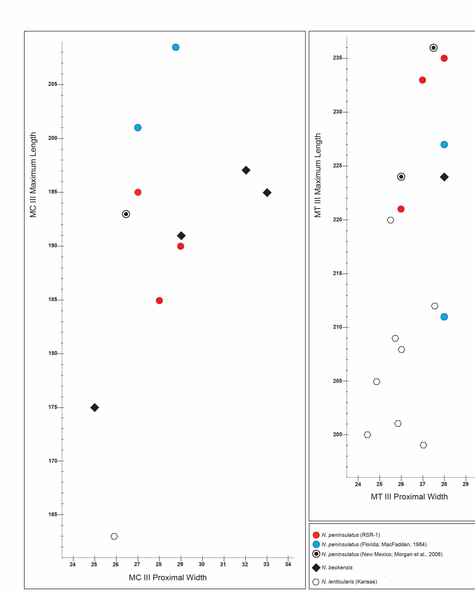

Figure 4. RSR-1 *Nannippus peninsulatus* right mandible segment. Note very high crown (72mm) and absence of protostylids.

Figure 5. Bivariate plot of metacarpal (left) and metatarsal (right) length and proximal width for *Nannippus peninsulatus, N. beckensis*, and *N. lenticularis*.

Biochronology

Nannippus peninsulatus is restricted to the Blancan Land Mammal Age (Bell et al., 2004). The earliest occurrence of *N. peninsulatus* appears to be from the Blancan component of Rancho El Ocote in Guanajuato, Mexico, fission-track dated to ~4.7-4.6 Ma (Carranza- Castañeda, 2006; Kowallis et al., 1998). This species is present in other early Blancan localities in Mexico, including Rancho La Goleta, that span from 4.1-3.6 Ma (Carranza-Castañeda, 2006). Beyond these early Blancan Mexican records, *N. peninsulatus* is typical of faunas in southern North America from approximately 3.6-2.1 Ma. The youngest occurrence of *Nannippus* is from Macasphalt Shell Pit, Florida at ~2.1 Ma (Bell et al., 2004). Most correlations, however, indicate *N. peninsulatus* is absent from western North America by ~2.5 Ma (Bell et al., 2004; Morgan and Lucas, 2003; Tedford, 1981).

Nannippus peninsulatus is present in the lower and upper Cita Canyon beds, spanning the Gauss and Matuyama chrons (late Pliocene-early Pleistocene; Bell et al., 2004). This horse also is present in the Blanco fauna, constrained to reversely magnetized sediments younger than 2.8 Ma (Lindsay et al., 1975). *Nannippus* occurs in the Hudspeth and Red Light local faunas of Trans-Pecos Texas, both potentially latest Pliocene and/or earliest Pleistocene in age (Akersten, 1970; Bell et al., 2004; Strain, 1966). In all of these Texas faunas, *N. peninsulatus* co-occurs with *Equus*. The earliest definite occurrence of *Equus* (*E. simplicidens*) dates to ~3.7 Ma (Azzaroli and Voorhies, 1993; Lindsay et al., 1980; MacFadden, 1992; Neville et al., 1979). The Texas records extend *Nannippus* (and *Nannippus*, *Equus* co-occurrence) into the early Pleistocene (Matuyama chron). All of these Texas records of *N. peninsulatus* are younger than Beck Ranch and are associated with South American immigrant ground sloths and glyptodonts (Akersten, 1970; Dalquest, 1975; Johnston and Savage, 1955; Strain, 1966).

Conclusions

The small RSR-1 hipparion is identified as *Nannippus peninsulatus* based on crown height, absence of protostylids, and metapodial elongation. Co-occurrence of *Equus* and *N. peninsulatus* indicates RSR-1 is younger than ~3.7 Ma, separating RSR-1 from the earliest known records of *N. peninsulatus* from Mexico. The derived form of *N. peninsulatus* relative to *N. beckensis* suggests that RSR-1 is younger than the medial Blancan Beck Ranch (~3.5 Ma). Presence of *N. peninsulatus* constrains the age of RSR-1 to between 3.5-2.1 Ma.

Acknowledgments

Thanks are due to Dr. Chris Sagebiel (Vertebrate Paleontology Laboratory, University of Texas, Austin), Drs. Desui Miao and David Burnham (University of Kansas Biodiversity Institute & Natural History Museum, Vertebrate Paleontology), and Amanda Millhouse (National Museum of Natural History, Paleobiology) for kindly granting access to specimens in their respective collections. Research at RSR-1 is funded by the Museum of Texas Tech University, two foundations that wish to remain anonymous, and the landowners. We are indebted to the landowners for access, donation of the generated collections to the Museum, their financial support, and continuing great interest in the research and dissemination of knowledge gained. This presentation is part of the ongoing Lubbock Lake Landmark regional research into Quaternary climatic, ecological, and biogeographic change on the Southern Plains.

References

Akersten, William A.
1970 Red Light Local Fauna (Blancan) of the Love Formation, Southeastern Hudspeth County, Texas. *Bulletin of the Texas Memorial Museum*, 20:1-52.

Azzaroli, Augusto and Michael R. Voorhies
1993 The Genus *Equus* in North America: The Blancan Species. *Palaentographica Italica*, 80:175-198.

Bell, Christopher J., Ernest L. Lundelius Jr., Anthony D. Barnosky, Russell W. Graham, Everett H. Lindsay, Dennis R. Ruez Jr., Holmes A. Semken Jr., S. David Webb, and Richard J. Zakrzewski.
2004 The Blancan, Irvingtonian, and Rancholabrean Mammal Ages. In: Michael O. Woodburne (ed.), *Late Cretaceous and Cenozoic Mammals of North America*, pp. 232-314. Columbia University Press, New York.

Carranza-Castañeda, Óscar
2006 Late Tertiary Fossil Localities in Central Mexico, Between 19°-23°N. In: Óscar Carranza-Castañeda and E.H. Lindsay (eds.), *Advances in late Tertiary Vertebrate Paleontology in Mexico and the Great American Biotic Interchange*, pp. 45-60. Universidad Nacional Autonoma de Mexico, Instituto de Geologia and Centro de Geociencias.

Dalquest, Walter W.
1975 Vertebrate Fossils from the Blanco Local Fauna of Texas. The Museum of Texas Tech University, *Occasional Papers*, 30:1-52.

1978 Early Blancan Mammals of the Beck Ranch Local Fauna of Texas. *Journal of Mammalogy*, 59(2):269-298.

Dalquest, Walter W. and Terrence J. Donovan
1973 A New Three-Toed Horse (*Nannippus*) from the Late Pliocene of Scurry County, Texas. *Journal of Paleontology*, 47(1):34-45.

Hulbert, Richard C., Jr.
1987 A New *Cormohipparion* (Mammalia, Equidae) from the Pliocene (Latest Hemphillian and Blancan) of Florida. *Journal of Vertebrate Paleontology*, 7(4):451-468.

1993 Late Miocene *Nannippus* (Mammalia: Perissodactyla) from Florida, with a Description of the Smallest Hipparionine Horse. *Journal of Vertebrate Paleontology*, 13(3):350-366.

Johnston, C. Stuart and Donald E. Savage
1955 A Survey of Various Late Cenozoic Vertebrate Faunas of the Panhandle of Texas. Part I: Introduction, Description of Localities, Preliminary Faunal Lists. *University of California Publications in Geological Sciences*, 31:27-49.

Kowallis, Bart J. Carl C. Swisher, III, Oscar Carranza-Castaneda, Wade E. Miller, and David G. Tingey
1998 Fission-Track and Single-Crystal 40Ar/39Ar Laser-Fusion Ages from Volcanic Ash Layers in Fossil-Bearing Pliocene Sediments in Central Mexico. *Revista Mexicana de Ciencias Geologicas*, 15(2):157-160.

Lindsay, Everett H., Noye M. Johnson, Neil D. Opdyke
1975 Preliminary Correlation of North American Land Mammal Ages and Geomagnetic Chronology. In: G.R. Smith and N.E. Friedland (eds.), Studies on Cenozoic Paleontology and Stratigraphy in Honor of Claude W. Hibbard, Claude W. Hibbard Memorial Volume 3, University of Michigan, *The Museum of Paleontology Papers on Paleontology*, 12:111-119.

Lindsay, Everett H., Neil D. Opdyke, and Noye M. Johnson
1980 Pliocene Dispersal of the Horse *Equus* and Late Cenozoic Mammalian Dispersal Events. *Nature*, 287:135-138.

MacFadden, Bruce J.
1984 Systematics and Phylogeny of *Hipparion, Neohipparion, Nannippus*, and *Cormohipparion* (Mammalia, Equidae) from the Miocene and Pliocene of the New World. *Bulletin of the American Museum of Natural History*, 179(1):1-195.

1992 *Fossil Horses: Systematics, Paleobiology, and Evolution of the Family Equidae*. Cambridge University Press, Cambridge.

MacFadden, Bruce J. and John S. Waldrop
1980 *Nannippus phlegon* (Mammalia, Equidae) from the Pliocene (Blancan) of Florida. *Bulletin of the Florida State Museum, Biological Sciences*, 25(1):1-37.

Moretti, John and Eileen Johnson
2011 Explorations in the Early Pleistocene of West Texas. *Current Research in the Pleistocene*, 28:176-178.

Morgan, Gary S. and Spencer G. Lucas
2003 Mammalian Biochronology of Blancan and Irvingtonian (Pliocene and early Pleistocene) Faunas from New Mexico. *Bulletin of the American Museum of Natural History*, 278:269-320.

Neville, Colleen, Neil D. Opdyke, Everett H. Lindsay, and Noye M. Johnson
1979 Magnetic Stratigraphy of Pliocene Deposits of the Glenns Ferry Formation Idaho, and its Implications for North American Mammalian Biostratigraphy. *American Journal of Science*, 279:503-526.

Strain, William Samuel
1966 Blancan Mammalian Fauna and Pleistocene Formations, Hudspeth County, Texas. *Bulletin of the Texas Memorial Museum*, 10:1-55.

Tedford, Richard H.
1981 Mammalian Biochronology of the late Cenozoic Basins of New Mexico. *Geological Society of America Bulletin*, 92:1008-1022.