SEASONAL PATTERN AND GENIC BALANCE

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IN A recent paper (Schwarz, Journ. Heredity, in press, 1941) it was pointed out that in mammals the difference in color and pattern between the normal summer and the normal winter coat is controlled by the genic balance of sex. The shift can be appraised by its effect upon the major pigment factors. It is in a direction which indicates a stronger action of the male principle during the autumn molt. This shift in its effect upon the various pigment factors can be summarized as follows: (1) eumelanin (black extension) = E: increase of black (shift in a dominant direction); (2) recessive white (color) = C: reduction of yellow (shift in a recessive direction); (3) agouti = A: more-distinct banding of the individual hairs; a more distinct demarcation between the upper and the lower sides (shift in a dominant direction). It was maintained that, as the molt occurs at a time of sexual inactivity, without endocrinal activity of the gonads, the genic balance of the tissue was re-established. The shift in the male direction, therefore, was in agreement with a preponderantly male genic balance, to be expected in mammals where the male sex is heterozygous.

If this assumption be true, it was to be expected that in those cases where the female sex is heterozygous, as in birds, the pigment cycle would be reversed, i. e., that the type of winter plumage would more closely approach that of the female, and the summer plumage that of the male. In detail this would mean that in birds the summer plumage should have (1) more black, (2) less red, and (3) the line of demarcation more distinct. The winter plumage should have (1) less black, (2) more red, and (3) a less pronounced line of demarcation between the upper and lower sides of the body. In addition to that, the effect of the sex factor can be more frequently appraised in birds than in mammals, by the phenotype controlled by the factor 'bar' which is well analyzed in the Domestic Fowl; its effect is increased by the male principle, and reduced by the female principle (Lamoreux, Journ. Heredity, 30: 78–80, 1939). In birds it would mean more distinct barring of the feathers in the summer, and a closer approach to the stippled pattern in the winter.

To check this hypothesis I have selected two typical cases in American birds where a definite difference between the summer and the winter plumage is found. The two species used are the Bay-breasted Warbler (*Dendroica castanea*) and the Scarlet Tanager (*Piranga erythromelas*). In *Dendroica castanea* the yellow pigment (phaeome-

lanin) is not an essential part of the pattern, and is best left out of consideration. However, there is a very marked difference in the amount of black between the summer and the winter plumage of the male; in the winter the feathers of the back and neck have hardly any black pattern, but in the summer there is a broad deeply black streak down the shaft, and the neighboring parts of the barb. Also the forehead and the post-ocular stripe are deep black in the summer, but the black is entirely absent in the winter. Moreover, in the winter, the demarcation between the upper and the lower sides is much less distinct than in the summer plumage. All this means that the pattern produced by the eumelanin and the agouti factors is more in the female line in the winter; in fact, there is very little difference between the sexes in the winter plumage. But the phenotype is in the male direction in the summer. This means that the shift of pigmentation during the autumn molt, when it is controlled by the genic balance of sex within the tissue, is in a direction opposite to that found in mammals.

The same opposite effect can be seen in those mammals and birds that turn white in the winter. In mammals the yellow (phaeomelanin) is the first to disappear (Schwarz, 1941, in press). In birds the reduction of pigment begins with the black (eumelanin). In the snowshoe rabbit hairs formed at different stages of the molt show that the white is due to a fading and widening of the pale subterminal band of the individual hair. In the ptarmigan (see also Salomonsen, Vidensk. Meddel. Dansk. Naturhist. Foren., 103: 1–491, 1939), on the contrary, it is the narrow black margin at the tip of the feather which is the first to be suppressed.

The most conspicuous difference between the sexes in *Dendroica castanea,* however, is in the type and variation of the lipochrome. Here two types can be distinguished: (1) chestnut, which is found on the crown, throat, and sides of the male in the summer plumage; (2) yellow, found in the summer and in the winter plumage of the female, pretty well all over the body. In the winter plumage of the male the chestnut lipochrome is almost completely absent; but the yellow lipochrome has been developed instead, in the same measure, and equally arranged, as in the female. A similar seasonal change of lipochromes is found in the Scarlet Tanager where the summer plumage of the male has a scarlet lipochrome; but the winter lipochrome is yellow like that of the female, and in every respect identical with that of the female lipochrome found in *Dendroica castanea.* The color of the young male in both the tanager and the warbler behaves like that of the female and that of the adult male in the winter.

This change of lipochrome with age and season, therefore, is completely in line with the seasonal change of pigment. It is the genic balance of sex which determines the type of lipochrome, as it determines that of pigment, in the absence of endocrinal activity of the gonads. In the two species of birds examined, the two types of lipochrome, the orange and the yellow, may occur together at the same time. In *Dendroica castanea* the male retains some of the chestnut lipochrome on the sides of the body in the winter plumage. On the other hand the female has a greater or lesser amount of it on the vertex and throat in the summer plumage. This means that we have two different factors for lipochromes: (1) the orange controlled by the male, and (2) the yellow controlled by the female; that is, by antagonistic principles.

It has been maintained that lipochromes do not occur in the skin of mammals. But recently it has been shown by spectroscopic analysis that they are present in the skin of man. It is not possible at present, therefore, to say whether in mammals 'male' and 'female' lipochromes occur. But as true carotinoids are known to occur in the liver of mammals, and as they are closely related to the vitamin-A complex, it will be important to find out whether there is a seasonal and age cycle in the carotinoids which can be isolated from mammalian tissue. The importance of such an analysis for an appraisal of the varying requirements of vitamin A connected with season and age, is obvious.

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