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# Results of Prof. E. Stromer's Research Expedition in the Deserts of Egypt

## II. Vertebrate Remains from the Baharîje Beds (lowermost Cenomanian)

### 3. The Type of the Theropod *Spinosaurus aegyptiacus* nov. gen., nov. spec.*

by

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## 3. The Type of the Theropod *Spinosaurus aegyptiacus* nov. gen., nov. spec.

Three km north of Gebel el Dist, thus in the plain at the base of the Baharîje Valley and in the deepest layer "7 p" (Stromer 1914, p. 28 and 29, fn. 1), out of a small hill, from a whitish-gray to yellowish, clayey, gypsum-free sandstone, below a cover of 30 cm ferruginous sandstone and 1 m of hard clay, in Spring 1912, the collector Markgraf excavated a number of remains, lying closely together, of a large theropod, namely the two mandibular rami without the posterior ends with a few teeth *in situ*, a ? left angular, a little piece of the left upper jaw, over a dozen individual teeth or tooth crowns, two cervical, seven dorsal, two and a half sacral, and one anterior caudal vertebrae, many incomplete ribs and lateral gastralia.

All these remains of brownish to gray color could be prepared out well, but in the washing many fell apart into many pieces, which had to be glued back together again with difficulty, and unfortunately many broken pieces became lost. Already in the stone much was deformed and shattered due to crushing, also the remains lay confusedly mixed. The skull seems to have been present, but due to its surficial deposition has been almost completely weathered away, since clearly the upper jaw piece shows the unmistakable character of weathering of a bone found on the surface and also the posterior ends of the mandibular rami, traversed by very many cracks, as well as the two cervical vertebrae, somewhat weathered especially in front, indicate a completely superficial disposition.

Of the girdle and extremity bones nothing at all has been found, so the skeleton would have been buried in an incomplete condition. In any case the soft parts were destroyed and with this the articulation of the individual bones was lost; many teeth, whose attachment was in part loosened on account of the replacement teeth pushing in, thereby fell out with their roots and all were confusedly mixed, thrown about either by scavengers or by flowing water. However, further transport of the remains, which show no trace of rolling and on which often very thin and fragile bone elements were perfectly preserved, certainly did not occur. Then in the stone the remains have suffered through compression, which clearly was more likely produced by displacement on account of the leaching of gypsum and salt than by tectonic processes.

Based on their position and preservation the remains belong to one individual, only the proportions in the sacral and caudal vertebrae make difficulties for this view, as is yet to be discussed in the description of these parts. In any case the jaws, teeth, and dorsal vertebrae suffice to characterize the form as new, which I will describe completely in the following, being sufficiently in contrast to all hitherto known dinosaurs.

### a) Mandible.

Taf. I, Fig. 6, 12 a, b and ? 3 a, b.

Only the dentary and splenial are preserved in natural articulation on both mandibular rami in a length of over 75 cm, and there is also perhaps an isolated left angular. The symphysis end is complete, the posterior part though is penetrated by very many cracks and at the edges is in part incomplete. On the right ramus it has apparently so considerably retained its natural form, but on the left it has been somewhat flattened from the side, since here the wall of the jaw canal for Meckel's cartilage is very thin. On the right ramus near the 5th alveolus there is present laterally a small pathologic thickening of the bone, clearly as the result of a healed wound. The bone sutures are in large part not certainly determinable due to the many cracks. The teeth, present only partially *in situ*, will be described separately at the end.

The sharp and almost straight anterior edge of the mandible descends ventrally and very little posteriorly in a length of 10 cm, the long ventral edge, preserved on the right in a length of 72 cm, continues for a stretch of about 15 cm straight posteriorly, but then it forms an arch, smoothly convex dorsally, whose highest point lies approximately below the 13th alveolus and whose posterior end, as far as is preserved, turns very gradually ventrally. The edge is in the middle and largest part broadly rounded, but narrower far forward and back, so that it becomes sharp-edged about 60 cm posterior to the anterior end.

The upper end is preserved 66 cm long on the left, 62 cm on the right. It forms an arch, dorsally convex up to the 6th alveolus, concave from there to the 12th, and then it clearly ascends posteriorly, just barely convex dorsally. On account of this the mandible is rather high anteriorly – up to 13.5 cm between the 3rd and 4th alveoli – but at the 7th alveolus only 9 cm, at the 15th already 15.5 cm and even, 10 cm behind this, 19 cm; it is thus relatively long and low and first becomes gradually high posteriorly. The breadth of the upper edge measures 5 cm between the 3rd and 4th alveoli, barely 3.5 cm at the 7th, and only 2.5 cm at the 15th, *i.e.,* the thickness of the jaw ramus decreases gradually toward the rear, which corresponds only in part with the changed size of the teeth. Medially along the alveoli follows a raised keel, which is sharp up to the 4th, but then becomes flattened and finally high and convex, and which rises above the alveolar part anteriorly by about 1 cm, then barely around 0.5 cm, but in the region of the 12th alveolus around 1.5 cm. It is provided with a longitudinal furrow directly laterally to the alveoli and is rough up to the 5th alveolus, then becomes smooth, and then proceeds, becoming gradually narrower and finally sharp, up to the posteriormost preserved part.

The smooth lateral side of the mandible is flat up to the 6th alveolus, then somewhat arched, especially in the lower third; behind the 15th alveolus it is arched here only, while clearly flat in the upper part. Along and also somewhat behind the anterior edge and along the upper edge up to the 6th tooth are present numerous small foramina, then to below the 15th alveolus in a flat channel, which extends 3-5 cm below the edge, still further in mostly larger irregular intervals. In *Dryptosaurus incrassatus* Cope according to Lambe (1904, Pl. 3) the distribution of these foramina is quite similar, but they are also still numerous in the posterior part below the alveolar rim; in *Tyrannosaurus* in contrast they are, according to Osborn (1912, Pl. 1), not present at the anterior rim.

The medial side would have been on the whole originally almost completely flat. Up to 3-4 cm behind the anterior edge it is rough, apparently on account of a not tight and very short symphyseal union, then completely smooth. A furrow, which would correspond to the so-called Meckel's furrow of *Tyrannosaurus* (Osborn 1912, Fig. 18 and 20), is certainly not present. About 12 cm from the front and 2.5 cm from below a small foramen appears to occur, above which the inner side on both sides is somewhat crushed in; the inner wall of the jaw canal is here thus apparently especially weak. 41 cm from the front and 1 cm above the convex ventral edge is a longitudinally oval fenestra of the canal for Meckel's cartilage, 13.5 cm in length and up to almost 6 cm in height, whose middle occurs below the gap between the 14th and 15th alveoli.

Here also the borders of the bones are clear, which in comparison with those of *Tyrannosaurus* (Osborn 1912, p. 22, Fig. 18) are easily understandable. Just as there the splenial (= operculare) at the lower edge of the fenestra forms a dagger-shaped point toward the front up to its middle, then the lower edge of this bone continues sharp-edged toward the back parallel to and a little below that of the dentary, but finally somewhat dorsally to at least 17 cm behind the fenestra. The well preserved posterior border of the splenial on the left mandibular ramus is very sharp, thin and weakly convex anteriorly and ascends dorsally and moderately anteriorly to a somewhat right-angled rounded upper corner, which occurs 14 cm behind the 15th alveolus. From here the thin upper edge seems to run rather straight anteriorly and moderately ventrally to about 7 cm in front of the fenestra, and from this anterior end on the lower edge runs horizontally posteriorly up to the anterior border of the fenestra. The course of this last border is yet uncertain, since longitudinal crack lines are confused with it. A supradentary seems to me not to be present, although somewhat in the position of the suture of the bone discerned by Osborn (1912, p. 24) in *Tyrannosaurus*, 2-3 cm under the alveolar border of the dentary on the right and left ramus, fracture lines run parallel to it. For the exclusion of a presplenial, as Lambe (1914, p. 11 and 15, Pl. 3 and 5) would have found in *Dryptosaurus*, there occurs here scarcely a clue.

On the outer side of the lower jaw the lower posterior end of the large long dentary is clearly not preserved, yet by comparison with *Tyrannosaurus* (Osborn 1912, Pl 1) very little would have been broken off on the right ramus, so that it may have been in its entirety somewhat over 80 cm long. A part of the upper posterior edge is, especially on the right ramus, well preserved as a straight, thin, but rounded edge, which is drawn out from back to front and moderately upward to the 15th alveolus; 9 cm from this however it appears to run jaggedly upward, to reach the upper edge of the jaw 6.5 cm behind it. Consequently, from the surangular on the right mandibular ramus there would still be preserved a small little piece of the upper edge. Supposing this latter is correct, then the upper edge of the dentary would be 60 cm long and on the assumption of similar length ratios as in *Tyrannosaurus* the now missing posterior part of the lower jaw would be yet over 60 cm, the total length of the mandible thus would be over 120 cm. It must indeed be remarked that if the dentary of *Tyrannosaurus* is relatively much higher than in the present form, then also its proportions could have been very different. In any case, to me, the length of the dentary and the small lateral upswing of its posterior part still preserved on the right ramus seem to prove that the two mandibular rami diverged little from the short symphysis on, and that they belonged to an animal with a longer and narrower snout.

It is noteworthy how thin and weak the posterior ends of the dentary and splenial are. In this region Meckel's cartilage must have formed the most essential connection of the anterior half, so strong anteriorly in its bony parts, and the posterior half of the jaw.

Only with the greatest reservation can I interpret as a component of this posterior half, perhaps the left angular, an asymmetrically constructed, flat and elongated bone (Taf. I, Fig. 3 a, b), which in its preservation and according to the place where it was found belongs just here. It is incomplete at the end, at least 25 cm long, at one end somewhat over 8 cm high, at the other broken end 5 cm high, but in the middle scarcely 4 cm high, here at the lower edge 0.8 cm thick, at the upper edge and at the higher end very thin, at the other end under 0.6 and over 0.2 cm thick. The upper edge is correspondingly sharp, especially in the higher half of the piece, likewise also clearly so was the edge at the end of this, at which it is scarcely much broken off, while it cannot be said how much is missing at the other end. The lower edge, finally, is rounded and in contrast to the higher end becomes too sharply keeled and bowed a little toward the inside.

The piece is somewhat laterally bent in the longitudinal direction, and also at the high end a little bent in the vertical direction, its smooth outer side is correspondingly arched, of course from the middle on up to the lower end in the upper part somewhat concave. The inner side is flat to flatly concave and smooth; only along the ventral edge do clear furrows run, which begin near to the lower end, up to the thin end.

Clearly after all it can only have to do with a part of the skull or lower jaw and the furrows medial to the ventral edge indicate the overlap of another bone, while ventrally on the lower edge, clearly also on the upper edge as well as to the thin end no other bone so closely affixed itself.

In size and form now a comparison seems to me to lie nearest to the left angular of *Tyrannosaurus* (Osborn 1912, Pl. 1), since it also, in contrast to that of other dinosaurs is overlapped only conspicuously little, close to its anterior end, on the inner side. In the present piece one must exactly accept that is was restricted as well as completely to the lateral side of the mandible. Its thin end would then come up close to the likewise thin posterior end of the dentary, on the upper edge it would have affixed itself to the surangular and in the furrows internally to the lower edge of the prearticular (= goniale of Gaupp).

In order to clarify the systematic position of the present form and to place many of its peculiarities in the proper light, it appears indicated to compare the individual skeletal parts with those of other genera, above all with those of similarly built Theropoda. Unfortunately there are only too many genera, often already established a long time ago, which are insufficiently known or inadequately described.

The mandibles of *Megalosaurus bucklandi* Meyer (Owen 1857, p. 20 ff., Pl. 11, Fig. 1, 2), *Megalosaurus bradleyi* (Woodward 1910, Pl. 13), *Streptospondylus cuvieri* (Phillips 1871, p. 320; Nopcsa 1906, Fig. 9, p. 69),[1] *Allosaurus agilis* (Osborn 1906, Fig. 2, p. 286) and *Ceratosaurus nasicornis* (Marsh 1896, Pl. 8; Hay 1908, Fig. 3, 4, p. 361, 362) all differ strongly from the present in their simple slender form – *Megalosaurus* also in its very low anterior end. The mandible of *Tyrannosaurus rex* (Osborn 1912, Pl. 1) and *Dryptosaurus incrassatus* (Lambe 1904, Fig. A, B, p. 25) possess clearly a rather high dentary, but even here a particular heightening in the anterior end with a lowering following behind it is lacking. The present dentary appears thus very particularly specialized in this, and characteristic. *Antrodemus* Leidy (= *Labrosaurus* Marsh) seems, in the toothless symphyseal region, specialized in another aspect, in the form of the dentary it is not dissimilar (Marsh 1896, p. 263, Pl. XIII, Fig. 2-4).

As far as the individual bones of the mandible of the Theropoda are concerned, the descriptions differ so strongly from each other in this regard, that clearly not insignificant differences are accepted, but apparently also errors are present. My findings regarding the dentary, splenial and the very questionable angular (p. 5 and 6), as was already mentioned, can be brought into agreement best with those of Osborn (1912) in *Tyrannosaurus rex*, but I can distinguish no supradentary, the splenial reaches less far in front of the inner fenestra and the ? angular is apparently completely restricted to the lateral side. Lambe (1904, p. 15, 16, Fig. A, B, p. 25), in *Dryptosaurus*, leaves a long low presplenial reach still further anteriorly than in *Tyrannosaurus*, and the angular broadens right on the inner side, but already Hay (1908, p. 363) remarked that he clearly misleads regarding the angular and the posterior end of the dentary and Huene (1914, p. 70, 71, Fig. 2-5) established the statement regarding the presence of a presplenial as the confusion of these bones. Hay (*loc. cit.*), in *Ceratosaurus*, lets the splenial cover almost the whole inner side in front of the inner fenestra and it reaches nearly up to the symphysis. Finally, according to Woodward (1910, p. 113), in *Megalosaurus bradleyi* the angular knocks up against the dentary below an outer fenestra in a V-shaped suture, but further back according to his figure it could be similar to that of *Tyrannosaurus* and to that of the present specimen.

[11] Nopsca's (*loc. cit.*) figure legend leaves much to be desired, since the designations in the figure and in the text are not comparable.

On the basis of my inadequate specimens I can scarcely do more than make note of these relationships. Naturally it would also lead too far to go into the homology of the individual parts of the reptilian mandible, a question addressed recently especially by Gaupp, Watson and Williston, but still in no way conclusively clarified.

### b) Skull.

There is only a 20 cm long straight piece of an alveolar border with the remains of 4 tooth alveoli preserved, in the second of which still is found one crushed tooth fragment. On no mandibular ramus is an alveolar piece missing, the premaxilla was certainly not so straight and scarcely so long, thus it can only represent a part of the maxilla and clearly the left, since the alveoli are directed a bit obliquely ventrally and anteriorly. A comparison of this so wretched piece with jaws of other dinosaurs is naturally not worth it.

### c) Dentition.

Taf. 1, Fig. 5, 7, 8, 9, 10 and 11.

As far as the position and number of teeth are concerned, this is established without doubt only in the mandible. There are 15 alveoli preserved in each ramus (Taf. 1, Fig. 6 and 12 b), indeed in the left 4 cm behind the 15th there is apparently yet a 16th. But since in the right ramus such a structure is certainly absent and a transverse break goes through here, it clearly represents only an artifact produced by preparation. Indeed the tooth number can vary by about one, since Osborn (1912, p. 26) in two individuals of *Tyrannosaurus* found 13 or 14 lower teeth, but here we have to deal with an asymmetric occurrence of a 16th tooth. The tooth row is thus 52.5 cm long.

The alveoli all stand thus rather vertical, the 1st-9th as well as the 10th and 11th rather close, since their separating walls are only about 1 cm thick, but the others are further from each other; then the separating walls between the 9th and 10th, 11th and 12th, as well as the 12th and 13th are approximately 2 cm thick; that between the 13th and 14th 2.5 cm and that between the 14th and 15th indeed 3.5 cm thick (Taf. I, Fig. 12 b). The posteriormost alveoli follow themselves thus in ever greater distances. Especially they become from the raised inner edge of the jaw (p. 4) so towering-up that it is reminiscent of pleurodont implantation of teeth. The anterior alveoli are circular, the 3rd as well as those behind a little longitudinally oval, the 15th clearly longitudinally oval. Their size and concomitantly that of the teeth is strongly different. The diameter increases namely from the 1st, where it scarcely measures 2 cm, quickly up to the 4th of over 3.5 cm, the 5th measures under 2 cm, the 6th-10th indeed only about 1.3 cm, the 11th-14th have long diameter 2.5-3 cm, the 15th rather only 2.5 cm. The transverse diameter of the 13th and 14th alveoli is about 2 cm, that of the 15th only 1.3 cm. The heterodonty in tooth size is thus very clear, in which the 2nd-4th teeth, which are greatly enlarged as canine teeth and stand in the raised part of the jaw, after intervention of the 5th tooth a row of 5 unusually small teeth follow in the lower section of the jaw (6th - 10th), then again a row of 4 larger ones (11th-14th) and finally a smaller one more strongly laterally flattened.

The teeth have almost all fallen out, which is related in part to the fact that the replacement teeth are in the act of replacing. On the right indeed only on the inner side of the 13th alveolus is the little tip of the replacement tooth visible, on the left but not exposed in the same position in the 6th, 12th, and 13th alveoli, rather reaching almost up to the upper edge of the alveolus in the 8th and 14th. Aside from small roots and 4 teeth *in situ*, 15 isolated teeth or tooth crowns are present, whose position and assignment to the upper or lower half of the dentition in part is not accomplished with certainty. For the sake of clarity, their measures are gathered together in the table on page 11.

All teeth are pointed awl-shaped, scarcely to very slightly recurved, and in cross-section mostly almost circular, only a few somewhat longitudinally oval. Their roots are very long, rather straight and in the upper part thicker than the crowns. Their enamel is in general smooth, only at the base is it sometimes finely vertically streaked and so finely wrinkled that one sees it only with the magnifying glass. In front and behind, where the enamel reaches more widely at the base than elsewhere, there is present almost regularly a smooth sharp keel. The pulp cavity of the adult tooth is very narrow and the enamel is very thin, the keels are also impressed on the dentine.

The crown of the 1st left tooth (Taf. I, Fig. 7 a, b, c), as well as the corresponding one on the right, is unfortunately so broken by preparation that it can no longer be attached well to the root sticking in the alveolus. It is relatively small, in cross-section almost circular, curved anteriorly and provided only with a very slight keel, but straight posteriorly and with a clear keel.

The crown of the 3rd left and 4th right tooth, found *in situ* (Taf. I, Fig. 12 a, b) is straight, anteriorly and posteriorly keeled in equal measure and somewhat longitudinally oval in cross-section at the base. It is about twice as high and at the base twice as long but not fully twice as thick as that of the 1st tooth. That of the 2nd tooth, as can be determined from the alveolus, was about equally as large as the 3rd and 4th but at the base scarcely longer than thick.

The 5th tooth, as can be determined from the alveolus, might have been a little smaller than the 1st. An isolated tooth crown with still wider pulp cavity, therefore of a still young tooth, may belong just here. It is scarcely arched backward and medially, anteriorly and posteriorly keeled and has a clearly longitudinally oval base.

Still much smaller must have been the 6th-10th teeth. There occur also 2 almost complete teeth (Taf. I, Fig. 5 a, b, c) and one crown, which correspond to these alveoli. Their crowns are laterally and anteriorly more convex than medially and posteriorly, thus very little arched medially and posteriorly, provided anteriorly and posteriorly with a keel and in basal cross-section almost circular. The root is much higher than it, a little arched, provided with quite flat vertical furrows and thickest in the upper third.

The 11th tooth may have corresponded in size with the 5th, the 12th, *in situ* on the right (Taf. I, Fig. 12 a, b), has a quite straight crown with a somewhat longitudinally oval basal cross-section and clear keels. The 13th and 14th were rather similar to it, the 15th was however somewhat smaller and basally certainly more longitudinally oval. Some of the individual teeth should belong just here, but none belong to the 15th alveoli. Except for the crown of a grand tooth, whose pulp cavity is still wide, there are namely two rather large crowns present, which could belong to the 12th to 14th teeth.

Further teeth preserved with their roots are uncertain with regard to their place. Most of them should be uppers, since their roots are too long (high) for the corresponding places of the mandible. According to the preserved teeth there is at the most one difference from the lower teeth, that the uppers are for the most part curved very little more medially and posteriorly. Further the probability is very great that also the upper dentition was clearly heterodont in size and spacing and the piece of the maxilla mentioned on page 7 gives us at least somewhat positive evidence on this latter. Its alveoli had to have approximately 2.5 cm longitudinal diameter, the first preserved separating wall was about 1.5 cm, the second 2 cm and the third clearly almost 3 cm thick, a possible fourth even over 3.5 cm. Thus there is established, as in the posterior part of the dentary, an increase of tooth distance, and it probably relates to the alveolar section of the left maxilla with the teeth which gripped in between the 11th-14th lower teeth.

Of the individual teeth, the two largest preserved with roots (Taf. I, Fig. 8, 9) should have been opposed to the 2nd through 4th lowers, thus clearly they belonged to the premaxilla, which, based on their roots, must have been very high. The smaller of these, namely according to its form, could have stood below only on the left, but since here the roots are still stuck in the 2nd-4th alveoli, it can only belong dorsally on the right and as the other according to its size could have been opposed only to that tooth. Its almost straight crown is in cross-section somewhat longitudinally oval and has in front and behind a similar clear simple keel as all further teeth. The almost straight root, which is also indeed much higher than the crown and which increases in circumference up to the upper third then gradually decreases, is clearly somewhat crushed, but in cross-section had been very clearly longitudinally oval, and in the lower part provided with a few smooth vertical furrows.

Whether a part of the small tooth described on page 9 belongs to the upper dentition unfortunately cannot be determined. Several larger teeth, which correspond in their size to the alveoli of the posterior piece of the maxilla, are present. One of these lay so in the rock that it was opposed to the 12th of the right mandibular ramus; it belongs indeed by its form in the left upper jaw, one of very similar form and similar size, which belongs to the opposite side, lay by the left lower jaw. Apparently then the position of the fallen-out teeth in the rock indicates nothing of their original position, as should have been assumed, since also large skeletal pieces have been laid extremely confusedly among each other.

The two mentioned teeth (Taf. I, Fig. 11 a, b, c), which correspond in their size to the 12th lower, differ from it in that their crowns are slightly medially bent and anteriorly convex. Its cross-section is very slightly longitudinally oval, its root is somewhat more the same. It shows some smooth vertical furrows and in the more complete right tooth medially at the basal part an indentation of the replacement tooth, its lateral side is more arched than the medial.

A very slightly larger ? left upper tooth differs from these in that its crown is almost straight and in cross-section a little more longitudinally oval. One crown shaped like this, but clearly smaller, with only a remnant of the root should belong accordingly to the upper left. Finally there is present a ? upper left tooth (Taf. I, Fig. 10 a-c), which agrees with the last mentioned tooth in size, whose complete root is not compressed and whose crown is damaged only posteriorly and at the tip. Its crown is laterally and anteriorly clearly more arched than medially and posteriorly, but yet is curved very slightly toward medial and posterior. The cross-section is also very slightly longitudinally oval in the upper part of the root which is more strongly arched laterally than medially. In the basal part the root is in cross-section clearly longitudinally oval, ornamented laterally and medially with two or three smooth vertical furrows and so damaged medially above the lower end by the pressure of the replacement tooth that the narrow pulp cavity lies free.

Measurements of the Teeth in mm.

| tooth | total height | crown | | |
|---|---|---|---|---|
| | | height | basal cross-section | |
| | | | longi-tudinal | trans-verse |
| 1st lower left (Fig. 7) | – | ca. 30 | 15 | 14 |
| ? 1st ? lower right | – | ? 30 | 15 | 14 |
| 3rd lower left | – | 70 | 28 | 20 |
| 4th lower left | – | – | ? 32 | ? 28 |
| 4th lower right | – | 64 | 28 | 24 |
| ? 5th ? lower right | – | 22 | 14 | 10.5 |
| ? 6th-10th ? lower right | – | – | 10.5 | 9 |
| ? " ? lower right | – | – | 10.5 | 10.5 |
| ? " ? lower left (Fig. 5) | 65 | 19 | 10 | 9.5 |

| | | | | |
|---|---|---|---|---|
| 12th lower right | – | 42 | ca. 20 | ca. 15 |
| ? 12th-14th ? lower | – | 40 | 20 | 16 |
| " lower | – | over 35 | 19 | 15 |
| " lower | – | ? 52 | 22 | 20 |
| ? 2nd-4th upper right (Fig. 8) | over 170 | 68 | 30 | ca. 23 |
| ? " upper left (Fig. 9) | over 230 | 85 | 34 | ? 24 |
| ? 12th ? upper right (Fig. 11) | over 125 | 47 | 20 | 17 |
| ? 12th ? upper left | over 110 | 49 | 21 | 18 |
| ? 13th-14th ? upper left | over 128 | 52 | 22 | 18 |
| " ? upper left (Fig. 10) | 138 | 41 | ? 19 | 17 |
| " ? upper right | – | 40 | 18 | 15 |

Among the dinosaurs only the theropods come into question for comparison. They possess however normally laterally compressed teeth, whose clearly recurved crowns have in front and in back a finely serrated keel.[2] The number of teeth above and below apparently varies somewhat as a rule, and seems often to waver between 12 and 20, their form and size as well as their spacing in a species seem to be in general rather similar, only note that the posteriormost teeth are smaller.

*Megalosaurus bradleyi* possesses, according to Woodward (1910), above 4 teeth in the premaxilla and apparently 18 in the maxilla, below at least 17 teeth should have been present; in any case more than in the present mandible. Most of the teeth are typical stately theropod teeth, but the anteriormost are small and similar in their slight lateral compression as well as in their slight recurvature to the present teeth, yet they possess posteriorly a pronounced keel. In the original of *Megalosaurus* Meyer, in *M. bucklandi*, there is nothing to note of this sort of difference of the anteriormost teeth from the posterior teeth (Owen 1857, Pl. 11, Fig. 1, 2).

*Streptospondylus cuvieri* H. v. M., according to Phillips (1871, p. 320) and Nopcsa (1905, p. 290), should have very *Megalosaurus*-like teeth – Huene (1908, p. 330) would unite the two genera, which in my opinion is not justified based on the strong difference of the vertebral centra. In his detailed letter (1906) Nopcsa unfortunately says nothing at all about the dentition, but according to the piece of the snout figured by him (*loc. cit.*, Fig. 9, p. 69) the same sort of teeth are present in similar spacing; only the 9th above seems much less recurved and twice as large as the others, yet this may only be a mistake of the draftsman and the great height may be a simulation on account of the slippage of the root out of the alveolus.

*Dryptosaurus* (*Laelaps*) *aquilunguis* Cope (1869, p. 101, Pl. X, Fig. 5, 6) has typical theropod teeth; almost nothing is known about their number and placement. *Dryptosaurus incrassatus* according to Lambe (1904, p. 9 and 11) possesses below 14, but in the upper jaw 12 very similar teeth, and below at the very front yet one more small posteriorly flattened tooth (*loc.*

[2] The Triassic *Plateosaurus* seems, according to newer discoveries, to have more relationship to the Sauropoda than to typical Theropoda; its numerous, straight, laterally compressed and (on the keels of the crown) denticulate teeth do not come into question for comparison with the present teeth.

*cit*. p. 11, Pl. 3). *Ceratosaurus nasicornis* has, according to Marsh (1896, p. 158) 15 teeth below, but 4+15 above, and *Allosaurus agilis* according to Osborn (1912, p. 28, Fig. 26) has even only12 below, yet above likewise 4+15 apparently similar teeth. Finally, *Tyrannosaurus rex* according to Osborn (1912, p. 26, 27, Pl. I, Fig. 20, 21, p. 23) possesses below 13 to 14, above 4+12 typical theropod teeth, which clearly show some differentiation in form and size, but not in their separation.

The form described by me thus falls well in line among the theropods named here in tooth number, and was apparently, as they, a predator whose enlarged lower 2nd through 4th teeth and their upper opponents served the roll of canine teeth, while the small teeth following behind might correspond in their significance to the weak anterior molar teeth (gap teeth) of some Carnivora. But in the special simplicity of tooth form they stand apart from the normal theropods and the named differentiations in the size as well as in the separation of the teeth speaks for a certain specialization among the theropods.

### d) Vertebrae.

Since the sequence of the vertebrae is not certainly established and their number even less so, I have designated them in the presumed sequence with letters. Their measurements are summarized in the table on a later page.

#### 1. Cervical Vertebrae.

Taf. II, Fig. 1 a, b and 2.

Vertebra "a", which is dorsoventrally compressed, whose arch is separated from the centrum and whose left postzygapophysis is shoved dorsally, and vertebra "b", which is laterally crushed, but in contrast to the other is rather completely preserved up to the prezygapophyses, are certainly cervical vertebrae.

The centrum is about twice as long as wide, thus clearly elongated, anteriorly clearly convex, posteriorly just as concave, therefore typically opisthocoelous. Ventrally and laterally it was apparently concave, these lateral depressions correspond to the pleurocentral holes of Nopcsa (1906, p. 61, Fig. 1, p. 63). The ventral surface is transversely convex without a crest, the thin edge of the posterior concavity is however laterally and ventrally ornamented with numerous longitudinal ribs. Above the parapophysis, a longitudinally oval opening, over 2.5 cm long and more than 1 cm high, leads into the apparently hollow interior of the centrum. Whether a funnel-shaped pit lying behind this and a further one which lies immediately behind the parapophysis also open into the interior of the vertebra, I can not determine; in any case they would have represented only small foramina.

The thick short parapophysis projects below the middle of the height of the centrum directly behind the arched anterior end of the centrum about 2.5 cm laterally and a little dorsally and ends with a blunt rough surface, and thus clearly possessed a cartilaginous union with the cervical rib.

The neural arch, united by a suture with the centrum, forms apparently a simple high arched roof, which ascends posteriorly. The neural canal is about as high as wide, highly arched and remarkably narrow. Its floor is formed in large part by the medially broadened pedestals of the pedicles of the neural arch. The posterior edge of the pedicel is somewhat concave, the anterior edge clearly only slightly so. On the latter a channel continues anteriorly from the neural canal through a lateral opening of the pedicle, probably for the spinal nerve, ventrally to the centrum down in front of the diapophysis. Dorsally however from out of this foramen of the pedicle a canal seems to continue posterodorsally within it, yet on account of crushing, the numerous breaks and the partial weathering of the surface of the vertebra especially on its anterior end, details about this cannot be established.

The diapophysis projects in the anterior half of each pedicle a little above the body and extends ventrally, somewhat laterally and posteriorly. It is dorsoventrally flat and completely smooth above laterally. Its end is missing, yet it was apparently short, its sharper anterior end should have proceeded dorsally below the prezygapophysis.

Of the prezygapophyses there is only one *in situ* on vertebra "a", the other is preserved broken off. According to this they project strongly anterolaterally and somewhat dorsally in front with longitudinally oval and scarcely arched articular surfaces, which face dorsally somewhat medially and posteriorly. Even longer, especially in "a", are the postzygapophyses, which to conclude from the apparently uncrushed left one of vertebra "a", project posteriorly, modestly laterally, and somewhat dorsally and whose longitudinally oval and smoothly concave articular surfaces face ventrally, somewhat laterally and a bit posteriorly. On them sit remarkably strong, thick and, especially in "a", posteriorly projecting epapophyses, from whose upper edge a thin high keel rises up dorsally, moderately anteriorly and medially to the posterior edge of the processus spinosus. These keels roof over, in "a", a very deep and broad, in "b", a nevertheless crushed together niche, which occurs above the neural canal between the postzygapophyses and whose roof in "a", but not in "b", possesses a median keel on its underside. This niche, reaching in "a" to above the neural canal anteriorly, just as the above mentioned canal in the pedicle, would appear also to provide the neural arches with hollow spaces.

The processus spinosus in "a" is apparently formed completely differently than in "b". Specifically, in "a" it arises along the whole length of the roof of the neural arch and of the niche and probably projects posteriorly somewhat dorsally, yet it is broken off over the posterior end of the mentioned niche. Its vertical blunt and rough anterior edge rises up only about 3.5 cm high, the upper edge, which is rough and blunt only in the anteriormost part, then becomes thin and sharp edged, then stands up posteriorly somewhat dorsally. In "b" in contrast the processus spinosus rises up rather vertically in general on the posterior half of the neural arch roof and was clearly about 18 cm high and 8 cm broad and truncated dorsally. Its damaged anterior edge apparently stood up from the anterior end of the roof dorsally somewhat posteriorly, then first as the posterior edge vertically. This is simple, blunt, and about 8 cm over the posterior articular surface.

What position the two cervical vertebrae occupy is difficult to say. To conclude from Plate 9, Fig. 2 and 4 in Marsh (1896), where vertebrae of *Ceratosaurus*, similar especially in the neural spines, were figured, but not more closely described, one could see in "a" the epistropheus, in "b" a cervical vertebra lying further posteriorly (6th). Also the neural spine and the postzygapophysis of the epistropheus of *Plateosaurus* are, according to v. Huene's figures (1907-8, Taf. 10, Fig. 2 a, 2 d, and Fig. 283, p. 280), similar to those of "a". The anteriorly strongly weathered centrum of "a" was in its form not in conflict with this interpretation, also not the well developed strong prezygapophyses, since the atlas of the dinosaurs took care to have well constructed postzygapophyses; yet the size of the prezygapophyses arouses concern. Therefore I might see in "a", only with reservation, the 2nd cervical vertebra, in "b" a middle one.

*Streptospondylus cuvieri* stands closest to the described form in its convex-concave and similarly elongated centra of the cervical vertebrae, but according to Nopcsa (1906, p. 61 ff., Fig. 1 and p. 70, Fig. 10, 11) possessed much deeper pleurocentral holes, ventral ridges on the middle cervical vertebrae and a posteriorly strongly projecting lower edge. The vertebrae figured by him (Fig. 1 and 11) show also no epapophyses; they certainly belong in the posteriormost cervical region according to the form of the diapophysis.

The very little known cervical vertebrae of *Megalosaurus* (Phillips 1871, p. 200, Fig. VIII, 4-6 and Lydekker 1889, p. 44, Fig. 2), by their insignificant elongation and the absence of a clear anterior convexity of the centrum, differ as clearly from those present before me as from those of *Streptospondylus* that I do not comprehend how Huene (1908, p. 330) could unite the latter genus with it. *Ceratosaurus nasicornis* has, according to Marsh (1896, p. 159), likewise on the centra anteriorly scarcely a swelling, in addition it has a ventral median keel and a keel extending from the diapophysis to the postzygapophysis, but according to the figures of the epistropheus (*loc. cit*., Pl. 9, Fig. 2 c, e), exhibits similarities with vertebra "a" in the form of the spinous process, in the possession of strong postzygapophyses thickened by epipophyses, and a posterior niche between them, as well as in the elongation of the centrum. Finally, *Tyrannosaurus rex* clearly has on the 2nd through 4th cervical vertebrae apparently likewise strong epipophyses

(Osborn 1906, p. 287, Fig. 3), but the neural spines of the middle cervical vertebrae are weak, and the centra only slightly opisthocoelous and above all very short.

The cervical and trunk vertebrae of *Antrodemus* Leidy (=*Poicilopleuron* Leidy, = Labrosaurus Marsh) should be distinctly opisthocoelous (Marsh 1884, p. 337; Leidy 1873, p. 267-269, p. 338, Pl. 15, Fig. 16-18) and contain hollow spaces in their interior, but the hitherto most highly insufficient descriptions of the remains of *Antrodemus* unfortunately do not permit closer comparison with those of our form.

### 2. Free Trunk Vertebrae.

Taf. I, Fig. 17-19 and Taf. II. Fig. 3-6.

Seven further vertebrae "c"-"i" are more or less damaged by loss of some parts and by crushing, especially on their diapophyses. Especially "g" (Taf. II, Fig. 4 a, b, c, d) is in this respect instructive, since its neural arch is shoved posteriorly and dorsally on the here uncrushed centrum; onto the middle of the anterior edge of its spinous process is pressed a part of the posterior edge of the vertebral centrum "i" (Taf. II, Fig. 6) and the upper part of the spinous process is transversely wavily curved. Only in "f" (Taf. 2, Fig. 3 a, b) is the neural arch still in natural articulation, in "g" less certainly, in "h" and "i" (Taf. II, Fig. 5 a, b and 6) very probably associated, while in "c", "d", "e" (Taf. I, Fig. 17 - 19) the centrum has unfortunately been lost.

The preserved centra are in their proportions and form little different among each other and from the two described cervical vertebrae, yet those of "c" and "d" should clearly have been shorter than the others, since here the neural arches are shorter. The preserved centra are clearly elongated, somewhat higher than wide, anteriorly moderately convex, in "g" slightly convex, posteriorly clearly concave, on the relatively thin edge of this concavity ventrally externally somewhat ribbed longitudinally, in "g" also on the anterior edge laterally and below a little so, but otherwise completely smooth without processes, keels, articular surfaces or foramina. In contrast to the cervical vertebrae they are internally not hollow, but likewise below and laterally, especially laterally far above, strongly concave, *i.e.* their pleurocentral pits (Nopcsa 1906, p. 61 ff.) are deep and very wide. Therefore they offer dorsally the pedestals of the neural arch only anteriorly and posteriorly broad rough articular surfaces, in the middle of the length however only very narrow ones, *e.g.* in "g" (Taf. II, Fig. 4 c, d) these are anteriorly 9.5 cm, in the middle only 5.5 cc wide. The vertebral centra are thus pinched in, *i.e.* they have an hourglass shape when viewed from above or below.

The neural arches are clearly regularly rather completely preserved, at least in "c", but mostly somewhat crushed. They are always highly arched and relatively narrow, the anterior and posterior edge of their pedicles are indented, the latter is sharply keeled, the former however is so only in "i", otherwise it is very broadly rounded. The narrow neural canal seems to have been originally dorsoventrally oval. Its arch is formed primarily by the medially broadened pedestal of the pedicle, yet it is a little sunk into the dorsal side of the centrum in the midline.

The diapophyses, unfortunately usually somewhat crushed or displaced and only in "c", "d", "e" and "h" at least on one side almost complete, otherwise broken off close to their base, appear to project in the normal way toward the side, a little to somewhat dorsally and a little posteriorly, and to jut out from the neural arch in the middle of the length and in the middle of the height of the postzygapophyses and clearly sticks up, as often in dinosaurs, from three support lamellae, namely one horizontal thin which unites the pre- and postzygapophyses, and one each from the lower anterior and from the lower posterior edges of the pedicle obliquely to the ventral side of the diapophysis. Below each diapophysis therefore there occur three approximately triangular deep funnel-shaped pits between these support lamellae. While the sharp edge of the horizontal lamella continues into the anterior and posterior edges of the diapophysis, the two oblique buttresses, mostly a little rounded on their edges, unite into an arched thickening of the under side of the diapophysis.

In "c" the part of the horizontal lamella forming the prezygapophysis is very broad, also likewise apparently well developed, in "f" and especially in "g" though only narrow, but the oblique buttresses in "i" (Taf. II, Fig. 6) are much weaker than otherwise, also approach each other, which latter is also the case however in "c" and "d". In "f" and "g" (Taf. II, Fig. 3 a, 4 b), certainly not in "d", "h" and "i" and apparently not in "c" and "e", the anterior buttress possesses about in the middle of its length an obliquely oval arched thickening, which gives the impression of a small articular head. It corresponds certainly to the somewhat more deeply lying thickening on the same buttress of *Megalosaurus*, which Owen (1855, Pl. 29 p) designated as parapophysis, without commenting that normally the articulation for the capitulum of the rib is yet larger and above all concave.

The diapophyses in "c" are rather long and seem to become somewhat shorter on the following vertebrae, provided that the sequence of vertebrae determined by me is correct. They are 5 - 6 cm broad, but apparently broaden toward the end (to 8 cm), dorsally flat to shallowly arched, dorsoventrally flat, but ventrally in its middle generally thickened. On the transversely truncated end, which unfortunately is never completely well preserved, they are provided with a somewhat rough, scarcely concave and ventrolaterally facing surface, which one must interpret as the articular surface for the tuberculum costae. In "i" (Taf. II, Fig. 6) the broken off diapophyses were formed certainly clearly differently from this norm, since its anterior edge was clearly moderately sharp, but its posterior edge not so dorsoventrally flat and sharpened as otherwise, but rather rounded, so that the width of the transverse process here measured only 4 cm.

The only moderately large prezygapophyses, both broken off in "c", otherwise often somewhat incomplete and crushed, project anteriorly somewhat laterally and somewhat to a little dorsally not to in front of the anterior end of the centrum and arise very close together, but are usually separated by a cleft. From their underside a keel extends ventrad posteriorly, in "i" to the anterior edge of the pedicle, otherwise to the middle part of the anterior oblique buttress lamella of the diapophysis, so that in the vertebrae "c" - "h" the anterior diapophyseal pit has a marked anterior border. The oval smooth articular surface faces dorsally and moderately medially or dorsomedially and somewhat anteriorly.

The also only moderately large postzygapophyses – in "i" both are present only in remnants, otherwise rather well preserved – arise likewise closely together and are united to a kind of hyposphene, similarly as Phillips (1871, p. 202, Fig. LIX, 5) figured in *Megalosaurus*, except that this union is restricted to the ventralmost part directly over the neural canal, while the upper parts are separated by a narrow cleft (Taf. II, Fig. 5 b) in contrast to the complete union in *Megalosaurus*. They project ear-shaped posteriorly and slightly laterally to a little behind the posterior end of the centrum. From its surface a keel rises up dorsally and a little medially to the posterior side of the spinous process. Its oval articular surfaces are flat to shallowly concave, face laterally and ventrally or laterally and moderately ventrally and are on vertebrae "c" to "e" smaller than on "f" to "h". Only in "g" are the concave articular surfaces on either side still discernible at the hyposphene, they are separated by that surface.

The spinous process is highly remarkable by its size and form and partly also by its orientation. It rises up usually to many times the vertebral height, namely to three to eight times, if one measures about 20 cm height for the centrum with its neural arch, and it is on the last vertebra "i" about twice as high and wide as on the first "c". On "c", "d" and "e" it is very clearly anteriorly inclined, on "f", "g" and "h" however only a little in ever decreasing degree, in "i" finally it is indeed a little posteriorly inclined. It arises on the entire length of the neural roof, then broadens rapidly and again narrows likewise, only to broaden again very gradually toward the end. Its posterior edge, which far ventrally is double edged, is then rounded and here rather often ornamented with a shallow channel (Taf. II, Fig. 4 a and 5 b), continues far below in "c", "d", "e" and "h" clearly, in "f", "g" and "i" only a little toward the back convex and is in "h" and "i" ornamented toward the back with a small corner and then rather straight, but the rounded anterior edge continues ventrally usually clearly toward the front convex and is in the upper posteriorly running part sharp edged, then likewise rather straight, then rounded and finally sharp edged. All neural spines are laterally flat and on the sides flat and rather smooth, only in "d" and still more in "c" is the lower half of the slender part somewhat arched, so that here the thickness measures up to 3 cm, but otherwise only about 2 cm. It decreases dorsally very gradually (Taf. II, Fig. 3 b), so that the upper end is very thin. This is generally truncated with rounded corners, but of somewhat varying form, in "g" and "h" it is of course so much broken off, that it can not be reconstructed with certainty. In "c", "d" and "e" the anterior edge is dorsally very little toward the front convex and the end is truncated from anterior below to posterior above, in "f" the posterior edge is above more swung toward the front than the anterior edge and the upper end is bounded simply high convex, in "h" and still more in "i" finally the anterior and posterior edge above is swung a little anteriorly and at least in "i" seems to continue the truncation of the end from anteroventral to posterodorsal.

Above all due to the incomplete preservation of the centrum and of the transverse process the correct sequence of the described seven vertebrae can hardly with certainty be established. In any case clearly "c", "d" and perhaps also "e", likewise again "f" and "g" follow immediately; in total they yet form no closed series, since especially "i" differs in its transverse process, in the buttresses of the diapophyses and prezygapophyses and also in its neural spine strongly from the others.

For establishing the order, I used first the condition of the neural spine, primarily its orientation and height, and second the rib articulations. According to the form of the neural spines of course "h" must connect up with "c", "d" and "e", which posteriorly bears, as does "h", but in contrast to "f", "g" and "i", in the lowest part of its posterior edge a clear convexity; but according to its height "h" can not belong between "e" and "f", nor can it belong between "f" and "g" on account of the lack of the parapophyseal tuberosity on the neural arch.

I might place "i" close in front of the sacrum, since: first, neither on the centrum nor on the neural arch is there present an articular place for the capitulum so that the rib could only have articulated to the diapophysis; second, the spinous process in its lowermost part resembles that of the 1st sacral vertebra (Taf. I, Fig. 16 c), which apparently was likewise posteriorly inclined; and third, it is especially high. In dinosaurs the neural spines in and in front of the sacral region tend to be posteriorly inclined and at their highest. Nevertheless "h" is closely associated with "i" in that only at the end of its diapophysis is an articulation for the rib present and in that its spinous process is very high and only very little anteriorly inclined and below at the posterior edge has a small corner; I therefore recognize in "h" one of the posterior thoracic vertebrae with single headed ribs and in "i" a lumbar vertebra. "f" and "g" must array themselves further forward in the thoracic region, since the little knob on the anterior oblique lamella below the diapophysis, as was mentioned on pages 15 and 16, should correspond to a parapophysis. Therefore of course as in *Megalosaurus* the capitulum costae must have a concave, rather than a convex, articular surface of remarkably small size.[3] Small concave rib heads are in reptiles something of a great rarity and

[3] One needs only compare the otherwise similar thoracic vertebrae of *Plateosaurus poligniensis* in Huene's illustrated work (1908, Taf. 27, Fig. 6) with its large concave articular surface on the anterior oblique buttress of the diapophysis!

in the ribs present before me the small head is always broken off; but that in dinosaurs such rib articular ends were present is proven by the remark of Riggs (1903, p. 177) about the "trough like fossae" on their mesial surfaces in the sauropod *Apatosaurus*.

"c", "d" and "e" possess no articular place for the capitulum costae on the neural arch or on their transverse processes, they could have been present on the unfortunately unpreserved centra, therefore deeply positioned, as is the case on the anterior thoracic vertebrae. Their spinous process becomes on the anterior vertebrae lower and ever more strongly anteriorly inclined. The latter condition has never yet been observed in dinosaurs to my knowledge and is a generally very uncommon condition. In dinosaurs the anterior neural spines tend to be vertical or slightly posteriorly inclined and lower than the presacrals, which are often somewhat posteriorly inclined, while in mammals in the trunk region the anteriormost neural spines are the highest and the most posteriorly inclined, the posteriormost are anteriorly inclined or vertical and at most moderately high. The Permian pelycosaur *Edaphosaurus*, to which my colleague Broili most graciously called my attention, shows however not only likewise extraordinarily high neural spines but also the anterior ones are anteriorly inclined and anteriorly curved.

It is noteworthy that the centra of these probable anterior thoracic vertebrae, as determined from the length of the neural arch roof, must have been shorter than the posterior free trunk vertebrae, which is also the case in two specimens of *Streptospondylus* (Nopcsa 1906, p. 80), as well as also in most of the mammals. Finally it is exceptional that the diapophysis of the anteriormost thoracic vertebra is a little longer than on the one lying behind it, while normally the reverse is the case.

A comparison of these free trunk vertebrae with those of the other theropods provides similar results as that of the cervical vertebrae. *Streptospondylus* c*uvieri* (Nopcsa 1906, p. 71, 72, Fig. 12, 13) shows similarity namely also here in the elongated, pinched-in and opisthocoelous centra as well as in the buttressing lamellae of the diapophyses, but also shows clear differences. Since the centrum of the posterior free thoracic vertebrae are anteriorly not arched, there also rises up a lamella of the diapophysis to the neural spine, which to all appearances offers nothing special in form, size and direction, and the hyposphene seems to be constructed more completely than I found it.[4]

*Megalosaurus bucklandi*, according to Phillips (1871, p. 201, 202, Fig. LIX), has shorter, very slightly opisthocoelous vertebral centra and likewise a better constructed hyposphene, but seems to have possessed very high neural spines and diapophyses similar to the present vertebrae. Provided that the vertebrae from the Wealden which Owen (1855, Pl. 19; 1857, p. 5, 6) assigned to this species really do belong to the same species or even to the same genus, then not only the

[4] Nopcsa (1906, p. 72, Fig. 13) speaks of a zygosphene, but this lies above the prezygapophyses of procoelous vertebrae.

diapophyses but also the parapophyseal tuberosities are constructed as in the vertebrae described here, but the neural spines are comparable only in size, since they stand vertically, have a simpler form and show strong roughenings for ligament and muscle attachments.

*Ceratosaurus*, *Creosaurus* (Marsh 1896, p. 160, Pl. 9 and 11) as well as *Tyrannosaurus* (Osborn 1906, p. 288, 289, Pl. 39) clearly differ greatly in the shortness of their vertebral centra, which are not swollen anteriorly, and in the small height of the vertical or slightly posteriorly inclined neural spines, their transverse processes have not been described; the first genera should have a hyposphene articulation, but *Tyrannosaurus* does not.

In any case the vertebrae lying before me stand in contrast in the size, form and orientation of their spinous process to those of other theropods. But in a notable way, very high neural spines on the free trunk vertebrae are already known in three dinosaur groups, namely in the above mentioned Upper Jurassic to Lowermost Cretaceous theropod *Megalosaurus* (Owen 1855, Pl. 18, Phillips 1871, Fig. LX, p. 203), the Uppermost Jurassic sauropod *Dicraeosaurus* Janensch (1914, p. 101 ff.) and the Upper Cretaceous ornithopod *Hypacrosaurus* Barnum Brown (1913). In all these, however, they stand vertically or slightly posteriorly inclined, in which it must be borne in mind that one knows well only the posterior free trunk vertebrae in *Hypacrosaurus* and only the anterior ones in *Megalosaurus*. Now while the neural spines of these two genera are rather simply formed, *i.e.* laterally flattened and having rather straight-line borders anteriorly and posteriorly, those of *Dicraeosaurus* are most highly peculiar in their midline cleavage and in the rotation of their flattening. Those lying before me are already in their form, especially in the broadening of their lowermost and uppermost part, somewhat unusual, but in their orientation they stand entirely unique not only among the hitherto known dinosaurs, but also in general among the tetrapodous vertebrates only a few have comparable forms, as already mentioned on page 18.

The significance of the oversized neural spines is not easily established with certainty. They could hardly have served for attachment of a powerful muscle mass. Of course in the bison the special height of the anterior neural spines of the thoracic region is correlated with the development of very strong neck muscles and of an uncommonly strong neck ligament[5] and it could have been similar in Owen's (1855, Pl. 19) *Megalosaurus* from the Wealden. In the present form however, already the smoothness of the lateral surfaces and the weakness of the upper ends contradict this, also here the largest neural spines are in the lumbar region, where it is difficult to envision a reason for such an unusual development of dorsal trunk musculature. With this naturally the meaning should not be given expression that strong interspinous muscles and

[5] Herr Inspector Küsthard of the Royal Zoological Collection, who has prepared a bison, most kindly wrote to me that the high withers consisted in general of a mass of muscle and were overlaid only with a thick layer of subcutaneous fat.

ligaments, as well as lateral longitudinal muscles, were not present, but rather only that they were not so powerfully developed so as to require the unusual size of the neural spines.

Rather, one could think of the presence of a large hump of fat, to which the processes gave an internal buttress.[6] In herbivores, such as the above-mentioned *Hypacrosaurus* or in the graviportal sauropods such as *Dicraeosaurus* such a structure could be assumed, in a carnivore such as *Megalosaurus* and the described form however such an assumption is extremely improbable.

Presumably we are here dealing only with the supports of a very high, narrow dorsal crest, yet it is remarkable that the spinous process is so heavily and massively built, since its interior is not comprised in any way of porous spongiosa, but rather of dense bone and very fine-meshed spongiosa.

Such high dorsal crest buttresses occur frequently in recent Lacertilia, *e.g.* a *Lophura amboinensis* present in the royal skeleton collection has rodlike, very high, posteriorly inclined neural spines on the anterior caudal vertebrae. *Chamaeleo cristatus* (Case 1909, p. 979, Fig. 1) is comparable even in detail. Here namely the vertical, then somewhat posteriorly inclined, neural spines become ever higher from the epistropheus to the 8th vertebra, then again lower to the 10th caudal vertebra, first after this very small. The lowermost parts are a little broadened for attachment of the trunk musculature, above this almost only a ligament web binds the neural spines, at the very top increases to a strong longitudinal ligament. One can also assume similar relationships of the soft parts for our form, especially that the trunk muscles deployed themselves very strongly only on the lower broadened parts. From the figure however still special similarities occur in that the 7th and 8th neural spine is at least in the upper part a little anteriorly bent and the 7th through 13th gradually broaden toward the top.

Also for this reason the presence of a dorsal crest is assumed for the Permian Pelycosauria such as *Edaphosaurus*, *Naosaurus*, *Dimetrodon* (Case and Williston 1913, p. 80). Also I consider this much more probable than the view of Abel (1912, p. 171-173), accepted by Jäkel, that it had to do with separated dorsal spines, even if the crest might have been possessed of horny denticulations and spines. Also the unusual orientation of the neural spines is associated with the form of the crest in *Edaphosaurus* and the present anterior thoracic vertebrae.

Movement of the vertebrae with respect to each other must cause great oscillation at the ends of the high neural spines and thus could lead to tearing of the soft parts at those places. It is therefore certainly of significance that this movement was very greatly reduced by the construction of hyposphenes on the present vertebrae; especially lateral movements could certainly occur only in very small measure. Similar devices for reducing movement of vertebrae

[6] The hump of fat of the camel and the zebu of course possesses no such buttress of elongated neural spines.

are also demonstrated in a portion of the other fossil genera which are distinguished by very high neural spines. It would be of interest to examine whether they are also encountered in the pertinent recent Lacertilia. In *Lophura amboinensis* in any case there is neither a hyposphene nor a zygosphene. These types of restriction-joint devices are therefore not absolutely necessary.

## 3. Sacral Vertebrae.

Taf. I, Fig. 16 a, b, c.

Of three fused vertebrae, there is unfortunately missing a part of the middle piece of the second and the posterior half of the third centrum, also the uppermost part of the centrum including the neural arches and their processes have been almost completely destroyed by weathering up to the lower part and the base of the first neural spine. Therefore the three pieces can no longer be joined to each other.

The centra in general bear the characters of the preserved free trunk vertebrae. The first is clearly just as high, but shorter and narrower, the anterior surface is indeed approximately dorsoventrally oval with the greatest width in the upper third and very slightly swollen. The lower and the lateral surfaces of the clearly elongated vertebra are completely smooth, transversely arched, but concave in the longitudinal direction, as well as in the upper third of the sides especially concave (pleurocentral pits!), but above this especially anteriorly again convex. A lateral blunt process anterodorsal to the first sacral vertebra is apparently the base of the anteriormost transverse process, which projects laterally only 1.5 cm, but is 5.5 cm long; otherwise these parts are unfortunately weathered away. As the broken places in the middle of the second and third vertebrae prove, the interior of the centrum is filled by close-meshed spongiosa, a deep irregular cavity in the anterior part of the first centrum thus probably originated only by weathering. The second and third centra are apparently a little smaller than the first, but the same as it in total form.

The preserved neural arch piece should belong to the first vertebra, to which it is suited in its length (about 13 cm); it is intimately united with a small remnant of the following arch. Only the lateral crushed roof of the neural canal is preserved, without transverse and articular processes. It was apparently highly arched and possessed, under the base of the neural spine on either side, a posteriorly continuing horizontal ridge.

## 4. Caudal Vertebra.

Taf. I, Fig. 1 a, b.

One last vertebra "n" is almost complete and nearly uncrushed up to the ends of the diapophyses and of the spinous process. Its centrum is scarcely half as long as those of the free trunk vertebrae, but a little higher and anteriorly as wide as high, not fully so posteriorly, thus clearly longer than those vertebrae. It is therefore clearly shorter and wider, but only somewhat higher than the sacral vertebrae. In contrast to all previous vertebrae, furthermore, the anterior almost circular end surface is distinctly concave, the posterior one is a little dorsoventrally oval but only very slightly concave. On it an artificial hole is present, which leads into an irregular hole in the middle of the centrum, which probably is likewise artificial, but its production was probably assisted on account of the especially porous spongiosa. The diaphysis of the centrum is as in the previous centra pinched in, *i.e.* longitudinally concave and transversely convex as well as smooth, except on the longitudinally grooved anterior and posterior edges, but on the lower edge of the posterior end surface two projections are present, which possess a rough surface facing posteriorly and somewhat ventrally, apparently for the attachment of a chevron.

The suture between the centrum and the neural arch cannot be seen clearly. This is low and broad and arises on the whole length of the vertebra. The rounded anterior edge of its pedicle is scarcely concave, the broad posterior edge somewhat so.

The neural canal is, especially anteriorly, broader than high, clearly lower and a little broader than on the free trunk vertebrae.

The side of each pedicle is completely taken up by the origin of the stout diapophysis, except that anteriorly there is on this a funnel-shaped pit; ventrally and posteriorly this base is massive in contrast to that of the free trunk vertebrae. The diapophysis is dorsoventrally flat, but in the proximal half dorsally concave, ventrally arched, its anterior edge moderately thin, the posterior dorsally thickened up to 12 cm of its length. It projects, without noticeably decreasing its breadth of 5.5 cm, toward the side, yet the anterior and posterior edges seem to swing extremely slightly backward. The end is missing.

The prezygapophyses, whose bases arise above the diapophyses and are separated by a median pit, project dorsally moderately forward and somewhat laterally to in front of the end of the centrum. Their dorsoventrally oval smooth articular surfaces face medially and moderately dorsally.

The postzygapophyses, separated by a median cleft, rise up likewise above the bases of the diapophyses and project ear-shaped laterally and a little posteriorly. Their dorsoventrally oval, smooth facets face laterally and ventrally. A hyposphene-like lower part is completely lacking. From their upper edge runs a keel medially and somewhat dorsally to the side of the base of the posterior edge of the spinous process.

This rises up on the whole length of the neural arch roof as a laterally flat, about 1 cm thick and moderately high process, rather vertically. Its blunt anterior and posterior edges appear a little bowed toward the posterior and its breadth decreases dorsally only a little. It is thus in its simple form and in its orientation strongly different from that of the free trunk vertebrae and of the first sacral vertebra, but is similar therein to that of the cervical vertebra "b" (Taf. II, Fig. 2).

According to its total form, especially on account of the possession of chevron articulations, in "n" we are undoubtedly dealing with the anterior caudal vertebra of a dinosaur. According to its place of discovery and its preservation condition it belongs to the described remains. The strong difference in the neural arches and their processes and above all in the shortness of the centrum and the form of its end surfaces do not contradict its assignment, since *e.g.* also in *Streptospondylus* the free trunk vertebrae are clearly opisthocoelous and elongated, but an anterior caudal vertebra is anteriorly more concave than posteriorly and clearly not as short as here, but still shorter than any. (Nopcsa 1906, p. 74 and 80). Very characteristic however is that the centrum is broader and higher than in the sacral vertebrae. The possibility has not been eliminated that vertebra "n" came among the other remains belonging to one individual on account of blurring; naturally it could in spite of this belong to the same species, and comes only from a larger specimen.

Similar proportions and form of the centrum are had by a caudal vertebra of the Triassic *Plateosaurus poligniensis*, which v. Huene (1908, p. 81, Taf. 29, Fig. 1) considered the second, while he assigned a slightly more elongate one further posteriorly. Also in mammals the anteriormost caudal vertebrae are often very short, the middle ones very elongated.

But the relatively small size of the neural spine in contrast to that of the posteriormost free trunk vertebrae can also arouse hesitation. One must accept that on the sacral vertebrae and the first caudal vertebrae the size of this process decreased very rapidly, and with that also the presumed dorsal skin crest becomes suddenly extremely small or ends altogether. An analogy to this occurs in the *Chamaeleo cristatus*, already brought in on page 20, where the high neural spines and the dorsal crest suddenly end on the 10th caudal vertebra.

Of undoubted anterior caudal vertebrae of *Megalosaurus* there has been extremely little described (Owen 1857, p. 12; Phillips 1871, p. 207, Fig. LXII). According to this the amphicoelous centrum is relatively longer than in the present vertebrae, namely as long as wide and with that a little shorter than the not long free trunk vertebrae. *Streptospondylus cuvieri* however has according to Nopcsa (1906, p. 74) anterior caudal vertebrae whose centra are likewise anteriorly more deeply concave than posteriorly and which also in their lateral and ventral surfaces as well as in the possession of posterior processes for chevrons compare to the present vertebrae, but they are somewhat elongated and their neural arches are unknown.

The elongated caudal vertebrae of *Poikilopleuron bucklandi* Deslongchamps (1838, p. 74 ff., Taf. 2), which according to Hulke (1879, p. 233 ff.) is to be united with *Megalosaurus*, but according to v. Huene (1908, p. 327) possibly belongs in a different family, comes from a region lying so much farther posteriorly, that a comparison is impossible. The described caudal vertebrae of *Dryptosaurus* (*Laelaps*) *aquilunguis* Cope sp. (1869, p. 101-103, Pl. 8, Fig. 2, 3; Pl. 9, Fig. 4 and Text-figure 30) are likewise amphicoelous and ventrally transversely convex as well as pinched in, but clearly elongated and their neural spines are small and longitudinally elongated; they almost all belong to the middle caudal region. In *Ceratosaurus* according to Marsh (1896, p. 160, Pl. 9, Fig. 6) one anterior amphicoelous caudal vertebra is clearly longer than one free trunk vertebra (P. 9, Fig. 6), finally in *Tyrannosaurus* Osborn (1906) unfortunately says nothing about the caudal vertebrae.

Consequently *Streptospondylus* offers also here the most similarity among the certainly very little comparable forms. The particular shortness of the present vertebra needs to have no greater significance than this, since, as mentioned on page 23, in long-tailed mammals the anteriormost caudal vertebrae are often very short and the vertebral length then rapidly increases up to the middle caudal vertebrae. That our form possessed a strong and long tail must however be accepted from the above, and is also proven by the size of the neural spine of the lumbar vertebra and of the first sacral vertebra as well as by the dimensions of the preserved caudal vertebra.

## Measurements of Vertebrae in cm.

| vert. | vertebral centra | | | foramen vert. | | postzyg | diapo- | spin. proc. | |
|---|---|---|---|---|---|---|---|---|---|
| | greatest length | height ant. | width ant. | height ant. | width ant. | over cent.[7] | physis length | height | width in middle |
| cerv. a | ? 19 | ? | ? 10 | ? 2 | 2.2 | ? | – | – | – |
| " b | 18.5 | ? 10 | > 7 | ? 2 | ? 2 | ca. 8 | > 5 | > 17 | > 6 |
| dors. c | — | – | – | – | – | > 8 | 16.5 | 73 | 5 |
| " d | – | – | – | ? | ? | 8 | 15 | ca. 95 | 6 |
| " e | – | – | – | ca. 3.5 | 3.9 | 7.5 | 13 | ca. 119 | 8.5 |
| " f | 19.5 | 13 | 10 | 4.4 | 3 | 8.3 | – | 130 | 7.5 |
| " g | 17 | 13 | 11.5 | ca. 3.5 | 3.3 | 8.3 | – | > 130 | 9.5 |
| " h | ca. 19 | 12.5 | 10 | 3.5 | 3.5 | ? 7 | 12 | > 139 | 9.5 |
| " i | ca. 21 | ca. 11.5 | ca. 10 | ca. 4 | 3.4 | – | > 7.5 | ca. 165 | 11 |
| sacr. k | 15.5 | 12 | 9 | – | – | – | – | > 20 | – |
| " l | > 13 | 10.5 | 7.5 | – | – | – | – | – | – |
| " m | > 9 | 9.5 | > 7 | – | – | – | – | – | – |
| caud. n | 9 | 13.5 | 13.5 | 2.2 | 3.7 | 7 | > 16 | > 21 | 6.3 |

## Measurements of the Thoracic Ribs in cm.

| | total length | length of neck | 1.5 cm below tuberculum | |
|---|---|---|---|---|
| | | | width | thickness |
| Rib a | over 40 | over 6 | 4.4 | 1.4 |
| " b | far over 45 | " 9 | 3.3 | 3.3 |

[7] This is the measured distance of the middle of the posterior edge of the postzygapophysis from the upper rim of the vertebral centrum.

| | | | | |
|---|---|---|---|---|
| " c | over 83 | " 10.5 | 3.2 | 3.3 |
| " d | " 55 | – | 4.2 | 2.8 |

### e) Thoracic Ribs.

Taf. I, Fig. 13-15.

Remains of the cervical ribs are unfortunately not present, and of the thoracic ribs only a few more or less complete ones are present. The articular ends are all damaged and the ventral ends missing. Three forms are present.

1. A two-headed small right rib "a" (Taf. I, Fig. 14) is simply curved and possesses a long neck, quite circular in cross-section, and a somewhat set off tuberculum. It is completely flattened ventral to it, in the ventral fragment however, which on account of the loss of an intermediate piece can no longer be attached, it becomes below again circular in cross-section. It apparently represents an anterior thoracic rib.

2. Two large right ribs, "b" and "c", (Taf. I, Fig. 15) and a small piece below the tuberculum of a left rib have likewise only a simple rather strong bending and a long neck. But this is flattened from front to back, the tuberculum projects very little and ventral to it the cross-section is primarily triangular with rounded anterior and medial keels and sharp posterolateral keel, whereby the lateral and anterior sides are somewhat arched, the back side smoothly concave. Then the cross-section becomes approximately transversely oval and finally almost circular. They are middle thoracic ribs.

3. One single-headed large right rib "d" (Taf. I, Fig. 13) with oval tubercular end is, below this, primarily as the former ones ventral to the tuberculum, then it becomes somewhat longitudinally oval in cross-section and finally somewhat transversely oval. It can only represent a posterior thoracic rib, since the normal thoracic ribs of dinosaurs are exclusively two-headed. The vertebra "h" (Taf. II, Fig. 5) possesses only one articulation at the end of the diapophysis on either side corresponding to this rib and in "i" (Taf. II, Fig. 6) this was clearly also the case, if "i" actually bore ribs.

Of the two-headed thoracic ribs of *Megalosaurus bucklandi*, which Owen (1857, p. 12, 13, Pl. 4, Fig. 2, 3) described and figured, Fig. 3 compares in general to my Fig. 15 (Taf. I), but the long neck and shaft is clearly different in cross-section. Also Phillips [sic] (1871, p. 204, 205, Fig. LIX, 6, 7) described two-headed ribs of this type, which differ from the present ribs in that the neck forms almost a right angle with the less curved shaft. Yet this difference could be founded on the fact that the ribs belong to a different part of the trunk.

Of *Poikilopleuron bucklandi*, numerous rib pieces are described and figured by Deslongchamps (1838, p. 108-110, Taf. 5), but unfortunately almost only middle pieces and ventral ends. The only rather complete rib (*loc. cit*. Fig. 1) seems also in its cylindrical ventral end to be very similar to my middle rib (Taf. I, Fig. 15), only it has clear roughenings for muscle insertion, which may indicate a greater age of that original. Further ribs however possess the peculiarity of bearing attachment points for the uncinate processes, of which I can find nothing in my poor material. Of *Streptospondylus*, *Dryptosaurus*, *Ceratosaurus*, *Tyrannosaurus* and other suitable theropods, unfortunately no thoracic ribs have been described. Thus it can be determined neither whether these afford actual systematically useful differences for our form nor whether especially the presence of single-headed ribs, established in it, represents a specialization. According to the literature hitherto known about theropods, the latter is of course assumed.

### f) Lateral Gastralia.

Taf. I, Fig. 2 and 4.

Gastralia which meet together in the midline are not present for me. I possess, in addition to about a half dozen pieces of small gastralia, only one rather complete larger piece (Taf. I, Fig. 4 a, b). It was originally clearly about 35 cm long and is approximately oval in cross-section (1.8:1.2 cm in the middle) and is a little simply curved both in the direction of the large as well as of the small diameter of this oval. The ends run out gradually to a point. The one end is simple; only a smooth furrow extends from it out to the concave narrow side of the gastral element up against the middle (Taf. I, Fig. 4 a). The other end however is complicated by sharp keels on the concave as well as on the convex narrow side, yet the somewhat recurved end tip itself is free from keels. From the broad side of the gastral element the convex side (Taf. I, Fig. 4 b) is overall clearly arched, but the concave is smooth to the latter end.

In the pointing of the two ends and in their differences it can only relate to a lateral gastral rib. The concave broad side should be the inner, the convex the outer = ventral side. It would thus correspond to an "Os de stylet" of *Poikilopleuron* (? = *Megalosaurus*) according to Deslongchamps (1838, p. 104, Taf. IV, Fig. 2 e), yet these are curved in an S-shape or are almost straight up to the ends and possess apparently no keels at one end.

The smaller pieces (Taf. II, Fig. 2 a, b) are in cross-section generally oval (1.2:0.8 cm, approximately), slender and up to over 20 cm long. Their ends are almost always broken off; one end in any case appears to run out into a point; here its cross-section is egg-shaped, in approaching to the other end it becomes very strongly oval by flattening of the broad side. The pieces are bent almost exclusively in the plane of the narrow side and are indeed clearly S-shaped. Also, most of the lateral gastral ribs of *Poikilopleuron* according to Deslongchamps, *loc. cit*., possess such a curving.

The gastral ribs of *Poikilopleuron bucklandi*, so thoroughly dealt with by him (1838, p. 100 ff., Taf. IV), thus clearly offer points of comparison with the complete piece from my paltry material, but a piece constructed in so complicated a manner as my most complete piece (Taf. I, Fig. 4 a, b) is apparently not present in his genus. Of *Tyrannosaurus rex* one knows from the description of Osborn (1906, p. 295) unfortunately only the pieces of the gastral ribs which bordered on the midline.

In any case the possession of gastral ribs presents nothing special among the theropods, a specialization could only be seen in the above mentioned form of the lateral piece.

**g) Summary of Results.**

After all comparisons, the following diagnosis ensues for the described form:

Large theropod with long lower jaw, whose dentary anteriorly and posteriorly is moderately high, small between, and on either side bears 15 awl-shaped teeth. Their crowns are rather straight, in cross-section very slightly to somewhat longitudinally oval, posteriorly and mostly also anteriorly ornamented with a smooth keel. They follow each other in somewhat irregular spacing and are greatly different in size, in that the 2nd to 4th are very large, the 1st and 5th to 10th very small. The upper teeth behave apparently in general in the same way, their number and position is unknown, likewise the skull.

The few known vertebral centra of the neck and the free trunk vertebrae are clearly elongated and pinched in as well as markedly opisthocoelous and without ventral keel or process. The cervical vertebrae possess hollow spaces in the centrum and neural arches, and on the postzygapophyses have strong epipophyses. The trunk vertebrae have a kind of hyposphene, their diapophyses have three buttressing lamellae and on the middle thoracic vertebrae strikingly small knob-shaped parapophyses on the neural arch. The neural spine of the cervical vertebra is moderately large, posteriorly angled or vertical, that of the free trunk vertebrae rather straight, laterally flat, ventrally and dorsally broadened and abnormally high. It becomes ever higher on the posterior free trunk vertebrae, is clearly anteriorly angled on the anterior ones, then ever less so, finally slightly posteriorly angled, probably in order to support a very high crest on the back.

The sacral vertebrae, at least three intimately united, have shorter centra than the free trunk vertebrae. They are indeed clearly elongated in a similar manner, pinched in and not keeled, but anteriorly only very slightly swollen. Their posterior ends and their neural arches are unknown, the neural spine of the first was probably very similar to that of the last free trunk vertebra. One anterior caudal vertebra has a pinched in, very short centrum, which is more deeply concave anteriorly than posteriorly and bears chevrons posteriorly. Its postzygapophyses form no hyposphene, the diapophyses are simple and without buttressing lamellae, also the neural spine is shaped simply, moderately large and only slightly angled backward. The number of vertebrae of the individual regions is unknown.

The few known thoracic ribs are relatively slender, only the anterior were flat in part, most are double headed with very long necks, one posterior is single headed. The cervical ribs and the number of ribs are unknown. There are slender gastral ribs present of unknown number. The rest of the skeleton is unknown.

That the so characterized form receives an independent position among the Saurischia and especially among the Theropoda, should arise with sufficient justification from the individual comparisons employed.[8] After this the establishment of a new genus and species is certainly justified, which I name, according to the most conspicuous character, the spinous processes of the trunk vertebrae, and after the land of origin, ***Spinosaurus aegyptiacus***. On this it must certainly be stressed that precisely the unusual height of the neural spine, so conspicuous, should not be overrated as a systematic character, since *Chamaeleo cristatus*, brought in for comparison on page 20, shows that here if anything only a species character is present, and it would be conceivable that male and female animals are held to differ in general in the size of the neural spine. Then in *Chamaeleo montanus* only the male animals have a crest supported by high neural spines, the females have generally none, as I could see myself in specimens which Herr Prof. L. Müller most kindly showed me in the Royal Zoological Collection.[9]

On the other hand the uniqueness of the tooth form in contrast to the norm of theropods (the absence of the clear recurvature of the crown and of the serration of their keels, as well as of greater flattening) can justify indeed the erection of a special new family, the S p i n o s a u r i d a e .

Certainly we are here dealing with a highly specialized form, as not only the body size but also the form of the upper edge of the dentary, the differentiation in tooth size and above all the size, orientation and form of the neural spines of the dorsal vertebrae prove. Whether it had descendants is quite uncertain, as ancestors such similar forms as *Streptospondylus*, which is only known from the Callovian of western Europe, can come into question. *Antrodemus* Leidy from the Jurassic and Cretaceous boundary layers of Colorado is too uniquely specialized in its edentulous symphysis to come into question as an ancestor, and the little knowledge of this genus does not permit it to be demonstrated whether any close relationship to our form is to be accepted.

To *Spinosaurus aegyptiacus* belong, aside from the type specimens described from the Baharîje Stage, still further remains, some with certainty, some with more or less great

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[8] I would not hold forth on possible relationship to the Sauropoda before the description of the extremities.

[9] High crests, supported in part by neural spines, are not rarely present in recent Lacertilia, which Hofmann (1890, p. 467) already indicated, especially in *Chamaeleo*, *Lophura, Basiliscus* and *Goniocephalus*, as Herr Prof. L. Müller had the kindness to show me.

probability. Above all, there are some opisthocoelous vertebrae from the same deepest horizon "p" of the stage and likewise from the neighborhood of Gebel el Dist, further, poorly preserved opisthocoelous vertebrae and ribs from the south slope of Gebel Maisâra as well as some teeth from there, but then also parts of the extremity skeleton from the first named locality (Stromer 1914, p. 28, 29). The description of these remains I delay, in the hope that after the world war, which also in my academic undertakings interferes in a disastrous way, later finds will here come about and permit me, with the greatest possible certainty and completeness, to clarify the skeleton construction of the remarkable dinosaur and then its systematic and evolutionary relationships.

The important question, whether referable remains are also known from other localities, I would like to address at present only by repetition of my cautious remark (1914, p. 42) on tooth remains from Djoua south of Tunisia. From those strata, which he assigned to the Albian and which in my view correspond in facies and age to the Baharîje Stage,[10] Haug (1905, p. 821, Taf. 17, Fig. 7, 8) described some teeth which he assigned as questionable to the fish genus *Saurocephalus*. Based on their size and form they could belong to *Spinosaurus aegyptiacus*, except that their pulp cavity is rather wide, which however could be associated with the fact that they are still not fully grown. The amphicoelous elongated vertebral centrum, which was found at the same place (Haug, *loc. cit*., p. 823, Taf. 17, Fig. 18), could belong to a posterior caudal vertebra of the same species, but is not determinable. Also the isolated teeth do not in general prove too much in systematic relationship. I would not like to go along with the nonsense which was perpetrated in *e.g*. *Megalosaurus* and unfortunately is still in vogue, that on each piece of tooth which is found from the Lias to the uppermost Cretaceous anywhere in the world and which in general resembles the teeth of *Megalosaurus bucklandi*, is based not only the presence of this genus, but also even that of a particular species.

[10] By mistake, in1914, p. 42, I wrote Aptian instead of Albian.

# Explanation of the Plates.

## Plate I.

Figures 1 through 4, 6, and 12 through 19 are drawn at $^1/_6$ natural size.
Fig. 5, and 7 through 11 are drawn at $^1/_2$ natural size.

Fig. 1 a, b. Anterior caudal vertebra "n" from posterior and from right. (p. 22)

Fig. 2 a, b. Piece of a small lateral gastral element from its narrow and broad side. (p. 26)

Fig. 3 a, b. ? Left angular from medial and lateral as well as a cross-section of the broken surface of the thicker end. (p. 6)

Fig. 4 a, b. Lateral gastral rib from its concave narrow side and its convex broad side as well as its cross-section in the middle. (p. 26)

Fig. 5 a, b, c. Smallest tooth (6th through 10th, lower left) from posterior, medial, and transverse through the base of its crown, $^1/_2$ natural size. (p. 9)

Fig. 6. Left mandibular ramus from medial with dentition restored based on the right and on isolated teeth and with posterior parts of the dentary restored based on the right. (p. 4) The 5th tooth is drawn too large.

Fig. 7 a, b, c. First left lower tooth from lateral, posterior and transverse through the base of the crown, $^1/_2$ natural size. (p. 8)

Fig. 8. Second largest isolated tooth (clearly 2nd though 4th upper right) cross-section through base of crown, $^1/_2$ natural size. (p. 9)

Fig. 9. Largest isolated tooth (clearly 2nd through 4th upper left) from lateral, $^1/_2$ natural size. (p. 9)

Fig. 10 a, b, c. Middle sized, probably posterior tooth (upper left) from medial, anterior and transverse through the base of the crown, $^1/_2$ natural size. (p. 10)

Fig. 11 a, b, c. Middle sized, probably posterior tooth (upper right) from lateral, anterior and transverse through the base of the crown, $^1/_2$ natural size. (p. 10)

Fig. 12 a, b. Right mandibular ramus from lateral and dorsal. (p. 4)

Fig. 13. Single-headed right rib "d" from posterior with cross-section in middle. (p. 25)

Fig. 14. Two-headed flat right anterior rib "a" from posterior with cross-section through the neck and through the middle. (p. 25)

Fig. 15. Two-headed large right rib "c" from posterior with cross-section though the neck and through the middle. (p. 25)

Fig. 16 a, b, c. Sacral vertebrae "k", "l", "m" from right, anterior side of centrum "k" and piece of the neural arch and neural spine of "k" from right. (p. 22)

Fig. 17. Neural arches with neural spine "c".

Fig. 18. " " " " " "d".

Fig. 19. " " " " " "e".

## Plate II.

All figures are drawn at $^{1}/_{6}$ natural size.

Fig. 1 a, b. Neural arches of an anterior cervical vertebra "a" (? axis) from posterior and from right. (p. 12)

Fig. 2. Middle or posterior cervical vertebra "b" from right. (p. 12)

Fig. 3 a, b. Middle thoracic vertebra "f" from right and from anterior. (p. 14)

Fig. 4 a, b, c, d. Middle thoracic vertebra "g" from posterior and from right, its centrum from ventral and from dorsal. (p. 14)

Fig. 5 a, b. Posterior free trunk vertebra "h" from right and its neural arches with the ventral part of the neural spine from posterior. (p. 14)

Fig. 6. Posterior free trunk vertebra "i" from right. (p. 14)