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ON THE SIGNIFICANCE OF THE "*PENDANT TROCHANTER*"
OF DINOSAURS

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In 1883, I proposed [1] an interpretation for the "third trochanter" of dinosaurs; I also suggested that this "third trochanter" henceforth be called the fourth trochanter, to distinguish it from the mammalian third trochanter. Both items appear to have been generally accepted. However, in 1885 [2] two objections were raised on the part of Dr. B. VETTER, Professor of Polytechnics at Dresden, to which I had desired to respond since that time, without finding the occasion. I will examine them successively today.

I.

There are two fourth trochanter types in dinosaurs: one, which could be called *crest*, in which the point is directed towards the tail [Ex. *Iguanodon* [3] (fig. 1)]; the other, called *pendant*, which turns its point towards the leg (in the restricted sense of the word, that is to say the second hindlimb segment) [Ex. *Hypsilophodon* [4], *Camptonodus* [5] (fig. 2)].

Mr. VETTER willingly admits that, according to my interpretation, the first has been created under the influence of an enormous development of the caudofemoralis muscle; but he strongly doubts that this explanation is applicable to the second.

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[1] L. DOLLO. Note sur le présence, sur les Oiseaux, du "troisième trochanter" des Dinosauriens et sur la fonction de celui-ci. *Bull. Mus. Roy. Hist. Nat. Belg*. T. II, 1883, P. 13.

[2] B. VETTER. Zur Kenntniss der Dinosaurier und einiger anderer fossiler Reptilien. *Kosmos*, 1885. Vol. I, p. 378.

[3] L. DOLLO. Troisième trochanter, etc. Pl. I, fig. 5, *c.*

[4] J.-W. HULKE. An Attempt at a complete Osteology of *Hypsilophodon foxii*, a British Wealden Dinosaur. *Phil. Trans. Roy. Soc. London*. 1882. Pt. III, pl. 80, fig. 1, *i. t.*

[5] O.-C. MARSH. Notice of new Jurassic Reptiles. *Amer. Journ. Sc.* (SILLIMAN). 879. Vol. XVIII, p. 502.

Moreover, note here how the German naturalist expresses his thoughts: ... "Moreover he knows my opinions on the function of the 'third trochanters' just by their form, where it is most strongly developed and where the sharp point rises on the underside, lest it be exhausted; the development of such a bony projection is well know to follow the pull of muscles, it must therefore be so for the upper thigh walking muscle, perhaps a specific head of the calf muscle takes origin there ..." (1).

Mr. VETTER therefore believes that the pendant trochanter serves as the origin for a leg muscle instead of the insertion for a muscle from the tail, and this, uniquely, because of its direction and construction. But it is clear that this interpretation is not resolved without difficulty, since, also precisely because of its direction and construction, the crest trochanter could only be utilized for the insertion of the caudofemoralis muscle, according to the method of argument of the Dresden professor. As a consequence, one must conclude that: while the fourth trochanter of certain ornithopod dinosaurs (2) was for the purpose of giving origin to a leg muscle, that of other ornithopod dinosaurs functioned to furnish an insertion site for a muscle from the tail. It would result that the fourth trochanter of dinosaurs is not a homologous structure throughout the group (not only in the ornithopod order), which is clearly inadmissible. It would be as if to say the third trochanter of *Equus* is not homologous to the third trochanter of *Rhinoceros.*

The explanation of the German naturalist cannot, therefore, give us satisfaction. And nevertheless the objection of Mr. VETTER is founded. My interpretation gives no statement about the pendant trochanter. How to proceed from this difficulty? This is what we are pursuing.

Consider the caudofemoralis muscle. This muscle is present in sauropsids in various aspects. It will suffice to consider three for the object of our pursuit.

1. The *first type* (fig. 3) shows only a single insertion. It is fixed to the femur, either alone or in the company of other muscles. It is found in birds (1).

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(1) B. VETTER. Dinosaurier, etc., p. 378.

(2) O.-C. MARSH. The classification and affinities of Dinosaurian Reptiles. *Nature.* Nov. 20, 1884, p. 68.

(1) H.-G. BRONN'S. *Klazsen und Ordnungen des Thier-Reichs. Aves* (E. SELENKA). Heidelberg, 1869, p. 141.

H. GADOW. Zur vergleichenden Anatomie der Musckulatur des Beckens und der hinteren Gliedmasse der Ratiten. *Iéna,* 1880, p. 37.

L. DOLLO. Troisième trochanter, etc., p. 15.

R.-W. SCHUFELDT. A review of the Muscles used in the Classification of Birds. *Journal of Comparative Medicine and Surgery*. October 1887, p. 336.

2. The *second type* (fig. 4) offers, more than the preceding type, a long tendon of insertion which attaches to the interarticular fibrocartilage of the knee. It is observed in lacertilians [2]. Note here how Mr SUTTON described it: ... "It is an exceedingly large muscle, and arises from the infero-lateral aspect of the caudal vertebrae: it is inserted by a large, broad, and strong tendon into the base of the trochanter on its external aspect. A little space before its insertion this tendon give off, at right angles to its lower border, a long, thin, and delicate one, which passes down the thigh, on the inner side of the great sciatic nerve, to the popliteal region, where it passes between the fibula and tibia to blend with the outer part of the inter-articular fibro-cartilage of the knee-joint."

For convenience of language, I propose to name this long tendon, *tendon of* SUTTON.

3. The *third type* (fig. 5) shows the tendon of SUTTON continuous with the external head of the gastrocnemius, where it is fixed to the interarticular fibrocartilage of the knee. It is seen in crocodilians [1].

This supposed, I believe that these diverse structural modes explain the origin of the crest trochanter and the pendant trochanter.

And at first it is clear that the two first types could only give rise to a crest trochanter, whatever their development. With regard to the third, it is necessary to distinguish two cases:

1. Where the tendon of SUTTON contacts the fourth trochanter;

2. Where it is detached more proximally from the caudofemoralis muscle to rest on this process.

In this last hypothesis, as a point of doubt, still only a crest trochanter could have been formed (*Iguanodon*, for example).

But in the first supposition, in contrast, it is evident [1] that the tendon of SUTTON, having become the tendon of origin for the gastrocnemius, will be detached from the caudofemoralis to fix on the point of the fourth trochanter, which was up to that moment a crest. As a result, this secondary process involved the elongation of the

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[2] ST.-GEORGE MIVART. Notes on the Myology of *Iguana tuberculata*. *Proc. Zool. Soc. London*, 1867, p. 774, fig. 5 F. C.

J.-B. SUTTON. The Nature of Ligaments (Part IV). *Journal of Anatomy and Physiology* (HUMPHRY, TURNER and McKENCRICK). 1885. Vol. XX, p. 40.

[1] J.-B. SUTTON. Nature of Ligaments, etc. (Part IV), p. 42.

[1] "It is evident," by the abundant myology compared in transformations of this genus. See, notably: J.-B. SUTTON. *Ligaments, their Nature and Morphology*. London, 1887.

aforementioned trochanter towards of the leg, and in this manner the pendant trochanter was created (*Hypsilophodon*, for example).

In summary:

1. The crest trochanter is primitive; it originates under the influence of an enormous development of the caudofemoralis muscle from the two first types or from the second variety of the third;

2. The pendant trochanter is secondary; it originates at the expense of the previous form under the influence of the gastrocnemius muscles;

3. It is possible to explain the two varieties of fourth trochanter of dinosaurs proceeding only from the third type of caudofemoralis muscle;

4. However, if one admits that dinosaurs are the ancestors of birds, it must also be accepted that they descended from forms having a crest trochanter which originated from the action of one of the two first types of caudofemoralis muscles. In effect, birds clearly become trochanter-bearing types, since I was able to find a rudimentary fourth trochanter in them [2] (fig. 6). And nevertheless, they can only have had a pendant trochanter formerly; because, if the gastrocnemius, enormously developed in this class [3], had at one time also possessed a firm attachment site, they would certainly have preserved it. But there is no point of connection between the caudofemoralis and gastrocnemius in birds [1];

5. From the above argument it proceeds that dinosaurs could have had the three types of caudofemoralis muscles. This variety should hardly be surprising, since, in speaking of the Ratites, Mr. GADOW expressed himself thus: "This ... muscle is the most greatly changed in ability" [2]. This is a stronger reason that it could have - and must have - been present in the aforesaid great reptiles;

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[2] L. DOLLO. Troisième trochanter, etc., p. 15.

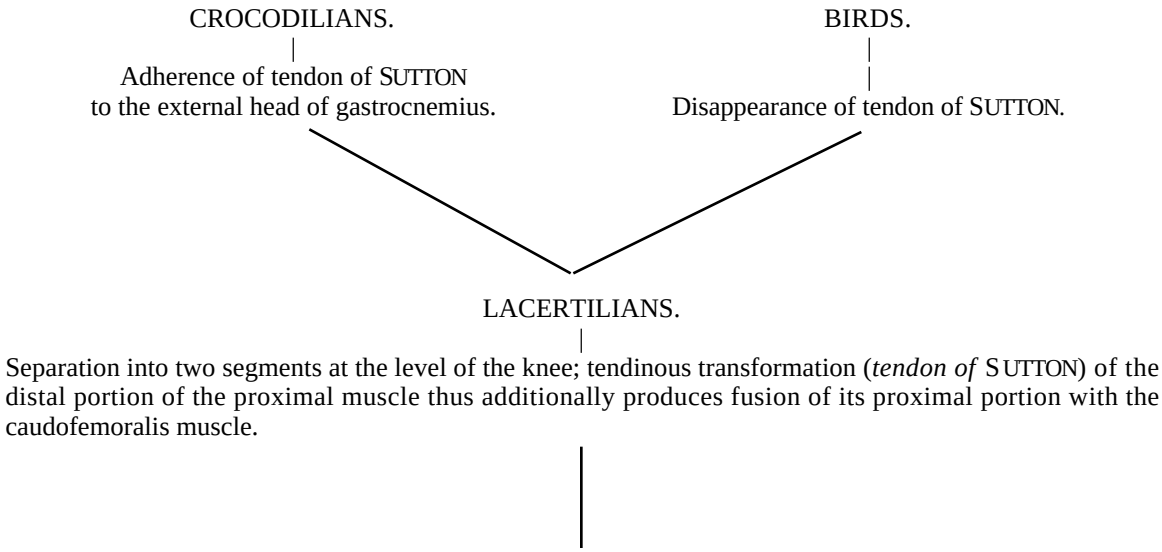
[3] H.-G. BRONN'S. Klassen, etc. *Aves* (H. GADOW), p. 183.

[1] E. SELENCKA, H. GADOW, L. DOLLO, R.-W. SCHUFELDT (*v. supra*).

[2] H. GADOW. Ratiten, etc., p. 38.

6. Consequently, the preceding confirms my first interpretation by completing it;

7. Finally, tendons and ligaments generally being nothing but degenerate muscles [3], it will not be without interest to retrace the history of the tendon of SUTTON in some lineages [4].



II.

The second objection of Mr. VETTER relates to the distinction which I established [1] between the third trochanter of mammals and the fourth trochanter of dinosaurs:

"That this 'third trochanter' of dinosaurs and some true birds, as the author meant, is thus something different from the third trochanter on the femur of mammals, especially that of perissodactyl ungulates, and some rodents and edentates, we would refrain from disputing; in any case, precise similarity of the musculature is additionally necessary, as DOLLO summarized here [2]."

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[3] J.-B. SUTTON. Ligaments, etc. (*v. supra*).

[4] J.-B. SUTTON. Nature of Ligaments, etc. (Part IV), p. 41.

[1] L. DOLLO. Troisième trochanter, etc., p. 18.

[2] B. VETTER. Dinosaurier, etc., p. 378.

But it seems to me that work in this direction was done by Mr. GADOW [1]. For how do we prove that two processes are, or are not, homologous? It would seem to me by demonstrating that the muscles which create them are, or are not, homologous. And how do we establish this? Clearly chiefly by the innervation.

But this is the view that the Cambridge naturalist followed and, nevertheless, it clearly separates the caudofemoralis from the gluteus maximus. Furthermore, if one refers to the detailed synonymy given by Mr. GADOW, one sees that *no* anatomist ever confounds the two cited muscles. Thus they are clearly two different muscles, and as a result, the third trochanter of mammals and the fourth trochanter of sauropsids are clearly two heterologous formations. The name of fourth trochanter, which I proposed, is, then, justified.

Brussels, 24 February 1888

FIGURES

Fig. 1. - Femur of *Iguanodon bernissartensis*, BLGR. *a*. - Head. *b*. - Greater trochanter. *c*. - Fourth trochanter (*crest*). *f*. - Postaxial crest of the ectocondyle. *g*. - Entocondyle.

Fig. 2. - Femur of *Camptonodus dispar*, MARSH (after O.-C. MARSH). *a*. - Head. *b*. - Greater trochanter. *c*. - Fourth trochanter (*pendant*). *f*. - Postaxial crest of the ectocondyle. *g*. - Entocondyle.

Fig. 3. - Hindquarters of *Anas boschas*, L., view of right side. *b*. - Greater trochanter. *e*. - Ectocondyle. *g*. - Entocondyle. *i*. - Ilium. *k*. - Ischium. *l*. - Pubis. *m*. - Caudal vertebrae. *n*. - Pygostyle. *o*. - Caudal vertebral chevrons. *p*. - Obturator foramen. *q*. - Iliosciatic foramen. *r*. - Tibia. *s*. - Fibula. *t*. - Tarsometatarsus. *u*. - Cuadofemoralis muscle. *v*. - Its insertion. *x*. - Its origin. *y*. - Ischiofemoralis muscle. *z*. - Its insertion. *w*. - Its origin.

Fig. 4. - Femur and caudofemoralis of *Iguana tuberculata*, LAUR. (after J.-B. SUTTON). *u*. - Caudofemoralis muscle. *v*. - Its insertion on the femur. *a*. - Femur. *b'*. - Tendon of Sutton. *c'*. - Femoral condyles. *d'*. - Biceps. *e'*. - Semimembranosus muscle. *f'*. - Interarticular fibrocartilage of the knee.

Fig. 5. - Caudofemoralis and gastrocnemius of *Alligator mississippiensis*, GRAY (after J.-B. SUTTON). *u*. - Caudofemoralis muscle. *b'*. - Tendon of Sutton. *g'*. - Gastrocnemius. *h'*. - Their external head.

Fig. 6. - Femur of *Cygnus atratus*, LATH. *a*. - Head. *b*. - Greater trochanter. *c*. - Fourth trochanter. *f*. - Postaxial crest of the ectocondyle. *g*. - Entocondyle.

[1] H. GADOW. Ratiten, etc. p. 36 and 37.