LATE PLEISTOCENE HORSES OF DRY CAVE, EDDY COUNTY, NEW MEXICO

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ABSTRACT. *Equus conversidens* Owen, *E. niobrarensis* Hay, *E. occidentalis* Leidy referred, *E. scotti* Gidley referred, and a small zebrine horse are recognized from late Pleistocene deposits of Dry Cave, southeastern New Mexico. *Equus midlandensis* Quinn is synonymized with *E. niobrarensis;* New Mexican specimens previously recognized as *E. scotti* are identified as *E. niobrarensis.* Cluster analysis of measurements of single elements, acting on matrices of taxonomic distances, appears to allow assignment of intermingled elements to species more successfully than do traditional comparative methods. Cluster analysis based on correlation matrices of limb proportions indicates close similarity of *E. niobrarensis* to *E. przewalskii* Poliakoff. Dental characters and cluster analysis suggest that *E. conversidens* belongs to the subgenus *Hemionus* or was derived from that subgenus.

Dry Cave, 24 km W Carlsbad, Eddy Co., New Mexico, 1,280 m, has produced many late Pleistocene fossils, including several hundred elements of horses (*Equus*, sensu lato), now stored in the Vertebrate Paleobiology Collections, Laboratory for Environmental Biology, The University of Texas at El Paso (UTEP). Most of the *Equus* material dates from between 15,030 and 10,730 radiocarbon years before present (BP), and is associated with a pluvial fauna. A few remains are about 34,000 years old and are accompanied by a fauna implying interstadial climate.

The fossils are from fissure fills. Most material is from the Entrance Fissure, the present entrance to the cave system. Approximately 10 m of fill has accumulated since the fissure first opened to the surface. The sediments are accessible at various places where passageways or chambers have intersected the fissure. Sites include UTEP Loc. 23, 11,880 BP (I-5987); Loc. 25, undated, but probably earlier than the previous locality; Loc. 31, between 11,880 and 15,030 BP, but nearer the latter date; and Loc. 22, with a bone date of 15,030 ± 210 BP (I-6201) at the lowest level of the fissure excavated. Other Pleistocene material entered by a now closed entrance, Bison Sink. Associated localities are UTEP Loc. 6, 14,470 ± 250 BP on rodent dung (I-3365); Loc. 4, >10,730, <14,470, on stratigraphic grounds; Loc. 3, no date; and Loc. 54, 10,730 ± 150 (I-6200). UTEP Loc. 12 contains modern sediments mixed with material derived from Loc. 54. Identifiable horse material from the interstadial deposits is limited to UTEP Loc. 26. A C^{14} date on bone carbonates is 33,590 ± 1,500 BP (TX-1773). Several areas produced associations of elements judged on spacial distribution, preservation, and size factors to be from single individuals.

The literature on fossil horses makes clear the inadequacies of traditional methods of study (e.g., see comments of Stirton, 1939; Savage, 1951; Dalquest, 1967). Most workers emphasized qualitative characters and have used few dental measurements; the same is true for cranial and post-cranial elements. Intraspecific variability commonly has been underestimated. As a result, more than 50 species of *Equus* have been named from the New World alone—yet only a fraction of this number can be valid and many are based on such inadequate holotypes as to be indeterminate. The objectives of this study included not only the identification, characterization, and comparison of the Dry Cave horses with other Southwestern occurrences, but also the testing of study methods seldom applied to the genus. These methods include several techniques derived from numerical taxonomy and multivariate discriminant analysis.

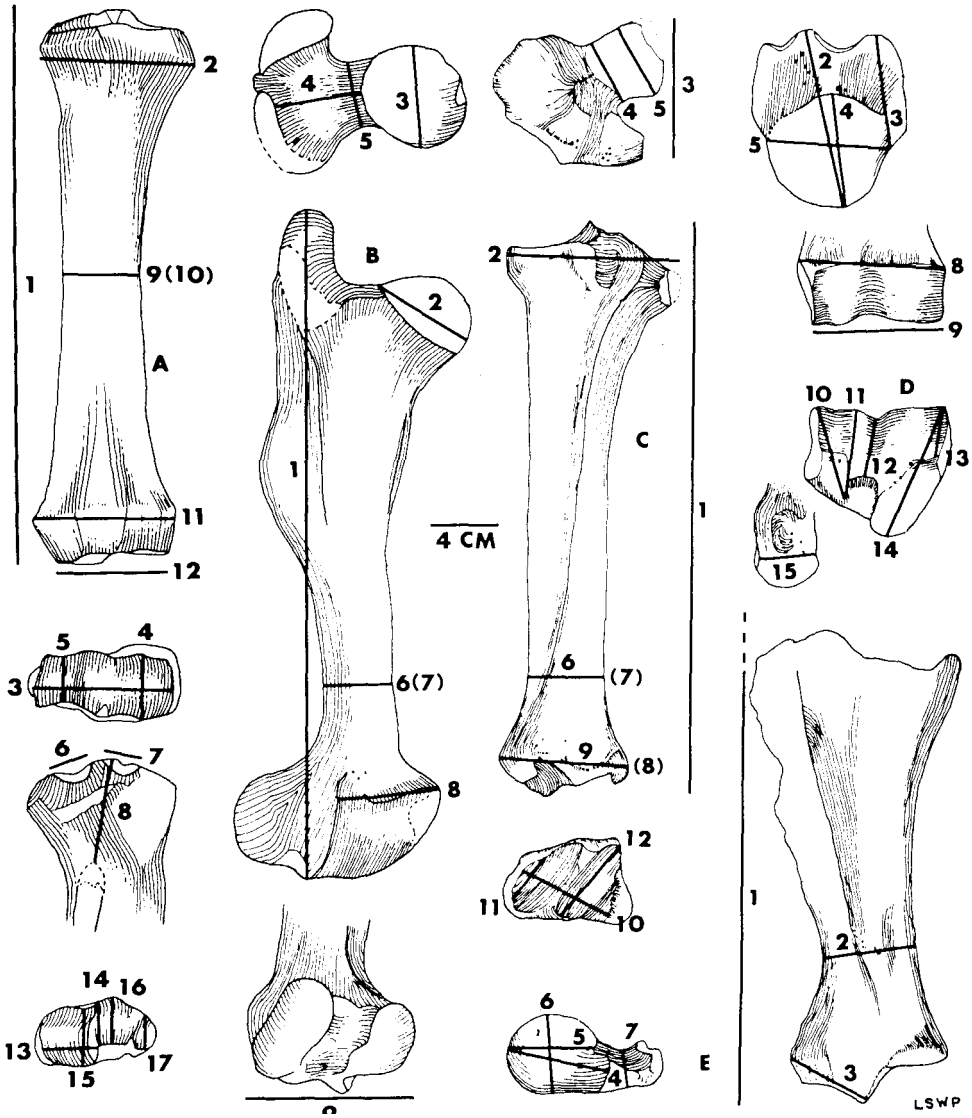

FIG. 1.—Definitions of measurements. A, radius (22-1423); B, femur (22-1557); C, tibia (22-1559; D. humerus (22-1386); E, scapula (22-1431). Not shown, humerus length, number 1. Measurements in parentheses are taken at right angles to view. All elements, *Equus niobrarensis*.

METHODS

Traditional measurements were taken on the dentition and major skeletal elements. measurements were made on limb and girdle elements (Figs. 1–3) and on several sets of teeth. Tooth variability with age and between individuals indicated the need for more material and time than were available for this study, so only traditional measurements of teeth are used here.

Measurements were subjected to several procedures (noted below) commonly used in numerical taxonomy. For discussion of these methods and their interpretation, see Sneath and

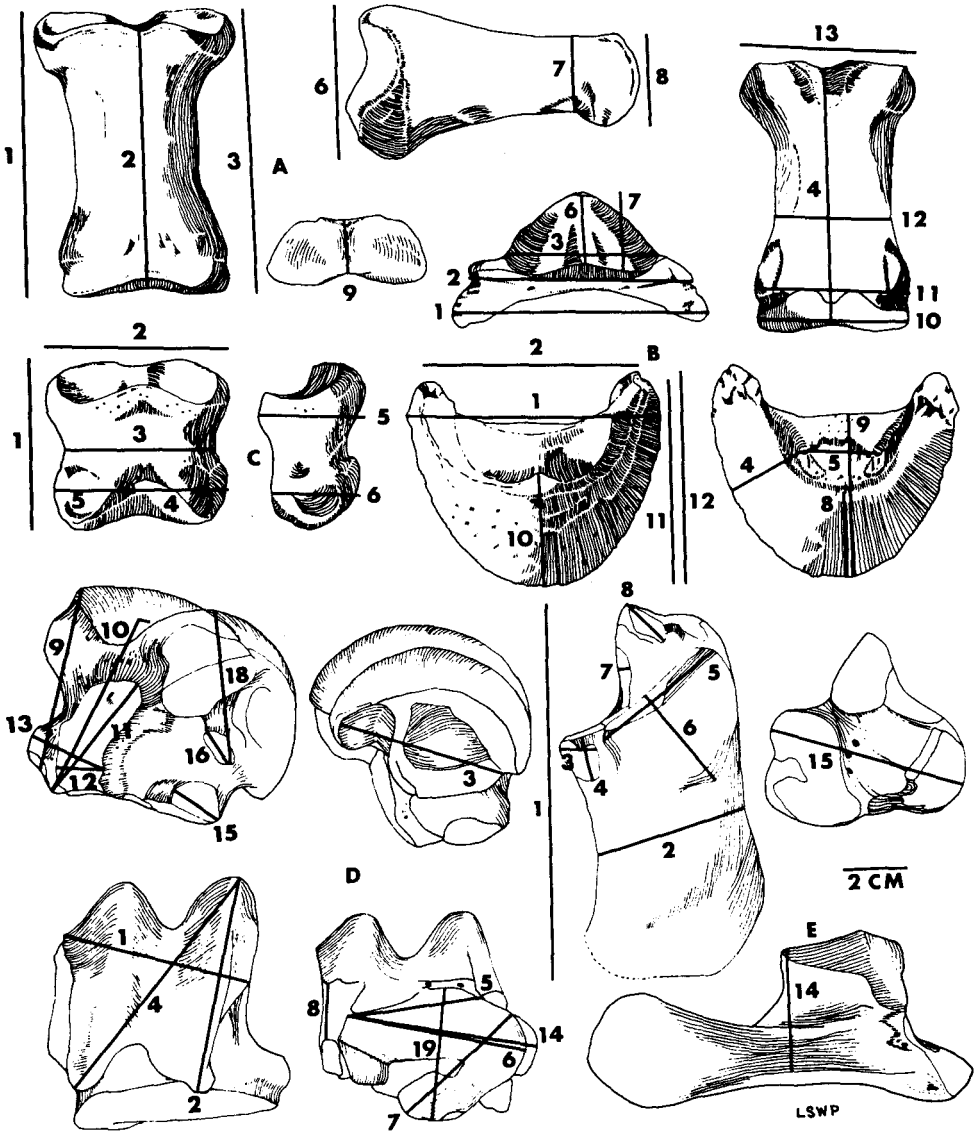

FIG. 2.–Definitions of measurements. A, phalanx I (22-702); B, phalanx III (22-1612); C, phalanx II (22-702); D, astragalus (22-1534); E, calcaneum (22-1501). All elements, *Equus niobrarensis*.

Sokal (1973) and the references cited in that work. Processing was by NT-SYS (Numerical Taxonomy System of Multivariate Statistical Programs). In initial stages, similarity and dissimilarity matrices and phenograms based on those matrices were constructed on raw measurements, standardized measurements, on measurements scaled by the method of Cain and Harrison, and by mid-range scaling [$X' = X/(X_{max} - X_{min}/2)$]. Similarity matrices were based on Pearson product moment correlation coefficients; distance matrices on the average taxonomic distance of Sokal. Manhattan and Euclidean distances also were calculated for some data sets. The unweighted pair-group method using arithmetic averages (UPGMA) was used on all matrices, although centroid averaging (UPGMC) also was tested. After initial recognition of clusters, a discriminant

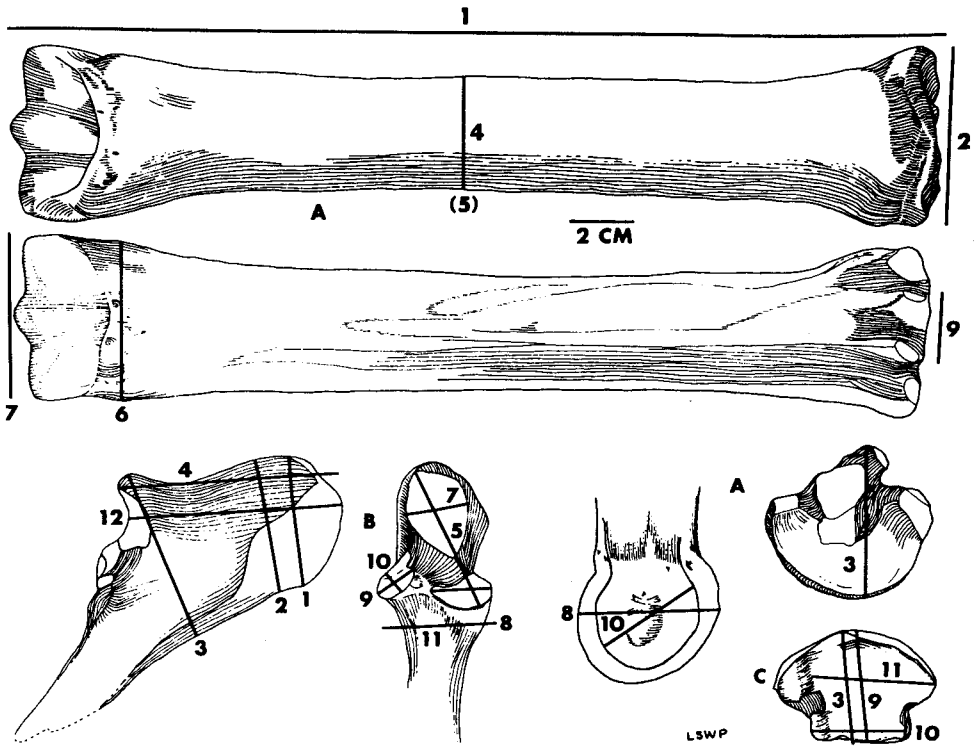

FIG. 3.—Definitions of measurements. A, metatarsal (22-688); B, ulna (22-986); C, metacarpal (22-676). Metacarpal measurements 1-2, 4-8, and 12 as for metatarsal; 13, diameter of medial condyle. B, *Equus conversidens;* others, *E. niobrarensis.*

analysis program, BMD07M (BMD Biomedical Computer Programs), was used with some elements to determine relative utility of individual measurements in separating clusters and in comparing the Dry Cave taxa with horse taxa discussed in the literature. Bivariate and standard statistical methods were used extensively to check conclusions derived from multivariate methods.

We have been unable to visit other institutions housing pertinent specimens and have based comparisons solely on literature sources.

RESULTS AND DISCUSSION

Selected measurements of limb bones are given in Table 1. We will supply the other measurements defined in Figs. 1 through 3 upon request. Some of the averages and standard errors may be biased because elements of opposite sides of the same individual might have been included. Tooth measurements are given in Tables 2 and 3.

We are aware that use of numerical taxonomic methods on fossil material does not meet the ideal criteria of the discipline. The value of the numerical taxonomic methods used lies mainly in their ability to integrate different data and summarize the results in usable form.

A test of clustering techniques on a series of metapodials of *E. caballus* Linnaeus (n = 11), *E. asinus* Linnaeus (n = 4), *E. grevyi* Oustalet (n = 1), and *E. burchelli* Gray (n = 1) indicated that the correlation matrices were of little value for the discrimination of metapodials. This was surprising because much has been made in the literature

TABLE 1.--*Summary of selected measurements (mm) and assigned specimens for Equus conversidens, E. niobrarensis, and E. scotti from Dry Cave. The first line of each data block gives the measurement number, observed range, and sample size (N); the second line (where applicable), the mean and standard error of the mean. Measurement numbers are defined in Figs. 1-3.*

		Astragalus		
E. conversidens (22-1515, 22-1516, 22-1517, 22-1518)				
4) 67.5-67.6 (2) *67.55*	*5) 29.6-32.3 (3)* *30.77 ± 0.80*	*10) 45.6-48.7 (4)* *47.03 ± 0.74*	*13) 34.1-39.0 (4)* *35.98 ± 1.07*	*18) 34.2-40.9 (4)* *37.43 ± 1.54*
E. niobrarensis (22-221, 22-1379, 22-1529, 22-1534, 22-1623, 25-536)				
4) 73.8-77.8 (5) *75.42 ± 0.83*	*5) 35.0-41.1 (6)* *38.28 ± 0.85*	*10) 52.0-57.3 (6)* *53.62 ± 0.79*	*13) 36.3-46.5 (6)* *41.12 ± 1.47*	*18) 40.8-50.7 (4)* *45.10 ± 2.10*
E. scotti referred (22-1626, 31-45)				
4) 90.5-91.3 (2) *90.90*	*5) 44.9-45.2 (2)* *45.05*	*10) 62.8-63.3 (2)* *63.05*	*13) 49.3-49.7 (2)* *49.50*	*18) 54.4-54.8 (2)* *54.60*
		Calcaneum		
E. conversidens (22-1502, 22-1504, 22-1505)				
1) 99.2-102.9 (3) *101.57 ± 1.19*	*2) 38.4-40.8 (3)* *39.93 ± 0.77*	*5) 33.4-36.5 (3)* *35.37 ± 0.99*	*9) 32.9-33.4 (3)* *33.20 ± 0.15*	*15) 48.4-53.2 (3)* *51.53 ± 1.57*
E. niobrarensis (4-5, 22-704, 22-1501, 22-1503)				
1) 108.4-117.7 (4) *112.35 ± 1.98*	*2) 41.6-47.0 (4)* *43.43 ± 1.23*	*5) 33.7-42.4 (4)* *36.80 ± 1.92*	*9) 31.6-40.6 (4)* *35.10 ± 1.93*	*15) 49.9-60.2 (4)* *54.35 ± 2.42*
E. scotti referred (22-1625, 31-45)				
1) 131.5-131.6 (2) *131.55*	*2) 58.0-58.2 (2)* *58.10*	*5) 46.1-46.7 (2)* *46.40*	*9) 40.0-40.7 (2)* *40.35*	*15) 65.1-65.2 (2)* *65.15*
		Femur		
E. conversidens (22-1399/1558, 23-21, 54-1437)				
1) 333-363 (3) *352.70 ± 9.84*	*3) 50.7-58.9 (3)* *55.43 ± 2.45*	*5) 32.3-39.1 (3)* *36.73 ± 2.22*	*6) 35.4-36.8 (3)* *36.17 ± 0.41*	*9) 82.8-91.1 (2)* *86.95*
E. niobrarensis (22-1397, 22-1398, 22-1479, 22-1557, 23-81)				
1) 389-395 (2) *392.0*	*3) 57.9-59.1 (2)* *58.58*	*5) 35.8-42.9 (3)* *39.03 ± 2.07*	*6) 42.1-45.1 (3)* *43.47 ± 0.88*	*9) 91.2-97.3 (5)* *94.04 ± 0.97*
E. scotti referred (31-50/66)				
1) 455 (1)	*3) 70.6 (I)*	*5) 49.6 (1)*	*6) 57.9 (I)*	
		Humerus		
E. conversidens (22-671/1571, 22-1385/1392, 54-1432)				
1) -260 (1)	*2) 91.0 (1)*	*6) 31.3-35.0 (3)* *33.00 ± 1.08*	*8) 69.5-72.1 (3)* *71.23 ± 0.87*	*12) 32.4-33.6 (3)* *32.97 ± 0.35*
E. niobrarensis (22-1386, 22-1387, 22-1390, 22-1622)				
1) 290-291 (2) *290.5*	*2) 106.6 (1)*	*6) 33.2-34.9 (2)* *34.05*	*8) 82.5-90.1 (2)* *86.30*	*12) 37.0-39.8 (4)* *37.85 ± 0.67*
E. scotti referred (31-65)				
1) 342 (1)	*2) 121.8 (1)*	*6) 44.0 (1)*	*8)103:1(1)*	*12) 44.4 (1)*
		Metacarpal		
E. conversidens (22-219 , 22-672, 22-685, 22-1496, 22-1497)				
1) 217-235 (5) *227.80 ± 3.37*	*2) 44.1-49.5 (5)* *46.52 ± 0.95*	*4) 30.3-32.9 (5)* *31.46 ± 0.54*	*5)22.6-25.6 (5)* *24.08 ± 0.57*	*7) 39.4-45.8 (5)* *42.72 ± 1.38*
E. niobrarensis (22-676, 22-678, 22-679, 22-680, 22-683, 22-692, 22-694)				
1) 221-243 (6) *232.00 ± 3.54*	*2) 51.9-56.0 (7)* *53.36 ± 0.63*	*4) 33.5-37.0 (7)* *35.59 ± 0.52*	*5) 24.7-29.5 (7)* *27.20 ± 0.75*	*7)46.7-54.5 (6)* *49.43 ± 1.10*

TABLE *l.-Continued.*

E. scotti referred (31-57)				
1)254(1)	2)58.6(1)	4)41.4(1)	5)31.0(1)	
		Metatarsal		
E. conversidens (22-690, 22-783, 22-784, USNM 175226)				
1) 262-274 (4) 266.75 ± 2.56	2) 44.3-47.7 (4) 45.90 ± 0.71	3) 40.0-45.6 (4) 43.35 ± 1.19	4) 30.0-30.4 (4) 30.28 ± 0.09	8) 30.8-34.3 (4) 32.90 ± 0.76
E. niobrarensis (22-686, 22-687, 22-688, 22-689, 22-691, 22-957)				
1) 263-288 (6) 277.20 ± 4.64	2) 50.5-54.4 (6) 53.00 ± 0.55	3) 49.1-55.7 (6) 52.27 ± 0.87	4) 32.5-37.4 (6) 34.77 ± 0.69	8) 38.3-43.2 (6) 39.55 ± 0.75
E. scotti referred (31-64)				
1) 304 (1)	2) 60.0 (1)	3) 59.7 (1)	4) 44.0 (1)	8) 39.8 (1)
		Phalanx I, anterior		
E. conversidens (6-395, 22-1511, 22-1512, 22-673)				
1) 81.2-87.2 (4) 83.45 ± 1.35	6) 31.5-34.8 (4) 32.88 ± 0.78	11) 37.0-40.3 (4) 38.25 ± 0.79	12) 27.2-29.4 (4) 28.25 ± 0.53	13) 43.2-48.5 (4) 45.03 ± 1.24
E. niobrarensis (22-50, 22-222, 22-697, 22-699, 22-1382, 22-1510, 22-1606)				
1) 84.9-90.3 (5) 87.90 ± 1.08	6) 37.8-44.2 (5) 40.50 ± 1.19	11) 44.4-50.4 (7) 47.80 ± 0.84	12) 33.1-36.2 (7) 35.43 ± 0.40	13) 55.8-58.7 (5) 57.40 ± 0.58
		Phalanx I, posterior		
E. conversidens (6-1, 22-674)				
1) 78.3-78.7 (2) 78.5	6) 35.1-35.2 (2) 35.15	11) 38.1-38.3 (2) 38.20	12) 27.9-29.3 (2) 28.60	13) 45.7-49.0 (2) 47.35
E. niobrarensis (22-675, 22-698, 22-700, 22-1610)				
1) 76.6-81.8 (4) 79.38 ± 1.24	6) 36.8-38.8 (4) 38.03 ± 0.43	11) 41.8-46.0 (4) 43.38 ± 0.93 '	12) 31.4-35.8 (4) 32.88 ± 1.00	13) 51.4-54.4 (4) 52.78 ± 0.66
E. scotti referred (31-63)				
1) 101.2 (1)	6) 41.7 (1)	11) 53.8 (1)	12) 41.3 (1)	13) 61.3 (1)
		Phalanx II		
E. conversidens (22-1507, 22-1508, 22-1509, 22-1660, 23-75)				
1) 41.5-45.4 (5) 43.42 ± 0.76	2) 40.5-44.8 (5) 42.48 ± 0.90	3) 34.5-39.1 (5) 36.52 ± 0.98	4) 36.9-42.2 (5) 38.86 ± 1.10	5) 26.9-29.6 (5) 28.20 ± 0.52
E. niobrarensis (22-684, 22-701, 22-702)				
1) 49.3-50.3 (3) 49.70 ± 0.31	2) 49.7-51.6 (3) 50.97 ± 0.63	3) 41.7-42.6 (3) 42.17 ± 0.26	4) 46.0-47.2 (3) 46.73 ± 0.37	5) 33.0-33.8 (3) 33.43 ± 0.23
		Phalanx III		
E. conversidens (22-1513, 22-1514, 22-1632)				
1) 47.9-49.2 (2) 48.55	3) 36.6-38.0 (2) 37.30	6) 16.2-16.3 (3) 16.23 ± 0.03	10) 39.6-41.8 (3) 40.37 ± 0.72	12) 44.9-49.2 (3) 46.87 ± 1.25
E. niobrarensis (22-60, 22-223, 22-703, 22-1612, 22-1613, 22-1831)				
1) 57.2-82.3 (6) 73.22 ± 3.79	3) 44.8-521(6) 47.75 ± 1.26	6) 17.4-20.2 (6) 18.85 ± 0.44	10) 49.9-58.0 (6) 54.58 ± 1.26	12) 50.3-67.0 (5) 60.20 ± 3.37
		Radius		
E. conversidens (22-986, 22-1419/1427, 31-58)				
1) 280-298 (2) 289.0	9) 36.9-39.0 (2) 37.95	10) 23.9-27.2 (2) 25.55	11) 66.3-67.2 (2) 66.75	14) 18.7-22.1 (2) 20.40
E. niobrarensis (22-976, 22-1417, 22-1418, 22-1423, 22-1426, 22-1658, USNM 171147)				
1) 319-355 (7) 334.1 ± 5.25	9) 40.9-45.5 (7) 42.99 ± 0.55	10) 26.7-29.3 (7) 28.16 ± 0.38	11) 71.2-82.0 (7) 76.94 ± 1.21	14) 20.7-26.3 (7) 24.11 ± 0.73

TABLE 1.-*Continued.*

		Scapula		
E. conversidens (22-1428, USNM 171148)				
3) 46.3-47.8 (2) 47.05	*4) 53.7-55.7 (2) 54.70*	*5) 46.0-51.8 (2) 48.90*	*6) 45.9-46.7 (2) 46.30*	*7) 18.8-20.5 (2) 19.65*
E. niobrarensis (22-1429, 22-1431, 22-1432, 22-1433, 22-1586)				
3) 54.0-56.9 (3) 55.37 ± 0.84	*4) 59.4-65.3 (5) 62.84 ± 1.22*	*5) 46.5-50.7 (4) 48.85 ± 0.88*	*6) 45.4-52.4 (3) 48.13 ± 2.16*	*7) 19.7-21.3 (4) 20.78 ± 0.36*
E. scotti referred (31-51)				
3) 51.7 (1)	*4) 71.9 (1)*	*5) 59.9 (1)*	*6) 57.5 (1)*	*7) 25.8 (1)*
		Tibia		
E. conversidens (22-1406, 22-1560, 22-1561, 22-1562, 54-1433, 54-1438)				
1) 295-338 (4) 323.3 ± 9.61	*4) 33.2-34.6 (4) 34.05 ± 0.30*	*6) 38.8-40.7 (4) 39.35 ± 0.45*	*9) 64.0-66.8 (6) 65.28 ± 0.37*	*10) 48:5-52.6 (6) 49.78 ± 0.74*
E. niobrarensis (22-1405, 22-1407, 22-1408, 22-1409, 22-1411, 22-1414, 22-1416, 22-1559, 22-1564, 22-1579, 22-1580, 22-1604, 22-1621, USNM 171149)				
1) 339-363 (5) 352.2 ± 3.99	*4) 36.2-41.1 (8) 38.63 ± 0.66*	*6) 42.4-45.9 (7) 43.76 ± 0.51*	*9) 70.9-83.2 (8) 74.94 ± 1.48*	*10) 54.9-61.3 (8) 57.11 ± 1.01*
E. scotti referred (31-53/54)				
1) 384 (1)	*4) 44.5 (1)*		*9) 89.1 (1)*	*10) 66.3 (1)*
		Ulna		
E. conversidens (22-986, 22-1427/1500, 22-1584)				
2) 42.7-44.7 (3) 43.53 ± 0.60	*3) 56.3-57.1 (3) 56.80 ± 0.25*	*7) 18.0-19.7 (3) 18.90 ± 0.49*	*11)38.7-42.0 (3) 40.00 ± 1.01*	*12) 64.8-70.6 (3) 66.97 ± 1.83*
E. niobrarensis (22-976, 22-1424, 22-1426, USNM 171185)				
2) 47.4-52.0 (4) 49.9 ± 0.99	*3) 64.2-69.0 (4) 66.05 ± 1.05*	*7) 21.0-23.4 (4) 22.25 ± 0.49*	*11) 46.3-49.8 (4) 47.95 ± 0.76*	*12) 76.3-84.9 (4) 80.35 ± 1.96*

of supposed shape differences (primarily measures of "robustness") among metapodials of both fossil and modern species (Quinn, 1957). It appears that there is only one major proportional difference between the metapodials of the species tested: that of total length compared to all other characters used. When a relatively large suite of characters is used, this single difference may be masked by age, sexual, and individual variation among the characters. That such variability is great is indicated by Willoughby's (1974) observation that metapodial shaft thicknesses of males are about 1.06 to 1.07 times those of females. In addition, our examination of modern and fossil material indicates that full breadth of the metapodial shaft is not reached until well after the epiphysis has fused, which introduces a significant age effect.

The distance matrices and resulting phenograms adequately separate metapodials of the modern horse and ass, but there was little overlap in size to begin with. The zebras, *E. grevyi* and *E. burchelli*, similar in size to *E. caballus* and *E. asinus*, respectively, were not separated from those species.

For most fossil elements, clustering results based on taxonomic distance are consistent with subjective criteria and, more importantly, with the earlier assignment of elements to single individuals based on size, preservation, and area of deposition.

Application of distance analysis to the Dry Cave limb material produced three major clusters (Fig. 4). Two of the taxa involved also are represented by cranial material, including dentition. The third, a partial skeleton from Loc. 31, has limb elements too large to match any recovered tooth material. Two other taxa are either not represented

TABLE *2.—Cheektooth measurements (mm) of adult specimens of* Equus *from Dry* Cave. *Measurements in parentheses are estimates. Unerupted teeth measured at midshaft.*

Species	Specimen	P^2	P^3	P^4	M^1	M^2	M^3	P^2-M^4	Wear
Ectoloph length									
E. conversidens	22-1609	35.4	25.0	25.0	23.0	24.1	23.9	(156.4)	Moderate
	31-47	34.7	28.6	28.4	24.6	24.8	25.2	161.7	Moderate
	54-1212	36.8	28.9	25.8	23.6	23.6	23.5	155.9	Moderate
E. niobrarensis	22-64		30.4	28.9	30.3	30.7			Slight
	22-981	35.3	26.1	27.9	23.7	24.6	33.9	167.1	Very heavy
	22-1608		32.3	30.0	27.7	27.9			Slight
Species A	25-537	30.8	25.1	25.5	22.0	22.2			(Midshaft)
Width perpendicular to ectoloph									
E. conversidens	22-1609	25.3	25.6	25.0	24.6	22.5	23.9		Moderate
	31-47	23.8	25.4	25.3	24.2	22.2	21.2		Moderate
	54-1212	23.4	25.5	25.5	24.8	23.4	22.1		Moderate
E. niobrarensis	22-64		27.5	25.1	27.6	24.7			Slight
	22-981	26.1	27.5	30.3	27.8	25.7	24.0		Very heavy
	22-1608		29.1	28.5	25.9	27.7			Slight
Species A	25-537	23.8	25.5	25.3	24.4	24.4			(Midshaft)
Protocone length									
E. conversidens	22-1609	8.9	10.9	12.8	11.8	12.9	12.6		Moderate
	31-47	8.9	12.5	13.3	12.3	12.7	12.7		Moderate
	54-1212	8.2	12.0	11.9	11.9	13.4	13.8		Moderate
E. niobrarensis	22-64		14.6	15.0	14.6	14.5			Slight
	22-981	11.8	15.6	17.9	14.5	17.2	17.1		Very heavy
	22-1608		16.2	17.1	15.3	15.7	14.9		Slight
Species A	25-537	8.7	12.0	13.1	13.0	13.2			(Midshaft)
		P_2	P_3	P_4	M_1	M_2	M_3	P_2-M_3	
Anteroposterior length									
E. conversidens	22-669	29.5	27.3	27.0					Moderate
	22-955	30.8	26.6	26.4	23.6	24.1	24.0	162.3	Moderate
	22-956	26.1	25.3	24.5	22.4	22.5	28.1	155.5	Very heavy
E. niobrarensis	22-61		31.9	30.8	28.6				Slight
	22-1528	31.5	29.3	28.8	25.5	26.6	36.1		Very heavy
	54-1312		27.0	28.7	25.7				Moderate
E. occidentalis	26-1064	32.5	30.4	29.6	26.5				(Midshaft)
Species A	25-537	28.8	25.9	25.4	23.0	23.1			(Midshaft)
Width perpendicular to ectoloph									
E. conversidens	22-669	10.2	14.0	13.9					Moderate
	22-955	12.1	16.3	16.3	13.8	13.4	11.5		Moderate
	22-956	10.4	14.3	15.4	14.8	(13.0)	12.0		Very heavy
E. niobrarensis	22-61		15.7	15.7	15.3				Slight
	22-1528	12.4	16.0	16.4	15.2	15.4	14.0		Very heavy
	54-1312		17.3	17.7	15.3				Moderate
E. occidentalis	26-1064	14.8	16.8	15.7	15.5				(Midshaft)
Species A	25-537	14.1	14.5	14.5	13.5	13.7			(Midshaft)

by identified skeletal remains or such remains were not discriminated by the clustering technique; however, in neither taxon have identifiable limb elements been associated with the dentition. We conclude that five species of horses are represented. For reasons detailed below, two are identified as *E. conversidens* Owen and *E. nio-*

TABLE *3.-Deciduous cheektooth measurements (mm) of specimens of* Equus *from Dry Cave.*

Species	Specimen	dP^2	dP^3	dP^4	Wear
Ectoloph length					
E. conversidens	*31-46*	*38.8*	*30.2*	*29.3*	Slight
E. niobrarensis	*22-985*	*43.9*	*31.6*	*33.9*	Moderate
	22-1611	*40.4*	*29.0*	*29.5*	Great
Species A	*25-537*	*34.9*	*25.1*	*25.5*	Great
Width perpendicular to ectoloph					
E. conversidens	*31-46*	*21.3*	*22.5*	*20.8*	Slight
E. niobrarensis	*22-985*	*25.6*	*25.6*	*25.1*	Moderate
	22-1611	*21.1*	*21.8*	*22.0*	Great
Species A	*25-537*	*20.8*	*21.8*	*22.6*	Great
Protocone length					
E. conversidens	*31-46*	*8.5*	*9.0*	*12.3*	Slight
E. *niobrarensis*	*22-985*	*8.6*	*9.7*	*12.7*	Moderate
	22-1611	*7.9*	*9.7*	*11.2*	Great
Species A	*25-537*		*9.4*	*10.6*	Great
		dP_2	dP_3	dP_4	
Anteroposterior length					
E. conversidens	*22-984*			31.3	Moderate
E. niobrarensis	*22-1563*			*33.9*	Moderate
E. occidentalis	*26-1064*	*32.7*	*31.0*	*32.4*	Moderate
Species A	*25-537*		*25.0*	*26.2*	Great
Width perpendicular to ectoloph					
E. conversidens	*22-984*			*12.3*	Moderate
E. niobrarensis	*22-1563*			*14.0*	Moderate
E. occidentalis	*26-1064*	*14.1*	*15.4*	*14.4*	Moderate
Species A	*25-537*		*12.8*	*12.7*	Great

brarensis Hay, and two are referred to E. *occidentalis* Leidy and *E. scotti* Gidley. An undescribed species is designated Species A for ease of discussion.

Equus conversidens Owen, 1869

Description of material.—Partial skulls of two adults and one colt are available. In both adults, all cheekteeth (except left P^2 of 31-47) are present, as are parts of the maxillae and ventral portion of the braincase, to and including part of the occipital complex. In 54-1212, sufficient contacts allow an approximate measurement of *352* mm from the anterior alveolus of P^2 to the posterior occipital condyle. A comparable measurement of an adult *E. asinus* (MSB 21468) from Sonora is 347 mm. The occipital condyles of both fossil specimens, however, are notably more robust than in *E. asinus.* The dorsal portions of the supraoccipitals are missing, but the more ventral areas show a well-marked medial area for muscle attachment, much as described by Lundelius *(1972).* Immediately above the occipital condyles is a pair of well-marked pits; dorsal and slightly medial to these is a second pair. Although occasionally visible in domestic horses and asses, none of our modern specimens has pits approaching the condition seen in both fossils. Two E. *grevyi* specimens display the pits, which are not well developed. The auditory meatus in the fossils is directed somewhat more dorsally and posteriorly than in E. *caballus* and considerably more so than in *E. asinus* and *E. grevyi.* The posterior palatine foramina lie opposite the central portion of M^2 in both specimens, with the palatal notch at essentially the same level in 54-1212 (broken in 31-47). The maxillary ridge ends above the posterior portion of P^4; the infraorbital foramen is above the anterior part of P^4 *(54-1212), 72* mm above the alveolar border.

The upper cheekteeth (Fig. 5A) seem to differ in no important way from those described by Hibbard (1955) and Lundelius (1972). They are somewhat larger than those cited by Hibbard and by Dalquest and Hughes (1965).

Premaxillae were not associated with the skulls described above. An isolated right premaxilla (22-1618) has three permanent incisors, which all show deep infundibulae. The breadth of this element (lateral I^3 to midline) indicates a muzzle breadth of about 70 mm. This is notably larger

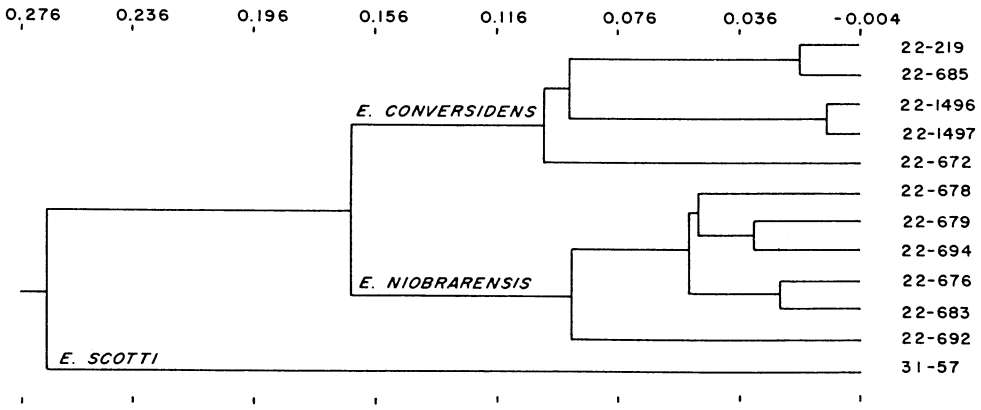

FIG. 4.-Distance phenogram of metacarpals of *Equus* from Dry Cave. Specimen catalog numbers are at right.

than in our comparative material of *E. asinus* (breadth < 60 mm, n = 7). The relative broadness of the muzzle also is seen in the breadth of the maxillae anterior to the cheekteeth.

The colt maxillae have the deciduous premolars in wear, but M^1 has not yet reached the alveolar surface. Thus, if tooth replacement is similar to that of the domestic horse, an age of somewhat less than 1 year is indicated. The deciduous premolars are shown in Fig. 5F.

The lower jaws are assigned to *E. conversidens* because the cheekteeth are smaller than those of *E. niobrarensis.* Individual teeth generally fit the description by Lundelius (1972); see Fig. 6C and H; Table 2. However, all lower incisors associated with 22-955 lack infundibulae (Fig. 6I), as does an I_3 from Loc. 12. Similarly, two incisors (I_2 and I_3) from the "NW Talus Slope" of Loc. 22 lack infundibulae despite little wear; this area has produced only *E. conversidens.*

Postcranial mensural data are summarized in Table 1.

Discussion.—The earlier taxonomic history of *E. conversidens* was adequately summarized by Hibbard *(1955),* and Dalquest and Hughes *(1965).* Dalquest *(1967)* and Mooser and Dalquest *(1975)* further characterized the species and discussed nomenclature.

Skinner (1942) referred a skull and post-cranial elements from Papago Springs Cave to *E. conversidens.* More recently, he became convinced that "the heavy limbs represent another form of *Equus* for which we found no dentition" (Skinner, 1972:125). This material, including the limbs, matches nicely the Dry Cave *E. conversidens* elements, judging from published data (Table 4).

Dalquest and Hughes (1965:414) assigned long, slender first phalanges to the hind limbs, stating that "in other species of horses the hind toes and hoofs are more slender and elongate than the anterior toes and hoofs. The difference in length and slenderness of the front and hind feet of *E. conversidens* seems to have been extreme." This is counter to our experience, where normally the anterior first phalanges are longer and more slender than the posterior; Eisenmann and De Giuli (1974) also noted this for *E. burchelli.*

After dentition, the metapodials have long been considered the most important equid elements for taxonomic and identification purposes because of relatively frequent preservation of these elements and because locomotive specializations are considered likely to be reflected in the metapodials. In the past, assignment of metapodials to *E. conversidens* has been necessarily tentative. In part, this has been because of the tendency to attribute great importance to overall length. However, discriminant analysis indicates that metapodial length by itself is of little value when separating *E. conversidens* from *E. niobrarensis* (univariate usefulness is 13th of 13 measure-

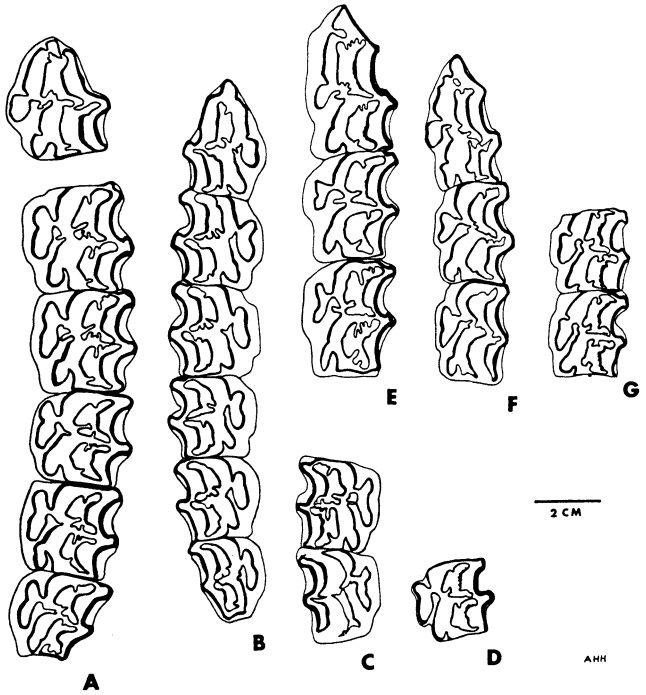

FIG. 5.-Upper cheekteeth of *Equus* from Dry Cave. A. P^2, moderate wear (22-1617); P^3-M^3, moderate wear (22-1608), *E. niobrarensis. B.* P^2-M^3, moderate wear (31-47), *E. conversidens. C.* M^{1-2}, slight wear (25-537), Species A. D. M^2, sectioned 52.1 mm below top of parastyle (25-537), Species A. E. dP^{2-4}, moderate wear (22-985), E. *niobrarensis.* F. dP^{2-4}, moderate wear (31-46), *E. conversidens.* G. dP^{3-4}, heavy wear (25-537), Species A.

ments). The univariate order for the six most useful measurements is 2, 5, 4, 8, 7, and 6 (see Fig. 3C for definitions of measurements).

There appears to be widespread misidentification of metapodials in the literature. For example, in a scattergram of two of the better discriminators commonly reported, proximal and midshaft widths, specimens assigned in the literature to *E. conversidens* span nearly the complete ranges of both *E. conversidens* and *E. niobrarensis* (Fig. 7).

We have been able to locate only one reference to the presence or absence of infundibulae in the lower incisors of *E. conversidens:* Lundelius and Stevens (1970:150) noted that "infundibulae occur on referred specimens of *E. conversidens."* Mooser (1958) mentioned that *Onager zoyatalis* Mooser lacks the infundibulae, but Mooser and Dalquest (1975:805) "suspect that the [type] specimen [of *Onager zoyatalis]* actually is *Equus conversidens,"* implying that their hypodigm of the latter also lacks the infundibulae.

Published data on this feature are lacking for many North American species and, when mentioned, seldom is it clear whether the infundibulae are lacking in all lower incisors or only in I_3.

Equus niobrarensis Hay, 1913

Description of material.—Parts of five skulls are available. Number 22-985 consists of right and left maxillae and right premaxilla of a young animal, with right $dI1-^3$, right and left dP^{2-4}, and right and left M^1 just beginning wear; unerupted M^2 is present (Fig. 5E). The presumptive

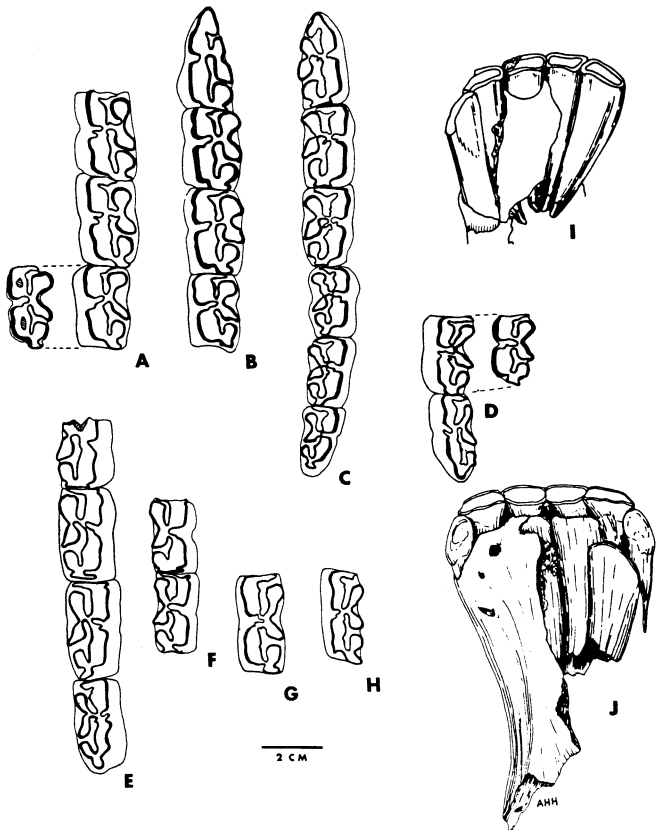

FIG. 6.—Lower teeth of *Equus* from Dry Cave. A. P_3-M,, little wear, with M, sectioned at 46.1 mm below top of metaconid (22-61), *E. niobrarensis.* B. P_2-M_1, heavy wear (54-1312), *E. niobrarensis.* C. P_2-M_3, little wear (22-955), *E. conversidens.* D. M_1-M_2, little wear, with M_1 sectioned 53.2 mm below top of metaconid (25-537), Species A. E. dP_2-M_1, moderate to slight wear (26-1064), *E. occidentalis* ref. F. dP^{3-4}, heavy wear (25-537), Species A. G. dP_4, moderate wear (22-1563), *E. niobrarensis.* H. dP_3 or dP_4, moderate wear (22-984), *E. conversidens.* I. Anterior mandible with right and left I_{1-2}, left I_3 (22-955), *E. conversidens.* J. Anterior mandible with right and left dI_{1-3}, unerupted I_{1-2}, and unerupted left I_3, left dC, and unerupted left C (26-1064), *E. occidentalis* ref.

age is about 1 year. Diastemal length is 87.9 mm. Number 22-1611 consists of paired maxillae with right and left dP^{2-4} and M^{1-2}; alveoli for P are present. Premaxillae with unerupted permanent incisors are associated. Presumed age is about 2 years. Diastemal length (alveolus dI^3 to dP^2) is 106.6 mm. In both 22-985 and 22-1611, approximate muzzle breadth is estimated at 76 mm, as it is in a partial pair of premaxillae (22-1589) from a 4-year-old. The maxillary ridge ends just anterior to the center of dP^4 in both 22-985 and 22-1611.

Number 22-64 is a right maxilla with P^3-M^3 and a fragment of the left maxilla with M^{1-3}; age is about 4 years. The maxillary ridge ends above the anterior end of M^1; the infraorbital foramen (measured from the alveolar margin to mid-foramen) is 87.6 mm above the center of P^4.

Number 22-1608 includes the posterior portion of the left maxilla with P^3-M^3 (Fig. 5A) and associated right P^4-M^2. This is a young adult, probably a 4.5- to 5-year-old.

Specimen 22-981 is the left maxilla with P^2-M^3 of an extremely old individual; the enamel of the fossettes has been entirely worn away from P^2 and P^3. The maxillary ridge lies above the posterior end of M^1; the infraorbital foramen is 71 mm above the alveolar margin at the center of P^4.

TABLE 4.-*Observed ranges of metapodial measurements of* Equus *from selected sites. Measurements from this study and from Dalquest, 1967; Lundelius, 1972; Quinn, 1957; Skinner, 1942; and Troxell, 1915.*

Site and taxon	Metacarpal				Metatarsal			
	Length	Prox. wd.	Midshaft wd.	Distal wd.	Length	Prox. wd.	Midshaft wd.	Distal wd.
E. conversidens								
Blackwater Draw	219	43.8	31.6					
Canyon, Texas	220	45.0	31.5	43.5				
Dry Cave	217-235	44.1-49.5	30.3-32.9	39.4-45.8	262-274	44.3-47.7	30.0-30.4	40.3-43.6
Papago Springs Cave	212.7							
Slaton Local Fauna	218-233	47.7-53.4	31.0-36.2	43.9-49.0	255-264	46.7-49.0	31.2-32.7	42.3-47.0
E. niobrarensis								
Blackwater Draw					290	55	40	53
Dry Cave	221-243	51.9-56.0	33.5-37.0	46.7-54.5	263-288	50.5-54.4	32.5-37.4	47.6-55.4
J. O. Baggett Ranch	234	52	36	49			39	51.5
Scharbauer Site					287	55.5	37	52
E. scotti								
Dry Cave	254	58.6	41.4		304	60.0	44.0	59
Rock Creek	244	57.3	41.0	57.7				

The anterior end of a lower jaw (22-1657) with right I_{1-3} and left I_{1-2} is an estimated 86 mm across the third incisors. The third incisor, and another from a different individual, has the infundibulum widely open posteriorly; other lower incisors have well-marked cups. A fragment of dentary and associated left P_2-M_3 and right P_3-M_3 (22-1528) are of a very old individual. Number 54-1312 (left P_2-M_1) is nearly as old (Fig. 6B). Other material is relatively scanty, with no more than three teeth in association. Specimen 22-61, of a young adult, consists of P_3-M_1 (Fig. 6A). With the roots not yet entirely closed, the greatest length of P_4 along the metaconid column is 96.0 mm; the same measurement of an *E. conversidens* P_4, specimen 22-669, in approximately the same stage of wear, is 87.2 mm.

Limb bone data are given in Table 1. Figures 1 to 3 show how measurements were taken, and are based on *E. niobrarensis* elements except for 22-986 (ulna).

Discussion.—In size, complexity, and configuration, the type specimen of *E. niobrarensis* matches the Dry Cave series, though with minor exceptions. The Dry Cave skull material complete enough for measurement is of animals younger than the type and, expectably, somewhat smaller. The protocone lengths of the type are consistently shorter than in the Dry Cave material, but another dentition assigned to the species by Hay (1913) has protoconal lengths within the range of the Dry Cave series. Finally, Hay (1913) emphasized the relatively great lateral extension of the post-protoconal valley. As measured from his figure of the type and from figures in Gidley (1901) of material assigned to E. *niobrarensis by* Hay, these extensions average greater, but overlap measurements of the Dry Cave specimens.

Lundelius (1972), working with specimens from Blackwater Draw, New Mexico, assigned several teeth, a distal metapodial fragment, and a phalanx to *E. niobrarensis.* All but the metapodial fit the Dry Cave series; the metapodial fits the measurements *of E. conversidens* (also recorded by Lundelius). This same *E. niobrarensis* material was assigned to *E. caballus laurentius* Hay by Quinn (1957), but differs in several ways from that taxon (Lundelius, 1972).

Lundelius (1972) assigned to *E. scotti* some Blackwater Draw specimens, material earlier assigned by Quinn (1957) to *E. midlandensis* Quinn and *E. caballus caballus* Linnaeus. Stock and Bode (1937) referred teeth of this size to *E.* cf. *excelsus* Leidy. All the tooth material seems to fall into or near the range of variation displayed by the Dry Cave specimens and we consider it to represent *E. niobrarensis.*

Lundelius (1972) synonymized *E. midlandensis* with *E. scotti* because he could find no distinctive difference between the teeth of the two, and because the mea-

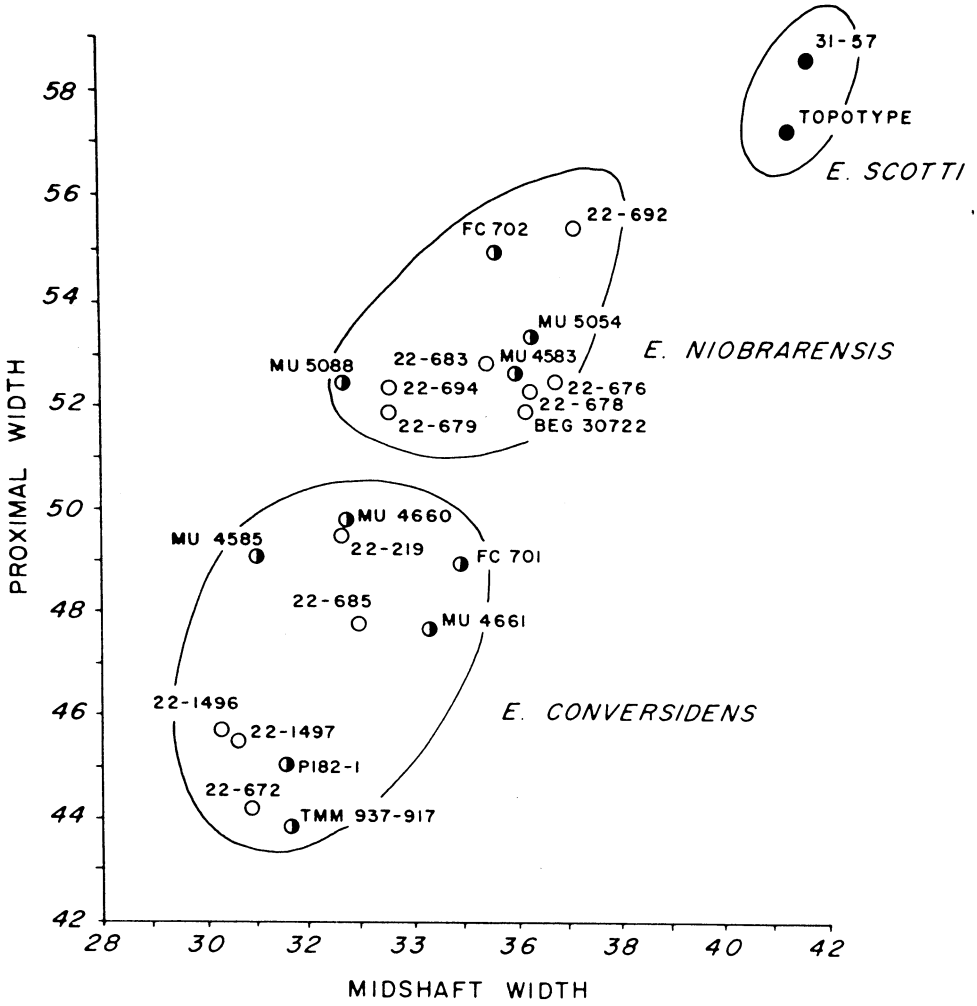

Fig. 7.—Scattergram of two metacarpal measurements (mm) of *Equus.* Encircled groups (based on data shown in Fig. 4) represent our identifications, except we express no opinion on FC 702. Half solid symbols are specimens identified in the literature as *E. conversidens.* BEG 30722 originally identified as *E. midlandensis* (Quinn, 1957). BEG = Bur. Eco. Geol. (Quinn, 1957); FC = Fauna Cedazo (Mooser and Dalquest, 1975); MU = Midwestern Univ. (Dalquest, 1967); P = Panhandle Plains Hist. Mus. (Dalquest and Hughes, 1965); TMM = Texas Memor. Mus. (Lundelius, 1972).

surements of a topotypical metacarpal of *E. scotti* "are approximately what would be expected for a metacarpal from the same species as the metatarsal from Blackwater Draw." However, the Blackwater Draw metatarsal is similar in size to Dry Cave *E. niobrarensis* metatarsals (Table 4), which accompany metacarpals distinctly smaller than that of the *E. scotti* topotype (Fig. 7, Table 4). A Dry Cave metacarpal near the size of the *E. scotti* metacarpal matches a metatarsal larger than the Blackwater Draw bone. Thus, the Blackwater Draw taxon is distinctly smaller than *E. scotti*. This also is true of metapodials from the J. O. Baggett Ranch and the Scharbauer Site that have been assigned to *E. midlandensis*.

Dalquest (1967), working with the probably early Illinoian Slaton local fauna from Lubbock Co., Texas, identified *E. niobrarensis* and *E. conversidens.* The limb material assigned to E. *niobrarensis* is like that in the Dry Cave series, but several metacarpals assigned to *E. conversidens* fall into the *E. niobrarensis* range of the Dry Cave series (Fig. 7).

In summary, all late Pleistocene horse material from the Southwest previously assigned by Johnson (1976), Lundelius (1972), Quinn (1955*b*, 1957), Slaughter (1975), and Stock and Bode (1937) to *E. caballus caballus, E. caballus laurentius, E. excelsus, E. midlandensis, E. niobrarensis,* and *E. scotti* appears assignable to *E. niobrarensis.* The same likely is true of *E. excelsus* from Burnet Cave figured by Schultz and Howard (1935), but they did not give measurements nor can dimensions be taken from the illustration because the reduction factor given is incorrect.

Equus occidentalis Leidy, 1865, referred

Description of material.--The anterior end of a mandible (26-1064; Fig. 6J) with all deciduous incisors, left deciduous canine, right and left unerupted I, and I_2, and left unerupted I_3 is accompanied by a fragment of the anterior right ramus with dP_{2-4} (Fig. 6E). Also present are unerupted permanent premolars (1-3) and a slightly worn M_1.

All incisors lack infundibulae, although dI_3 is slightly scooped posteriorly. Deciduous P_{2-3} display well-marked hypostylids (Fig. 6E). The parastylid is well marked in dP_4 and definitely present, but weak, in dP_3. The ectoflexids do not pass between the metaconid-metastylid folds. The metaconid-metastylid groove is open, but definitely V-shaped, rather than U-shaped, in all cheekteeth.

Tooth measurements are given in Tables 2 and 3. The width of the anterior mandible (from the lateral sides of right and left dI_3) is 67.9 mm. The greatest length of M_1 as preserved (the ventral end is missing) is 82 mm.

Discussion.—The tooth measurements and the absence of infundibulae in the lower incisors suggest *E. occidentalis* (sensu Merriam, 1913). Merriam implied that only I_3 of *E. occidentalis* lacks the infundibulum, but Hoffstetter (1950) pointed out that Merriam's figures indicate absence on all lower incisors. Cope (1896) stated that infundibulae are as well developed in E. *occidentalis as* in E. *caballus,* but his specimens appear to have been of *E. pacificus* Leidy (Gidley, 1901).

The Dry Cave specimens may differ from E. *occidentalis* in the occurrence of hypostylids on dP_{3-4}; their presence was not mentioned by Merriam (1913) nor did they appear in his illustrations. The linguaflexids illustrated by Merriam (1913) appear U-shaped, rather than open V-shaped as are the Dry Cave teeth. Miller (1971:21), however, stated that this "groove varies from a wide V-shape to a broad U-shape."

Savage (1951) questioned the application of the name *E. occidentalis* to Merriam's specimens from Rancho La Brea, but his reasons are not completely clear. He noted that lower cheekteeth from Asphalto (mistakingly believed by him to be the type locality) are plesippine in that they bear a V-shaped groove between metaconid and metastylid. However, rather than contrasting this with the groove shape in the Rancho La Brea specimens, he assigned the latter to the true caballine horses on the basis of "the character of its deciduous dentition" (Savage, 1951:246). Nevertheless, a well-developed parastylid in dP_4 (Merriam, 1913:Fig. 14) is a non-caballine trait (McGrew, 1944).

Without attempting to further resolve this question, we tentatively refer 26-1064 to *E. occidentalis* as understood by Merriam (1913).

Equus scotti Gidley, 1900, referred

Description of material.--No cranial or dental material referable to this species has been recovered from Dry Cave. Mensural data of limb elements are given in Table 1.

Discussion.—The literature descriptions of *E. scotti* are unsatisfactory despite excellent typical and topotypical material. Troxell (1915) gave metacarpal measurements that are comparable to those of our material (Table 4). Our tentative identification is based on size similarity alone.

Lundelius (1972), on the basis of material from Blackwater Draw, synonymized E. *scotti* and *E. midlandensis.* Our reasons for rejecting this synonymy in favor of synonymizing E. *midlandensis* and *E. niobrarensis* are given in the *E. niobrarensis* account.

Species A

Description of material.—Number 25-537 includes right and left I^{1-2}, dP^{3-4}, P^{2-4} (all unerupted), M^{1-2}, I_{1-2}, dP_4, P_3-$_4$ (unerupted), M_3; right dP^2, M^3 (unerupted), dP_3, M_3 (unerupted); and left P_2 (unerupted) and M_1 (Figs. 5C, D, G; 6D, F). Fragments of a poorly preserved dentary and skull also are present.

Specimen 25-538 consists of left dP_{2-4} with all teeth just barely in wear on the highest points, and an associated fragment of the dentary. Because of the stage of wear and the poor preservation, attribution is not certain.

The lower incisors of 25-537 lack any sign of infundibulae. The well-worn deciduous lower premolars (Fig. 6F) possess well-developed parastylids and hypostylids. Molars and deciduous premolars have the ectoflexid passing into the metaconid-metastylid column. Length of the metaconid column of M_2 (roots unformed) is 83.6 mm; of the mesostyle of M^2 (roots unformed), 85.6 mm. Permanent lower teeth have a parastylid that is little more than a shoulder.

Discussion.—The dentition of 25-537 appears to be of a zebrine about the size of Burchell's zebra or somewhat smaller. It has, for example, all the zebrine features noted by McGrew (1944)—the V-shaped metaconid-metastylid groove and the well-developed parastylid and hypostylid on dP_3. As noted by Quinn (1955*a*) in modern zebras, the ectoflexid intrudes well into the metaconid-metastylid column, dividing it into a pre-isthmus and a post-isthmus.

We find no qualitative differences in the upper permanent dentition that clearly separate 25-537 from *E. conversidens.* The lower cheekteeth, however, not only are separable on the basis of the greater intrusion of the ectoflexid into the metaconid-metastylid column, an occasionally variable feature, but on the basis of a suite of other characters. *E. conversidens* does not (in our examples) have a parastylid that is as well marked in the permanent teeth and lacks the hypostylid throughout all but the base of the dP_4 (or dP_3).

Insofar as we can ascertain from the literature available to us, well-marked zebrine characters in North American fossil *Equus* are known only in the early Pleistocene plesippine horses assigned by Skinner (1972) to the subgenus *Dolichohippus,* and in the late Pleistocene *E. (Parastylidequus) parastylidens* Mooser (Mooser and Dalquest, 1975). Our specimens differ from known members of *E. (Dolichohippus)* in size and in development of the protocone; from *E. parastylidens* by smaller size and lesser development of the parastylids in permanent dentition. The upper dentition *of E. parastylidens* is unknown.

Although our literature search has not revealed a North American taxon that is similar, we prefer not to propose a new name until we have examined more of the named taxa.

Comparisons with Other Southwestern Faunas

Unlike the situation farther east in the Great Plains, relatively few late Pleistocene equid faunas have been recorded from the Southwest. Sites within Arizona, New Mexico, the Llano Estacado, and Trans-Pecos Texas include Papago Springs Cave (Skinner, 1972) in Arizona; Blackwater Draw (Lundelius, 1972; Quinn, 1957; Slaugh-

ter, 1975; Stock and Bode, 1937), Sandia Cave (Hibben, 1941), Burnet Cave (Schultz and Howard, 1935), the Isleta Caves (Harris and Findley, 1964), and Dry Cave (Harris, 1970), in New Mexico; and the Lubbock Lake Site (Johnson, 1976), the Scharbauer Site (Quinn, 1955*b*, 1957), the J. O. Baggett Ranch near Odessa (Quinn, 1955*b*), Tule Canyon south of Amarillo (Gidley, 1901), and Williams Cave (Ayer, 1937)—all in Texas. Of these, *E. conversidens* occurs at the Scharbauer Site, the Baggett Ranch, Blackwater Draw, Dry Cave, and Papago Springs Cave. Ayer (1937) assigned the Williams Cave material to *E. semiplicatus* Cope. Dalquest (1967) believed *E. semiplicatus* to be a synonym of *E. conversidens;* the measurements given by Ayer are consistent with such an interpretation. Lundelius (in litt., 1973) tentatively identified *E. conversidens* from Dark Canyon Cave, southwest of Carlsbad, New Mexico, the small amount of *Equus* material in our collection from that site also seems referable to this species.

Equus midlandensis has been reported from the Baggett Ranch, the Scharbauer Site (type locality), and from both the Brown Sand Wedge and the Gray Sand units of Blackwater Draw. As noted earlier, these records appear to represent *E. niobrarensis. E. scotti* is recorded from the Gray Sand of Blackwater Draw and the Lubbock Lake Site, and Lundelius (in litt., 1973) tentatively recognized *E. scotti* from Dark Canyon Cave. These specimens apparently also represent *E. niobrarensis. Equus niobrarensis* is noted by name from Blackwater Draw (Lundelius, 1972) and from Tule Canyon (Hay, 1913). Although the Isleta Caves material has been reported only as *Equus* sp. (Harris and Findley, 1964), cursory examination indicates presence of *E. niobrarensis.*

Hibben (1941) reported *E.* nr. *occidentalis* from the Folsom level of Sandia Cave and *E. excelsus* from the Sandia cultural level. Schultz and Howard *(1935)* recorded *E. excelsus* and *E. tau* Owen from Burnet Cave. *E. tau* also was reported from Papago Springs Cave (Skinner, 1942). These materials need to be reexamined in the light of more recent studies.

Skinner (1972) mentioned *E. (Hemionus)* from the Laguna Indian Reservation, New Mexico. Johnson (1976) reported as *Equus* sp. a taxon with long, slender metapodials and mentioned that the same taxon was present in Dark Canyon Cave.

Relationships of the Dry Cave Taxa

Figure 8 shows some phenetic relationships among horses based on a maximum of 15 limb and girdle measurements. Measurements of *E. conversidens, E. niobrarensis,* and the referred *E. scotti* from Dry Cave are averages of available elements. All Dry Cave taxa lack two or more measurements. Measurements of all other taxa are from Willoughby (1974). Although horse taxonomists do not agree on the number of living and historically extinct species, the phenogram presents one reasonable interpretation of modern horse taxonomic relationships at both the subgeneric and specific levels.

In conjunction with dental characters, some degree of confidence may be placed in the results shown in Fig. 8 for the taxonomic assignment of *E. conversidens* and *E. niobrarensis* to major groups.

Quinn (1955*b*, 1957) placed *E. conversidens* in the genus *Asinus*, although with reservation in his 1957 paper. Skinner (1972) considered *E. conversidens* to represent the subgenus *Hemionus,* particularly on the basis of the lower dentition, but may have been applying the name to a different taxon. *E. conversidens* is separated clearly from the subgenus *Asinus* on limb proportions (Fig. 8) and by several characters noted in the description of cranial material. Although the metapodial lengths are less extreme than in living members of subgenus *Hemionus,* there appears to be no strong reason to question the assignment of *E. conversidens* to that subgenus.

In Fig. 8, *E. niobrarensis* is seen to be most similar to *E. przewalskii;* the next most similar groups are the "warmblooded" domestic horses (*E. caballus caballus)* and the

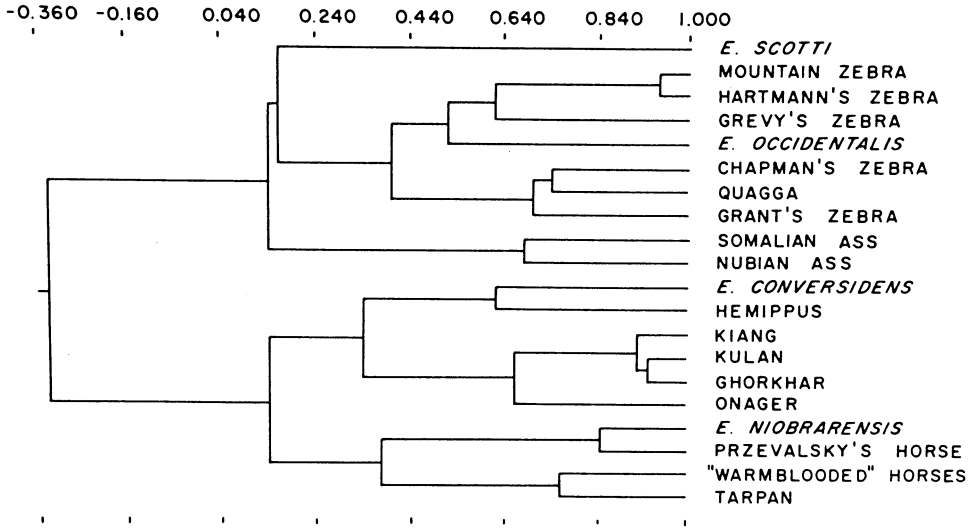

FIG. 8.-Correlation phenogram of *Equus* based on the lengths of 14 skeletal elements plus metacarpal mid-breadth. *"E. scotti"* is based solely on the Dry Cave referred specimen.

tarpan (*E. caballus gmelini*). The lower dentition has a generally U-shaped groove between the metaconid and metastylid, a character of the subgenus *Equus.* The ectoflexids do not extend as far internally as Hopwood (1936), Dalquest (1978) and others have considered typical of subgenus *Equus;* however, von Reichenau (1915) pictured a mandible of *Microhippus przewalskii* (=*E. przewalskii*) that shows ectoflexids similar to those of *E. niobrarensis.*

Equus przewalskii has been considered a subspecies of *E. caballus* by some workers, such as Hopwood (1942), and as a separate species by others (Azzaroli, 1966). In view of differences in chromosome number between the two (Benirschke et al., 1965) and the rather strong differences in proportions indicated in Fig. 8, we tentatively accept Przewalsky's horse as separate from *E. caballus. E. niobrarensis is* 5 to 10% larger than *E. przewalskii,* a size difference not unusual between equids within the same species (Willoughby, 1974). The degree of difference shown in Fig. 8 also is less than that separating some recognized subspecies. These features suggest close relationship between the two taxa and possible conspecificity. Until we have examined specimens of *E. przewalskii* in detail, we prefer to retain *E. niobrarensis* as a separate taxon.

Dalquest (1978) recognized *Equus* and *Asinus* as separate genera, the latter including the living African asses, *A. (Asinus),* and the Asiatic half asses, *A. (Hemionus).* He considered subgenus *Equus* to be exclusively Old World, with post-Blancan New World horses belonging to subgenus *Parastylidequus*—one species—and *Asinus* of several subgenera. *E. conversidens* was placed in *A. (Amerhippus),* not *A. (Hemionus).* He considered (in litt., 1979) that *E. niobrarensis* and perhaps *E. scotti* were closely related to *E. conversidens.*

If Dalquest (1978) is correct, then the relationships hypothesized here are wrong and the similarities a result of convergence rather than phylogeny. In our opinion, however, *E. conversidens* differs too much from *E. niobrarensis* to be closely related.

The Dry Cave specimen referred to *E. scotti* shows general phenetic similarity in limb proportions to the African zebras (Fig. 8), but is close to none. Only 10 of 15 pertinent measurements were possible on our material; thus, the reliability of ex-

pressed phenetic relationship is low. At best, Fig. 8 may indicate that the taxon differs strongly from extant Eurasian taxa in proportions.

The possible relationships of Species A were mentioned in the species account. *E. occidentalis is,* in limb proportions, similar to several of the zebras, particularly E. *grevyi.* Willoughby (1974) assigned *E. occidentalis* to the *E. burchelli—E. quagga* group, which he recognized as the subgenus *Quaggoides* on the basis of limb proportions. However, lack of congruence with dental characters suggests to us that similarity in limb proportions indicates convergence in this case rather than close genetic relationship.

The lack of infundibulae in the lower incisors of *E. occidentalis, E. conversidens,* and Species A suggests relationship to South American forms (subgenus *Amerhippus),* which also lack infundibulae (Hoffstetter, 1950), but further study is needed.

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LITERATURE CITED

AYER, M. Y. 1937. The archaeological and faunal material from Williams Cave, Guadalupe Mountains, Texas. Proc. Acad. Nat. Sci. Philadelphia, 88:599—618.

AZZAROLI, A. 1966. Pleistocene and living horses of the Old World. Paleontogr. Ital., 61:1-15.

BENIRSCHKE, K., N. MALOUF, R. J. LOW, AND H. HECK. 1965. Chromosome complement: differences between Equus caballus and Equus przewalskii. Science, 148:382—383.

COPE, E. D. 1896. On some Plistocene Mammalia from Petite Anse, La. Proc. Amer. Philos. Soc., 34:458—468.

DALQUEST, W. W. 1967. Mammals of the Pleistocene Slaton local fauna of Texas. Southwestern Nat., 12:1—30.

———. 1978. Phylogeny of American horses of Blancan and Pleistocene age. Acta Zool. Fennica, 15:191-199.

DALQUEST, W. W., AND J. T. HUGHES. 1965. The Pleistocene horse, Equus conversidens. Amer. Midland Nat., 74:408-417.

EISENMANN, V., AND C. DE GIULI. 1974. Caracteres distinctifs des premieres phalanges anterieures et posterieures chez certains equides actuels et fossiles. Bull. Soc. Geol. France, Ser. 7, 16:352-361.

GIDLEY, J. W. 1900. A new species of Pleistocene horse from the Staked Plains. Bull. Amer. Mus. Nat. Hist., 13:111—116.

———. 1901. Tooth characters and revision of the North American species of the genus Equus. Bull. Amer. Mus. Nat. Hist., 14:91—140.

HARRIS, A. H. 1970. The Dry Cave mammalian fauna and late pluvial conditions in southeastern New Mexico. Texas J. Sci., 22:3-27.

HARRIS, A. H., AND J. S. FINDLEY. 1964. Pleistocene-Recent fauna of the Isleta Caves, Bernalillo County, New Mexico. Amer. J. Sci., 262:114—120.

HAY, O. P. 1913. Notes on some fossil horses, with descriptions of four new species. Proc. U.S. Natl. Mus., 44:569—594.

HIBBARD, C. W. 1955. Pleistocene vertebrates from the Upper Becerra (Becerra Superior) Formation, Valley of Tequixquiac, Mexico, with notes on other Pleistocene forms. Contrib. Mus. Paleo., Univ. Michigan, 12:47—96.

HIBBEN, F. C. 1941. Evidences of early occupation in Sandia Cave, New Mexico, and other sites in the Sandia-Manzano region. Smithsonian Misc. Coll., 99:1-64.

HOFFSTETTER, R. 1950. Algunas observaciones sobre los caballus fosiles de la America del Sur. Amerhippus Gen. Nov. Bol. Inform. Cient. Nat., Ecuador, 3:426—454.

HoPwooD, A. T. 1936. The former distribution of caballine and zebrine horses in Europe and Asia. J. Zool., 106:897-912.

———. 1942. Notes on Recent and fossil equines.--I. Anatomical features of certain limb-bones. Ann. Mag. Nat. Hist., Ser. 11, 9:73—94.

JOHNSON, E. NI. 1976. Investigations into the zooarchaeology of the Lubbock Lake Site. Unpubl. Ph.D. dissert., Texas Tech Univ., Lubbock, 589 pp.

LEIDY, J. 1865. Bones and teeth of horses from California and Oregon. Proc. Acad. Nat. Sci. Philadelphia, 17:94.

LUNDELIUS, E. L. 1972. Vertebrate remains

from the Gray Sand. Pp. 148–163, in Blackwater Locality No. 1. A stratified early man site in eastern New Mexico (J. J. Hester, ed.). Publ. Fort Burgwin Res. Center, 8:1–239.

LUNDELIUS, E. L., AND M. S. STEVENS. 1970. *Equus francisci* Hay, a small stilt-legged horse, middle Pleistocene of Texas. J. Paleo., 44:148–153.

MCGREW, P. O. 1944. An early Pleistocene (Blancan) fauna from Nebraska. Field Mus. Nat. Hist., Geol. Ser., 9:33–66.

MERRIAM, J. C. 1913. Preliminary report on the horses of Rancho La Brea. Bull. Dept. Geol., Publ. Univ. California, 7:397–418.

MILLER, W. E. 1971. Pleistocene vertebrates of the Los Angeles Basin and vicinity (exclusive of Rancho La Brea). Bull. Los Angeles Co. Mus. Nat. Hist., Sci., 10:1–124.

MOOSER, O. 1958. La fauna "Cedazo" del Pleistoceno en Aguascalientes. An. Inst. Biol., 29:409–452.

MOOSER, 0., AND W. W. DALQUEST. 1975. Pleistocene mammals from Aguascalientes, central Mexico. J. Mamm., 56:781–820.

OWEN, R. 1869. On fossil remains of equines from Central and South America referable to *Equus conversidens Ow., Equus tau, Ow.,* and *Equus arcidens, Ow.* Philos. Trans. Royal Soc. London, 159:559–573, pls. 61–62.

QUINN, J. H. 1955*a*. Miocene Equidae of the Texas Gulf Coastal Plain. Publ. Bur. Econ. Geol., Univ. Texas, 5516:1–102.

___. 1955b. Appendix 1. Report on the horse remains from the Scharbauer Site. Pp. 117–118, in The Midland discovery (F. Wendorf, A. D. Krieger, and C. C. Albritton, eds.). Univ. Texas Press, Austin, 139 pp.

_____. 1957. Pleistocene Equidae of Texas Bur. Econ. Geol., Rept. Invest., 11:1–51.

SAVAGE, D. E. 1951. Late Cenozoic vertebrates of the San Francisco Bay region. Bull. Geol. Sci., Publ. Univ. California, 28:215–314.

SCHULTZ, C. B., AND E. B. HOWARD. 1935. The fauna of Burnet Cave, Guadalupe Mountains, New Mexico. Proc. Acad. Nat. Sci. Philadelphia, 87:273–298.

SKINNER, M. F. 1942. The fauna of Papago Springs Cave, Arizona, and a study of *Stockoceros;* with three new antilocaprines from Nebraska and Arizona. Bull. Amer. Mus. Nat. Hist., 80:1–220.

_____. 1972. Order Perissodactyla. Pp. 117 125, *in* Early Pleistocene pre-glacial and glacial rocks and faunas of north-central Nebraska (M. F. Skinner and C. W. Hibbard, eds.). Bull. Amer. Mus. Nat. Hist., 148:1 148.

SLAUGHTER, B. H. 1975. Ecological interpretation of the Brown Sand Wedge local fauna. Pp. 179–192, *in* Late Pleistocene environments of the Southern High Plains (F. Wendorf and J. J. Hester, eds.). Publ. Fort Burgwin Res. Center, 9:1–290.

SNEATH, P. H. A., AND R. R. SoKAL. 1973. Numerical taxonomy. W. H. Freeman and Co., San Francisco, 573 pp.

STIRTON, R. A. 1939. Cenozoic mammal remains from the San Francisco Bay Region. Bull. Dept. Geol. Sci., Publ. Univ. California, 24:339–410.

STOCK, C., AND F. D. BODE. 1937. The occurrence of flints and extinct animals in pluvial deposits near Clovis, New Mexico. Part III,–Geology and vertebrate paleontology of the late Quaternary near Clovis, New Mexico. Proc. Acad. Nat. Sci. Philadelphia, 88:219–241.

TROXELL, E. L. 1915. The vertebrate fossils of Rock Creek, Texas. Amer. J. Sci., 39:613 638.

VON REICHENAU, W. 1915. Fossiler Pferde aus Deutschem Pleistozan. Geol. Land. Darmstadt, 7:1–155, 14 pls.

WILLOUGHBY, D. P. 1974. The empire of Equus. A. S. Barnes and Co., South Brunswick, 475 pp.

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