THREE NEW SAUROPOD DINOSAURS FROM THE UPPER JURASSIC OF COLORADO

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ABSTRACT.—From 1972 to 1982 three exceptionally large sauropod scapulocoracoids and other equally large sauropod bones were collected from the base of the Brushy Basin Member of the Upper Jurassic, Morrison Formation, in western Colorado. Two of the scapulae are conspecific, but the third represents a second genus and possibly a new family. The two conspecific specimens are described here as: *Supersaurus vivianae*; the second genus is described as *Ultrasaurus mcintoshi*, and a large, robust anterior dorsal vertebra of unique form is described as *Dystylosaurus edwini*. Various miscellaneous elements are referred to the three genera.

Historical

The genus *Brachiosaurus*, named by E. S. Riggs (1903), was part of an articulated skeleton from the Upper Jurassic Morrison Formation within the present city limits of Grand Junction in western Colorado. Riggs believed the genus represented a land-dwelling animal, rather than one preferring an aquatic habitat.

No one took him seriously at the time, but modern interpretations of sauropod habits and paleoenvironments agree with him. The brachiosaurs are now considered to be the largest terrestrial animals to have lived on earth.

The first uranium boom during World War II triggered the discovery of the second known North American brachiosaur; it was found by prospectors Eddie and Vivian Jones who were looking for uranium, circa 1943, when they collected a brachiosaur humerus from the Uncompahgre Upwarp and donated it to the Smithsonian Institution, where it was put on display. However, no credit was given to the collectors.

That display led to the discovery of the Uncompahgre fauna and the materials described herein. The author saw the Jones humerus in 1958 and later in Colorado found the Jones family, who took him to the location on Potter Creek. They also took him to three other major fossil localities on the Uncompahgre Upwarp that together produced a relatively new dinosaur fauna, described as the Uncompahgre fauna (Jensen, in preparation). The author later returned to Potter Creek and collected additional brachiosaur material (being described elsewhere).

Dry Mesa Quarry

Three large sauropod scapulocoracoids were collected from one of the Jones localities near Dry Mesa, Mesa County, 35 miles west of Delta, Colorado. Over a period of 10 years the site proved to be very productive, yielding many tons of field blocks and packages of dinosaur material. It was named after Dry Mesa and is located near the base of the Brushy Basin member of the Morrison Formation and, consequently, is not easily confused with the overlying Lower Cretaceous, Cedar Mountain Formation when making simple stratigraphic determinations. The top of the Morrison Formation is easy to follow cross-country because the superior Cedar Mountain sediments are set-back above it, forming a prominent shoulder from 100 to 500 m wide. Sag-ponds are a characteristic feature of this shoulder, being produced by land-flow and slumping that crush and mutilate fossils contained in the moving sediments. Its bentonitic clays and mudstones, interbedded with soft sandstones, grits, and fine gravels, respond actively to cyclic wet/dry stressing, accelerating the deterioration rate of fossil

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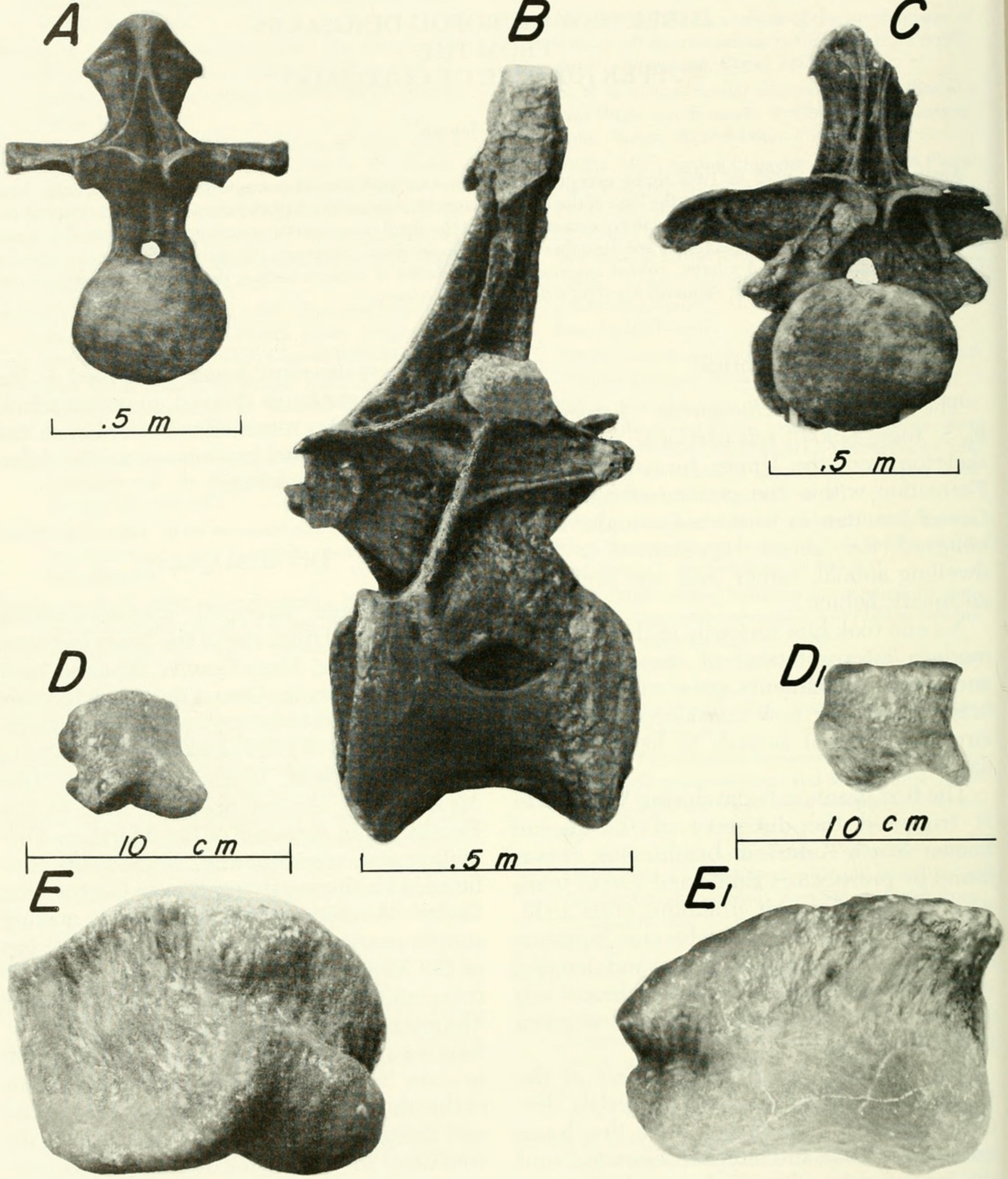

Fig. 1. A, *Brachiosaurus* sp., dorsal vertebra. B, Holotype, *Ultrasaurus macintoshi*, posterior dorsal vertebra, BYU 5000. C, Holotype, *Dystylosaurus edwini*, anterior dorsal vertebra, BYU 5750. D, E1, unidentified manual phalanges.

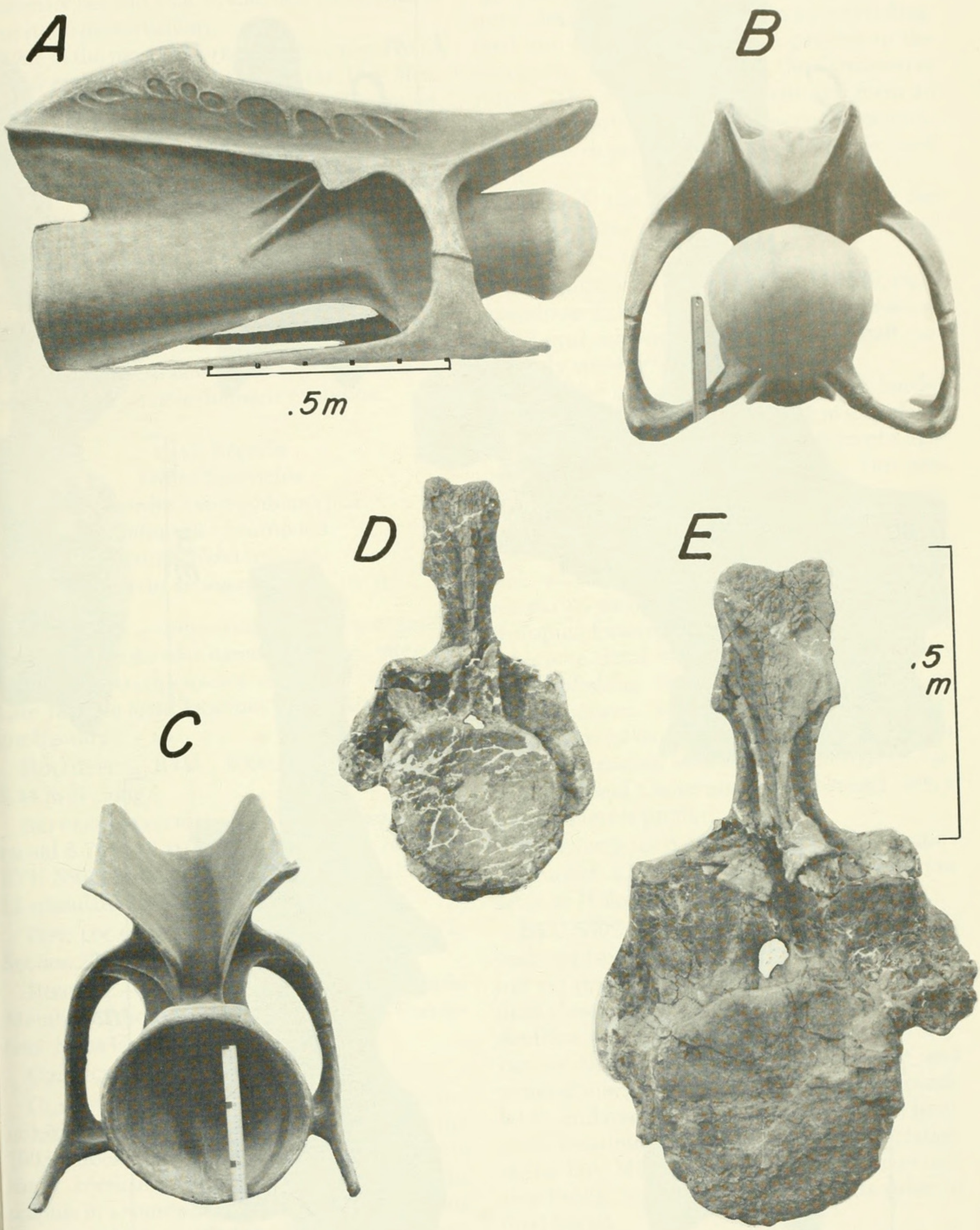

Fig. 2. A–C, Model of referred specimen, *Ultrasaurus macintoshi*, midcervical vertebra: A, right lateral view. B, anterior view. C, posterior view. D–E, Referred specimen, *Ultrasaurus macintoshi*, anterior caudal vertebra. D, anterior view. E, posterior view.

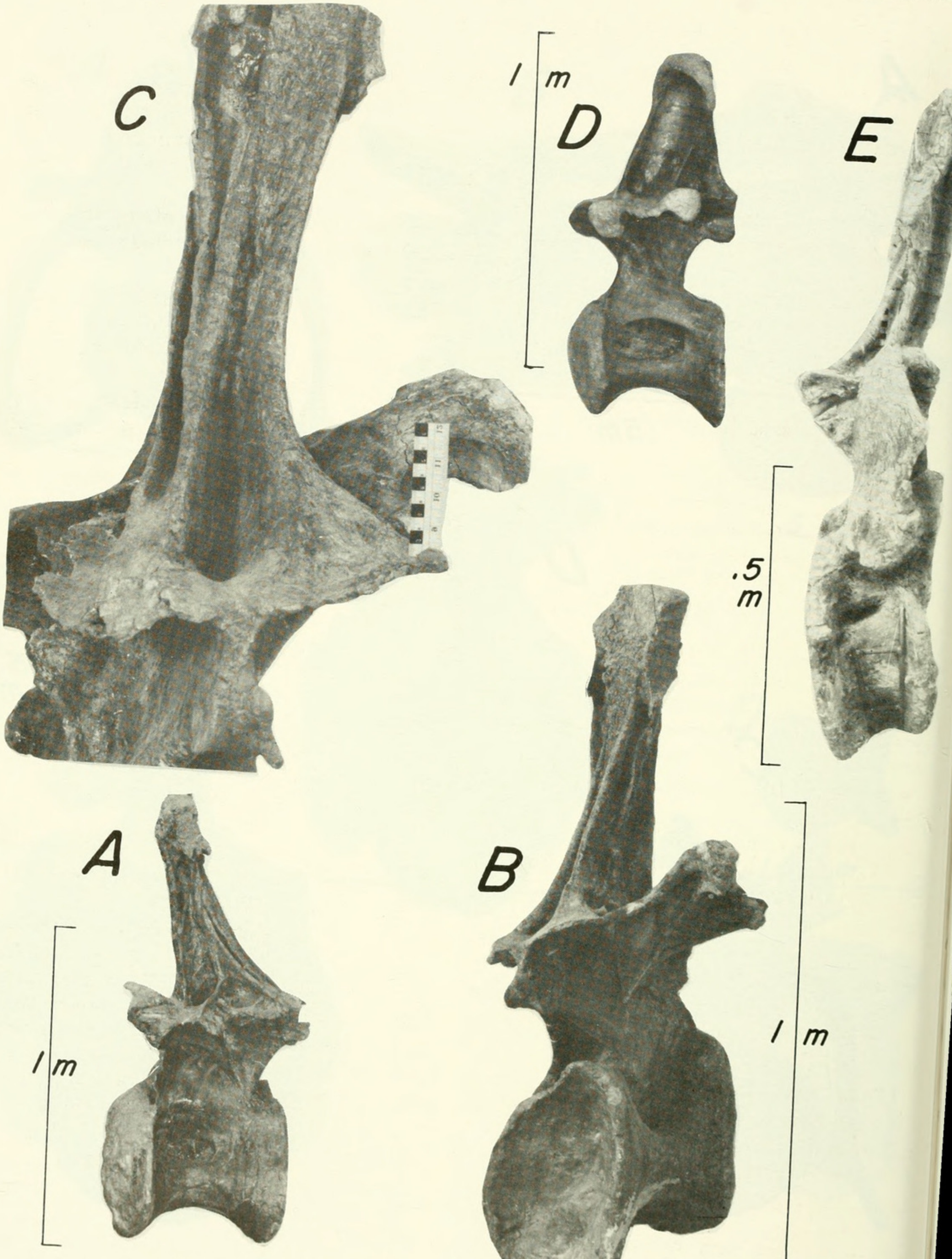

Fig. 3. A–C, Holotype, *Ultrasaurus macintoshi*, posterior dorsal vertebra: A, left lateral view. B, oblique posterior view. C, detail of neural spine. D, *Brachiosaurus* sp., dorsal vertebra, left lateral view. E, *Ultrasaurus macintoshi*, referred specimen, anterior caudal vertebra, left lateral view.

materials beyond that of calcified sandstone or limestone preservations.

One of the most important problems yet to be solved is that of the exact age of the Dry Mesa sediments. It is mapped as Morrison Formation, but the fauna does not match taxa of classical Morrison localities. The assemblage is not only very diverse but contains many taxa previously unknown in the Upper Jurassic of North America.

The author believes the Morrison sediments exposed along the eastern monocline of the Uncompahgre Upwarp are younger than the Morrison in previously described localities, and that the Uncompahgre fauna may represent the last expression of Jurassic dinosaur evolution.

Class Reptilia
Order Saurischia
Suborder Sauropodomorpha
Infraorder Sauropoda
Family indeterminate
Supersaurus vivianae, n. gen., n. sp.

ETYMOLOGY.—*Supersaurus*, internationally published vernacular name; *vivianae*, after Vivian Jones, co-discoverer of all the important Late Jurassic fossil localities on the Uncompahgre Upwarp.

HOLOTYPE.—BYU 5500, scapulocoracoid 2.44 m (8') long.

REFERRED MATERIAL.—BYU 5501, scapulocoracoid 2.70 m (8,10") long; BYU 5502, ischium; BYU 5503, medial caudal vertebra; BYU 5504, 12 articulated caudal vertebrae.

TYPE LOCALITY.—Dry Mesa quarry; E 1/2, Section 23: T 50N, R 14W, NMPM.

HORIZON.—Near the base of the Brushy Basin Member of the Upper Jurassic Morrison Formation, Mesa County, Colorado.

COLLECTOR.—James A. Jensen 1979.

CLARIFICATION.—Sauropod scapular terminology in the literature is not uniform (Hatcher 1903, Mook 1921, Gilmore 1936), resulting in some confusion. This paper describes the scapula in a somewhat normal orientation; using an external view with the glenoid cavity down and the coracoid on the right end, the right scapula will be described. Descriptive terminology used: narrow midsection is the "shaft"; left end is the "distal" end; upper edge is the "superior border"; lower edge is the "inferior border"; ventral projection of glenoid area is the "glenoid process"; ridge separating the two muscular fossae and running on a curved diagonal line up from the glenoid process to the maximum scapular width is the "transverse ridge." This ridge and the shaft-axis form an angle that varies in different sauropod genera. The great depressions to the left (above) and right
(below) of the transverse ridge are the "superior fossa" and "inferior fossa," respectively.

DESCRIPTION.—(Holotype BYU 5500; right scapulocoracoid) Scapula long but not robust; distal end expanding moderately; shaft not severely constricted in midsection.

A shallow outward curve in inferior border slightly proximad to greatest width of scapula, at top of transverse ridge, indicates origin of a ligament, possibly M. scapulohumeralis. This process also present on *Diplodocus*, occurring considerably higher up on *Cetiosaurus* and most prominently developed on *Ultrasaurus*, but absent or insignificant in *Brachiosaurus*, *Apatosaurus*, and *Camarasaurus*. Inferior border of scapula forming a gentle curve from glenoid process to distal end, resembling *Apatosaurus* and *Diplodocus* rather than *Brachiosaurus* or *Camarasaurus*. Inferior fossa not broadly expanded as in *Brachiosaurus* and longer than wide, contrasting with opposite design in *Apatosaurus* and *Camarasaurus*. Coracoid with a subrectangular profile.

REFERRED MATERIAL.—BYU 5501, scapulocoracoid 2.70m (8' 10") long. Description same as Holotype, BYU 5500.

BYU 5502, 12 articulated caudal vertebrae: each approximately 30 cm long, collected but not yet prepared for study. They were examined closely in the field by the author, and a decision was made to refer them to *Supersaurus* on the basis of their massive size and general morphology. They were found parallel to, and near the *Supersaurus* scapula; however, location is not a criterion for association in the Dry Mesa quarry because of the extensive fluvial transport of all elements prior to final burial.

BYU 5503, ischium (Fig. 7A): straight shaft, more robust than *Diplodocus*; distal end expanded dorsally, truncated ventrally. Very similar to *Diplodocus*.

BYU 5504, two medial caudal vertebrae (Figs. 7C, D, D1). C, double-keeled, diplo-

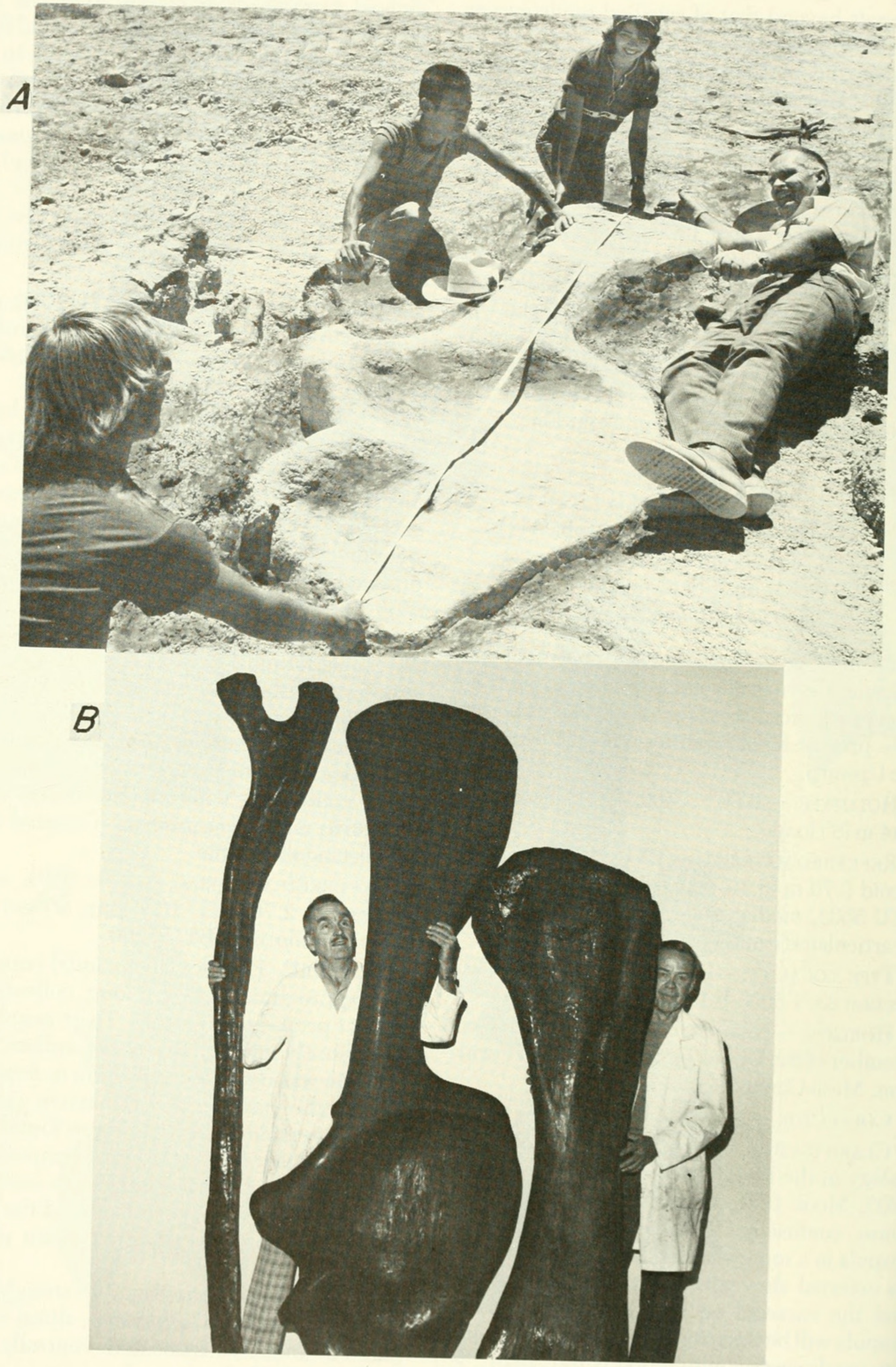

Fig. 4. A Measuring *Ultrasaurus macintoshi* scapulocoracoid at discovery site. Author lying beside specimen. Three reproductions: left, *Brachiosaurus* sp. rib 2.75 m (9') long; middle, *Ultrasaurus macintoshi* right scapulocoracoid; right, left humerus of *Brachiosaurus* sp. from Potter Creek. J. A. Jensen (left) and Adrian M. Bouche (right).

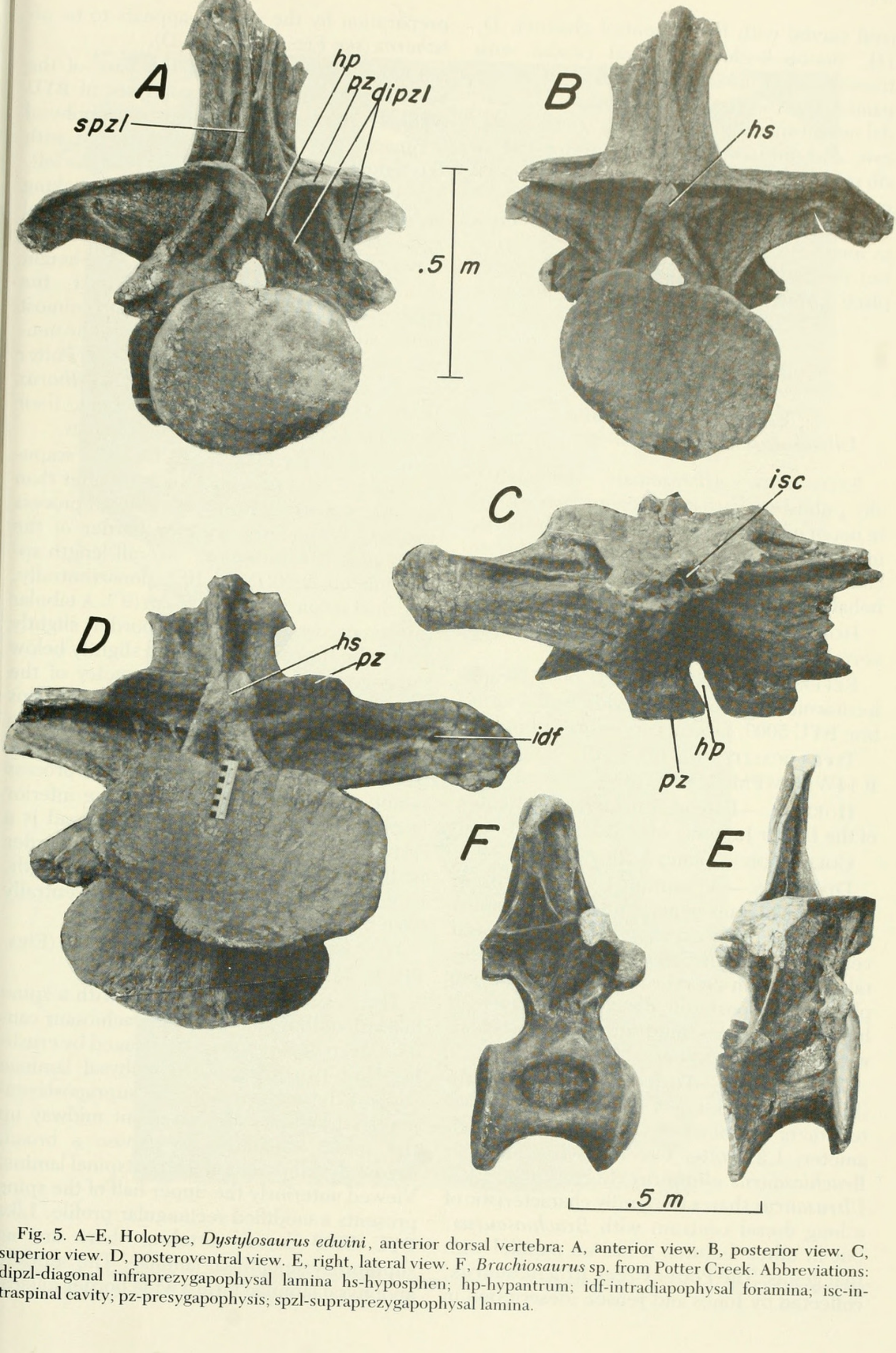

Fig. 5. A–E, Holotype, *Dystylosaurus edwini*, anterior dorsal vertebra: A, anterior view. B, posterior view. C, superior view. D, posteroventral view. E, right, lateral view. F, *Brachiosaurus* sp. from Potter Creek. Abbreviations: dipzl-diagonal infraprezygapophysal lamina hs-hyposphen; hp-hypantrum; idf-intradiapophysal foramina; isc-intraspinal cavity; pz-presygapophysis; spzl-supraprezygapophysal lamina.

coid caudal with broad ventral channel; D, D1, double-keeled diplocoid caudal with transversely thick neural spine that is expanded dorsoventrally at its summit. The caudal neural spines of *Diplodocus* are thin, narrow, and unexpanded at the summit; caudal rib missing, no pleurocoel but a short channel exists below base of caudal rib. Proportion of diameter-to-length would place the specimen as number 12 in a *Diplodocus* caudal series, but the reduction of the neural arch would place it much further back in the same series.

Order Saurischia
Suborder Sauropodomorpha
Infraorder Sauropoda
Family Brachiosauridae
Ultrasaurus macintoshi, n. gen., n. sp.

ETYMOLOGY.—*Ultrasaurus*, internationally published vernacular name; *macintoshi*, in honor of John S. McIntosh, an enthusiastic, indefatigable student of sauropods who encourages everyone to greater effort in their behalf.

HOLOTYPE.—BYU 5000, posterior dorsal vertebra.

REFERRED MATERIAL.—BYU 5001, scapulocoracoid; BYU 5002, anterior caudal vertebra; BYU 5003, medial cervical vertebra;

TYPE LOCALITY.—E 1/2 Section 23, T 50N, R 14W, NMPM, Mesa County, Colorado.

HORIZON.—Base of Brushy Basin Member of the Upper Jurassic, Morrison Formation.

COLLECTOR.—James A. Jensen 1979.

DIAGNOSIS.—A sauropod differing from other brachiosaur genera in having a scapula with a moderately expanded distal end; dorsal vertebrae with anteroposteriorly narrow neural spines; midcervical vertebrae lacking pleurocoels; posterior dorsal vertebrae with high neural spines; anterior caudal vertebrae with high neural spines.

DESCRIPTION.—Posterior dorsal vertebra (Figs. 1B; 3A, B, C). A long centrum characteristic of brachiosaurs: ratio of length to diameter, 1.2; Potter Creek brachiosaur, 1.3; *Brachiosaurus altithorax* (Riggs 1903), 1.07. *Ultrasaurus* shares the family characteristic of a long dorsal centrum with *Brachiosaurus*, but in other features it has no parallel with that genus. The Potter Creek *Brachiosaurus*, collected by Jones and Jensen (description in preparation by the author) appears to be *altithorax* (see Figs. 1A, B; 3A-D).

Figure 3C is a detail of the base of the neural spine and postzygapophyses of BYU 5000. The form of the suprapostzygapophysal laminae is greatly altered by assymetry, with the right side being more robust than the left. The vertebra is crushed transversely, making an anterior view nearly useless. The neural spine is tall and buttressed posteriorly by suprapostzygapophysal laminae 2/3 the height of the spine (Fig. 3B). In contrast, the supraprezygapophysal laminae are almost nonexistent. The general structure of the neural spine is fragile compared to the Potter Creek specimen (Fig. 1A) and *altithorax* (Riggs 1903). Pleurocoels are present, their length being less than twice their height.

REFERRED MATERIAL.—BYU 5001, scapulocoradoid. The inferior fossa is broader than in *Supersaurus* (Figs. 4A, B); glenoid process projects beyond the inferior border of the shaft as in *Brachiosaurus*; overall length approximately 2.70 m (8' 10"); dorsoventrally, midshaft is constricted to 23 cm (9"). A tabular process occurs on the inferior border, slightly above the transverse ridge and slightly below the minimum dorsoventral diameter of the flattened shaft (Fig. 4A). The function of this tabular process is unknown but appears to support the origin of an intercostal muscle or possibly an m. humeroscapularis. The process is not a gentle convexity below the inferior border, as in *Supersaurus*, but instead is a distinct tab erupting from the inferior border with a base approximately 100 mm in length, extending approximately 50 mm ventrally from the edge of the scapula (Fig. 4B).

BYU 5002, anterior caudal vertebra (Figs. 2D, E, 3E).

This is probably No.3 caudal with a spine taller than those on anterior brachiosaur caudals. All zygapophyses are damaged by crushing, but two infraprezygapophysal laminae support the anterior pair. The suprapostzygapophysal laminae diverge about midway up the spine, expanding to expose a broad, rugose development of the postspinal lamina. Viewed anteriorly the upper half of the spine presents a modified rectangular profile. Like BYU 5000 dorsal vertebra, there are no supraprezygapophysal laminae. The supradiapophysal laminae form a wide border enclos-

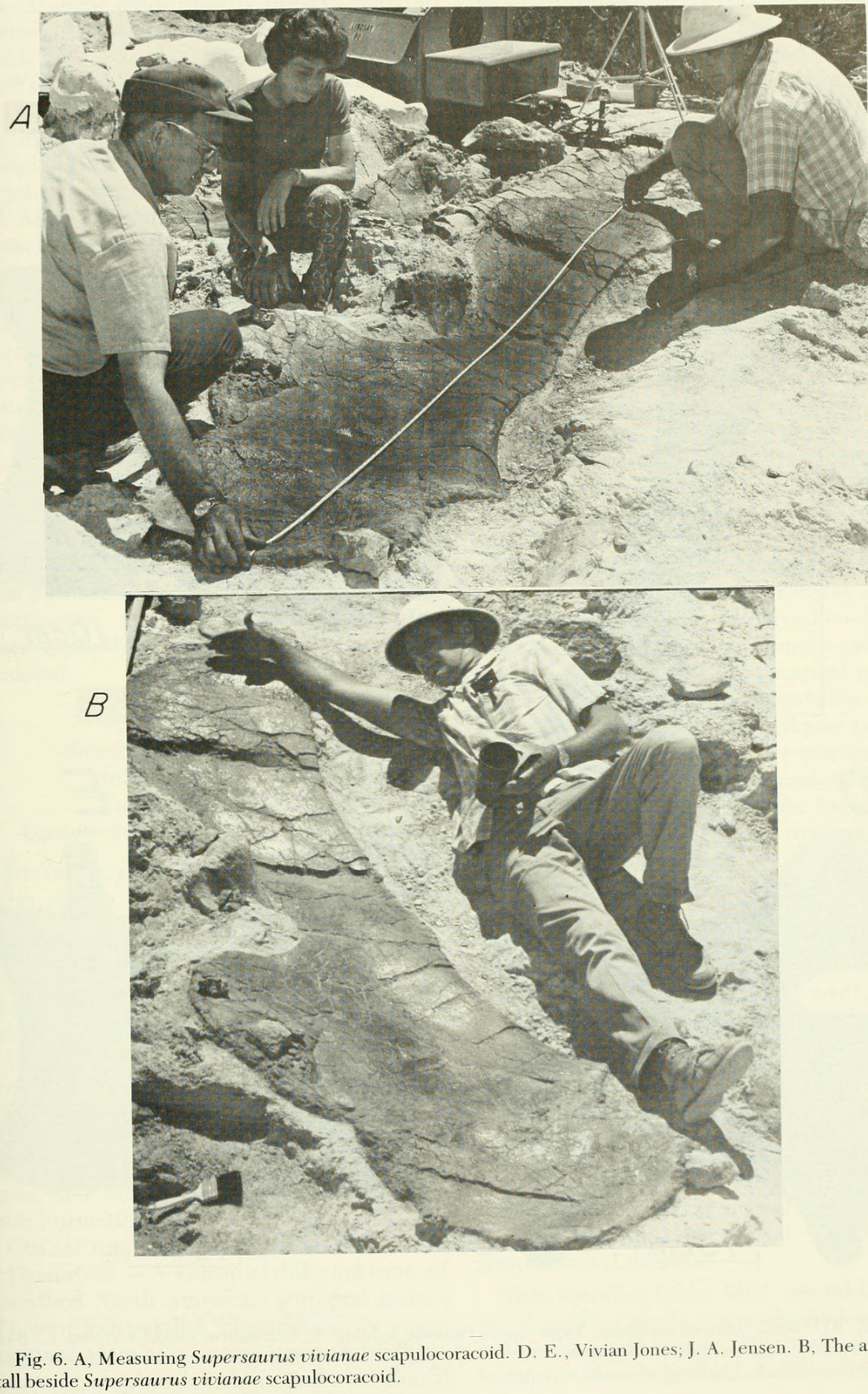

Fig. 6. A, Measuring *Supersaurus vivianae* scapulocoracoid. D. E., Vivian Jones; J. A. Jensen. B, The author, 6'3" tall beside *Supersaurus vivianae* scapulocoracoid.

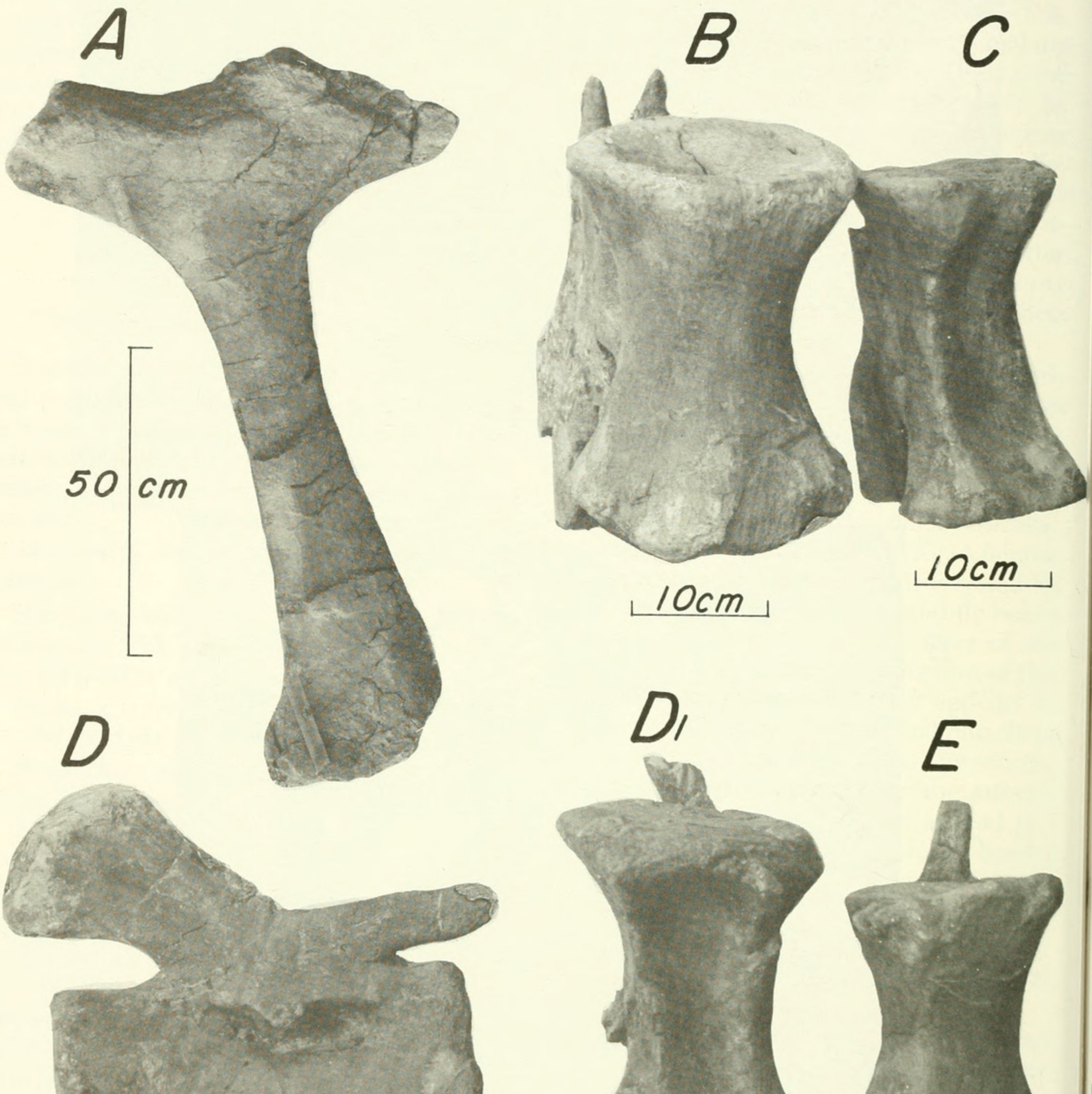

Fig. 7. A, BYU 5503, referred specimen, *Supersaurus vivianae* ischium. B, Ultrasaurus caudal vertebra. C, BYU 5503, *Supersaurus vivianae*, referred specimen, ischium. D, D1, BYU 5504, *Supersaurus vivianae*, referred specimen, caudal vertebra. E, unidentified caudal vertebra.

ing a narrow, but prominent, prespinal lamina. A small pleurocoel is present and the centrum is not procoelous but both ends are nearly flat.

BYU 5003, medial cervical Vertebra (Fig. 2A, B, C). The original referred specimen is not illustrated. What is seen is a life-sized model of BYU 5003, constructed from careful measurements taken from the crushed original. All brachiosaur cervical vertebrae are extremely fragile in construction and generally found badly crushed. The cervical rib is arbitrary, but the vertebra was modeled as carefully as possible from the original. One remarkable feature is the absence of pleurocoels, so radically developed in some sauropod families, such as that of the *Diplodocidae*. Also, the postdiapophysal, or horizontal, laminae are missing. The spine is single, being slightly lower than the summit of the supraprezygapophysal laminae, which align with the elevated suprapostzygapophysal laminae to provide a channel for the long cervical flexor muscles. The anterior convexity is exaggerated approximately 5%, and the postzygapophysal articular facets were not modeled.

Order Saurischia
Suborder Sauropodomorpha
Infraorder Sauropoda
Family indeterminate
Dystylosaurus edwini, n. gen., n. sp.

Etymology.—Greek: *di*, two; *stylos*, beam; *sauros*, lizard; *edwini*, in honor of the late Daniel Edwin (Eddie) Jones, who, with his wife, Vivian, brought more new dinosaur taxa to science than any other two amateurs while providing 20 years of logistic support for fieldwork on the Uncompahgre "Plateau."

Holotype.—BYU 5750, anterior dorsal vertebra.

Type locality.—E 1/2, Section 23; T 50N, R 14W, NMPM.

Horizon.—Near the base of the Brushy Basin Member of the Upper Jurassic Morrison Formation.

Collector.—James A. Jensen 1972.

Diagnosis.—A sauropod differing from all described North American sauropod genera in having two parallel, diagonal infraprezygapophysal laminae supporting each hypantrozygapophysal arch in anterior dorsal vertebrae; lower half of neural arch massive, the neurocentral suture occupying nearly 7/8 the length of the centrum; neural spine fragile, being transversely broad but anteroposteriorly thin; supraprezygapophysal laminae not convergent at midshaft as in *Brachiosaurus*; neural arches of dorsal vertebrae completely pneumatic, including spine, transverse processes, and zygapophyses.

Description.—The location of the parapophyses at the neurocentral suture and the presence of a strongly developed hyposphen/hypantrum articulation locates the vertebra anterior to No. 3. Lower half of neural arch massive, being characterized on its anterior face by four diagonal infraprezygapophysal laminae, two below each zygapophyses. Each pair of these diagonal supports are spaced well apart and more or less parallel, supporting the hypantrozygapophysal arch on each side (Fig. 5A). The hypantrum consists of two opposing articular faces formed by the down-turned, medial edges of the prezygapophyses. Each zygapophysis thus specialized forms an arch termed a hypantrozygapophysal arch. The ventral ends of these four laminae rise from the anterior surface of the parapophyses; internal lamina of each pair supports the ventral end of the hypantrum; external pair supports the prezygapophyses. No other sauropod family displays such a well-designed mechanical arrangement for supporting the hypantrozygapophysal arches. Thin supradiapophysal laminae rise to the lateral spur near the summit of the neural spine, making the spine transversely broad (5A). However, viewed laterally (5E), the spine is very slender and fragile when compared to the lower half of the neural arch. By comparison the neural spine of *Brachiosaurus* (5F, E) is deep and robust anteroposteriorly, but the base of the neural arch occupies no more than 2/3 the length of the centrum; the neurocentral suture on *Supersaurus* extends approximately 7/8 the length of the centrum. The zygapophyses are small and weak, but the hyposphen/hypantrum structure is as strongly developed as it is in the anterior dorsal vertebrae of *Barosaurus* (Lull 1919).

This vertebra bears little resemblance to any described genus and no doubt represents a new sauropod family. Many elements belonging to it were probably collected from the

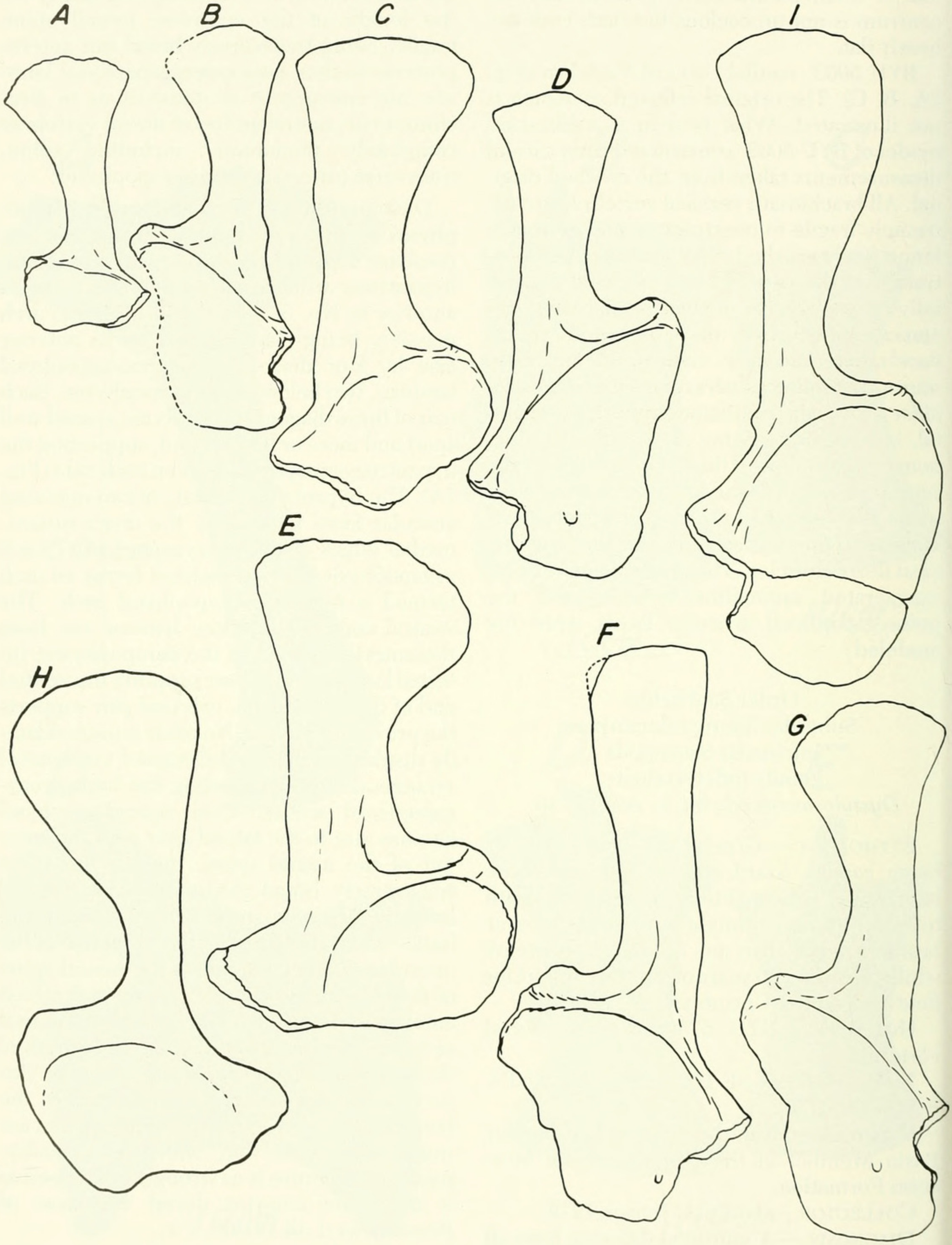

Fig. 8. For comparison only; not to scale. Profiles of various sauropod scapulae and scapulocoracoidae: A, C, E, G, scapulae; B, D, F, H, I, scapulocoracoidae. A, *Haplocanthosaurus* sp. B, *Supersaurus vivianae*, first specimen. C, *Cetiosaurus* sp. D, *Diplodocus longus*. E, *Camarasaurus supremus*. F, *Apatosaurus louisae*. G, *Supersaurus vivianae* second specimen. H, *Brachiosaurus brancai*. I, *Ultrasaurus macintoshi*. B is 2.44 m (8') long; G is 2.74 m (8'10") long.

Dry Mesa quarry, but correct association is difficult when dealing with masses of disarticulated elements belonging to undescribed genera.

DISCUSSION.—In 1983 the unprepared dinosaur materials collected by the author for the Earth Science Museum at Brigham Young University amounted to approximately 100 tons. This mass of material will require many years of careful preparation and, as of this writing, only a very small part of it had been prepared for study. The Uncompahgre fauna came from massive deposits of disarticulated bones, except two more or less complete articulated sauropod skeletons from the Dominguez/Jones quarry, and it will be difficult, if not impossible, to properly associate many of the elements into generic sets. One paper including a faunal list is in press, and a second much larger paper is in preparation illustrating most of the prepared material and giving some brief descriptions.

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