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SOME OBSERVATIONS ON THE COMPARATIVE ANATOMY OF THE FIBULA

BY

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Art. XXIX.—*Some Observations on the Comparative Anatomy of the Fibula.*[1]

By WILLIAM MACKENZIE, M.D., F.R.S. (Edin.).

(With Plates LXXVI.—LXXVIII).

[Read 10th November, 1910].

Bone serves various uses in the animal economy. Of its subservience to muscle there are numerous instances scattered throughout the comparative world. Thus, muscle dominance produces a broadening of the bone surface where muscle attachment is required, and a narrowing or rotundity where such attachment is diminished or absent, compactness or lightness of bone where strength or otherwise is requisite, and bony ridges, and projections to afford leverage, as, for example, in the case of the attachment of the two thigh flexors in the leg of the Koala *Phascolarctus*. As obviously the erect position adopted by man and consequent mode of progression have impaired the function of numerous muscles throughout the body, recognition of accompanying bony changes becomes a matter not only of comparative, but also of surgical interest.

If we regard the extremities, one would naturally expect such changes to be more marked in the lower than the upper limb, and indeed that is so. Man's hand not distinguishable much from that of the tree climber, and having independent thumb action is capable of numerous possibilities of adaption, though Koala with his two thumbs is to be envied; but in the lower limb which we use solely for ambulation no longer have we the approximating Hallux of the Koala or Lemur—we simply require a broadened surface for support; the intermediate position between the Hallux of man and of the Lemur or Koala being seen in the Baboon. Associated with this alteration of

1 The work in connection with this paper was done in the Anatomical Department, Veterinary School, Melbourne University.

the position of the Hallux and the loss of power of adduction we have an impairment of the mobility of the foot, the diminished call for work resulting in lessened extent and variety of muscular activity and subsequent changes in the bones of the leg.

In the upper limb associated with the adduction of the thumb we have the movements of pronation and supination, and for this, two forearm bones are necessary. In the Koala and Lemur with great mobility of the feet, the uses of which are almost, if not as great as those of the hand, we find both bones of the leg, namely, the Tibia and Fibula well developed and in the Koala little distinguishable in size, and both entering into the formation of the ankle and knee-joints; but in man and the Kangaroo, where the erect position predominates and support only is requisite, the question of the utility of a second bone in the leg is raised.

Hence a comparison is necessary, the basis of which depends on the mobility or otherwise of the ankle-joint which is itself a natural association of an approximating Hallux.

Before entering into this consideration a brief review may be made of the Fibula as occurring in man. Although the Tibia —the companion bone in the leg—is the longest and largest in the skeleton excepting the Femur, the Fibula is on the other hand, in proportion to its length, the most slender of all the long bones. Its upper end forms no part of the knee-joint, its chief function being to increase the surface for muscular attachment, while at the lower end it supports the outside of the ankle-joint. It may, though rarely, be completely absent, an instance of which Hughes reported at a recent meeting of the Intercolonial Medical Congress. In some instances the upper and lower ends may be distinct, the shaft having disappeared, being represented but by a thickening of the interosseous membrane connecting the two ends. In fact congenital absence of part of the bone is more frequent than that of the whole bone, which when present causes great disability of the foot and difficulty of ambulation, not on that account only but owing to its frequent association with an imperfect development of the tarsal bones and an absence of one or more of the four outer toes.

A not infrequent condition is a separation of the shaft into two portions at the junction of the middle and lower thirds. Though unassociated with disability in walking yet in some cases the ends may form prominences beneath the skin for which the surgeon may be consulted. That there is a lack of resistance of the narrow lower third of the leg is undeniable, affecting not only the bony structures but the soft also, since Rickets here first manifests itself, and ulcers of the leg are usually met with at this spot.

Associated with the narrowing of the lower third of the leg which is necessary for activity of movement, since size and weight would impede locomotion, we have practically no origin of muscular fibres; the muscles are becoming more or less tendinous; they lie close to the bones and are held firmly in position by strong bands of fascia.

It will now be necessary to enter on a description of the Fibula as it occurs in animals of different species, the animals chosen having undoubtedly an important bearing on the comparison.

Koala (*Phascolarctus cinereus*).

In both the Koala and the Australian Phalanger with the hind foot broad and an opposable and serviceable Hallux there exists a greater freedom of movement between the Tibia and Fibula than in others of the marsupialia, approaching in some degree to the rotation between the Radius and Ulna. In Koala the disproportion between the Tibia and Fibula is slight and excepting the monitor lizard (*Varanus*) less than that occurring in the other forms examined. The head of the bone is well developed and articulates with the Sesamoid bone in the outer head of the Gastroenemius with the outer tuberosity of the Tibia and also with the outer condyle of the Femur, so that it partakes in the knee-joint. The lower end is well developed, with the outer Malleolus slight, and the Fibula is seen to play as almost an important part in the formation of the ankle-joint as the Tibia.

Lemur (*Lemur catta*).

Here as in the case of the Koala there is a wide range of movement at the ankle-joint and the Fibula is well developed

and distinct all through from the Tibia. Above we find the outer tuberosity of the Tibia forming a smooth projecting rim round which the head of the Fibula is allowed to play, resembling somewhat the condition found in the Radius and Ulna of the forearm. The lower end is well developed and takes an important part in the formation of the ankle-joint. There is good muscular attachment of the Extensor muscles and Peronei along the shaft of the Fibula. The disproportion between the two bones is not so marked as in man or the higher mammalia.

"Opossum" (*Trichosurus*).

Here we have introduced as accessory to the use of the fore and hind limbs that of the tail. There is a well-marked disproportion between the Tibia and Fibula and both the upper and lower ends are less defined than in Koala. Furthermore the lower end partakes less in the formation of the ankle-joint.

Wombat (*Phascolomys*).

Here the disproportion in size between the bones of the leg is very pronounced—the atrophying Fibula and the enlarging Tibia being well shown. The Interosseus muscle in contrast to other parts of this marsupial's musculature shows marked evidences of fibrous degeneration. The shaft is complete and the upper end articulates with the Femur and Tibia and also with the Sesamoid Bone. At the ankle-joint the chief articulation is between the Tibia and the Astragalus and the Inner Malleolus partakes in the articulation; but the Outer Malleolus though well developed does not. Below there is a well marked Firbro-cartilage evidently to increase the surface of Fibula for articulation.

Kangaroo (*Macropus*).

Here the lower half of the Fibula as a distinct separate bone has disappeared and the evidence of such is distinguished by a groove. The upper half is distinct and separated from the Tibia though fused to that bone at its lower end. The head is poorly formed though it articulates with the Sesamoid bone and the Outer Tuberosity of the Tibia.

Carnivorous Marsupials

(*Dasyurus viverrinus* and *Sarcophilus satanicus*).

In both the native cat and the Tasmanian Devil we see a marked disproportion between the Tibia and Fibula. These animals represent, with their long Pes and close approximation of Tibia and Fibula below, an approach to the Kangaroo type. The head articulates with the Tibia and the Sesamoid bone. Below the amount of surface entering into the formation of the ankle-joint is insignificant and chiefly through the intervention of the Fibro-cartilage present. The bones are well separated throughout the shafts, but approach below and are firmly bound together. These features are more marked in the Cat (*Dasyurus*) than in the Tasmanian Devil.

Echidna (*Tachyglossus aculeatus*).

Here we have the presence of a Hallux, though not nearly so distinct as in Koala. The shaft of the Tibia is larger than the Fibula, although the disproportion is not very marked. At the upper end we get the prolongation into a broad, flattened process resembling an olecranon, and articulating with both the Femur and Tibia. The lower end is well developed and partakes almost as freely in the formation of the ankle-joint as the Tibia.

Lace Monitor (*Varanus varius*).

In this Australian reptile, where a great mobility of the foot is permissible, we have a much larger Fibula than Tibia, not only as regards the shaft but also at the upper and lower ends. The principal articulating surface both below with the Tarsus and above with the Femur is supplied by the Fibula.

Armadillo.

Both bones are commonly ankylosed together at each extremity but the shafts curve away from each other, leaving a wide interosseous space.

Hare (*Lepus europaeus*).

This animal, with his long foot at a right angle like the Kangaroo, and able also to sit up, shows an even more advanced type of disappearance of the Fibula than seen in that marsupial. Only the upper third remains. No trace of the lower half can be distinguished. The lower end of the fragment is fused to the Tibial shaft, and the upper extremity is fused to the outer Tuberosity of the Tibia.

Sheep (Bovidae).

The Fibula as such has disappeared. There are no evidences of it above, except a well marked fibrous band extending from the External Tuberosity of the Tibia to just above the middle of the shaft of that bone. On the lower, articular face of the Tibia a groove is seen representing the former separation of the Fibula.

Deer (Cervidae).

Here the Fibula has disappeared, the only trace being a bony spicule about three-quarters of an inch long, depending from the outer Tuberosity of the Tibia.

Mongoose (*Herpestes*).

Here we have long feet giving a good base to allow for springing. The Fibula is thin and slender especially in the upper third. There is an ill-defined articulation above with the outer Tuberosity of the Tibia. The lower end does not partake in the formation of the ankle-joint acting merely as an outside support to the articulation.

Horse (*Equus*).

The Fibula is represented by a spicule of bone abutting down from the Outer Tibial Tuberosity. The Koala does not depend on the peloic limb for propulsion speed nor for continuous support. Where high speed continued over long periods is necessary, as in the horse, a bone like the Fibula would undoubtedly weaken the Tarsal articulation.

Agouti (*Dasyprocta*).

Here we obtain marked evidences of the disappearing Fibula, which has assumed a thin almost transparent cartilaginous character with a transparent interosseous membrane. At the upper end no true articulation even with the Tibia is seen, it being retained in position by fibrous bands. It is closely attached to the Tibia below and takes only a very slight part in the formation of the ankle-joint by articulating with the small outer facet on the astragalus.

Buffalo (*Bubalus*).

A groove is seen on the lower articular face of the Tibia representing the original separation of the Fibula. The only representation of the Fibula is a thick fibrous band from the Outer Tuberosity of the Tibia to the junction of the upper and middle thirds of that bone.

Cat (*Felis domestica*).

This animal is able to spring and can broaden his base when sitting by resting on the whole foot. Here we get a slender rounded Fibula tightly attached, especially below to the Tibia. This rotundity shows the absence of necessary muscular pull; the lowest ratio of area to volume is found in the spherical form and for muscular attachment we require area—i.e., surface. It articulates above with the Outer Tuberosity of the Tibia and below enters slightly into the formation of the ankle-joint through the outer facet of the Astragalus.

Baboon.

Here we have a contrast with the Lemur. There is a distinct separated Hallux, but approaching the Anthropoid type. The formation of the ankle-joint with its deep socket and having both Malleoli projecting well down laterally is opposed to lateral movement. The Tibia and Fibula are well bound together and there is little elasticity present. In the Lemur the Fibula articulates with the upper surface of the Astragalus.

In the Baboon the outer Malleolus articulates with the outer facet on the Astragalus, there being a marked ridge separating the upper and the outer surfaces not met with in the Lemur. There is more marked differentiation between the Tibia and Fibula than in the Lemur, and the Fibula is more rounded. There is not the lipping at the outer Tuberosity for easy articulation, as in the Lemur, although some movement is allowable; but the bones are much more firmly attached.

Conclusions.

That the Fibula is undergoing marked evolutionary changes is undeniable, and no doubt the condition in the Kangaroo points the way. Possibly the absence of the Fibula with loss of the outer toes seen occasionally in congenital cases in man serves as an indication of ultimate destination; though obviously here Nature creates a condition for which the erect position has not yet educated itself. Processes of this character are slow and gradual, as seen in the Marsupial, where, as in the Kangaroo, by a fusion to the Tibia, and so a broadening of its surface and strengthening the outer ankle, the bone still performs a function. In the cases of congenital absence of the bone it would be interesting to know had the Fibula really disappeared or was there a fusion to the Tibia, and so a broadening of its surface? In man the marked contrast between the relative size of Tibia and Fibula, and the fact that the latter has been pushed from the knee-joint, and partakes little in the formation of the ankle-joint are indications of its retrogression. The shaft of the bone is undoubtedly thinning, and scarcely do we find two bones alike in size, whilst at the same time the Tibia is uniformly broad and compact. From previous considerations one would naturally expect changes to occur at the lower third of the bone, and thinning is in my experience most marked here, of which the so-called congenital fractures must be regarded as advanced evidences. Probably these cases of so-called fractures are best undetected as the question may be raised of reconstituting the Fibula, i.e., a bone becoming obsolete in the animal economy. One might expect a better result to be obtained if the ends projecting under

the skin were removed, or an endeavour might rather be made to attach them to the Tibia. On the other hand, cases of congenital absence of the Fibula in man, since, as before stated, it may be associated with absence of outer toes, but occasionally with loss or deformity of the inner toes, are associated with impairment of gait and operative interference is necessary. The loss of inner toes seems to have caused difficulty to surgeons in explaining, but the reason is easily understood on comparative lines. On examining the foot of the Kangaroo we see two degenerate inner toes, a powerful middle toe, which is practically the continuation of the foot, and a small, though intermediate, outer toe. No doubt the position and length of the middle toe have been the determining factors in its natural selection; but in spite of this change in the foot the Fibula is not congenitally absent, as a reference to the description will show. Thus from a consideration of the mode of disappearance of the Fibula in animals master exponents of the same mode of progression as Homo Sapiens exhibits, it is obvious that in causing a congenital absence of the Fibula to occur in man, Nature has carried the progress of one of the consequences of the erect position, and associated gait beyond that of the other consequences with which it should be co-ordinate, although she may thereby give us a hint of to what this evolution is tending. In other words, if the consequences of the assumption of the erect attitude with its associated gait are manifold, and must in the type which will be naturally selected and eventually persist be co-ordinate; and if Nature has in these congenital Fibulae cases allowed one member of the associated group of consequential processes to progress disco-ordinately in advance of the rest, it suggests itself that the indicated method of correction of the natural error lies along either one of two directions. Firstly, bringing back the advanced member, e.g., plastically replacing the undeveloped mid-fibula; or, secondly, recognising and permitting the condition of this disco-ordinate member, and artificially re-establishing co-ordination through the other members of the associated group of consequences of the assumption of the erect attitude and gait.

So when one comes to the question of which of the two lines is the correct one to follow one must decide for the latter—or deny the doctrine of evolution, and ignore the results of comparative anatomy.

It is a decision arrived at on philosophical grounds, and without appeal to the question of expediency, involved in the deficient vitality, and hence of energy of repair in the atrophying parts, upon which one depends for union in the plastic operation—apart from the difficulty of obtaining suitable human bone with which to make the attempt.

Recognising the lesson as previously stated that bone is dominated by muscle, it is scarcely understandable that anatomists should pay so much attention to the minute description of bones, and yet such little regard—as evidenced in any anatomical text book—to the important factor of muscular action, on which the bony changes depend, and which the science of evolution shows us existed before bone had its being.

I beg to thank Dr. Stapley for valued assistance, and the use of material—Mr. Lewis, B.V.S., Research Scholar, for the photographs, and Mr. Thwaites, M.Sc., for help in the preparations of the dissections, and for some physiological considerations of the functions of the parts concerned.

EXPLANATION OF PLATES LXXVI.-LXXVIII.

Plate LXXVI.

Fig. 1.—Tibia and fibula of Koala (Phascolarctus cinereus).
„ 2.— „ of Lace lizard or Monitor (Varanus varius).

Plate LXXVII.

Fig. 3.—Tibia and fibula of Kangaroo.
„ 4.— „ of Sheep.

Plate LXXVIII.

Fig. 5.—Tibia and fibula of Opossum (Trichosurus).
„ 6.— „ of Agouti (Dasyprocta).
„ 7.— „ of Hare (Lepus).
„ 8.— „ of Echidna (Tachyglossus aculeatus).
„ 9.— „ of Wombat (Phascolomys sp.).

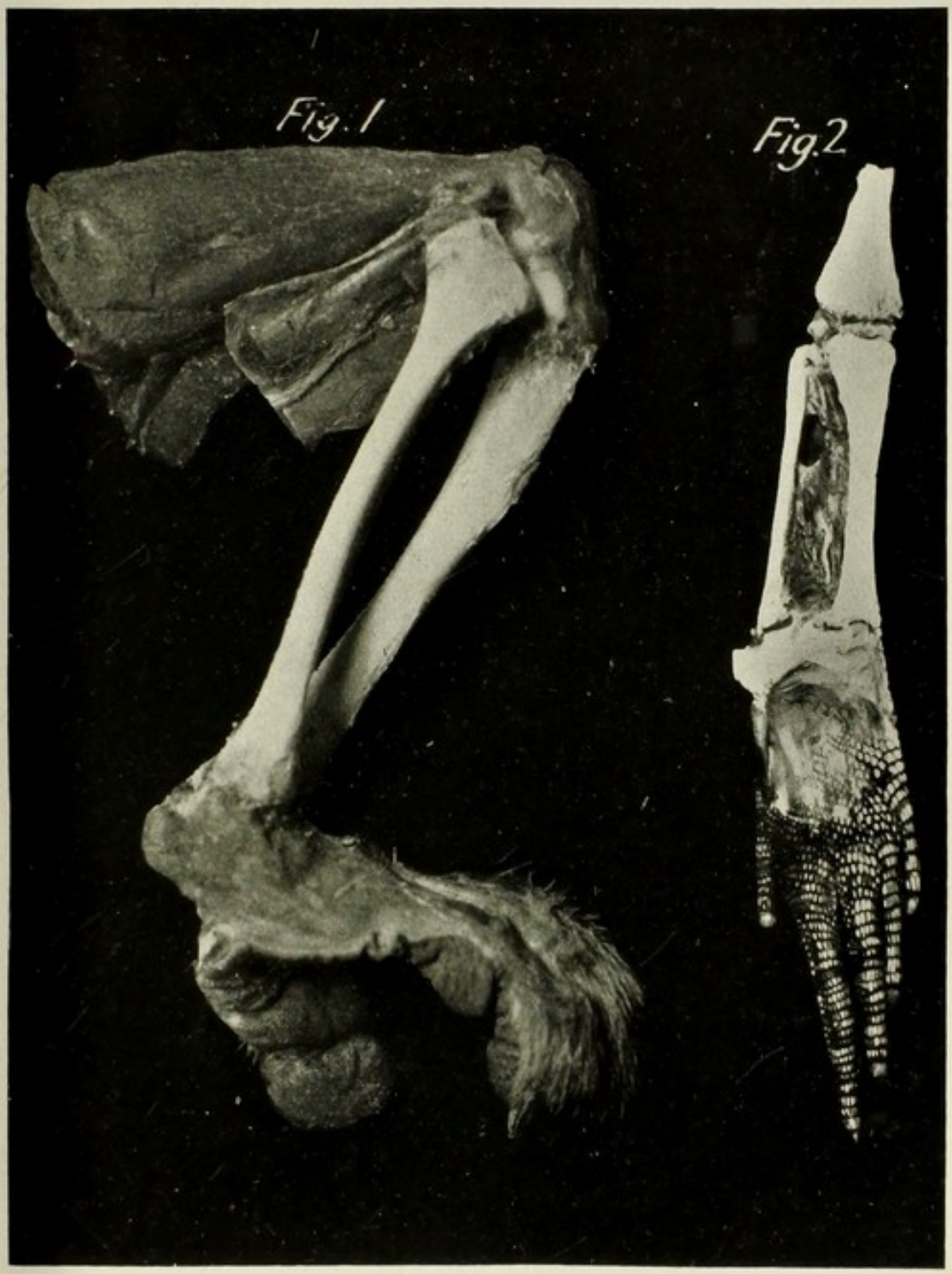
Fig. 1
Fig. 2

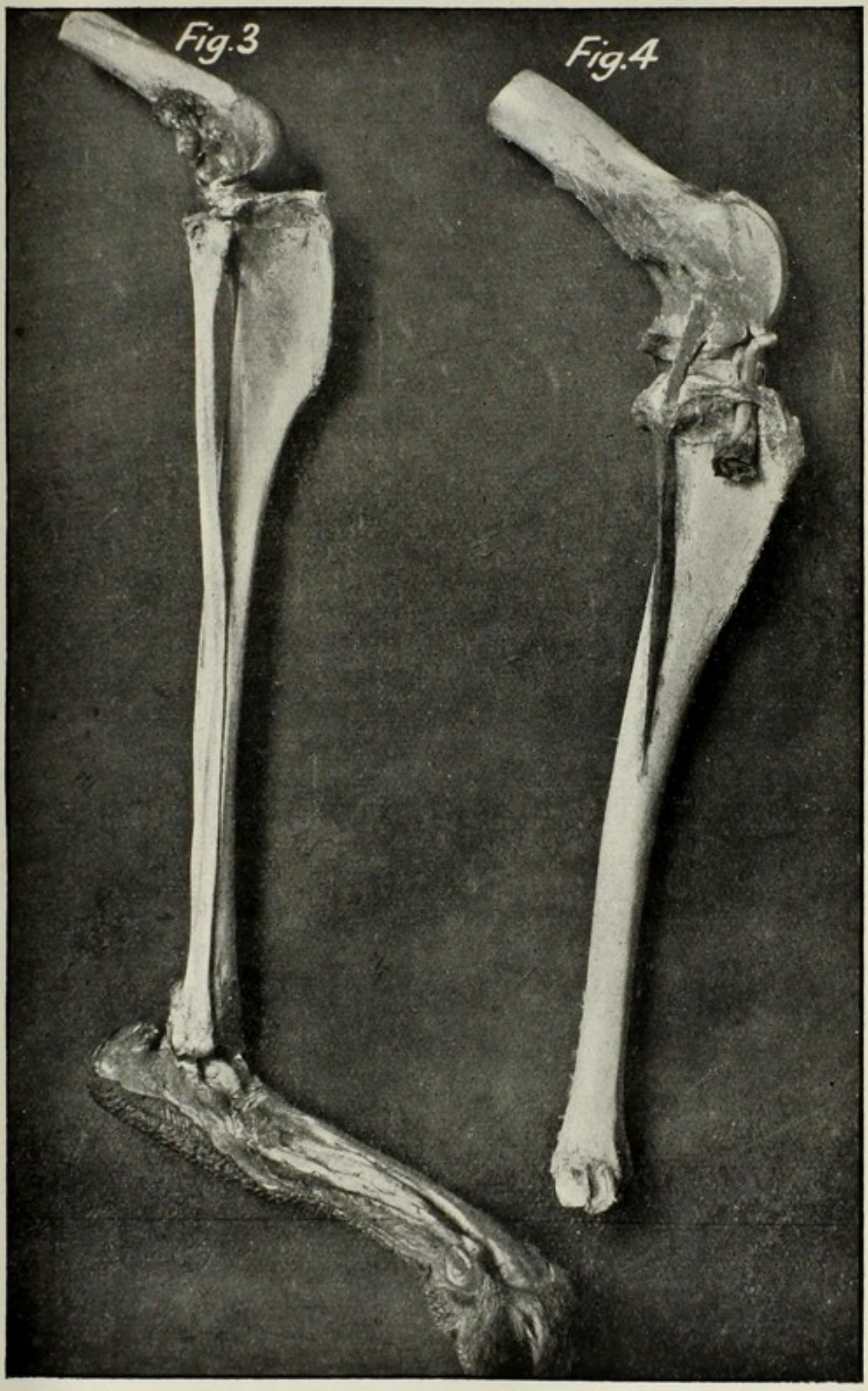
Fig.3
Fig.4

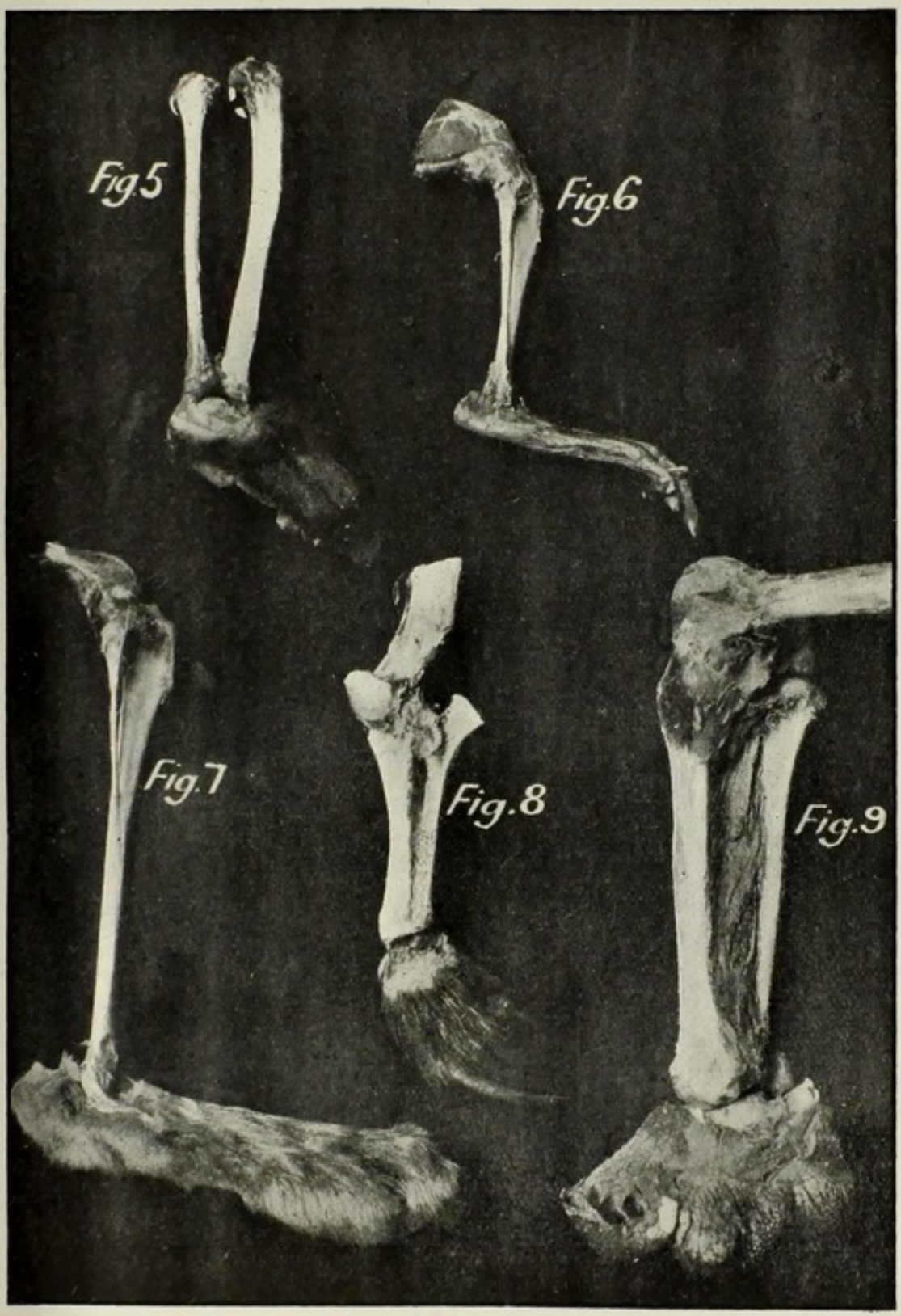
Fig.5
Fig.6
Fig.7
Fig.8
Fig.9