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Coelurosaur Bone Casts from the Connecticut Valley Triassic

BY EDWIN HARRIS COLBERT[1] AND DONALD BAIRD[2]

INTRODUCTION

An additional record of a coelurosaurian dinosaur in the uppermost Triassic of the Connecticut River Valley is provided by a block of sandstone bearing the natural casts of a pubis, tibia, and ribs. This specimen, collected nearly a century ago but hitherto unstudied, was brought to light by the junior author among the collections (at present in dead storage) of the Boston Society of Natural History. We are much indebted to Mr. Bradford Washburn and Mr. Chan W. Waldron, Jr., of the Boston Museum of Science for their assistance in making this material available for study.

The source and history of this block of stone are revealed in brief notices published at the time of its discovery. The Proceedings of the Boston Society of Natural History (vol. 10, p. 42) record that on June 1, 1864, Prof. William B. Rogers "presented an original cast in sandstone of bones from the Mesozoic rocks of Middlebury, Ct. The stone was probably the same as that used in the construction of the Society's Museum; it was found at Newport among the stones used in the erection of Fort Adams, and he owed his possession of it to the kindness of Capt. Cullum." S. H. Scudder, custodian of the museum, listed the

[1] Curator of Fossil Reptiles and Amphibians, the American Museum of Natural History.

[2] Assistant Curator of Vertebrate Paleontology, Princeton University, Princeton, New Jersey.

specimen as an important donation; and the donor's brother, Henry D. Rogers, exhibited a plaster cast of it before the British Association for the Advancement of Science at Bath in 1864 (Scudder, 1865; Rogers, 1865). Perhaps as a result of the deaths of Edward Hitchcock in 1864 and H. D. Rogers in 1866, no further notice was taken of the specimen, and its origin and history were lost sight of.

Despite the statement quoted above, this specimen cannot have come from Middlebury, which lies outside the Triassic belt in Connecticut. "Middlebury" is almost certainly a *lapsus* for Middletown, and the actual source must have been the famous Portland brownstone quarries which formerly lay within the boundaries of the town of Middletown (Rice and Foye, 1927). This conclusion is supported by the lithology of the specimen, a reddish brown arkosic sandstone. The source formation may thus be taken as the Portland arkose, the youngest of three formations that constitute the Newark group in the Connecticut Valley.

The preservation of these bones as natural casts is unusual enough to require explanation. Adhering to the surface of the block are traces of a soft red shale which evidently represents the alluvial plain on which the bones had come to rest, half embedded in silt. This silt became indurated enough to retain the imprints of the bones after the bones themselves had been swept away by the early freshets of the rainy season. Overflowing streams soon mantled the flood plain with arkosic sand from the fault-scarp uplands to the east, and this sand filled the bone impressions just as it did the footprints of dinosaurs and pseudosuchians on the plain. This interpretation of the occurrence follows Krynine's (1950) reconstruction of the climate and topography of the ancient Connecticut Valley.

Interestingly enough, Peabody (1956) has recently reported another example of the same phenomenon in the Moenkopi formation (late lower Triassic) of Arizona. In this case the palatal aspect of an archosaur skull has been preserved as a natural cast in sandy limestone deposited over a red mud flat. The circumstances of preservation as interpreted by Peabody seem to have been essentially similar to those of the Connecticut Valley find.

DESCRIPTION

Coelophysis sp.

SPECIMEN UNDER CONSIDERATION: B.S.N.H.[1] No. 13656 (casts:

[1] Boston Society of Natural History.

A.M.N.H. No. 7636, M.C.Z.[2] No. 2768), a sandstone slab containing natural casts of a right pubis, right tibia, and some ribs.

HORIZON: Probably Portland arkose of the Newark group.

LOCALITY: Probably the quarries at Portland, Connecticut, across the Connecticut River from Middletown.

It may be said without qualification that these natural bone casts, forgotten for almost a century, indicate a small, lightly built coelurosaurian dinosaur of the type that was so characteristic and widespread throughout the world during late Triassic times. The genera of upper Triassic coelurosaurian dinosaurs known from North America are *Podokesaurus*, which, as does the present specimen, occurs in the Portland arkose of the Newark group in the Connecticut Valley, and *Coelophysis* from the Chinle formation of the southwestern United States. *Ammosaurus*, commonly designated as a coelurosaur, is probably a prosauropod, related to *Anchisaurus*. *Segisaurus*, from the Navajo sandstone of Arizona, is here regarded as of Jurassic age. The bone casts here under consideration are certainly most closely comparable to the homologous elements in *Coelophysis* and *Podokesaurus* and particularly to the bones of the first named of these two genera.

In size the dinosaur from the Connecticut Valley may be compared with the largest known individuals of *Coelophysis*, and indeed the bone casts exceed somewhat the largest *Coelophysis* specimens in the collections of the American Museum of Natural History. The once unique specimen of *Podokesaurus* (the original is now destroyed, and the type is known only from casts) is generally comparable in size to the smallest of the *Coelophysis* specimens in an ontogenetic series collected at Ghost Ranch, New Mexico, some years ago by an American Museum expedition; consequently there is a considerable difference in size between the fossil now under consideration and the type of *Podokesaurus*. By comparison with the completely articulated skeletons of *Coelophysis*, it seems evident that these fossil bone casts from Connecticut represent a coelurosaurian probably about 2.5 or 3 meters in length, or about 9 feet from the tip of the skull to the tip of the tail. In this connection it must be remembered that the dinosaur now being viewed in our mind's eye was a very lightly built and slender animal; therefore it did not bulk very large.

This dinosaur shows, in spite of certain obvious differences, various striking resemblances to *Coelophysis*. The pubis is almost as long as the tibia, as in the case in *Coelophysis*, and it is safe to infer that the

[2] Museum of Comparative Zoölogy at Harvard College.

pubis was appreciably longer than the femur. Although slender and delicately constructed, it shows a rather flattened shaft, so that its dimensions at right angles to the long axis appear much greater than those of the same bone in *Coelophysis* when seen in lateral view. It seems probable, however, that the shaft of the pubis has been twisted somewhat during fossilization, so that what we see is not the shaft in lateral view but more nearly in an oblique view. A similar condition is seen in a pubis of one of the American Museum specimens of *Coelophysis* (A.M.N.H. No. 7249), so that a comparison of this particular specimen with the Connecticut specimen indicates reasonably close resemblances in form between the two. It is probably significant that the Connecticut dinosaur shows a transverse break of the pubis in its proximal portion, a break that would allow a certain twisting of the more distal segment of the bone.

The flattened shaft of the pubis is quite characteristic of the coelurosaurs, and it seems likely that in this dinosaur, as in *Coelophysis*, there was a long pubic symphysis. Certainly there is no great expansion of the distal end of the pubis into a "foot," which is also characteristic of the coelurosaurs. The distal expansion of the pubis was to take place during Jurassic times.

The upper end of the proximal end of the bone is characterized by a large facet for articulation with the ilium, and a second, somewhat smaller, facet for articulation with the ischium, these two articulations being separated by the curving edge of the obturator fenestra. Thus it is evident that the articulation for the head of the femur was open, as is so characteristic of dinosaurs in general, and that its lower half was about equally shared by the pubis and the ischium, which is typical of the coelurosaurs.

The question as to which pubis this may be is a vexing one. Are we looking at the frontolateral exposure of a right pubis, or the posterointernal exposure of a left pubis? The answer is not easy. It is our belief that we are looking at a right pubis, of which the anterior portion of the shaft is largely exposed. The transverse curve of the bone in this region seems to indicate this, for if the posterior surface of the bone were the one exposed there should be more indication of a transverse concavity in its form. If this interpretation is correct, the shaft of the pubis curves the "wrong" way as it is now exposed, for the bone appears to curve slightly upward, whereas it should curve downward to a considerable degree. But we think that perhaps the natural warping and cracking of the bone while it lay weathering on the mud flat dur-

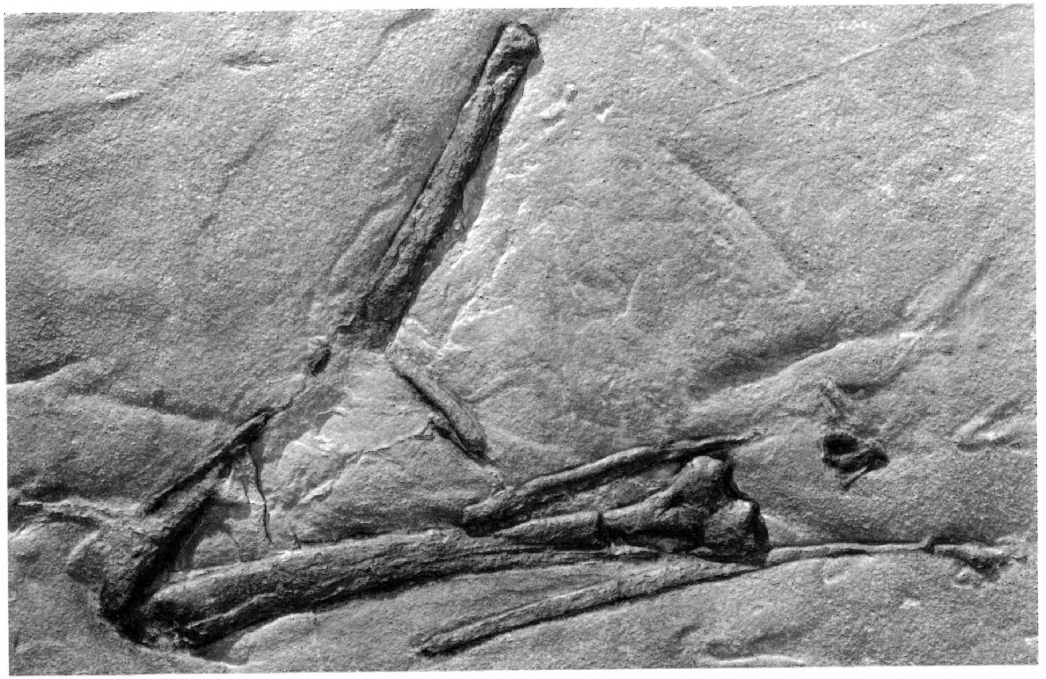

FIG. 1. *Coelophysis* sp. (A.M.N.H. No. 7636), a cast. Right pubis (large, horizontally placed bone), right tibia (long, oblique bone), and portions of several ribs. Note break in pubis, near proximal end. Portion of bone below this break is twisted in relation to small, proximal portion of bone. Note also gap in tibia between proximal and distal portions. One-third natural size.

ing late Triassic times account for this discrepancy in the form of the cast.

The tibia is elongated and very slender, an indication that this dinosaur, like so many of the coelurosaurians, had long lower-limb segments, similar in general proportions to those of certain modern, large, running birds. Like an ostrich, the Triassic dinosaur must have been capable of running at high speed across the open ground. This tibia has a very strong cnemial crest, similar in proportions to the cnemial crest in *Coelophysis*, an indication of a strong triceps emoris muscle.

The bone appears to have been broken before it came to rest on the flood plain or while it lay exposed there, for its proximal end is at a considerable angle to the distal end. Presumably the same forces that deformed the pubis were also responsible for the distortion of the tibia. The break in the tibia introduces an element of uncertainty into the study of proportional relationships, presented in some subsequent paragraphs, between tibia and pubis in this dinosaur and in a series of *Coelophysis* from New Mexico. A maximum and a minimum length for the tibia can be assumed, depending upon how the two pieces of the bone are adjusted to each other. The difference between maximum and minimum lengths is on the order of about 15 per cent of the maximum length. Allowances were made for this difference in the preparation of figure 2.

The complete rib, exposed parallel to and near the pubis, is long, about equal in length to the pubis, and comparatively straight. This is probably one of the anterior thoracic ribs. The other rib fragments are too small to have much significance.

COMPARISONS

With such scanty materials upon which to base our deductions it is not possible to attempt any detailed comparative studies. Nevertheless a comparison of proportions among various coelurosaurs between the length of the pubis and the length of the tibia (as these are the bones available in the present specimen) may help to give an idea of what the reptile was like. The comparison has been made between the specimen from Portland, the type of *Podokesaurus holyokensis*, and several measurable specimens of *Coelophysis bauri* in the American Museum of Natural History. Results are shown on the graph (fig. 2).

Figure 2 shows that the several specimens of *Coelophysis*, ranging from rather small individuals to animals that may be regarded as sexually mature adults, form a fairly uniform regression series, as might be expected. It is interesting to see that the type of *Podokesaurus* is

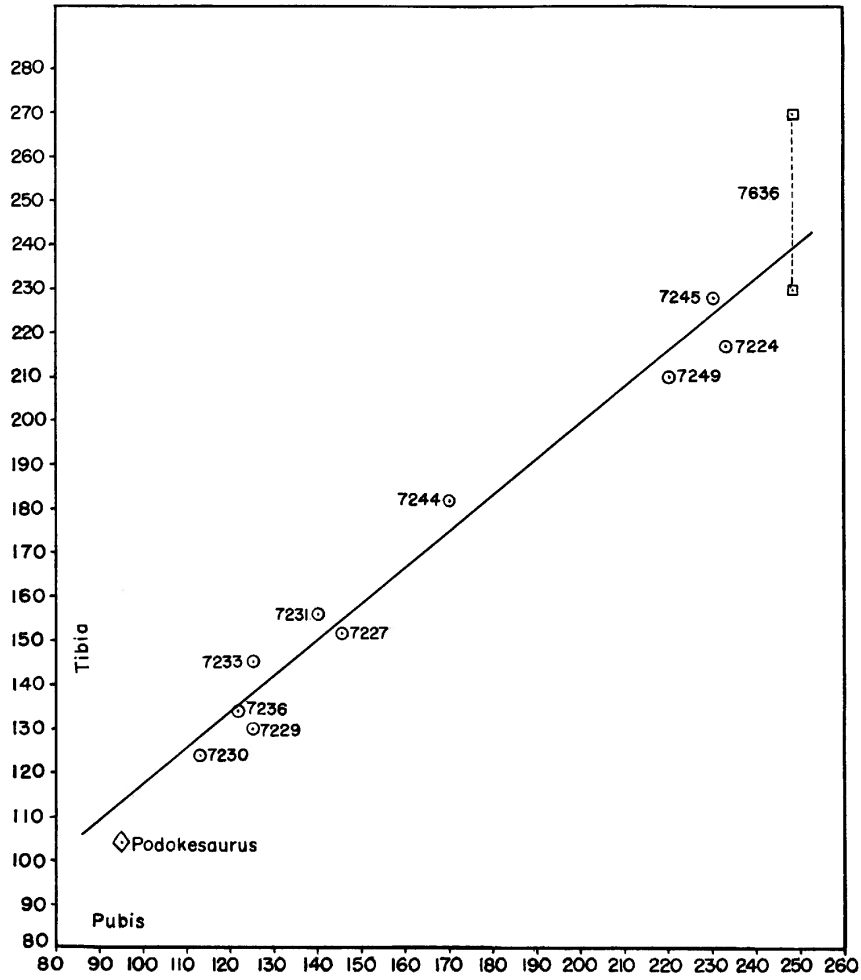

FIG. 2. The relationships of the length of the tibia (ordinates) to the length of the pubis (abscissas) in various Triassic coelurosaurians. The two points plotted for *Coelophysis* sp. from Portland, Connecticut (A.M.N.H. No. 7636, cast of B.S.N.H. No. 13656), are based on maximum and minimum allowable lengths of the tibia. The regression line is based on a series of *Coelophysis bauri* (A.M.N.H. Nos. 7224, 7227, 7229–7231, 7233, 7236, 7244, 7245, 7249) from a single quarry in the Chinle formation at Ghost Ranch, New Mexico.

not very far removed from the lower end of the regression line, on the basis of the two measurements used. This may indicate a rather close relationship between *Podokesaurus* and *Coelophysis* and raises a question as to the validity of the genus *Podokesaurus*.

If one assumes the maximum allowable length for the tibia of the coelurosaurian from Portland, then this fossil occupies a position well above the regression line as drawn for *Coelophysis*. If, however, one assumes the minimum allowable length for the tibia, the position of the Connecticut fossil on the graph is slightly below the regression line. Therefore it seems very probable that the relationship between length of tibia and length of pubis in the coelurosaur from Portland may place this dinosaur closely in line with *Coelophysis*.

Because, as is shown above, the osteological characters of the bones in the Portland specimen resemble rather closely the characters of comparable bones in *Coelophysis*, it is our opinion that the probabilities favor a generic identity between the Portland specimen and the genus *Coelophysis* of the Chinle formation of New Mexico and adjacent states. There is some temptation to give this fossil a new name in spite of its fragmentary nature, because of the rarity of dinosaur bones from the Connecticut Valley sediments, but we feel that the conservative course is to designate it as *Coelophysis* sp. This may not be quite so convenient a "handle" for the specimen as would be a new name for future references in the literature, which probably will be fairly

TABLE 1

MEASUREMENTS (IN MILLIMETERS) AND RATIOS

	Length of Pubis	Length of Tibia	Ratio
Coelophysis sp.			
A.M.N.H. No. 7636[a]	248.0	230–270[b]	*92–108*
Coelophysis bauri			
A.M.N.H. No. 7223	—	212.0	—
A.M.N.H. No. 7224	233.0	217.5	*107*
A.M.N.H. No. 7227	145.4	151.8	*96*
A.M.N.H. No. 7229	125.0	130.0	*96*
A.M.N.H. No. 7230	113.0	123.9	*91*
A.M.N.H. No. 7231	139.8	156.0	*90*
A.M.N.H. No. 7232	—	150.0	—
A.M.N.H. No. 7233	125.0	145.0	*86*
A.M.N.H. No. 7236	122.0	134.1	*91*
A.M.N.H. No. 7244	170.0	182.0	*94*
A.M.N.H. No. 7245	230.0	228.0	*101*
A.M.N.H. No. 7249	220.0	210.0	*105*
Podokesaurus holyokensis	95.0	104.0	*90*
Anchisaurus colurus	183.5	147.0	*125*

[a] Cast of B.S.N.H. No. 13656.

[b] Maximum and minimum allowable values.

numerous, but it seems to us that an honest appraisal of taxonomic realities is of more scientific value than convenience in future discussions.

One aspect of the problem that must not be forgotten in this connection is that of the stratigraphic relationships involved. The Portland arkose is placed as a Rhaetic equivalent in the correlation of the Triassic formations of North America (Reeside *et al.*, 1957). *Coelophysis* from the southwestern states is found in the Chinle formation, a Keuper equivalent, at a level considerably below the indicated position of the Portland. Designation of the Connecticut specimen as *Coelophysis* sp. implies an extension for the vertical range of this genus beyond the limits now given it, or a shifting of the Newark group in Connecticut to a position lower than that indicated in the new correlation. To the senior author it seems that either of these alternatives may be tenable. Studies of the stratigraphic distribution of Triassic reptiles and reptile footprints (Baird, 1954, pp. 184–187; 1957, pp. 501–503) lead the junior author to concur with the interpretation published in the correlation chart. Further evidence is needed before this question can be considered closed.

ASSOCIATED FAUNA

Although no other skeletal material is known from the Portland quarries, the brownstone rocks record a variety of reptilian footprints which cast some light on the fauna to which this coelurosaur belonged. The following interpretations of these footprints in zoological terms are those of the junior author, based for the most part on osteological analyses which are discussed in a recent paper (Baird, 1957). Lull (1953, p. 76) has identified the footprints found at Portland as follows:

Grallator gracilis, G. tenuis, G. cuneatus
Anchisauripus sillimani, A. tuberosus, A. exsertus
Eubrontes giganteus
Gigandipus caudatus
Batrachopus gracilis, B. deweyi
Otozoum moodii

Of the additional species listed by Lull, *Cunichnoides marsupialoideus* and *Isocampe strata* are indeterminate, and *Hoplichnus equus* is an erosional scour mark.

Species of the first three genera, here arranged in order of increasing size, appear to represent coelurosaurs that range in size from animals smaller than *Podokesaurus* to forms that approach the huge podokesaurid *Halticosaurus* of the European Keuper. *Gigandipus* repre-

sents an even larger dinosaur, perhaps a teratosaurid, which differed from most theropod track makers in having a continuously dragging tail. The species of *Batrachopus* are very plausibly interpreted by Lull as small pseudosuchians on the order of *Stegomosuchus*, the only skeleton of which comes from the Portland formation of Massachusetts. Lull has suggested that *Otozoum* may represent a prosauropod dinosaur, but another interpretation views this track maker as a giant bipedal pseudosuchian the closest affinities of which lie with chirotheriid footprints in which the thumb-like, fifth-pes digit had become reduced to a heel pad. In summary, the known fauna of the Portland quarries consists entirely of archosaurs, among which the dinosaurs far exceed the pseudosuchians in number and variety. This situation is fairly representative of late Triassic ecology in the Connecticut Valley area of deposition.

As no foot material is associated with the tibia and pubis described above, little comparison can be made between the skeleton and track makers from Portland except on a basis of gross size. If we assume that the relative lengths of tibia and pes were much the same in the new *Coelophysis* as in other specimens, its foot might be comparable in size to a large footprint of *Anchisauripus tuberosus*. But as the two may have differed significantly in foot structure, no correlation is attempted here.

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