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PLIOCENE (BLANCAN) VERTEBRATE FOSSILS FROM THE CAMP RICE FORMATION NEAR TONUCO MOUNTAIN, DOÑA ANA COUNTY, SOUTHERN NEW MEXICO

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Abstract—The Tonuco Mountain local fauna is proposed as a new name for a middle Blancan (late Pliocene) vertebrate assemblage from the Cedar Hill area southeast of Tonuco Mountain in Doña Ana County, southern New Mexico. The fossils are derived from the Camp Rice Formation in the western Jornada Basin. The stratigraphic section of the Camp Rice Formation at Cedar Hill consists of about 50 m of sandstone and conglomerate, with a minor component of sandy mudstone. The Tonuco Mountain fauna is composed of 16 species, including: the mud turtle *Kinosternon;* the land tortoises *Gopherus* and *Hesperotestudo*; a duck; a rabbit; the badger *Taxidea*; the coyote-like canid *Canis lepophagus*; the bone-eating dog *Borophagus*; the horses *Nannippus* cf. *N. peninsulatus*, *Equus (Dolichohippus) simplicidens*, and *E. scotti*; the peccary *Platygonus* cf. *P. bicalcaratus*; the camels *Camelops*, *Hemiauchenia blancoensis*, and a small undescribed species of *Hemiauchenia*; and the gomphotheriid proboscidean *Cuvieronius*. Among these taxa, *C. lepophagus*, *Borophagus*, *Nannippus* cf. *N. peninsulatus*, *E. simplicidens*, *Platygonus* cf. *P. bicalcaratus*, and *H. blancoensis* are indicative of the Blancan land mammal age (between 4.5 and 2.0 Ma). Several taxa help to further limit the age of this fauna within the Blancan. *E. simplicidens* is absent from very early Blancan faunas, *Platygonus* and *Camelops* do not appear until the beginning of the middle Blancan (about 3.7 Ma), and most Blancan records of *Nannippus* in the southwestern United States predate the Gauss-Matuyama magnetic reversal at about 2.6 Ma. The absence of South American immigrants suggests the fauna is older than 2.8 Ma, the earliest date for the onset of the Great American Faunal Interchange. These biostratigraphic data restrict the age of the Tonuco Mountain local fauna to the middle Blancan (between 3.7 and 2.8 Ma). Previous magnetostratigraphic studies of the Camp Rice Formation at Cedar Hill help to further constrain the age of this fauna. The entire section is within the Gauss chron (younger than 3.6 Ma), and the fossiliferous interval is below the top of the Kaena subchron (older than 3.0 Ma). The presence of a carpal bone of the rhinoceros *Teleoceras* from the Rincon Valley Formation in the Cedar Hill area suggests a late Miocene (Hemphillian) age, which is in accordance with a radioisotopic date of 9.6 Ma on the Selden Basalt Member of the Rincon Valley Formation.

INTRODUCTION

Over the past decade, Jerry MacDonald collected Pliocene (Blancan) vertebrate fossils in the Cedar Hill area southeast of Tonuco Mountain in the western portion of the Jornada Basin, southern New Mexico. The fossils were recovered from a small series of badlands in the Camp Rice Formation, between Interstate Highway 25 and the Rio Grande about 10 km northwest of Radium Springs and 5 km southeast of Tonuco Mountain (also known as San Diego Mountain) in Doña Ana County (Figs. 1 and 2). MacDonald donated these fossils to the New Mexico Museum of Natural History (NMMNH). In December 1996 and September 1997, MacDonald and field crews from the NMMNH, including the three authors, spent four days collecting additional vertebrate fossils from throughout the Camp Rice section in the Cedar Hill/Tonuco Mountain area. Greg Mack also collected samples of vertebrate fossils from these same outcrops during his studies of the magnetostratigraphy of the Camp Rice Formation (Mack et al., 1993). In their studies of the geology of the San Diego Mountain area, Seager et al. (1971, p. 18) mentioned that "horse teeth, fragments of mastodont teeth, and miscellaneous bone fragments of medium-to-large size vertebrates have been recovered..." [from the Camp Rice Formation in the vicinity of Cedar Hill] and "...are currently being studied by W. S. Strain, University of Texas at El Paso." Strain, now deceased, apparently never published these specimens and we have been unable to determine their whereabouts. We also measured and described a stratigraphic section of the Camp Rice Formation in the Cedar Hill area (Figs. 2 and 3).

We propose the name Tonuco Mountain local fauna (lf) for the vertebrate fossil assemblage recovered from the Camp Rice Formation near Tonuco Mountain. The Tonuco Mountain lf is composed of 16 species, including an aquatic turtle, two species of land tortoises, a duck, and 12 species of mammals (Table 1). This fauna is fairly typical of New Mexico Pliocene (Blancan) sites (e.g., Tedford, 1981; Lucas and Oakes, 1986; Morgan et al., 1997). The fossils occur in axial river deposits of an ancestral Rio Grande, which helps to explain the presence of several aquatic forms, including the mud turtle *Kinosternon* and a duck. However, these aquatic species are rare in the fauna, which is dominated by large terrestrial taxa, including land tortoises (*Hesperotestudo*), horses (two species of *Equus*),

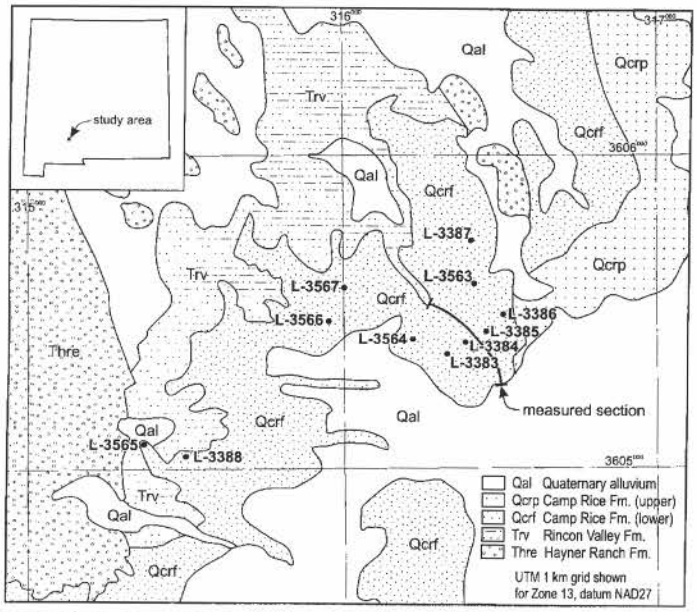


FIGURE 1. Map of Cedar Hill area southeast of Tonuco Mountain, Doña Ana County, New Mexico. Location of measured section and NMMNH fossil sites are indicated, as is the distribution of geologic units.

TABLE 1. List of vertebrates identified from the middle Blancan (late Pliocene) Tonuco Mountain local fauna, Doña Ana County, New Mexico

- Reptilia
  - Testudines
    - Kinosternidae
      - *Kinosternon* sp.
    - Testudinidae
      - *Gopherus* sp.
      - *Hesperotestudo* sp.
- Aves
  - Anseriformes
    - Anatidae
      - genus and species undetermined
- Mammalia
  - Lagomorpha
    - Leporidae
      - genus and species indeterminate
  - Carnivora
    - Mustelidae
      - *Taxidea* sp.
    - Canidae
      - *Canis lepophagus*
      - cf. *Borophagus* sp.
  - Perissodactyla
    - Equidae
      - *Nannippus* cf. *N. peninsulatus*
      - *Equus* (*Dolichohippus*) *simplicidens*
      - *Equus scotti*
  - Artidactyla
    - Tayassuidae
      - *Platygonus* cf. *P. bicalcaratus*
    - Camelidae
      - *Camelops* sp.
      - *Hemiauchenia blancoensis*
      - *Hemiauchenia* sp.
  - Proboscidea
    - Gomphotheriidae
      - *Cuvieronius* sp.

(*Cuvieronius*). We have not yet located sediments in this vicinity that are suitable for microvertebrate screenwashing. Small vertebrates in the fauna are limited to shell fragments of mud turtles and postcranial elements of ducks, rabbits, and small carnivores.

Vertebrate fossils from the Tonuco Mountain lf are housed in the NMMNH in Albuquerque and the New Mexico State University Museum (NMSU) in Las Cruces. Several fossils from the Frick Collection of the American Museum of Natural History (F:AM), New York, are also cited.

STRATIGRAPHY AND FOSSIL LOCALITIES

We collected vertebrate fossils from 12 localities in a series of outcrops of the Camp Rice Formation southeast of Tonuco Mountain, Doña Ana County, New Mexico (Fig. 1). The Camp Rice Formation is well exposed in this area on the north- and northwest-facing escarpment of Cedar Hill (Fig. 2), where it rests with angular unconformity on red mudstones of the Miocene Rincon Valley Formation and is overlain by a Holocene(?) petrocalcic paleosol (Hawley et al., 1969; Seager et al., 1971). We measured a 52.3 m-thick section of Camp Rice Formation (Fig. 3). Almost all of this section consists of sandstone (57%) and conglomerate (38%), whereas sandy mudstone (5%) is a minor component.

Twelve localities yielded the Tonuco Mountain lf, including NMMNH localities L-2934, L-3383 to L-3388 and L-3563 to L-3567. All of these sites are in the Camp Rice Formation and are located in the NW¼ sec. 16 or the N½ sec. 17, T20S, R1W on the Selden Canyon 7.5-min quadrangle. Section 16 is administered by the U.S. Bureau of Land Management, whereas section 17 is part of the New Mexico State University Animal Science Ranch. We have not detected any differences in the age of the fossil mammals recovered from various stratigraphic levels within the Camp Rice Formation in the Tonuco Mountain/Cedar Hill area, and thus the Tonuco Mountain lf is considered a single biostratigraphic assemblage.

NMMNH locality L-2934 includes all fossils collected from the Camp Rice Formation southeast of Tonuco Mountain for which the specific locality is unknown. The collections of Jerry MacDonald and Greg Mack were made before we visited the Tonuco Mountain/Cedar Hill area in 1996 and 1997 and established formal localities. Therefore, we do not know the exact locality for some of the fossils collected in this area. Locality L-2934 includes the entire section of the Camp Rice Formation in the NW¼ sec. 16 and the N½ sec. 17, T20S, R1W. The exact locations of the other 11 sites are plotted on Figure 1. Detailed map data for these sites are on file at the NMMNH.

SYSTEMATIC PALEONTOLOGY

Class Reptilia
Order Testudines
Family Kinosternidae
Kinosternon sp.

Referred specimens

Locality L-2934: NMMNH P-25455, anterior part of left plastron.

Locality L-3384: NMMNH P-27160, partial costal; NMMNH P-27161, plastral fragment.

Locality L-3563: NMMNH P-27197, partial costal; NMMNH P-27198, anterior part of left plastron.

Discussion

Five fossils from the Tonuco Mountain lf represent a small, thin-shelled turtle. The most diagnostic fossils are two specimens of the fused anterior portion of the plastron (NMMNH P-25455, P-27198, Fig. 4A). The posterior edge of this fused plastral element has a hinge-like suture. The fused anterior plastron with a hinge on the posterior surface, as well as small size, identify these elements as members of the family Kinosternidae, the mud turtles. Measurements (in mm) of these two anterior plastra (P-25455, P-27198, respectively) are: maximum length along midline, 36.3, 28.8; maximum width along posterior edge, 30.5, 22.6.

The Tonuco fossils compare well with the genus *Kinosternon*, but are not identified to the species level. Repenning and May (1986) reported the extant species *Kinosternon flavescens* from the early Blancan Truth or Consequences lf in Sierra County. There are two living species of *Kinosternon* in New Mexico; *K. flavescens* is fairly widespread in the state, whereas *K. sonoriense* is restricted to the extreme southwestern corner (Degenhardt et al., 1996). The occurrence of kinosternids in the fauna indicates the presence of aquatic habitats.

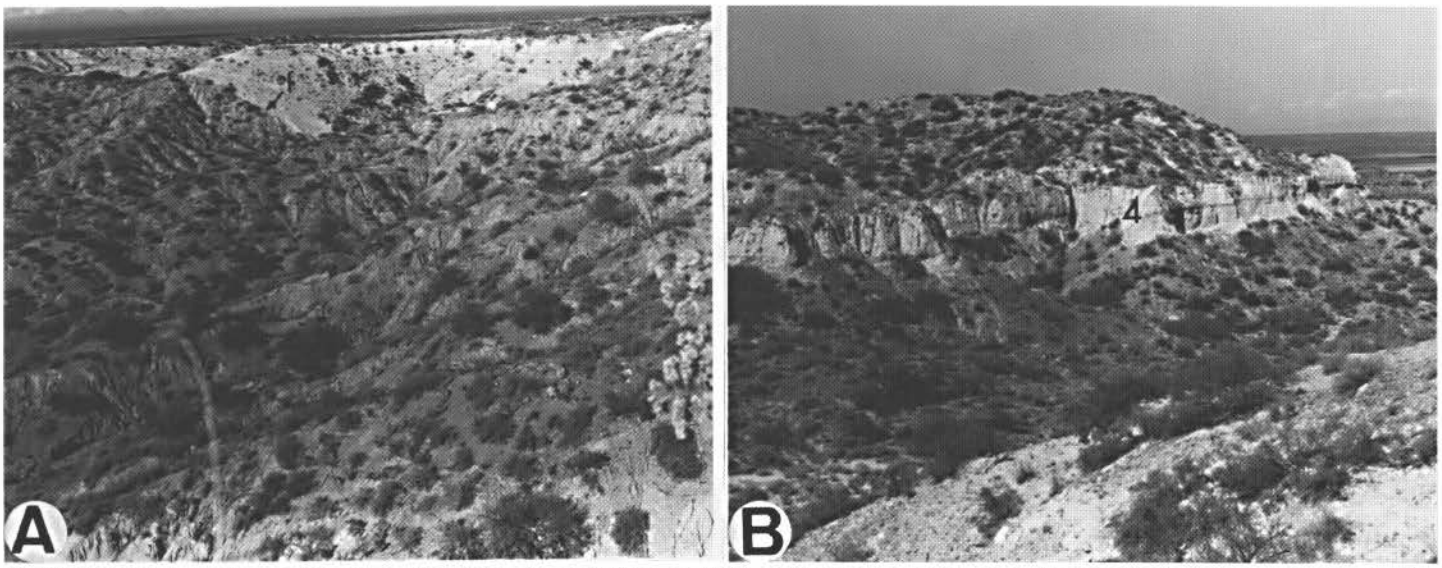


FIGURE 2. Selected outcrops of the Camp Rice Formation, NW¼ sec. 16, T20S, R1W, Cedar Hill area, Doña Ana County, New Mexico. **A,** View looking northeast, fluvial facies of Camp Rice Formation in fault (f) contact with lighter colored piedmont facies of Camp Rice Formation. **B,** View looking west, lower part of fluvial facies of Camp Rice Formation showing marker bed (4) of measured section.

Family Testudinidae
Gopherus sp.

Referred specimens

Locality L-3383: NMMNH P-27148, parts of two costals.

Discussion

These costals are rather large and broad (at least 70 mm wide), but are very thin-shelled (between 2.1 and 4.0 mm thick), lack concentric growth rings, and have deeply incised scute sulci (Fig. 4B). These features are typical of the genus *Gopherus*, which includes the gopher and desert tortoises. Two fragmentary costals are insufficient for a species-level identification.

This is the first Blancan record of *Gopherus* from New Mexico. Several extinct species in this genus are known from Blancan sites in Texas (Auffenberg, 1974), including *G. canyonensis* from Cita Canyon, *G. huecoensis* from Hudspeth, and *G. pertenuis* from Mt. Blanco. Vanderhill (1986) tentatively identified *Gopherus* from the Irvingtonian (early Pleistocene) of the Mesilla Basin in southern New Mexico, and the extant desert tortoise, *G. agassizii*, has been reported from several Pleistocene sites in the southern half of the state (Harris, 1993; Lucas and Morgan, 1996a). McCord (1994) summarized the fossil record of *Gopherus* in Arizona, which includes four late Pleistocene sites with *G. agassizii* and seven sites (six late Pleistocene and one late Pliocene) with *G. flavomarginatus*, an extant species now restricted to northern Mexico. *Gopherus* presently occurs in Arizona, but is unknown as a living animal in New Mexico (Degenhardt et al., 1996).

Hesperotestudo sp.

Referred specimens

Locality L-2934: NMMNH P-25456, partial carapace with one complete peripheral, one complete costal, and parts of three additional costals; NMMNH P-25458-25461, neurals; NMMNH P-25467-25469, peripherals; NMMNH P-25457 and NMSU 134, partial plastron including parts of the epiplastron, entoplastron, and hyoplastron; NMMNH P-25470, hyoplastron.

Locality L-3383: NMMNH P-27146, partial carapace with 3rd through 7th neurals and associated costals; NMMNH P-27147, partial carapace with 4th and 5th neurals and proximal ends of associated costals.

Locality L-3384: NMMNH P-27162, peripheral.

Locality L-3385: NMMNH P-27164, two articulated bridge peripherals.

Locality L-3563: NMMNH P-27190, peripheral; NMMNH P-27194, partial plastron including parts of the epiplastron, entoplastron, and hyoplastron; NMMNH P-27195, hypoplastron; NMMNH P-27191, xiphiplastron.

Locality L-3567: NMMNH P-27221, epiplastron.

Discussion

Isolated shell elements of land tortoises are the most common fossils in the Tonuco Mountain sites. The list of referred specimens includes only the more complete and identifiable fossils in the sample. Most fossils of land tortoises from New Mexico have been referred to the genus *Geochelone* (Lucas and Oakes, 1986; Sena and Thomas, 1989; Harris, 1993). Recent phylogenetic analyses of tortoises (see summary in Meylan, 1995) have shown that species placed in *Geochelone* do not constitute a monophyletic group. There has been a recent trend to restrict usage of *Geochelone* to certain Old World tortoises, and to recognize New World tortoises formerly referred to this genus as a distinct monophyletic group, the genus *Hesperotestudo*.

The sample of *Hesperotestudo* fossils from the Tonuco Mountain lf covers a wide range of sizes, and may include more than one species, although the predominance of isolated shell elements makes species-level identification difficult. Most of the fossils appear to represent a medium-sized, relatively thick-shelled tortoise. Auffenberg (1974) recognized two subgenera of land tortoises within the genus *Geochelone* in North American late Cenozoic faunas, *Caudochelys* and *Hesperotestudo*, both of which are now placed in the genus *Hesperotestudo*. The principal differences between the two subgenera of *Hesperotestudo* are in characters of the caudal vertebrae and caudal osteoderms, which are not present in the Tonuco tortoise sample.

Auffenberg (1974) referred most species of *Hesperotestudo* from western Blancan sites to the subgenus *Hesperotestudo*, including: *H.*

campester from Mt. Blanco, Texas; *H. johnstoni* from Cita Canyon, Texas; *H. rexroadensis* from Rexroad, Kansas, and *H. riggsi* from Saw Rock Canyon, Kansas. *H. johnstoni* and *H. riggsi* are small tortoises in the *H. turgida* evolutionary line, which also includes *H. wilsoni,* a Pleistocene species known from several New Mexico sites (Harris, 1993). *H. campester* and *H. rexroadensis* are larger tortoises possibly related to the large *H.* (*Caudochelys*) *hayi* from the Hemphillian of Florida (Auffenberg, 1974). Lucas and Oakes (1986) referred a partial plastron of a small tortoise from the Blancan Cuchillo Negro Creek lf in Sierra County to the *Geochelone* (*Hesperotestudo*) *turgida* group. Three partial *Hesperotestudo* plastra from the Tonuco Mountain lf are much larger than the Cuchillo Negro plastron, which measures 210 mm in width. Estimates of the anterior width of the plastron for the Tonuco specimens range from 300-400 mm. The Tonuco tortoise is probably related to one of the larger Pliocene species of *Hesperotestudo*, including *H. campester*, *H. hayi*, and *H. rexroadensis*.

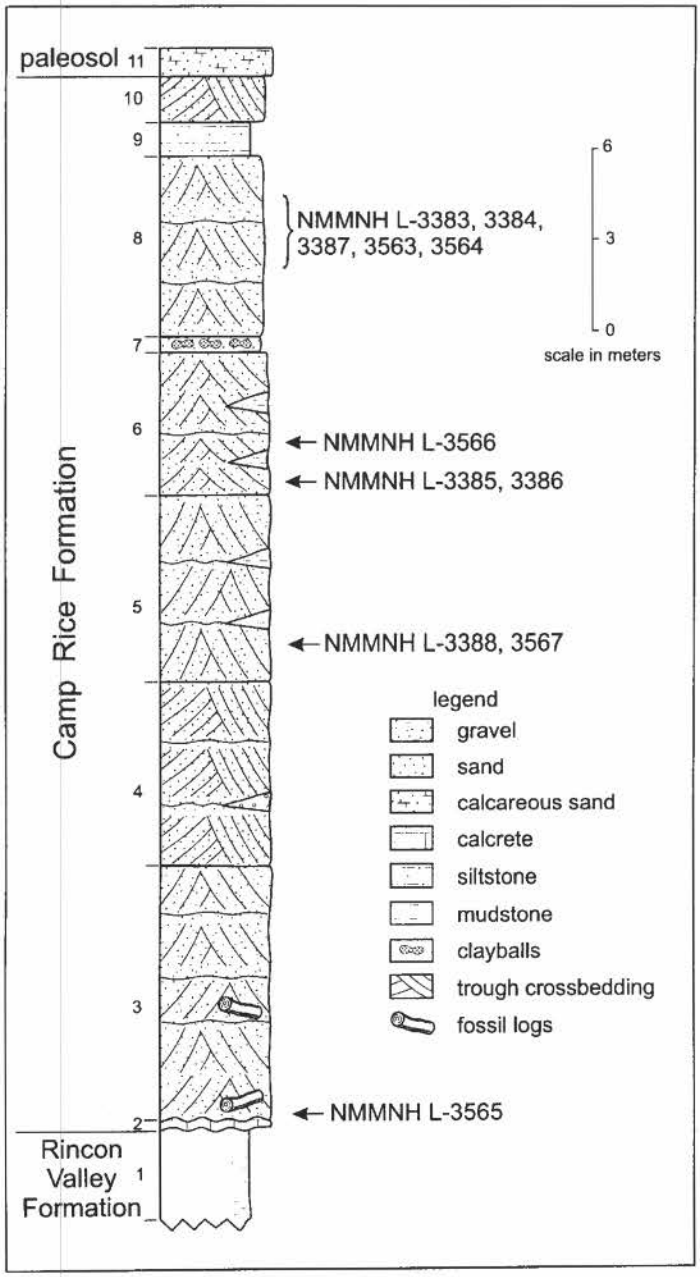


FIGURE 3. Measured stratigraphic section of Camp Rice Formation, NW¼ sec. 16 and NE¼ sec. 17, T20S, R1W, Cedar Hill area, Doña Ana County, New Mexico.

Measurements (in mm) of selected *Hesperotestudo* specimens from the Tonuco Mountain lf are provided below. Measurements of a complete 3rd costal (Fig. 4E) and a fourth or fifth peripheral (4F), respectively, from the same partial carapace (NMMNH P-25456) are: total length, 205, 142; proximal width, 70, 66; distal width, 53, 91; maximum thickness, 15.5, 31.7. A complete 4th neural (NMMNH P-27147) measures 96 in maximum width. A nearly complete epiplastron (NMMNH P-25457, Fig. 4D) is 182 mm long along the lateral margin and has a maximum thickness of 40.8. The thickest elements in the sample are an epiplastron (NMMNH P-27221) with a maximum thickness of 42.4 and a peripheral (NMMNH P-25467) with a maximum thickness of 46.5. With the exception of the length of the epiplastron of NMMNH P-25457, these measurements are smaller than a large land tortoise of middle Miocene (Barstovian) age from the Española Basin in northern New Mexico (Sena and Thomas, 1989, table 1). The Española tortoise, tentatively referred to *Geochelone* (=*Hesperotestudo*) *osborniana* by Sena and Thomas (1989), consists of a nearly complete plastron and carapace having a total length of 810 mm. The Tonuco tortoise was a smaller species than the Española tortoise, probably with a total shell length of between 600 and 700 mm.

Two of the Tonuco *Hesperotestudo* specimens may represent a smaller species. Both fossils are plastral elements, including a nearly complete hypoplastron (NMMNH P-27195, Fig. 4C) and a partial hyo/hypoplastron (NMMNH P-25462). These fossils are characterized by their small size, thin shells (between 2.8 and 3.5 mm thick), and well developed concentric growth rings (Fig. 4C). They represent either juveniles of the common large tortoise in the Tonuco fauna or a smaller species of *Hesperotestudo*, presumably in the *H. turgida* species group.

Land tortoises of the genus *Geochelone* (=*Hesperotestudo*) have long been used as indicators of Pleistocene climate (e.g., Hibbard, 1960). Living species of giant land tortoises are restricted to tropical regions, and are intolerant of freezing temperatures. The presence of giant land tortoises in North American late Cenozoic sites is generally thought to indicate frost-free winters (Hibbard, 1960). Several species of *Gopherus* occur in south temperate regions of the southeastern and southwestern United States, and may dig burrows to escape freezing conditions. The living desert tortoise, *G. agassizii*, is restricted to the Sonoran and Mojave deserts, which are characterized by fairly mild winters, and is absent from New Mexico. The presence of land tortoises in the Tonuco Mountain fossil sites, including species of both *Hesperotestudo* and *Gopherus*, suggests that this region was characterized by milder climatic conditions (i.e., frost-free winters) than occur at present in southern New Mexico.

Class Aves
Order Anseriformes
Family Anatidae
genus and species undetermined

Referred specimens

Locality L-3387: NMMNH P-27181, proximal end of right carpometacarpus; NMMNH P-27182, distal end of left tibiotarsus.

Discussion

Two partial limb bones of a medium-sized duck are the only bird fossils in the Tonuco Mountain lf. Detailed comparisons with modern skeletal material and other Blancan anatids will be required for more precise identification of these specimens. Both Tonuco duck fossils were collected from a sandy layer high in the Camp Rice

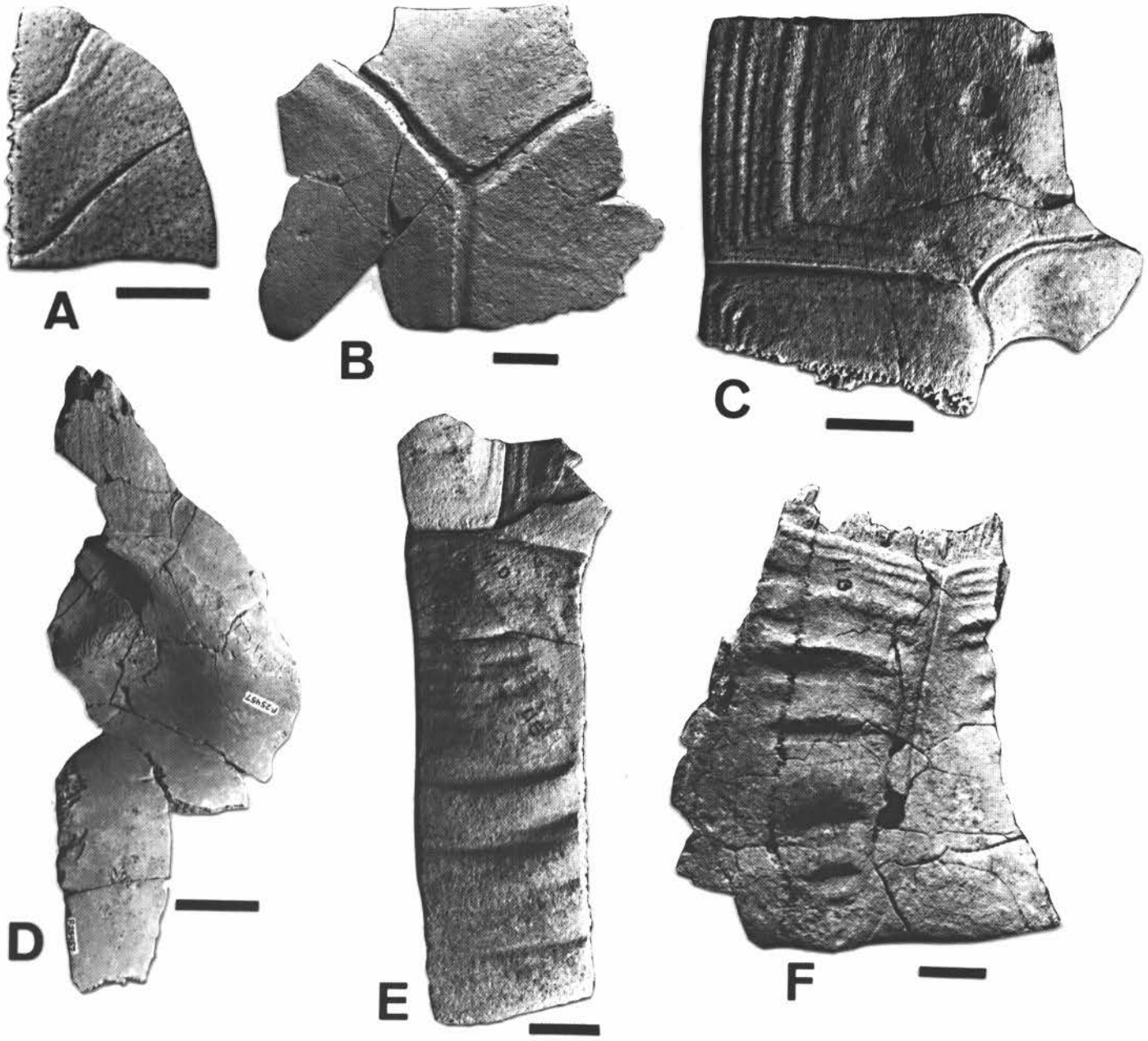


FIGURE 4. Fossil turtles and tortoises from the Blancan (Pliocene) Tonuco Mountain local fauna, Doña Ana County, New Mexico. **A,** *Kinosternon* sp., anterior part of left plastron, NMMNH P-27198. **B,** *Gopherus* sp., partial costal, NMMNH P-27148. **C,** *Hesperotestudo* sp., left hypoplastron, NMMNH P-27195. **D,** *Hesperotestudo* sp., partial plastron, NMMNH P-25457. **E,** costal and **F,** peripheral, *Hesperotestudo* sp., NMMNH P-25456. Scale bars are 1 cm for A-C; 2 cm for E, F; 5 cm for D.

Formation. Morgan et al. (1997) reported fossils of anatids, including both ducks and geese, from the Blancan Buckhorn lf in Grant County, southwestern New Mexico.

Class Mammalia
Order Lagomorpha
Family Leporidae
genus and species indeterminate

Referred specimens

Locality L-2934: NMMNH P-27130, proximal end of left femur.
Locality L-3563: NMMNH P-27199, partial innominate.

Discussion

The two rabbit postcranial elements from the Tonuco Mountain lf cannot be identified below the family level. Lagomorphs occur in four other New Mexico Blancan sites: *Hypolagus vetus* and *Notolagus lepusculus* from the Truth or Consequences lf in Sierra County (Repenning and May, 1986); *Hypolagus* cf. *H. gidleyi* from Tijeras Arroyo in Bernalillo County (Lucas at al., 1993), *Aluralagus virginiae* from the Mesilla basin in southern Doña Ana County (Vanderhill, 1986), and leporid postcranials from the Buckhorn lf in Grant County (Morgan et al., 1997).

Order Carnivora
Family Mustelidae
Taxidea sp.

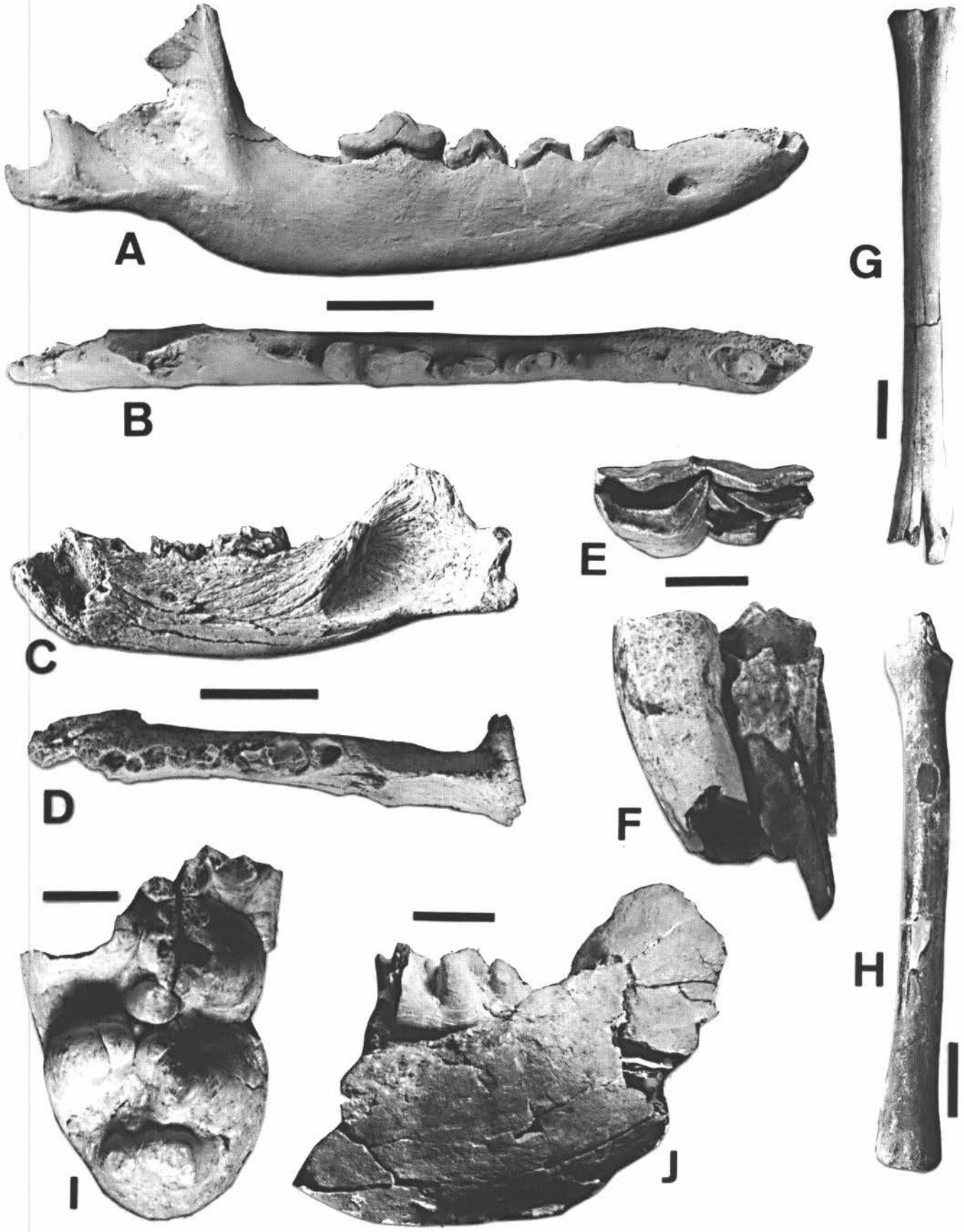


FIGURE 5. Fossil carnivores, camels, and proboscideans from the Blancan (Pliocene) Tonuco Mountain local fauna, Doña Ana County, New Mexico. **A,** right lateral view and **B,** occlusal view, *Canis lepophagus*, right mandible with p2-m1, NMMNH P-27149. **C,** left lateral view and **D,** occlusal view, *Taxidea* sp., left mandible with partial m1, NMMNH P-27166. **E,** occlusal view and **F,** medial view, *Camelops* sp., lower m2, NMSU uncat. **G,** *Hemiauchenia blancoensis*, metacarpal, NMMNH P-27141. **H,** *Hemiauchenia* sp., juvenile radius-ulna, NMMNH P-27140. **I,** occlusal view of m3 and **J,** medial view of mandible, *Cuvieronius* sp., NMMNH P-27217. Scale bars are 2 cm for A–F, I; 5 cm for G, H, J.

Referred specimens

Locality L-3385: NMMNH P-27166, left mandible with partial m1 and roots of p2-p4.

Locality L-3563: NMMNH P-27200, proximal end of left ulna.

Discussion

A nearly complete left dentary with a partial m1 (Figs. 5C, 5D) is very similar to a mandible referred to the badger *Taxidea* (F:AM 62842) from the Blancan Buckhorn lf (Morgan et al., 1997). The two Blancan badger mandibles from New Mexico are similar in size, dental morphology, and conformation of the ramus to mandibles of the living badger, *T. taxus,* a common living inhabitant of New Mexico. These mandibles are considerably larger and the talonid of m1 is comparatively shorter than in fossils of the extinct genus of badger, *Pliotaxidea*, from Hemphillian sites in western North America (Wagner, 1976).

Measurements (in mm) of the Tonuco *Taxidea* mandible are as follows (all dental measurements are of the alveoli; measurements in parentheses are from the Buckhorn *Taxidea* mandible, F:AM 62842): p3 length, 7.1 (6.9); p4 length, 9.3 (8.4); m1 length, 15.5 (14.4); m1 talonid width, 7.5 (7.2), alveolar length of tooth row (c1-m2), 52.8 (54.3); total length of dentary (mandibular symphysis to articular condyle), 88.4 (Buckhorn jaw incomplete).

Taxidea has been reported from several other Blancan faunas in western North America, including Hagerman in Idaho, Broadwater and Sand Draw in Nebraska, Rexroad in Kansas, and Cita Canyon and Red Light in Texas (Kurtén and Anderson, 1980). Additional comparisons with other Blancan badgers are necessary before the *Taxidea* mandibles from the Tonuco Mountain and Buckhorn local faunas can be identified to the species level.

Family Canidae
Canis lepophagus Johnston, 1938

Referred specimens

Locality L-2934: NMMNH P-25480, right calcaneum; NMMNH P-25479, proximal end of left metacarpal II.

Locality L-3383: NMMNH P-27149, right mandible with p2-m1.

Locality L-3567: NMMNH P-27222, proximal end of right ulna.

Discussion

A right mandible with p2-m1 (Figs. 5A, 5B) of a medium-sized canid is referred to the widespread Blancan coyote-like species, *Canis lepophagus*. The dentary is nearly complete, lacking only the proximal portion of the coronoid process. The horizontal ramus is long and slender and has a strong, hook-like angular process. A single mental foramen is located on the lateral surface of the dentary below p1. The mandibular symphysis extends posteriorly to a point below the anterior root of p2. All four of the preserved teeth are heavily worn, but retain enough of the crown for accurate measurements (see below). The canine is separated from the p1 by a sizeable diastema (8.1 mm), and all of the premolars are separated by diastemata, ranging from 4.0 mm between p1 and p2 to 1.5 mm between p3 and p4. The p1 is absent but was a small, single-rooted tooth. The remaining three premolars are two-rooted and rather narrow. Both p3 and p4 have a posterior accessory cuspule. Most dental features on the m1 have been obliterated by heavy wear, but a fairly large metaconid appears to have been present. The Tonuco mandible compares closely to the description and figures of *Canis lepophagus* from the Blancan Hagerman lf in Idaho (Bjork, 1970) and the Cita Canyon (Kurtén, 1974) and Red Light (Akersten, 1972) local faunas in Texas.

Measurements (in mm) of the *Canis lepophagus* mandible (NMMNH P-27149) from the Tonuco Mountain lf are: c1 length (alveolus), 13.7; c1 width (alveolus), 6.9; p2 length, 10.5; p2 width, 3.9; p3 length, 11.4; p3 width, 4.5; p4 length, 12.8; p4 width, 5.1; m1 length, 21.3; m1 trigonid width, 8.9; m1 talonid width, 8.5; alveolar toothrow length (c1-m2), 102.2; total length (symphysis to angular process), 165. These measurements are generally within the range of variation for measurements of *C. lepophagus* lower teeth from Hagerman, Cita Canyon, and Red Light (Bjork, 1970; Akersten, 1972; Kurtén, 1974). Several measurements of the Tonuco mandible, including length of m1, are somewhat larger than these other Blancan *C. lepophagus*. The overall similarity in size and morphology of the Tonuco Mountain canid with published samples of *C. lepophagus* from other western Blancan faunas confirms its identity as this species. The three postcranial elements are tentatively referred to *C. lepophagus* based on their resemblance in size and morphology to the coyote, *C. latrans*.

Canis lepophagus is a characteristic Blancan species (Kurtén and Anderson, 1980), occurring in many faunas in the western United States spanning the time range from the early through the late Blancan (between about 4.5 and 2.0 Ma). *C. lepophagus* is a good Blancan indicator, but its presence does not help to place the Tonuco Mountain lf more precisely within the Blancan. The Tonuco jaw is slightly larger than a coyote-like mandible, tentatively identified as either *C. latrans* or *C. lepophagus*, from an early Irvingtonian fauna in the Mesilla Basin in Doña Ana County, New Mexico (Vanderhill, 1986).

cf. *Borophagus* sp.

Referred Specimen

Locality L-2934: NMMNH P-25478, proximal end of right metacarpal IV.

Discussion

A proximal metacarpal IV is from a canid, but it is much larger than the coyote-sized species, *Canis lepophagus*. This specimen is about the size of the comparable element in the wolf, *C. lupus*, which puts it in the size range of the only large Blancan canid, the borophagine *Borophagus*. Measurements of the Tonuco metacarpal IV (NMMNH P-25478) are: proximal width, 12.0 mm; proximal depth, 13.3 mm. The only previous record of *Borophagus* from New Mexico is a complete mandible and an incisor of *B. diversidens* from the middle Blancan Cuchillo Negro Creek lf in Sierra County (Lucas and Oakes, 1986). The hyaena-like or bone-eating dogs of the genus *Borophagus* are among the most characteristic of all Blancan mammals.

Order Perissodactyla
Family Equidae
Nannippus cf. *N. peninsulatus* (Cope, 1885)

Referred specimens

Locality L-3383: NMMNH P-27150, left dp2.

Locality L-3566: NMMNH P-27218, edentulous fragment of left mandible.

Discussion

A deciduous lower premolar and a partial edentulous mandible from Tonuco Mountain are identified as the small three-toed horse, *Nannippus* cf. *N. peninsulatus*. An isolated unworn dp2 (NMMNH P-27150) is much smaller than the dp2 of any Blancan species of Equus. This tooth is completely unworn, suggesting it came from a very young juvenile. This tooth retains a rather thick coating of cementum on the crown, but the visible enamel pattern appears to be rather simple, except for a series of plications along the internal border of the hypoconid (Figs. 6B, 6C). This tooth is more elongate antero-posteriorly and narrow transversely than the permanent p2. Owing to the overall shape of the tooth, many of the dental features are also narrow and elongated compared to the p2, including the protoconid, hypoconid, and metaconid/metastylid. The Tonuco dp2 closely matches the descriptions and figures of *Nannippus peninsulatus* (=*N. phlegon*) dp2s from two late Blancan sites, Mt. Blanco, Texas and Santa Fe River, Florida (MacFadden and Waldrop, 1980). Measurements (in mm) of the Tonuco *Nannippus* dp2 are: antero-posterior length at top of crown, 22.8; antero-posterior length at base of crown, 20.2; maximum width, 7.9; metaconid/metastylid crown height, 21.3. These measurements are within the range of variation for dp2s of *N. peninsulatus* from Mt. Blanco and the Santa Fe River (MacFadden and Waldrop, 1980, tables 3, 4).

An edentulous fragment of a left dentary with alveoli for p2-m2 (NMMNH P-27218) is also tentatively referred to *Nannippus peninsulatus*. A long diastema separating the incisors from the cheek teeth, molariform premolars, and small size confirm the identification of this specimen as *Nannippus* (Fig. 6A). The presence of well-defined roots suggests that this mandible was from a fairly old individual. The alveoli for p2 through m1 are complete. Measurements (in mm) of these alveoli are: p2 length, 14.9; p2 width, 8.4; p3 length, 13.7; p3 width, 10.2; p4 length, 14.5; p4 width, 10.2; m1 length, 12.9; m1 width, 10.0. These measurements compare well with measurements of the lower cheek teeth (which average slightly larger than alveolar measurements) of *N. peninsulatus* from Mt. Blanco and Sante Fe River (MacFadden and Waldrop, 1980, tables 3, 4).

Two species of *Nannippus* occur in the Blancan. The widespread *N. peninsulatus* (generally called *N. phlegon* in the older literature) has been reported from early through late Blancan faunas in Arizona, Florida, Kansas, Nebraska, New Mexico, and Texas (Kurtén and Anderson, 1980; MacFadden and Waldrop, 1980). *N. beckensis* is known only from the middle Blancan Beck Ranch lf in Texas (Dalquest and Donovan, 1973). The measurements of the Tonuco dentary are at the small end of the size range for *N. peninsulatus* from Texas and Florida (MacFadden and Waldrop, 1980) and are smaller than *N. beckensis* (Dalquest and Donovan, 1973). The length of the Tonuco dp2 overlaps with both of these species, but is narrower than any of the dp2s of *N. beckensis*. The two Tonuco *Nannippus* fossils are tentatively referred to *N. peninsulatus* on the basis of their similarity in size.

There are four other Blancan records of *Nannippus* from New Mexico: Las Palomas Creek in Sierra County (Tedford, 1981), the Mesilla Basin in Doña Ana County (Vanderhill, 1986), Buckhorn in Grant County (Morgan et al., 1997), and Pearson Mesa in Hidalgo County (Tedford, 1981; Tomida, 1987). Both Tedford (1981) and Tomida (1987) suggested that the occurrence of *Nannippus* was indicative of pre-late Blancan faunas (older than 2.5 Ma) in the southwestern United States. Tomida (1987) placed the Pearson Mesa fauna in the middle Blancan within the Gauss Chron. Vanderhill (1986) considered his Faunule A in the Mesilla Basin to be about 2.5 Ma in age based on the association of Nannippus with the Neotropical immigrant glyptodont, *Glyptotherium*, and on their occurrence in normally magnetized sediments of the late Gauss chron.

Equus (Dolichohippus) simplicidens (Cope, 1893)

Referred specimens

Locality L-2934: NMSU 126, left M1 or M2; NMSU 137, metacarpal III.

Locality L-3383: NMMNH P-27151, partial left M1 or M2; NMMNH P-27152, partial right m3.

Locality L-3385: NMMNH P-27168, right m2.

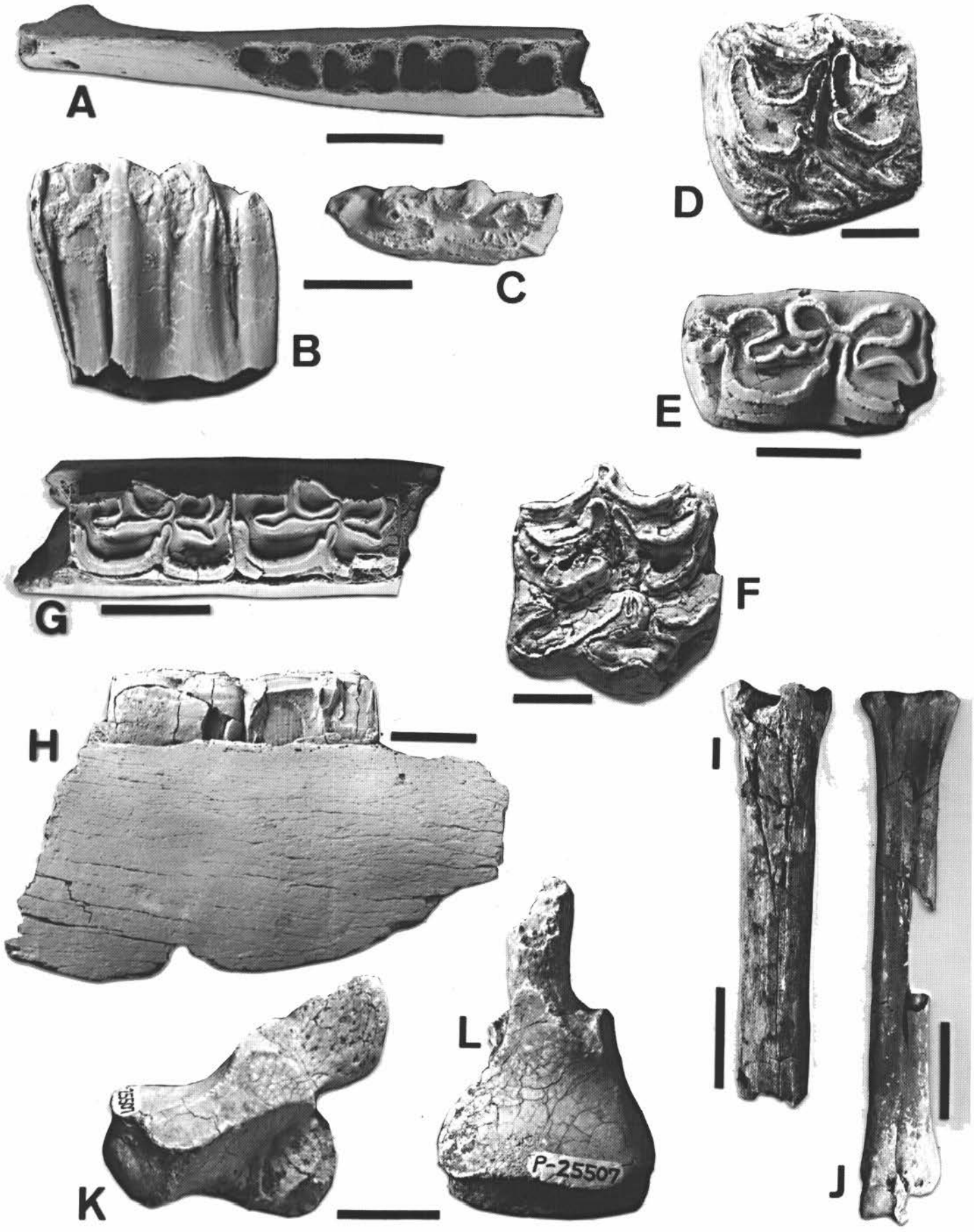
Locality L-3388: NMMNH P-27187, metatarsal III.

Discussion

There are two species of *Equus* in the Tonuco Mountain lf, both of which are fairly large. Four isolated teeth are referred to the typical Blancan horse, *Equus simplicidens*. A complete upper M1 or M2 (NMSU 126, Fig. 6D) is characterized by its simple enamel pattern (the fossettes have no more than two enamel plications), short protocone lacking a lingual identation, strong hypoconal groove, and lack of a pli caballin. An unworn and probably unerupted M1 or M2 (NMMNH P-27151) is lacking the lingual half of the tooth, but the fossettes have a simple enamel pattern. Measurements (in mm) of these two M1/M2s (NMSU 126; NMMNH P-27151, respectively) are: antero-posterior length, 27.3, 28.3; transverse breadth, 28.6, (NMMNH P-27151 is broken lingually); crown height, 67, 72. Two lower molars are identified as *E. simplicidens* by their size and the deep penetration of the ectoflexid between the metaconid and metastylid, nearly contacting the linguaflexid (Fig. 6E). Measurements of these two lower molars (NMMNH P-27168, right m2; NMMNH P-27152, right m3, respectively) are: antero-posterior length, 25.4, 32.7; transverse breadth, 14.5, 15.0; crown height, 65, 50.

Numerous postcranial elements of *Equus* are represented in the Tonuco Mountain lf, but only a few of these are complete enough to be identified to the species level. A metacarpal III and a metatarsal III (Fig. 6J) are referred to *E. simplicidens* primarily on the basis of size. They are from a fairly large horse, but are neither as large nor as robust as a proximal metatarsal III from the Tonuco Mountain lf referred below to *E. scotti*. They are shorter and more robust than comparable metapodials of the stilt-legged horse, *E. calobatus*, and are larger than metapodials of *E. cumminsii* (Akersten, 1972; Vanderhill, 1986). Measurements (in mm) of a metacarpal III (NMSU 137) and a metatarsal III (NMMNH P-27187), respectively, from the Tonuco fauna are: total length, 240, 278; proximal width, 48, 50; proximal depth, 37, 42; distal width, 45, 43; distal depth, 33, 34.

FIGURE 6. Fossil horses from the Blancan (Pliocene) Tonuco Mountain local fauna and a rhinoceros (*Teleoceras*) carpal from the Miocene Rincon Valley Formation, Doña Ana County, New Mexico. **A,** *Nannippus* cf. *N. peninsulatus*, edentulous fragment of left mandible, NMMNH P-27218. **B,** medial view and **C,** occlusal view, *Nannippus* cf. *N. peninsulatus*, left deciduous p2, NMMNH P-27150. **D,** *Equus simplicidens*, left M1 or M2, NMSU 126. **E,** *Equus simplicidens*, right m2, NMMNH P-27118. **F,** *Equus scotti*, right M1 or M2, NMMNH P-27167. **G,** occlusal view and **H,** lateral view, *Equus scotti*, partial right mandible with p3-p4, NMMNH P-27201. **I,** *Equus scotti*, proximal end of metatarsal III, posterior view, NMMNH P-27202. **J,** *Equus simplicidens*, metatarsal III, posterior view, NMMNH P-27187. **K,** medial view and **L,** proximal view, *Teleoceras* sp., magnum, NMMNH P-25507. Scale bars are 1 cm for B–F; 2 cm for A, G, H, K, L; 5 cm for I, J.


A
B
C
D
E
F
G
H
I
J
K
L
P-25507

Equus simplicidens is one of the most characteristic and widely distributed mammals in North American Blancan faunas. This horse has a long stratigraphic range covering much of the Blancan, but appears to be absent from very early Blancan faunas (Kurtén and Anderson, 1980). *E. simplicidens* is known from five other Blancan faunas in New Mexico: Arroyo de la Parida in Socorro County (Tedford, 1981); Cuchillo Negro Creek (Lucas and Oakes, 1986), Elephant Butte Reservoir, and Las Palomas Creek (Tedford, 1981) in Sierra County; and Buckhorn in Grant County (Morgan et al., 1997).

Equus scotti Gidley, 1900

Referred specimens

Locality L-3385: NMMNH P-27167, right M1 or M2.

Locality L-3563: NMMNH P-27201, fragment of right mandible with p3-p4; NMMNH P-27202, proximal end of metatarsal III.

Discussion

A second large species of *Equus* is represented in the Tonuco Mountain lf by an upper molar, a partial mandible, and a proximal metatarsal. An isolated M1 or M2 (NMMNH P-27167) differs in several important dental characters from upper molars referred above to *E. simplicidens*, including a more complicated enamel pattern (five to seven enamel plications are present on the fossettes); more elongated protocone with a lingual indentation; and well-developed pli caballin (Fig. 6F). This tooth is also somewhat less curved and higher crowned than upper cheek teeth of *E. simplicidens*. Measurements (in mm) of the Tonuco *E. scotti* M1/ M2 (NMMNH P-27167) are: antero-posterior length, 28.6; transverse breadth, 28.2; protocone length, 12.5; crown height, 72.7.

A partial mandible with right p3-p4 (Figs. 6G, 6H) is referred to *Equus scotti* based on its similarity in size and dental pattern to *E. scotti* lower dentitions from the Gilliland lf of Texas (Hibbard and Dalquest, 1966, fig. 6, table II). The lower premolars from Tonuco Mountain are considerably larger, particularly in the transverse dimension, than lower cheek teeth of *E. simplicidens* from this site. Measurements of Tonuco *E. scotti* lower premolars (NMMNH P-27201; p3 and p4, respectively) are: antero-posterior length, 32.1, 31.5; transverse breadth 22.6, 22.1. A proximal metatarsal (Fig. 6I) from Tonuco Mountain is also referred to *E. scotti* on the basis of its large size and robust shaft compared to an *E. simplicidens* metatarsal from the same site (see account above). Measurements of the Tonuco *E. scotti* metatarsal (NMMNH P-27202) are: proximal width, 56; proximal depth, 46. These are very similar to measurements of *E. scotti* metatarsals from Gilliland, Texas (Hibbard and Dalquest, 1966).

Equus scotti is a common large horse in late Blancan and early Irvingtonian faunas in the southwestern United States. Other records of *E. scotti* from New Mexico include Santo Domingo Pueblo (latest Blancan) in Sandoval County (Tedford, 1981), Tijeras Arroyo (early Irvingtonian) in Bernalillo County (Lucas et al., 1993), Arroyo de la Parida (middle or late Blancan) in Socorro County (Tedford, 1981), and the Mesilla Basin (late Blancan/early Irvingtonian) in Doña Ana County (Vanderhill, 1986; Harris, 1993).

Order Artiodactyla

Family Tayassuidae

Platygonus cf. *P. bicalcaratus* Cope, 1892

Referred specimens

Locality L-2934: NMMNH P-27136, mandible fragment; NMMNH P-25486, left distal tibia; NMMNH P-25487, proximal metapodial; NMMNH P-27142, proximal phalanx.

Discussion

There are four peccary fossils from the Tonuco Mountain sites, only one of which, a mandibular fragment, provides much useful taxonomic information. The mandible (NMMNH P-27136) consists of a partial symphysis with alveoli for the left and right canines, the diastema on the right side, and alveoli and roots for the right p2. It compares closely to a mandible of *Platygonus compressus* from a late Pleistocene site in northern New Mexico, but is larger. The Tonuco jaw is tentatively referred to the large Blancan species of *Platygonus*, *P. bicalcaratus*, originally described from Mt. Blanco, Texas. Tayassuids have been reported from two other Blancan faunas in New Mexico, Las Palomas Creek in Sierra County (Tedford, 1981) and Buckhorn in Grant County (Morgan et al., 1997).

Family Camelidae

Camelops sp.

Referred specimens

Locality L-2934: NMMNH P-27137, partial upper molar; NMSU uncatalogued, m2; NMMNH P-27138, ascending ramus of mandible with coronoid process and articular condyle; NMMNH P-27139, left proximal femur.

Locality L-3564: NMMNH P-27216, partial proximal phalanx.

Discussion

Several teeth and postcranial elements of large camels from the Tonuco Mountain lf are referred to *Camelops*. These fossils are larger than comparable elements of *Hemiauchenia*, but are smaller than the giant Blancan camels such as *Gigantocamelus* and *Titanotylopus*. A partial upper molar and a nearly complete lower m2 are similar in morphology and size to *Camelops*. The partial upper molar (NMMNH P-27137) has a transverse width of 29.5; the lower m2 (NMSU uncat.) has an antero-posterior length of 52.5 and transverse width of 21.1. The upper molar is within the size range of *C. hesternus* from the Pleistocene (Webb, 1965, table 5). The m2 is larger than lower molars of *C. hesternus* and lacks cement in the enamel lakes (Figs. 5E, 5F), and thus is similar to several *Camelops* lower molars from the Mesilla Basin in southernmost New Mexico (Vanderhill, 1986). A large undescribed species of *Camelops* appears to be present in the Mesilla Basin and several other southwestern Blancan faunas (Vanderhill, 1986), possibly including Tonuco Mountain.

Comparisons with measurements of *Camelops hesternus* in Webb (1965) and with a mounted specimen in the NMMNH indicate that several other large camelid specimens from the Tonuco Mountain sites are referable to *Camelops*, including an edentulous mandible fragment, a proximal femur, and a proximal phalanx. Postcranials of *Camelops* also were reported from the Blancan Buckhorn lf in Grant County (Morgan et al., 1997).

Hemiauchenia blancoensis (Meade, 1945)

Referred specimens

Locality L-2934: NMMNH P-27141, metacarpal.

Locality L-3383: NMMNH P-27154, distal tibia.

Locality L-3386: NMMNH P-27176, proximal metacarpal.
Locality L-3564: NMMNH P-27215, right astragalus.

Discussion

The smaller camels in the Tonuco Mountain lf are identified as *Hemiauchenia*. Two species of *Hemiauchenia* appear to be present, a larger species referred to the common Blancan camel, *H. blancoensis*, and a smaller species that may be undescribed. The most diagnostic bone of *H. blancoensis* from Tonuco Mountain is a nearly complete metacarpal (Fig. 5G). This fossil is much longer, but has a narrower proximal end and more slender shaft than metacarpals of *Camelops* (Webb, 1965, table 10). Measurements of the Tonuco *H. blancoensis* metacarpal (NMMNH P-27141) are: total length, 463; proximal width, 56; midshaft width, 33. A proximal metacarpal (NMMNH P-27176) from locality L-3386 is somewhat larger (proximal width 67) than P-27141, but is much smaller than *Camelops* and is also referred to *H. blancoensis*. Dalquest (1975) reported a metacarpal of *H. blancoensis* that is very similar in size to the more complete Tonuco metacarpal, measuring 465 mm in length. Two other camelid postcranial elements are referred to *H. blancoensis*, a distal tibia (NMMNH P-27154) with a distal articular width of 62 and an astragalus (NMMNH P-27215) with an antero-posterior length of 72.

Hemiauchenia blancoensis is a common species that occurs in faunas ranging in age from early Blancan to early Irvingtonian. *H. blancoensis* has been identified from two other Blancan sites in New Mexico, Buckhorn in Grant County (Morgan et al., 1997) and Faunule A from the Mesilla Basin in Doña Ana County (Vanderhill, 1986). Lucas and Oaks (1986) reported *Hemiauchenia* sp. from Cuchillo Negro Creek in Sierra County.

Hemiauchenia sp.

Referred specimens

Locality L-2934: NMMNH P-27140, juvenile radius-ulna; NMSU 124, proximal phalanx.

Discussion

A radius-ulna of a juvenile camelid from Tonuco Mountain is nearly complete, except that it lacks the distal epiphysis (Fig. 5H). This specimen is similar in morphology to the radius-ulna of *Hemiauchenia*, but is much smaller than *H. blancoensis*, the smallest camel reported from southwestern Blancan faunas. Measurements of the small Tonuco radius-ulna (NMMNH P-27140) are (measurements in parentheses are of the radio-ulna of *H. blancoensis* from the Blancan Buckhorn fauna, Morgan et al., 1997, table 8): total length, 381-estimated length with epiphysis about 400 (520); proximal articular breadth, 44 (67); distal breadth (just proximal to articular surface), 42 (86). Even taking into account that the Tonuco fossil is from a juvenile individual, these measurements are all considerably smaller than the comparable measurements of *H. blancoensis*. A proximal phalanx (NMSU 124) from Tonuco Mountain (total length, 85) is also much smaller than proximal phalanges of *H. blancoensis*.

Morgan et al. (1997) noted that several postcranial elements from the Blancan Buckhorn lf, including a proximal phalanx and two astragali, appeared to be smaller than typical *Hemiauchenia blancoensis*. Here we document the presence of a small *Hemiauchenia* in a second New Mexico Blancan site. Although *H. blancoensis* is supposedly the only species of this genus in the Blancan (Kurtén and Anderson, 1980), a second smaller and much rarer species may also be present. An undescribed dwarf species of *Hemiauchenia* is also known from several earliest Irvingtonian (latest Pliocene) sites in peninsular Florida (Morgan and Hulbert, 1995).

Order Proboscidea
Family Gomphotheriidae
Cuvieronius sp.

Referred Specimens

Locality L-3383: NMMNH P-27158, distal femur.
Locality L-3563: NMMNH P-25495-25497, 27207-27209, tooth fragments; NMMNH P-25498-25499, 27210, 27211, tusk fragments.
Locality L-3565: NMMNH P-27217, partial right mandible with incomplete m3.
Locality L-3567: NMMNH P-27226, 2 tooth fragments; NMMNH P-27227, nearly complete femur.

Discussion

The identification of *Cuvieronius* from the Tonuco Mountain lf is based primarily on a right dentary fragment with an incomplete m3 (NMMNH P-27217, Figs. 5I, 5J) from locality L-3565. The m3 is bunolophodont with at least four lophids and simple, single trefoils. The maximum width of the m3 is 78 mm. The small size and relatively simple crown pattern of this tooth conforms very well to the gomphothere *Cuvieronius* (e.g., Osborn, 1936; Lucas and González-León, 1997), and differs from *Stegomastodon*. It is possible that this specimen is *Rhynchotherium*, but this is difficult to determine because the symphyseal region is lacking in the fossil. The presence of lower tusks in *Rhynchotherium* and their absence in *Cuvieronius* is the most important morphological character separating these two genera. The lower third molars of *Rhynchotherium* are more lophodont, with smaller trefoils, than are those of *Cuvieronius* and the Tonuco fossil (Lucas and Morgan, 1996b; Lucas et al., 1997). We assign NMMNH P-27217 to *Cuvieronius*, although a species-level identification is not possible given the confused taxonomy of this genus. The remainder of the proboscidean fossils from the Tonuco Mountain sites are very fragmentary, and are only tentatively assigned to *Cuvieronius*.

This is the second Blancan record of *Cu ieronius* from New Mexico. Vanderhill (1986) reported *Cuvieronius* from his Faunule B, a Blancan/Irvingtonian transitional fauna from the Mesilla Basin in southernmost New Mexico. Early Irvingtonian fossils of *Cuvieronius* are known from several sites in the Las Cruces region (Hawley et al., 1969; Vanderhill, 1986; Harris, 1993; Lucas et al., this guidebook).

AGE OF THE TONUCO MOUNTAIN LOCAL FAUNA

Six species of mammals in the Tonuco Mountain local fauna are indicative of the Blancan land mammal age (between 4.5 and 2.0 Ma), *Canis lepophagus*, *Borophagus sp*., *Nannippus* cf. *N. peninsulatus*, *Equus* (*Dolichohippus*) *simplicidens*, *Platygonus* cf. *P. bicalcaratus*, and *Hemiauchenia blancoensis*. Several taxa help to further constrain the age of the Tonuco Mountain lf within the Blancan. *E. simplicidens* is absent from very early Blancan faunas (Kurtén and Anderson, 1980). There are a number of mammalian genera that appear in North American faunas at the beginning of the middle Blancan (at about 3.7 Ma), two of which occur in the Tonuco sites, *Platygonus* and *Camelops* (Lindsay et al., 1984). Most Blancan records of *Nannippus* in the southwestern United States predate the Gauss-Matuyama magnetic reversal at 2.58 Ma, and

are thus either early or middle Blancan in age (Tedford, 1981; Galusha et al., 1984; Vanderhill, 1986; Tomida, 1987). Based on these first and last appearance data, the association of *Nannippus*, *E. simplicidens*, *Platygonus*, and *Camelops* in the Tonuco Mountain lf would seem to rule out both early Blancan (4.5-3.7 Ma) and late Blancan (2.5-2.0 Ma) faunas, restricting the age of this fauna to middle Blancan (3.7-2.5 Ma).

The absence of Neotropical immigrants (glyptodonts, ground sloths, capybaras, and porcupines) from the Tonuco Mountain sites suggests that this fauna predates the Great American Faunal Interchange, which began in the latter part of the middle Blancan (late Gauss chron) between 2.8 and 2.6 Ma (Galusha et al., 1984; Lindsay et al., 1984). It is prudent to be very cautious when using the absence of taxa in biostratigraphic studies; however, the Tonuco Mountain sites have been collected extensively over the past ten years, and no specimens of South American immigrants are known from among the more than 150 identifiable vertebrate fossils. Fossils of the immigrant glyptodont *Glyptotherium* occur in association with *Nannippus* in the late Gauss age Faunule A in the Mesilla Basin in Doña Ana County (Vanderhill, 1986), located about 60 km south of the Tonuco Mountain sites near the Texas and Mexico borders. Other faunas in the region that record the association of *Nannippus* and *Glyptotherium* in the late Gauss chron are the Hudspeth lf in southwestern Texas (Strain, 1966; Vanderhill, 1986) and the 111 Ranch fauna in southeastern Arizona (Galusha et al., 1984; Tomida, 1987).

Mack et al. (1993) analyzed the magnetostratigraphy of the Camp Rice Formation section in the vicinity of Cedar Hill southeast of Tonuco Mountain, the same strata that produced the Tonuco Mountain lf. Mack et al. (1993, fig. 5) determined that the entire Camp Rice section at Cedar Hill is within the Gauss chron (between 3.58 and 2.58 Ma), and includes both the Mammoth (between 3.33 and 3.22 Ma) and Kaena (between 3.11 and 3.04 Ma) subchrons. We follow the revised dates of Berggren et al. (1995) for the chron and subchron boundaries. Our measured section of the Camp Rice Formation at Cedar Hill (Fig. 3) and the section of Mack et al. (1993, fig. 4) are very similar in thickness (about 50 m), and therefore we can make a reasonable estimation where the vertebrate fossils fit relative to the magnetostratigraphy. We found fossils throughout the Camp Rice Formation in the Cedar Hill area, from near the base of the section in unit 3, in the lower normal portion of the Gauss (younger than 3.6 Ma), up through unit 8, which appears to correspond to either the normal zone between the reversed Mammoth and Kaena subchrons or to the Kaena subchron. We did not find any fossils above unit 8, indicating that the Tonuco fossil sites are all older than the top of the Kaena (older than 3.0 Ma). The magnetostratigraphy of the Camp Rice Formation at Cedar Hill (Mack et al. 1993) constrains the age of the strata containing the Tonuco Mountain lf to between 3.6 and 3.0 Ma, which corroborates the middle Blancan age indicated by the mammalian biostratigraphy.

More than ten Blancan vertebrate faunas are now known from New Mexico, most of which are clustered in the Rio Grande rift basins from Albuquerque south to the Texas and Mexico borders (Tedford, 1981). Two other Blancan faunas, Buckhorn (Morgan et al., 1997) and Pearson Mesa (Tomida, 1987), are located in the Gila River Valley in the southwestern part of the state not far from the Arizona line. New Mexico's Blancan faunas cover most of the Blancan land mammal age from the early Blancan (about 4.0 Ma) at Truth or Consequences lf (Repenning and May, 1986) to the Blancan/Irvingtonian transitional faunas (2.5–2.0 Ma) in the Mesilla Basin (Vanderhill, 1986). The majority of New Mexico Blancan faunas appear to be middle Blancan (between 3.7 and 2.5 Ma), and are thus broadly similar in age to the Tonuco Mountain lf.

The middle or late Blancan Arroyo de la Parida lf from the Sierra Ladrones Formation northeast of Socorro in Socorro County shares the horses *Equus simplicidens* and *E. scotti* with the Tonuco Mountain lf (Tedford, 1981; Lucas and Morgan, 1996b). Several middle Blancan faunas from the Palomas Formation in the vicinity of Truth or Consequences in Sierra County, including Cuchillo Negro Creek (Lucas and Oakes, 1986), Elephant Butte Reservoir, and Las Palomas Creek (Tedford, 1981), are similar to Tonuco Mountain. Las Palomas Creek and Tonuco Mountain both record the association of *Nannippus* and *E. simplicidens*. Faunule A from the Mesilla Basin in southern Doña Ana County (Vanderhill, 1986) and the Hudspeth lf from the Hueco Bolson southeast of El Paso in Hudspeth County, Texas (Strain, 1966) are derived from the Camp Rice Formation. These two faunas document the co-occurrence of *Nannippus* and *Glyptotherium* in the upper Gauss chron, and are thus somewhat younger (late middle Blancan, between 2.8 and 2.6 Ma) than Tonuco Mountain. The Buckhorn lf from the Mangas Basin in Grant County is close in age to Tonuco Mountain, perhaps slightly older (between 4.0 and 3.0 Ma). Buckhorn and Tonuco Mountain share at least five species of mammals, including the horses *Nannippus* and *E. simplicidens*, the camels *Camelops* sp. and *Hemiauchenia blancoensis*, and the badger Taxidea (Morgan et al., 1997).

In summary, the Tonuco Mountain lf is early late Pliocene in age (between 3.6 and 3.0 Ma), which correlates with the middle Blancan of Tedford (1981). This equates with the late Blancan III or early Blancan IV of Repenning (1987), although it is difficult to make detailed comparisons with Repenning's biochronology because it is based on microtine rodents, which are not known from the Tonuco Mountain sites. Outside of New Mexico, other Blancan local faunas from the southwestern United States that are approximately correlative with the Tonuco Mountain lf are (ages mostly from Repenning, 1987; but also see Johnson et al., 1975; Dalquest, 1978; Czaplewski, 1987): Benson, Duncan, and Clarkdale in Arizona, Arroyo Seco in California; and Beck Ranch inTexas.

AGE OF THE RINCON VALLEY FORMATION

The Rincon Valley Formation mostly consists of a reddish mudstone that unconformably underlies the Camp Rice Formation throughout the Cedar Hill area southeast of Tonuco Mountain. Although the Rincon Valley Formation is generally unfossiliferous, Jerry MacDonald collected a single diagnostic vertebrate fossil from this unit in the Cedar Hill area, from either the NW¼ sec. 16 or the N½ sec. 17, T20S, R1W (NMMNH locality L-3003). The Rincon Valley fossil (NMMNH P-25507; Figs. 6K, 6L) compares well in morphology and size (maximum length 68.6 mm) to the magnum (carpal) of the rhinoceros *Teleoceras fossiger* from the early Hemphillian (late Miocene) Mixson Bone Bed in northern Florida (Harrison and Manning, 1983). This fossil can be excluded from the Blancan Tonuco Mountain fauna because it belongs to the family Rhinocerotidae, a group that became extinct in North America at the end of the Hemphillian land mammal age, about 4.5 Ma. The presence of rhinoceroses distinguishes the Hemphillian from the younger Blancan. Furthermore, a small sample of the reddish mudstone matrix of the Rincon Valley Formation still adheres to the specimen. A K-Ar date of 9.6 Ma for the Selden Basalt Member of the Rincon Valley Formation in Broad Canyon about 5 km southwest of the Cedar Hill fossil sites (Seager et al.,1984), is in reasonably close agreement with the Hemphillian age (between 9 and 4.5 Ma) indicated by the presence of *Teleoceras* cf. *T. fossiger*.

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A Laramide (latest Cretaceous–Eocene) thrust fault exposed at San Diego Mountain. Precambrian crystalline basement on the right is thrust over mostly silicified Paleozoic carbonate rocks. Photograph by Greg Mack.