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Publications and Maps of the Geology Department



Cover: Cretaceous coals near Castle Gate, Utah.

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Editors

W. Kenneth Hamblin
Cynthia M. Gardner

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A New Large Theropod Dinosaur from the Upper Jurassic of Colorado

PETER M. GALTON¹ AND JAMES A. JENSEN²

¹Department of Biology, University of Bridgeport, Bridgeport, Conn. 06602

²Earth Science Museum, Brigham Young University, Provo, Utah 84602

ABSTRACT.—A preliminary diagnosis is given for *Torvosaurus tanneri* n.g. et sp. (Carnosauria: Megalosauridae), a large theropod dinosaur from the Morrison Formation (Upper Jurassic) of western Colorado. The form of the forelimb (massive straight humerus, short ulna, short first phalanx of digit I) and pelvic girdle (no emargination ventrally of subacetabular part of pubis and ischium so pelvis has an extensive ventromedial symphysis) is extremely conservative for a carnosaur. *Torvosaurus* is more similar to carnosaur from the Middle Jurassic of Europe than it is to the other Morrison carnosaur. *Stokesosaurus* Madsen is a valid genus of Morrison theropod rather than a junior synonym of *Iliosuchus* Huene.

INTRODUCTION

During the last six years the junior author has been collecting fossil bones of large theropod dinosaurs from a quarry in the Upper or Brushy Basin Member of the Morrison Formation (Upper Jurassic) at Dry Mesa in Montrose County, western Colorado. The horizon is a fine- to coarse-grained lenticular sandstone in the upper part of the Morrison Formation (Upper Jurassic, upper Kimmeridgian at base of Tithonian), approximately 30–45 m below the base of the overlying Cedar Mountain Formation of Lower Cretaceous age. Disarticulated and scattered remains of vertebrates of all sizes are represented, ranging from an indeterminate caudal vertebra 7 mm long to a sauropod cervical vertebra more than 1.3 m in length. Included in this random assortment are several kinds of ornithomids, large theropods, and sauropods, most of which appear to represent new species. The fossil remains display a complete range of stream abrasion from perfect, unabraded bones to bone chips and smoothly rounded bone pebbles, all of which are size sorted. One result of the sorting is the concentration of small, lightweight debris in pockets in restricted horizontal zones. It is here that delicate fragments, including those of pterosaurs (Jensen and Ostrom 1977) and one that is possibly avian (Science News 1977), are preserved.

Comparisons of many of the theropod bones with those of the large- and medium-sized Morrison theropods described to date—the well-known *Allosaurus fragilis* (see Gilmore 1920, Madsen 1976a; often known as *Antrodemus valens*) and *Ceratosaurus nasicornis* (see Gilmore 1920) plus the pelvic elements of *Stokesosaurus clevelandi* Madsen (1974) and *Marbosaurus bicentisimus* Madsen (1976b)—show that a new taxon of large theropod is represented. The purpose of this paper is to provide a preliminary diagnosis of this taxon, based on the material prepared to date, and to give a description of the forelimb and pelvic girdle. A description of the axial skeleton and hind limb is being prepared. This new theropod is listed as a new genus of the family Megalosauridae in tabulations of the Morrison dinosaur fauna given by Galton (1977a,b).

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the Brigham Young University Research Support Fund and the National Geographic Society, and collection was authorized by permits issued by the U.S. Forest Service. We thank the following people for all their assistance while studying specimens under their care: Dr. John H. Ostrom, Peabody Museum of Yale University; Mr. H. Philip Powell, University Museum, Oxford; and Dr. Frank Westphal, Museum der Paläontologie, Universität der Tübingen. Figure 5 was drawn by Mr. Patrick Lynch of Yale University (Department of Medical Illustration). Mr. H. Philip Powell of Oxford and Dr. Samuel P. Welles of the University of California, Berkeley, kindly provided the drawing from which figure 3F was taken, and figure 3T is based on a drawing kindly supplied by J. H. Madsen, Jr., state paleontologist of Utah, Salt Lake City. Support for P. M. Galton, provided by NSF Grant DEB 77-24048 that contributed \$350 towards publication of this paper.

SYSTEMATIC SECTION

CLASS	REPTILIA
ORDER	SAURISCHIA
SUBORDER	THEROPODA
INFRAORDER	CARNOSAURIA
Family	Megalosauridae

Torvosaurus n. gen.

Type species: *Torvosaurus tanneri* n. sp.

Etymology: Latin *torvus*, savage, cruel, wild; Greek *sauros*, lizard.

Distribution: Known only from the Upper Jurassic of Colorado.

Diagnosis: Same as for species, given below.

Torvosaurus tanneri n. sp.

Holotype: BYU 2002*, left and right long bones of forelimb.

Occurrence: The specimen was collected by J. A. Jensen from near the bottom of the Upper or Brushy Basin Member of the Morrison Formation (Upper Jurassic) at the Dry Mesa Quarry, sec. 23, T.50 N, R.14 W, Montrose County, western Colorado.

Hypodigm: The holotype and the following paratypes: BYU 2003, left dentary; BYU 2004, cervical vertebrae 3, 4, and 5; BYU 2005, cervical vertebra 7; BYU 2006–2010, dorsal vertebrae 5, 7, 10, and 12; BYU 2010–2012, left metacarpals I, II, and III; BYU 2013, right ilium; BYU 2014, left and right pubes; BYU 2015, right ischium; BYU 2016, right tibia, fibula, astragalus, and calcaneum; BYU 2017, right tibia; BYU 2018, left first phalanx of digit I of manus.

Etymology: Named in honor of N. Eldon Tanner, first counselor in the First Presidency of The Church of Jesus Christ of Latter-day Saints.

Diagnosis: A large and heavily built theropod with a total body length up to about 10 m. Humerus relatively straight and massive with a strongly indented head, large deltopectoral crest,

*Institutional names cited in this paper have been abbreviated as follows: BYU, Brigham Young University, Vertebrate Paleontology Research Laboratory; OUM, Oxford University Museum, England; UT, University of Tübingen, Germany; YPM, Yale Peabody Museum, New Haven, Conn.

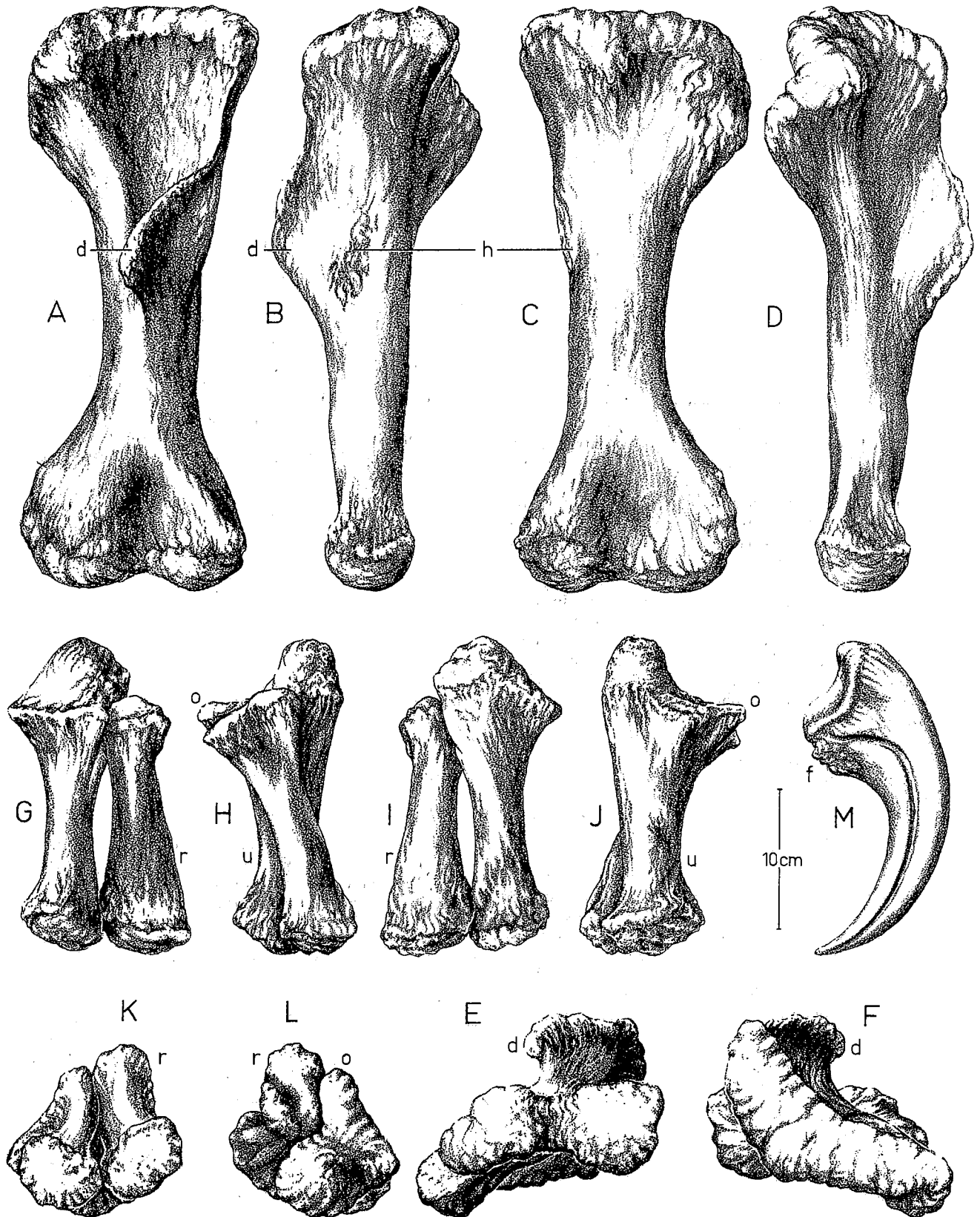


FIGURE 1.—*Torvosaurus tanneri* n. gen. et sp., forelimb X0.20. A–J, holotype BYU 2002, left forelimb, A–F, humerus and G–J, radius and ulna in anterior (A,G), lateral (B,H), posterior (C,I), medial (D,J), proximal (F,I) and distal (E,K) views; M, referred specimen BYU 2020, ungual phalanx of digit I. d, deltopectoral crest; f, flexor tendon attachment area; h, humeroradialis attachment area; o, olecranon process; r, radius; u, ulna.

and a broad distal end with a large squarish radial condyle, a small rounded ulnar condyle, and a large ulnar epicondyle; the ratios of maximum length of humerus to the maximum proximal and distal widths are 2.2 and 2.6, respectively; forearm short with ratio of maximum lengths of humerus to radius at 2.2, proximal end of ulna massive with ratio of maximum length to maximum proximal width at 2.1. And from referred specimens: Metacarpal I with square proximolateral corner and first phalanx of digit I is stout, short, and twisted along its length, metacarpal II short but extremely massive with ratio of maximum length to maximum proximal width at 1.5, metacarpal III massive (same ratio 2.2). Ilium heavy with a very low dorsal blade tapering to a rounded point posteriorly and a wide brevis shelf, acetabulum wide but shallow, transversely wide distal end to pubic peduncle. Pubis and ischium subequal in length and subacetabular region deep and unemarginated with an almost continuous ventromedian symphysis, obturator foramen in pubis that terminates in a small anteroposteriorly ex-

panded foot or pedicle, indentation in posterior edge of pubis to receive corresponding anterior part of ischium that is posteriorly bowed. Massive tibia. Dorsal process of astragalus is triangular in outline with a vertical lateral edge, metatarsus massive. Dentary short with nine teeth and no Meckelian groove exposed on the medial surface. Centra of the vertebrae from the third cervical to the middle of the dorsal series are markedly opisthocoelous, and the ball-like area is delimited by a groove from the more peripheral anterior surface of the centrum. In vertebrae of the posterior half of the dorsal series the posteroventral surfaces of each pair of transverse processes form one continuous curve which passes through a large fenestra in the pillar carrying the postzygapophyses and zygosphenes. In the vertebrae of the posterior third of the dorsal series the superior surfaces of the prezygapophyses are overlapped from their rear by an expansion from the base of the supraprezygapophysial laminae.

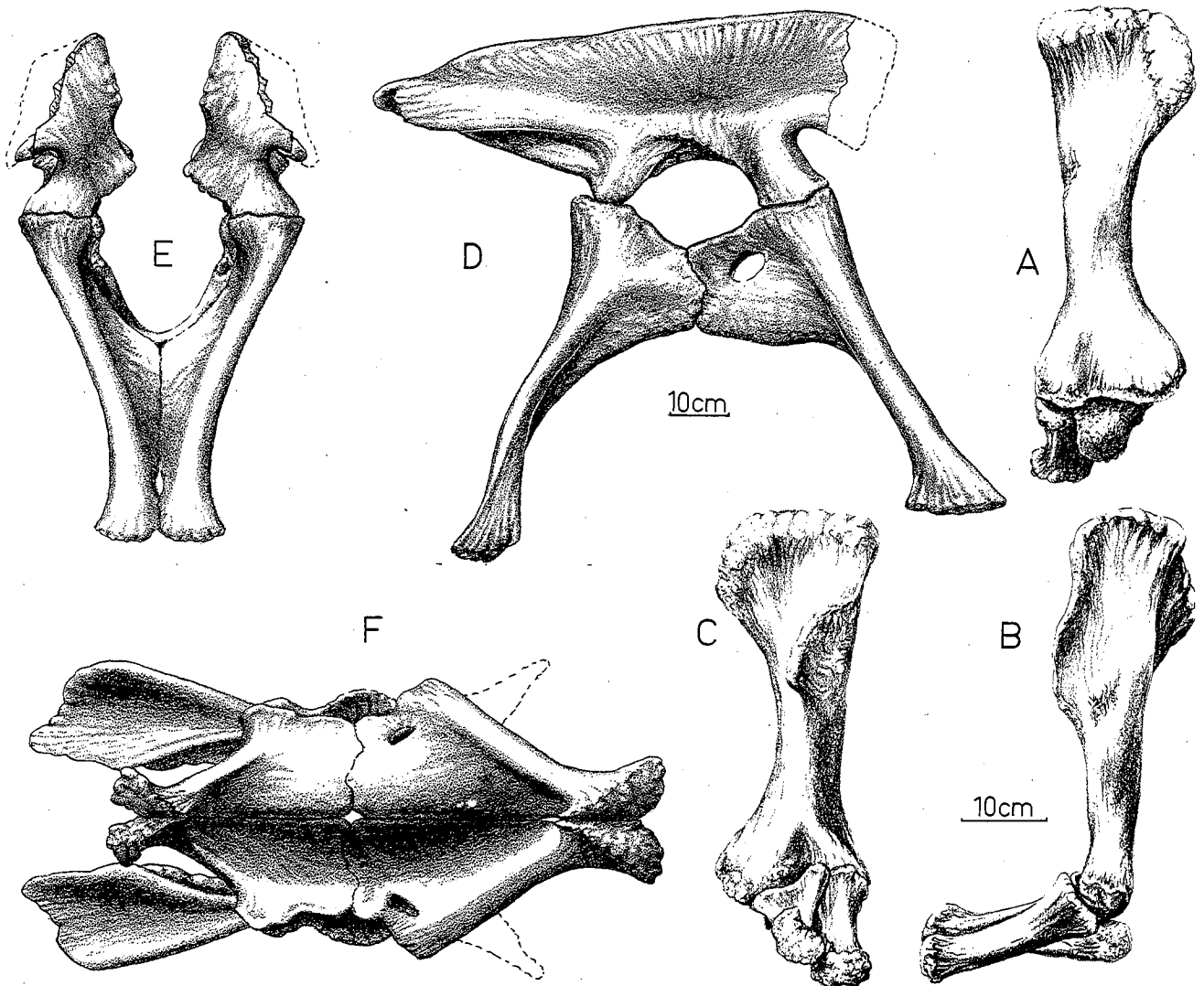


FIGURE 2.—*Torvosaurus tanneri* n. gen. et sp. Articulated forelimb and pelvic girdle. A–C, holotype BYU 2002 X1/8, left humerus, radius and ulna in A, posterior view; B, lateral view; C, anterior view; D–F, paratypes BYU 2013–2015 X1/12, right pelvic girdle in D, lateral view; E, anterior view; F, ventral view.

DESCRIPTION AND COMPARISONS

Humerus, Radius, Ulna

As with most of the material of *Torvosaurus tanneri* (exception three cervicals BYU 2004), the six bones of the holotype were found disassociated but in the same section of the quarry. The sizes of corresponding bones are almost identical, the bones articulate well together at the elbow joint, and no other long bones of the forelimb were found in that section of the quarry. Consequently, the bones of the holotype undoubtedly represent left and right sides of the same animal and have been numbered accordingly.

The humerus (figs. 1A–1F, 2A–2C) is almost straight in lateral view (fig. 1B), the proximal and distal ends are broad (figs. 1E, 1F), and the deltopectoral crest is large (figs. 1A, 1B, 1D, 1F), extending down the shaft to a point just beyond mid-length. A rugose area on the lateral surface of the shaft posterior to the deltopectoral crest (fig. 1B) is probably the area of origin of the humeroradialis muscle (cf. Gilmore 1920, pl. 6, figs. 2,4 and Madsen 1976a, figs. 7A,C for *Allosaurus*). The radius and ulna are proportionally short but stout bones (figs. 1G–1L, 2B), with the proximal part of the ulna (figs. 1G–1J, 1L) and the distal part of the radius (figs. 1G–1K) being particularly massive. The principal measurements and ratios of the bones of the forelimb of *Torvosaurus* and other theropods are given in tables 1 and 2.

The only other Upper Jurassic theropod with a straight-shafted humerus is the primitive ornithomimid (see Russell 1972) *Elaphrosaurus* (Janensch 1925), but the bone is very slender with a low deltopectoral crest as is also the case in Cretaceous ornithomimids (Osborn 1917). The shaft of the humerus of some Cretaceous tyrannosaurids is also straight (fig. 3D; *Tarbosaurus*, Maleyev 1974, *Tyrannosaurus* Osborn 1917), and the ulna is proportionally short. However, comparisons of the forelimb of *Torvosaurus* with the other bones of the body show that it is proportionally large rather than relatively small as in tyrannosaurids. The humerus, radius, and ulna of *Allosaurus* (fig. 3C; Gilmore 1920, Madsen 1976a) and the radius and ulna of *Ceratosaurus* (fig. 3J; Gilmore 1920) are very different from the corresponding bones of *Torvosaurus* (figs. 1A–2C, 3A, 3G). However, the humerus of *Ceratosaurus* (fig. 3T) is

similar to that of *Torvosaurus* (J. H. Madsen, Jr. pers. comm.). Certain theropod forelimb bones from the Middle Jurassic of Europe are similar to those of *Torvosaurus*: an isolated humerus and ulna from southern England that are referred to *Megalosaurus* (figs. 3E, 3I) and the forelimb of *Poikilopleuron* (figs. 3B, 3H; Eudes-DeLongchamps 1838) from France. In both cases the humerus is massive with a large deltopectoral crest, and the ulna is proportionally short with a massive proximal end. However, the outlines of the deltopectoral crests are different (figs. 3A, 3B), and for *Megalosaurus* the distal part of the humerus is slightly curved (fig. 3E), and the outline of the proximal part of the ulna differs from that of *Torvosaurus* (figs. 3G, 3I). The proximal ends of the radius and ulna of *Poikilopleuron* differ from those of *Torvosaurus* (figs. 3G, 3H), and the radius has a unique protuberance on the middle of the shaft (fig. 3H). Hulke (1879) reidentified with the radius and ulna of *Poikilopleuron* as metatarsals, and this is accepted by Steel (1970), but it is incorrect. The humerus of *Eustreptospondylus* Walker (1964) from the upper Middle Jurassic of England has a low deltopectoral crest (fig. 3F).

Manus

The metacarpus of *Torvosaurus* consists of at least three stout metacarpals (fig. 3L), and, although not discovered to date, it is probable that metacarpals IV and possibly V were also present because IV is present in *Ceratosaurus* (fig. 3N), and von Huene (1926) reports a metacarpal V in *Poikilopleuron*. Metacarpal I (figs. 3L, 4A–4C) differs from those of *Allosaurus* (fig. 3O) and *Poikilopleuron* (fig. 3M) in being more massive, the proximolateral corner is square (figs. 3L, 4A) rather than carrying an obliquely inclined surface (figs. 3M, 3O; part of intermedium fits against this surface, Gilmore 1920, Madsen 1976a). The form of metacarpal I (fig. 3N) of *Ceratosaurus* is not clear from the illustrations given by Gilmore (1920), but it appears to be a more lightly built element. Metacarpal II of *Torvosaurus* (figs. 3L, 4D–4F) is massive compared to that of *Ceratosaurus* (fig. 3N) and extremely massive and short compared to that of *Allosaurus* (figs. 3O, 4G, 4H). If correctly identified, metacarpal III of *Torvosaurus* (figs. 3L, 4I–4K) is proportionally shorter and stouter than that of *Allosaurus* (fig. 3O) and shorter and more slender than that of *Ceratosaurus*

TABLE 1
MEASUREMENTS (in mm) OF FIGURED FORELIMB BONES
OF *TORVOSAURUS TANNERI* N. GEN. ET SP.

Bone	L	S	PT	PW	DT	DW
Humerus	424	70	60	192	55	164
Radius	188	38	45	71	47	68
Ulna	220	55	69	106	53	89
MC I	72.3	45	52	50	—	47
MC II	117.5	48.5	57.3	80	—	64
MC III	96.5	24	52.0	45*	—	45

DT, thickness of distal end (diameter at right angles to maximum width); DW, maximum width of distal end; L, maximum length; PT, thickness of proximal end (diameter at right angles to maximum width); PW, maximum width of proximal end; S, maximum shaft diameter at level of smallest diameter when viewed anteriorly; *estimated.

TABLE 2
RATIOS FOR ASSOCIATED FORELIMB BONES OF CARNOSAURIAN THEROPODS

Genus	H (in mm)	H/R	H/U	H/MC	U/PU
<i>Poikilopleuron</i>	306*	1.8	1.7	—	2.2
<i>Torvosaurus</i>	425	2.2	1.9	—	2.1
<i>Allosaurus</i> ¹	310	1.4	1.2	2.9	4.4 ¹
<i>Tarbosaurus</i> ²	255	2.3	2.2	2.6	4.3
<i>Daspletosaurus</i> ³	225	2.3	1.9	3.3	3.9
<i>Albertosaurus</i> ⁴	324	2.1	1.8	3.3	3.3

H, maximum length of humerus; MC, maximum length of metacarpal II; PU, maximum width of proximal end of ulna; R, maximum length of radius; U, maximum length of ulna.

¹Gilmore (1920); ²Maleyev (1974); ³Russell (1970); ⁴Lambe (1917); *this ratio is 2.5 for *Ceratosaurus*; *estimated.

(fig. 3N). Proximally, a well-striated area on the medial surface (figs. 4I, 4J, 4K) was overhung and contacted by metacarpal II (figs. 3L, 4F).

An isolated phalanx (figs. 3L, 4L-4N) bears no resemblance to any phalanges of the manus of *Allosaurus* (fig. 3O; Gilmore 1920, Madsen 1976a) or of any other theropod from the Upper Jurassic or Cretaceous. However, apart from being

somewhat more massive, this phalanx is similar to the left first phalanx of digit I of prosauropod dinosaurs (figs. 3R, 3S, 5; Galton 1976, Galton and Cluver 1976). In particular, the phalanx is twisted along its length (fig. 5E-5H) so the distal condyles are set at an angle to the proximal end (fig. 5F). The first phalanx of digit I has a twisted form but is much more slender in the Upper Triassic coelurosaur *Syntarsus* (fig. 3Q) and in the

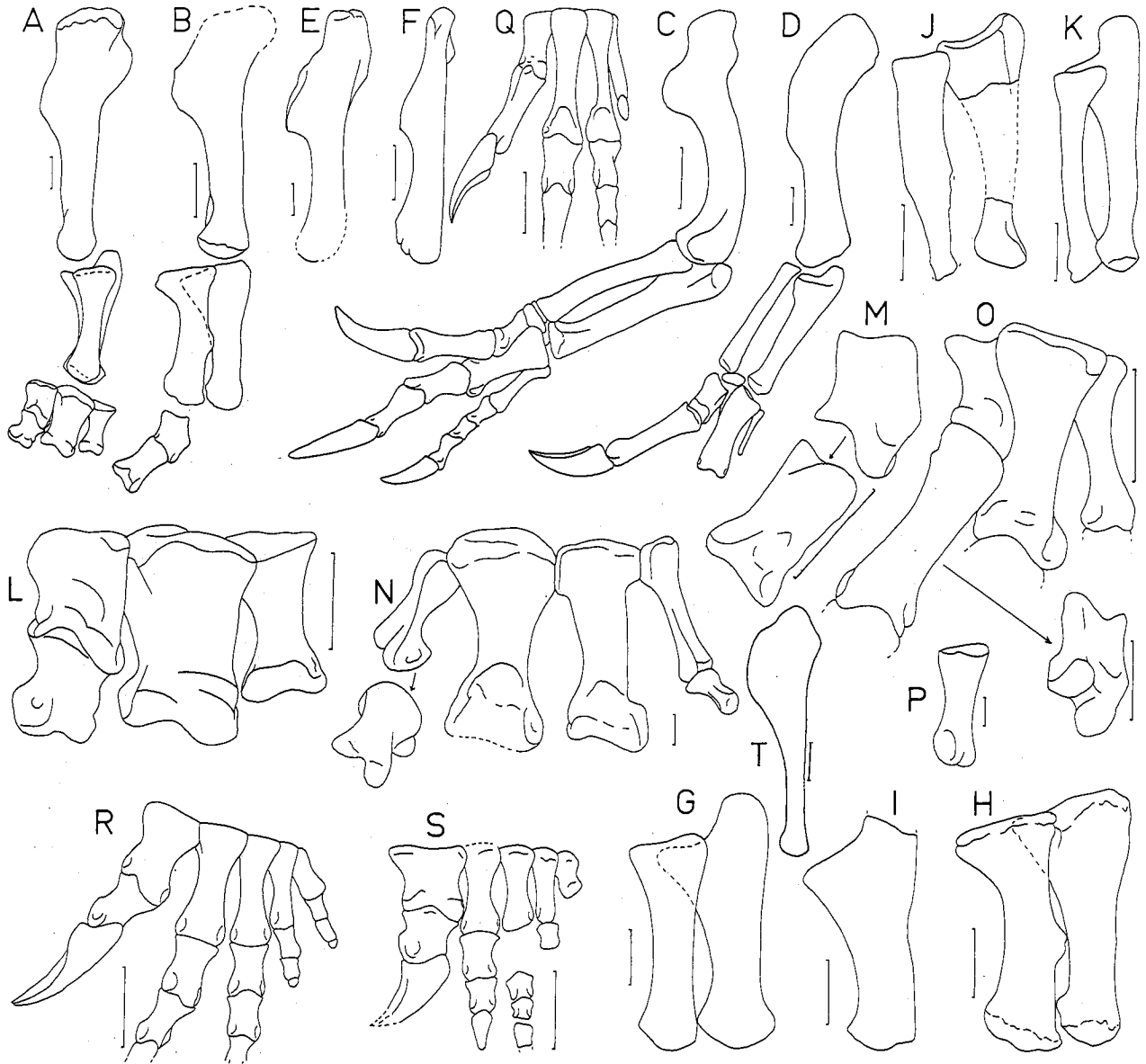


FIGURE 3.—Comparisons of bones of left forelimb, mostly of theropod dinosaurs. A-F, lateral view with humerus reduced to unit length, A, *Torvosaurus tanneri* n. gen. et sp.; B, *Poikilopleuron* from Middle Jurassic of France, cast YPM 4839 with digit I after Eudes-Deslongchamps (1838); C, *Allosaurus* from Upper Jurassic of Colorado, Utah, and Wyoming, after Gilmore (1920); D, tyrannosaurid *Daspletosaurus* from Upper Cretaceous of Alberta, modified after Russell (1970); E, *Megalosaurus* from Middle Jurassic of England, after Huene (1926); F, *Eustreptospondylus* from Middle Jurassic of England, after figure provided by H. P. Powell and S. P. Welles; G-K lateral view of forearm with ulnae reduced to unit length; G, *Torvosaurus*; H, *Poikilopleuron*; I, *Megalosaurus*, after Huene (1926); J, *Ceratosaurus* from Upper Jurassic of Colorado and Utah, after Gilmore (1920); K, *Allosaurus*; L-S manus in anterior or dorsal view; L, *Torvosaurus*; M, *Poikilopleuron* metacarpal and first phalanx of digit I, after Eudes-Deslongchamps (1838); N, *Ceratosaurus*, after Gilmore (1920); O, *Allosaurus* with metacarpal I after Madsen (1976a); P, *Eustreptospondylus*, first phalanx of digit I, after Huene (1926); Q, coelurosaurian theropod *Syntarsus* from Upper Triassic of Rhodesia, after Galton (1970); R, prosauropod *Plateosaurus* from Upper Triassic of Germany, UT 1; S, prosauropod *Lufengosaurus* from Upper Triassic of China, after Galton and Cluver (1976; see figure 7 for manus of other prosauropods); T, humerus of *Ceratosaurus*, after figure supplied by J. H. Madsen, Jr. Scale lines represent 1 cm (N,P,Q) or 5 cm.

Middle Jurassic megalosaurids *Poikilopleuron* and *Eustreptospondylus* (figs. 3M, 3P). The phalanx is very elongate but shows some twisting in *Allosaurus* (fig. 3O) and in the Cretaceous tyrannosaurids *Albertosaurus* (Lambe 1917) and *Dapletosaurus* (fig. 3D).

The large ungual phalanx of digit I (fig. 1M) may be referable to *Torvosaurus*, but it should be noted that it was found at Calico Gulch Quarry in Moffat County, Colorado, 195 km from the Dry Mesa Quarry. The area of attachment of the flexor tendons is more rugose than is the case in *Allosaurus* (Gilmore 1920, Madsen 1976a).

Pelvic Girdle

A slightly crushed right ilium (fig. 6A–6E), both pubes (fig. 6F–6H), and the right ischium (fig. 6I) of *Torvosaurus* have been recovered to date and, on the basis of the closeness of the fit of the bones of the right side (figs. 2D–2F, 7), it is reasonable to assume that those bones came from the same individual. The main body of the ilium is low (figs. 2D, 6A, 7) with a long tapering postacetabular process and a relatively shallow acetabulum with a relatively strong ischiadic peduncle and a weak pubic peduncle, the transverse width of which is greater than the anteroposterior width (figs. 6A, 6B, 6D).

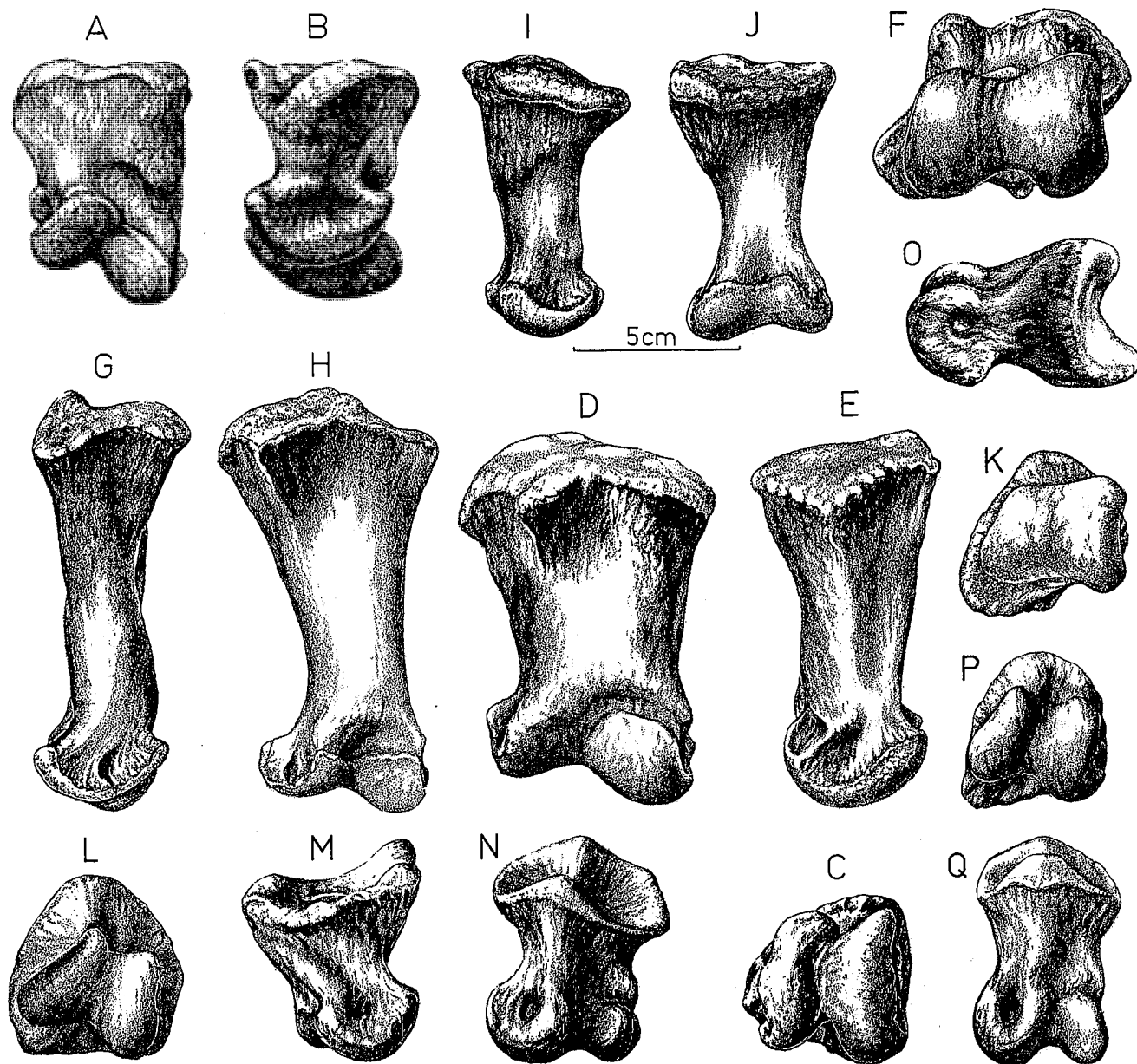


FIGURE 4.—Manus elements of *Torvosaurus tanneri* n. gen. et sp. (paratypes A–F, I–N) and *Allosaurus* (G,H), all from left side X0.5. A–C, metacarpal I, BYU 2010 in A, dorsal; B, medial; and C, distal views; D–F, metacarpal II, BYU 2011 in D, dorsal; E, medial; and F, distal views; G,H, *Allosaurus*, BYU 2021 in G, medial; and H, dorsal views; I–K, metacarpal III, BYU 2012 in I, medial; J, dorsal; and K, distal views; L–N, phalanx 1 of digit I, BYU 2018 in L, distal; M, lateral; and N, dorsal views; O–Q, phalanx 1 of digit I from smaller individual of ?*Torvosaurus*, BYU 2021 in O, lateral, P, distal, and Q, dorsal views.

However, this apparent weakness may be an artifact of crushing during preservation. In ventral view (fig. 6B) the acetabulum and brevis shelf are both wide. The subacetabular part of the pubis and ischium is unmarginated (figs. 2D, 2F, 6G, 6I, 7) so an almost continuous medial symphysis is present (fig. 2F), the obturator foramen of the pubis is enclosed (figs. 2D, 2F, 6G), and an obturator process is not delimited from the rest of the ischium (figs. 2D, 6J). The pubis and ischium meet along an extensive suture, are subequal in length, and are shorter than the ilium (figs. 2D, 7). The iliac articulation of the pubis is shorter than the part bordering the acetabulum (figs. 2D, 6G). The thicker parts of the pubis are the acetabular margin and the anterolateral part (figs. 2D-2F, 6F-6H) that expands distally to form a small foot or pedicle, whereas the ventromedial part is a thin sheet (figs. 2E, 2F, 6F-6H). The ischium is broad proximally (figs. 2D, 6I) with a thin medial part (figs. 2F, 6J), and the distal part is bowed posteriorly with a small, symmetrically expanded end (fig. 2D, 6I).

The ilium of *Allosaurus* (fig. 8J; Gilmore 1920, Madsen 1976a) differs from that of *Torvosaurus* (figs. 6A-6E, 8H) in the following features:

1. Body deep with a deep acetabulum.

2. Postacetabular process squared off posteriorly with rounded corners.
3. Massive pubic peduncle with transverse width greater than anteroposterior thickness.
4. Relatively weak ischiadic peduncle.
5. Narrow acetabulum and brevis shelf in ventral view.

The ilium of *Ceratosaurus* (fig. 8G; Gilmore 1920) also differs in features 1, 3, and 4 and in the narrowness of the notch between the anterior process and the pubic peduncle. The ilium of *Marsbosaurus* (fig. 8I; Madsen 1976b) differs in features 1 to 4, and the brevis shelf appears to be narrow. The ilium of *Stokesosaurus* (fig. 8K; Madsen 1974) differs in features 1 and 3-5, and, in addition, there is a prominent vertical ridge above the acetabulum that is also present on the ilium of *Iliosuchus* (figs. 8R, 8S) from the Middle Jurassic of England. A similar but less strongly developed ridge is present on the ilium of *Megalosaurus* (fig. 8O) that also differs in features 1, 3, 4, and 5 from the ilium of *Torvosaurus*. The incomplete ilium of *Eustreptospondylus* is similar to that of *Torvosaurus* (fig. 8R), but only the lateral view is figured.

The pubis of *Allosaurus* (fig. 8J) differs from that of *Torvosaurus* (figs. 2D-2F, 6F-6H, 8H) in the following features:

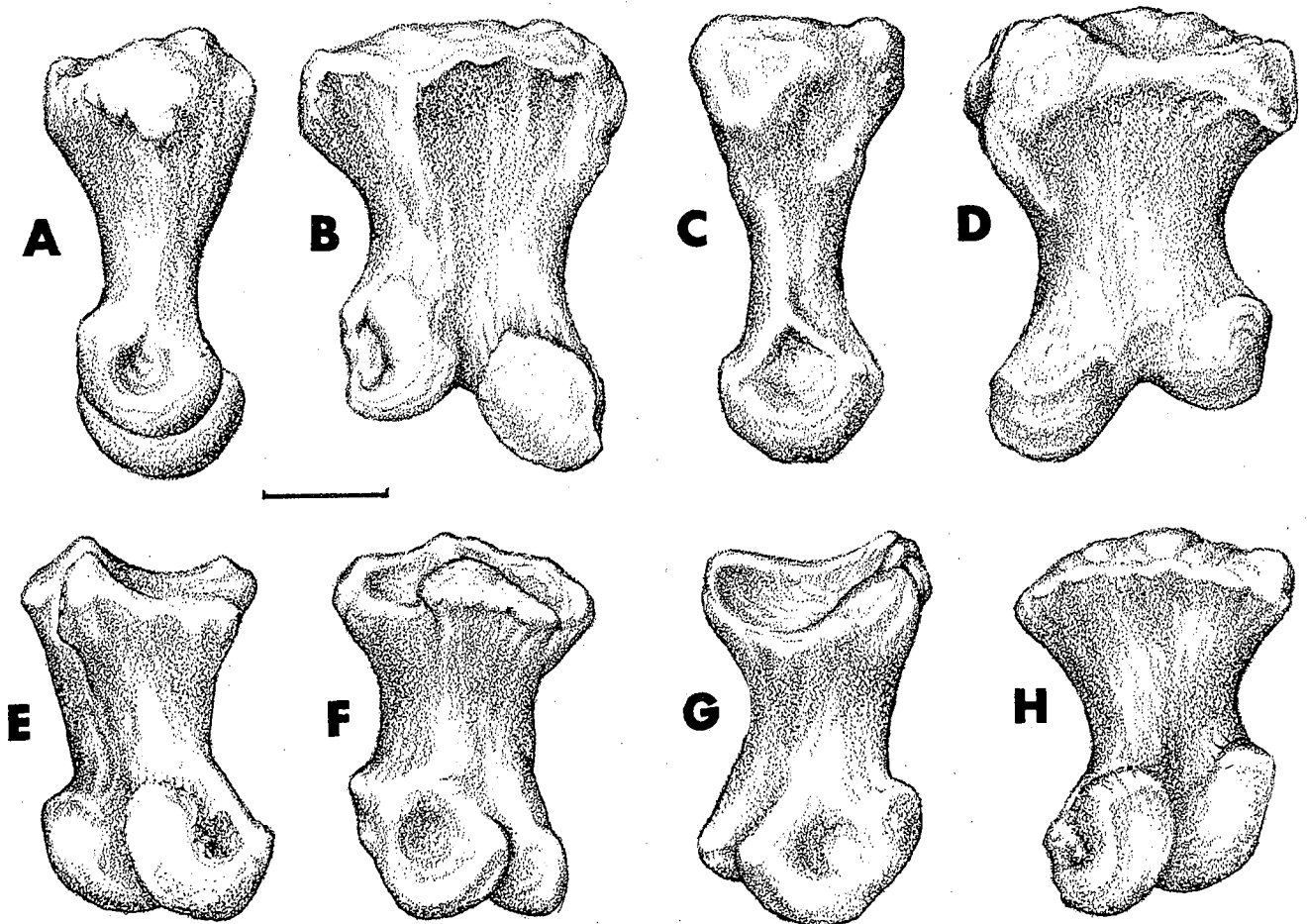


FIGURE 5.—*Plateosaurus* from Upper Triassic of Germany, UT 1, approx. X0.5, left metacarpal (A-D) and phalanx 1 (E-H) of digit I of manus in medial (A,E), dorsal (B,F), lateral (C,G), and ventral (D,H) views. Scale line 2 cm.

1. Ventrally, subacetabular part emarginated.
2. Open obturator notch present.
3. Pubis longer than ischium
4. Iliac articulation longer than acetabular margin.
5. Large foot or pedicle.

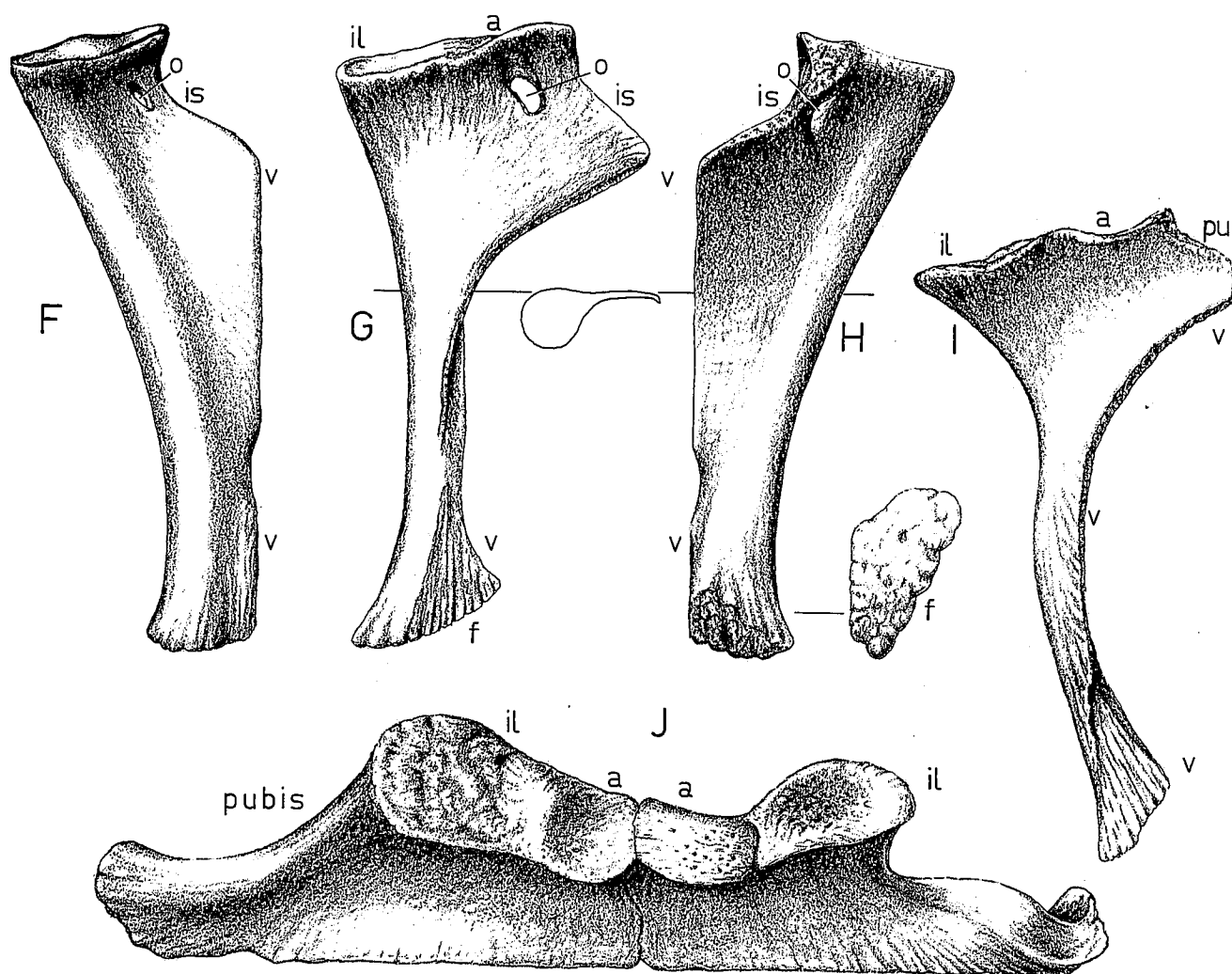
The pubis of *Marshosaurus* (fig. 8I) differs in features 1 to 4, and that of *Ceratosaurus* (fig. 8G), in features 1 and 3-5 from the pubis of *Torvosaurus*. The pubis of *Eustreptospondylus* (figs. 8P, 8Q) had an enclosed obturator foramen (Huene 1926), but the bone is more slender than that of *Torvosaurus*, and only the distal half of the pubes were in contact (fig. 8Q). The pubis of *Megalosaurus* (fig. 8L) is shown very similar to that of *Torvosaurus*, but in the text Huene (1926, p. 51) notes that "very remarkable is the extremely narrow, in fact rodlike, pubis—the proximal widening containing the obturator foramen disappears within a short distance from the proximal end." However, Walker (1964) shows that the subacetabular region is deep and that the pubes were joined for most of their length (figs. 8M, 8N).

The ischia of *Allosaurus*, *Ceratosaurus* and *Marshosaurus* (figs. 8G, 8I, 8J) differ from that of *Torvosaurus* (figs. 2D-2F,

6I, 8H) in the development of an obturator process as the result of ventral emargination and in the straightness of the bone. *Megalosaurus* is shown with a deep ischium (fig. 8L), but it is uncertain how much of the subacetabular region is restored.

DISCUSSION

The morphology of the forelimb and pelvic girdle of *Torvosaurus* is more similar to that of the Middle Jurassic theropods *Megalosaurus* and *Poikilopleuron* of Europe than it is to that of the other genera from the Morrison Formation of the western United States. It is for this reason that *Torvosaurus* is referred to the family Megalosauridae rather than to the Allosauridae. In several features the anatomy of *Torvosaurus* is more conservative for a carnosaur than is that of *Allosaurus*, *Ceratosaurus*, and *Marshosaurus*, and this is particularly true for the form of the pubis and ischium (figs. 8G-8J). A complete obturator foramen in the pubis is extremely unusual in theropods and is reported only in the Upper Triassic coelurosaur *Syntarsus* (fig. 8E), in the Middle Jurassic carnosaur *Megalosaurus* and *Eustreptospondylus* (figs. 8L, 8P; Huene 1926), and in *Ceratosaurus*



(fig. 8G). An obturator foramen is present in *Herrerasaurus* (fig. 8C; Reig 1963) from the early Upper Triassic, but the family Herrerasauridae is regarded as *Saurischia incertae sedis* by Galton (1977c) and as the earliest sauropod dinosaur by Van Heerden (1978). An obturator foramen was described for the Lower Cretaceous theropod *Deinonychus* (Ostrom 1969) but the element concerned was reidentified as a coracoid (Ostrom 1974), and there is no room for an obturator foramen in a recently described pubis (Ostrom 1976). An obturator foramen is present in the pubis of members of the Upper Triassic Ornithosuchidae, a family Walker (1966) transferred to the Theropoda, but Walker (1977) now follows Bonaparte (1969, 1975) in placing this family in the Thecodontia (i.e., non-dinosaurian). The pubes and ischia meet for most of their length at a medial symphysis in only four saurischians (other than prosauropods and sauropods) described to date: *Herrerasaurus*, *Syntarsus*, *Megalosaurus* (pubis), and *Torvosaurus* (figs. 8C, 8E, 8H, 8M, 8N).

In discussing the pelves of Triassic dinosaurs, Colbert (1964) distinguishes between the brachyiliac type of pro-

sauropods (fig. 8A, 8B; sauropod pelvis derived from this type) and the dolichoiliac type of coelurosaur (fig. 8F) from which he derives the "true carnosaurian" pelvis (fig. 8J). The dolichoiliac type of pelvis probably evolved from the brachyiliac type of pelvis of the basal saurischian stock in a mosaic fashion at different rates in several different lines of saurischian dinosaurs. The earliest saurischian dinosaur described to date, *Staurikosaurus pricei* from the uppermost Middle Triassic of Brazil (Colbert 1970), already has a dolichoiliac-type pubis and ischium associated with a basically brachyiliac-type ilium (fig. 8D; Galton 1973, 1977c). *Staurikosaurus* may be an early coelurosaur, but it is probably best regarded as *Saurischia incertae sedis* (Galton 1977c). In *Torvosaurus*, the ilium is dolichoiliac, but the pubis and ischium are brachyiliac. This is the first demonstration of this combination in a carnosaurian theropod from the Upper Jurassic. Bonaparte (1969, p. 480) noted that the "evidence for linking the Carnosauria with the Coelurosauria (Colbert 1964; Charig and others 1964) is as ambiguous as that for linking the Carnosauria with the Prosauropoda (Huene 1956; Romer 1956)." It should be noted that the division of

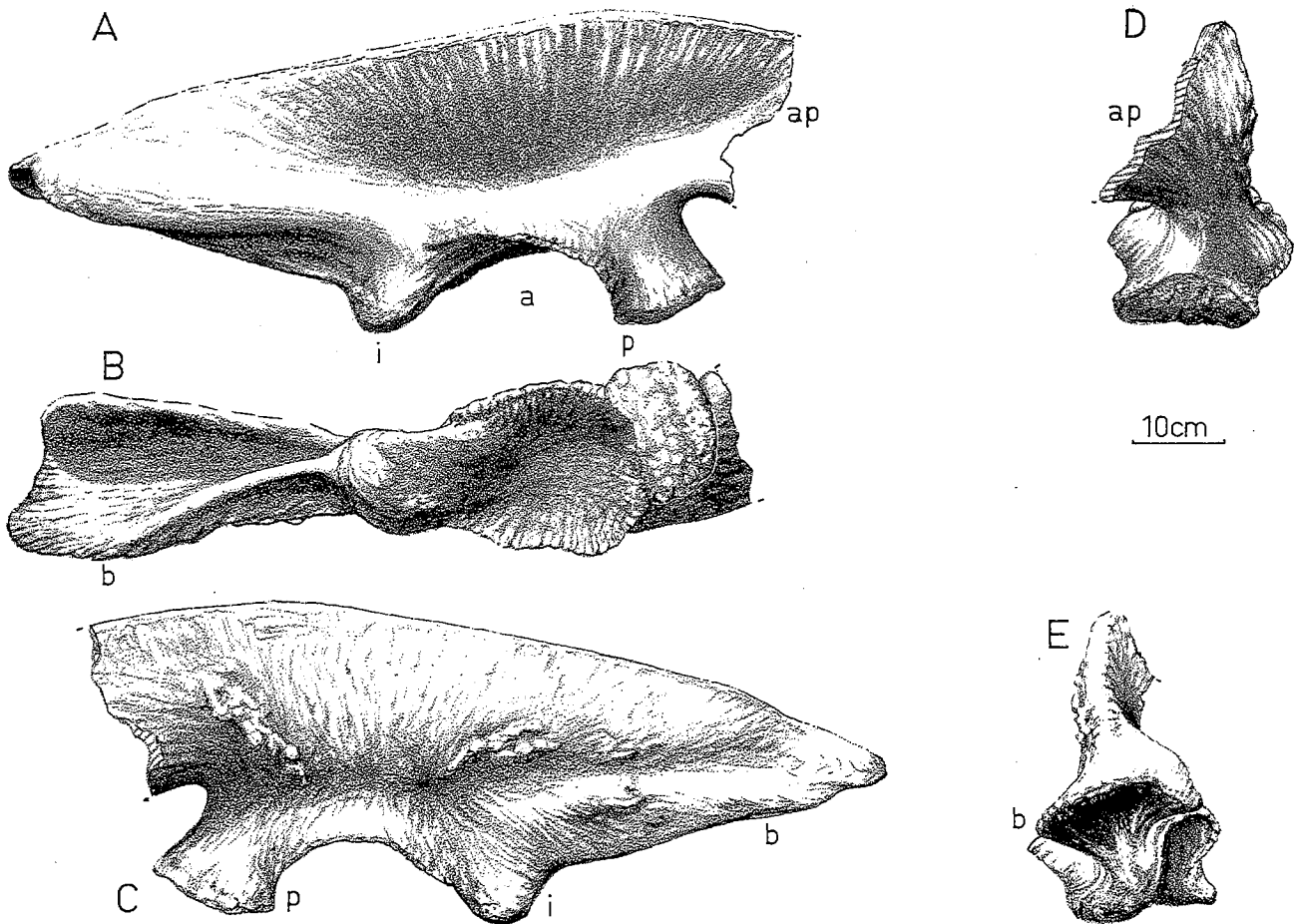


FIGURE 6.—*Torvosaurus tanneri* n. gen. et sp. right pelvic girdle, paratypes X1/8. A–E, ilium BYU 2013 in A, lateral; B, ventral; C, medial; D, anterior; and E, posterior views; F–H, pubis BYU 2014 in F, anterodorsal view; G, medial view with section; H, posteroventral view with distal end; I, ischium BYU 2015 in medial view; J, pubis and ischium in dorsal view. a, acetabulum; ap, anterior process; b, brevis shelf; f, foot or pedicel; i, ischiadic head; il, surface for ilium; is, sural surface for ischium; o, obturator foramen; p, pubic peduncle; pu, surface for pubis; v, ventral symphysis between pubes or ischia.

the Theropoda into the Coelurosauria and Carnosauria may be artificial (Ostrom 1969, 1978) because the Upper Jurassic theropod *Compsognathus* (family Compsognathidae) is very small, yet it has many carnosaurlike characters (Ostrom 1978), and the Cretaceous family Dromaeosauridae show a combination of coelurosaurian and carnosaurian characters (Ostrom 1969). Colbert and Russell (1969) erected a third theropod infraorder, the Deinonychosauria, for the last family that probably originated from a line close to the Upper Jurassic coelurid *Ornitholestes* (Ostrom 1969). We suggest that the anatomy of the pubis and ischium of *Torvosaurus* strengthens the case for regarding the Jurassic Megalosauridae (and the Carnosauria if this is a natural group) as descendants of the Prosauropoda rather than of another theropod currently included in the Coelurosauria. It should also be noted that the form of the humerus and phalanx 1 of digit I of the manus of *Torvosaurus* is more similar to those of prosauropods than to those of coelurosaurs.

The ilium of *Stokesosaurus clevelandi* Madsen 1974 has a prominent vertical ridge above the acetabulum (fig. 8K). This ridge is also present on ilia of *Iliosuchus incognitus* (Huene 1932) from the Middle Jurassic of England (figs. 8S, 8T) and, on the basis of this feature, Galton (1975) suggested that the Morrison species should become *Iliosuchus clevelandi* (Madsen). However, a similar but less pronounced vertical ridge is also present on an ilium of *Megalosaurus bucklandi* (fig. 8O), although no indication of it was given by Walker (1964, fig. 16d). The outline of the ilium of the Upper Cretaceous *Tyrannosaurus* is different, but there are traces of a vertical ridge (Romer 1923, fig. 1) which is interpreted by Russell (1972) as the boundary between the areas of origin of the anterior and posterior heads of the iliofemoralis muscle. In reconsidering the problem, the senior author now considers that there is insufficient evidence to justify making *Stokesosaurus* Madsen 1974 a junior synonym of *Iliosuchus* Huene 1932. Consequently, the genus *Iliosuchus* is re-

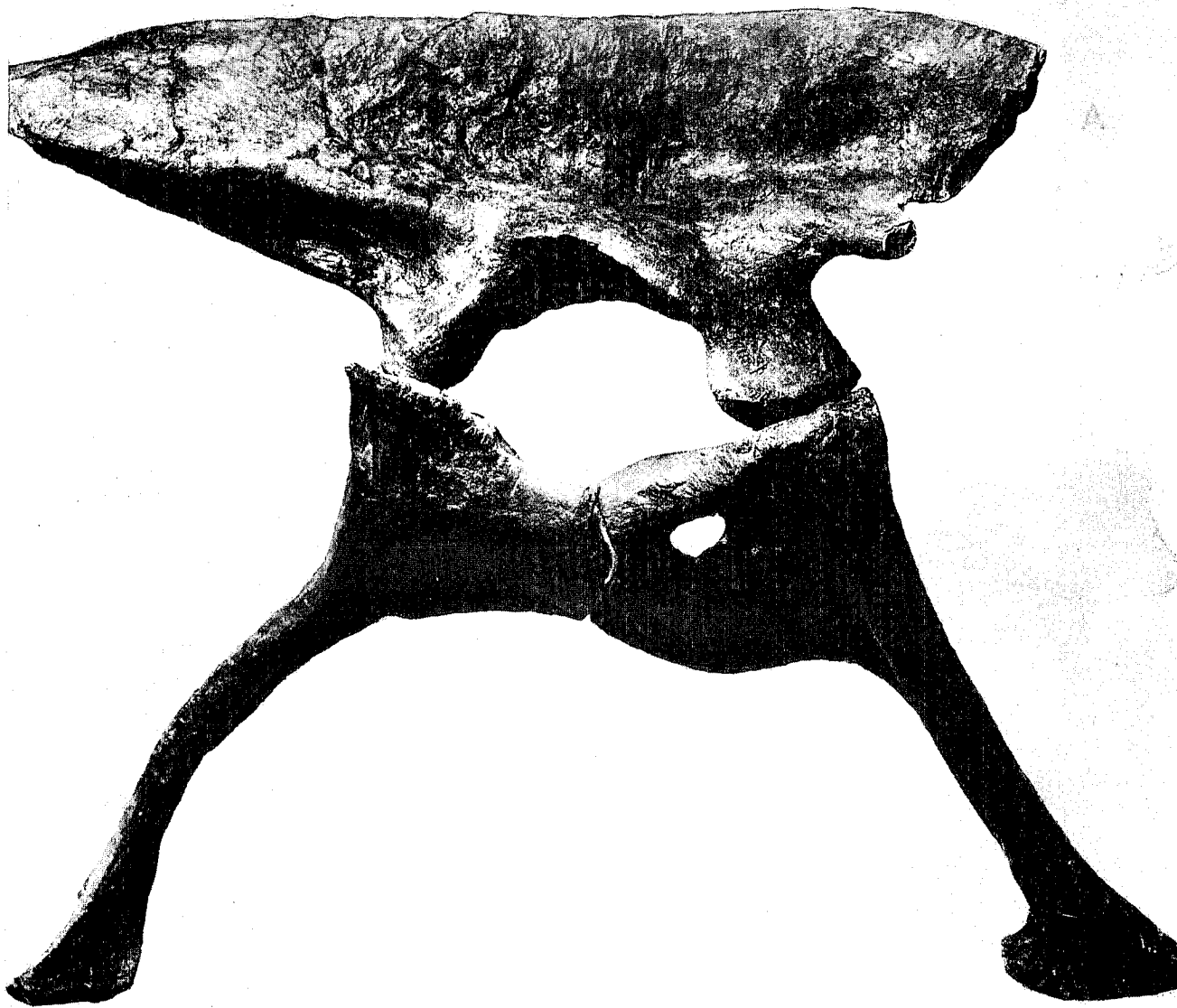


FIGURE 7.—*Torvosaurus tanneri* n. gen. et sp., right pelvic girdle in lateral view, paratypes BYU 2013–2015, approximately X0.20.

stricted to the Middle Jurassic of southern England and is not present in the Upper Jurassic of western United States. However, *Iliosuchus incognitus* Huene is still regarded as a valid taxon distinct from its much larger contemporary *Megalosaurus bucklandi*.

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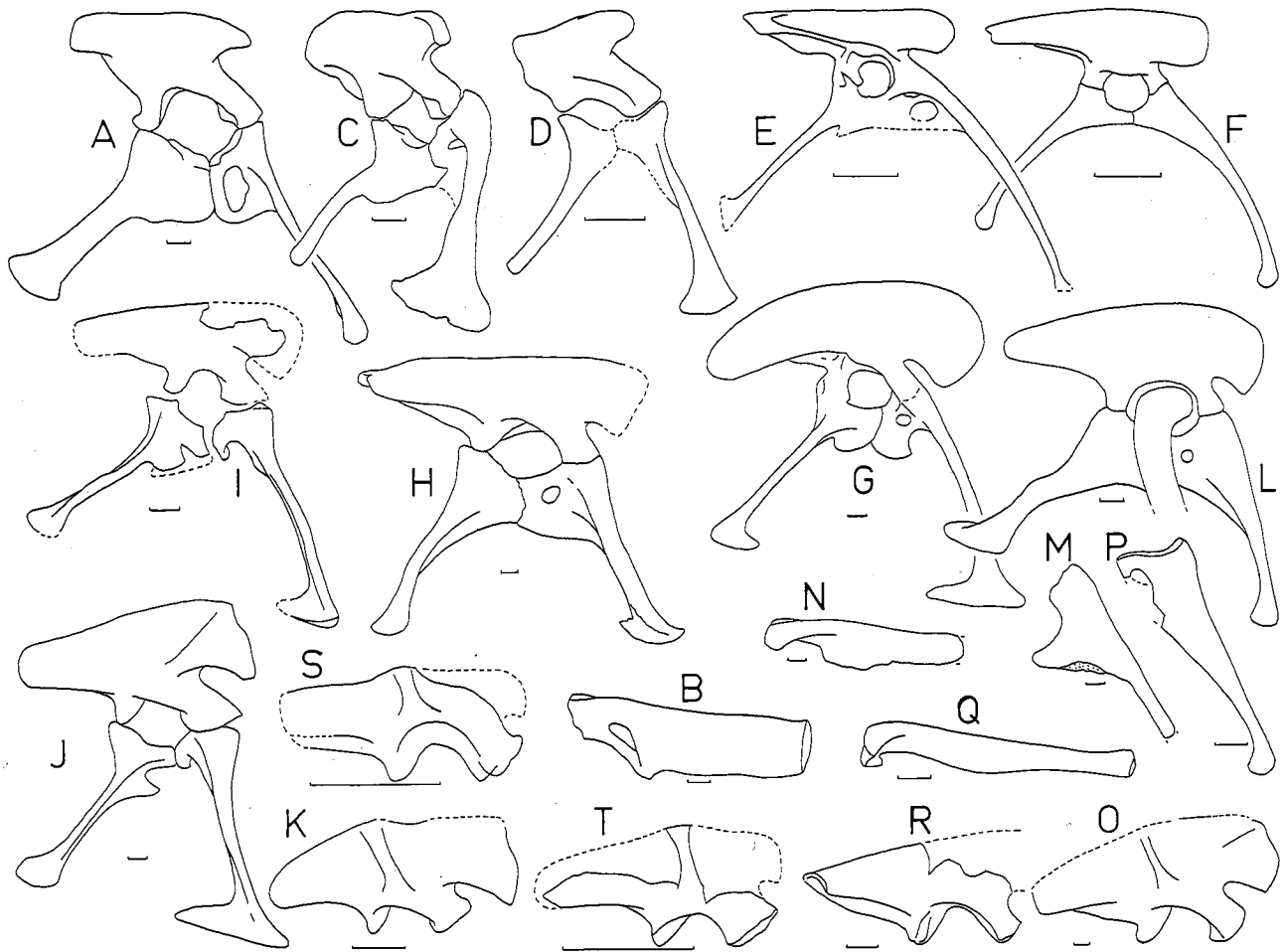


FIGURE 8.—Pelvic girdles of saurischian dinosaurs, all lateral view of right side (except L, M, O, P). A, prosauropod *Plateosaurus* from Upper Triassic of Germany, after Huene (1926); B, as A, anterodorsal view of left pubis; C, saurischian *Herrerasaurus* from Upper Triassic of Argentina after Reig (1963); D, saurischian *Staurikosaurus* from Middle Triassic of Brazil, after Colbert (1970); E, coelurosaurian theropod *Syntarsus* from Upper Triassic of Rhodesia, after Raath (1969); F, coelurosaur *Coelophysis* from Upper Triassic of New Mexico, after E. H. Colbert in Raath (1969); G, carnosaurian theropod *Ceratosaurus* from Upper Jurassic of Colorado, after Gilmore (1920); H, *Torvosaurus tanneri* n. gen. et sp.; I, *Marshosaurus* from Upper Jurassic of Colorado, after Madsen (1976b); J, *Allosaurus* from Upper Jurassic of Wyoming and Colorado, after Gilmore (1920); K, ilium of *Stokesosaurus* from Upper Jurassic of Colorado, after Madsen (1974); L-O, *Megalosaurus* from Middle Jurassic of England: L, after Huene (1926), M, N after Walker (1964), left pubis in M, medial, and N, anterodorsal views; O, ilium, OUM J13560 after photograph supplied by H. P. Powell; P-R, *Eustreptospondylus* from Middle Jurassic of England, after Huene (1926 as *Streptospondylus*); P, Q, left pubis in P, medial, and Q, anterodorsal views; R, ilium; S, T, ilia of *Iliosuchus* from Middle Jurassic of England, after Galton (1976). Scale lines represent 5 cm.

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