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ANALYSIS OF HORSE (*EQUUS*) METAPODIALS FROM THE LATE PLEISTOCENE OF THE LOWER NUECES VALLEY, SOUTH TEXAS

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Abstract.—Ninety-eight relatively complete metapodials (29 metacarpals and 69 metatarsals) of *Equus* were recovered from late Pleistocene terrace and valley fill deposits along the Nueces River in western Nueces and San Patricio counties, Texas. Sixteen measurements were taken on each metapodial. Three species of *Equus* were determined to be present using discriminant functions and bivariate and multivariate plots of the data. *Equus* cf. *conversidens*, the most abundant species, is a small- to average-sized horse with normal length metapodials. It is similar to members of the *E. alaskae* group. The second species, represented by 24 metapodials, is assigned to *E.* cf. *scotti*. These are larger horses with robust limbs that resemble members of the *E. scotti* and *E. laurentius* groups. The third, represented by six specimens, is a stilt-legged horse of the *E. francisci* group.

The Wright Material Inc., sand and gravel pits along the Nueces River in western Nueces and San Patricio counties, Texas have produced a diverse assemblage of late Pleistocene fossils. Twenty-six species of mammals have been identified from here (Baskin 2000). Equids are among the most common fossils recovered. Living *Equus* includes horses, asses and zebras. Identification of fossil *Equus* to species from isolated teeth and bones is difficult at best (Winans 1989; Dalquest & Schultz 1992). Additionally, although most of the approximately 60 North American species that have been named are junior synonyms or invalid, the taxonomy of *Equus* itself is far from agreed on. Dalquest & Schultz (1992) identified seven or eight species of *Equus* from the Pleistocene (Irvingtonian and Rancholabrean) of northwestern Texas alone. Azzaroli (1998) recognized up to ten Pleistocene North American species. Winans (1989) recognized five species groups of North American *Equus*, of which no more than four groups were extant at a given time. Winans (1989) considered the possibility that each group represented a single species and that therefore only four species of *Equus* were present in North America during the Pleistocene.

The purpose of this paper is to determine how many species of *Equus* were present in the late Pleistocene Nueces River Valley deposits of south Texas and identify them. Voucher specimens are deposited with the holdings of the Texas Memorial Museum (TMM) of the University of Texas, Austin.

GEOLOGIC SETTING

Four alluvial terrace units and three younger valley fill units are recognized from late Pleistocene and Holocene sediments in the lower Nueces River Valley, Nueces and San Patricio counties, west of Corpus Christi, Texas, between Odem and Mathis, where the Nueces River is entrenched in the late Pleistocene Beaumont Formation (Cornish & Baskin 1995). The valley fill units are included in the Cayamon Creek Alloformation. Most of the metapodials described in this paper come from channel fill and point bar sands and gravels of the Cayamon Creek allomember 1 at the Wright Materials, Inc. quarries (TMM localities 43059 and 43064), approximately 4 km north of Bluntzer, Nueces County, Texas. A log buried in this unit has been carbon dated at 13,230 $\pm$ 110 YBP (Baskin 1991). Seven metatarsals were recovered across the river in the Angelita Terrace, San Patricio County (TMM locality 18594). These late Quaternary terraces and valley fill deposits have produced a mixed assemblage of early Pliocene and Pleistocene fossil vertebrates. The Pliocene horses are reworked from older updip deposits, presumably of the upper Goliad Formation (Baskin 1991).

Whether the Pleistocene vertebrates are all contemporaneous with the latest Pleistocene alluvium or are to some degree reworked cannot be easily determined. There is a wide variation in the nature of the preservation. Some of the bones and teeth are darkly stained and appear to be partly mineralized. Other specimens are quite fresh in appearance. The fossils consist mainly of isolated teeth and durable postcranial elements such as astragali, phalanges and metapodials that indicate that transportation and sorting of specimens has occurred (Hanson 1980). Some of the specimens are waterworn, but most are not. The fact that there are more than twice as many complete metatarsals as metacarpals is further evidence of hydrodynamic sorting. The presence of jaws of *Equus*, *Bison*, *Tapirus* and *Camelops* and a mammoth skull and associated partial skeleton suggests that some, if not most, of the Pleistocene specimens were not transported very far. *Bison* in the fauna is also indicative of a Rancholabrean (late Pleistocene) age. The presence of both *Bison latifrons* and *B. antiquus* may indicate some degree of mixing for the Rancholabrean fauna, because *B. latifrons* is sometimes considered an early Rancholabrean species (Guthrie 1970). However, *B. latifrons* may have survived into the late Rancholabrean (Pinsof 1991; Wyckoff & Dalquest 1997).

Methods and Materials

Metapodials are usually the most useful skeletal element available for identifying fossil *Equus* (Winans 1989). Skulls are rarely preserved and isolated teeth are highly variable. Ninety-eight complete metapodials (29 metacarpals and 69 metatarsals) were analyzed. Sixteen measurements (Eisenmann 1979; Winans 1989) were taken on each (Tables 1, 2). All measurements are in mm. Winans (1989: table 14.1) developed discriminant functions based on eight of these measurements to assign specimens to one of her five species groups: the *E. simplicidens* (early Blancan), *E. scotti* (late Blancan to early Rancholabrean), *E. laurentius* (Rancholabrean), *E. francisci* (Irvingtonian to Rancholabrean), and *E. alaskae* (Irvingtonian to Rancholabrean) groups. The Nueces River metapodials were initially assigned to one of the five species groups using these discriminant functions. Because reliability of these discriminant functions to correctly assign specimens to species varied from 61-91% (Winans 1989), the measurements were analyzed graphically using bivariate and multivariate plots (Figs. 1, 2) of the data to look for groupings of specimens and to emend species assignments. For the principal components analyses (Fig. 2), measurements (Tables 1, 2) used are 1, 4, 5, 10, 12, 14 and 15 for the metacarpals, and 1, 4, 5, 6B, 7, 10, 11, and 15 for the metatarsals (Fig. 2). This was done to compare the Nueces River results with the average values Winans (1989) used to determine her discriminant functions.

Material examined.—Equus cf. *conversidens* metacarpals TMM 43059-19 to -21, metatarsals TMM 43059-10 to -35 and TMM 18594-19 to -24; *Equus* cf. *scotti* metacarpals TMM 43059-22 to -32, metatarsals TMM 43059-36 to -59; *Equus* cf *francisci* metacarpals TMM 43059-33 to -35, metatarsals TMM 43059-61 to -62 and TMM 18594-25.

Results

The most common equid species from the Nueces River gravel pits is represented by 13 metacarpals and 42 metatarsals. These form relatively distinct clusters (Figs. 1, 2) centered near average values for the *E. alaskae* group of Winans (1989: table 14.2). They are assigned to *Equus* cf. *conversidens*, a small- to medium-sized horse with normally proportioned (i.e., stout-legged) metapodials. Winans (1989) assigned the small, stout-legged horses of Rancholabrean age to the *Equus alaskae* (originally *E. niobrarensis alaskae*) group. Azzaroli (1998) synonymized *E. niobrarensis alaskae* and *E. laurentius* with *E. ferus*

Table 1. Univariate statistics on metacarpal III's of *Equus* from the Nueces River Valley. Measurements are 1, greatest length [1, 1]; 2, lateral length [2,-]; 3, mid-shaft width [3, 6]; 4, mid-shaft anteroposterior breadth [4, 7]; 5, proximal articular width [5, 2]; 6, proximal articular breadth [6, 3]; 7, width of magnum facet [7, 5]; 8, width of anterior unciform facet [8, -]; 8', width of posterior unciform facet [8', -]; 9, width of trapezoid facet [9, -]; 10, distal supra-articular width [10, 8]; 11, distal articular width [11, 9]; 12, anteroposterior breadth of median ridge of trochlea [12, 11]; 13, least breadth of medial distal condyle [13, -]; 14, greatest breadth of medial distal condyle [14, 10]; 15, width plantar process [-, 4]. Numbers in brackets refer to the corresponding measurements in Eisenman (1986, fig. 39) and Winans (1989, fig. 14.5), respectively. A "-" indicates that measurement was not used by the respective author.

	Equus cf. *conversidens*				Equus cf. *scotti*				*Equus* cf. *francisci*		
	n	X ± *SD*	OR	cv	*n*	X ± *SD*	OR	cv	*n*	X	OR
1	13	221.1 ± 5.88	214-233	2.7	11	237.1 ± 8.76	224-252	3.7	3	246.3	244-249
2	13	215.5 ± 5.076	208-226	2.4	11	229.6 ± 8.65	217-245	3.8	3	241.3	237-244
3	13	31.91 ± 1.879	27.3-34.7	5.9	11	39.94 ± 1.710	37.3-42.4	4.3	3	32.90	31.4-34.6
4	13	24.73 ± 1.048	22.7-26.2	4.2	11	29.72 ± 1.273	28.0-31.3	4.3	3	25.90	24.9-26.9
5	13	45.19 ± 2.990	40.6-50.0	6.6	11	55.62 ± 1.505	53.2-58.4	2.7	3	46.20	43.9-48.9
6	13	31.16 ± 1.757	28.1-34.7	5.6	11	37.69 ± 1.959	35.7-41.8	5.2	3	32.13	30.9-33.1
7	13	38.11 ± 2.509	32.0-42.0	6.6	11	47.09 ± 2.165	43.9-51.0	4.6	3	39.33	38.0-41.3
8	11	12.48 ± 1.781	10.5-15.4	14.3	10	16.34 ± 1.838	13.7-19.2	11.2	3	13.63	13.0-14.9
8'	4	7.25 ± 1.613	6.1-9.6	22.3	10	11.05 ± 1.846	9.4-14.6	16.7	3	8.33	7.5-9.5
9	6	5.92 ± 1.028	4.5-7.2	17.4	8	7.75 ± 1.214	6.0-9.7	15.7	1	6.60	6.6-6.6
10	13	40.63 ± 4.377	29.3-45.8	10.8	11	52.49 ± 1.604	49.5-55.0	3.1	3	42.10	38.7-44.2
11	13	40.50 ± 3.086	35.6-44.7	7.6	11	52.18 ± 1.965	48.5-54.6	3.8	3	42.90	41.5-44.2
12	13	30.61 ± 2.589	27.2-34.8	8.5	11	40.12 ± 1.711	37.3-42.1	4.3	3	32.50	30.5-34.9
13	13	26.88 ± 1.817	22.5-29.7	6.8	11	32.81 ± 1.010	31.6-34.7	3.1	3	28.07	26.7-28.8
14	13	27.28 ± 2.217	22.0-30.8	8.1	11	34.61 ± 1.174	33.0-36.5	3.4	3	28.87	27.7-30.1
15	13	26.00 ± 2.052	23.2-29.3	7.9	11	33.81 ± 1.822	30.8-36.2	5.4	3	28.43	26.9-30.3

Table 2. Univariate statistics on metatarsal III's of *Equus* from the Nueces River Valley. Measurements are 1, greatest length [1, 1]; 2, lateral length [2,-]; 3, mid-shaft width [3, 6]; 4, mid-shaft anteroposterior breadth [4, 7]; 5, proximal articular width [5, 2]; 6a, medial proximal articular breadth [6, -]; 6b, lateral proximal breadth [-, 3]; 7, width of ectocuneiform facet) [7, 5]; 8, breadth of cuboid facet [8, -]; 9, breadth of mesoentocuneiform facet [9, -]; 10, distal supra-articular width[10, 8]; 11, distal articular width [11, 9]; 12, anteroposterior breadth of median ridge of trochlea [12, 11]; 13, least breadth of medial distal condyle [13, -]; 14, greatest breadth of medial distal condyle [14, 10]; 15, width plantar process [-, 4]. Numbers in brackets refer to the corresponding measurements in Eisenman (1986, fig. 39) and Winans (1989, fig.14.5), respectively. A "-" indicates that measurement was not used by the respective author.

	Equus cf. *conversidens*				Equus cf. *scotti*				*Equus* cf. *francisci*		
	n	X ± *SD*	OR	cv	*n*	X ± SD	OR	cv	*n*	X	OR
1	42	258.8 ± 9.56	236-273	3.7	25	286.9 ± 7.89	265-302	2.7	3	283.7	275-291
2	42	254.1 ± 9.59	232-270	3.8	24	280.4 ± 8.60	259-300	3.1	3	280.0	273-285
3	42	31.94 ± 2.766	24.7-37.9	8.7	25	37.73 ± 3.129	31.3-43.4	8.3	3	31.67	30.3-33.7
4	42	30.07 ± 2.219	24.0-35.1	7.4	25	35.10 ± 2.697	29.1-39.9	7.7	3	30.97	30.4-32.0
5	41	44.93 ± 3.577	35.9-50.5	8.0	25	54.19 ± 4.163	46.5-63.1	7.7	3	45.00	42.3-48.3
6A	37	38.88 ± 3.336	28.8-44.0	8.6	24	46.28 ± 4.077	37.8-52.1	8.8	2	41.15	39.5-42.8
6B	37	41.01 ± 3.411	34.0-46.6	8.3	24	49.45 ± 4.261	40.7-55.4	8.6	2	41.45	39.7-43.2
7	39	42.17 ± 3.169	35.9-48.0	7.5	24	50.35 ± 3.725	43.7-59.3	7.4	3	43.13	42.2-45.0
8	33	12.62 ± 1.549	9.4-15.5	12.3	21	13.92 ± 2.010	10.7-18.4	14.4	2	12.80	12.6-13.0
9	28	6.57 ± 1.526	4.5-10.3	23.2	18	8.48 ± 1.792	4.8-11.2	21.1	1	6.0	
10	42	42.79 ± 3.448	34.3-48.4	8.1	25	52.61 ± 4.052	45.6-61.4	7.7	3	36.80	28.1-44.3
11	42	41.77 ± 3.442	33.3-48.1	8.2	25	51.51 ± 3.469	45.6-59.2	6.7	3	40.43	38.3-43.0
12	41	32.13 ± 3.301	25.0-38.7	10.3	25	39.90 ± 2.756	34.4-45.1	6.9	3	30.37	27.4-32.2
13	41	26.42 ± 2.087	22.5-32.4	7.9	25	31.48 ± 1.997	27.2-35.7	6.3	3	25.70	22.6-27.9
14	41	28.39 ± 2.348	22.3-34.2	8.3	24	34.15 ± 2.176	30.0-37.0	6.4	3	27.70	24.8-29.3
15	39	19.97 ± 2.412	12.5-24.1	12.1	24	25.10 ± 3.170	19.9-31.2	12.6	3	21.03	20.8-21.5

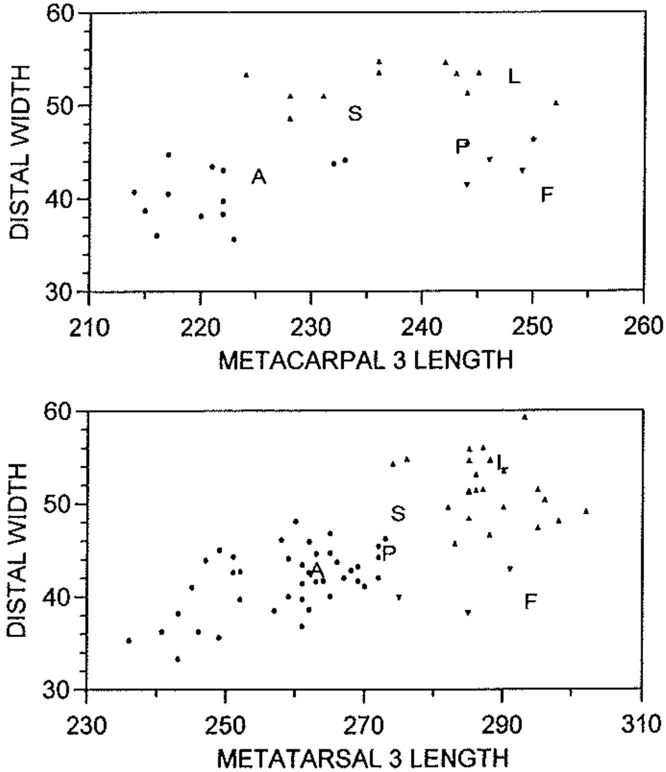

Figure 1. Scatterplots of greatest length versus distal articular width for medial metacarpals and metatarsals of *Equus*. Circles are specimens from the Nueces River Valley assigned to *E.* cf. *conversidens*, to *E.* cf. *scotti*; inverted triangles, to *E.* cf. *francisci*; and stars, to *E.* sp. The letters P, S, L, F and A refer to the average values for these measurement for the *E. simplicidens*, *E. scotti*, *E. laurentius*, *E. francisci* and *E. alaskae* groups (Winans 1989), respectively.

(=*E. caballus* - the extant domestic horse). He retained *E. conversidens* for the horse from San Josecito Cave and the smaller horse from Slaton (Dalquest & Hughes 1965). The dimensions of these metapodials (Tables 1, 2) are similar to those of *Equus* species A from the Irvingtonian Leisey Shell Pit of Florida. Hulbert (1995) noted that this taxon was intermediate in tooth row length between *E. conversidens* and *E. scotti*. However, metatarsals from Slaton assigned to *E. conversidens* are similar in length and distal width to the Leisey and Nueces River taxon. Length and distal width of metapodials of *E. conversidens* from San Josecito Cave are also within this range (Lundelius 1984).

These metapodials have somewhat higher coefficients of variation (Tables 1, 2), even for length, when compared to samples that are

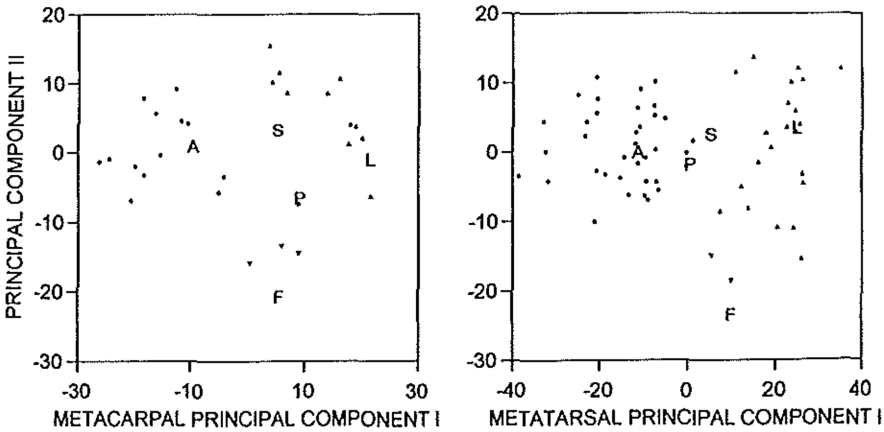

Figure 2. Principal components analysis using a covariance matrix on six measurements taken on medial metacarpals and metatarsals. See Fig. 1 for an explanation of the symbols and Tables 1 and 2 for measurements used. Principal component one accounted for 72% and 82% of the variance, and principal component 2, 24% and 14% for the metacarpals and metatarsals respectively.

probably not as temporally mixed, such as Rancho La Brea (Willoughby 1948) or Leisey (Hulbert 1997). This may indicate that more than one species is represented or time averaging within this species has occurred. Removing the six smallest metatarsals results in CV's that are comparable to the Rancho La Brea or Leisey samples. Although, these six are within the size range given by Winans for the *E. alaskae* (or even *E. scotti*) group, they could represent early Pliocene *Dinohippus* or a smaller species of *Equus* (e.g., *E. tau*, although Dalquest [1979] assigned relatively elongate metatarsals to that species). Two of these specimens are very worn distally, three display average wear, and one has no evidence of transport. Mooser & Dalquest (1975) attributed metatarsals and dentitions of the smallest horses from Cedazo to *E. conversidens*. These are similar in size to these six smallest Nueces River specimens. Somewhat larger, but similarly proportioned metatarsals, were assigned to *E. excelsus* (Mooser & Dalquest 1975). Rodruiguez Avalos (1999) referred all horses from Cedazo to a single species. Dalquest (1979) referred metatarsals 240-265 mm in length to *E. conversidens*, which would also include *E. excelsus* from Cedazo. Howe (1970) reported high CV values for *E. simplicidens* from Broadwater, comparable to the Nueces River sample, and concluded that because measurements were normally distributed, only a single species was present. Likewise, the smallest Nueces metatarsals are retained in *E.* cf. *conversidens*.

Equus cf. *scotti* is represented by 11 metacarpals and 24 metatarsals that are for the most part intermediate in size between the mean measurements determined by Winans (1989) for her *E. scotti* and *E. laurentius* groups. These are large horses with normally proportioned to robust limbs. Measurements (Tables 1, 2) are similar to those for *E. occidentalis* from Rancho La Brea (Willoughby 1948). The discriminant functions of Winans (1989) assigned the smaller of these individuals to the *E. scotti* group, the larger to the *E. laurentius* group. Four of the five metacarpals assigned to the *E. scotti* group are relatively short and stout. Winans (1989) used the *E. scotti* group for late Blancan to early Rancholabrean large, stout-legged horses and included *E. hatcheri* and *E. niobrarensis* in this group. Winans used the *E. laurentius* group for later Rancholabrean large horses which are similar to *E. scotti*. *Equus laurentius* is probably based on a recent specimen (Winans 1989; Azzaroli 1998) and is therefore an invalid name. Winans (1989) referred *E. occidentalis* to the *E. laurentius* group. Scott (1998) stated that *E. scotti* was replaced by *E. occidentalis* in the late Pleistocene of California.

The most important previous collections of Rancholabrean *Equus* from South Texas are from Ingleside (Lundelius 1972), Berclair terraces (Quinn 1957), and Cueva Quebrada (Lundelius 1984). The Ingleside sample, which does not include any metapodials, was originally referred to three species: most of the specimens to *E. complicatus*, a few larger specimens to *E. pacificus* and a few smaller to *E. fraternus*. Winans (1989) referred the entire sample to the *E. scotti* group. Two species were described from Cueva Quebrada: a stouter *E.* cf. *scotti* and a slenderer *E. francisci*. Winans (1989) referred the stout-limbed species to the *E. laurentius* group; the stilt-limbed is not discussed, but belongs to the *E. francisci* group. The stout-legged metapodials are similar to those from the Nueces River Valley. Azzaroli (1998) referred the large stout-limbed horses from the late Pleistocene of South Texas to *E. excelsus*, which he considered a senior synonym of *E. scotti*. He differentiated *E. excelsus* from *E. occidentalis* on the basis of dentition, but suggested the two were closely related. Dalquest & Schultz (1992) stated that *E. excelsus* was a medium-sized horse and that the larger caballine horses of the late Pleistocene may have been *E. scotti*.

The third species, represented by six specimens, is a stilt-legged ass of the *E. francisci* group. The metapodials are similar in size to specimens assigned to *E. francisci* (e.g., Lundelius & Stevens 1970;

Lundelius 1984). The type of *E. francisci* is from the Lissie Formation, Wharton County, Texas (Lundelius & Stevens 1970). Dalquest and Schultz (1992) recognized three or four species of stilt-legged horses, including *E. pseudaltidens*. *Equus pseudaltidens* (Hulbert 1995) was described from the late Pleistocene Berclair terrace, Bee County, Texas as *Onager altidens* Quinn (1957). The reported metatarsal length is 283 mm, similar in size to specimens referred to *E. francisci*. Based on dental characteristics, Hulbert considered *E. pseudaltidens* to be distinct from *E. francisci*.

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Errata

Specimens analyzed are *Equus* cf. *conversidens* metacarpals TMM 43059-72 to 84, metatarsals 43059-10 to 45 and 18594-19 to 24; *E.* cf. *scotti* metacarpals 43059-88 to 98, metatarsals 43059-48 to 71; and *E.* cf. *francisci* metacarpals 43059-85 to 87, metatarsals 43059-46 and 47 and 18594-25.