A FOUR-WINGED WILD-DUCK.

BY CHARLES EUGENE JOHNSON.[1]

Plates XXVII–XXIX.

ON November 18 last, the Zoölogical Museum of the University of Minnesota received through Mr. James Ford Bell of this city, a wild duck possessing a pair of supernumerary wings. The specimen had been shot by Mr. J. H. Stadon, of Minneapolis, a few miles west of Wyoming, Minnesota. While in Mr. Bell's possession, the specimen was examined also by the veteran ornithologist Dr. Thomas S. Roberts. The anomaly was considered sufficiently unusual and interesting to merit detailed study and publication.

Supernumerary parts in connection with the appendages of the body occur not infrequently among both vertebrates and invertebrates. Among vertebrates they appear in a variety of forms, such as supernumerary fingers and toes, tails, horns, mammæ, earlike appendages, etc. There appear also the more complex anomalies known as "double hands," and "double feet;" and more rarely there is found an extra pair of limbs nearly entire in themselves, attached in the vicinity of a normal pair, with more or less abnormal condition of the girdle, but in a body in other respects normal. The relative frequency of such abnormalities apparently varies in different groups of vertebrates. Bateson ('94) in his extensive work, calls attention to the many cases of polydactylism for instance, known in the horse, pig, and cat, and the complete absence of any records for the ass and very few for the sheep and dog. For the human species there is a rather extensive record of such cases. In birds, according to the same author, the total number of cases recorded is comparatively small. While in the domestic fowl polydactylism is common, in other groups it is rare; in pigeons, ducks and geese it does not seem to be known.

In the literature accessible, I have found no record of any avian abnormality similar to the case to be here described. Broom ('97)

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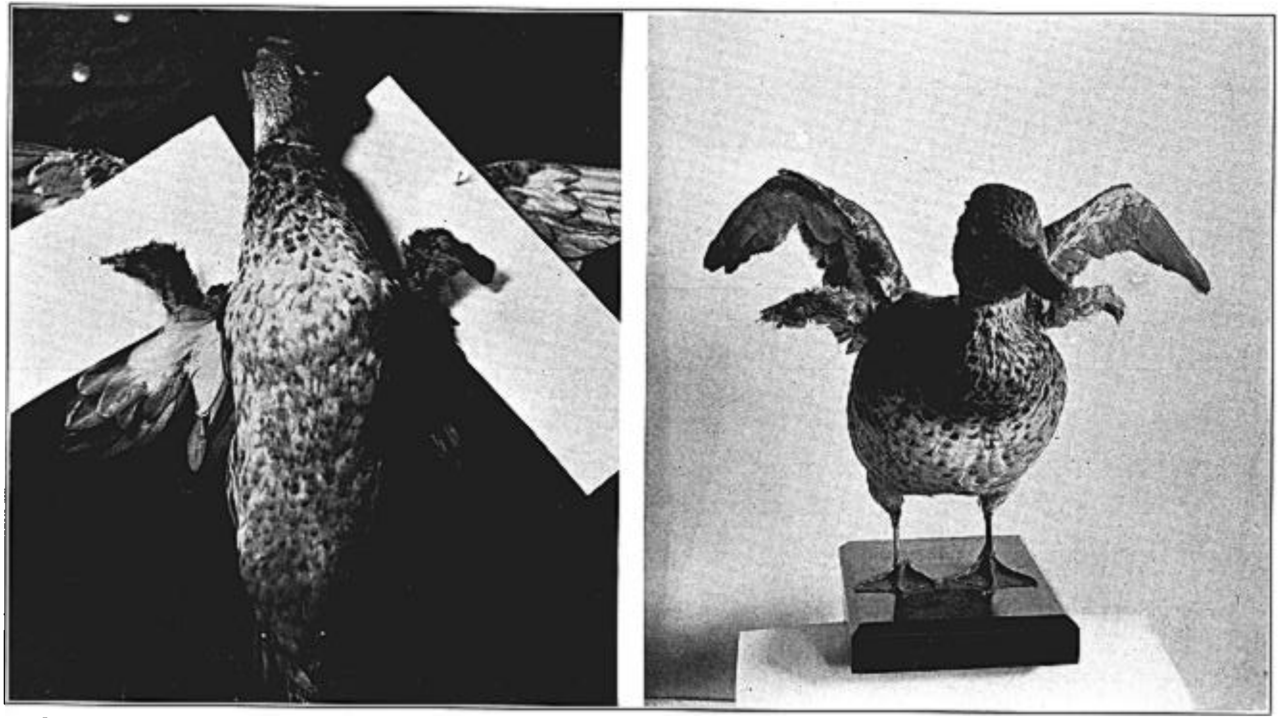
[1] From the Laboratory of Comparative Anatomy of Vertebrates, Department of Animal Biology, University of Minnesota, Minneapolis.



PHOTOGRAPHS OF FOUR-WINGED TEAL.

FIG. 1. IN THE FLESH. FIG. 2. MOUNTED, CHAS. BRANDLER, TAXIDERMIST.

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FIG. 1. IN THE FLESH. FIG. 2. MOUNTED, CHAS. BRANDLER, TAXIDERMIST.

records a "four-winged chick" but his specimen is of an entirely different character, possessing not only four wings but also four legs, and two tails. The spine is bifid, beginning at the base of the neck, and each spinal column has a corresponding pair of wings, a pair of legs and a tail. Diard ('97) reports a four-footed duck six months old. In this case there is a supernumerary pair of feet separate and distinct as far as the ankle joint, where each has its own articulation with a bifid enlargement at the end of a shaft of bone which apparently corresponds to fused tibio-tarsal elements of the two appendages. There is no distinct femoral segment differentiated, the feet being suspended from the previously mentioned shaft which articulates with the pelvis on the left dorsal side, at the junction of the synsacrum and caudal vertebræ. The feet themselves are abnormal. The left is larger and possesses three toes fully webbed; the smaller right foot has only two well formed webbed toes and an inner rudimentary digit. The fourth, posterior toe is lacking in each. The feet are furthermore somewhat deformed and atrophied and incapable of movement.

Tornier ('01) describes among other abnormalities three hens and two ducks, each with a pair of supernumerary legs appended to an abnormal pelvis. In addition to the accessory limbs, each of these specimens had two supernumerary cæca and the rectal segment of the gut was forked, presenting two cloacal chambers and anal openings.

The subject of the present paper is an adult female Green-winged Teal (*Nettion carolinense*). In a letter describing the circumstances in which the specimen was obtained, Mr. Stadon says:

"It may be of interest to know that the bird had no difficulty in flying but was peculiar from the fact that it flew out from some thick grass bordering a small creek back in the woods, whereas this species of duck, in my experience, more often stays along the protected shore of a lake when resting. Furthermore, I had not seen another Green-wing in that locality for at least two weeks before this one was killed. Pretty sure the rest of the species had migrated."

External features. The left wing of the normal or primary pair had been shot off at the elbow, otherwise the two sides are essentially alike in external appearance. When the primary wings are raised the supernumerary wings appear as a miniature set springing from the under side of the former at the region of the elbow, presenting corresponding surfaces and with divisions of forearm and hand clearly indicated. The feathery covering shows no modifications representing flight feathers but consists of under wing-coverts which belong primarily to the feather tracts of the normal pair. The broadly white-tipped posterior series of under wing-coverts of the primary wing continues onto the posterior margin of the supernumerary appendage while the rest of the latter is covered with the smaller, darker feathers of the anterior series.

The accessory wing of each side feels rigid at the elbow and has no movement independent of the primary wing. It is partly flexed at the point corresponding to the carpal region and here it can be felt that a slight movement is possible, but apparently complete flexion or extension can not take place. When the primary wings are folded in place against the body the tips of the smaller set project beyond their margins ventrally as a pair of inconspicuous feather tufts. The right projects a trifle further, and the integument covering its tip is scarred. The accessory wings may possibly during life have interfered somewhat with the folding of the larger pair though in the dead bird this is not apparent.

Skeleton. It is evident that in an abnormality like the present case any attempt to speak of homologies must result more or less unsatisfactorily. This applies to the bony parts as well as to the muscles, and while in the following account the supernumerary parts may be referred to in terms of normal structures it is not intended to convey the impression that homologies in any strict sense exist.

No abnormal features were found in the shoulder girdle. On the two sides the bony elements of the accessory wings are essentially alike from the elbow joint distally but the upperarm portions present markedly different conditions.

On the left side (Fig. 5) the distal end of the humerus of the primary wing is shattered. The remaining part of the bone is of normal shape. On the inner aspect of this bone, at the junction of the shaft with the head is a slender process of bone 7 mm. in length, extending roughly parallel with the shaft of the humerus. At its distal end the process passes into a slender, cylindrical, tendinous ligament 15 mm. in length, which continues toward the elbow joint, and somewhat beyond the proximal half of the humerus, passes over into another bony process, similar to the first mentioned but longer, measuring about 18 mm. in total length. This process terminates in an enlarged headlike end, which, in life, was anchylosed on its lateral side to the median epicondylar region of the humerus of the primary wing by a rather narrow, low ridge of bone. The ligament, near its proximal end has a loop which evidently has resulted from tension exerted by the nerves to the biceps muscle, which lie in this loop. The median nerve passes distally between the ligament and the shaft of the humerus. The parts described, it will thus be seen, represent the imperfectly developed humerus of the left secondary or accessory wing.

On the right side, the humerus of the primary wing is somewhat stouter than that on the left. At about the middle of the shaft (Fig. 3) on its inner aspect, there becomes evident a rather narrow, rounded ridge of bone which further distally differentiates into a slender cylindrical shaft, terminating in an enlarged end similar to that of the left side, and anchylosed to the median epicondylar region of the primary humerus. This represents the humerus of the right accessory wing. At only one place does this shaft become entirely free from the primary humerus; here a narrow foramen is formed, about 6 mm. in length, transmitting a branch of the Nervus brachialis longus inferior.

The forearm skeleton is represented by a single bone. The general shape and articular relations are those of a radius rather than an ulna. It is set at an angle of about thirty-three and a third degrees with the corresponding humeral element, with the distal end of which it is firmly anchylosed. The bone measures 43 mm. in length, as compared with 50 mm. of the radius of the primary wing, and is approximately of the same diameter as the latter. The corresponding bone of the right side is practically identical in size and shape but is anchylosed at right angles to the upperarm segment. The exact relations of the left forearm bone to the primary humerus have been destroyed by the shot wound, but its lateral surface shows that an anchylosis has existed similar to that of the right side. The principal difference is that the left forearm bone forms a sharper angle with the two humeri. On the right side where the elbow articulations are intact, the accessory

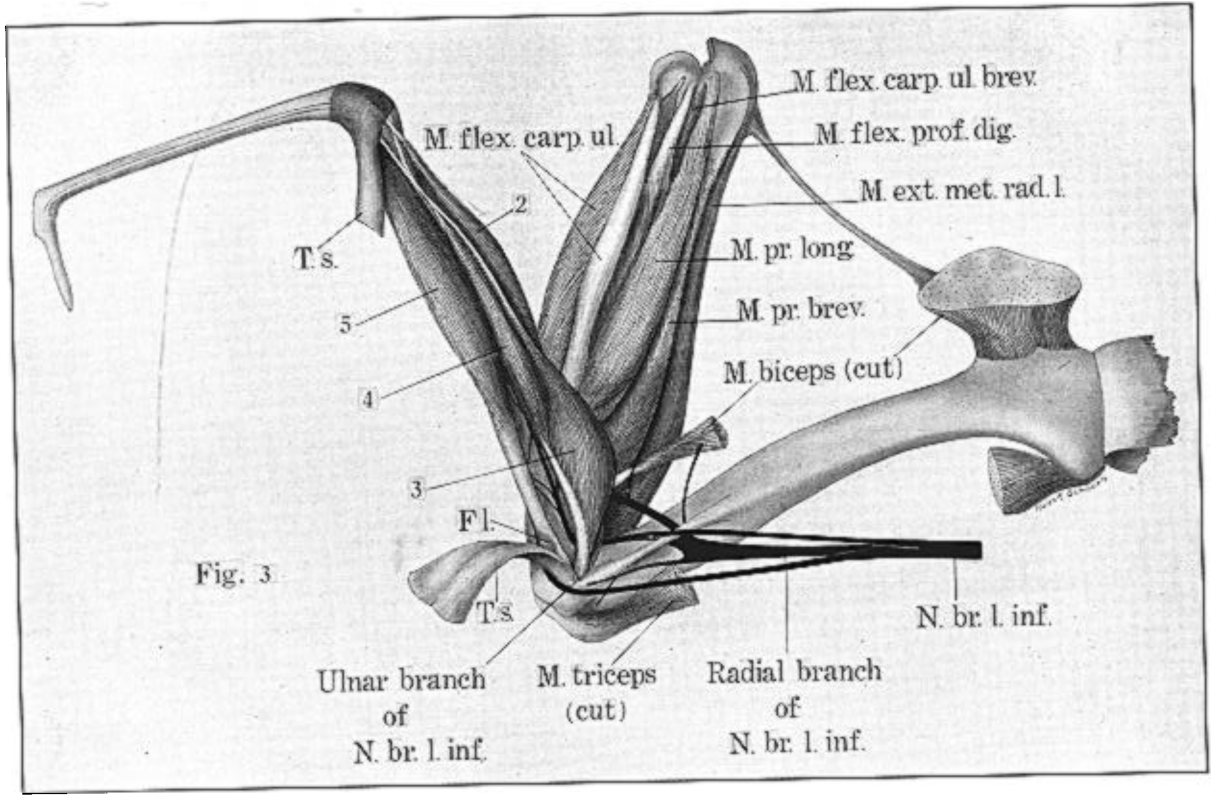

FIG. 3. DISSECTION OF MUSCLES AND NERVES OF THE RIGHT SIDE, FROM INNER ASPECT.

forearm forms an angle of about forty degrees with the plane of motion of the primary forearm upon the upperarm, and evidently could offer no hindrance to the movements of the large wing in flight.

Distally, the forearm bone articulates with two small bony elements which from their position would seem to represent respectively the radial (Rad. carp.) and ulnar (Ul. carp.) carpal bones of the normal wing.

The carpal region of the right side possesses no separate radial element, but such a bone is possibly represented by a knob-like process on the metacarpal element, which forms the articulation with the radius.

The metacarpal skeleton consists of a single elongate, cylindric bone, somewhat enlarged at its proximal end. It is approximately two-thirds the length of the forearm bone. Articulating with the metacarpal bone and terminating the series is a single relatively short phalanx.

On the right side (Fig. 3) there is likewise but a single phalangeal element; it is slightly longer than the left and bent medially at right angles to the metacarpal element with which it is immovably anchylosed.

It will be seen in the figures that a different degree of flexion exists at the two carpal joints. While the joint surfaces here permit of motion, it is clear from the restrictions of the fascia about these joints, as well as from the inadequate muscle supply later described, that movement must necessarily have been very limited.

Muscles and nerves. Like the skeleton, the muscles of the two accessory wings present similar conditions from the elbow distally, but in the upperarm the left side alone possesses muscles and these are only two in number and of rudimentary character. Distad of the carpal region there are no muscles, but a tendon from one of the forearm muscles finds its insertion beyond this region.

The rudimentary muscles of the left upperarm are innervated by branches from the nerves to the biceps muscle of the primary wing. The nerve connections to the accessory forearm muscles of this side could not be positively made out on account of previous mutilation. The muscles of the corresponding right forearm receive their innervation from the Nervus brachialis longus inferior

(Fig. 3, N. br. l. inf.). A single nerve enters the fleshy part of the forearm at its base, on the under side, and distributes to the various muscles. This nerve is formed by the union of two branches from the N. brachialis longus inferior, one of which accompanies the radial branch of the last named through the slit-like passage formed between the upperarm bones. No branch from the Nervus radialis was found to pass to the muscles of the supernumerary wing.

The ulnar branch of the N. brachialis longus inferior, instead of crossing the hollow of the elbow as in normal conditions, reaches its destination by passing around over the convex surface of the anchylosed elbow joint of the accessory wing.

With regard to symmetry, the arrangement of the muscles and nerves seems to indicate that the primary and accessory wings on each side are not related to each other as right and left, that is, as halves of the undivided wing; but that the smaller wing represents an imperfect copy of the larger.

On the left side two slender but well defined muscles are connected with the upperarm bone of the supernumerary wing. Both arise as offshoots from the biceps muscle of the primary wing; one from the posterior edge of the tendon of origin of the short head, near its attachment to the head of the humerus; the other from the ventral surface of the belly of the muscle at its proximal end. The fleshy part of the latter of these two muscles extends distally beyond the former, reaching nearly to the elbow joint. Here both insert by closely associated tendon slips, in the angle between the distal, bony process of the accessory humeral element and the corresponding forearm bone.

On the anterior face of the forearm bone lies a relatively large, dorso-ventrally flattened muscle (Fig. 4, 1) which arises by two short heads; one from the area of anchylosis between the forearm and the corresponding upperarm bones, on the outer anterior surface; the other from the anterior surface of the last named bone, adjacent to the anchylosis. The innervating branch from the N. brachialis longus inferior enters between the two heads. The muscle inserts for the greater part of its length on the forearm bone, extending distally as far as the last quarter of the shaft. In position, form and insertion, and in a general way in its origin, this muscle corresponds to the M. pronator brevis of normal wings.

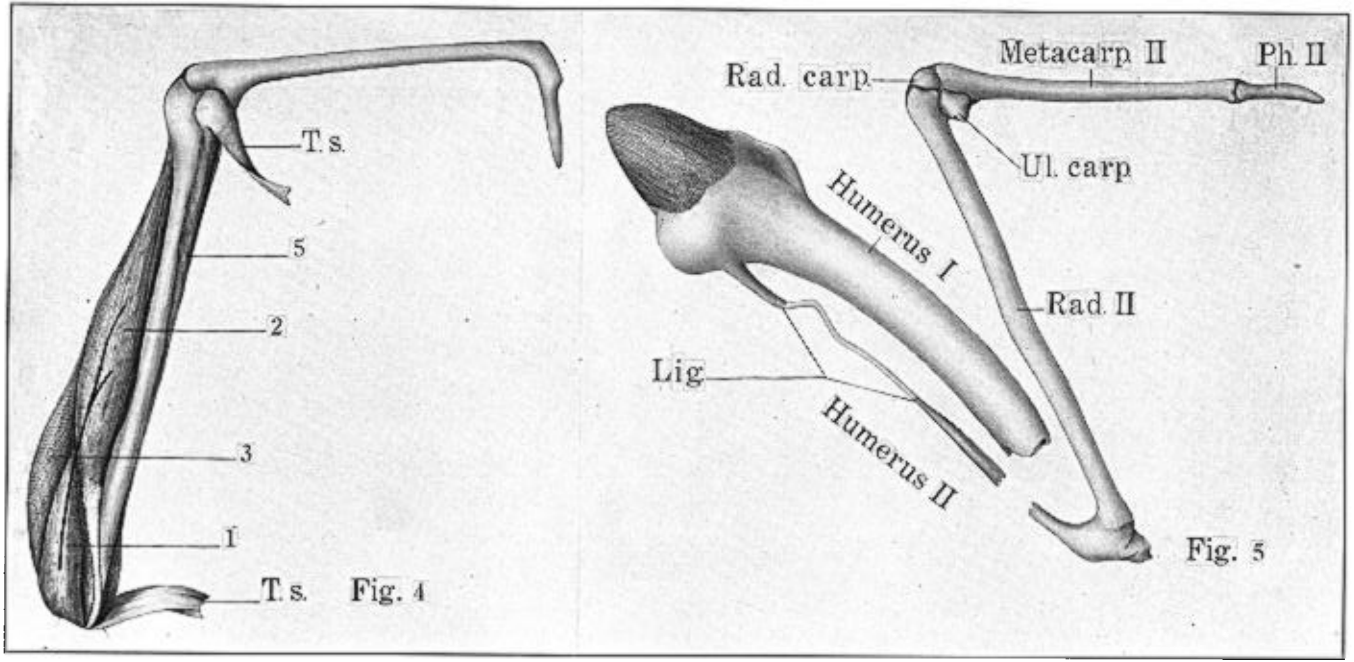

FIG. 4. MUSCLES OF RIGHT ACCESSORY WING, FROM OUTER ASPECT.

FIG. 5. PRIMARY HUMERUS AND SKELETON OF THE ACCESSORY WING OF THE LEFT SIDE. THE RUDIMENTARY HUMERUS WAS ACCIDENTLY BROKEN DURING DISSECTION.

To the outer side of this muscle is a spindle-shaped muscle (Fig. 4, 2) originating by a relatively long, narrow and flattened tendon from the outer, posterior surface of the anchylosis and passing distally, obliquely across the anterior surface of the forearm bone, to become inserted also by a relatively long, slender tendon on the anterior, inner surface of the proximal end of the metacarpal bone. The relations of this muscle closely approach those of the M. extensor metacarpi radialis longior of the normal wing, but the two well defined heads of the latter are here lacking. This muscle would have a pronating action upon the metacarpus in addition to the extending function. It is to be noted that the innervation of this muscle is by a branch from the N. brachialis longus inferior, while the M. extensor metacarpi radialis longior in the normal wing is supplied by the Nervus radialis.

On the under or medial surface of the anchylosed area there arises, partly by fleshy fibers and partly by a flattened tendon, a muscle mass which further distally is differentiated into two muscles, each with a long, slender tendon. One of these components (Figs. 3 and 4, 3) is proximal, and its tendon which is much the longer, passes to the under side of the wrist where it is held in place by a fibrous sheath, and thence courses along the under surface of the metacarpal bone to become inserted at the base of the phalanx. The other, more distal muscle becomes inserted into the fibrous capsule of the wrist joint, on its under side and anteriorly, where its tendon is held in place by the tendon of muscle 2. The first of these muscles has an insertion corresponding rather closely to the M. flexor profundus digitorum, the second to the M. flexor carpi ulnaris brevior of normal wings.

On the ulnar side of the under surface of the forearm is a superficial, broad, thickened, tendinous sheath (Figs. 3 and 4, T. s.). This sheath encloses the elbow joint of the supernumerary wing proximally, and about the middle of the forearm it separates into two bands which diverge, one passing to the outer side of the carpal joint where it inserts, and the other, a narrower band, passing to its insertion on the inner side of the joint. This tendinous sheath encloses a comparatively stout muscle, 5, which is exposed in its distal half by the division of the sheath. The muscle originates on the inner epicondylar region of the rudimentary upperarm bone by a thickened fibro-cartilaginous ligament (Fig. 3, Fl.) about 6 mm. in length by 2 mm. in width, which strongly suggests the humero-ulnar pulley of the normal wing. The ligament is followed by a flattened tendon of origin and this, at about the second third of the forearm, passes into the muscular portion which has its insertion direct upon the entire posterior border of the ulnar bone of the carpus. Some fibers of the muscle arise from the inner surface of the enveloping tendinous sheath. This muscle occupies a position corresponding to that of the M. flexor carpi ulnaris of the normal wing.

Viewing the muscles of the abnormal wing as a whole, one may fancy the arrangement as an attempt to dispose of the muscles formed, in a manner as closely approaching the normal plan as the skeletal conditions of the case and the muscle material available would permit.

The question of causes. With regard to the causes underlying the formation of supernumerary digits or limbs in nature, it may be said that our knowledge is very meager. That supernumerary structures of this kind may be artificially induced in some of the lower vertebrates, often with constant and predictable results, has long been established. And that such parts occur in nature from causes analogous to those of the experimental laboratory is doubtless true; but it is also undoubtedly true that a great many cases occur which are entirely independent of such external causes.

As Barfurth ('95) has pointed out, a number of investigators have held the theory — and he calls this the atavistic theory — that polydactylism represents a "throw-back" (Rückschlag) to an older primitive type of limb which possessed more than five digits. This, because it had been observed that the accessory digit occurred especially in connection with either the first or the last digit of the normal series, and a like supernumerary digit was often known to occur in the same individual on both hand and foot, and was inheritable. Bardeleben, Wiedersheim and others, for instance, assumed that the primitive mammalian limb was not pentadactyl but heptadactyl. Still others pointed further back to the rays of an ancestral fin type.

It would indeed seem that if, in an animal where the normal digital condition for its particular group represents a reduction in number from the pentadactyl type of its class, the full number of five digits should abnormally occur, these accessory digits might in reality represent a reversion to the ancestral type; as for example, when a fifth finger occurs in some urodelous amphibians which normally possess four fingers.

A second view is that of double embryonic anlagen. Here the normal anlage has become divided either through some extrinsic perhaps mechanical agency, or through an intrinsic peculiarity of the germ-plasm.

According to a third view, the supernumerary digits or limbs are simply malformations or pathological growths that belong in the category of duplicate formations (Doppelbildungen) which first arise as germinal variations, and are inheritable.

In the efforts of the various authors holding the views just mentioned, Barfurth finds a more or less evident tendency to assign all cases of supernumerary digits etc. to a common cause. He, himself, believes that they result from a variety of causes.

Among external influences the amnion is considered by some authors as the cause of accessory appendages. Tornier ('97) considers it an established fact that amniotic folds or bands are responsible for some cases of supernumerary digits or limbs in mammals; that this is true not only where such parts occur on one side of the body, but also where they appear on both sides, similar and simultaneous. He cites the case of a pig's foot in the Zoölogical Institute of the University of Leipzig, in which he declares one may follow out in detail the history of the processes by which the end result was produced. According to his view an amniotic band or fold may press against the pelvis or a shoulder blade of the embryo in such a way that a portion becomes pinched off; or a swelling or protuberance arises in which a process of regeneration sets in, producing a structure that in greater or less degree is a duplicate of the part from which it sprang; or a growing limb bud may be split by the penetration into it of such folds or bands. Tornier based his conclusions upon a study of both birds and mammals.

Opposed to this view in regard to the influence of the amnion stand the observations of Kaufmann-Wolf ('08). In an extensive study on the domestic fowl in adult and in embryo, this investigator found no evidence that the embryonic membranes, amnion or allantois, play any part in the formation of polydactylism, and believes that these membranes cannot be adduced as causative factors in the production of such anomalies. Painstaking search in embryonic stages showing incipient polydactylism — one series in particular having the embryonic membranes faultlessly preserved — failed to suggest the possibility of amniotic influence. Furthermore the early appearance of the anlage of the supernumerary digits, at a time when the foot-plate possesses no indentations whatever, speaks against such external agency and justifies the view that if in any other amniote, in much later stages, amniotic bands or folds are found in the clefts between supernumerary digits, they have invaded the depressions secondarily. Kaukmann-Wolf holds the view that polydactylism is due to internal influences which in our present state of knowledge cannot in detail be satisfactorily analyzed.

In certain amphibians which possess notably marked capacity for regeneration, such as Siredon and Triton, Barfurth, and Tornier ('97) produced with regularity supernumerary limbs by means of more or less complex amputations and other forms of injury, the accessory parts being here produced by regeneration at the wound surfaces. From the results of his experiments Tornier concluded that embryonically initiated extra digits or limbs in Anamnia are due to influences analogous to those produced by the embryonic membranes of Amniota; that is, to some stress producing a warping, twisting or splitting of the developing part, thereby inducing regenerative processes or complete division. In both vertebrate groups Tornier thus believes that the underlying causes are of external nature.

From the opposing views here briefly outlined it will be seen that the problem of causes is far from a satisfactory solution.

In regard to the case recorded in this paper it would seem that the embryonic membranes must be excluded as causative factors. The fact that the radial branch of the N. brachialis longus inferior lies between the primary and accessory upper arm bones, indicates that the latter of these bones is not the result of a splitting off from an originally normal embryonic humerus by the ingrowth of an amniotic band, or other mechanical agency, for in that case we should expect to find the nerve which precedes the skeletal parts in development, mesiad of the accessory element; and there is no reason to believe that the distal and proximal parts of the supernumerary wing are not the result of the same cause. Furthermore, it seems improbable that complications in the embryonic membranes should arise on the two sides simultaneously, of such nature as to produce substantially identical results. Taking this anomaly as a whole, the extent to which the entire wing is involved, the imperfect separation of the accessory upper arm bone, the absence of other impressions and disturbances in adjacent soft parts which one might expect as a result of such agencies, there seems to me no basis for believing that embryonic membranes have here been implicated directly or indirectly. What other extrinsic agencies acting merely on the skeletal anlage of the wing alone, or upon the wing-bud as a whole, might have produced the conditions found, are difficult to imagine. The more probable view for this case, it appears to me, is that it resulted from some inherent abnormality of the anlage of the extremity, of germinal origin.

BIBLIOGRAPHY.

BANTA, A. M., and GORTNER, R. A.
1915. Accessory appendages and other abnormalities produced in amphibian larvæ through the action of centrifugal force. Journ. of Exper. Zool., vol. 18.

BARFURTH, D.
1895. Die experimentelle Regeneration uebershüssiger Gliedmassentheile (Polydactylie) bei den Amphibien. Arch. für Entw.-Mech., Bd. 1.

BATESON, WM.
1894. Materials for the Study of Variation. Macmillan & Co., New York.

BONNET, M.
1777. Mémoire sur la reproduction des membres de la Salamandre aquatique. Paris. Mémoire X.
1779. Observation sur la physique, etc. par Rozier. Mémoire XIII.

BROOM, ROBT.
1897. On the anatomy of a four-winged chick. Trans. Nat. Hist. Soc., Glasgow, N. S. vol. 4, pt. 3.

DIARD,
1897. Canard a quatre pattes (monstre pygomèle). Bull. Soc. Hist. nat., Autun. No. 10, pt. 2.

DWIGHT, THOMAS.
1893. Fusion of hands. Anat. Anz.

FACKENHEIM, J.
1888. Ueber einen Fall von hereditärer Polydactylie. Jenais. Zeitschr. fur Naturw., Bd. 22.

GADOW, H.
1891. Bronn's Klassen und Ordnungen. VI. 4.

GEGENBAUR, C.
1880. Kritische Bemerkungen ueber Polydactylie als Atavismus. Morph. Jahrb., Bd. 6.

GRÖNBERG, G.
1894. Beitrage zur Kenntniss der polydactylen Hühnerrassen. Anat. Anz.

KÆSTNER, S.
1899. Neuer Beitrag zur Casuistik der Doppelbildungen bei Hühnerembryonen. Arch. f. Anat. u. Entwick., Anat. Abth.
1898. Doppelbildungen bei Wirbelthieren. Ein Beitrag zur Casuistik. Arch. f. Anat. u. Entwick., Anat. Abth.

KAUFMANN-WOLF, MARIE.
1908. Embryologische und anatomische Beiträge zur Hyperdactylie (Houdanhuhn). Morph. Jahrb., Bd. 38.

KIRKHAM, W. B. and HAGGARD, H. W.
1915. A comparative study of the shoulder region of the normal and of a wingless fowl. Anat. Rec., vol. 9, No. 2.

LEIGHTON, V. J.
1894. The development of the wing in Sterna wilsonii. Amer. Nat., vol. 28.

LILLIE, F. R.
1908. The development of the chick. Henry Holt & Co., New York.

MALL, F. P.
1908. A study of the causes underlying the origin of human monsters. Journ. of Morph., vol. 9.

PATERSON, A. M.
1888. On the fate of the muscle-plate and the development of the spinal nerves and limb plexuses in birds and mammals. Quart. Journ. Micr. Sci., vol. 28.

SHUFELDT, R. W.
1890. The myology of the raven. Macmillan & Co., New York.

TORNIER, G.
1897. Ueber experimentell erzeugte dreischwänzige Eidechsen und Doppelgliedmassen von Molchen. Zool. Anz., Bd. 20.
Ueber Operationsmethoden welche sicher Hyperdactylie erzeugen mit Bemerkungen über Hyperdactylie und Hyperpedie. Zool. Anz., Bd. 20.
1898. Ein Fall von Polymelie beim Frosch mit Nachweis der Entstehungsursachen. Zool. Anz., Bd. 21.
1901. Neues über das natürliche Entstehen und experimentelle Erzeugen überzähliger und Zwillungsbildungen. Zool. Anz., Bd. 24.