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## A REASSESSMENT OF *ULTRASAURUS MACINTOSHI* (JENSEN, 1985)

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**ABSTRACT:** The validity of the sauropod dinosaur *Ultrasaurus macintoshi* (Jensen 1985a) as a unique genus and species has been re-evaluated. The *Ultrasaurus* holotype dorsal vertebra BYU 9044 is here shown to be a non-brachiosaurid caudal dorsal and is referred to *Supersaurus vivianae* Jensen, 1985, thereby making *Ultrasaurus macintoshi* a subjective junior synonym of the former. The scapulocoracoid BYU 9462, referred to *Ultrasaurus* by Jensen (1985a) due to its large size, is no larger than the largest known *Brachiosaurus* scapulae and is here referred to *Brachiosaurus* sp.

### INTRODUCTION

The validity of *Ultrasaurus macintoshi* is disputed by many authors. Paul (1988) synonymized *U. macintoshi* with *Brachiosaurus altithorax*, while Horrocks (1989, unpublished manuscript) referred *U. macintoshi* to a new species, *B. macintoshi*. Britt's (1991) Dry Mesa Quarry faunal list suggests "*Brachiosaurus* Riggs 1904 (= ? *Ultrasaurus* Jensen 1985)." Miller *et al.* (1991) noted "the anatomy of the [*Ultrasaurus*] dorsal vertebra [BYU 9044] shows similarity to that of the anterior sacral vertebra in the sacrum of the [*Supersaurus*] pelvic complex....," suggesting a possible diplodocid affinity for the *Ultrasaurus* holotype dorsal (BYU 9044). The referral of BYU 9044, here fully described and compared with brachiosaurid and diplodocid dorsal vertebrae, to *Supersaurus vivianae* stems from numerous diplodocid apomorphies. The *Ultrasaurus* scapulocoracoid (BYU 9462), here shown to be no larger than the largest Tendaguru specimens (Table 1), is referred to *Brachiosaurus*. Confusion surrounding the generic name *Ultrasaurus* results from a complex nomenclatural history, which will be discussed in depth here.

### INSTITUTIONAL ABBREVIATIONS

AMNH = American Museum of Natural History, New York City, New York  
 BYU = Brigham Young University, Provo, Utah  
 CM = Carnegie Museum, Pittsburgh, Pennsylvania  
 FMNH = Field Museum of Natural History, Chicago, Illinois  
 HM = Humboldt Museum, East Berlin, Germany  
 YPM = Yale Peabody Museum, New Haven, Connecticut.

### HISTORY

In 1979 a brachiosaurid scapulocoracoid eight feet ten inches long (BYU 9462, Figure 1a) was uncovered by Jensen at the Dry Mesa Quarry, in the Morrison Formation of western Colorado. From 1979 to 1985, Jensen informally called the dinosaur *Ultrasaurus* (without italics or quotation marks) because he concluded that he had discovered "probably the ultimate in size for a land animal," (Jensen, 1985b).

In 1983, apparently unaware of Jensen's use of the informal name *Ultrasaurus*, Kim described a putative neural spine and a very large proximal ulna from Korea, and he formally named it *Ultrasaurus tabriensis*. Interestingly, two versions of Kim's (1983) paper exist, identical in all respects except for the species' trivial name. One version supplies the trivial name *tabriensis*, but the other gives no trivial name at all. It is unclear which version appeared first, and the trivial-name-less version may be a pre-print (D. Chure pers. com, 1995).

Believing his informal use of *Ultrasaurus* since 1979 granted that name nomenclatural priority, Jensen (1985a) described his sauropod material from Dry Mesa and formally named it *Ultrasaurus macintoshi*. However, the use of the generic name *Ultrasaurus* for two different animals violates the rules of the International Code of Zoological Nomenclature (Ride *et al.*, 1985). Even though Kim's ulna is actually an undiagnostic eroded proximal humerus, the designation of a holotype specimen accompanied by a formal description gives *Ultrasaurus* Kim 1983 nomenclatural priority over *Ultrasaurus* Jensen 1985.

Olshevsky discovered the nomenclatural problems regarding the name *Ultrasaurus* and contacted Jensen, proposing that *Ultrasaurus macintoshi* be renamed *Jensenosaurus macintoshi* (Olshevsky pers.

Catalog No.	Element	LC	GBC	L	ML	GPB	LB	GDB	TG
BYU 9462	r scap-coracoid	510	570	1990	2500	1000	220	605+	210
FMNH P25107*	l coracoid	540	840	-----	-----	-----	-----	-----	-----
HM Ki 74**	l scap-coracoid	230a	250a	840+	1070+	445	120	-----	110
HM Sa 9**	r scapula	-----	-----	1930	2430b	1000	270	660	270
HM S II**	r coracoid	450	840	-----	-----	-----	-----	-----	-----

**TABLE 1.** Measurements of brachiosaurid scapulae and coracoids (in millimeters). LC, maximum length of coracoid; GBC, greatest breadth of coracoid; L, maximum length of scapula; ML, maximum length (including coracoid); GPB, maximum diagonal breadth (taken at proximal end of scapula); LB, least breadth (taken at midshaft); GDB, greatest distal breadth; TG, thickness at glenoid; l, left; r, right; scap-coracoid, scapulocoracoid.

\*-from Riggs (1904). \*\*-from Janensch (1961).

a-estimated from Janensch (1961) Plate 15, Figure 3a.

b-assuming a 500 mm long coracoid.

com., 1996). Jensen was not fond of the proposed generic name, so he suggested *Ultrasaurus* instead (Jensen pers. com., 1996). Olshevsky (1991) followed this suggestion and published the species name as *Ultrasaurus macintoshi*, a spelling that Weishampel *et al.* (1990) embraced and attempted to use throughout the book *The Dinosauria* (Weishampel pers. com., 1996). Unfortunately, not all of the *Ultrasaurus macintoshi* spellings were changed to *Ultrasaurus* in the book, resulting in confusion as to which is the correct spelling. We follow Olshevsky (1991) and use the slightly modified spelling suggested by Jensen, *Ultrasaurus*, when discussing *Ultrasaurus macintoshi* Jensen, 1985.

Back when he formally named *Ultrasaurus macintoshi*, Jensen (1985a) designated a dorsal vertebra (BYU 9044, Figures 1b, 2, 5a, 6a,c), rather than the large scapulocoracoid (BYU 9462), as the holotype. He referred the scapulocoracoid (BYU 9462), a cervical vertebra (BYU 9024) and a caudal vertebra (BYU 9045) to this new taxon due to their large size. Later (Jensen, 1987) he acknowledged an error in referring the cervical to his *Ultrasaurus* based on size alone and reassigned the vertebra to *Supersaurus* due to diplodocid apomorphies (bifid neural spine, neural arch occupies nearly the entire superior centrum surface). Curtice (1995), citing slight neural spine emargination, mild pneumatic fossae and a procoelous centrum, referred the caudal vertebra to *Supersaurus* as well, leaving only the holotype dorsal vertebra and the referred scapulocoracoid as belonging to *Ultrasaurus*.

Due to the referral (see below) of the *Ultrasaurus* holotype dorsal vertebra to *Supersaurus*, *Ultrasaurus macintoshi* (Jensen 1985) Olshevsky 1991 is now a subjective junior synonym of *Supersaurus vivianae* Jensen 1985. Following McIntosh (1990), we consider

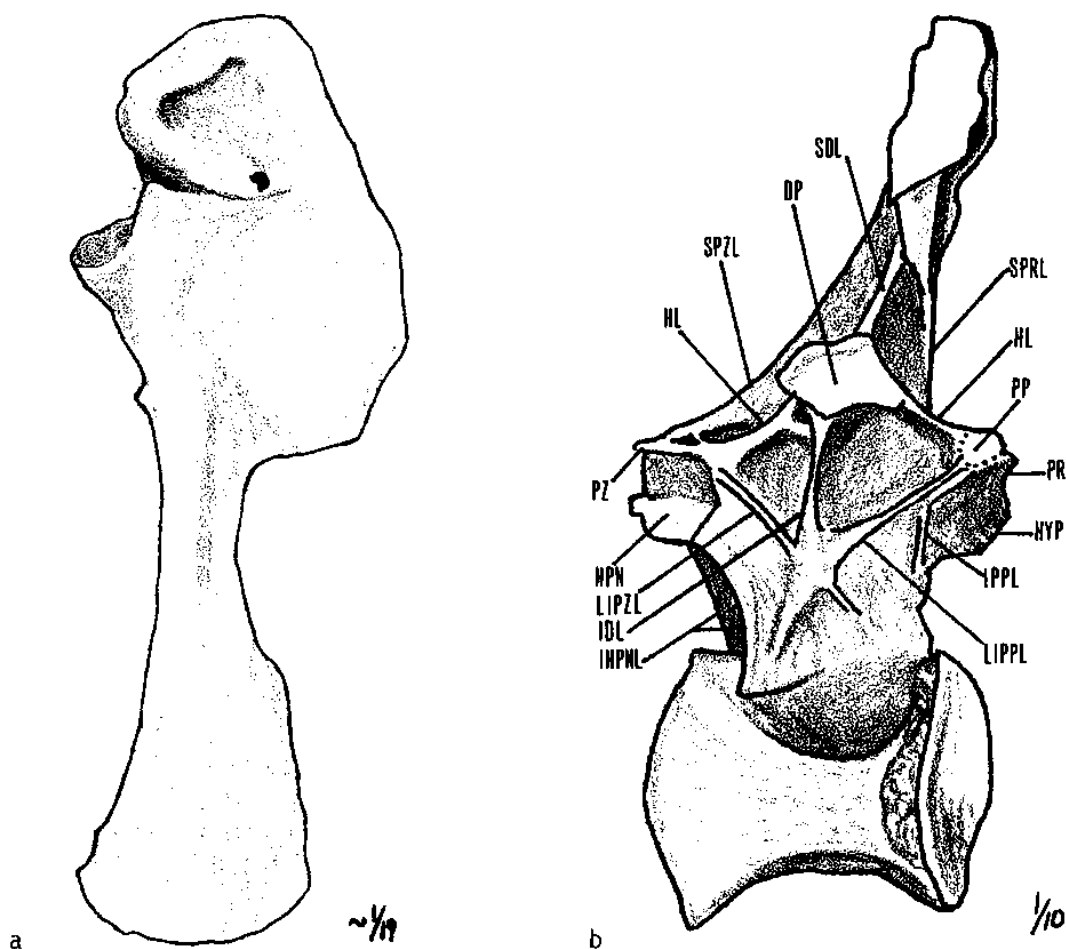
*Ultrasaurus tabriensis* Kim 1983 to be a *nomen dubium*, thereby restricting the name *Ultrasaurus*.

#### DORSAL VERTEBRAE

Various interpretations of the position of the *Ultrasaurus* holotype dorsal (BYU 9044) within the vertebral column exist. Jensen (1985a) advocated a caudal dorsal position based on an "anteroposteriorly narrow neural spine" (Jensen 1985a), while Paul (1988) called for a cranial dorsal placement due to its "transversely narrow neural spine with a small head." McIntosh (1990) suggested a "cranio-middle position" but gave no reasons (McIntosh 1990). Neural spine shape alone is not a reliable indicator of position. Using the following characters (location of the parapophysis, neural spine height and shape, centrum length and shape, and transverse process breadth), a very accurate assessment of a dorsal's position is obtained. These characters will be used here to demonstrate marked differences between brachiosaurid and diplodocid dorsals and to establish the position and taxonomic affinity of BYU 9044.

The parapophyses of caudal cervical vertebrae are very low on the centrum, and remain so in the most cranial dorsals, after which the parapophyses move to the centrum/neural arch boundary. Beyond this the parapophyses are on the neural arch, gradually rising to a position caudolateral to the prezygapophyses on the transverse processes.

Diplodocid dorsal neural spine heights increase caudally, with the highest neural spines in the most caudal dorsals (Figure 3; Holland 1901). Brachiosaurid neural spine heights, lowest in the caudal dorsals, increase cranially, and reach their zenith in the shoulder region (Figure 4).



**FIGURE 1.** Elements previously referred to *Ultrasaurus macintoshi*: a, *Brachiosaurus* sp. right scapulocoracoid, BYU 9462; b, schematic of *Supersaurus vivianae* caudal dorsal, BYU 9044, right lateral view. Abbreviations: dp, diapophysis; hl, horizontal lamina; hpn, hyposphene; hyp, hypantrum; idl, infradiapophysial lamina; ihpnl, infrapapophyseal lamina; ippl, infrapapophyseal lamina; lippl, lateral infrapapophyseal lamina; lipzl, lateral infrapostzygapophysial lamina; pp, parapophysis; pr, prezygapophysis; pspl, prespinal lamina; pspl, postspinal lamina; pzl, postzygapophysis; sdl, supradiapophysial lamina; sprl, supraprezygapophysial lamina; spzl, suprapostzygapophysial lamina.

Diplodocid cranial dorsal neural spines are deeply bifurcate. This cleft gradually fuses caudally until its disappearance in the caudal dorsals (Figure 3). Undivided diplodocid neural spine apices are rectangular, with dorso-ventrally elongate lateral plates on either side (Figures 1b, 5b, 6b). Brachiosaurid dorsal neural spines are undivided throughout the series and possess triangular apices (Figure 4, 5c), a feature Upchurch (1995) suggests is a derived character of the Camarasauridae and the Brachiosauridae.

The breadth of a diplodocid transverse process, measured from the midline to the diapophysis, is nearly equal to the height of the neural spine above the superior border of the centrum only in the most cranial dorsals

(Figure 3a); thereafter the neural spine is at least twice as tall as the transverse breadth of the transverse process (Figure 3b, 6b). Brachiosaurid dorsal neural spine heights are equal to or slightly greater than their transverse process breadths (Figures 4a, b) throughout the dorsal series.

#### DESCRIPTION OF BYU 9044

(Figs. 1B, 2, 5A, 6A, C)

Strong supraprezygapophysial laminae bifurcate near the apex of the tail neural spine, the inferior branch unites with the supradiapophysial laminae. The laminar complex so formed continues upwards, buttressing the neural spine apex and forming a laminar "wall"

separating pneumatic fossae on the anterior and posterior neural spine face. The superior branch continues upward a short distance before giving way to neural spine rugosity. Non-bifurcating suprapostzygapophysial laminae attain the same height as the supraprezygapophysial laminae and terminate at the inferior border of the neural spine rugosity. The left suprapostzygapophysial lamina is a "double lamina," the division begins at a point shortly above the postzygapophysis and continues to the inferior neural spine rugosity. Large lateral plates adorn the rectangular, highly rugose neural spine top, the apex of which is gently rounded superiorly. The left side of the neural spine top has been crushed obliquely, resulting in a triangular appearance, the right shows signs of slight transverse crushing but retains the natural rectangular shape.

The hypanthrozygapophyses (made up of prezygapophyses and hypantra) are transversely crushed and nearly touch; the hypantra are nearly as large as the prezy-

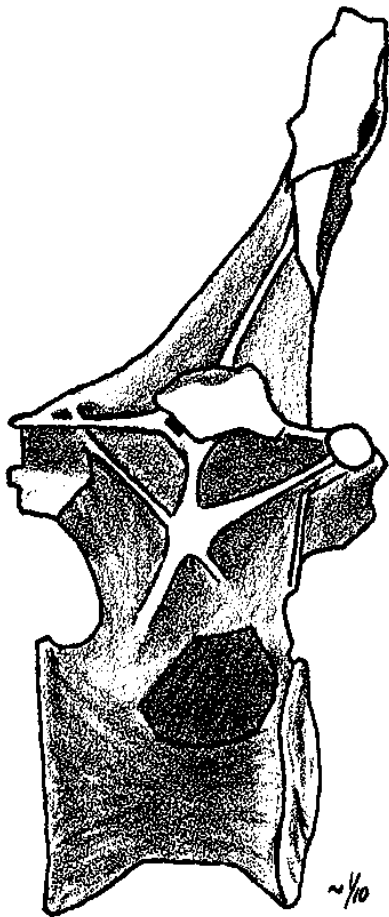


FIGURE 2. "Uncrushed" *Supersaurus vivianae* caudal dorsal, BYU 9044, right lateral view.

gapophyses. The infraprezygapophysial laminae is very short and thick. The prespinal lamina is very pronounced but does not project farther anterior than the supraprezygapophysial laminae. Large fossae are present on the lateral surface of the prespinal lamina near its termination.

Thick infrahyposphenal laminae (between which is a deep vacuity) buttress the large hyposphene. Cranially these laminae become very thin. The infrahyposphenal vacuity enters the hyposphene from inside the neural arch. The surface area of the postzygapophyses is only slightly larger than that of the hyposphene. The postspinal lamina, though well developed, does not project farther posterior than the suprapostzygapophysial laminae.

The parapophyses, supported by infra- and lateral infraparapophysial laminae, are caudolateral to the prezygapophyses and sit atop short stalks. The lateral edge of the prezygapophyses nearly touch the medial edge of the parapophyses, and the posterolateral edge of the parapophyses fuse with horizontal laminae that connect to large, well developed, diapophyses.

The transversely short transverse process has strongly developed infraparapophysial, infradiapophysial, lateral infraparapophysial, lateral infrapostzygapophysial, horizontal, and supradiapophysial laminae. The infraparapophysial and lateral infraparapophysial laminae are very thin transversely, however the latter gradually thicken as they approach the infradiapophysial laminae. These laminae buttress the parapophyses from below. The inferiormost portion of the obliquely running infradiapophysial laminae is extremely thick, and serves as the origin for the lateral infraparapophysial and lateral infrapostzygapophysial laminae. The latter laminae pass through the infradiapophysial laminae, resulting in a raised inverted 'V'-shape being formed. The supradiapophysial laminae join the suprapostzygapophysial laminae, both of which continue to the apex of the neural spine. A small oblique lamina on either side connects the base of the suprapostzygapophysial laminae with the horizontal laminae.

The centrum appears strongly opisthocelous, however extensive transverse and oblique crushing artificially elongate the centrum and exaggerate the anterior ball. The dorso-ventrally distorted posterior centrum face creates the illusion of short pedicels. Without the crushing the neural arch raises, the pedicels become moderate in size, and the centrum shrinks considerably in length. The large pneumatic fossae occupy a considerable portion of the centrum and, on an uncrushed centrum, their superiormost borders would enter the base of the neural arch. Two peculiar thin struts of bone are present in the left pneumatic fossa.

## DISCUSSION

A correct interpretation of BYU 9044 relies on establishing its position within the dorsal column. The

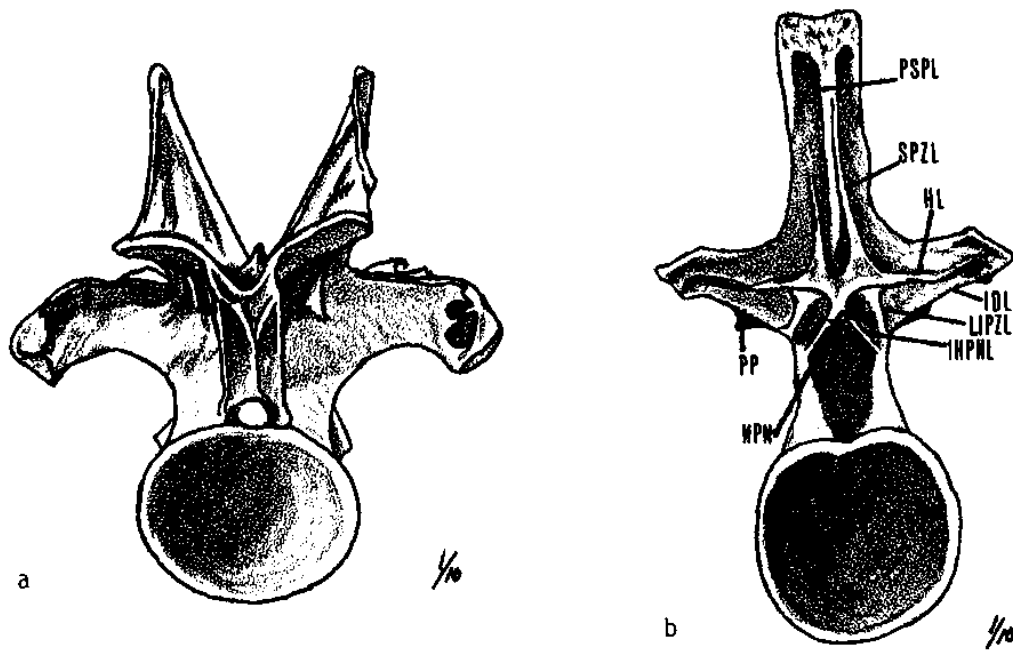


FIGURE 3. *Diplodocus* dorsal vertebrae, posterior view: a, presacral 8, *Diplodocus carnegii*, CM 84 (after Hatcher); b, presacral 2, *Diplodocus carnegii*, CM 84 (after Hatcher).

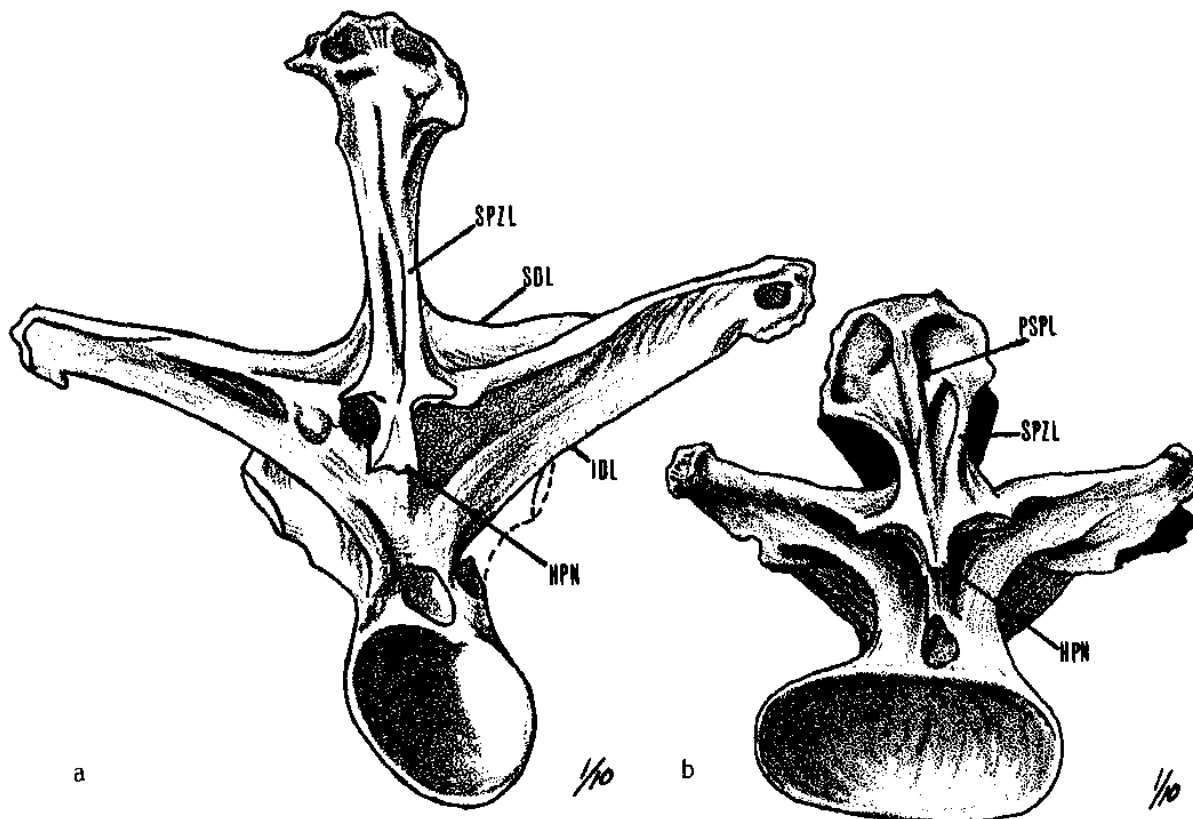


FIGURE 4. *Brachiosaurus* dorsal vertebrae, posterior view: a, presacral 9, *Brachiosaurus brancai*, HM S II 17ter (after Janensch); b, presacral 1, *Brachiosaurus brancai*, HM S II 24ter (after Janensch).

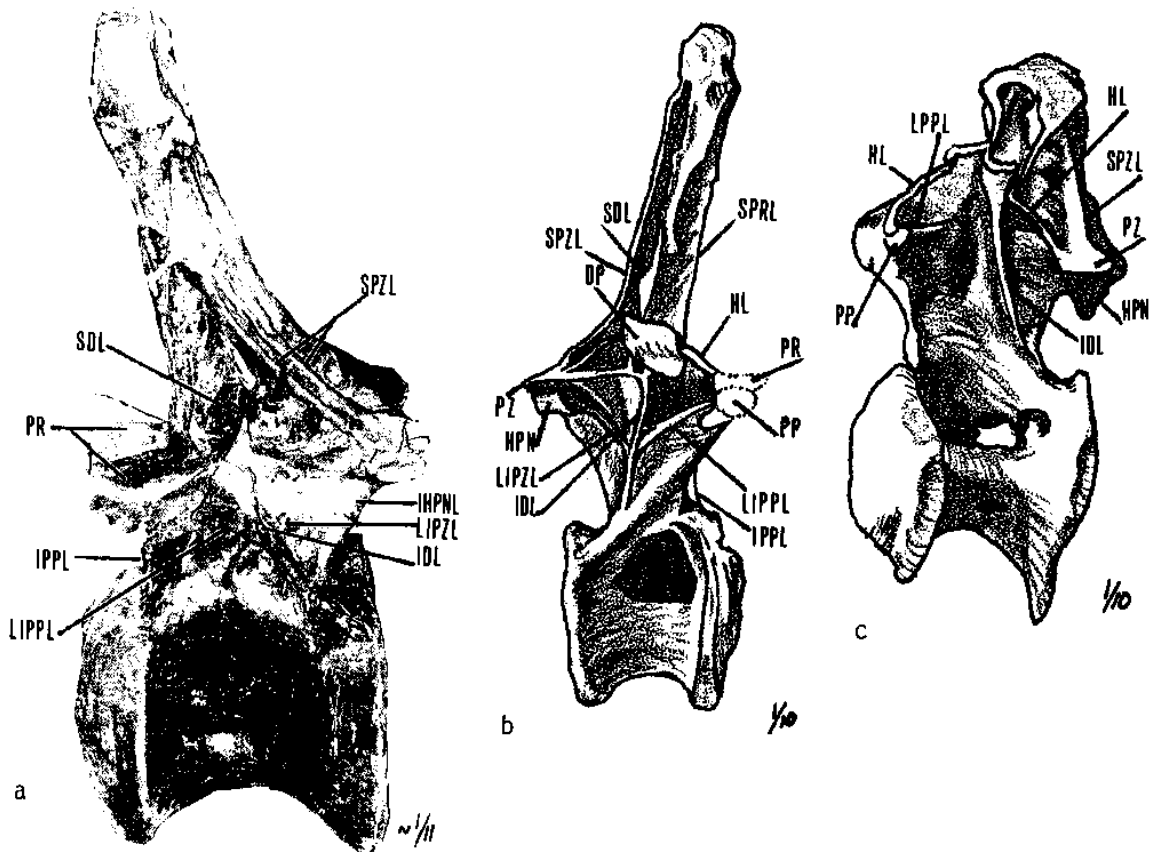


FIGURE 5. Dorsal vertebrae: a, caudal dorsal, *Supersaurus vivianae*, BYU 9044, left lateral view; b, presacral 2, *Diplodocus carnegii*, CM 84 (after Hatcher), right lateral view; c, caudal dorsal, *Brachiosaurus brancai*, HM No 8 (after Janensch), left lateral view.

non-bifurcate neural spine removes it as a diplodocid cranial or mid-dorsal vertebra. The tall neural spine and comparatively short transverse process breadth prevents referral to brachiosaurid cranial, mid- or caudal dorsals. Diplodocid caudal dorsals possess tall neural spines with short transverse processes, matching the morphology of BYU 9044. The location of the parapophysis on a stalk caudolateral to the prezygapophysis on the transverse process confirms a caudal position within the vertebral column. Comparisons with *Diplodocus* (AMNH 223, CM 84 and USNM 10865) suggest BYU 9044 is either presacral 1 or 2.

The large infrahyposphenal vacuity of BYU 9044 is identical to that of *Diplodocus* (Figure 6b). Brachiosaurids lack this vacuity (Figure 4). The pneumatic fossae located on *Diplodocus* caudal dorsal centra enter the base of the neural arch (Figure 5b; Plate VII of Hatcher [1901]), as do those of BYU 9044. Brachiosaurid dorsals exhibit this character only rarely.

The well developed supraprezygapophysial laminae of diplodocids terminate near the apex of the neural spine throughout the dorsal column, differing markedly from the short, thick laminae of brachiosaurids. Diplodocid supraprezygapophysial laminae aid in the formation of dorso-ventrally elongate pneumatic fossae present on the anterior and posterior neural spine faces. The neural spine of BYU 9044 is morphologically identical to those of diplodocids.

Prominent caudal dorsal opisthocoely, unknown in the Diplodocidae, occurs in all but possibly presacral 1 of the Brachiosauridae (Figure 5b, c). BYU 9044 is opisthocoelous, but not as strongly as a cursory examination indicates, for extensive lateral and oblique crushing (Figure 6a) of the highly pneumatic centrum exaggerates the anterior ball. Table 2 best shows the extent of this crushing, with the uncrushed measurements stemming from a careful analysis of crushing vectors. The presence of opisthocoely may be a result of large size,

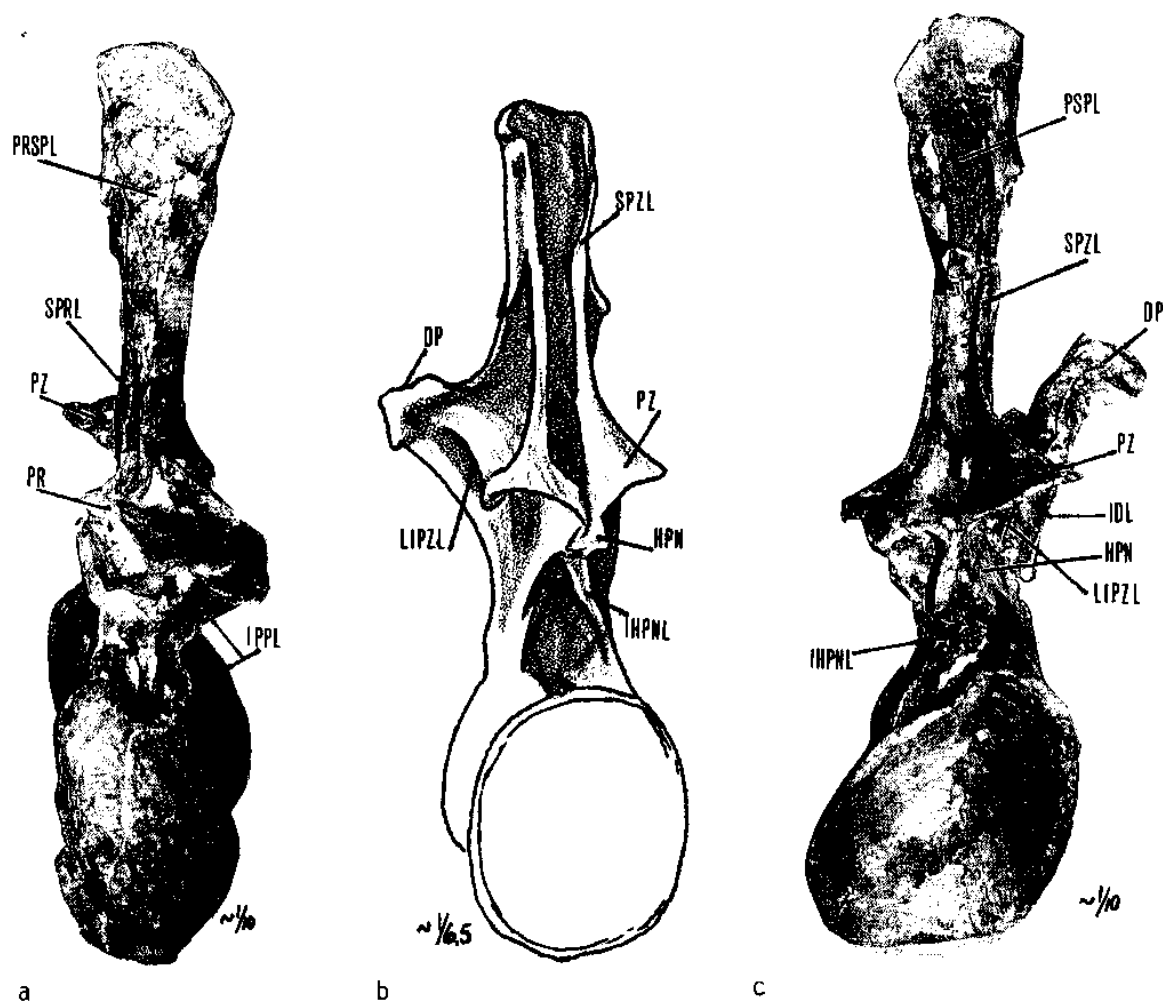


FIGURE 6. Caudal dorsal vertebrae: a, *Supersaurus vivianae*, BYU 9044, anterior view; b, *Diplodocus longus*, AMNH 223, posterior view; c, *Supersaurus vivianae*, BYU 9044, posterior view.

individual variation, or may be of generic significance. We do not feel opisthocoely alone is strong enough to prevent the referral of BYU 9044 to the Diplodocidae.

#### RIGHT SCAPULOCORACOID BYU 9462 (Fig. 1)

The narrow scapular neck, distal blade expansion, and irregular shape of the coracoid are brachiosaurid characters all possessed by BYU 9462. Jensen (1985a, b) lists the overall length of BYU 9462 as 2.70 m. Paul (1988) seemingly converts this 2.7 meter measurement into millimeters to arrive at the 2690 mm figure given in his Table 1. In actuality BYU 9462 is 2500 mm long. Measurements given by Janensch (1961) and Riggs (1904) suggest BYU 9462 is no larger than the largest known *Brachiosaurus* specimens and is probably smaller than the largest Tendaguru individual (Table 1).

The coracoid breadths of FMNH P25107 and HM S II are 840 mm each (Riggs 1904; Janensch 1961), a figure much wider than the 580 mm breadth of BYU 9462 (Table 1). Sauropod scapulae and coracoids are highly variable between individuals (compare Figures 75-80 of *Camarasaurus supremus* [Osborn and Mook 1921]; J. McIntosh pers. com., 1996) therefore the large coracoid breadth disparity may be due to variation. However, the measurement disparities between the substantially thicker and wider *Brachiosaurus brancai* scapula, HM Sa 9, cannot be due to variation alone.

#### TAXONOMIC AFFINITY

The diplodocid morphology of BYU 9044 necessitates a reinterpretation of its taxonomic affinity. Dry Mesa has produced arguably the world's largest diplodocid, *Supersaurus vivianae*, known from a cervical,

Catalog No.	L	AW	AH	PW	PH	PR	PZ	T	TP
BYU 9044*	500	330	500	300	460	800	710	1330	900
BYU 9044	400	360	360	380	400	615	715	1310	960
FMNH P25107**									
Presacral 7	430	-----	288a	300	270	480	480a	910	804a
Presacral 2	350	-----	288a	310	280	510	432a	800	-----
Presacral 1	270	-----	288a	300	260	500	396a	760	-----
S II***									
Presacral 9	360	270b	250b	-----	260	450b	540b	1070	1060b
Presacral 1	260b	-----	-----	450b	210b	-----	450b	790+	770b
No 8**** (cdl dorsal)	350b	456	327	447	381	450b	530b	828	-----
CM 84****									
Presacral 8	326	330c	270c	311	290c	490c	510c	820c	724
Presacral 2	290	300	270	300	300	490	530	995	570
Presacral 1	270	310	290	320	300	515	570	1065	585

**TABLE 2.** Measurements of dorsal vertebrae (in millimeters). L, maximum length of centrum; AW, anterior width of centrum; AH, anterior height of centrum; PW, posterior width of centrum; PH, posterior height of centrum; PR, height from ground to bottom of prezygapophyses; PZ, height from ground to bottom of postzygapophyses; T, total height of vertebra from ground to neural spine apex; TP, breadth across transverse processes.

\*-"as is" measurements. Hypothetical "uncrushed" estimates on row below.

\*\*-from Riggs (1904). Distortion present to varying degrees on each centrum.

\*\*\*-from Janensch (1950). Marked centrum distortion present on presacral 9 and No 8.

\*\*\*\*-presacral 8 from Hatcher (1901), presacral 1 and 2 from measurements of casts.

a-estimates from Riggs (1904) Plate LXXII.

b-estimates from Janensch (1950) Figures 53, 54, 62-66.

c-estimates from Hatcher (1901) Plate VII.

six caudals, a pelvis with four sacrals, an ilium, a pubis, ischia, a phalanx and a carpal (Stadtman, Wilhite, Curtice in preparation). The dorso-sacral of the *Supersaurus* pelvis is missing, however the neural spine morphology of the first true sacral (sacral 2) is identical to that of BYU 9044, and the centrum is of the correct size to belong with it.

BYU 9044 was collected between the *Supersaurus* scapulocoracoids and very near the *Supersaurus* ischia. The *Supersaurus* pelvis was excavated a few meters downstream from and directly on the paleoflow direction determined by Richmond (1994). BYU 9462 was found some distance away from BYU 9044 and the pocket of *Supersaurus* elements. The proximity of all exceptionally large diplodocid elements in the Quarry to one another further substantiates the referral of BYU 9044 to *Supersaurus*.

The opisthocoelous nature of BYU 9044 may result from the large size of *Supersaurus*. The well developed hyposphene/hypantrum complex on *Supersaurus* proximal caudal vertebrae resists torsion and increases rigidity of the vertebral column, suggesting a functional need for additional vertebral support, as this complex is vestigial or non-existent in all other diplodocids (Curtice 1995). The hyposphene/hypantrum complex of BYU 9044 is extremely well developed for a diplodocid, however the need for supplementary articulations in the caudal vertebrae may indicate the need for additional dorsal support as well, a need possibly fulfilled by opisthocoelous centra.

BYU 9044 belongs to *Supersaurus vivianae* due to its diplodocid affinity, large size, morphological similarity to the second sacral of *Supersaurus*, and quarry position. Plans to prepare all large sauropod elements



located on the paleocurrent gradient are underway in order to determine the predictive power of the composite quarry map as well as to, hopefully, obtain more *Supersaurus* elements.

### CONCLUSION

The binomial *Ultrasaurus macintoshi* is now a subjective junior synonym of *Supersaurus vivianae* due to the referral of its holotype specimen (BYU 9044) to *Supersaurus*. The scapulocoracoid (BYU 9462) originally referred to *Ultrasaurus (Ultrasaurus) macintoshi* (Jensen 1985a) is here referred to *Brachiosaurus* sp., pending a more thorough review of the Dry Mesa *Brachiosaurus* material.

Nearly all previous estimates of the size and weight of *Ultrasaurus* relied on the assumption that the dorsal vertebra BYU 9044 is brachiosaurid and the scapulocoracoid BYU 9462 is much larger than all other *Brachiosaurus* scapulae, both now known to be false. The Dry Mesa *Brachiosaurus*, though large, is no larger than the mounted *B. brancai* (S II), and speculative weights exceeding those of S II are unwarranted and incorrect.

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