BRACHYDACTYLY AND SYNDACTYLY IN PTILOPOD DOMESTIC FOWL, *GALLUS DOMESTICUS*

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There have been described in the domestic fowl many syndromes which result from abnormal development. Some of these are heritable. Some are present in a non-hereditary form and are commonly referred to as "accidents of development." Often non-heritable forms which mimic genetically controlled characters are called phenocopies. Rumplessness, consisting of a rudimentation of the caudal vertebrae, is produced by a dominant gene. A non-heritable phenocopy occurs sporadically in nature (about one in one thousand individuals). By exposing eggs to varying abnormal temperatures during the first week of incubation, Danforth, 1932, has succeeded in increasing its frequency up to 7⅛ per cent of the treated eggs. This phenomenon of a "sensitive" period is explained by the assumption that the affected region of the embryo at this time grows and differentiates faster than others. A general retardation at the opportune moment has a differential effect.

Landauer in a series of papers (see Landauer, 1934) has studied a condition in the Creeper fowl which shows a general achondroplasia of the bones in heterozygous condition, the homozygote being lethal. In this case the gene acts upon the early embryonic anlage of the limb slowing up differentiation and apparently not changing the growth variables of the limb. Further Landauer has shown that the distal bones are more affected than the proximal. Again it appears that parts in most active growth are affected to a greater extent than those growing or being differentiated at a slower rate.

Rumplessness and the skeletal achrondoplasia of the Creeper fowl are only two of the embryological malformations which have been carefully studied. Similar to these are the conditions of brachydactyly and syndactyly which are commonly found in ptilopod fowl. Brachydactyly has been described as a condition in which the lateral or fourth toe is shorter than the medial or second. More pronounced cases may be observed as early as the end of the tenth day of incubation. Syndactyly often associated with brachydactyly and occurring slightly earlier in ontogeny consists of a fusion of the third and fourth toes as a result of increased growth of the web. Ptilopody with which syndactyly and brachydactyly are usually associated is a condition of feather formation on the lateral edges of the tarso-metatarsus and dorsal surface of the phalanges. The developmental relations of syndactyly, brachydactyly and ptilopody have been carefully studied by Danforth, 1919 (a) and 1919 (b).

Syndactyly appears to have reached its "sensitive" period by the seventh to eighth day of incubation. Brachydactylous changes may be produced between the eighth and tenth day of development. They vary in expression from restriction of nail size to a complete absence of the third, fourth and fifth phalanges of the fourth toe. Basal and terminal phalanges appear to be most stable. Intermediate stages exhibit shortening, fusion, or both shortening and fusion of the third and fourth phalanges. In the studies reported later reduction of nail size on either of the fourth toes is considered to be evidence of brachydactyly.

Ptilopody is a character which primarily affects the scales of the foot and, according to Danforth, in slightly affected specimens is usually detected by certain changes in the imbrication of the scales. Even though feather germs may be absent, longitudinal lines and grooves on the scales may present a sculptured effect which is first evidence of ptilopody. Excessive, moderate and non-ptilopody are found as true-breeding forms in some of the common breeds of fowl.

Danforth, 1919a and 1919b, postulated a single gene which varied in the time at which its influence affected development, early influence of the gene producing syndactyly with later action producing brachydactyly and ptilopody, respectively. Since the more extreme forms of ptilopody are explained on the action of two dominant gene pairs (see Lambert and Knox, 1929), Danforth, 1929, attributed syndactyly and brachydactyly to both pairs of ptilopod genes. However, Lambert and Knox observed only one case of brachydactyly in several hundred ptilopod fowl and assumed that the ptilopod genes could not be responsible for brachydactyly.

In cognizance of these facts the author has observed all hatchings during the past two years at the Oklahoma agricultural experiment station. The ptilopod fowl belong to the breed designated as the Light Brahma and in one case, the first cross of a Light Brahma male with non-ptilopod Rhode Island Red females. The non-ptilopod fowl consisted of seven different breeds. In over 5,000 individuals of the latter, about one in one hundred exhibits slight evidence of ptilopody but no cases of brachydactyly or syndactyly have been observed.

In the excessive and moderately ptilopod fowl only two out of 161 individuals were free from any evidence of brachydactyly or syndactyly. These ptilopod chicks may be grouped in three types of matings each consisting of one male and several females. Mating I, brachydactyly Light Brahmas, produced 82 progeny all of which exhibited some degree of brachydactyly and no syndactyly. This sire when mated to non-ptilopod Rhode Island Red females produced 23 chicks, 22 of which had a reduced nail size on at least one lateral toe. The results of mating III are given in the table. It consists of a non-related Brahma male mated with female progeny of mating I. All parents have moderately shortened fourth toes and reduced nail size.

PROGENY OF BRAHMA MATING III

Dam's identification	Syndactyly distinct	Syndactyly questionable	Brachydactyly slight	Brachydactyly extreme	Total individuals
Q3	0	0	12	0	13
Q11	2	0	6	0	6
Q12	2	0	10	1	11
Q14	0	3	7	0	7
Q15	5	4	4	15	19

Slight brachydactyly consists of only slight to moderate reduction in toe length, all being identified by fine toe nails. Extreme cases have no or only slight nail formation and extreme shortening of one or both lateral toes.

These results indicate that brachydactyly, syndactyly and ptilopody result from the action of the same genes. The final expression of these genes is apparently due to varying degrees of "penetrance" produced by modifying factors. Presumably the presence of such modifying genes determines the duration and time at which the ptilopod genes affect the developing embryo.

Many other examples attributable to varying "penetrance" are available in genetic literature.

The exact physiological mechanics by which syndactyly, brachydactyly and ptilopody are produced in the embryo remain for future elucidation. The nearest approach to a solution of such embryological mechanics and physiology is being suggested by the very recent informative researches of Willier and Rawles, 1939. By a process of ectodermal and mesodermal grafts in very early embryo stages, these authors have succeeded in demonstrating new and highly specific influences of embryonic tissue cells or diffusible elements from these cells. It is researches of this nature from which further elucidation of the nature of organizing action in the ontogenetical processes might be expected.

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