THE SKELETON RECONSTRUCTION OF BRACHIOSAURUS BRANCAI

BY

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WITH PLATES VI – VIII

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A reconstruction of the skeleton of *Brachiosaurus brancai* has been erected in the public palaeontological display collection of the Berlin Geological-Palaeontological Institute and Museum, in the spacious atrium of the Museum of Natural History. The large skeleton S II forms the foundation of this plastic reconstruction as well as for the graphic presentation, which I have published in several brief papers.

The original plan to erect the entire skeleton out of plaster casts and models of the original bones was abandoned, although its execution would have offered the advantage of significantly easier technical mounting work, and such a reconstruction, consisting of only cast or modeled bones, could have attained a high degree of scientific accuracy with careful correction of all defects of preservation. However, another path was adopted in the execution of the plastic reconstruction, since it appeared more proper to show the museum visitor real remains of the giant dinosaur. Therefore all bones from the foundation skeleton that were suited to mounting in the skeletal assembly were used even if at times with significant difficulties. They include the existing elements of the pectoral girdle, the forelimbs, the pelvis, the hind limbs and those of the dorsal rib cage. The entire presacral vertebral column, the collective vertebrae of which are preserved, even if incompletely to a large degree, were modeled in plaster along with the cervical ribs. To mount them as original elements would have caused difficulties that could hardly have been overcome due to the tremendous weight and the extraordinary fragility of the highly complexly constructed vertebrae, would, however, in any case have demanded such extensive support structure that the overall view would have been very strongly affected; also, they would have been so far removed from the eye of the viewer that the details of the highly complicated external architecture could no longer have been looked at closely. The precious available cranial material of the foundation skeleton was not mounted and thereby removed from all closer viewing; rather, the skull was also modeled. Missing elements of the forelimbs and their girdle from one side were replicated from existing elements of the other side, or also replaced with other finds of matching or nearly matching size. The latter also applied for the elements that are completely absent in the foundation skeleton, above all for the tail. Missing elements that were not available in the appropriate size had to be modeled as enlargements of smaller elements. Elements of the skeleton reconstruction that are not mounted as originals or are modeled from existing original bones include only a very few dorsal ribs, a few elements of the foot, a number of haemapophyses and a few rod-vertebrae at the end of the tail.

The use of bones from other localities and thus other individuals naturally presents a source of error. Such bones would mostly not possess the precisely correct dimensions; they can also, if they originate from animals of a different age or different sex, be habitually formed somewhat differently than those of the foundation skeleton; also, individual variability, which in my opinion one has to consider to a significant degree in the larger saurischians, can interfere. In the case of our reconstruction it can further appear questionable that bones from the Upper Saurian

Marl were included, despite the fact that the foundation skeleton originates from the Middle [Saurian Marl]. It would certainly be incorrect if the *Brachiosaurus* of the higher horizon was a different species than that of the lower. No confirmed indications exist for this, in contrast to an interpretation originally advocated by me. On the whole, however, it can be said that in the plastic reconstruction of the *Brachiosaurus*, the unavoidable errors under the prevailing circumstances are not so significant that they have a noteworthy effect on the overall picture.

The requisite modeling of the supplementary skeletal elements, which, especially in the presacral vertebral column, placed a particularly high demand on skill and sense of form, was completed with the best result by Senior Preparator E. SIEGERT. The erection of the skeleton presents a technical master work of Preparator J SCHOBER †. The manner in which he succeeded in integrating the elements of construction that bear the tremendous weights into a strength that matches the tremendous demands without disturbing the organic lines is exemplary and unsurpassed.

Material of the reconstruction.

The important foundation for the modeling of the skull was supplied by the existing elements of the “face-skull” of Skeleton S II, among them the complete dentaries; for the missing [elements], particularly the skull cap, the complete Skull t 1 served as a pattern. The presacral vertebrae with the exception of the atlas and axis were modeled after the vertebrae that were present completely from the 3rd onward. The incompleteness of several anterior dorsal vertebrae, preserved only as centra, was not too serious since they could be reconstructed with sufficient certainty according to existing neighbouring vertebrae. The missing or only very incomplete neural arches of the posterior cervical vertebrae and anterior dorsal vertebrae were freely shaped through interpolation, which naturally could only be correctly attained with a limited degree of probability.

The mostly extraordinarily long shafts of the cervical ribs were reconstructed according to numerous nearly completely preserved ribs and the often quite long fragments of other ribs; in contrast, the dorsal ribs were mounted as originals, which for the most part were found more or less complete with the skeleton; several were present in their entire length, the missing [sections] of the remainder were easy to estimate and to restore. Four dorsal ribs that were completely absent were modeled from corresponding pieces of the opposite side. The sacrum was mainly reconstructed from the incomplete sacrum of Find Aa from the Middle Saurian Marl; with respect to the centra, according to the juvenile sacrum of Find T from the Upper Saurian Marl.

The series of 50 vertebrae of Find no from the Upper Saurian Marl was used as the tail, as it obviously matched the size of Skeleton SS II [sic] well. The missing 1st vertebra was reproduced; in addition 4 rod vertebrae in plaster were added to the end of the tail. Nine haemapophyses from the same find were mounted, the missing [haemapophyses] in the anterior third of the tail reconstructed after those of Find Aa from the Upper Saurian Marl [sic]; those farther caudal were freely modeled. Since the caudal vertebrae from Find no frequently experienced a shape distortion to a considerable degree in the manner that, in connection with splitting and crystallization of calcium carbonate, a strongly distorting shrinkage, particularly on the centra, has set in, the caudal vertebral column, especially in the anterior half, appears much less solid than if it was preserved unaltered.

From the pectoral girdle, the left scapula, both coracoids as well as sternal plates from the foundation skeleton were mounted; the right scapula attached in plaster. The right forelimb is complete except for a carpal that was replicated from a smaller original; the three main bones from the left are present, the remaining elements reconstructed.

Of the pelvis, only the two pubes from Skeleton S II could be mounted as originals. For it and for the forelimbs, foreign original elements were inserted for numerous missing elements. The ilium from Locality Ma in the Middle Saurian Marl was used as the right ilium, the maximum length of which, 122 cm, should have an estimated 5 cm added, since the margin of the anterior wing is missing a strip about this wide. In size this ilium matches very precisely, since the calculation of the total length of the ilium of Skeleton S II amounted to 123 cm, if one takes as a basis the length of the fibula of S II as well as the fibula and the ilium of Find J from the Upper Saurian Marl. Furthermore, a foreign, incomplete right ischium was delivered by Find L in the Upper Saurian Marl. The total length of the ischium of S II was calculated at about 109 cm by using the dimensions of the ischium and pubis of Find J and the right pubis of S II. The left ischium was modeled after the right. Since the shaft of the right femur is missing for the most part, it was restored to a length of 196 cm, calculated from other finds. On the left, the 189-cm-long femur from Locality Ni, that certainly could be a few cm too short, was used. Tibia and fibula of the right hind limb were available; the former, shortened by compression, was lengthened to the measurement calculated from the fibula. The bone pair from Find Bo of the Middle Saurian Marl, which in size completely matches S II, serves as the left tibia-fibula. The two tarsals from Find Bo served as the pattern for the modeling of these elements that were missing in the main skeleton. From this skeleton in contrast, the metapodials and phalanges, mostly preserved only as fragments, together with numerous other isolated finds of smaller size, furnished the material for the quite complete reconstruction of the foot skeletons.

Position of the skeleton and its individual parts.

In the important and, as well known, strongly discussed question of the position of the limbs in the sauropods, I could already demonstrate my interpretation at the mounting of the skeleton of *Dicraeosaurus hansemanni* (1935). In the forelimb the humerus, with its unmistakable s-shaped curvature in uncrushed condition, and with its proximal articular condyle clearly directed against the dorsal side of the bone, displays characters that are similar to the conditions of the humerus of lacertilians, crocodylians and *Sphenodon*, even if pronounced to a lesser degree, which, however, show that, in the type of motion of the upper arm, a component of lateral splaying was included. Thereby it appears to me that, in adaptation to the enormous load, an on the whole upright position of the humerus is the correct one, particularly since the distal articular end would only offer a very insignificant support surface in a horizontal position. The columnar hand, characterized by the reduction of the fingers, [and] the plate-like carpal, declares compellingly for the vertical position of the long metacarpal and the lower arm.

The determination of the position of the shoulder joint in relation to the ribcage is particularly important for the erection of the skeleton. The sternal plates sat with their anterior ends at least as deep as the ends of the anterior ribs; probably even a bit deeper, since it may be assumed that the sternal ribs belonging to them sloped down somewhat medially. The sternal plates received a posteriorly descending inclined placement in the display, that could not be avoided if the ribcage was not to be directed even farther upward, and the dorsal vertebral column thereby receive an excessive and improbably strongly posteriorly inclined position. C. W. GILMORE (1930) found the scapula on the skeleton of *Camarasaurus lentus* of the Carnegie Museum attached in situ ascending weakly to the rear, not approximately vertical as in lacertilians. This determination is taken into account in the mount. A vertical orientation of the scapula would have caused an increased elevation of the anterior end of the dorsal vertebral column and exaggeration of the inclination. These deliberations about the inclination of the sternal plates and the scapula led to the determination of the position of the shoulder joint as the skeleton reconstruction shows.

It has become evident in the hind limb of the sauropods that an articulation of the femur in the hip socket is only possible that very closely approaches that of the proboscidians and other mammals, and that restricts a swinging of the femur to a sagital plane, or at least one that approached this plane. This type of motion conforms to the seating of the femur head and the distal articular surfaces. The foot, with its well-developed toes, could only have been plantigrade or at most, weakly semiplantigrade.

The position of the dorsal vertebral column is determined by the height of the shoulder joint and the hip joint as well as the position of the scapula in relation to the ribcage. In our Brachiosaurus it attained a pronounced ascent cranially. Since it cannot be assumed that the neck was carried stretched forward, that is in a pose that due to the enormous length and the weight of the neck would have enormously stressed the dorsal ligaments and the neurapophyses that bore them, the neck in the reconstruction is presented steeply ascendant. Only the anteriormost neck section is bent forward, so that the skull and its lower axis and the horizontal arch of the labyrinth are suspended horizontally. Observations in the genus *Camarasaurus*, related to *Brachiosaurus*, are also important for the estimation of the orientation of the skull on the neck. According to C. W. GILMORE's (1907, pl 13) illustration of the Marsh type example, which consists of the posterior cranial section and the first three cervical vertebrae connected with it, the cranial vault, that is, the surface of the frontals with the axis of the second and third cervical vertebrae forms an angle of about 55º, and I find [an angle of] about 60º between the cranial vault and the axis of the axis [epistropheus] in the illustration of GILMORE (1925), which the skeleton of *Camarasaurus lentus* (MARSH) in the Carnegie Museum exhibits.

Following the descent of the dorsal vertebral column to the rear, the sacrum has also received a strong inclination. The available sacra provide no information about whether the sequence of the sacral centra was bent concavely upward, as was found in numerous genera of sauropods, as in *Diplodocus* and *Dicraeosaurus*. But even if one assumes such a concave arching of the sacrum of *Brachiosaurus*, it cannot have been so strong that the adjoining anteriormost section of the caudal vertebral column had been oriented horizontally or nearly horizontally. Since none of the anterior centra are wedge-shaped, the tail undoubtedly immediately descended clearly from the sacrum onward. The skeleton of *Diplodocus longus* erected in Washington has received a horizontal, posteriorly directed orientation of the anterior tail section. C. W. GILMORE (1932, p. 9) states that this orientation is caused by the wedge-shaped form of the centrum of the 3rd caudal vertebra, which is much shorter above than below.

A greater ventral length of the centrum in the 1st and 3rd caudal vertebra is also unmistakable in the illustration of the skeleton of *Camarasaurus lentus* (MARSH) in GILMORE (1925, pl. 14), while the reconstruction picture on pl. 17, which depicts the anterior caudal section oriented almost rectilinearly horizontal, does not exhibit this characteristic. In this mount the tail first touches the ground at a considerable distance from the sacrum which is also the case in the skeleton of *Camarasaurus lentus* in the Yale Museum (R. S. LULL, 1930), the skeleton of *Dicraeosaurus hansemanni* in Berlin, and in GILMORE's reconstruction of *Apatosaurus louisae* HOLLAND (1936, pl. 34). In contrast, in *Brachiosaurus* the tail that descends sharply from the sacrum reached the ground at a relatively much shorter distance. The tail of *Brachiosaurus*, with its low neurapophyses, weak for a sauropod, was probably carried more strongly lowered and therefore somewhat divergent from the named genera.

In the graphic skeleton reconstruction that Frh. v. HUENE (1932, pl. 56, Fig. 2) gives of *Cetiosaurus oxoniensis* PHILLIPS from the English Oxford, which, like *Brachiosaurus*, even if to a lesser degree, is built tall in its forelimbs, the tail descends immediately from the pelvis onward, thus similar to the *Brachiosaurus* skeleton.

W. D. MATTHEW (1915) [sic] has given a reconstruction sketch of the skeleton of *Brachiosaurus*. It is based, according to the author's statements, on pieces from the Field Museum and the Berlin Museum, thus on both species *B. altithorax* and *brancai*. The entire appearance of the animal has turned out quite similar to that of the Berlin reconstruction; a difference is that the skull is not presented as angled against the neck, that the caudal vertebral column is somewhat shorter, initially proceeds less steeply downwards, but then from the 10th vertebra onward, descends even more strongly. However, for an alteration of the curve at this point there were no indications in the caudal vertebrae of *B. brancai*.

The orientation of the limbs of the skeleton depicts the following motion phases: the right forefoot is lifted from the ground, which certainly is not very distinctly pronounced, and is moved forward; the right hind foot begins to roll of the ground, to be lifted after setting down of the left forefoot, furthermore, it would, corresponding to the stride length apportioned to the rear limbs, be set down close behind the right forefoot.

For answering the question of how the limbs of the sauropods were positioned in life, the discovery of tracks from the Lower Cretaceous of Texas, about which R. T. BIRD (1939, 1941, 1944) reports, is therefore particularly important because through them it is unequivocally proved that the track width was narrow in them [the sauropods]; the rows of footprints have no more distance between them than the width of a single pace of the hind foot. In these trackways the stride length is admittedly somewhat smaller than in the *Brachiosaurus* reconstruction, in which it measures 2 m; further, in the former the track width is identical in the fore and hind limbs; in *Brachiosaurus* those of the rear are similarly small, those of the forelimbs in contrast, noticeably larger. This difference was produced as a consequence of the great length of the humerus in the mount. This greater width of the forefeet appears to me, however, not to be proved absolutely incorrect by the Texas trackways. In those, the impressions of the forefeet are smaller and shallower than the rear, so that a lesser load and thereby a lighter anterior body, and likely also shorter forelimbs, can be concluded. The significant length of the forelimbs in *Brachiosaurus* could very likely have caused the greater distance of the forefeet. That the impressions of the rear feet sit directly behind those of the forefeet agrees with our skeleton mount. As with the pace length, in our *Brachiosaurus* the width of the hind foot, with more than 80 cm, is also greater than in the trackways, in which they measure about 65 cm; their strikingly great length of almost 1 m could well be caused by sliding in soft ground.

The skeleton reconstructed on the foundation of the find S II still does not display the maximum size that *Brachiosaruus brancai* reached, despite its giant dimensions. This is demonstrated by the fibula from the Locality XV in the sandstone-like layers between the Middle and Upper Saurian Marl that, with its length of 133 1/2 cm, considerably exceeds the 118-cm-long fibula of Skeleton S II, and permits the conclusion of dimensions that were still at a minimum 10% larger.

I (JANENSCH 1938d) estimated the live weight of a *Brachiosaurus* the size of the skeleton reconstruction, based on more exact calculations, to be about 40 t. For the animal from which the large fibula originates, a 1/3 greater weight would be assumed.

The graphic reconstruction pl. 8 depicts the skeleton in orthoscopic projection and in nearly identical orientation and pose as the plastic reconstruction. The deviations and corrections that were performed are so insignificant that they do not deserve to be specially emphasized.

Dimensions.

The reconstruction of the skeleton of *Brachiosaurus* exhibits the following dimensions:

Length along the neural canal	22.46 m
Height to the cranial roof	11.87 “
Height in the region of the scapula	5.83 “
Length of the skull	0.77 “
Length of the neck along the neural canal	8.78 “
Length of the torso “ “ “ “	3.92 “
Length of the sacrum “ “ “ “	1.07 “
Length of the tail “ “ “ “	7.62 “

As for the length measurements of the entire skeleton and the tail it is to be noted that the last available caudal vertebrae were supplemented with a length of 26 cm in plaster, since vertebrae are likely missing from the end of the tail, the total number of which is not known. Since in the tail of *Brachiosaurus* the tendency toward significant length development is not pronounced, as it is expressed in the elongation of the vertebrae of the middle section in *Diplodocus* and *Apatosaurus*, it can also not be assumed that the tail of *Brachiosaurus* terminated in such a long, whip-like end, as in those two genera and that a significant number of rod-like vertebrae are to be regarded as missing and to be supplemented.

Literature.

BIRD, R. T. 1939 : Thunder in his footsteps. Natural History, 254–261. New York.
– – 1941 : A Dinosaur walks into the Museum. Ebenda, 74–81.
– – 1944 : Did *Brontosaurus* ever walk on Land? Ebenda, 61–67.
GILMORE, C. W. 1932 : On a newly mounted Skeleton of *Diplodocus* in the United States National Museum. Proc. U. S. Nat. Mus. 81, 1–21.
HUENE, Frh. v. 1932 : Die fossile Reptilordnung *Saurischia*, ihre Entwicklung und Geschichte. Monogr. z. Geol. u. Paläont. Ser. I, Heft 4. Leipzig 1932.
JANENSCH, W. 1935 . Ein aufgestelltes Skelett von *Dicraeosaurus hansemanni*. Palaeontogr. Suppl. VII, 1. Reihe. Teil 2, 299–308.
– – 1937 : Skelettrekonstruktion von *Brachiosaurus brancai* aus den Tendaguru-Schichten Deutsch-Ostafrikas. Z. d. geol. Ges. 89, 550–552.
– – 1938 a : *Brachiosaurus*, der gröβte sauropode Dinosaurier aus dem oberen Jura von Ostafrika. Forsch. U. Fortschr. 14, 140–141.
– – 1938 b : Aufstellung der Skelettrekonstruktion des *Brachiosaurus*. Aus der Heimat. 51, 124–128. Öhringen (Wűrtt.).
– – 1938 c : Vom Urweltriesen *Brachiosaurus*. Aus der Natur. 15, 1–4. Berlin-Lichterfelde.
– – 1938 d : Gestalt und Gröβe von *Brachiosaurus* und anderen riesigwűchsigen Sauropoden. Der Biologe. 7, 130–134.
LULL, R. S. 1930 : Skeleton of *Camarasaurus lentus*, recently mounted at Yale. Am. Journ. Scie. 19, 1–5.
MATTHEW, W. D. 1935 : Dinosaurs. Am. Mus. of Nat. Hist. 1935. Handbook Series No. 5.

Explanation of plates.

Plate VI.

Skeleton reconstruction of *Brachiosaurus brancai*, lateral view.

Plate VII.

Skeleton reconstruction of *Brachiosaurus*, view diagonally from the rear.

Plate VIII.

Graphic reconstruction of the skeleton of *Brachiosaurus brancai* in 1/30 nat. size.

Dorsal vertebrae of Brachiosaurus altithorax and Brachiosaurus brancai in posterior and lateral views, equally scaled, from Taylor (2009:fig. 1). A, B, E, F, I, J, M, N, B. altithorax holotype FMNH P 25107, modified from Riggs (1904:pl. LXXII); C, D, G, H, K, L, O, P, B. brancai lectotype HMN SII, modified from Janensch (1950a:figs.Â The skeleton in the figure is scaled to the size of the individuals in the Smithsonian and at UT Austin. The scale bar is 1 meter, which by my calculations gives that individual the following dimensions: Total length: 15.8 meters (52 feet). Giraffatitan brancai was first named and described by German paleontologist Werner Janensch in 1914 as Brachiosaurus brancai, based on several specimens recovered between 1909 and 1912 from the Tendaguru formation.[1] It is known from five partial skeletons, including three skulls and numerous fragmentary remains including skull material, some limb bones, vertebrae and teeth. It lived from 145 to 150 million years ago, during the Kimmeridgian to Tithonian ages of the Late Jurassic period.Â "The Skeleton Reconstruction of Brachiosaurus brancai": 97â€“103. Cite journal requires |journal= (help). ^ Colbert, E (1962). This reconstruction was done using the nearly complete neck of HMN SII, without including any of the proportionally shorter HMN SI material which is typically frankensteined onto it by Greg Paul and others.Â This long road of research and sweat from the development of a new restoration from all available data on all known specimens has revealed hundreds of errors in past scientific restorations of the skeleton.Â "Das Handskelett von Gigantosaurus robustus und Brachiosaurus brancai aus den Tendaguru-Schichten Deutsch-Ostafrikas".Â Taylor, M.P. (2009). "A Re-evaluation of Brachiosaurus altithorax Riggs 1903 (Dinosauria, Sauropod) and its generic separation from Giraffatitan brancai (Janensch 1914)."