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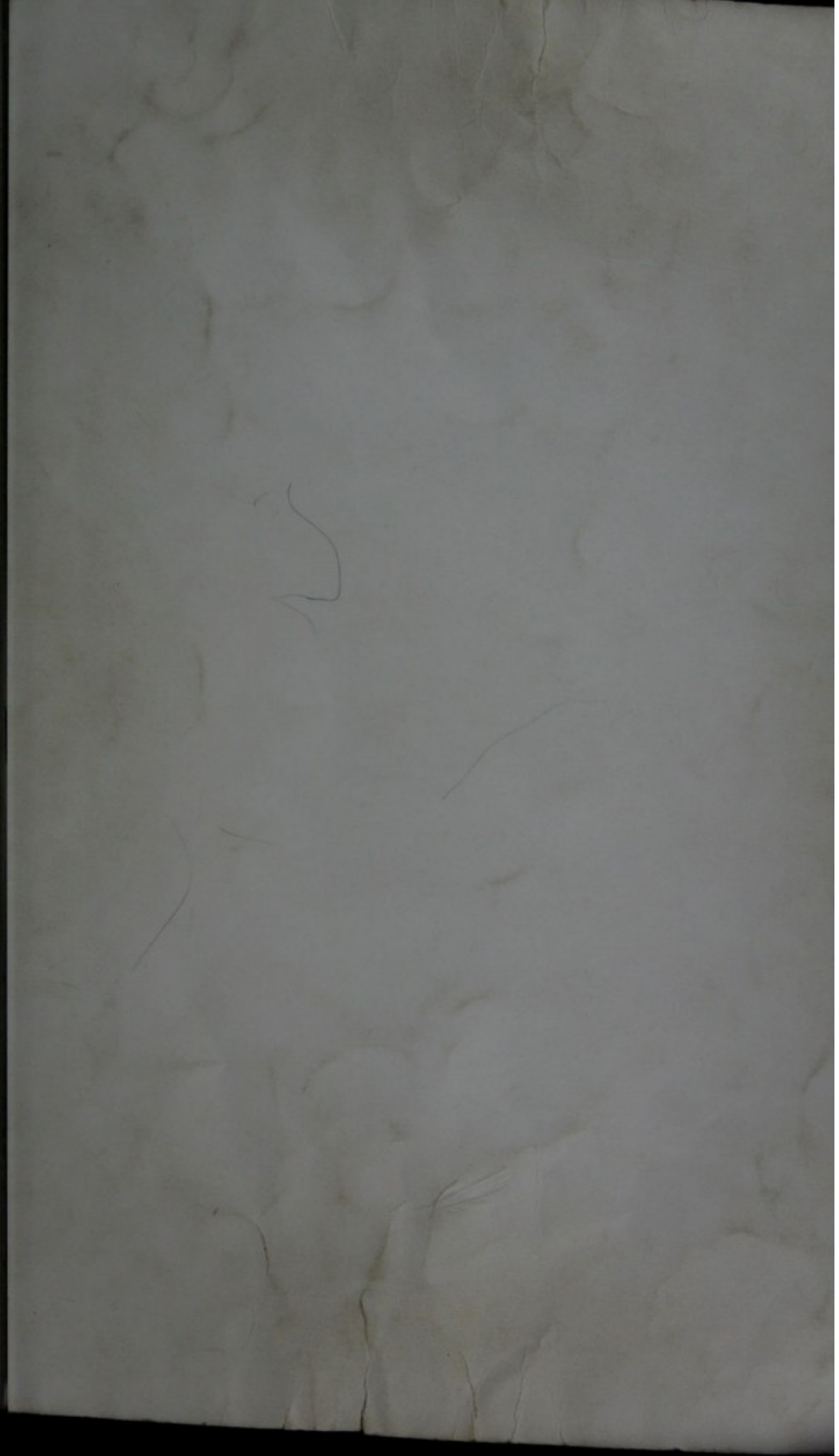
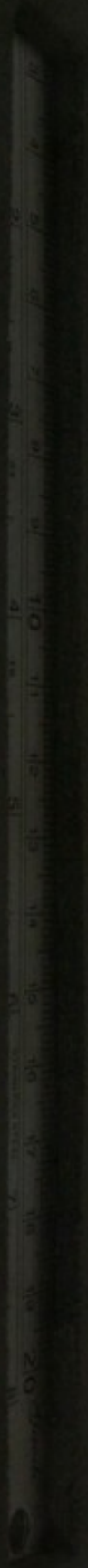
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NOTES
ON ANIMAL MECHANICS
BY THE REV. SAMUEL HADLEY
FELLOW OF TRINITY COLLEGE,

[Read before the Royal Irish Academy]

No. VI.—ON THE MUSCULAR ANATOMY

During the Easter recess of 1864, I had a long conversation with Professor Gratiolet,* of Paris, the object of which was to explain to him the theory I had formed to explain it. This did not the honour of approving of my explanation even a Crocodile, in the posterior limb of which I find a mechanical problem exceeding in complexity the leg of the ostrich, and as yet unsolved by

* The invaluable loss that science has sustained by the premature death of this gifted anatomist, is even to those who were his personal acquaintances a source of regret. I extract from the "Journal de l'École Polytechnique" the following just tribute to his memory:—
"Les sciences viennent de faire une perte aussi cruelle que précieuse. M. Gratiolet, professeur de zoologie à la Faculté des Sciences de Paris, est mort le 15 mai 1864."

"M. Gratiolet n'était pas seulement un homme de lettres, mais un homme de science. Il avait travaillé à son laboratoire de zoologie à l'École Polytechnique, et il avait été l'un des premiers à se consacrer à l'étude de l'anatomie comparée. Son œuvre est une œuvre de haute portée scientifique, et il a laissé une œuvre qui sera précieuse à tous les yeux. M. Gratiolet était un homme de bien, et il a été un grand maître. Ses travaux d'anatomie comparée, ses recherches sur les muscles, etc., ont été une œuvre de haute portée scientifique, et il a laissé une œuvre qui sera précieuse à tous les yeux. M. Gratiolet était un homme de bien, et il a été un grand maître. Ses travaux d'anatomie comparée, ses recherches sur les muscles, etc., ont été une œuvre de haute portée scientifique, et il a laissé une œuvre qui sera précieuse à tous les yeux."

"La mort est venue le frapper au moment où, après avoir consacré sa vie à l'étude de l'anatomie comparée, il se préparait à publier son ouvrage sur les muscles."

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NOTES

ON ANIMAL MECHANICS.

BY THE REV. SAMUEL HAUGHTON, M. D.,

FELLOW OF TRINITY COLLEGE, DUBLIN.

[Read before the Royal Irish Academy, June 26, 1865.]

No. VI.—ON THE MUSCULAR ANATOMY OF THE CROCODILE.

DURING the Easter Recess of 1864, I had an opportunity of explaining to Professor Gratiolet,* of Paris, the investigations I had made with respect to the mechanism of the leg of the Ostrich, and the theory I had formed to explain it. This distinguished anatomist did me the honour of approving of my explanation, and urged me to procure a Crocodile, in the posterior limb of which he assured me I should find a mechanical problem exceeding in complexity that presented by the leg of the Ostrich, and as yet unsolved by anatomists.

* The incalculable loss that science has sustained in the early part of the present year by the premature death of this gifted anatomist, is exceeded by the loss experienced by his friends, to whom his genial social qualities endeared him even more than his brilliant scientific attainments. I extract from the "Journal des Debats" of the 19th February, 1865, the following just tribute to his memory:—

"Les sciences viennent de faire une perte aussi cruelle qu'imprévue; M. Gratiolet, professeur de zoologie à la Faculté des Sciences de Paris, a succombé hier matin à une attaque d'apoplexie.

"M. Gratiolet n'avait pas cinquante ans; avant-hier, encore plein de vie et de santé, il travaillait à son laboratoire du Muséum d'histoire naturelle lorsque, à deux heures, frappé d'une congestion subite, il dut être ramené à son domicile; quelques heures plus tard, il avait perdu connaissance; hier matin à quatre heures, il rendait le dernier soupir.

"Nous ne saurions peindre l'émotion profonde qu'a causée dans le monde scientifique l'annonce de cette mort prématurée. M. Gratiolet était aimé de tous; son affabilité, la droiture de son caractère lui avaient concilié toutes les sympathies.

"Ses travaux d'anatomie comparée, ses recherches sur le système nerveux et sur le cerveau, etc., l'avaient mis au nombre des naturalistes les plus distingués de notre pays; son merveilleux talent d'élocution l'avait placé au premier rang parmi nos professeurs les plus renommés, et l'aptitude de son esprit pour les études métaphysiques avait imprimé à ses œuvres un caractère d'originalité qu'appréciaient les philosophes aussi bien que les savans.

"La mort est venue le frapper au moment où, après de longues années de lutte, il semblait sur le point de recueillir le fruit de ses laborieux efforts.

"AIMÉ GIRARD."

During the month of March last I was furnished with a young Crocodile from Egypt, by Mr. Thomas Moore, Curator of the Derby Museum, Liverpool, to whom I had communicated my earnest desire to have an opportunity of dissecting such an animal; and the results of my examination fully bear out the anticipation of Professor Gratiolet, and also furnish a complete confirmation of the principles I made use of in my theory of the leg of the Ostrich.

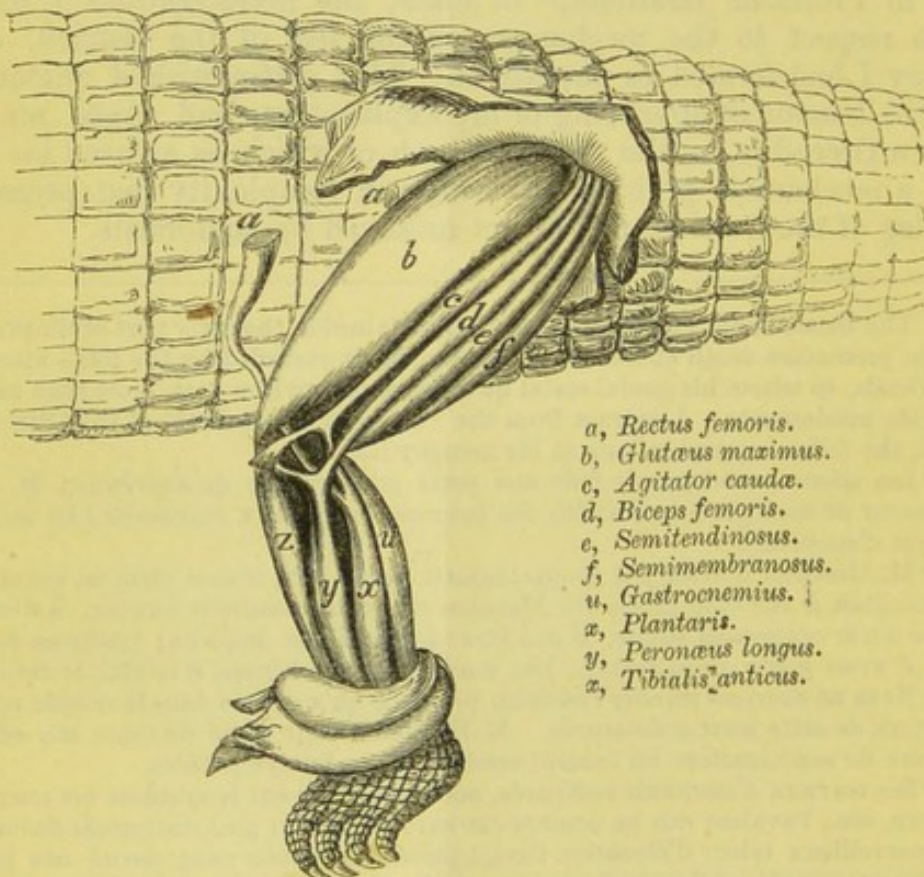
The interlacing of tendons in the hind leg of the Crocodile is very remarkable, and more complex than in the Ostrich, although in one respect it somewhat resembles it.

PART I.—DISSECTION OF LEG OF CROCODILE.

On removing the skin and dissecting away the fat, the muscles shown in Fig. 19 are exposed.

Fig. 19.

LEFT LEG OF CROCODILE (with skin removed, to show the superficial muscles).



- a, *Rectus femoris.*
- b, *Glutæus maximus.*
- c, *Agitator caudæ.*
- d, *Biceps femoris.*
- e, *Semitendinosus.*
- f, *Semimembranosus.*
- u, *Gastrocnemius.*
- x, *Plantaris.*
- y, *Peronæus longus.*
- z, *Tibialis anticus.*

1. *M. Glutæus maximus* (b), 0.15 oz.

Origin; from central half of the ilio-ischiadic line.

Insertion; into the fascia outside and above the knee joint.

This is a broad flat muscle, and straps down the tendon of the *rectus femoris* in its passage over the knee.

2. *M. rectus femoris (a)*, 0·08 oz.
 Origin; from anterior spine of the ilium, close to the acetabulum.
 Insertion; as in the leg of the Ostrich, into a tendon passing over the knee outwards, and terminating in a remarkable muscle* (*x*), in the calf of the leg, associated with the *gastrocnemius (u)*, and deriving a second origin from the *agitator caudæ (c)*, as shown in the figure.
3. *M. agitator caudæ (c)*, 0·03 oz.
 Origin; from the ischiadic line, behind the *glutæus maximus*.
 Insertion; by a double tendon.
1. One tendon passes through a pulley on the outside of the knee, formed by the tendon of the *biceps (d)* as it passes to its fibular insertion, and is then inserted in the head of the muscle (*x*), in the calf of the leg.
2. The second insertion is by means of a tendon that goes to the top and front of the tibia; this second tendon also serves to strap down the tendon of the *rectus femoris (a)*.
4. *M. biceps femoris (d)*, 0·05 oz.
 Origin; from the ilioischium, under and behind the origin of the *glutæus maximus*.
 Insertion; partly into the top of the fibula, forming a pulley for the *agitator caudæ (c)*, and an additional strap for the *rectus femoris (a)*; and partly by means of another tendon into the head of the *peronæus longus (y)*.
5. *M. semitendinosus (e)*, 0·18 oz.
 Origin; from the posterior point of the tuber ischii.
 Insertion; by a remarkable looped tendon, having one end inserted into the back of lower end of femur, and the other end into the os calcis.
6. *M. semimembranosus (f)*, 0·11 oz.
 Origin; tuber ischii.
 Insertion; into the top of the tibia, by a tendon common to this muscle and *gracilis*.
 The muscles of the calf shown in the figure are the following:—
7. *M. gastrocnemius (u)*, 0·14 oz.
 This muscle, as usual, has an outer and inner head.
Outer head, 0·11 oz.
 Origin; from the tendon of the great caudal extensor of the thigh, half an inch from its insertion into the outer condyle (vide *a*, Fig. 20).
 Insertion; into the under side of the outer tarsal bone, and into the plantar fascia.
- Inner head*, 0·03 oz.
 Origin; from the top of fibula and inner condyle of femur.

* This muscle may be the *plantaris*.

Insertion; by a tendon, which unites with that of the outer head before reaching the os calcis, under which it passes to be inserted into the outer and under side of the outer tarsal bone.

8. *M. plantaris* ? (*x*), 0.04 oz.

Origin; double; from *rectus femoris* and from *agitor caudæ*.

Insertion; having become partially blended with the outer *gastrocnemius*, it is inserted into the os calcis, and under surface of the plantar fascia.

9. *M. peronæus longus* (*y*), 0.03 oz.

Origin; from the shaft of the fibula, and from the tendon of the biceps femoris (*d*).

Insertion; into the outer tarsal bone, uniting with the tendon of the *gastrocnemius*.

10. *MM. tibialis anticus et extensor digitorum communis* (*z*), . . . 0.11 oz.

Insertion; into the tarsal end of the 1st, 2nd, and 3rd metatarsal bones.

The interlacing of muscles in the thigh and leg of the Crocodile, just described, is very remarkable, and more complicated than that found even in the Ostrich; and at first I was disposed to think that it threw some doubt on the explanation I had given previously of the reason for such an arrangement in the bird's leg. In the case of the Ostrich the necessity for strict simultaneity of action was made evident by the great force of the muscles employed, and the great delicacy of the bones on which they had to act. What could there be in the case of the Crocodile to correspond to such a peculiarity in the case of the Ostrich? After some careful dissection I found the ready answer to my question in the remarkable muscle which I shall now describe.

On clearing away the superficial muscles of the thigh and tail, I found the enormous mass of muscle, figured at *b*, Fig. (20), which acts as the chief and powerful extensor of the thigh.

11. *M. extensor femoris caudalis* (*b*),* 1.81 oz.

Origin; from the transverse and inferior spinous processes of the caudal vertebræ, from the 3d to the 15th, inclusive.

Insertion; into the back of the upper part of the femur, and into a great round tendon, which receives, in particular, the anterior

* This remarkable muscle is noticed and accurately described by Meckel, in tome iii., pp. 152, 153, of his "System der vergleichenden Anatomie" (Halle, 1828); but it is very strange that he transposes its origin and insertion, and seems not to have had any idea of its real use. It is regarded from his point of view as a descriptive anatomist, and without the remotest reference to its final cause. He says:—"Der zweite, tiefere weit dickere Muskel ist von dem ersten [the superficial muscle of the tail] wie einer breiten Binde umgeben, entspringt mit zwei ganz getrennten, 1) einer weit kürzern, breiten Sehne oben von den hintern Fläche des Oberschenkelbeines; 2) durch eine weit längere, schlanke, unten zwischen den beiden Gelenkknorren desselben Knochens, und setzt sich an die ganze Seitenfläche der untern Dornen, so wie der Zwischendornenhaut und die untere Fläche der Wurzeln der Querfortsätze."

fibres of this enormous muscle, and, passing down the back of the femur, is inserted by a strong common aponeurosis into the outer condyle of the femur, and into the head of the fibula. This common aponeurosis also gives a partial origin to the *gastrocnemius* (a), Fig. 20, and to the *plantaris* (x), Fig. 19.

There are two muscles, accessory to this great caudal extensor in their action, which are as follows:—

12. *M. extensori femoris caudali accessorius*, . . . 0·01 oz.

Origin; from the fascia covering the great caudal extensor, and by a tendinous head from the *quadratus femoris*, which is also an accessory to the great caudal.

Insertion; into the looped tendon of the *semimembranosus*, already described.

13. *M. quadratus femoris*,
0·05 oz.

Origin; posterior, superior, and inner surface of the pubis, near its symphysis.

Insertion; into the back of the femur, with the action and position of the *quadratus femoris* in mammal quadrupeds, and into the tendon of the great caudal extensor.

The effect of the interlacing of the tendons of the various



COMMON CROCODILE OF EGYPT (with superficial muscles removed, to show the great deep flexor of the thigh).

Fig. 20.

muscles already described must be to produce simultaneity of action among them, such as I have already endeavoured to describe in my account of the leg of the Ostrich; and in the present instance of the Crocodile there seems to be a similar principle involved. The Crocodile, resting on mud, progresses chiefly by using his hind feet as paddles; and in this use of them the great caudal extensor of the thigh is the most powerful and important muscle employed; and it seems to me that the simultaneity of action of all parts of the leg, rendered necessary by the employment of so powerful a muscle, is fully secured by the interlacing of the tendons I have described, which renders it impossible for one set of muscles to act without the others being also exerted.

The remaining muscles of the posterior limb are as follows:—

14. *M. glutæus medius*, 0·06 oz.
Origin; from the central part of the ilio-ischiadic surface.
Insertion; its tendon passes over the great trochanter to be inserted into a line down the upper half of the outside of the femur, between the origins of the two portions of the *vastus externus*.
15. *M. Glutæus minimus*, 0·02 oz.
Origin; from the anterior point of the ilium.
Insertion, into the inner side of the knee, under the fascia of the *rectus femoris*.
16. *MM. vastus internus, externus, et cruræus*, 0·22 oz.
The *vastus externus* consists of two distinct muscles, as in the Ostrich.
17. *M. psoas*, 0·57 oz.
This large muscle takes an origin as high as the last rib, and is inserted into the lesser trochanter, and the intertrochanteric line leading to the outer side of the femur. It lies outside the *iliacus*.
18. *M. iliacus*, 0·11 oz.
Origin; from the anterior transverse surface of the ilium, with a slip from the spine.
Insertion; altogether into the lesser trochanter.
19. *M. sartorius*, 0·04 oz.
Origin; behind the origin of the *rectus*, on the inner side, at the junction of the ilium and marsupial bone.
Insertion; into the fascia of the inner side of the thigh, for two-thirds of its length.
20. *M. gracilis*, 0·08 oz.
Takes an origin from two heads—one at the posterior point of the pubis, and the other on the pectinæal line.
Insertion; into the head of the tibia by a tendon common to it with the *semimembranosus*.
21. *M. pectinæus*, 0·06 oz.

Origin; between the two heads of *gracilis*, from the central part of the surface of the pubis and from the pectinæal line.

Insertion, into the top of the linea aspera.

22. *MM. adductores*, 0·21 oz.

There are three adductor muscles:—

- 1st *Adductor*, 0·13 oz.

Origin; anterior pectinæal line of pubis.

Insertion; into the upper half of the linea aspera.

- 2nd *Adductor*, 0·03 oz.

Origin; from the posterior edge of the pubis, its middle third.

Insertion; into the middle of the linea aspera.

- 3rd *Adductor*, 0·05 oz.

Origin; from the posterior edge of the pubis, close to the symphysis.

Insertion; into the back of the top of the fibula, with a fascial union with the tendon of the *semitendinosus*.

23. *M. obturator externus*? 0·13 oz.

Origin; from the tuber ischii, the posterior edge of the ischium, and the obturator membrane.

Insertion; into an oblique line on the back of the femur, below the insertion of the *quadratus femoris*.

24. *M. marsupialis externus*, 0·07 oz.

25. *M. marsupialis internus*, 0·10 oz.

These two muscles take their origin, respectively, from the outer surface of the marsupial bone, and from its inner surface and the last abdominal rib; and they are inserted by a common tendon into the top of the posterior intertrochanteric line. Their action is to rotate the femur directly inwards.

26. *M. flexor proprius hallucis*, 0·02 oz.

Origin; from the outer condyle of femur.

Insertion; into the first, second, and third toes.

27. *M. flexor digitorum communis*, 0·05 oz.

Origin; from the fibula and tibia.

Insertion; into the first, second, and third toes.

28. *M. tibialis posticus*, 0·06 oz.

This muscle is inserted into the tarsal ends of the first, second, and third metatarsal bones.

29. *M. peronæo-calcaneus*, 0·01 oz.

Origin; from the lower part of the shaft of the fibula.

Insertion; into the upper surface of the calcaneum.

PART 2.—DISSECTION OF ARM OF CROCODILE.

The muscular anatomy of the anterior limb of the Crocodile presents no such remarkable peculiarities as those I have described in the leg, and therefore a rapid enumeration of its muscles will be sufficient. It

is necessary to bear in mind, for the purpose of comparison with the muscles of the leg, that

The Marsupial bone represents the clavicle;
 „ Pubis, „ „ coracoid;
 „ Ilium, „ „ acromion;
 „ Ischium, „ „ scapula.

1. *M. trapezius*, 0·10 oz.
 Origin; from the occipital and cervical scutes, as far back as the shoulder joint.
 Insertion; into the anterior edge of the acromion.
2. *M. latissimus dorsi (humerodorsalis)*, 0·12 oz.
 Origin; from the four anterior dorsal scutes.
 Insertion; into the back of the humerus, having its tendon conjoined with that of the *teres major*.
3. *M. teres major*, 0·02 oz.
 Origin; posterior superior portion of scapula.
 Insertion; with *latissimus dorsi*.
4. *M. sterno-atlanticus*, 0·22 oz.
 Origin; from the sternum, in front of its articulation with the coracoid.
 Insertion; into the side of the atlas.
5. *M. pectoralis major*, 0·77 oz.
 Origin; from top of sternum, and its entire length, and from the abdominal ribs two-thirds of the distance to the pelvis.
 Insertion; into the outer edge of the great pectoral ridge of the humerus.
6. *M. pectoralis minor*, 0·04 oz.
 Origin; from the outer surface of the acromion and coracoid, lying under the tendon of the *biceps humeri*.
 Insertion; inner side of pectoral ridge.

In this muscle is also included the *supraspinatus*, which is represented by the portion of the muscle taking its origin from the scapular border of the acromion, inside the origin of the deltoid. These two pectorals draw the arm forward in swimming.

7. *M. pectoralis secundus*, 0·04 oz.
 Origin; from the first sternal rib.
 Insertion; into the posterior edge of the coracoid.

This muscle draws the arm backwards, by acting on the coracoid, and may represent the second pectoral of birds.

8. *M. sternomastoideus*, 0·17 oz.
 Origin; from top of sternum.
 Insertion; into the posterior third of inner side of lower jaw.

9. *M. Omo-hyoideus*, 0·06 oz.
Origin; from the acromion, just above the glenoid cavity.
Insertion; into the descending wing of the hyoid bone.
10. *M. deltoideus*, 0·15 oz.
Origin; from a broad rim of the acromion, and from the inner surface of the acromion, winding out over the edge to form the inner portion of the deltoid.
Insertion; into the deltoid ridge of the humerus.
11. *M. infraspinatus*, 0·02 oz.
Origin; from the outer surface of the scapula, which is altogether occupied by this muscle and the *teres major*.
Insertion; by a long tendon into the greater tuberosity.
12. *M. rhomboideus*, 0·02 oz.
Origin; from spinous processes of the last cervical and the first dorsal vertebra.
Insertion; under surface of vertebral edge of scapula.
13. *M. serratus magnus*, 0·26 oz.
Origin; from the transverse processes of the vertebræ, from 2nd to 8th, inclusive.
Insertion; all round the edge of acromion, and anterior and vertebral edge of the scapula.
- This muscle is continuous with the next, which may be regarded as equivalent to the scapulocostal *latissimus dorsi* muscle found in the Seal.
14. *M. latissimus dorsi scapulocostalis*, 0·15 oz.
Origin; from the ribs of the 9th to 14th vertebræ, inclusive.
Insertion; into the posterior edge of the scapula.
15. *M. triceps*, 0·25 oz.
Origin, threefold:—
1. From the posterior edge of the scapula, near the glenoid;
2. By a bifurcate tendon from the coracoid and scapula, allowing the *subscapularis* to pass between the two tendons.
3. From the outer and inner surfaces of the back of the humerus.
16. *M. subscapularis*, 0·05 oz.
Origin; from the inner surface and anterior edge of the scapula.
Insertion; into the lesser tuberosity, and into the line leading from it down the inner side of the arm.
17. *M. biceps humeri*, 0·03 oz.
Origin; from the inner side of the anterior edge of the coracoid, in front of the glenoid.
Insertion; into the radius.
18. *M. brachialis externus*, 0·03 oz.
Origin; from the line outside and below the pectoral ridge.
Insertion; into the radius, outside the insertion of the *biceps*, the tendon of the *brachialis anticus* lying between them.

19. *M. brachialis anticus*, 0·02 oz.

This muscle is inserted into the radius, between the insertions of the *biceps* and *brachialis externus*.

20. *M. extensor carpi radialis*, 0·01 oz.

21. *M. supinator radii longus*, 0·02 oz.

22. *M. extensor digitorum communis*, 0·01 oz.

23. *M. anconæus*, 0·01 oz.

Origin ; from the outer condyle of the humerus.

Insertion ; into the ulna, along the whole length of its outer side.

24. *M. extensor carpi*, 0·04 oz.

Origin, from the radius and ulna, and from the interosseous septum.

Insertion ; into the middle carpal bone.

25. *M. pronator radii*, 0·03 oz.

Origin ; from the inner condyle of the humerus.

Insertion ; into the whole length of the radius.

26. *M. flexor carpi ulnaris*, 0·03 oz.

Origin ; from the inner condyle.

Insertion ; into the outer carpal bone, articulating with the ulna.

27. *M. palmaris* (?), 0·01 oz.

Origin ; from the inner condyle.

Insertion ; into the tendon of the *flexor digitorum communis* in the centre of the palm. Its force is expended on the index and middle fingers.

28. *M. flexor digitorum communis*, 0·03 oz.

Origin ; from the whole inner surface of the ulna.

Insertion ; into the ungual phalanges of the thumb, index, and middle fingers.

There are, in addition, short flexors in the palm, terminating in the metacarpal ends of the phalanges at each side, allowing the tendon of the long flexor to pass through.

The ring and little fingers seem to be flexed altogether by these palmar tendons.



