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Geology

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Giant Short-Faced Bear (*Arctodus simus yukonensis*) Remains from Fulton County, Northern Indiana

Ronald L. Richards
William D. Turnbull

With an Appendix by E. J. Neiburger

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Giant Short-Faced Bear (*Arctodus simus yukonensis*) Remains from Fulton County, Northern Indiana

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Giant Short-Faced Bear (*Arctodus simus yukonensis*) Remains from Fulton County, Northern Indiana

Ronald L. Richards **William D. Turnbull**

Abstract

Major portions of the skeleton of the extinct giant short-faced bear (*Arctodus simus yukonensis*) were recovered from Fulton County, northern Indiana, in 1967. The bones provided a radiocarbon age of 11,500 ± 520 years B.P. (apatite fraction). The skeleton was deposited in a shallow lake, perhaps in or near an open or patchy boreal forest dominated by spruce, after the recession of Wisconsinan ice. The bear was large, comparable in size to Rancholabrean specimens from Alaska and the Yukon. It is the only tremarctine recorded from Indiana, is one of two specimens from the Great Lakes region, and is one of the most nearly complete skeletons known. Most of the other known specimens are highly incomplete, so the Indiana specimen provides a firm basis for assessing variation in the subspecies. The skull is relatively short compared to the limb bones, is markedly wide, and has a very narrow interorbital width. Several of the vertebrae and limb bones exhibit pathological conditions. The pathologies were described previously and are further described here and discussed by Neiburger in the Appendix. A full set of measurements is presented. Comparisons are made with other *A. simus* specimens, yielding important data that have not previously been reported.

Introduction

In 1967 Mr. William Lane of the Northern Indiana Public Service Company (NIPSCO) unearthed and collected some large bones while operating a backhoe. He contacted the Department of Biology, North Central Campus, Purdue University, Westville, Indiana, transferring the remains to Dr. Greta Woodard. After identifying the remains as those of *Arctodus simus* (giant short-faced bear) with the aid of one of us (W.D.T.), plans were laid for a joint report on the bones. With the untimely death of Dr. Woodard, that report was not realized, and the bones, returned to the Field Museum in 1970 by Dr. Woodard's spouse, were deposited in the fossil mammal collection (catalogue PM #24880). The specimen was used by Jay H. Matternes in his reconstruction of *Arctodus simus* for an article by Guthrie (1972) and for a life-sized restoration of the bear in a mural at the National Museum of Natural History, Smithsonian Institution. In 1983 we undertook a study of the specimen, reported herein. A magazine article subsequently illustrated a lateral view of the articulated skull and jaws (Richards, 1983).

Arctodus simus is a large tremarctine with relatively robust dentition and skeleton and proportionately long legs (Kurtén, 1967). It is known from more than 100 localities in North America, ranging in age from middle Irvingtonian through Rancholabrean (Kurtén, 1967; Richards et al., in press). Kurtén (1967) recognized two subspecies, the smaller *Arctodus simus simus* and the larger *A. s. yukonensis*. There is some debate over whether the bear was an omnivore/herbivore or a predator (Emslie & Czaplewski, 1985; Voorhies & Corner, 1986).

The skeleton reported here is the first record of *Arctodus simus* in Indiana and one of two specimens from the Great Lakes region. The second specimen was recently recovered from a cave in Wyandot County, Ohio (Hansen, 1992; H. G. McDonald, pers. comm. to Richards, 6 Jan. 1992). Richards et al. (in press) present an expanded coverage of North American *Arctodus simus* localities and materials.

Occurrence

The remains were found south of Rochester, Fulton County, Indiana. The exact site is uncertain. Because the bones were unearthed by a backhoe during excavation of a pipeline trench, and some were recovered from the spoil heaps, the exact stratigraphic placement is unknown. The land surface was modified shortly thereafter by earth-moving equipment.

A complex record of glacial sediments is preserved in what is now Fulton County, Indiana, representing the effects of three lobes of Wisconsinan ice (Gray, 1989). Most of the county is blanketed by northeastern-source till of the Trafalgar Formation, deposited by the East White Sublobe (Huron-Erie Lobe). A recessional edge moraine of Trafalgar ice ("Packerton Moraine") transects the southeastern corner of the county (Bleuer & Melhorn, 1989). Northern-source tills and moraines of the Michigan Lobe terminate in northwestern Indiana to the west of Fulton County, but a complex series of associated alluvial fans and fan heads ("Maxinkuckee Moraine") enter the northwestern part of Fulton County. Both the "Maxinkuckee" and "Packerton" features were previously believed to have been terminal moraines of the northeastern-source Saginaw interlobe (Wayne & Zumberge, 1965; Schneider & Johnson, 1967), which is now believed to have terminated much farther to the north in Indiana (Bleuer & Melhorn, 1989). The primary advance of the Trafalgar ice margin occurred at approximately 20,000 B.P., and a recent date suggests that ice was present at the present site of Plainfield, Hendricks County (about 150 km south of Fulton County), at 17,650 ± 190 B.P. (N. Bleuer, pers. comm. to Richards). A later advance of Lagro ice (Miami Sublobe, Huron-Erie Lobe) to the east of Fulton County deposited a classical series of curved recessional moraines in northeastern Indiana (Gray, 1989; Mickelson et al., 1983). The earliest Lagro advance occurred at approximately 15,500 B.P. (after the "Erie Interstade"), with ice receding to near the eastern border of Indiana (Fort Wayne Moraine) by approximately 14,800 B.P. (Mickelson et al., 1983).

The initiation of the Lagro sequence ca. 15,500 B.P. indicates the period when Fulton County was deglaciated of Wisconsinan ice. Deglaciation left numerous kettle depressions across the landscape, many of which held water. Deposition of calcareous clay (marl) and peat are typical in "kettle lakes" of northern Indiana (Wayne, 1971; Schneider & Moore, 1978). Sediments and the occasional remains of mastodonts or other vertebrates deposited in these kettles typically date from the past 13,000 years (Wayne, 1963; Wayne & Zumberge, 1965).

Calcareous clays containing aquatic snails (including *Gyraulus, Valvata,* and *Heliosoma /Planorbella*) adhering to some of the bones and filling their cavities indicate that the Fulton County *Arctodus* remains were deposited in a shallow kettle lake. The period of deposition is indicated by a radiocarbon date of 11,500 ± 520 B.P. (Geochron Laboratories, GX-12483; C-13 corrected) on *Arctodus* bone apatite (a portion of the left #7 rib).

Description

Genus *Arctodus* Leidy, 1854
Arctodus simus (Cope, 1879)
Arctodus simus yukonensis (Lambe, 1911); Kurtén, 1967

The skeleton is clearly assignable to *Arctodus simus* using the criteria of Merriam and Stock (1925) and Kurtén (1967). The remains are illustrated in Figures 1–16, and measurements are presented in Tables 1–7. These tables include measurements of some elements (i.e., atlas, axis, sacrum, and scapula) that have previously been measured only in the smaller-sized Potter Creek, California, *Arctodus simus* population (Merriam & Stock, 1925) or that were entirely lacking in the literature (e.g., pelvis, caudal #1, ribs). Kurtén (1967) presented scant size information on these elements for the larger *A. s. yukonensis.*

Most North American *Arctodus simus* occur as isolated individuals, but Rancholabrean-aged population samples are available for Potter Creek Cave and Rancho La Brea, California (Merriam & Stock, 1925), and from the Fairbanks, Alaska, area (Kurtén, 1967). Table 8 presents comparisons of the Indiana specimen with those population samples using data from Merriam and Stock (1925) and Kurtén (1967) and additional information from Richards, Churcher, and Turnbull (in press). The Potter Creek population is composed predominantly of females (Kurtén, 1967), the Rancho La Brea population may be composed largely of females and adolescent males (Agenbroad & Mead, 1986), and the Fairbanks material appears to include both sexes. Although there are some robust skeletal elements from Rancho La Brea, the Fair-

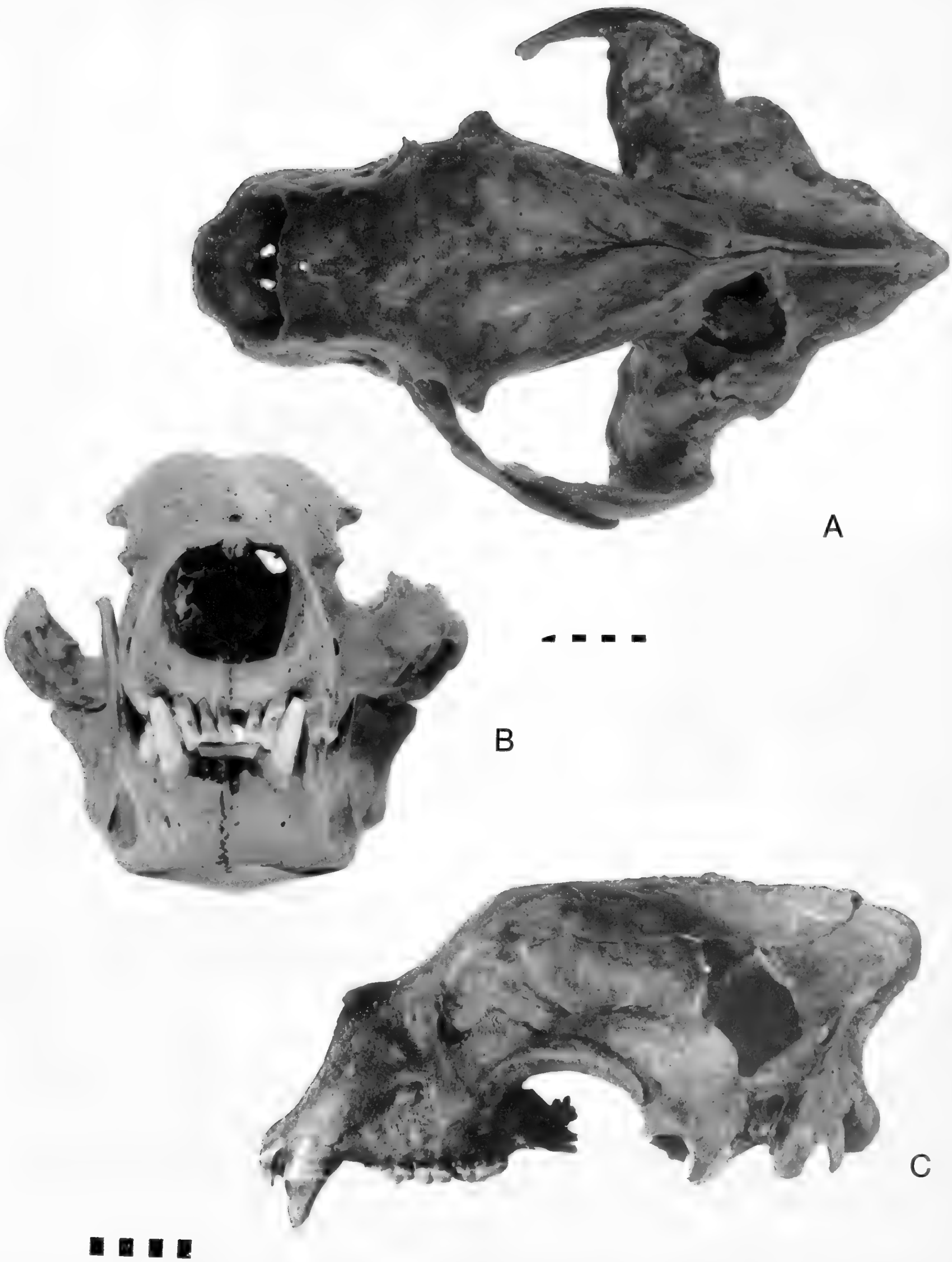

Fig. 1. **A.** Skull, dorsal view. **B.** Skull with dentaries articulated, rostral view. **C.** Skull, left lateral view. Scale in cm.

FIG. 2. **A.** Upper incisors, occlusal view. **B.** Upper right premolars, occlusal view (scale to right). **C.** Upper left tooth row, occlusal view. **D.** Skull, palatal view. Scale in cm.

banks material assigned by Kurtén (1967) to the subspecies *A. s. yukonensis* appears to be of larger size than either of the California samples. The large size of the Indiana remains compares closely to that of the Fairbanks, Alaska, material. *Arctodus simus* teeth, however, display a great range in size and do not segregate readily into the two subspecies that are indicated by limb bone length. Teeth of the Indiana specimen, with the exception of the large canines, fall within the middle range of size. Figures 17–20 show size relationships of selected elements of PM #24880 within a broader sample of North American *Arctodus simus,* including large specimens of Irvingtonian age. (An expanded variety of elements and measurements is presented in Richards et al. [in press].) The large

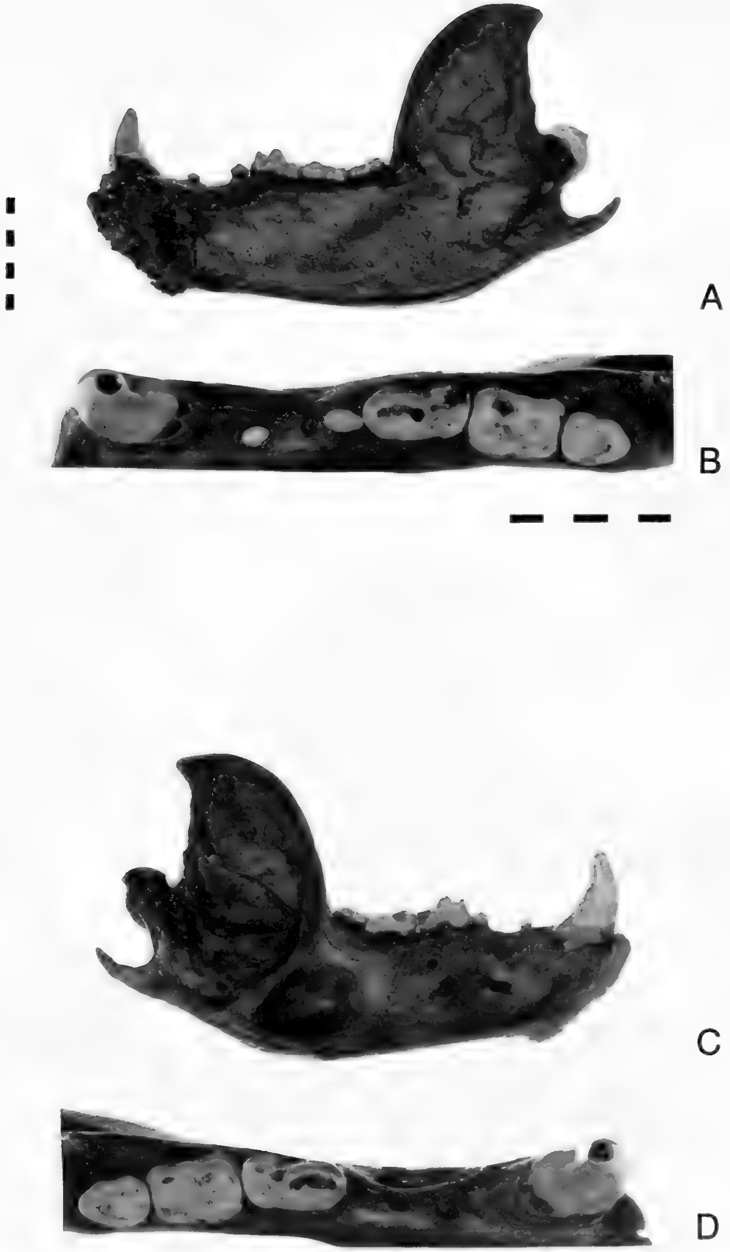

FIG. 3. **A.** Right dentary, lingual view. **B.** Right dentary, occlusal view of tooth row. **C.** Right dentary, labial view. **D.** Left dentary, occlusal view of tooth row. Scale in cm.

size of the Indiana remains compares closely to that of Irvingtonian-aged specimens from the central and northern Great Plains and to that of Rancholabrean-aged specimens from Alaska and the Yukon, while tooth dimensions appear not to be diagnostic. Differentiation between the two subspecies rests on the length of the skull, jaws, and limb bones. Based on the long limb bones, the Indiana skeleton is referred to the subspecies *A. s. yukonensis.*

The excellently preserved, medium brown, hard bones of the specimen include the nearly complete but broken skull with jaws and most of the major skeletal elements. Some elements show patholog-

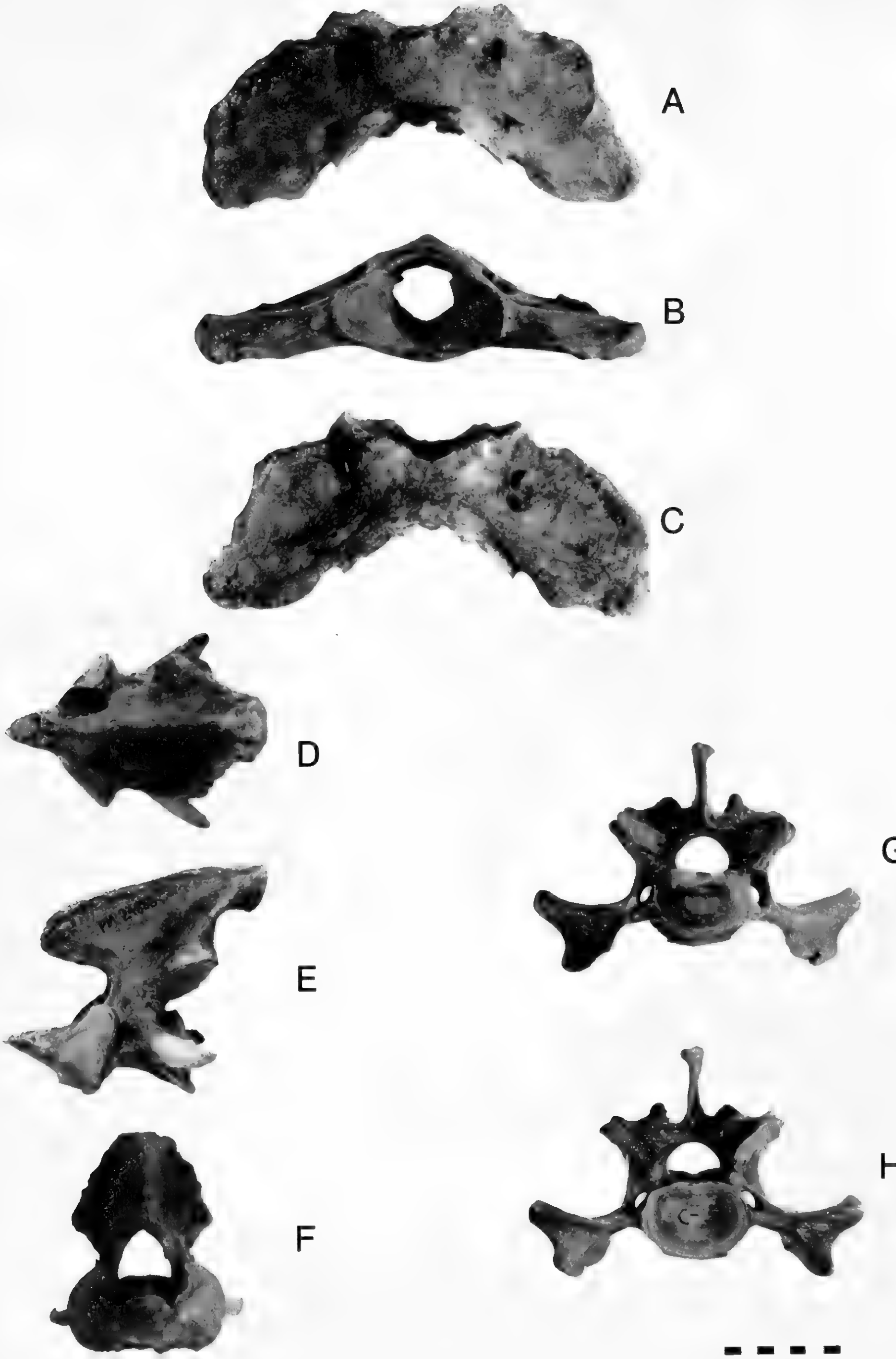

FIG. 4. **A.** Atlas, dorsal view. **B.** Atlas, posterior view. **C.** Atlas, ventral view. **D.** Axis, dorsal view. **E.** Axis, left lateral view. **F.** Axis, anterior view. **G.** Fourth cervical vertebra, anterior view. **H.** Fourth cervical vertebra, posterior view. Scale in cm.

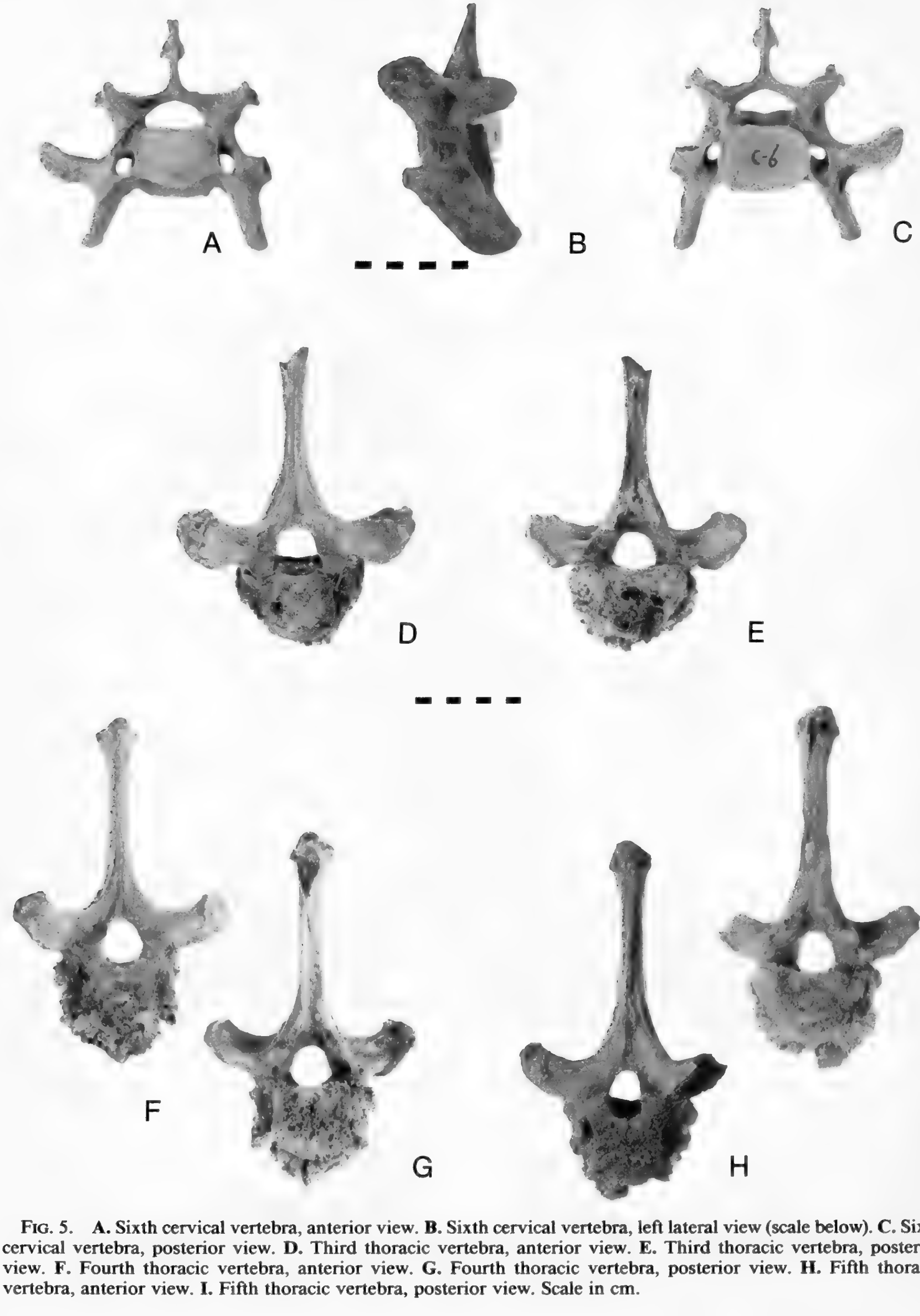

FIG. 5. **A.** Sixth cervical vertebra, anterior view. **B.** Sixth cervical vertebra, left lateral view (scale below). **C.** Sixth cervical vertebra, posterior view. **D.** Third thoracic vertebra, anterior view. **E.** Third thoracic vertebra, posterior view. **F.** Fourth thoracic vertebra, anterior view. **G.** Fourth thoracic vertebra, posterior view. **H.** Fifth thoracic vertebra, anterior view. **I.** Fifth thoracic vertebra, posterior view. Scale in cm.

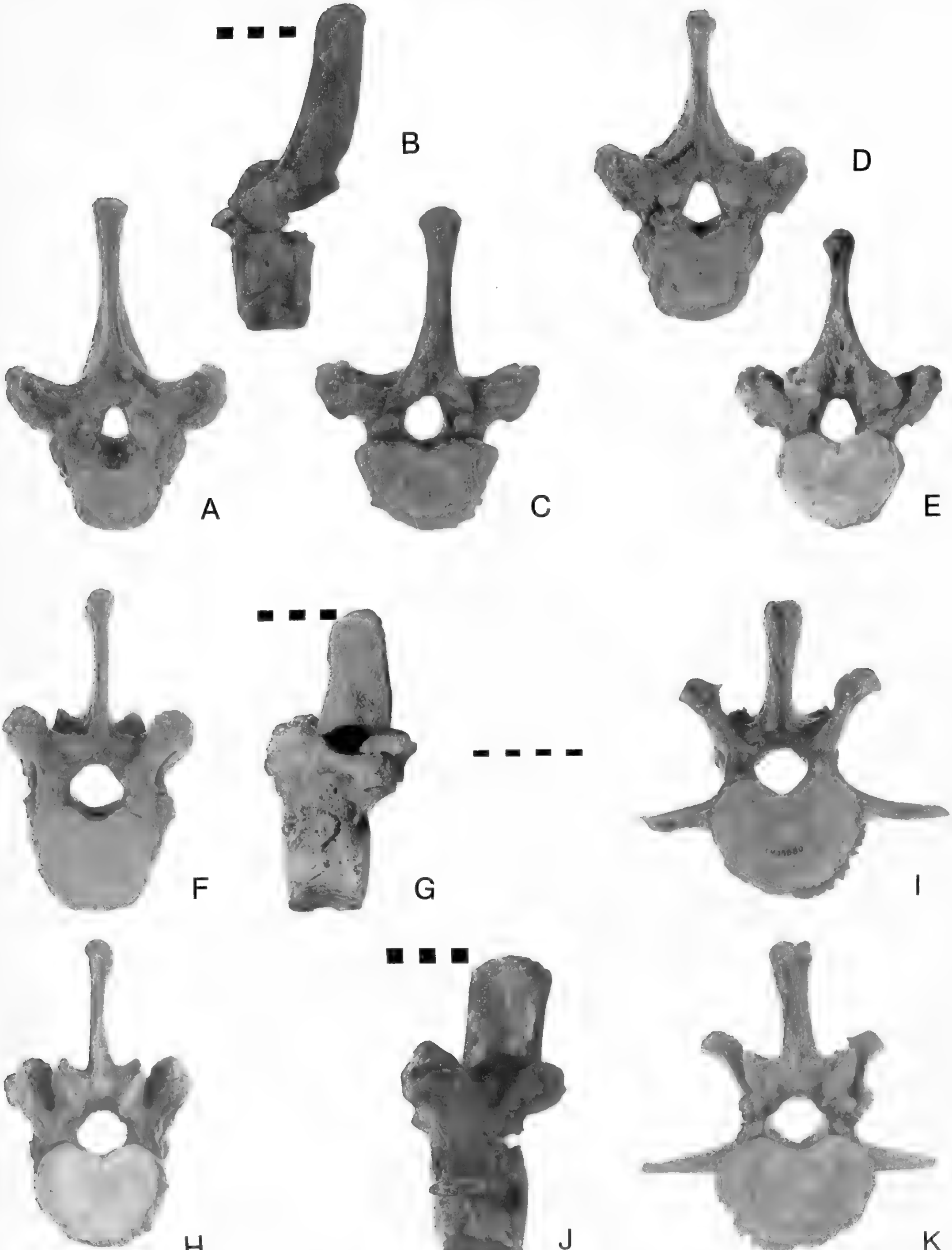

FIG. 6. **A.** Tenth thoracic vertebra, anterior view. **B.** Tenth thoracic vertebra, left lateral view (scale to left). **C.** Tenth thoracic vertebra, posterior view. **D.** Eleventh thoracic vertebra, anterior view. **E.** Eleventh thoracic vertebra, posterior view. **F.** Thirteenth thoracic vertebra, anterior view. **G.** Thirteenth thoracic vertebra, left lateral view (scale to left). **H.** Thirteenth thoracic vertebra, posterior view. **I.** Second lumbar vertebra, anterior view. **J.** Second lumbar vertebra, left lateral view (scale to left). **K.** Second lumbar vertebra, posterior view. Scale in cm.

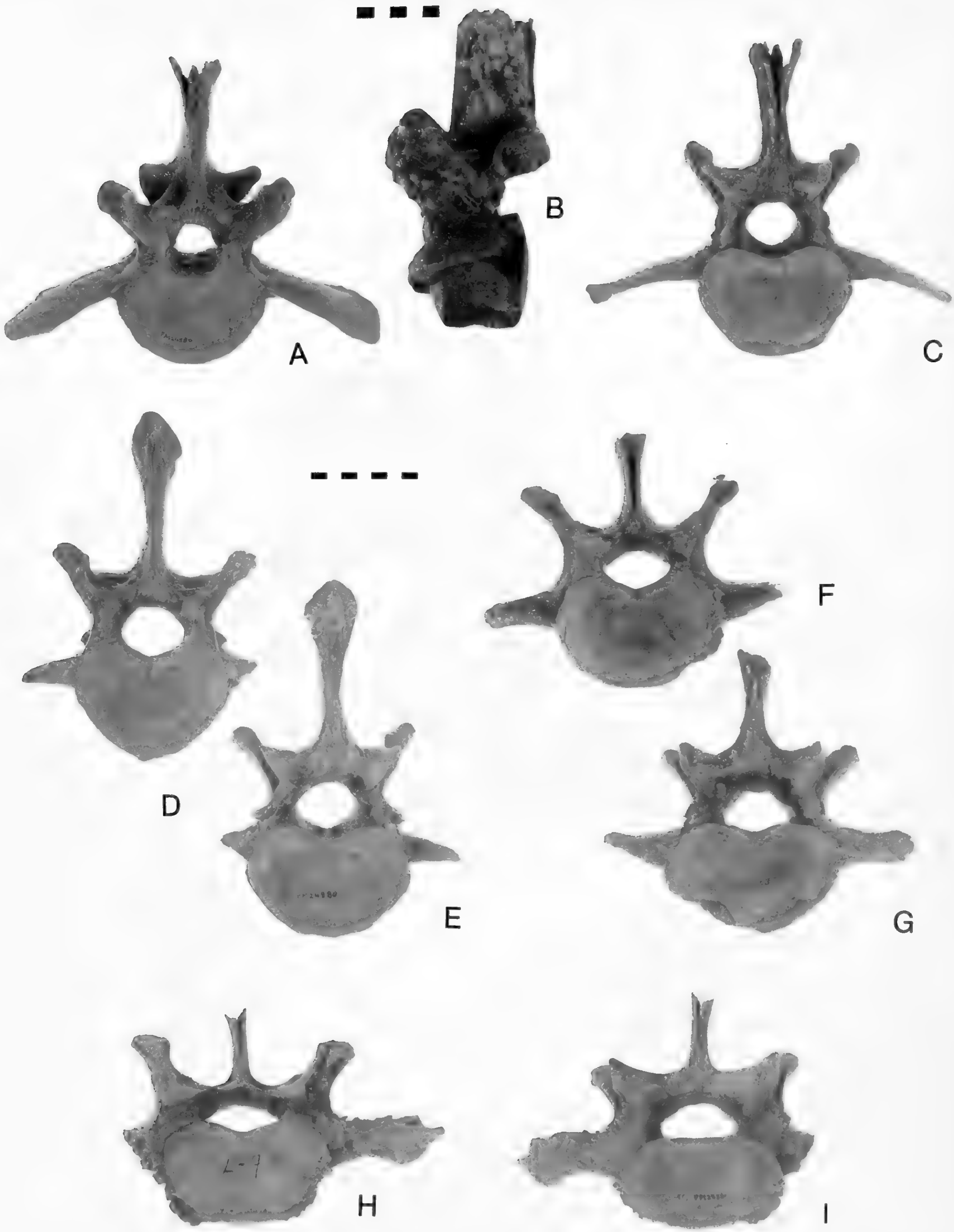

FIG. 7. **A.** Fourth lumbar vertebra, anterior view. **B.** Fourth lumbar vertebra, left lateral view (scale to left). **C.** Fourth lumbar vertebra, posterior view. **D.** Fifth lumbar vertebra, anterior view. **E.** Fifth lumbar vertebra, posterior view. **F.** Sixth lumbar vertebra, anterior view. **G.** Sixth lumbar vertebra, posterior view. **H.** Seventh lumbar vertebra, anterior view. **I.** Seventh lumbar vertebra, posterior view. Scale in cm.

FIG. 8. Pathologic detail of thoracic vertebrae. **A.** Fourth thoracic vertebra, anterior centrum face pathology. **B.** Fifth, fourth, and third thoracic vertebrae articulated, right lateral view. **C.** Fifth thoracic vertebra, posterior centrum face pathology. Scale in cm.

ical conditions of varying severity, which we describe here. Rothschild and Turnbull (1987) reported a positive treponemal reaction in some of the thoracic vertebrae, and Neiburger and Turnbull (1990, and unpublished) made a differential diagnosis of all of these pathologic conditions. The ulnar pathologies are discussed by Neiburger in the Appendix. The fragmented skull, scapulae, pel-

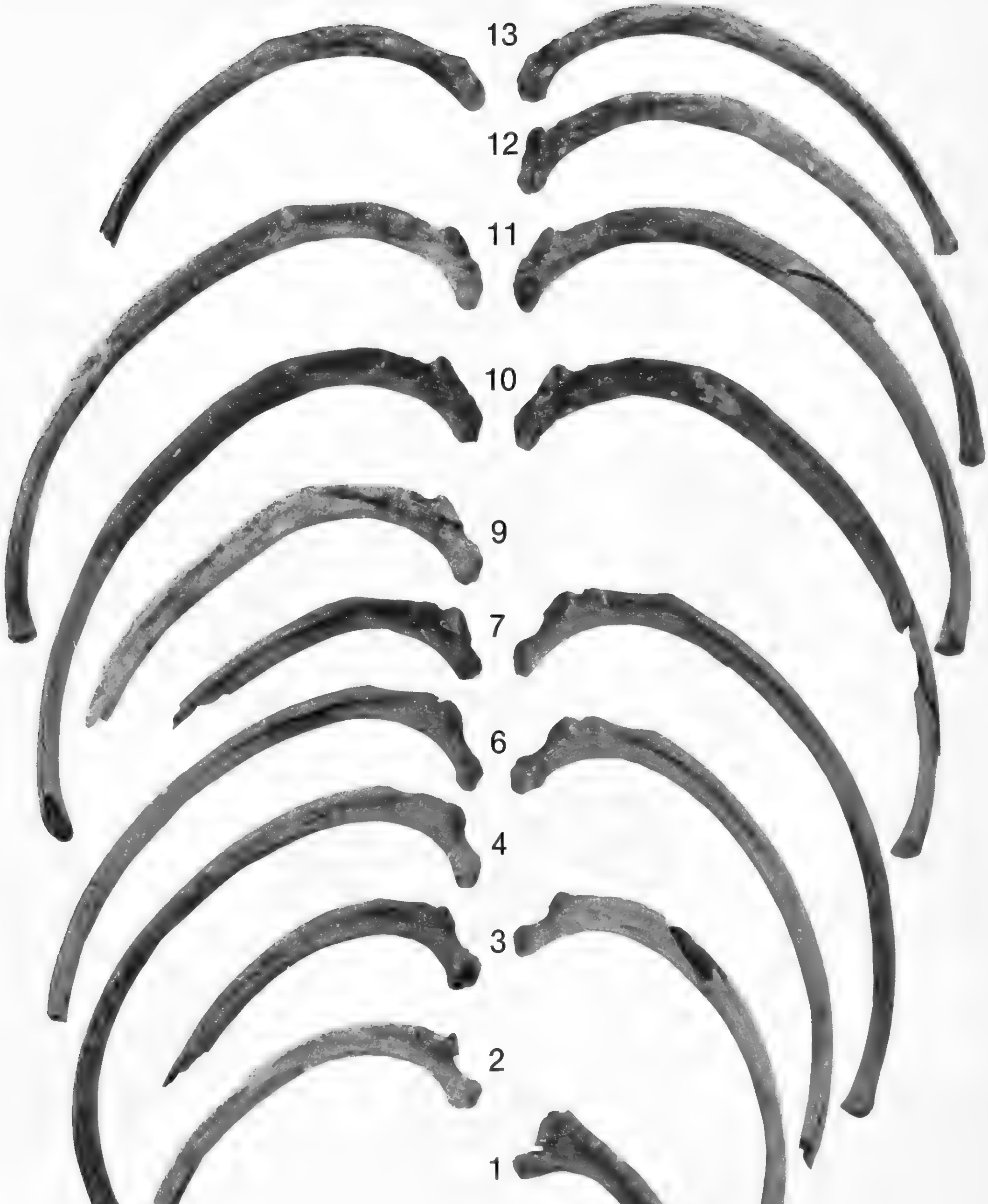

FIG. 9. Ribs, numbered in position, posterior view. Scale in cm.

vis, tibia, and ribs, among others, without sediment impacted into the bone interiors, appear to have been broken either upon their discovery or during subsequent excavation. Missing elements, or broken-off parts of bones, were lost as a result of inexperience on the part of the collector, who nevertheless did well, inasmuch as this specimen is one of the more nearly complete and best preserved skeletons of *Arctodus* in existence.

The bones lack rodent gnawing and other ob-

FIG. 10. **A.** Left scapula, lateral view. **B.** Left scapula, medial view. **C.** Right scapula, lateral view. **D.** Right scapula, medial view. Scale in cm.

vious indications of predepositional disturbance. It is apparent that one individual is represented, that the bones were in relatively close association (most probably in articulation) when discovered, and that the skeleton must have undergone a relatively rapid burial. Considering the hand-collected method of recovery, without screening or washing of the sediments or following of anatomical relationships to ensure completeness of wrist, ankle, and foot bones, the lack of small elements

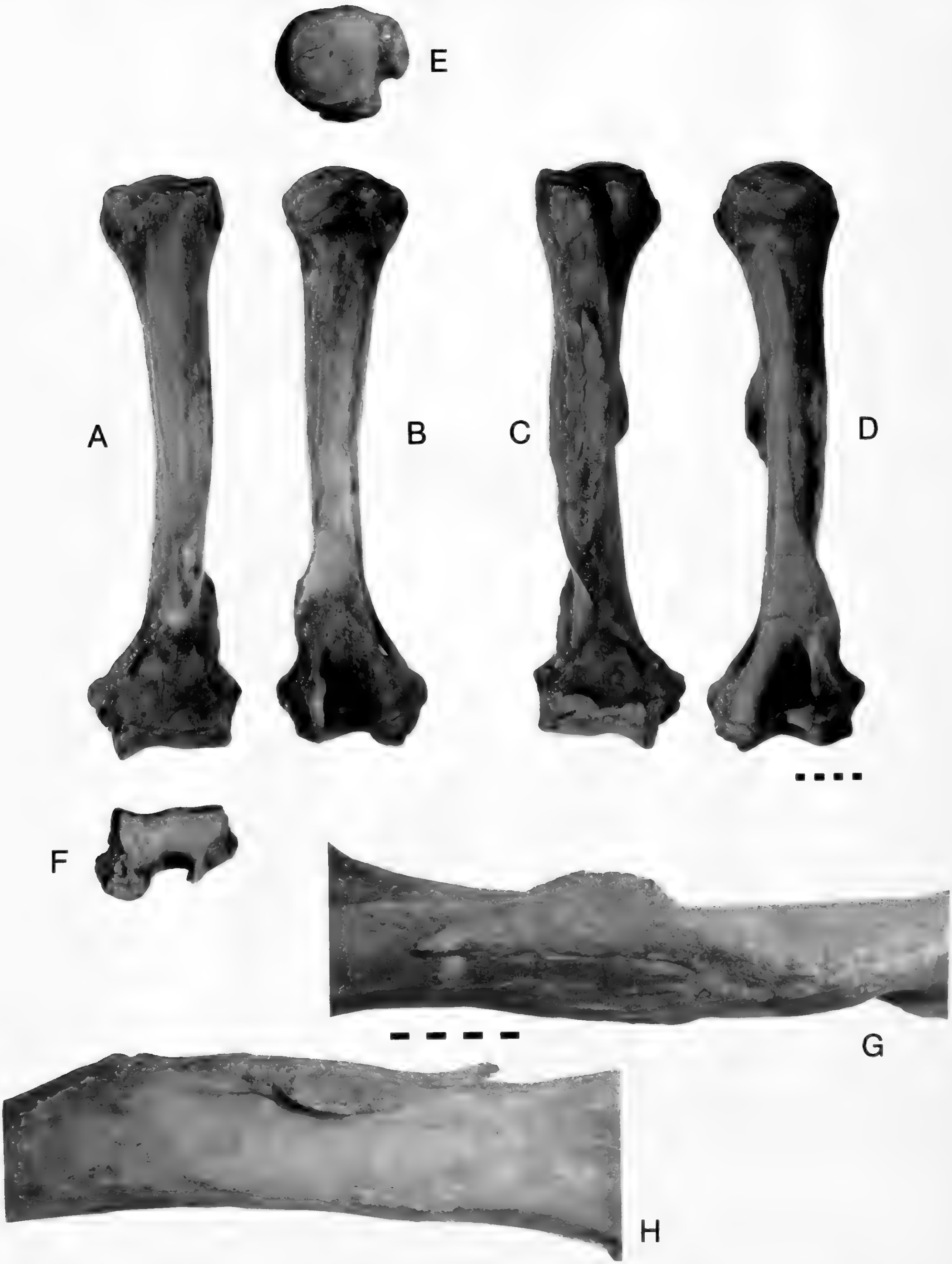

FIG. 11. **A.** Left humerus, anterior view. **B.** Left humerus, posterior view. **C.** Right humerus, anterior view (note shaft pathology). **D.** Right humerus, posterior view (note shaft pathology). **E.** Left humerus, superior view. **F.** Left humerus, inferior view. **G.** Right humerus, anterior view of pathology. **H.** Right humerus, medial view of pathology. Scale in cm.

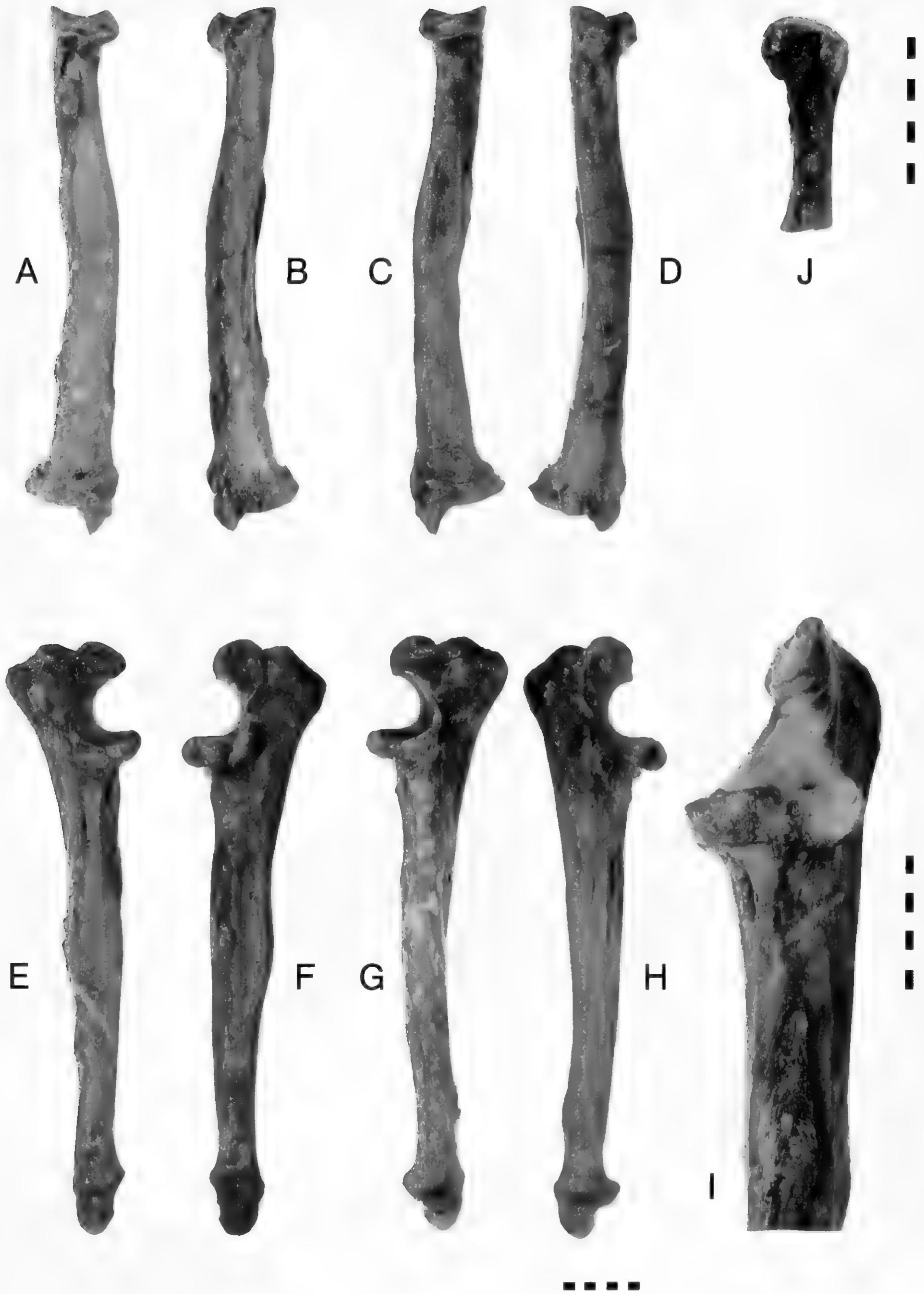

FIG. 12. **A.** Left radius, anterior view. **B.** Left radius, posterior view. **C.** Right radius, anterior view. **D.** Right radius, posterior view. **E.** Left ulna, right lateral view. **F.** Left ulna, left lateral view. **G.** Right ulna, left lateral view. **H.** Right ulna, right lateral view. **I.** Left ulna, proximal end, anterior view. **J.** Left metacarpal IV, right lateral view. Scale in cm.

FIG. 13. **A.** Pelvis, superior view. **B.** Pelvis, inferior view. **C.** Pelvis, right lateral view. Scale in cm.

or associated fauna (except molluscs) is not surprising. The bones have been consolidated with glyptal, carried by acetone.

Skull, Dentaries, and Teeth

The skull, broken by the backhoe and recovered as front and rear halves, is nearly complete. The skull lacks a section of the left parietal wall, right sphenoid, and most of that portion from the vomer area forward, including the nasal turbinates, most of the palatines, the posterior part of the right maxilla, and the anterior section of the right zygomatic arch. The skull and its dentition represent an early middle-aged adult. Externally, sutures are closed, most with some "bridging" of the ele-

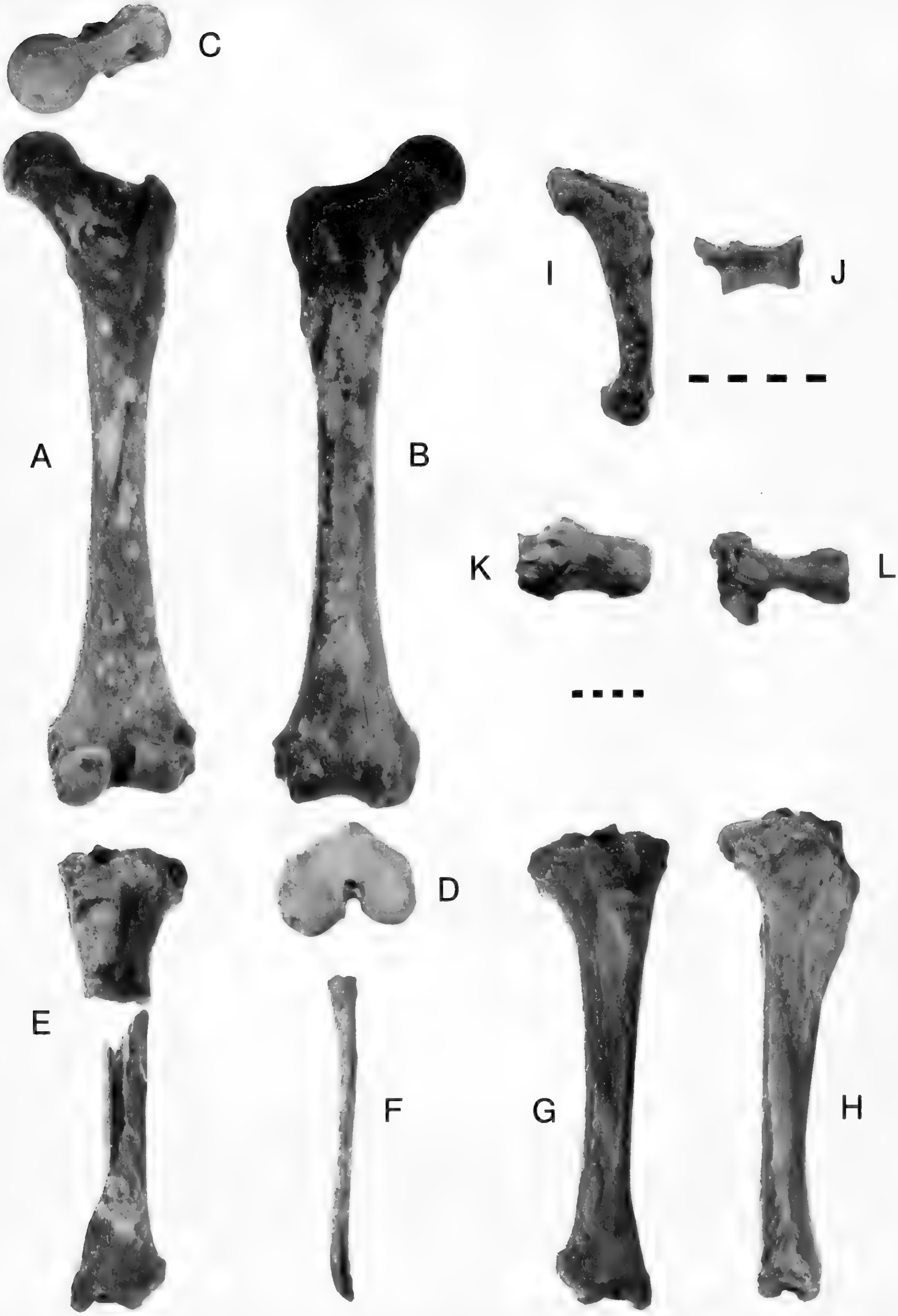

FIG. 14. **A.** Right femur, posterior view. **B.** Right femur, anterior view. **C.** Right femur, superior view. **D.** Right femur, inferior view. **E.** Left tibia, anterior view. **F.** Right fibula shaft. **G.** Right tibia, anterior view. **H.** Right tibia, right lateral view. **I.** Right metatarsal V, right lateral view. **J.** Left ectocuneiform. **K.** Right calcaneum, left lateral view. **L.** Right calcaneum, superior view. Scale in cm.

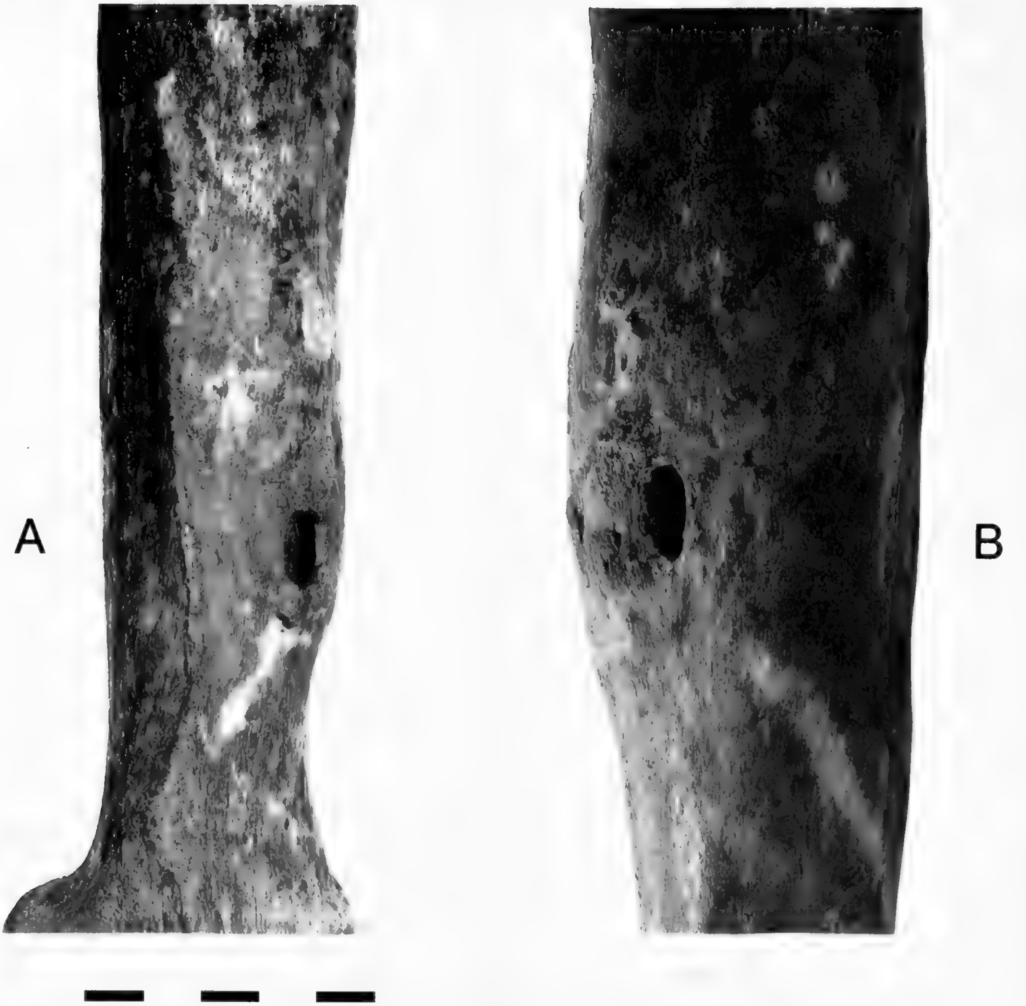

FIG. 15. **A.** Right ulna, left lateral view of pathology. **B.** Left ulna, posterior view of pathology. Scale in cm.

ments, and some sutures are nearly obliterated (e.g., squamosoparietal and anterior maxillopremaxillary). The sagittal crest rises to a maximum of 50 mm above the braincase. Features typical of the species include the short, wide snout (including nasal), the large narial opening, the high-vaulted skull, three anterior palatine foramina, and double infraorbital and large parietal foramina (Merriam & Stock, 1925). The frontals are somewhat inflated.

Both dentaries are complete. The premasseteric fossae, typical of the Tremarctinae, are well developed, as are multiple mental foramina. The large mental foramen is below p3 on the right dentary and below the p3–p4 junction on the left. The right dentary has four and the left dentary three small accessory foramina. The angles project posteriorly beyond the condyles.

The dental formula for *Arctodus* is that of the Ursidae: $\frac{3\text{-}1\text{-}4\text{-}2}{3\text{-}1\text{-}4\text{-}3}$. The P4 metacone forms somewhat of a shearing blade, as does the m1 trigonid (Merriam & Stock, 1925). The P4 protocone has a relatively anterior position (Kurtén, 1967). Several teeth had been shed while the bear was alive, the alveoli closing or containing bony trabeculae: LI1 (trabeculae); LP1 (alveolus closed); L,Ri1 (?trabeculae), and Lp4 (alveolus closed) (loss of anterior premolars is a usual condition in bears). Several teeth have been lost from their alveoli post mortem: RP2; RP3; L,Ri2; L,Ri3; L,Rp1; Lp2; and L,Rp3. Crowns fractured from the roots (presumably by the backhoe) and lost post mortem

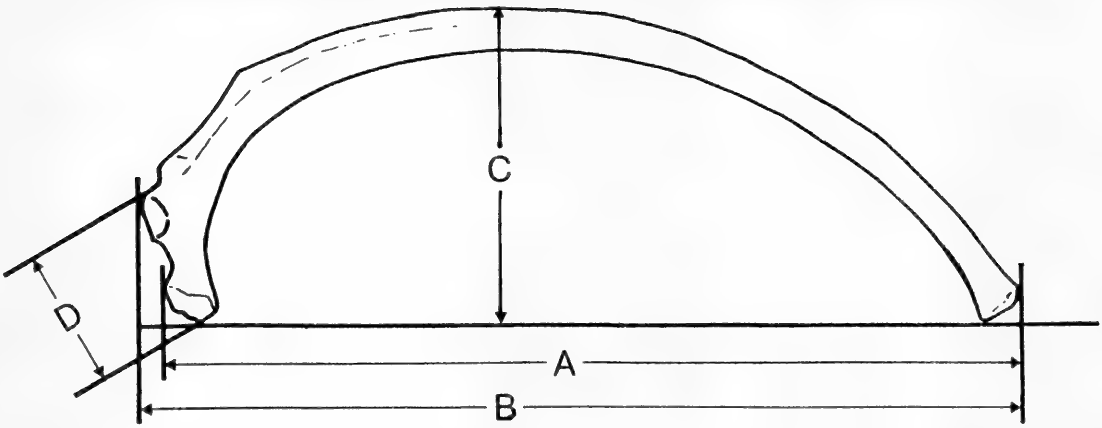

FIG. 16. Right rib, showing measurements for data compiled in Table 4 (after Kurtén, 1966). Scale in cm.

include RC; RP4; RM1; and RM2. Tooth wear ranges from slight or moderate on the molars to moderate on the carnassials and incisors, where the dentine is exposed.

The upper premolars are relatively crowded. Premolar spacing in the left maxilla is as follows: LC alveolus-LP2, 11.49 mm (LP1 shed); and LP2, LP3, and LP4 are in contact. LP2 is twisted obliquely inward anteriorly, its long axis being turned inward 55°. The posterior end of LP3 is located slightly medial to the anterior end of LP4. Premolar spacing in the right maxilla is as follows: RC-RP1 alveoli, adjacent; RC-RP2 alveoli, 11.15 mm; RP2-RP3 alveoli, 3.44 mm; and RP3 alveolus adjacent to the anterior RP4 root and alveolus. RP1 is the largest of the first three anterior premolars, and RP2 and RP3 appear to be slightly larger (by alveoli) and less crowded than those of the left series.

The lower premolars are not as crowded. Premolar spacing in the left dentary is as follows: Lc-Lp1 alveoli, 2.3 mm; Lp1-Lp2 alveoli, contacting; Lp2-Lp3 alveoli, 7.63 mm; and Lp3-Lm1 alveoli, 13.68 mm (Lp4 shed, no alveolus). Premolar spacing in the right dentary is as follows: Rc-Rp1 alveoli, 3.3 mm; Rp1-Rp2 alveoli, 2.08 mm; Rp2-Rp3 alveoli, 9.16 mm; and Rp3-Rp4 alveoli, 4.33 mm, with Rp4 contacting Rm1. The anterior end of Rp2 is twisted slightly inward. Thus, the longest lower tooth row diastemata are between p2 and p3, a condition noted in the Frankstown Cave (Peterson, 1926) and Hay Springs (Kurtén, 1967) materials.

Vertebrae

Recovered vertebrae include the atlas, axis, cervical vertebrae C-4 and C-6, thoracic vertebrae T-3, T-4, T-5, T-10, T-11, and T-13, lumbar vertebrae L-2, L-4, L-5, L-6, and L-7, and five fused sacral vertebrae with a sacralized caudal #1. The preserved vertebrae posterior to the atlas and axis were determined as to position by comparison with one modern skeleton each of *Tremarctos ornatus* and *Ursus americanus* (14 thoracic vertebrae; Kurtén, 1966) and based on a thoracic count of 13 in *Arctodus* (Merriam & Stock, 1925; Kurtén, 1967). The recovered vertebrae are nearly complete. T-3, L-2, L-4, L-6, and L-7 each lack the tip of the neural spines. Transverse processes are fragmented or missing on T-5 (R), L-2 (L,R), L-5 (L,R), L-6 (L), and L-7 (R). T-3, T-4, and T-5 display extensive osteophytosis (discussed later). Measurements of all preserved vertebrae are presented in Table 3. Few vertebral measurements are available from the literature (Kurtén, 1967).

Ribs

A relatively complete set of ribs is present. Based on 13 pairs of ribs, allotment is the following: R#1, L#2, L,R#3, L#4, L,R,#6, L,R#7, L#9, L,R#10, L,R#11, R#12, and L,R#13, and a distal rib section. Lacking distal sections are the following: L#2, L,R#3, L,R#6, L#7, L#9, L#10, and L#13. Heads of several anterior left ribs have minor pathological exostoses.

Kurtén (1966) compared several of the ribs of *Tremarctos ornatus, T. floridanus,* and *Ursus americanus,* but those of *Arctodus simus* have not been described. The ribs are not morphologically different from those of other ursids but are distinct in size and proportions. Comparison of measurements in Table 4 to those of Kurtén (1966) for ribs #1, #4, #9, #11, and #12 show those of *A. simus* to be considerably longer than those of the above species, with all of the *A. simus* ribs from at least #4 through #13 exceeding all ribs of the above species in length. Though rib #9 is incomplete, #10 appears to be the longest rib in *A. simus,* as may be the case with the above species. The ribs of *A. simus* also appear to be distinct from those of the above species in their relatively small amount of lateral "bow" (radius; Kurtén, 1966), falling equal to or less than those of *T. floridanus* and one specimen of *U. americanus* in absolute values. *Arctodus simus* is also unusual in that the radii of the posterior rib series (#12 and #13) are less than that of #4; in the above bears, the radii of the posterior rib series (including #9 through #12) are greater than that of #4. Rib proportions thus suggest a deep, relatively narrow chest in *Arctodus simus.*

TABLE 1. *Arctodus simus* (PM #24880)—Cranial and dentary measurements (mm).

Skull		
Basal length of skull		396
Condylobasal length of skull		422
Extreme length of skull		453
Zygomatic width		319
Rostral width at canines		126.4
Interorbital width		135.3
Width over postorbital processes		170.7
Width over postorbital constriction (estimate)		94
Postorbital height (top of frontal to posterior inferior rami of palatines)		174
Width of nasal opening (inner rim of premaxillae)		86.4
Front of premaxillae to hinder ends of M2		174.5
Bottom of glenoid fossa to junction of frontal and occipital sutures (height of cranium)		207
Braincase width (estimate)		141
Width across occipital condyles		88.8
Occipital height (base of condyles to top of occipital crest)		181.6
Mastoid breadth (estimate)		218
Width across base of incisors		68.6
Height of foramen magnum		30.5
Width of foramen magnum		35
Dentaries	***Left***	***Right***
Length, anterior edge of canine to rear of condyle	299	297.3
Length, tip of angular process to anterior end of symphysis	324	325
Depth of coronoid process (from bottom of angle)	153	155
Depth at diastema	64.1	63.7
Ramus depth between m1 and m2 (lateral face)	64.7	68.2
Ramus depth behind m3	86.4	89.9
Length, p4–m3	—	94.9

Forelimb and Girdle

Forelimb elements include both scapulae, humeri, ulnae, radii, and L metacarpal IV. The right scapula is nearly complete, lacking the anterior midsection of the blade. The calcified suprascapular cartilage of the R scapula is unfused to the blade on its inner surface. The left scapula lacks much of the anterior and posterior blade margins and the spine above the coracoid process. The limb bones, especially the ulnae and radii, are relatively long and slender. The ulnae, radii, and humeri are complete, the latter bearing the entepicondylar foramina characteristic of the Tremarctinae (Merriam & Stock, 1925). The R humerus, both ulnae, and the L radius display pathology. The L metacarpal IV lacks the distal end.

Hind Limb and Girdle

Hind limb elements include the pelvis, R femur, L, R tibiae, R fibula shaft, R calcaneum, L ectocuneiform, and R metatarsal V. Much of the pelvis is present, the right innominate (in two parts) lacking the pubic symphysis area; the left is represented by the ischium only (in two parts) contacting a small scrap of the ilium. The slightly fragmented sacrum is co-ossified with both innominates (suture obliterated), unifying the pelvis, which was fragmented into more than five parts by the backhoe.

The pelvis was compared with descriptions of materials of *Tremarctos* (Kurtén, 1966) and of *Arctodus simus* (Merriam & Stock, 1925) and with FMNH specimens 123369 (*Tremarctos ornatus*), 63803 (*Ursus arctos gyas*), and 27268 (*Ursus arctos*). The ilium of *Arctodus simus* is relatively short

TABLE 2. *Arctodus simus* (PM #24880)—Dental measurements (mm).

Upper teeth	*Left*	*Right*
C		
Width at base of enamel	23.03	—
Length at base of enamel	32.75	—
Width at alveolar border	25.42	—
Length at alveolar border	39.04	—
P1		
Length	—	10.24
Width	—	7.34
P2		
Length	7.61	—
Width	4.73	—
P3		
Length	8.92	—
Width	5.44	—
P4		
Length	23.47	—
Width	16.8	—
Paracone height	9.8	—
M1		
Length	26.06	—
Anterior width	24.04	—
Posterior width	25.64	—
Paracone height	10.02	—
Metacone height	8.37	—
M2		
Length	36.52	—
Anterior width	24.50	—
Central width	21.68	—
Paracone height	9.28	—
I1, transverse diameter	—	8.88
I2, transverse diameter	9.56	9.79
I3, transverse diameter	14.13	14.8
Length C–M2	150.9	—
Length, posterior edge of C alveolus to anterior edge of M1	48.2	—
Length, M1–M2	61.4	—
Length, posterior edge of C to anterior edge of P4	27.6	—

Lower teeth*	*Left*	*Right*
c		
Width at enamel base	24.22	24.14
Length at enamel base	32.9	34.1 (e)
Width at level of alveolus	24.39	24.82
Length at level of alveolus	41.67	37.82
p1		
Alveolar length	7.3	6.5
Alveolar width	5.6	6.8
p2		
Length	8.1 (alv.)	9.04
Width	6.2 (alv.)	5.94 6.0 (alv.)
p3		
Alveolar length	8.1	5.6

TABLE 2. *Continued.*

Lower teeth (*cont.*)	*Left*	*Right*
Alveolar width	4.5	4.6
p4		
Length	—	12.59
Width	—	7.0
m1		
Length	33.1	33.92
Anterior width	16.1	17.0
Posterior width	16.92	17.04
Trigonid length	23.03	23.69
Protoconid height		
Labial	15.12	15.18
Lingual	14.33	13.95
Hypoconid height	11.8	ca. 10.14 (f)
m2		
Length	30.35	31.8
Anterior width	21.14	21.48
Posterior width	19.75	19.63
Protoconid height	12.57	ca. 10.58 (f)
Hypoconid height	9.21	10.16
Metaconid height	9.62	11.16
m3		
Length	22.31	22.19
Width	16.55	16.50
i1, transverse alveolar diameter	7.9 est.	8.5 est.
i2, transverse alveolar diameter	—	7.4 est.
i3, transverse alveolar diameter	10.1	9.5 est.
Length, c–m3	170.8	171.7
Length, posterior edge of c alveolus to anterior edge of m1	44.4	48.8
Length, m1–m3	83.4	82.8

* e, enamel limit difficult to determine; f, cone fractured or worn; alv., alveolar measurement; est., estimate.

(Merriam & Stock, 1925), and the more complete Rochester specimen displays ilia that flare anterolaterally more than those of the three FMNH specimens, distinctively producing a relatively large width across the outer iliac blades for the size of the pelvis. The neck of the ilium immediately in front of the acetabulum is massive, and relatively more so than in the FMNH specimens. The acetabulum is very large, but not relatively larger than in *Ursus*. The Rochester specimen displays a more pronounced development of the ventral shelf running from the lower border of the acetabulum to the obturator foramen than do the FMNH specimens, a condition noted to be absent in *Tremarctos* (Kurtén, 1966). The ischial bar above the obturator foramen is similar to that of *Ursus* and not compressed from the sides as in *Tremarctos* (Kurtén, 1966). Unlike a pubis of *A. simus* which was relatively narrower than that of *Ursus* or *Tremarctos* (Merriam & Stock, 1925), the Rochester pubis is proportioned similar to that of *Ursus*.

The interpretation of five sacral vertebrae with a sacralized caudal #1 might alternatively be interpreted as four true sacrals with one totally fused caudal #1 and an additional sacralized caudal #2. By comparison, two FMNH specimens displayed four true sacrals and a sacralized caudal #1 (*Tremarctos ornatus,* 123369; *Ursus arctos gyas,* 63803), and another specimen was composed of five true sacrals (*Ursus arctos,* 27268).

The right femur and right tibia are complete. The left tibia is present as proximal and distal ends, lacking the middle of the shaft, and the fibula lacks both proximal and distal ends. The calcaneum, ectocuneiform, and R metatarsal V are complete. The hind limb bones, especially the femur, are relatively long and slender.

Epiphyses on all postcranial elements are closed, with the lines of union obliterated, indicating full adult stature.

TABLE 3. *Arctodus simus* (PM #24880)—Vertebral measurements (mm).

Atlas	
Greatest width across lateral process	243
Greatest width across anterior articulating facets	97
Greatest width across posterior articulating facets	91
Least anteroposterior diameter of dorsal arch	44
Anteroposterior diameter of ventral arch at midline	38
Greatest anteroposterior length (including lateral processes)	112
Greatest depth	64
Least width between atlantic foramina	64
Length from anterior end of articulation for condyles to posterior end of articulation for axis	89

Axis	
Greatest ventral length, including odontoid process	104
Ventral length of odontoid process from transverse ridge	39
Greatest width across anterior articulating facets	86
Greatest width across postzygapophyses	78
Greatest transverse width across posterior epiphysis of centrum	58
Depth of centrum at midline of posterior surface	39
Least anteroposterior diameter of pedicle of neural arch	33
Anterior width of odontoid process (at base)	24.5
Extreme posterior depth of dorsal edge of neural spine	121
Anteroposterior length of neural spine	121

Cervical vertebrae	***C-4 (or 5)***	***C-6***
Ventral length of centrum from midpoint of anterior surface	53	53
Length of centrum measured normal to posterior face and along median line	48	46
Greatest width of posterior end of centrum	61	61
Depth of centrum at midline of posterior surface	43	43
Depth of centrum measured normal to floor of neural canal and across posterior epiphysis	42	42
Length from end of anterior zygapophysis to end of posterior zygapophysis	83	88
Width across anterior zygapophyses (not the supporting bosses)	94	98
Width across posterior zygapophyses	95	96
Greatest width of neural canal at anterior end	ca. 33	ca. 42
Greatest width across outer ends of transverse processes	182	—
Height from middle of ventral border of posterior epiphysis of centrum to top of neural spine	117	120

Thoracic vertebrae	***T-3***	***T-4***	***T-5***	***T-10***	***T-11***	***T-13***
Ventral length of centrum from midpoint of anterior surface	43	ca. 40*	39	47	49	56
Greatest width of posterior end of centrum	87*	86*	82	91	85	87
Depth of centrum at midline of posterior surface	48	48	49	53	56	58
Depth of centrum measured normal to floor of neural canal and along median line of posterior epiphysis	ca. 48	ca. 48	49	53	56	57
Length of centrum measured normal to posterior face and along median line	43*	ca. 41*	38*	47	49	57
Length from end of anterior zygapophysis to end of posterior zygapophysis	75	ca. 72	76	84	84	99

TABLE 3. *Continued.*

Thoracic vertebrae (*cont.*)	*T-3*	*T-4*	*T-5*	*T-10*	*T-11*	*T-13*
Greatest width across anterior zygapophyses	59	57	53	56	54	(facets) 80
Width across posterior zygapophyses	59	56	61	55	78	62
Greatest width, across outer ends of transverse processes	150	143	—	141	(metapophyses) 135	115
Greatest length from end of metapophyses to end of anapophyses						
Left						88
Right						85
Greatest anteroposterior diameter of outer end of transverse process (vertical diagonal)						
Left	—	40	—	45	51	86
Right	43	43	40	44	56	88
Height of neural canal at anterior end	28	29	30	33	31	32
Height from middle of ventral border of posterior epiphysis of centrum to top of neural spine (centrum vertically)	—	207 229*	207 215*	203	189	195
Depth of centrum measured normal to floor of neural canal and along median line of posterior epiphysis (including pathology)	54*	66*	61*	—	—	—

Lumbar vertebrae	*L-2*	*L-4*	*L-5*	*L-6*	*L-7*
Ventral length of centrum from midpoint of anterior surface	58	59	60	61	59
Length of centrum measured normal to face of posterior epiphysis and along median line	60	63	62	62	59
Greatest width of posterior end of centrum	98*	95	100	107*	101*
Depth of centrum at midline of posterior surface	61	63	62	59	55
Depth of centrum measured normal to floor of neural canal and across posterior epiphysis	61	63	64	61	56
Greatest length from anterior end of metapophyses to end of posterior zygapophyses	104	100	98	100	96
Greatest width across metapophyses	120	119	122	131	139
Greatest width across posterior zygapophyses	67	81	86	89	106
Width across transverse processes	—	240	—	—	—
Height from middle ventral border of anterior epiphysis of centrum to top of neural spine	—	—	218	—	—

* Measurements include or influenced by pathology.

Pathology

Pathological lesions occur in the lower jaws, the vertebral column and associated ribs, and the bones of both forelegs. Minor abscesses are present between m1 and m2 of both dentaries. The left dentary has some bone resorption and small drainage channels for the abscess. Abscessing was less developed in the right dentary, with only minor resorption of the alveolar edge.

An irregularly shaped area approximately 65 mm long and 46 mm high on the labial surface of the right dentary (below p4, m1, and the anterior ½ of m2) is penetrated by approximately 40 to 50 minute pits ranging from 0.5 to 1.0 mm in diameter and is likely the result of disease. One accessory mental foramen (below the anterior root of p4) appears to have been invaded with this diseased condition, resulting in somewhat of an hour-glass-shaped foramen.

TABLE 4. *Arctodus simus* (PM #24880)—Rib measurements (mm).

Rib No.	Ribs† A	B	C	D	E
R#1	171	170	71	64	50
L#2	—	—	—	66	—
L#3	—	—	—	68	—
R#3	—	—	—	frag. 67+	—
L#4	440	455	167	73*	frag. 24+
L#6	—	—	—	76	—
R#6	—	—	—	77	—
L#7	—	—	—	—	—
R#7	493	503	182	80	31
L#9	—	—	—	79	—
L#10	505 (+?)	512 (+?)	181 (+?)	78	—
R#10	501	508	185	78	—
L#11	500	503	178	74	31
R#11	495	497	186	75	33
R#12	467	471	166	59	30
L#13	—	—	—	48	—
R#13	399	399	135	46	41
? Left distal end					33

* Measurements include or influenced by pathology.

† Rib measurements (see also Fig. 16 for illustration): A, chord length (to head); B, chord length (to tubercle); C, radius; D, length from external edge of tubercle to end of head; E, greatest width, distal end (parallel to outer surface).

There is extensive erosion on the centra faces of thoracic vertebrae T-3, T-4, and T-5 (especially the posterior face of centrum T-3). These same vertebrae exhibit spondylosis deformans (osteophytosis; Morse 1978), but eburnation is not apparent on the involved centra. Bony proliferation had begun to bridge the three centra on ventral and ventrolateral surfaces, and compression of the vertebrae initiated reactive bone growth between adjacent centra faces. The inferior edges of T-3 and T-4 were closely appressed, the posteroinferior margin of the centrum of T-3 fitting into an eroded pit in the centrum of T-4, resulting in a slight upward hunch between the vertebrae, similar to Pott's disease in humans (tuberculosis spondylitis). Centra of T-4 and T-5 were also closely appressed, with the prezygapophyses of T-5 dropping ca. 3 mm downward, slightly constricting the neural canal from above. The greatest reactive bone buildup was on the ventral surfaces of the centra: T-3, 9.8 mm; T-4, 17 mm; and T-5, 13.4 mm. On the ventral and ventrolateral surfaces of the centra, reactive bone encircled the rib heads, with most of the rib facets (except for R#3) slightly eroded. Loss of the supportive function of the centra apparently allowed sufficient slippage to have precipitated such bone reaction. Rothschild and Turnbull (1987) suggested that these and other lesions of the skeleton resulted from infection of the animal with syphilis or yaws, and Neiburger and Turnbull (1990) have completed a differential diagnosis that suggests tuberculosis, osteomyelitis, arthritis, or some mycotic (fungal) infection, either singly or in combination, as additional possible causes.

The heads of ribs L#2, L#3, and L#4 have moderate exostoses, and there is slight development on the heads of L,R#6.

The skeleton shows little osteoarthritis, though minor "lipping" is present on the centra of the atlas, axis, C-4, C-6, T-10, T-11, T-13, L-2, L-4, L-7, and the sacrum and on articular facet margins of the radii and ulnae. All "lipping" appears to be the result of ontogenetic stress on the joints of this early middle-aged adult bear.

The R humerus and both ulnae display lesions and possibly traumatic injury. A bony flap 190 mm long (46 mm wide at the middle) projects medially from the anteromedial edge of the shaft ca. 260 mm from the distal end of the R humerus. It terminates proximally in a bony spur and distally in a muscle scar. Arguably this could be a healed fracture as originally thought. However, radiographic evaluation suggests an unusual form of periosteal reaction rather than fracture. The shaft is predominantly swollen in the anteroposterior plane at the distal end of the pathology. Interestingly, shaft alignment and total length are identical to that of the L humerus.

Both ulnar shafts have abscesses. The abscess of the L ulna (15.9 mm × 6.5 mm, and 12.7 mm deep) orients with the long axis of the shaft and expands in size below the smooth-edged orifice. It centers 253 mm from the distal end of the shaft. The abscess area of the shaft is swollen over 10 mm greater than that of the R ulna. Some reactive bone formation is present in the abscess area. The abscess on the posteromedial margin of the R ulna is 11.7 mm long aligned with the shaft axis, 5.6 mm wide, and 10 mm deep. The orifice edges are rounded, and there are osteophytes and small bony spurs around the abscess area. The abscess centers 116 mm from the distal end of the shaft. The shaft in the abscess area is swollen in the anteroposterior (somewhat diagonal) plane 6 mm more than that of the L ulna. Both abscesses appear to have a common origin. Rothschild and Turnbull (1987) suggested that these and other skeletal lesions originated as a pathogenic (treponemal) infection (Benditt, 1989). Neiburger (1984, 1988, and the Appendix) does not accept that diagnosis and favors origin by an infected wound, and Neiburger and Turnbull (1990) give a full differential diagnosis that implicates osteoarthritis and tuberculosis, in addition to the contracted syphilis with long-term infection. The convex side of the L radius shaft is rough and thickened just below the level matching the abscess on the L ulna. Perhaps it represents an adjustment to the weakening of the L ulna.

Discussion and Conclusions

The Indiana specimen is the only *A. s. yukonensis* fossil known east of the Mississippi River. The Frankstown Cave, Pennsylvania (Peterson, 1926), and at least one of the two Kentucky finds (Proctor Cave; Wilson, 1981) represent the smaller *A. s. simus*. The Sheriden Pit, Ohio, specimen has the small size of *simus* females from Rancho La Brea (McDonald, pers. comm. to Richards, 6 Jan. 1992). Both subspecies may have co-inhabited (and likely interbred in) the lower Great Lakes region for a short time in the very late Pleistocene.

Kurtén (1955) related that the canines showed the strongest sexual dimorphism in the dentition (and skeleton) of *Ursus spelaeus* (cave bear). Assuming like conditions for *Arctodus*, Kurtén (1967) suggested that *Arctodus simus* canines wider than 19.5 mm [tended to] represent presumed male individuals. The Indiana canine teeth range from 23.0 (upper) to 24.2 (lower), indicating a male bear by this criterion.

TABLE 5. *Arctodus simus* (PM #24880)—Forelimb and girdle measurements (mm).

Measurement	Left	Right
Scapulae		
Greatest length, from coracoid process to top of scapula, measured along spine axis	462+	478
Distance from inner border of glenoid cavity to top of spine	409	409
Length, from inferior rim of glenoid articulation to dorsal border, along axis of spine	431	436
Greatest anteroposterior width of facet of glenoid cavity	96	97
Greatest transverse diameter of glenoid cavity	70	73
Least anteroposterior width of neck at articulating end	125	126
Least thickness of neck at articulating end	46	46
Transverse width of glenoid articulation to outer side of acromion process	141	152
Greatest width taken normal to the anterior edge of the spine to the greatest extension of the posterior blade part of the scapula	—	225
Humeri		
Total length	594	594
Greatest proximal width	126	128
Greatest proximal anteroposterior diameter	145	146
Least width of shaft (in plane of axis of distal end)	55	55
True least width of shaft	51	50
Minimum midshaft circumference	196	—
Greatest width across epicondyles	160	161
Greatest transverse width of distal articulation surfaces	125	127
Greatest transverse width of distal articulation (facets only)	116	119
Ulnae		
Greatest length	542	545
Proximal diameter from tip of coronoid process to Margo dorsalis	108	113
Smallest diameter from bottom of semilunar notch to Margo dorsalis	61	64
Inner diameter of semilunar notch	49	48
Least transverse diameter of shaft above capitulum	36	34
Radii		
Greatest length	481	479
Proximal end, long diameter	69	68
Proximal end, short diameter	56	56
Middle of shaft, long diameter	44	43
Middle of shaft, short diameter	34*	30
Distal end, long diameter	92	95
Distal end, short diameter	60	61

* Measurement includes or influenced by pathology.

TABLE 6. *Arctodus simus* (PM #24880)—Hind limb and pelvis measurements.

Pelvis	*Left innominate*	*Right innominate*
Greatest length	—	516
Length of ilium from anterior margin of acetabulum	—	260
Greatest length of ischium, from posterior border of acetabulum	170	169
Anterior end of ilial blade, long diameter	—	241
Least depth of ilial neck	—	83
Least thickness of ilial neck	—	67
Least depth of ischium bar above obturator foramen	49	51
Least width of same	37	37
Diameter of acetabulum (anteroposterior)	—	90
Pelvis, greatest length	466	
Pelvis, width from outer edges of ischia	234	
Pelvis, width from tubercles, anterior edge of acetabula	ca. 274	
Pelvis, width across outer iliac blades (left ilium absent; R-midline = 267 mm)	ca. 534	
Sacrum		
Central length	225	
Central depth, anterior	50	
Central width, posterior	33	
Greatest width of third sacral vertebra across transverse processes	ca. 156	
Centrum length, caudal #1	ca. 34	
Length, anterior end of sacrum to posterior end of caudal #1	259	
Right femur		
Greatest length		651
Greatest proximal width		174
Caput diameter (anteroposterior)		79
Least transverse width of shaft		57
Minimum midshaft circumference		171
Greatest distal width over epicondyles		145
Least depth of collum		67
Tibiae	*Left*	*Right*
Greatest length	—	478
Greatest proximal width	—	140
Least width of shaft	—	49
Greatest distal width, measured in plane of articulation	114	113
Anteroposterior diameter of distal end	65	64
Right fibula		
Least diameter in proximal half of shaft		13.6

TABLE 6. *Continued.*

Right fibula	
Least diameter in distal half of shaft	10.5

Comparison of the measurements of the largely disassociated elements plotted in Figures 17 and 20 suggests that the Indiana specimen has a relatively small skull in relation to the length of the long bones. The few skulls with associated long bones include presumed male individuals from Hay Springs, Nebraska (Kurtén, 1967), and Hot Springs, South Dakota (Agenbroad & Mead, 1986), and a presumed female from Cueva Quebrada, Texas (Lundelius, 1984) (Table 9). Comparison with those specimens indicates that the Indiana specimen has a relatively short, wide skull that is

TABLE 7. *Arctodus simus* (PM #24880)—Podial measurements (mm).

Right calcaneum		
Greatest length		135
Greatest width, obliquely across sustentaculum		81.5
Least width of tuber calci ("neck")		30.1
Depth of tuber calci (mid-"neck")		57.8
Width of cuboid facet		47.6
Depth of cuboid facet (difficult to align)		31.4
Long diameter of sustentacular facet		49.5
Short diameter of same		37.8
Width of inner astragalar facet		29.6
Width of tuber calci (terminal)		53.8
Depth of tuber calci (terminal; difficult to align)		62.5
Left ectocuneiform		
Greatest dorsoventral depth		56.2
Greatest width		33.4
Greatest proximodistal length (dorsal)		27.3
Metatarsal facet, long diameter		40.2
Metapodials	*Left metacarpal IV*	*Right metatarsal V*
Greatest length	—	135
Proximal width (with distal end "squared up")	29.8	45.1
Proximal anteroposterior diameter	41.8	51.8
Least transverse width of shaft	21.0	17.2
Greatest distal width over epicondyles	—	31.4

TABLE 8. Comparison of the Indiana *Arctodus simus* specimen with populations from Potter Creek Cave and Rancho La Brea, California (Merriam & Stock, 1925), and Fairbanks, Alaska (Kurtén, 1967) ($\bar{x}$ = arithmetic mean; O.R. = observed range; N = number of specimens; measurements in millimeters).

	Potter Creek Cave			Rancho La Brea				Fairbanks, Alaska		
Measurement	$\bar{x}$	(O.R.)	N	$\bar{x}$	(O.R.)	N	Indiana	$\bar{x}$	(O.R.)	N
Basal length of skull	345	(345)	2	354	(348–360)	2	396	414	(414–415)	2
Zygomatic width	241	(241)	1	271	(222–345)	3	319	279	(275–283)	2
Interorbital width	120	(117–123)	2	130	(126–132)	3	135	133	(106–153)	3
Width over postorbital processes	149	(147–151)	2	159	(142–180)	3	171	174	(151–194)	3
Crown lengths: C–M2	137	(137)	1	145	(144–146)	2	151	152	(143–165)	4
Canine width, at base of enamel	19.3	(18.5–19.9)	6	21.6	(20.6–23.4)	4	23.0	22.2	(21.4–22.9)	2
Length, P4	21.0	(19.4–22.5)	8	22.4	(20.5–24.2)	7	23.5	22.3	(20.9–23.7)	4
Width, P4	15.5	(14.3–16.1)	8	16.8	(15.8–18.3)	7	16.8	16.2	(15.4–17.0)	4
Length, M1	24.8	(23.7–26.0)	8	26.1	(25.2–28.0)	16	26.1	26.2	(25.5–27.5)	3
Width, M1	23.4	(22.4–24.7)	8	24.9	(22.8–26.1)	16	25.6	24.8	(24.0–26.0)	3
Length, M2	35.6	(33.3–37.1)	8	38.3	(36.2–40.9)	13	36.5	38.7	(36.8–40.4)	3
Anterior width, M2	22.5	(21.3–23.6)	7	24.0	(22.0–24.9)	13	24.5	25.4	(24.1–26.6)	4
Dentary, depth at diastema	53	(51–55)	2	64.3	(57–70)	3	63.9	52.5	(47.8–56.6)	4
Lower canine, width, at base of enamel	19.4	(18.2–20.8)	7	21.4	(19.9–23.2)	6	24.2	19.4	(17.6–21.2)	2
Length, p4	11.8	(11.0–12.2)	4	13.6	(13.4–13.7)	2	12.6	10.9	(10.3–11.5)	2
Width, p4	6.9	(6.3–7.7)	3	8.1	(7.3–8.8)	2	7.0	6.6	(6.2–6.9)	2
Length, m1	31.4	(30.9–32.0)	5	33.9	(32.7–35.3)	10	33.5	30.8	(29.6–32.0)	2
Trigonid length, m1	22.2	(22.0–22.4)	4	24.8	(23.8–26.1)	9	23.4	21.1	(19.7–22.4)	2
Posterior width, m1	16.5	(15.8–17.3)	5	17.4	(16.7–18.1)	10	17.0	15.5	(15.1–15.9)	2
Length, m2	28.9	(28.5–29.7)	7	31.5	(30.2–33.6)	15	31.1	29.5	(28.2–30.7)	4
Anterior width, m2	19.8	(19.5–20.0)	6	21.8	(20.6–22.7)	15	21.3	19.4	(18.7–19.8)	3
Length, m3	19.7	(19.0–20.3)	4	22.4	(19.0–24.2)	10	22.3	21.6	(19.9–22.9)	3
Width, m3	16.1	(15.9–16.2)	3	17.7	(15.4–19.1)	11	16.5	16.8	(16.5–17.3)	3
Humerus, total length	443	(436–454)	6	469	(440–497)	2	594	555	(555)	1
Humerus, greatest distal width across epicondyles	123	(122–123)	3	136	(126–156)	3	161	148	(123–170)	6
Ulna, greatest length	432	(418–446)	7	460	(435–475)	3	544	539	(536–542)	2
Radius, greatest length	380	(366–394)	5	—	—	—	480	476	(436–511)	3
Femur, greatest length	509	(491–524)	3	505	(502–507)	2	651	—	—	—
Femur, greatest distal width across epicondyles	107	(106–108)	3	109	(109–110)	2	145	—	—	—
Tibia, greatest length	379	(360–390)	3	404	(404)	1	478	462	(462)	1
Tibia, least width of shaft	35.1	(33.1–37.1)	3	41.9	(40.7–43.0)	2	49.0	47.2	(46.9–47.5)	3
Calcaneum, greatest length	106	(101–112)	4	118	(112–127)	4	135	132	(130–135)	2
Calcaneum, greatest width across sustentaculum	71.0	(69–78)	4	83.8	(75.8–87.2)	4	81.5	91.2	(90.7–91.8)	2
Metatarsal V, greatest length	106	(106)	1	118	(110–129)	3	135	121	(121)	1
Metatarsal V, greatest distal width across epicondyles	23.2	(23.2)	1	26.5	(24.3–30.8)	3	31.4	30.3	(30.3)	1

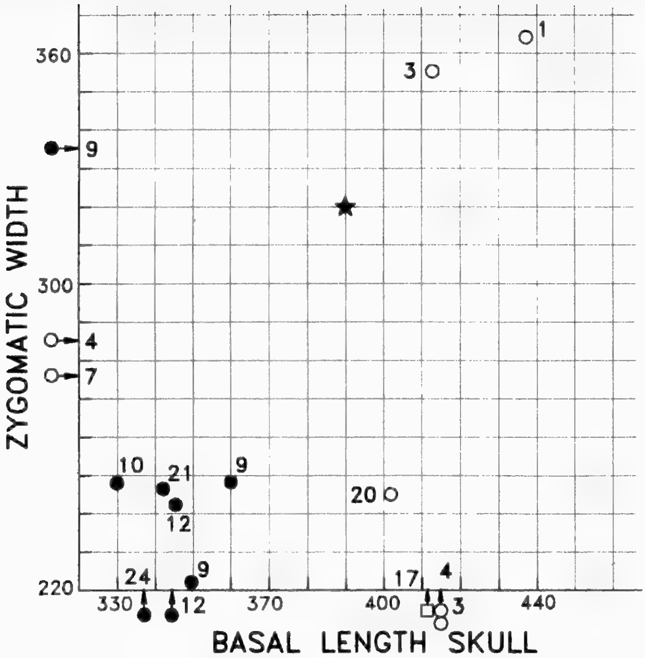

FIG. 17. Bivariate graph of *Arctodus simus*—Skull length by zygomatic width of Indiana specimen compared with others. For explanations of abbreviations, symbols, and type localities, see below.

Abbreviations and symbols: RAN, Rancholabrean; IRV, Irvingtonian; UNK, unknown. Primary reference(s) for measurements follows age. Boxes encase the range of measurements from Rancho La Brea (Locality 9) and Potter Creek Cave (Locality 12). Symbols: solid circle, *A. simus simus* (RAN); hollow circle, *A. simus yukonensis* (RAN); hollow square, *A. simus yukonensis* (IRV); "winged" circle, subspecies uncertain (RAN); "winged" triangle, subspecies and age uncertain; star, Fulton County, Indiana (PM #24880). Symbols along graph margins show isolated, singular measurements.

Key to type localities for Figures 17–20:

1. Gold Run Creek, Yukon Territory (RAN; Kurtén, 1967; Harington, 1977).
2. New Fern Cave, Jackson County, Alabama (RAN; Ray, 1969).
3. Upper Cleary River Beds, Alaska (RAN; Kurtén, 1967; Richards et al., in press).
4. Ester Creek, Alaska (RAN; Kurtén, 1967; Richards et al., in press).
5. Engineer Creek, Alaska (RAN; Richards et al., in press).
6. Cleary, Alaska (RAN; Richards et al., in press).
7. Goldstream ("G. S. Dredge"), Alaska (RAN; Richards et al., in press).
8. Keams Canyon, Navajo County, Arizona (RAN; Ray, 1969).
9. Rancho La Brea, Los Angeles County, California (RAN; Merriam & Stock, 1925; Kurtén, 1967; Agenbroad & Mead, 1986).
10. McKittrick, Kern County, California (RAN; Schultz, 1938; Kurtén, 1967).
11. Irvington, Alameda County, California (IRV; Kurtén, 1967).
12. Potter Creek Cave, Shasta County, California (RAN; Merriam & Stock, 1925; Kurtén, 1967; Ray, 1969).
13. Jinglebob, Lone Tree Arroyo, Meade County, Kansas (RAN; Kurtén, 1967).
14. Arkalon, Seward County, Kansas (IRV; Richards et al., in press).
15. Bat Cave, Pulaski County, Missouri (RAN; Hawksley, 1965; Kurtén, 1967).
16. Perkins Cave, Camden County, Missouri (RAN; Hawksley, 1965; Kurtén, 1967).
17. Hay Springs, Sheridan County, Nebraska (IRV; Kurtén, 1967; Richards et al., in press).
18. Labor-of-Love Cave, White Pine County, Nevada (RAN; Emslie & Czeplewski, 1985).
19. Frankstown Cave, Blair County, Pennsylvania (RAN; Peterson, 1926; Kurtén, 1967).
20. Hot Springs Mammoth Site, Fall River County, South Dakota (RAN; Agenbroad & Mead, 1986).
21. Cueva Quebrada, Val Verde County, Texas (RAN; Lundelius, 1984).
22. Rock Creek (2 mi north of *Equus* quarry), Briscoe County, Texas (IRV; Kurtén, 1967).
23. Silver Creek, Salt Lake County, Utah (RAN; Nelson & Madsen, 1983).
24. Natural Trap Cave, Big Horn County, Wyoming (RAN; Agenbroad & Mead, 1986).
25. Little Box Elder Cave, Converse County, Wyoming (RAN; E. Anderson, 1968) (as *Ursus arctos*).
26. Zacoalco, Jalisco, Mexico (UNK; Aviña, 1969).
27. Tequixquiac, exact locality unknown, Mexico (RAN; Freudenberg, 1910; Richards et al., in press).

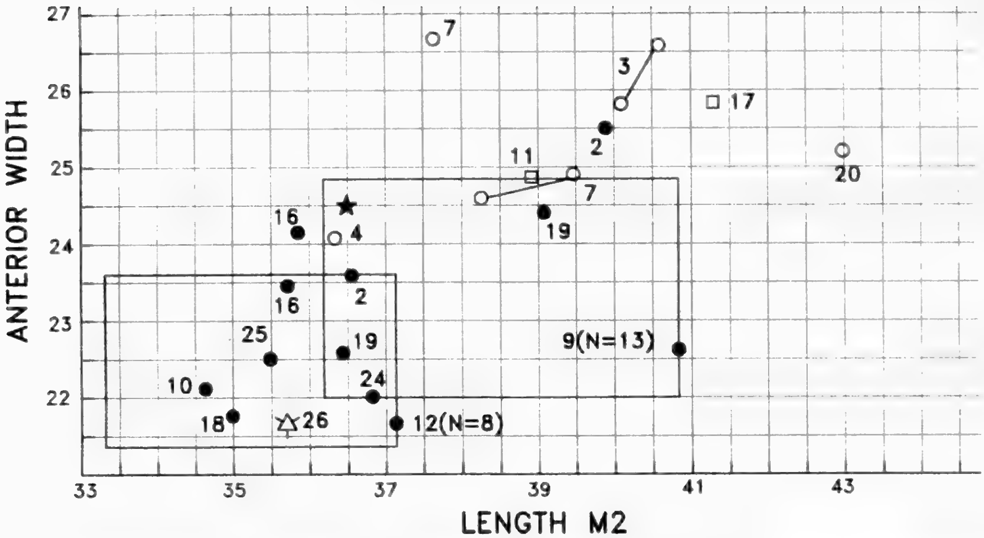

FIG. 18. Bivariate graph of *Arctodus simus*—Length and anterior width of M2. For explanations of abbreviations, symbols, and type localities, see p. 28.

slightly shorter in relation to the femur than in the other individuals. This is apparently not a sexual characteristic, as the Cueva Quebrada specimen (considered to be a female) has the longest skull in proportion to the femur length. A peculiarity of the Indiana specimen is the extreme narrowness of the postorbital constriction.

In limb proportions, the radius/humerus (100 × radius/humerus) and the tibia/femur (100 × tibia/femur) indices (values of 80.8 and 73.4, respectively) are within the range reported for other *A. simus* specimens (Kurtén, 1967; Emslie & Czaplewski, 1985).

In life the Indiana *Arctodus* specimen would have stood more than 158 cm (5′2″) at the shoulder. Using the combined minimum midshaft circumference of the femur (171 mm) and humerus (196 mm) as predictors of body mass (J. F. Anderson et al., 1985; Roth, 1990; Damuth & MacFadden, 1990), the weight of the Indiana specimen was calculated at 766 kg. This is about the weight for the largest of the Alaskan brown bears (*Ursus arctos*, up to 780 kg; Walker, 1964), and heavier than the values for *A. s. yukonensis*, based on the area of the cross-section of the femoral shaft presented in Kurtén (1967; 590–630 kg) and Nelson and Madsen (1983; 620–660 kg).

The radiocarbon date of 11,500 ± 520 B.P. is among the few direct dates available on *Arctodus* bone and is among the youngest dates for the species. Other young dates on materials associated with *Arctodus simus* are 11,220 ± 110 to 11,420 ± 110 B.P., Huntington Dam, Sanpete County, Utah (Gillette & Madsen, 1992); 12,650 ± 350 B.P., Lubbock Lake, Lubbock County, Texas, where *A. simus* foot bones have aboriginal cut marks (Kurtén & Anderson, 1980; Johnson, 1987); 12,650 ± 70 B.P., Silver Creek, Salt Lake County, Utah (Nelson & Madsen, 1983); and ca. 11,500 B.P., Burnet Cave, New Mexico, where *A. simus* was associated with a Clovis point (Hester, 1967). Emslie and Czaplewski (1985) reported a date of 5,320 ± 120 B.P. for the Labor-of-Love Cave, White Pine County, Nevada, specimen but did not accept it as giving the true age of the specimen. Churcher et al. (1993) summarized other radiocarbon dates available for *Arctodus simus.*

Pollen spectra from several Indiana localities suggest the dominant regional vegetation at the time the bear at the Rochester site was deposited. Marls from a kettle lake at the Wells Mastodont Site, Fulton County (about 11 km northwest of the *Arctodus* locality), were dated at 12,000 ± 450 B.P. in the mastodont level (Gooding & Ogden, 1965). Pollen spectra were dominated by spruce (*Picea*), with ash (*Fraxinus*), fir (*Abies*), and birch (*Betula*) represented, until 10,500 B.P. when the coniferous forest gave way to oak (*Quercus*).

At another site, the Kolarik mastodont locality, Starke County (about 35 km northwest of the Rochester *Arctodus* locality), mastodont bones were associated in a sandy muck with pollen, indicating

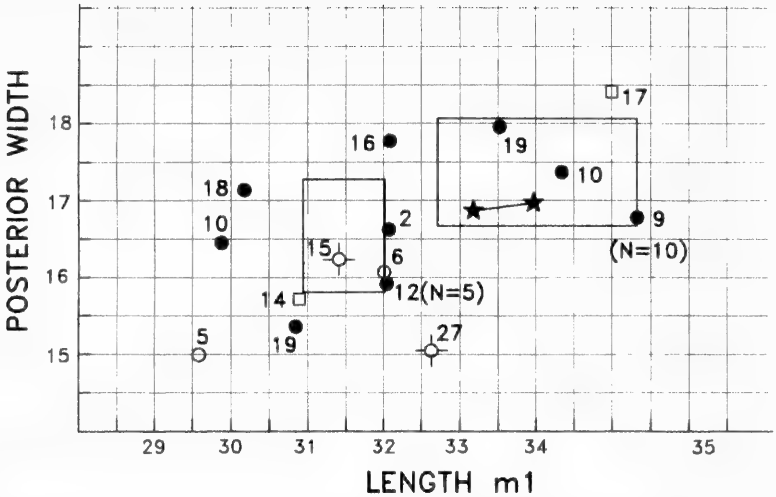

FIG. 19. Bivariate graph of *Arctodus simus*—Length and posterior width of m1. For explanations of abbreviations, symbols, and type localities, see p. 28.

an open or patchy boreal forest dominated by spruce, with a high percentage of fir, ash, and herbs and a low percentage of pine, oak, and other hardwoods (Jackson et al., 1986). This sequence, dated at >12,000 B.P. to at least 11,000 B.P., was succeeded by a dominance of pine and other hardwoods. Clayey marls preceded the bone-bearing sandy muck level.

The Christensen mastodont locality, 145 km to the south, preserved an open, white spruce-dominated boreal forest at 14,000–13,000 B.P. associated with the bone levels. This forest was followed thereafter by the immigration of hardwoods (Whitehead et al., 1982). Similar pollen spectra are known throughout the central Great Lakes region (Bailey, 1972; Bailey & Ahearn, 1981; King,

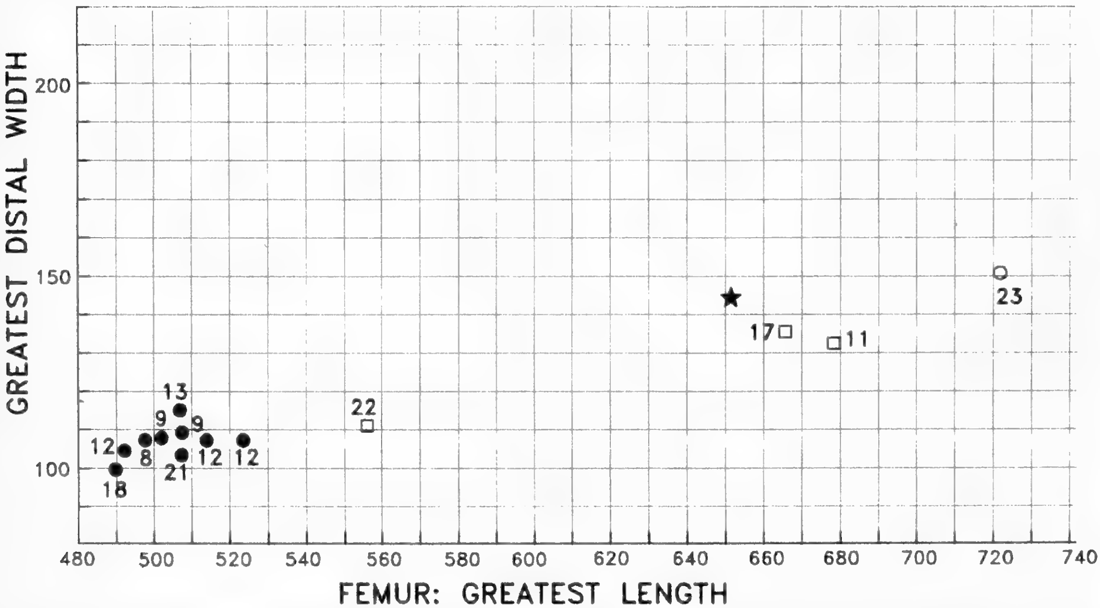

FIG. 20. Bivariate graph of *Arctodus simus*—Femur, greatest length and distal width. For explanations of abbreviations, symbols, and type localities, see p. 28.

TABLE 9. Absolute dimensions and ratio (%) of skull length to the other skull dimensions and to other select elements among associated *Arctodus simus* specimens. (Measurements in millimeters.)

Measurements	Rochester, Indiana		Hay Springs, Maine	Hot Springs, South Dakota	Cueva Quebrada, Texas
Skull, basal length	396		a413	402	343
Skull, zygomatic breadth	319	(124%)	—	244.5 (164%)	207 (166%)
Skull, width over postorbital processes	170.7	(232%)	a184 (224%)	167 (241%)	—
Dentary, canine to condyle	298 (av.)	(133%)	295 (140%)	—	—
Femur, greatest length	651	(61%)	658 (63%)	—	508 (68%)
Tibia, greatest length	478	(83%)	492 (84%)	—	—

1981) and the eastern United States (Delcourt & Delcourt, 1981). Thus, the Quaternary palynology of the region suggests that the Rochester *Arctodus* likely existed in an open or patchy boreal forest dominated by spruce.

Kurtén (1967) visualized *Arctodus simus* as a long-legged, fast-running, powerful predator, capable of preying on bison, deer, horse, or ground sloth. Emslie and Czaplewski (1985), however, suggested that *A. simus* was an omnivore or herbivore, highly capable of scavenging, and that the proportions of the long limbs were not necessarily adapted for running, but perhaps for pulling down vegetation or for increased visibility within tall ground cover in open habitat. Voorhies and Corner (1986) felt that the skull morphology and jaw mechanics of *A. simus* confirmed its predaceous nature. Shaw and Cox (1994) believe that *A. simus* was more carnivorous than living bears, except the polar bear. With most modern ursids being omnivorous, it seems to us unlikely that a tendency for the omnivorous way of life would have been abandoned by *Arctodus*, even though its teeth and limbs strongly suggest that it also had specialized for a predatory life-style. Thus, we suggest that *Arctodus simus* was a highly predaceous omnivore, with a preference for larger-sized prey.

Harington (1980), examining the geographic distribution of *A. simus*, suggested that the species occupied high, well-drained grasslands. Both Kurtén (1967) and Nelson and Madsen (1983) have suggested that *A. simus* inhabited open prairie or savanna environments. The context of the isolated Indiana specimen suggests only that short-faced bears occupied the open boreal forests of northern Indiana ca. 11,000–13,000 years ago. Apparently *Arctodus* occasionally also frequented lowland lake and swamp environments such as the depositional situation described in this paper suggests.

Potential local prey may have included the large species: Jefferson's ground sloth (*Megalonyx jeffersonii*), giant beaver (*Castoroides ohioensis*), American mastodont (*Mammut americanum*), Jefferson's mammoth (*Mammuthus columbi jeffersonii*), tapir (*Tapirus* sp.), horse (*Equus* sp.), flat-headed peccary (*Platygonus compressus*), long-nosed peccary (*Mylohyus nasutus*), stag-moose (*Cervalces scotti*), elk (*Cervus elaphus*), white-tailed deer (*Odocoileus virginianus*), caribou (*Rangifer tarandus*), ancient bison (*Bison bison antiquus*), Harlan's musk ox (*Bootherium bombifrons*), and tundra musk ox (*Ovibos moschatus*) (Richards, 1984). Potential plant foods have not been investigated.

Cave finds of *A. simus* are common (Emslie, 1985; Emslie & Czaplewski, 1985; Hansen, 1992; Hawksley, 1986; Kurtén & Anderson, 1980; Nelson & Madsen, 1983; Puckette, 1976), and some "bear beds" present in Missouri caves appear to indicate denning (Hawksley, 1965).

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Appendix

Osteomyelitis in the Ulnae of the Bear, *Arctodus simus*

E. J. Neiburger[1]

Lesions on the Ulnae

Each ulna exhibits an area of osteolytic-osteoplastic activity.

1. The right ulna shows an area of periostitis with one defect located 11 cm from the distal end of the bone. The defect is an oval opening 1.5 cm × 0.8 cm in size and dissecting through the cortex to a depth of 2.0 cm. The opening is surrounded by a 0.5-cm elevation of bone extending in an area 3 cm in diameter around the opening. This bone is quite dense.

There are four exostoses (0.2–0.8 cm) located on the edge of the defect, probably caused by hyperplastic bone formation responding to an infection.

2. The left ulna presents three related lesions encircling the midshaft area, 24 cm from the distal end. The largest lesion is 1.0 cm in diameter with a slightly raised lip and a few small (0.1–0.3 cm) exostoses protruding from the edge. The lesion dissects 2.0 cm into the cortex. The second lesion is located 2 cm posterior to the first. It is 0.5 cm in diameter and 0.5 cm deep. The third lesion is located 1.0 cm posterior from the second. It is 1.0 cm wide and 0.5 cm deep.

These lesions do not appear interconnected by blunt probing but occupy a slightly elevated area of bone that "rings" the shaft. The bone surrounding the lesions in both ulnae is dense and has little porosity and no fracture lines or other defects.

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Interpretation

These lesions are quite typical of the abscess-fistula formation seen with osteomyelitis, a chronic infection of the bone.

These lesions are localized and have not spread to the medullary portions of the bone shaft. They are well circumscribed, only slightly hyperplastic and dense. These conditions are typical of a long-standing (multi-year) infection in which the bear's resistance is just able to contain the infection but not strong enough to heal it. Such infection results from either lowered host resistance or a very virulent pathogen. In this situation, the area becomes a localized sore that constantly drains, repeatedly flares up, and then partially heals, only to flare up again.

The area of the lesion is occasionally painful but not totally debilitating. Such wounds could be initiated by a penetrating or crushing injury that breaks the skin surface and becomes infected.

In wild animals, these wounds quickly heal or progress to a fatal condition. It is rare to see such wounds, as in this case, remain in a static state for such a length of time as to produce the hyperplastic bone formations noted.

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