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Growth Rates of Successive Feathers from Single Follicles in the Juvenile Brown Leghorn.*

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The juvenile plumages of the Brown Leghorn of both sexes pass through a series of changes in pigmentation during successive regenerations. These changes are particularly notable in the feathers which are present at hatching, or emerge shortly after hatching. In the wings and tails, for example, the first feathers to appear are stippled or mottled. The second generation of these feathers shows marked changes towards the adult pattern. In pigmentation, third generation feathers are practically identical with homologous feathers of the adult.

It has been shown previously from this laboratory that there is a direct relation between the concentration of female hormone or thyroxin required for reaction and rate of growth of feathers. (Juhn and Gustavson,[1] Juhn, Faulkner and Gustavson,[2] Lillie and Juhn[3]). There is also a definite range of growth rates characteristic of the feather tracts, and of individual feathers within the tract (Juhn, Faulkner and Gustavson, 1931). These growth relations known to exist in the adult suggest that the juvenile pattern types and changes in these types may be correlated with changes in rates of feather growth during successive juvenile regenerations. In order to test this assumption, we have determined the rates of growth of feathers from a number of tracts in Brown Leghorn chicks. Measurements of length of feathers were begun as soon as possible after hatching, or appearance of feathers, and continued over 2 (in some cases 3) successive regenerations. In all cases which we have studied the rate of growth of the first feather from a given follicle is lowest; second and in many instances third generation feathers grow at increasing rates.

The changes in rates of growth of successive feathers from a single follicle are well illustrated by the main tail feathers. These are present at hatching or appear shortly thereafter. Typical growth

* This investigation was supported in part by funds from a grant by the Rockefeller Foundation to the University of Chicago in aid of biological research.

1 Juhn, Mary, and Gustavson, R. G., *J. Exp. Zool.*, 1930, **56**, 31.

2 Juhn, Mary, Faulkner, G. H., and Gustavson, R. G., *J. Exp. Zool.*, 1931, **58**, 69.

3 Lillie, Frank R., and Juhn, Mary, *Physiol. Zool.*, 1932, **124**.

curves for first, second, and third generation feathers from the No. 2 follicle (counting from center of body laterally) are shown in Fig. 1. Abscissas represent time in days; ordinates give length of feathers

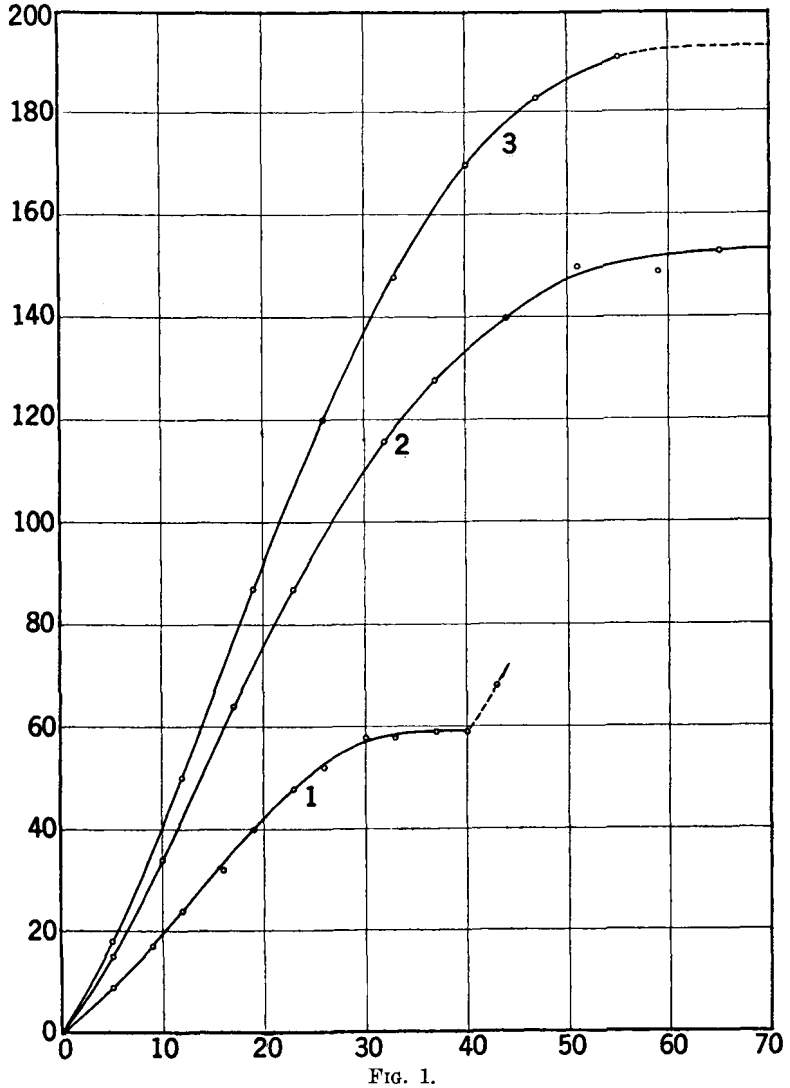

FIG. 1.

Growth curves for first, second, and third regenerates (curves 1, 2, and 3), main tail feather No. 2 (medio-lateral order), right side male Brown Leghorn chick. Abscissas, time in days; ordinates, lengths in mm. The circles represent measured lengths; the common point of origin (0) of the three curves is obtained by transposing individual smoothed curves to a single set of coordinates, taking 0 to be fixed. The increase in length shown by the first feather after completion of its growth (the dotted segment originating on the 40th day) represents growth by the feather of the next generation (curve 2).

in mm. The time of emergence of each feather has been determined by extrapolation of smoothed curves drawn through the indicated points. The numbers on curves (1, 2 and 3) denote first, second, and third generation feathers from the single follicle.

The rates of growth of these feathers expressed in mm. per day are given in Fig. 2, curves 1, 2, and 3 referring to first, second, and third generation feathers. It is clear that there is a rapidly increasing rate of growth at comparable levels of development in successive feathers. A similar order of change has been found in all tail feathers of both sexes, in wing feathers (primaries and secondaries), and in breast feathers.

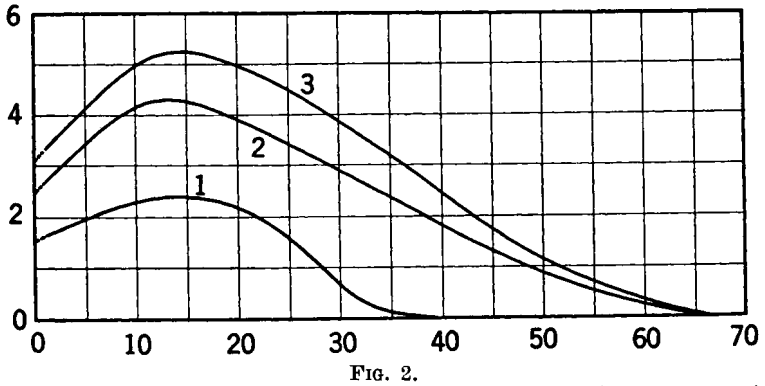

FIG. 2.

Growth rate curves for first, second, and third generations from a single follicle. The rate curves are obtained from the smoothed curves of the preceding figure rather than from the original measurements. Abscissas, time in days from initiation of growth; ordinates, rate of growth in mm. per day.

The change in growth level is much greater between first and second generation feathers (curves 1 and 2 of Figs. 1 and 2) than between second and third generation feathers (curves 2 and 3 of Figs. 1 and 2). This greater shift in growth rate between first and second generation feathers is correlated with a proportionately greater change in pigmentation pattern towards the adult type in these feathers. The first generation feather from the No. 2 follicle of the tail is buff-stippled (or buff-mottled) from apex to base. The second feather from this follicle is typically stippled only at its apex; the remainder of the feather is solid black. The third feather is usually solid black. There is thus a well defined correlation between pigmentation pattern and shifts in rates of growth through the juvenile succession in this particular case.

The length of successive feathers grown from a single follicle increases in approximately the order of shift in growth curves (compare lengths shown by curves 1, 2, and 3 of Fig. 1).

The correlation described here between rate of growth and pigmentation (and feather length) is based strictly upon successive feathers from a single follicle. Feathers composing a given tract, as for example the main tail sequence, do not emerge simultaneously. The last feather of the first generation sequence to appear resembles the second generation feather from the follicle first in order of emergence. The second generation feather of any follicle must accordingly be compared with the first generation feather from that follicle alone. In the breast regions first generation feathers emerge relatively late. These feathers are accordingly much more similar to the adult type than are the first generation tail feathers which bear no resemblance whatever to the black adult feather. In terms of the view previously put forward, the specific pigmentation pattern found in a given feather appears to be a function of its rate of growth. The results described here are taken to support this earlier interpretation of the rôle of growth rates in the determination of pigmentation patterns.

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Paralysis in Old Age in Rats on a Diet Deficient in Vitamin E.*

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On January 3, 1935, a group of rats, just weaned, were put on a highly purified fat-free basal diet, 550-B.[1] Supplements consisted of British Drug House vitamin A, viosterol, and yeast from which practically all fat had been removed with alcohol and ether. This yeast proved to be slightly deficient in vitamin B_1 (antineuritic) and was supplemented with 10 gammas daily of crystalline B_1. Fat deficiency symptoms soon developed and were cured by the daily addition of 5 drops of linseed oil. The only factor which was known to be low or absent was vitamin E. The animals (all females) grew moderately well, and at the end of one year had an average weight of 172 gm. During the second year of life 3 of the 8 animals died from unknown causes. The survivors maintained their weight well in spite of the relatively high purity diet. In September, 1936, when

* The work was aided by grants from National Live Stock and Meat Board and from the Research Fund of the Graduate School of the University.

[1] Burr, G. O., and Burr, M. M., *J. Biol. Chem.*, 1929, **82**, 345.