A STUDY OF THE VARIATIONS OF POLYDACTYLY OCCURRING IN THE WING OF THE CHICK

by

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B. S., Kansas State College
of Agriculture and Applied Science, 1939

A THESIS

submitted in partial fulfillment of the

requirements for the degree of

MASTER OF SCIENCE

Department of Zoology

KANSAS STATE COLLEGE
OF AGRICULTURE AND APPLIED SCIENCE

1941

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INTRODUCTION

Near the end of the nineteenth century Bateson made a study of the polydactyl condition occurring in the human hand. Newman (1923) made similar studies. Using the data which he had obtained along with the findings of Bateson he formulated a theory of polydactyly for the hand. More recently Dr. D. C. Warren of the Department of Poultry Husbandry discovered that a polydactyl condition existed in the feet of some of the chicks he was breeding (Warren, 1941). Various aspects of this condition were studied by Harman and Alsop in 1938. Further studies of this condition in the feet are now being made by Robert Chapman. It was discovered that the wings of chicks from this same stock were polydactyl. This problem was undertaken for the purpose of studying these wings and to compare this condition with the polydactyly occurring in the feet of the chick, in the human hand, and with the normal wing.

ACKNOWLEDGMENTS

Indebtedness is acknowledged to Dr. Mary T. Harman, Professor of Zoology, for suggesting this problem and for her helpful criticism, and to Dr. D. C. Warren of the Department of Poultry Husbandry for furnishing the material.

REVIEW OF LITERATURE

The osteology of the wing of the fowl was studied by Gegenbaur (1878) who stated that the three digits of the normal chicken wing corresponded to the first, second, and third of the pentadactyl hand, and that digits one and three had one phalanx each. Digit two had two phalanges. He claimed that in the early development of the wing there were four digits, but that the fourth disappeared and that its metacarpal was found at the side of the third metacarpal.

Wiedersheim (1886), Parker (1888), Kaupp (1918), Sisson (1938), and Bradley (1915) were agreed that the digits which remained were the first, second, and third. Bradley said, however, that from embryological evidence the digits seemed to be the second, third, and fourth of the pentadactyl hand.

Owen (1866) believed the digits which remained were the second, third, and fourth of the pentadactyl hand. He said

that from geological evidences the ancient bird, Archaeopteryx, had four digits which corresponded to the first, second, third, and fourth of the pentadactyl hand.

Lillie (1908) called the digits the second, third, and fourth. He stated that in the "hand" of a six-day chick, five digital rays grew out simultaneously from the carpal region. The first and fifth digits were smaller than the remaining three, and later disappeared leaving the second, third, and fourth digits. Lillie claimed that in the wing of a seven-day chick, three metacarpals remained representing the three permanent metacarpals, and digits two and four had two phalanges. Digit three had three phalanges.

Kingsley (1912) stated, "Development shows that the first digit is entirely lost and a fifth metacarpal, which is present in the early embryo, fuses early with the fourth, so that the digital formula is II, III, IV".

Hyman (1922) claimed the remaining digits were the second, third, and fourth. She said, "The second metacarpal is fused to the preaxial side of the proximal end of the third metacarpal where it forms a pronounced hump. From this hump projects the second digit. The third digit is the longest and consists of two phalanges". The first and fifth digits were absent.

Warren (1934) said that from embryological evidence the digits were the second, third, and fourth, and that the first and fifth digits were wanting. He also held that on the seventh day the metacarpals were represented by three cartilages which

corresponded to the three persisting digits of the wing.

Harman and Alsop (1938) in a study of the polydactyly in the foot of the chick found that the extra structures, in most instances, were confined to the region of the hallux. They said, "Polydactylism in the chick is a condition of hyperphalangy of the hallux, manifested either as a lengthening or as a splitting of the digit".

According to Flemming (1940) five digits were present in the "hand" of a six-day chick. The first and fifth digits became smaller by the eighth day of development and disappeared before the tenth day leaving the second, third, and fourth digits. Flemming agreed with Lillie (1908) in that five digital rays were present in the "hand" of the six-day chick. The projection in the wing of the ten-day chick which Parker (1888) called "the accessory cartilage of the first metacarpal" and which Lillie described as the rudimentary first digit, was confirmed by Flemming's evidence. Flemming said, "Results in this study agreed with those of Gegenbaur (1873), Parker (1888), and Hyman (1922) in that digits two and four had one phalanx each and that digit three had two phalanges".

According to Newman (1923), Bateson in 1894 claimed that the "supernumerary appendages" of the vertebrate hand were a matter of "limb-doubling". He believed the extra structures were either separate outgrowths near the normal appendage, or outgrowths from an appendage. He attempted to show by diagrams that the various degrees of duplicity of the human

hand occurred in a logical series.

Newman (1923) advanced a theory of polydactyly for the human hand in which he said, "that the plane of symmetry in the vertebrate hand falls between the thumb and the index finger and that the thumb is the reduced equivalent, on the radial side of the limb, of the four fingers on the ulnar side of the limb". If this theory were correct no more than eight digits would appear on a double hand. Newman said, "No instances of more than eight digits have come to our attention, and whenever there are eight digits they occur in two mirror-image sets".

MATERIAL AND METHODS

The embryological material for this problem was furnished by Dr. D. C. Warren, Professor of Poultry Husbandry. About thirty pairs of polydactyl wings were obtained, all of which were studied. The chicks from which these wings were obtained ranged in age from twelve to twenty days.

The material was first cleared by placing it in one percent potassium hydroxide. When all the tissue other than bone was rendered transparent, the specimen was placed in fresh one percent potassium hydroxide to which had been added enough alizarine red S. to make the liquid a deep wine color. The specimen was allowed to undergo this staining process until the ossified portions were stained a deep pink color. The

material was then placed in Mall's solution, which consists of one part of glycerine to four parts of the clearing solution. The container was covered with tissue paper or cheese cloth so that the potassium hydroxide could evaporate. From time to time glycerine was added until a pure solution of glycerine was in the container. With this technique the ossified portions of the wing were stained adequately.

The photographs of the specimens were made by Mr. E. A. Jensen using a Speed Graphic camera, size three and one fourth by four and one fourth. The exposure time was one tenth of a second at F. 22. The type of lens used was a Ziess Tessar F 4.5 and the focal length was 13.5 centimeters. The photographs were made on Eastman Panatomic X film and printed on single weight smooth white glossy paper. All of the wings were photographed with the "palmar" surface up.

OBSERVATIONS

The variations of polydactyly occurring in the wing of the chick were numerous. They occurred in chicks of the same age, in chicks of different ages, and even in the same chick. Out of a total of thirty pairs of polydactyl wings studied ten pairs were alike and twenty pairs were unlike. Seventeen pairs of wings came from male chicks, thirteen pairs came from female chicks. In all of the specimens the extra structures seemed to be of common origin and all were formed

on the thumb or radial side of the limb. Variations appeared in the number of extra phalanges, the number of extra metacarpals, and in the positions which each assumed.

The most common type of polydactyly in the wing (Fig. 1) exhibited one extra metacarpal with one phalanx distal to it. The specimen illustrated came from a nineteen-day male chick. This type occurred most frequently and was almost equally distributed between right and left wings. A few wings varied slightly from this type. Some of them possessed the one extra metacarpal with two phalanges distal to it, others possessed the one extra metacarpal but no phalanx distal to it. This condition produced one extra digit which varied among specimens with respect to the number of phalanges present.

Another type of polydactyly in the wing (Fig. 2) exhibited two extra metacarpals, the one to the radial side had two phalanges, the other one had only one phalanx. The specimen illustrated came from an eighteen-day male chick. This second type did not occur as frequently as the first one described but it was distrubuted almost equally between right and left wings. Here again variations occurred. A few of the wings had the two extra metacarpals with one phalanx distal to each of them. Others had the two extra metacarpals with no phalanges. Still others had the two extra metacarpals with two phalanges distal to the one on the radial side, and no phalanx distal to the other one.

A third type of polydactyly occurred in the wing (Fig. 3)

in which three extra metacarpals were present. The one on the radial side had two phalanges, the other two had one phalanx each. In this particular wing a small extra bone appeared alongside the radius near its proximal end. This specimen came from a seventeen-day female chick. As in the first two types, this type also had variations. In one specimen the three metacarpals were present. The one on the radial side had two phalanges, the next one had one phalanx, and the next one had no phalanx. Another specimen had the three extra metacarpals, the radial one had no phalanx, and the other two had one phalanx each. Still another specimen possessed the three extra metacarpals, the radial one had one phalanx, and the other two had no phalanges. None of the specimens exhibited more than two phalanges for each extra digit in any of the three types.

An interesting variation was noted which seemed to be common to all three types discussed. It appeared as an in-between stage. The specimen illustrated in Figure 4 was taken from an eighteen-day male chick. The metacarpal on the radial side appeared as a V-shaped structure. One phalanx was seen at both tips formed by the V. This was hardly one extra metacarpal but definitely more than merely the normal bone. This condition held true for other specimens. The wing shown in Figure 5 came from an eighteen-day male chick. One extra metacarpal with two phalanges was seen clearly, and a V-

shaped structure appeared with one phalanx at each tip of the V. This produced more than one extra metacarpal but the additional element was not a complete one. In this particular specimen the radius was almost absent. In the other wing of this pair (Fig. 6) the radius was completely gone. This condition appeared in four specimens, but it seemed to have nothing to do with the polydactyl condition. Some specimens were found in which the V-shaped structures appeared with no phalanges at the tips formed by the V. One wing was found (Fig. 7) in which two extra metacarpals were present, one of which formed a V-shaped structure. This produced slightly more than two extra metacarpals but not three. One phalanx was seen at each tip of the V.

In several instances variations occurred between the two wings of a pair. In one pair, for example, the left wing had three extra metacarpals, while the right wing had only two extra metacarpals. The left wing of this pair, however, did not conform to the third type of polydactyly described previously in that the metacarpal on the radial side had no phalanges distal to it. This pair of wings, which came from an eighteen-day male chick, is illustrated in Figure 8. Another pair was found (Fig. 9) in which the left wing had one extra metacarpal while the right wing had two extra metacarpals. Here again the left wing did not conform to the first type described above. The extra metacarpal had two phalanges

distal to it rather than one. The right wing was similar to the one described in the second type. Three pairs of wings were found in which one wing of the pair was normal while the other one was polydactyl. In these three instances the polydactyl wing had only one extra metacarpal.

The wings illustrated in Figure 10 were both normal wings. The smaller one came from a seventeen-day female chick, the larger one came from a twenty-day male chick. The younger wing had three metacarpals. The radial one had one phalanx distal to it, the middle one had two phalanges distal to it, and the ulnar one had no phalanx. The older wing had the three normal metacarpals. The middle one had two phalanges distal to it, the other two had one phalanx each.

DISCUSSION

A polydactyl wing compared with a normal wing of similar age indicated a marked difference between them. The normal wing had three metacarpals with three digits, which, according to a recent investigation, (Flemming 1940), were the second, third, and fourth. The second and fourth digits had one phalanx each, digit three had two phalanges. If the extra structures of a polydactyl wing were disregarded then that wing would look exactly as if it were normal. In other words, the ulnar group of bones in the polydactyl limb ex-

hibited the bone structures and their positions in the same relation that they were exhibited in the ulnar group of the normal wing. The radial group displayed the extra structures. This held true for every polydactyl wing studied.

Evidence in this study agreed, in part, with the work of Bateson (Newman, 1923) and Newman (1923). Bateson figured a logical series of developments which showed the variations of polydactyly in the human hand. He had one specimen that appeared normal except for the thumb. This was more like a little finger but was slightly larger. It had three phalanges. Other specimens had two, three, and four extra fingers in the place of the thumb. All of them were about the size of the normal fingers of the ulnar group.

Newman (1923) called the ulnar and radial groups with four fingers each, double hands, or mirror-image sets. He claimed that a double hand could not have more than eight digits, and if eight were present they occurred as mirror-images.

Findings in this study showed that one, two, or three extra digits could be present in a polydactyl wing. These extra digits always occurred on the radial side of the limb. This seemed to indicate that the polydactyl condition was not a reversion to the pentadactyl form. However, no more than three extra digits were ever found, and they were never exact mirror-images of the normal structures on the ulnar side of

limb. They differed with respect to the positions of the extra metacarpals and the number of extra phalanges.

One similarity could be seen between the human hand and the wing of the chick with respect to the formation of mirror-image sets. The hand, of course, had four metacarpals and four digits in both ulnar and radial groups while the wing had only three metacarpals and three digits. But since it is normal for the hand to have four and also normal for the wing to have three this similarity seemed reasonable. As stated before, the two forms differed in that no instances were found in the wings in which the radial group was the exact mirror-image of the ulnar group.

The findings in this study were similar to those of Harman and Alsop (1938) who found that the extra structures of the foot, in most instances, were confined to the region of the hallux. The extra structures in the wing were confined to the radial side. This position is analogous to the hallux region of the foot. Their statement, however, that "polydactylism in the chick is a condition of hyperphalangy of the hallux, manifested either as a lengthening or as a splitting of the digit" does not hold true for the wing since there is no pollex normally in this limb. The extra structures in the wing seemed to have a common origin in the region distal to the radius but a lengthening or a splitting of the pollex would not have been possible because there was

no pollex.

SUMMARY

1. Thirty pairs of polydactyl wings were studied. Of these ten pairs were alike, twenty pairs were unlike. Seventeen pairs of wings came from male chicks, thirteen pairs came from female chicks.

2. The variations of polydactyly appeared in the number and positions of the bone elements present. These occurred in chicks of the same age, in chicks of different ages, and even in the same chick.

3. Three groups of wings were found displaying three different degrees of polydactyly. One group had one extra digit, another group had two extra digits, and a third group had three extra digits. No wings were found with more than three extra digits, and none of these extra digits had more than two phalanges. What seemed to be in-between stages appeared between these three groups.

4. Variations of polydactyly occurred between wings of a pair. Instances were found in which one wing had one extra digit, while the other one had two extra digits. Other pairs were found in which one wing had two extra digits, while the other one had three extra digits. Some pairs were found in

which one wing was polydactyl while the other one was normal.

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EXPLANATION OF PLATE I

II, III, IV, digits of the ulnar group; Pd I, Pd II, Pd III, digits of the radial group; M, metacarpal; P, phalanx; U, ulna; R, radius; H, humerus. The metric scale indicates the degree of enlargement.

Fig. 1. Left wing of a nineteen-day male chick.

Fig. 2. Right wing of an eighteen-day male chick.

Fig. 3. Right wing of a seventeen-day female chick. E, extra bone.

Fig. 4. Left wing of an eighteen-day male chick. MV, V-shaped formation of a metacarpal.

Fig. 5. Right wing of an eighteen-day male chick. MV, V-shaped formation of a metacarpal.

Fig. 6. Left wing of an eighteen-day male chick. Note absence of the radius.

PLATE I

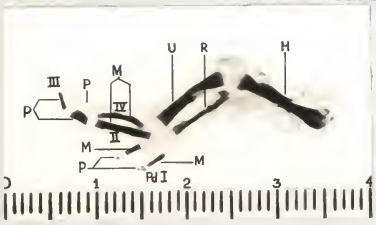

Fig. 1

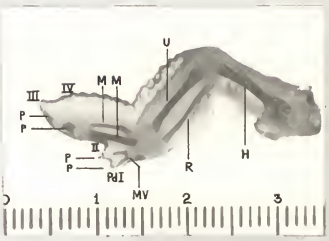

Fig. 4

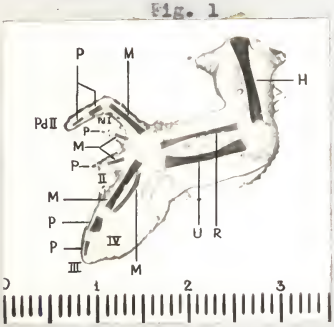

Fig. 2

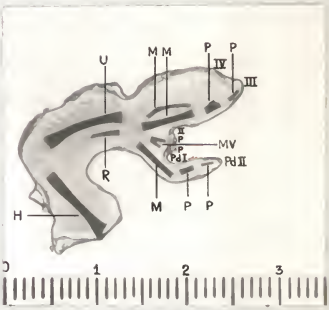

Fig. 5

Fig. 3

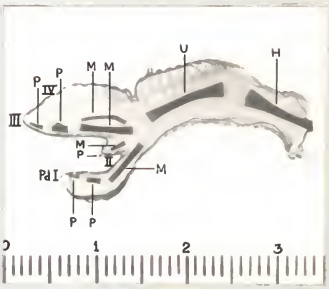

Fig. 6

EXPLANATION OF PLATE II

Fig. 7. Right wing of an eighteen-day male chick. MV, V-shaped formation of a metacarpal.

Fig. 8. Right (below) and left (above) wings of an eighteen-day male chick.

Fig. 9. Right (below) and left (above) wings of an eighteen-day male chick.

Fig. 10. Normal wings. The one above from a seventeen-day female chick, the one below from a twenty-day male chick.

PLATE II

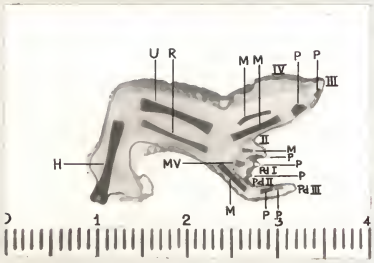

Fig. 7

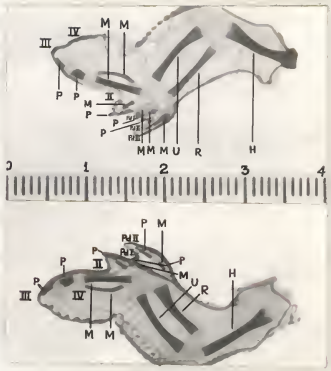

Fig. 8

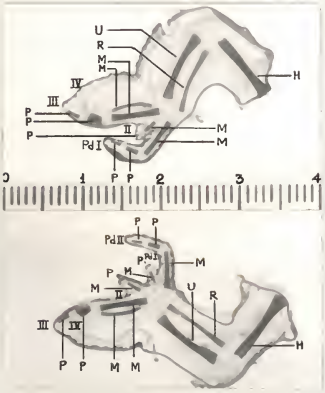

Fig. 9

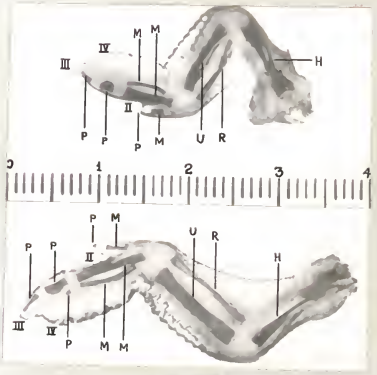

Fig. 10