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Remains of *Mammuthus* housed in the collections of the Instituto Nacional de Antropología e Historia, México

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The paleontological collection of the 'Instituto Nacional de Antropología e Historia' houses mammoth remains from 55 sites in 17 states in México. This collection has been formed in the past 40 years, primarily from the Estado de México and the Distrito Federal. The remains represent at least 84 individuals. Based on adult cranial elements, two species of mammoth are identified for México: *Mammuthus hayi* for the Middle Pleistocene and *M. columbi* for the Late Pleistocene. The distribution of the genus in México is primarily in the Nearctic region.

La colección paleontológica del Instituto Nacional de Antropología e Historia aloja restos de mamut procedentes de 55 localidades ubicadas en 17 estados de México. Dichas colecciones han sido reunidas a lo largo de 40 años, concentrándose la mayor parte en el Estado de México y el Distrito Federal. Los materiales representan al menos 84 individuos. Con base en los individuos adultos y solamente los elementos craneales de la colección, se identificaron dos especies de mamut para México: *Mammuthus hayi* para el Pleistoceno medio y *M. columbi* para el Pleistoceno tardío. La distribución del género en México es principalmente neártica.

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INTRODUCTION

In Mexico, Pleistocene fossils are frequently found during building or sewage construction, opening of new roads, agricultural plowing or through research in relationship to the first appearance of people. Among others, remains of horse (*Equus*) and mammoth (*Mammuthus*) are the most abundant. The 'Instituto Nacional de Antropología e Historia', or otherwise National Institute of Anthropology and History (INAH by its Spanish initials) is the federal agency in charge of verifying and studying the reported findings. As a result, for the past 40 years, a large amount of material has accumulated from the salvage as well as archaeological

and paleontological excavations. This material includes the corresponding documentation, and most data are still unpublished.

The mammoth species in the Americas are not clearly understood as number of species and their diagnostic characters are still matters of controversy. Osborn (1942) considered that there were 15 species, while Maglio (1973) only recognised four. Madden (1981), as yet unpublished but widely cited, and Shoshani & Tassy (1996) did the last revisionary works about these taxonomic problems. Madden (1981) pointed to the validity of six species: *Mammuthus hayi*, *M. imperator*, *M. exilis*, *M. columbi*, *M. jacksoni* and *M. mammonteus*. On the other hand, Shoshani & Tassy (1996) agreed on seven species: *M. primigenius*, *M. columbi*, *M. exilis*, *M. hayi*, *M. imperator*, *M. jeffersonii* and *M. meridionalis*. The same problems are found in Mexico. For example, Silva-Bárcenas (1987), when listing the mammoth remains on deposit at the 'Instituto de Geología, Universidad Nacional Autónoma de México', recorded the genera *Elephas* and *Mammuthus* for the country. Another recent study using measurements and dental data, recorded the presence of *Mammuthus columbi* and *M. imperator*, assuming that both species lived at the same time at the Late Pleistocene (Polaco Ramos 1983).

In agreement with Agenbroad (1984), it is important to provide published documentation of the mammoth records in collections in order to gain updated knowledge on the distribution and geological time duration of the different species in a region, and also to clarify the taxonomy. Because of that, this work outlines which mammoth species are found in the country, using INAH's paleontological collection holdings as a base line.

MATERIAL AND METHODS

Based on INAH's paleontological collection catalog, a database was created of mammoth remains, including locality data and anatomical sorting (e.g., cranial, postcranial). The database was reviewed based on the available specimens, and all those that were uncataloged were added. The specimens were sorted by age, and only the adult individuals were subsequently analysed. For the study of the upper and lower molars, criteria proposed by Aguirre (1969), as modified by Maglio (1973), were followed. Molar analysis was done using four main measurements: greatest width of molar, plate number, lamellar frequency, and enamel width. Using such data, descriptive statistics were obtained (average, minimum, maximum, standard deviation) for each identified species. Specific locality data are available in the database upon request to the authors.

RESULTS AND DISCUSSION

The material on deposit at INAH's Paleontological Collections is from 55 localities in 17 states (see Appendix), with Tocuila (Estado de México) being the latest one and currently under study (Morett *et al*. 1998a, b). Only postcranial materials have been found at 10 localities, while only cranial elements were recovered from 30 localities. The remaining 15 localities have both cranial and postcranial bones (Fig. 1a). Most of the localities are from Central Mexico, mainly from the Estado de México and the Distrito Federal, and greatly concentrated in the Basin of Mexico (Fig. 1b). Most of the findings are isolated and eroded individuals. However, some localities have large amounts of materials found in *situ*. Because of that situation, these localities have been of prime interest for INAH's researchers who undertook stratigraphically controlled excavations. Some examples include, in the Estado de México, the sites at Santa Lucía with two individuals, and Tocuila which has at least five animals (Morett *et al.* 1998a, b). In the state of San Luis Potosí, El Cedral has at least 22 individuals and Laguna de las Cruces, Salinas in Laguna, has nine mammoths (Polaco-Ramos 1983).

Some bones in the available material have marks of possible human activity at the time of the animal's death. Two have been documented in the literature: from Santa Isabel

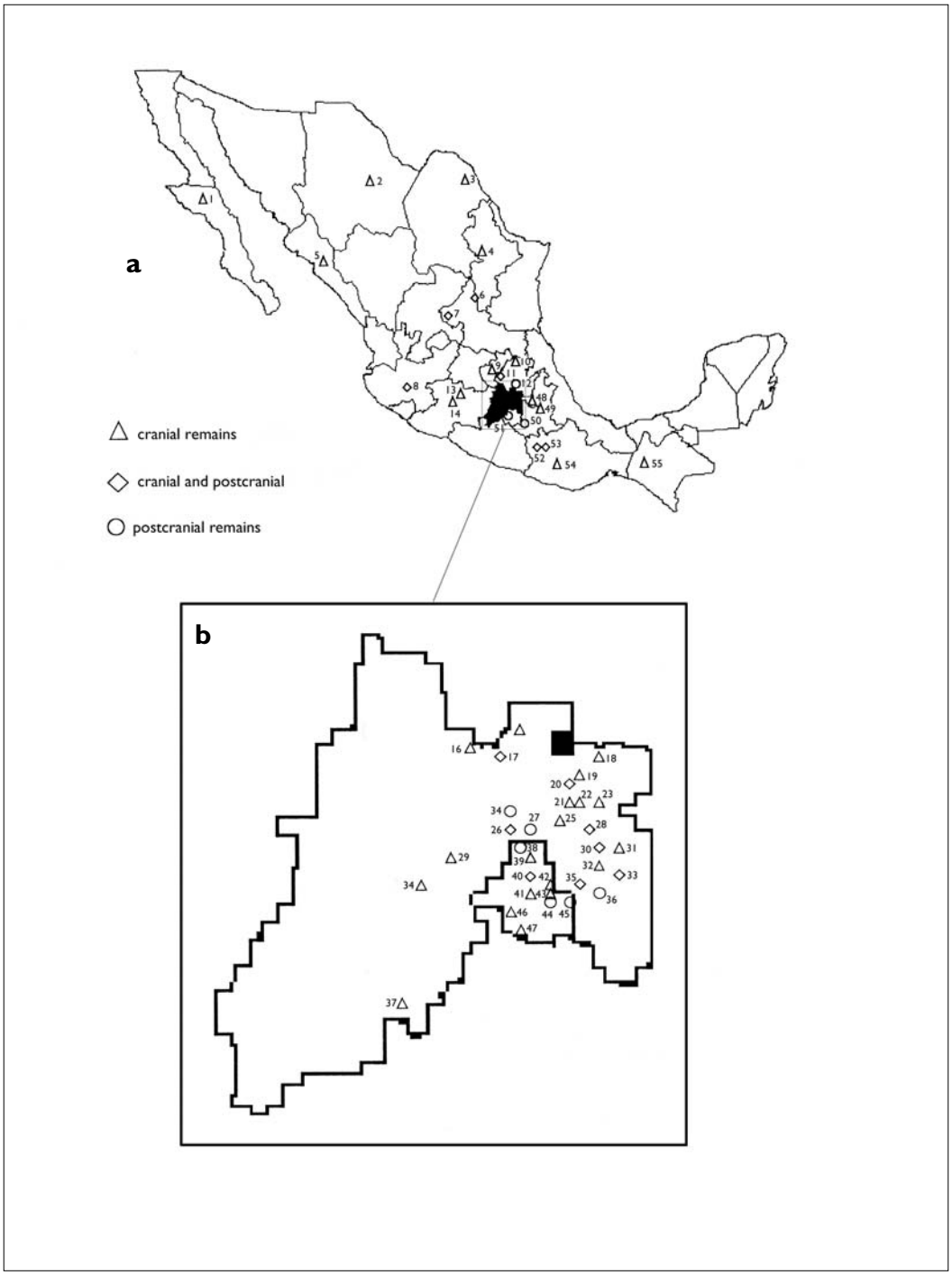

Figure 1 Map showing the localities from Mexico where mammoth remains have been collected and are on deposit at the paleontological collection of the Instituto Nacional de Antropología e Historia, México. The number refers to the localities listed in Appendix 1. **a** = entire México; **b** = more detailed map of Estado de México and the Distrito Federal.

Table 1 Measurements (in mm) of *Mammuthus hayi* third molars from México at the paleontological collection of the Instituto Nacional de Antropología e Historia, México. i = left; d = right; **P** = plate number; **L** = length; **W** = width; **ET** = Enamel thickness; **H** = height; **LF** = lamellar frequency. Superscript refers to plate number on which W and H measurements were taken.

upper						
catalog	**P**	**L**	**W**	**ET**	**H**	**LF**
1182i	+12	213.8	111.2^{6}	4	90.4^{10}	4.2
1182d	+12	239	118.3^{5}	4	90.5^{10}	4
average	12	226.4	114.75	4	90.45	4.1
desv	0	17.8	5	0	0.07	0.14
lower						
catalog	**P**	**L**	**W**	**ET**	**H**	**LF**
1825	12	306.7	114.5^{6}	4	124.9^{9}	4
1824	11	288.6	111.9^{6}	4.1	122.4^{9}	4
average	11.5	297.65	113.2	4.05	123.65	4
desv	0.7	12.8	1.8	0.07	1.8	0

Iztapan, Estado de México, a rib fragment with cut and blow marks (Aveleyra A. de Anda 1956). The other one is at El Cedral, San Luis Potosí, where several mammoth foot bones showing burning marks were found around a fireplace (Alvarez & Polaco 1982). From Tocuila, five modified bones are currently under study (Morett *et al*. 1998b). Another important locality with a large number of cut marks on the bones is Villa de Guadalupe, Distrito Federal, with a tusk and mandibular ramus covered by marks all over their surface. The mandibular ramus was dated at 11,300 ± 120 years (González *et al*. in press). Finally, at Zacapú, Michoacán, a tibia fragment is very much alike in terms of number and kind of marks to the rib from Santa Isabel Iztapan, but twice its size.

For the specific identification, only adult animals were studied, including six complete mandibles, eight mandibular rami, and 50 third molars. Two species were identified; one represented by two individuals, the upper molars of an individual from El Mezquital, Baja California Sur, and both lower molars from Culhuacan, Distrito Federal. The upper molars have 12 plates, probably lack the first one and the heel, and the lamellar frequency is 4.1. The lower molars have 11 or 12 plates, and a lamellar frequency of 4. Both molar pairs showed a strong asymmetry between them (Table 1). These molars pertained to a large-sized mammoth with a low number of plates. Such characteristics are similar to *Mammuthus meridionalis*, recorded at some points in the Americas (e.g. Dubrovo 1990; Lucas 1995). Similar molars were identified from Arispe, Sonora; these are the type of *Archidiskodon sonoriensis* from Osborn (1942). Lucas & León-González (1996) identified those molars as *M. imperator*, while Webb & Dudley (1995) assigned those remains to *M. hayi*. We assigned the studied specimens to *M. hayi*, taking into account that *M. imperator* has been referred synonymous with *M. columbi* (e.g. Kurtén & Anderson 1980); this is a conservative approach since the presence of *M. meridionalis* in the Americas is still in doubt. The age of the studied materials is unknown, but Lucas & González-León (1996) assigned a Middle Pleistocene age to this type of molar.

The second species comprises 29 individuals that have large, narrow molars, with a width of 75 to 108.5 mm (average 92); the enamel width is between 1.5 and 3.8 mm; and they have a strongly crenulated pattern. The lower molars have from 14 to 22 plates with a mean

of 16, lamellar frequency of five plates (Appendix 2); the upper molars have from 13 to 22 plates, with a mean of 17, and a lamellar frequency of 5 to 7 (Appendix 3). Those specimens are within the variation intervals for the diagnostic characters of the Late Pleistocene species *Mammuthus columbi*. The fossil age is Late Pleistocene.

Most of the problems within the mammoth taxonomy are due to the poor descriptions that are generally based on few remains, even including fragments. Furthermore, no consideration has been given to intraspecific variation, which is very large in the studied material. Besides secondary sexual dimorphism, other sources of variation are molar asymmetry, differences between the cement width, and the wear pattern of molars that may be in relationship to the food habits and the tooth replacement pattern. Also, the presence of some pathologic specimens could add to species variation. The study of a large series of molars, and specially those from a single locality is important, to assess the range of intraspecific variation and what is causing it, in order to clarify the taxonomy of the group.

CONCLUSION

Based on the material in the collections at INAH and a publication in the present volume (Arroyo-Cabrales *et al*. 2002), it is clear that the genus *Mammuthus* occurred in Mexico mainly with a Nearctic distribution pattern. Few localities are on the coastal lowlands in the present Neotropical region. Mammoth may not have reached southeastern Mexico (Tabasco and the Yucatan Peninsula), where at present they have not been found. We suggest that only two species occurred in Mexico, the very scarce *Mammuthus hayi* that is known from only two localities, and the more widely distributed *Mammuthus columbi*.

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APPENDIX 1

List of mammoth localities represented at the Paleontological collection of the Instituto Nacional de Antropologia e Historia, Mexico.

1. El Mezquital, Baja California Sur
2. San Diego de Alcalá, Chihuahua
3. Ciudad Acuña, Coahuila
4. Monterrey, Nuevo León
5. Rancho El Aguaje, Mocorito, Sinaloa
6. El Cedral, San Luis Potosí
7. Laguna de Las Cruces, Salinas, San Luis Potosí
8. Jocotepec, Jalisco
9. Amealco, Querétaro
10. Tlaxcoapan, Hidalgo
11. Tula, Hidalgo
12. Majay, Hidalgo
13. Laguna de Cuitzeo, Michoacán
14. Felipe Carrillo Puerto, Buenavista, Michoacán
15. Tequixquiac, México
16. Zumpango, México
17. Santa Lucía, México
18. Teotitlán, México
19. San Juan Teotihuacán, México
20. Tecnila, Proyecto Teotihuacán, México
21. Venta de Carpio, México
22. Tepexpan, México
23. San Francisco Mazapa, México
24. Chiconautla, México
25. Santa Isabel Iztapan, México
26. San Juan Ixhuatepec, México
27. Atzacoalco, México
28. Chinconcuac, México
29. San Pedro Totoltepec, México
30. Tocuila, México
31. Texcoco, México
32. San Vicente Chicoloapan, México
33. Chimalhuacán, México
34. San Mateo Atenco, México
35. Los Reyes La Paz, México
36. Tlapacoya, México
37. Tonatico, México
38. San Bartolo Atepehuacán, Distrito Federal
39. Avenida 100 Metros, Delegación Gustavo A. Madero, Distrito Federal
40. Sistema de Transporte Colectivo Metro Línea 1, Distrito Federal
41. Culhuacán, Distrito Federal
42. Cerro de la Estrella, Distrito Federal
43. Barrio Santa Rosa, Iztapalapa, Distrito Federal
44. Iztapalapa, Distrito Federal
45. Tlahuac, Distrito Federal
46. Santa Fe, Distrito Federal
47. Tlalpan, Distrito Federal
48. Ojo de Agua, Tlaxcala
49. San Baltazar Tetela, Puebla
50. Cerro Piulco, Puebla
51. Temixco, Morelos
52. Coixtlahuaca, Oaxaca
53. Jicotlán, Oaxaca
54. Nochistlán, Oaxaca
55. Aguacatenango, Chiapas

APPENDIX 2

Measurements (in mm) of *Mammuthus columbi* lower third molars from México at the paleontological collection of the Instituto Nacional de Antropología e Historia, México. Same abbreviations as in Table 1.

catalog	P	L	W	ET	H	LF
1547i	18+	243.8	75.4[7]	2.5	-	5
1547d	+19	259.1	79.4[7]	2.6	-	5
ch1984d	15+	262.9	104.1[5]	3.1	-	4.6
ch1984i	15+	261.3	104.8[5]	3.1	-	4.6
757d	15+	278.3	80.7[4]	2.5	-	5
757i	+13+	231.6	79.9[4]	2.5	-	5
1631	+16+	275.9	108.2[7]	3.1	-	5
4948	13+	252	87.2[5]	3.1	-	4.6
438d	16+	310.5	102.5[8]	2.5	-	4.6
438i	+8+	-	76[3]	2.5	-	4.6
1971	+15+	229.8	95.8[5]	3.1	97.7[10]	5
763	+12+	296.8	105.2[3]	3.3	147.2[12]	5.4
1848	18+	282.4	85.8[6]	1.8	154[12]	5.6
671	+9+	190.1	83[1]	2.3	139[4]	5.4
2372i	+15	295.8	95[6]	3.1	135[11]	4.6
1949	19+	269.9	90.9[5]	3	149.3[11]	6
1633	+15	231.8	104.8[5]	2.8	116.3[7]	5.3
1996	20	223.8	76.9[4]	2.1	-	6
1972	14	171.2	91.9[4]	3.2	150[10]	5
409	14	253.1	103.9[6]	2.7	110.7[8]	5
512	14	272.7	108.5[6]	2.7	110.5[8]	5.2
4343	14	227.3	97.3[7]	2	103.2[7]	5
2372d	15	282.7	93.2[8]	3.5	140.2[10]	4
2397	17	206.8	75.7[3]	3.1	155.3[12]	6.6
4489	17	168.1	98.1[5]	3.3	181.3[9]	5
3733i	22	197.7	90.2[7]	3.6	168.8[11]	5
3733d	20	199.9	91.5[7]	3.5	169.5[10]	5
average	16.7	245.2	92	2.8	139.2	5
desv	3	39	10.9	0.47	25.0	0.52
min.	14	168.1	75.4	1.8	97.7	4
max.	22	310.5	108.5	3.6	181.3	6.6

APPENDIX 3

Measurements (in mm) of *Mammuthus columbi* upper third molars from México at the paleontological collection of the Instituto Nacional de Antropología e Historia. México. Same abbreviations as in Table 1.

catalog	P	L	W	ET	H	LF
2300	18+	214.2	93.2[8]	2.5	202.7[13]	5.5
2401	+18	171.5	103.1[4]	2.9	197[12]	6.6
1975	+9+	65.3	90.9[1]	3	190[3]	6
1976	+12+	185	93[5]	3	202.2[11]	5
1977	+14+	209.2	109.6[5]	2	202.9[12]	5.3
1985	14+	103.4	84.2[1]	3	214.3[9]	6.6
1987	+16	173.2	84.1[1]	3.3	174.6[9]	6.3
1986	+20	177.5	101.5[5]	3	1461[3]	6
1984	+15	180.2	102.9[4]	2.4	181.5[12]	6.3
1983	+17	203.8	93.8[5]	2.7	201.9[12]	6.3
277	+21	235.8	86.4[4]	2.1	197.8[9]	7.4
208	22+	324.2	116.4[4]	2.3	265.6[8]	5.8
412	+16	281.3	94.6[2]	2.3	176.6[8]	5
1194	+18	305.5	100.3[4]	2.9	205.4[11]	6.6
414	14+	262.2	83.3[3]	2.6	234.2[10]	6.4
4340	+12+	157.9	99.2[4]	2.3	176.8[8]	6
4488	14	245.5	110.9[7]	3.8	165[13]	5.5
2383i	17	136.1	105.9[4]	3.1	243.3[9]	6
2383d	19	150.1	102.1[4]	3.1	207[13]	6.6
3729	19	199.1	95.9[6]	3.1	211.6[10]	6.6
2400	17	75.1	66[3]	1.5	178.5[10]	7
2298d	21	139.2	97.6[3]	3.7	238.8[8]	6.6
2298i	22	160	90.8[3]	2.9	237.9[9]	6.6
1988	15	111.7	81.8[2]	2.9	191.5[7]	6
1980i	13	67.7	65.9[2]	2.2	173.9[7]	7
1980d	14	79.1	64.9[1]	2.2	180.1[5]	6.5
413	19	327.4	94.9[3]	2.6	265.3[10]	5.4
1948	18	219.4	102.2[5]	3.4	211.6[10]	5
1947	19	146.7	101.3[3]	3.2	211.1[8]	5
4342	17	185.4	98.9[4]	2.7	154.1[9]	5
2395i	17	83.3	81.3	2.1	-	7
2395d	19	80.9	82.3	2.1	-	7
average	17.5	176.8	93.1	2.7	201.3	6.1
desv	2.5	74	12.6	0.52	29.5	0.69
min.	13	80.9	64.9	1.5	146	5
max.	22	327.4	116.4	3.8	265	7

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