

SHORT REVIEW OF THE PRESENT KNOWLEDGE OF THE SAUROPODA.

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THE Sauropoda are the hugest continental animals the earth has ever seen. They lived from the middle Jurassic to the Danian period of the uppermost Cretaceous. Much has been written about them, but nevertheless their natural classification and development do not yet appear in a desirable clearness. In this respect the immense size of the Sauropoda has been an obstacle.

The satisfactory excavation of such gigantic skeletons is difficult, and the preparation, which is still more important, needs trained, skilful men working for years. The scientific value of a skeleton is determined in advance by the degree of care by which, during the excavation, the original articulation or the original positions of the bones to each other in the rock is dealt with by sketch-plans in scale as to make sure specially the sequence of the vertebræ. Because of the failure of this in many cases, we still know so astonishingly little about the natural classification of the Sauropoda as a whole.

Most has been written and spoken on the North American Sauropoda. Too little has been done with the earlier Sauropoda. The knowledge of the Upper Cretaceous Sauropoda until now is quite insufficient. The large amount of Tendaguru Sauropoda at Berlin and the recent excavations of the Carnegie Museum at Pittsburgh have not yet been described; they will probably complete and alter our ideas of the development and classification of the Sauropoda.

The external appearance of the Sauropoda during Jurassic and Cretaceous times does not change much in general; that means, in their adaption and biology they are very similar to each other. Therefore it is necessary to judge from minor differences in the more conservative parts of the skeleton such as the neural parts of the skull and especially the vertebral column. These are the essential parts to deal with.

(1.) The *Family of the Cetiosauridæ* has been considered as the most primitive division of the Sauropoda. But they have to be divided into two families :—

(a) Subfamily **Cardiodontidæ** (Owen).

Teeth with sharp anterior and posterior edges and flat lingual face. Neural part of skull similar to *Plateosaurus*. Vertebral formula (in *Haplocanthosaurus*) 13 (?) cervicals, 12 dorsals, 5 sacrals consisting of 1 dorsosacral,

3 original sacrals and 1 caudosacral). Neural spines of presacrals undivided. Slight cavernosity of presacrals. Cervicals prolonged and opisthocœlous; dorsals short and opisthocœlous; caudals amphi- or platy-cœlous. Distal extremity of tail consisting of rod-like elements. Two sternal plates. Ilium without much of a posterior spine. Pubis broad plate in whole length. Ischium even distally fairly broad. Fore leg much shorter than hind leg. Leg bones solid. Fibula without prominent muscular attachment above middle of shaft. Long metacarpals and short metatarsals.

Middle and Upper Jurassic. The main genera are :—

Cetiosaurus (Owen). Middle Dogger, England.

Cetiosauriscus (Huene). Oxford Clay in England, Kimmeridge zone in Switzerland.

Haplocanthosaurus (Hatcher). Lowest part of Morrison beds, North America.

Dystrophæus (Cope). Lowest part of Morrison beds, North America.

Remarks.

Cetiosaurus has been described in many places. Compare mainly R. Owen: Reptiles of the Mesozoic Formations, Pt. II. in Palæont. Soc., 1875. See also J. Phillips: Geology of Oxford and the Valley of the Thames, 1871.

Cetiosauriscus for *Cetiosaurus leedsi*, A. S. Woodward: Proc. Zool. Soc. London, 1906, 232-243. Dorsal and caudal vertebræ much shorter than in *Cetiosaurus*, broad neural spines. Fore leg much shorter relatively than in *Cetiosaurus*. Low ilium and slender femur as in *Haplocanthosaurus*. "*Ornithopsis*" (?) *Greppini* (Huene) also belongs to this genus; see *Eclogæ geologicæ Helvetiæ*, XVII., 1, 1922, 80-94.

Haplocanthosaurus, see Hatcher: Mem. Carnegie. Mus., II., 1, 1903. Several vertebræ are missing and the present writer gives a different interpretation of the vertebral formula from Hatcher.

Dystrophæus, see Huene in: Neues Jahrbuch f. Min. etc. Beil. Bd. 19, 1904, 319-333.

(b) Subfamily **Brachiosauridæ** (Riggs).

Teeth similar to those in *Cardiodontidæ*. Skull relatively primitive (not yet described, from Tendaguru). Vertebræ more cavernous than in *Cardiodontidæ*. Neural spines of præsacral vertebræ undivided. 5 sacrals as in preceding group. Front leg nearly as long (*Bothriospondylus*) or longer (*Brachiosaurus*) than hind leg. Girdles similar to those in preceding group.

Middle Jurassic to Lower Cretaceous. The main genera are—

Bothriospondylus (Owen). Middle Dogger in England and Madagascar, Malm in England and France.

Pelorosaurus (Mantell). Kimmeridge in England and France, Wealden in England.

Brachiosaurus (Riggs). Upper part of Morrison beds in North America, Jura-Cretaceous-limit at Tendaguru.

? *Pleurocælus* (Marsh). Potomac, eastern North America.

Remarks.

Bothriospondylus. See specially A. Thevenin : Dinosauriens de Madagascar. Annales de Paléontologie, II., 1907.

Pelorosaurus, introduced 1850. The genus is identical with *Ornithopsis* (Seeley 1870) and *Dinodocus* (Owen). See the literature in A. S. Woodward and D. Sherborn : Brit. Foss. Vertebr., 1890.

Brachiosaurus, see mainly E. S. Riggs : Publ. 94 of the Field Columbian Museum, Geol. Ser. II., Chicago, 1904, p. 229 ff. W. Janensch : Uebersicht über die Wirbeltierfauna der Tendaguruschichten. Archiv. f. Biontologie, III., 1, 1914, p. 86.

Pleurocælus, see O. C. Marsh : Dinosaurs of North America, Papers Ann. Rep. Director U.S. Geol. Surv., 1895, p. 183-185, Pl. 40-41.

(2) Family **Morosauridæ** (Marsh).

Teeth similar to those of Cetiosauridæ. Skull relatively primitive, snout not flattened in front as it is in *Diplodocus*. Large nasal openings above the snout. Upper and lower jaw with strong teeth. Quadrate normally built. Deep infundibulum. Formula of præacral vertebræ not certain. 5 sacrals. Præacrals very cavernously built, far more so than in the Brachiosauridæ. Neural spines divided from 7th cervical to about 6th dorsal. Caudal centra relatively longer than in Brachiosauridæ, amphicelous; præacrals opisthocelous. Sternal plates similar to those in Cetiosauridæ. Pubis little narrower than in Cetiosauridæ. Fore legs much shorter than hind legs. Humerus broad and with very prominent Processus lateralis, comparable with Plateosauridæ. Fibula with slight prominent muscular attachment above middle of shaft.

Upper Jurassic. The main genera are :—

Camarasaurus (Cope). Upper Morrison Beds, North America.

Amphicælias (Cope). Same beds, North America.

Barosaurus (Marsh). Same beds, North America.

? *Gigantosaurus* (E. Fraas). Jura-Cretaceous-limit at the Tendaguru in former German East Africa.

Remarks.

Camarasaurus (= *Morosaurus*, Marsh, = *Brontosaurus*, Marsh) is here taken in the sense of Osborn and Mook : Mem. Amer. Mus. Nat. Hist., New Series III., Pt. 3, 1921; the species there described must be something quite different

from what Gilmore describes under the name *Camarasaurus lentus* (Marsh) with a skull like *Camarasaurus* and with the præsaclal formula: 12 cervicals, 12 dorsals, and 5 sacrals; see C. W. Gilmore:—"A nearly complete skeleton of *Camarasaurus*, a Sauropod Dinosaur from the Dinosaur National Monument, Utah." Mem. Carnegie Mus., X., 3, 1925, 347-384. This vertebral formula is certain as the skeleton was articulated; the number of cervical vertebræ is lower than in *Camarasaurus excelsus* described by Osborn and Mook, though the actual number of cervicals in that form is not known; this latter species also had probably less dorsals than the skeleton described by Gilmore. This demonstrates much uncertainty in the edifice of the natural classification of the Sauropoda. If "*Morosaurus*" *brevis* (Owen) belongs to that genus, it would also occur in the English Wealden.

Amphicælias, see in the mentioned Memoir of Osborn and Mook.

Barosaurus, see R. S. Lull: The sauropod Dinosaur *Barosaurus* Marsh, redescription of the type specimens in the Peabody Museum, Yale University. Mem. Connecticut Acad. Arts and Sci., VI., 1919, 1-42.

Gigantosaurus (E. Fraas, non Seeley), see W. Janensch, Uebersicht über die Wirbeltierfauna der Tendaguruschichten Archiv. f. Biontologie, III., 1, 1914.

(3) Family **Dicræosauridæ.**

Skull similar to *Camarasaurus*. Neural spines of præsaclal vertebræ higher and more deeply divided than in *Morosauridæ*. Vertebræ differently and less cavernous than in *Morosauridæ*; centra without pleurocæls. Short neck. Præsaclal formula not published yet.

Jura-Cretaceous limit. Only genus:—*Dicræosaurus* (Janensch). Jura-Cretaceous-limit at the Tendaguru in former German East Africa.

Remarks.

Dicræosaurus, see Janensch l.c. 1914. Posterior part of skull in: Pompeckj, Sitz. ber. Gesellsch. naturforsch. Freunde, Berlin, 1920, 3, p. 120, fig. 4.

Should perhaps the skeleton described by Gilmore as *Camarasaurus lentus* (see above) belong to this family? This is but a faint suggestion; the writer does not know.

(4) **Diplodocidæ.**

Numerous tack-like teeth. Skull much modified as compared with *Camarasaurus*. Nasal openings pushed up to the front. Situation of orbita very high. Snout low. Both pairs of temporal openings much pushed together. Quadrate ham-like in form. Longitudinal axis of skull broken. Very deep infundibulum. Neural part of skull high. Vertebral formula: 15 cervicals, 10 dorsals, 5 sacrals, amongst which 1 dorsosacral, as in all of the former families. Præsaclals very cavernous. Neural spines deeply divided from the 7th cervical to the 5th dorsal (the 6th is less divided). Also anterior caudals still

cavernous. Caudals amphicœlous. Extremity of tail consisting of rod-like elements. Distal hæmapophyses forming double lashes. Abdominal ribs existing. 2 sternal plates. Pubis narrower at distal end than in *Morosauridæ*. Fore legs much shorter than hind legs. Humerus broad with strong *Processus lateralis*.

Upper Jurassic. Only genus :—

Diplodocus (Marsh). Morrison beds of North America.

Remarks.

The most important descriptions of *Diplodocus* are by Hatcher: Mem. Carnegie Mus. I., 1, 1901. Holland: *Ibidem*, II., 6, 1905. Holland: *Ibidem*, IX., 3, 1924.

(5) Family **Apatosauridæ** (Riggs).

Essential characters same as in *Diplodocidæ*, skeleton more bulky. 15 cervicals, 10 dorsals, 5 sacrals. Following indications given by Holland this family will possibly become united with *Diplodocidæ*.

Upper Jurassic. The genera are :—

Apatosaurus (Marsh). Morrison beds of North America.

? *Uintasaurus* (Holland). Same beds of North America.

Remarks.

Apatosaurus, see mainly E. S. Riggs in Publ. 82 of Field Columbian Mus. Geol. Ser., II., 4, 1903, p. 165–196.

Uintasaurus, see J. W. Holland in Ann. Carnegie Mus., XV., 1924, p. 119–138.

(6) Family **Titanosauridæ**.

Numerous weak tack-like teeth as in *Diplodocus*. Also external form of skull similar to that genus. Longitudinal axis of skull broken. Upper orbital rim higher than middle of skull-roof. Both temporal openings shortly pushed together. Neural part of skull very high, snout low and broad. Basipterygoid processes shorter than in *Diplodocus*. Supraoccipital of specially primitive form as in *Morosauridæ*. Formula of the opisthocœlous præsacral vertebræ not known, but with a minimum of 12 and a maximum of 14 cervicals; in the same sense, 10–12 dorsals. 6 sacrals amongst which 2 dorsosacrals and 1 caudosacral, all firmly ankylosed. First caudal biconvex, the following caudals procœlous. Neural arch in middle and posterior caudals fixed only in anterior part of centrum. Extremity of tail consisting of rod-like elements. Two long narrow sternal plates. Coracoid rectangular. Pubis broad plate in whole length with small foramen. Fore leg shorter than hind leg. *Processus lateralis* in humerus only little prominent. Fibula with rather thick proximal extremity and very prominent muscular attachment above middle of shaft.

From Lower to uppermost Cretaceous. The genera are :—

Titanosaurus (Lydekker). Wealden to Danian, England, France, Transylvania, India, Madagascar, Patagonia, Brazil.

Laplataosaurus (Huene). Turonian to Senonian, Madagascar, India, Patagonia.

Argyrosaurus (Lydekker). Senonian, Patagonia.

Antarctosaurus (Huene). Senonian, Patagonia.

Macrurosaurus (Seeley). Cenomanian in England, Senonian in Patagonia.

Aepisaurus (Gervais). Aptian, Southern France.

Hypselosaurus (Mathéron). Danian, Southern France.

? *Alamosaurus* (Gilmore). Danian, New Mexico.

Remarks.

Titanosaurus, see R. Lydekker in *Palæontologia Indica* (Mem. Geol. Surv. Ind.) (4), I., 3, 1879, p. 20 ff. Lydekker: *The Dinosaurs of Patagonia*. An. Mus. La Plata, II., 1893. Also: *Quart. Journ. Geol. Soc. London*, 43, 1887, 156–160. *Quart. Journ. Geol. Soc. London*, 44, 1888, p. 58. Ch. Depéret in *Bull. Soc. géol. France*, (3), 24, 1896, 178 ff. Thevenin in *Ann. Pal.* II., 1897, p. 13–14. Depéret in *Bull. Soc. géol. France*, (3), 28, 1900, 107–108. Nopcsa in *Quart. Journ. Geol. Soc. London*, 79, I., 1923, 100–116. Nopcsa in *Mitteil. a. d. Jahrb. Ungar. Reichsanstalt*, 23, 1, 1915, p. 14–15.

Laplataosaurus and *Antarctosaurus* are new genera; they will soon be published in the *Anales del Museo de La Plata*.

Argyrosaurus, see Lydekker in *Mus. La Plata*, II., 1893.

Macrurosaurus, see mainly H. G. Seeley in *Quart. Journ. Geol. Soc. London*, 32, 1876, 440–444.

Aepisaurus, see P. Gervais: *Zool. et Pal. Françaises*, 1852, Vol. I., p. 263; Vol. II., *Explanation of Plates*, p. 8; Vol. III., Pl. 63, fig. 3–4.

Hypselosaurus, see Mathéron in *Mém. Acad. Imp. Sci. Marseille*, 1869, 1–39; and in *Bull. Soc. géol. France*, (2), 26, 1869. Nopcsa in *Quart. Journ. Geol. Soc. London*, 79, 1, 1923, 108.

Alamosaurus, see Ch. W. Gilmore: *A new Sauropod Dinosaur from the Ojo Alamo formation of New Mexico*. *Smithson. Miscell. Coll.*, 72, 14, 1922 (Jan.), 9, p. 1–9.

This short review demonstrates quite plainly, that in the families *Morosauridæ*, *Dicræosauridæ*, and *Apatosauridæ* our present knowledge of the *Sauropoda* still is quite insufficient. But there are hopes that this lack will soon be filled up.

Quite recently also Australia has begun to contribute to the history of the *Sauropoda* (H. A. Longman: *A giant Dinosaur from Durham Downs, Queensland*. *Mem. Queensland Mus.* VIII., 3, 1926, 183–194; *ibidem*, IX., 1927, pp. 1–18).