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by

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# THE MODE OF INHERITANCE OF THE BAREBACK CHARACTERISTIC IN RHODE ISLAND RED CHICKS

#### AN ABSTRACT

Experimental work was undertaken in an effort to discover the possible genetic cause of the poor feathering quality of back feathering frequently encountered in the Rhode Island Red breed of domestic fowl which characteristic had severely militated against this particular breed with the rapidly grownig importance of the broiler aspect of the poultry industry.

Feathering data on the 1948 and 1949 hatches of the UBC strain are presented and analyzed in this light. Data on experimental matings, involving "bareback" Rhode Island Red sires mated to "bareback" Rhode Island Red dams, to slowfeathering Barred Plymouth Rock and New Hampshire dams and to homozygous early- and normal-feathering White Leghorns, are treated in a like manner.

C Consequent to the observations made and deductions drawn, the writer postulates a "Theory of Inhibitors" as an explanation of this unfavourable feathering aspect of the Rhode Island Red. Four factors are believed to be involved. The experimental work presented was insufficient to demonstrate whether three of these - one "major" and two "minor" inhibitors - were sex-linked or autosomal in nature, while the fourth appeared to act as a sex-linked recessive gene. The major inhibitor apparently did not find expression in the Rhode Island Red and was assumed to constitute a normal complement of the Rhode Island Red's characteristic type of feathering. In inter-breed matings, however, it appeared to be dominant to normal Leghorn feathering in suppressing tail development. The two minors, in cumulative action with the major, were believed to be responsible for the variations in secondary flight and tail feather development observed in Rhode Island Red chicks.

The sex-linked recessive gene apparently gave rise to a retarded type of back feathering, which effect was observed to extend posteriorly to similarly retard the development of the central tail feathers and, in conjunction with the major inhibitor or the two minor inhibitors, was primarily responsible for the "bareback" condition.

Further experimental work was indicated to definitely prove this hypothesis and to ascertain the mode of inheritance of the genes involved.

#### ACKNOWLEDGEMENT

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### The Mode of Inheritance of the Bareback Characteristic in Rhode Island Red Chicks

#### Introduction

The importance of early- and full-feathering in the domestic fowl has been emphasized by the recent **phenomenal** increase on this continent in the demand for the frying type of chicken. This market adaptation underwent a "mushroom" growth during the war and has continued to grow during the intervening years.

While the broiler and fryer types of chickens are defined in terms of weight<sup>1</sup>, consistent with a well-fleshed carcass, such terms can, by transposition, be defined with fair accuracy in terms of age with regard to any specific breed. Thus, a marketable frying chicken must be fully feathered by twelve weeks of age and comparatively free of pin feathers in order to meet the desired level of quality in dressing. Even younger birds are required to satisfy variations in demand, which factor is of particular importance with the heavier breeds.

This trend in demand has induced the poultry breeder to give closer attention to the feathering qualities of his flock. As a result, the slow-feathering breeds, such as the

1. Canadian specifications, as set forth in the "Regulations Made Under the Provisions of the Live Stock and Live Stock Products Act, Chapter 120 of the <u>Revised Statutes of Canada</u>, 1927, Respecting the Grading and Marking of Dressed Poultry, as published in the <u>Canada Gazette</u>, November 19, 1928, and Incorporated Amendments in the <u>Canada Gazette</u>, December, 1931, and November, 1934" are as follows: (the dozen. Squab Broilers: Young chickens not more than 19 lbs. to Broilers: Young chickens not more than 28 lbs. to the dozen. Fryers: Chickens from 29 lbs. to 42 lbs. to the dozen. Rhode Island Red and the Barred Plymouth Rock, and more particularly certain strains of these breeds, have suffered considerably in popularity with poultry breeders in spite of their other favourable economic characteristics.

In considering rapidity of feathering, it should be borne in mind that the first quarter of this century was still the era of the poultry fanciers who were not concerned with this particular characteristic in their birds. Insofar as plumage was concerned the factors of color and color pattern were indeed of primary importance but, as the interests of these breeders lay solely in the production of exhibition birds, there was no significance attached to the time element required in reaching these objectives. Thus. while the first principle adopted by the American Poultry Association<sup>2</sup> was "that in each breed then existing the most useful type should be made the Standard type". 3 it should be remembered that the word "useful" did not carry then the economic implications which are now automatically accepted in the light of the present market demand for poultry products. The fact that the Mediterranean breeds, symbolized in America chiefly by the White Leghorn, were rapid feathering and that the heavier breeds, including both the Americans and Asiatics, were generally slow feathering was given no official recognition whatsoever. Similarly, the

2. Organized by the poultry breeders in 1873 at Buffalo, N.Y.

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<sup>3.</sup> The American Poultry Association, Inc., <u>The American Stan-</u> <u>dard of Perfection</u>, Davenport, Iowa, Published by the editors, revised edition, 1945, p. 6.

productive capacity of any breed did not concern the association. While both of these characteristics were left solely with the discretion of the individual breeder in the development of his particular strain, it required the demands of a commercialized poultry industry to focus attention upon their economic value. The growing importance of this aspect was accompanied by the establishment of annual egg-laying contests throughout the United States. During this period certain breeders of the American breeds, notably the Rhode Island Red, were highly successful in disproving the widelyaccepted supposedly-inherent poor laying qualities of these Through their efforts the overriding importance of breeds. strain rather than breed has been firmly established, with the result that the Rhode Island Red is today the main contender to the White Leghorn in these contests.

While the consumption of poultry meat in the form of broilers and fryers has undergone a phenomenal increase, attention must also be given to the fact that the demands for mature birds as roasting chicken have also risen considerably. Undoubtedly this was occasioned primarily by the shortage of red meats during the war years, but its effect in popularizing roast chicken on the average American menu has continued to enjoy an increasing trend. As an answer to the combined market demands for both eggs and poultry meat, breeders began to devote more of their attention to the American breeds which had been developed originally to meet such a dual purpose. Within this group the Rhode Island Red,

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which arose from Red Malay Game, Leghorn and Asiatic ancestry, became particularly popular. This has resulted in certain strains of this breed being second to none in the production of roasting poultry meat.

Recognition of the commercial importance of broiler and fryer production became publicly evident with the holding of the "Chicken of Tomorrow" contest<sup>4</sup> in the United States during the years 1946-48 inclusive. The results of this contest showed the Rhode Island Red to be conspicuously absent.<sup>5</sup> In view of its valuable dual productive qualities noted above, it scarcely needs mentioning that its slow feathering characteristic, particularly the widespread poor quality of its back feathering, severely militated against its choice by the breeders striving for acclaim in this contest.

The demise of the important role of the poultry fancier was accompanied, and to a large extent accounted for, by the rise of the science of genetics in general, and, in particular, by the increase in the knowledge of the heritable characteristics which determine the production results which can be expected subsequently in the poultry

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<sup>4.</sup> Sponsored by the Great Atlantic and Pacific Tea Company primarily as an incentive towards the production of better 12-week-old frying chicken. This objective was stressed entirely during the first year, to a lesser extent in 1947, while other factors were given consideration also in 1948, mainly egg production, viability and feed efficiency.

<sup>5.</sup> At least within the first eight leading entries which the writer saw published.

flock.<sup>6</sup> Progress in this field, and in the field of nutrition, has contributed greatly to the continued increase in productive capacity in terms of both eggs and meat. The importance of the role played by a bird's genetic constitution being thus accepted, a genetic approach towards solving the feathering problem, posed by the recent transitional trend in the demands of the poultry market, is not only logical but well justified. However, in spite of considerable research work which has been conducted in an effort to overcome the inferior feathering quality of the Rhode Island Red, the persistence of the "bareback" still remains as a widespread disparaging characteristic of this In this regard the University of British Columbia breed. strain has not remained immune.

6. Punnett, in the preface to his book <u>Heredity in Poultry</u>, cites that "happily there are signs that the poultry industry is beginning to recognize the practical value of organized research, and it is in the hope of stimulating that recognition that I have tried to summarize our present knowledge, meagre though it is." Dated Cambridge, Dec. 1922. The MacMillan Co. of Can. Ltd., Toronto, 1923.

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### Review of Literature

Investigation of the genetic constitution of the domestic fowl, insofar as it concerns the rate of feathering, was first reported by Serebrovsky (1922). Working with Russian Orloffs and Barred Plymouth Rocks, he demonstrated the presence of a sex-linked gene in the latter breed which "retards development of feathering in the chicks, so that at the age of 1 to 1.5 months they have very small tails."<sup>7</sup> Development of flight feathers was also noted to be "very slow".<sup>8</sup>

Warren (1925) noted that Leghorn chicks showed tail development by the ninth day at the latest, while no Jersey Giant chicks showed similar development by the . sixteenth day with a large majority of them lacking such growth until the thirtieth or thirty-seventh day (weekly observations were made after the ninth day). Reciprocal matings and back crosses demonstrated the dominance of the slow feathering characteristic of the Jersey Giant over the rapid feathering of the Leghorn and also that the genes responsible were sex-linked.

Kinugawa (1927) presented evidence to show that Leghorns, Minorcas, Hamburgs and Nagoyas were characteristically early feathering because they possessed in homozygous condition the recessive sex-linked allele.

Hays and Sanborn (1942) cite that "Saharova (1926)

8. <u>Loc</u>. <u>cit</u>.

<sup>7.</sup> Serebrovsky, A.S., "Crossing-over Involving Three Sexlinked Genes in Chickens", <u>Amer</u>. <u>Nat</u>., 56:571-572, 1922.

called attention to sex differences in the rate of feathering of the general purpose breeds, to the slow feathering in the Asiatic breeds, and to the rapid feathering in the Mediterranean breeds. He indicated that the dimorphic type of feathering was dominant over rapid feathering, was not sex-linked but was sex limited."9 The dimorphic type of feathering which he noted, whereby the females tend to feather more rapidly than the males, has been corroborated by many investigations regarding the American breeds. Among these has been the work of Martin (1929) dealing with Barred Plymouth Rocks, Radi and Warren (1938) and Hays and Sanborn (1942) with Rhode Island Reds. Darrow and Warren (1944) with both White and Barred Plymouth Rocks and Rhode Island Reds and Glazener and Jull (1946) with Barred Plymouth Rocks and New Hampshires.

Several investigations in this field have all demonstrated the dominance of the late-feathering sex-linked gene (now known as K) over its early-feathering allele (k). Mediterranean breeds appear to be normally homozygous for "early" and much credit has been given to such possession of this gene in appraising the superiority of the "Leghorn type" of feathering over that usually encountered with the heavier birds, including the American breeds. However, while no research work has ever shown the possession of this gene in homozygous form to be other than beneficial, it is

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<sup>9.</sup> Saharova, L.N., <u>Genetics of the Rate of Feathering</u>, edited by Koltzoff, 1926, p. 130. Quoted from Hays, F.A. and Sanborn, R., <u>Breeding Rhode Island Reds For Rapid Feathering</u>, Mass. Agric. Expt. Sta. Bulletin No. 396, p. 2.

open to question whether it has merited in its entirety the degree of importance given to it by some investigators in securing rapid fullness of feathering. In this regard, Jaap and Morris (1937) noted that "Warren (Payne and Scott, 1934)<sup>10</sup> by use of the sex-linked gene for early tail and wing feathering, has been able to produce a strain of Rhode Island Reds which feather out 'like Leghorns'. While this may be the simplest solution to the feathering problem it may be interesting to note that the rapid-feathering Buff Orpingtons previously discussed contain very few, if any, sex-linked rapid feathering individuals."<sup>11</sup> Reference is made here to a strain of Buff Orpingtons, data on which were omitted from their calculations regarding the influence of various factors on the rate of feathering, because they "were practically all well feathered at eight weeks of age". 12 It should be noted in passing that the University of British Columbia strain of New Hampshires also exhibits this characteristic to a high degree, i.e., early fullness of feathering but not early feathering in the sense implied by the possession of the early-feathering gene in homozygous form.

Danforth (1929), by means of skin transplantation on newly-hatched chicks, produced evidence of there being two

- Payne, L.F. and Scott, H.M., <u>International Poultry Guide</u> for Flock Selection, International Baby Chick Association, Kansas City, Missouri, 1934.
- 11. Jaap, R.G. and Morris, L. <u>Genetic Differences in Eight-</u> week Weight and Feathering, Poultry Science 16: p. 47.(1937).
- 12. Loc. cit.

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entirely different factors capable of producing slow feathering in the young chick, one sex-linked, the other autosomal. Aside from these conclusions, however, their data were insufficient to indicate the exact mode of inheritance involved. Rhode Island Reds apparently possessed only the sex-linked gene, while Barred Plymouth Rocks possessed both.

Warren (1933) reported a modifying autosomal gene in White Leghorns which inhibited the development of tail feathers and some of the secondary flight feathers. He termed the gene "retarded", and showed evidence of it being recessive to normal feathering. Because of the greater retardation in feather development resulting from the presence of the dominant sex-linked late-feathering gene, the expression of "retarded" became masked when both of the genes were present in the individual.

Radi and Warren (1938) developed three strains of Rhode Island Reds, the first of which was homozygous for the sexlinked early-feathering gene, while the other two were homozygous for the dominant allele. By selection within the early-feathering strain, they succeeded in producing chicks of both sexes which were practically fully feathered at four weeks of age "much like ordinary Leghorns".<sup>13</sup> Using

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<sup>13.</sup> Radi, M.H., and Warren, D.C., "Studies on the Physiology and Inheritance of Feathering in the Growing Chick", <u>Journal of Agricultural Research</u>, 1938, Vol. 56, p. 695.

extremes in the extent of back feathering as a basis of selection, they attempted to establish two late-feathering strains which they called "well-feathering"<sup>14</sup> and "poorfeathering". They concluded that "well-feathering" was incompletely dominant to "poor-feathering", and that the former was conditioned by autosomal factors. The similarity of results of reciprocal crosses did not indicate the presence of any important sex-linked factors being responsible for the difference in the genetic constitutions of the two strains.

Lloyd (1939) observed varying degrees of reathering in Rhode Island Reds, Barred Plymouth Rocks, Cambars and White Leghorns at four, six and eight weeks of age. His observations would seem to indicate the dominance of early

14. In order to avoid misunderstanding of the phenotypic descriptions involved in the terms "well-feathering" (as used here by Warren) and "full-feathering" (as used throughout this paper), it should be noted that they do not bear similar connotation. While the latter permits a literal interpretation in its entirety, the former allows such interpretation only in the narrow sense of opposition to "poorfeathering" as used here also by Warren. While his use of the term "well-feathering" would, therefore. seem to constitute a decided misnomer in the light of the present demand for early fullness of back feathering, it is to be remembered that such emphasis is of comparatively recent origin and that at the time Warren's paper was prepared the "bareback" constituted what could probably be stated to be the normal condition of the Rhode Island Red at the broiler age.

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feathering<sup>15</sup> in some strains of Rhode Island Reds. It is of interest to note that the male bird, used in these findings, was secured from one of the families of the McRae (Milwaukie, Oregon) strain in which the males were as well feathered as the females at four weeks of age. Such males appeared "to be 'hen-feathered' with long tail feathers similar to those of the pullets",<sup>16</sup> and showed "an amount and length of feathering over the breasts, backs, and thighs equal to that found on the pullet chicks of the same age."<sup>17</sup> From the description given, it would appear that in the development of at least some of the families of the McRae strain the normal dimorphic feathering of the American breeds had been lost, and that this aspect of their genetic constitution exerted a dominant influence over dimorphism. If this interpretation is correct, such findings are certainly at variance with feathering

- 15. It is to be noted that, during the last fifteen years, the term "early feathering" has been variously used as descriptive terminology in reports relative to the feathering characteristics of the domestic fowl. In some cases, such as here, reference is actually made to what may more specifically be called "early fullness of feathering" rather than the narrower meaning, for which it is now reserved, of the expression of the recessive sex-linked gene (k) in well-developed primary flight feathers of the 1-day-old chick and, presumably, in the prominent tail feathers of the 10-day-old chick. As fullness of feathering appears to be governed by autosomal genes, at least insofar as past research has been able to show, it is advisable to bear this fact in mind as an explanation to what otherwise may appear to be conflicting results of research in this field.
- 16. Lloyd, E.A., "Breeding for Egg and Meat Production", <u>Procl Seventh World's Poultry Congress and Exposition</u>, Cleveland, Ohio, 1939, p. 484.

17. Loc. cit.

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characteristics usually encountered with this breed.

Darrow (1941) made observations on heavy birds showing possession of the sex-linked, early-feathering gene and found " a fairly high correlation between the numbers and lengths of secondary wing feathers and the degree of development of the tail feathers, at ten days of age."18 He states that "a strong tendency exists for the day-old chick having the greater number and length of secondary wing feathers to be better feathered at the broiler age."<sup>19</sup> Observations made in this (the writer's) experiment corroborated this tendency with intrabreed matings. However, when a bare-backed male was used in interbreed matings, such a tendency, while holding within each of the two resulting broad groups (based upon juvenile tail development), did not apply to the hatch as a whole. Darrow further states that "probably the highest correlation is between a well-developed tail at 10 days and good back feathering at 6 weeks of age."<sup>20</sup> Here, again, observations made by the writer necessitate modification of this conclusion to apply only to the progeny of intrabreed matings. Results obtained from interbreed matings involving a bare-backed male show that, while all the progeny having good tail development at ten days possess good back feathering at six weeks, the reverse certainly does not hold true.

18. Darrow, M.I., "Relation of Day-old Chick Wing Feather Development to Feathering at the Broiler Age", <u>Poultry</u> <u>Science</u>, 1941, Vol. 20, p. 458.

19. <u>Loc. cit</u>.

20. Loc. cit.

McClary and Bearse (1941) reported a recessive autosomal gene in White Leghorns which was found to retard normal feathering. As this factor was "expressed in the absence of all tail feathers and secondary wing feathers, and slow growth of primaries and body feathers until the chicks are four to six weeks of age",<sup>21</sup> it would seem unlikely that this could be the same as the "retarded" gene reported by Warren, as the degree of retardation of feather development reported in this paper was of greater severity.

Hays and Sanborn (1942) presented their results of ten years' selection and breeding for improvement of back feathering in Rhode Island Reds. By selection on the basis of the condition of back feathering only, at eight weeks of age, progress had been positive but slow. The study indicated the possibility of accelerating the rate of improvement by restricting this method of selection to only those birds which showed tail development at ten to twelve days of age. They concluded that, in addition to the recessive sex-linked earlyfeathering gene, there was a dominant autosomal gene for better feathering which acted in a cumulative manner with the former to give complete back feathering at eight weeks of age.

Darrow and Warren (1944) elaborated upon the previous study by Darrow (1941) and investigated the extent of the correlation between flight feather development and the degree

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<sup>21.</sup> McClary, C.F. and Bearse, G.E., "Recessive Autosomal Factor for Slow Plumage Development in the Chick", <u>Poultry</u> <u>Science</u>, 1941, Vol. 20, p. 466.

of feathering at the broiler age. They noted that "in sexlinked early feathering birds there are many variations in the degree of feathering."<sup>22</sup> In addition to the above, they undertook a study of "the nature of the heritable factors involved in bringing about the differences in degree of feathering."23 The correlation between 10-day tail development and 6- and 8week back feathering was the highest obtained in this study, and they concluded that tail development at 10 days was a valuable characteristic for prediction of primary feathering. They also obtained a highly significant correlation between the number of day-old secondaries to 10-day tail development and to 6- and 8-week back feathering. The correlation between both the number and the length of day-old primaries to 10-day tail development and to 6- and 8-week back feathering, while statistically significant, was not sufficiently so to form a reliable basis of prediction. A similar correlation was found between the length of day-old secondaries to both 10-day tail development and to 6- and 8-week back feathering, indicating that it was a less dependable factor on which to base prediction than was the number of secondaries.

Results of their experimental work indicated the presence of "a major autosomal recessive factor producing

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<sup>22.</sup> Darrow, M.I., and Warren, D.C., "The Influence of Age on Expression of Genes Controlling Rate of Chick Feathering", <u>Poultry Science</u>, 1944, Vol. 23, pp. 199-212.

<sup>23.</sup> Loc. cit.

defective tail feathering at the 10-day age",<sup>24</sup> which they termed "modified early". They suggested that this gene was possibly the same as "retarded" previously found in White Leghorns, and postulated the presence of additional modifiers since all of the offspring from <u>inter se</u> matings could not be classed as either "modified early" or "retarded".

Results of their work with birds possessing the sexlinked late-feathering gene indicated the presence of an autosomal dominant modifier of the late-feathering gene which "somewhat improves primary feathering"<sup>25</sup> and which they termed "intermediate". Chicks possessing this gene are "distinguishable from sex-linked early by possessing lengthened primaries and coverts of about equal length, and by having more slender primaries than are found in early stock",<sup>26</sup> the primaries and their coverts being "of similar length of diameter". 27 This gene apparently expresses itself better in males that are heterozygous for late feathering. The genetic constitution of the heterogametic female also appeared unfavourable to the expression of "intermediate", as there was a shortage of expected females of this type in their matings. From results presented, it would not appear that either "modified early" or

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24. Darrow, M.I., and Warren, D.C., op. cit., p. 208.
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- 25. <u>Ibid</u>., p. 210.
- 26. Ibid., p. 209.
- 27. <u>Ibid</u>., p. 210.

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"intermediate" could be the "dominant autosomal" gene of Hays and Sanborn which, as stated above, had a cumulative action in conjunction with the sex-linked early-feathering gene to produce complete back feathering at 8 weeks of age.

Jones and Hutt (1946) reported the existence of a multiple allelic series of autosomal genes in White Leghorns, consisting of the dominant "normal" gene, the secondary dominant "retarded" gene (previously reported by Warren) and the recessive "tardy" gene. The phenotype of a homozygous "tardy" chick exhibited normal primary but usually no secondary flight development although a few birds were observed which showed "normal development of the first two or three secondaries." 28 No development of tail feathers appeared "until at least eight weeks of age and even then they grow very slowly."<sup>29</sup> From the respective descriptions given in their reports, it would seem that it was this "tardy" gene with which McClary and Bearse (1941) had been working for, as noted previously, the degree of retardation of feather development which they reported was more severe than could be attributed to the action of the "retarded" gene.

McGibbon and Halpin (1946) simultaneously reported the existence of such an allelic series. However, their report did not substantiate the degree of dominance within this series

29. <u>Op</u>. <u>cit</u>., p. 199.

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<sup>28.</sup> Jones, D.G., and Hutt, F.B., "Multiple Alleles Affecting Feathering in the Fowl", <u>Journal of Heredity</u>, 1946, Vol. 37, pp. 109-199.

that the former investigators claimed to exist. Rather, their observations indicated that heterozygosity, of "retarded" and "tardy" (or "slow", as they termed it) at least, gives rise to an intermediate expression in the phenotype. This report also mentioned the existence of the "retarded" gene in their particular strain of Rhode Island Reds which acted as an autosomal recessive in a manner similar to its expression in the White Leghorn and in the six-week-old bird was "expressed by a narrow median band of feathers on the back while the tail feathers approximate in length those of normal early feathering chickens."<sup>30</sup>

30. McGibbon, W.H., and Halpin, J.G., "Three Alleles Affecting Completeness of Feathering in the Chicken", <u>Poultry Science</u>, 1946, Vol. 25, p. 406. - 18 -

#### The UBC Strain of Rhode Island Reds

(a) History

The original birds of the UBC RIR flock were imported in 1918 from the University of Massachusetts, where selection for early maturity and high fecundity over the previous six years had produced very favourable results in egg production. However, this selected breeding had led to such characteristics as variegated, light plumage color and small size, which were quite <u>mal a propos</u> the standard requirements of the Dominion Government's ROP poultry breeding program, in which the UBC flock was entered.

Improvements of color and type was thus adopted as an immediate objective. As selection along these lines did not produce satisfactory results in the following three generations, a male, which was outstanding in these respects, was secured in 1921 from a well known exhibition strain in which mass selection for egg production had been given considerable attention.

While serving the desired objective, the introduction of this 'blood line' resulted in deterioration of feathering by injecting the now-known dominant slow-feathering characteristic into the genetic constitution of the resulting progeny. It is to be remembered, however, that such a characteristic was not one given particular significance by breeders of that day and, equally important, that the mode of inheritance of this feathering characteristic was not known at that time. Consequently, for almost the next decade, primary consideration was given to improving color and type, consistent, of course, with ROP specifications regarding egg production. By this time emphasis upon this latter characteristic was assuming increasing importance as the rising demand for eggs focused the breeders' attention upon the economic value of productive capacity.

In the face of this rising demand, an effort to further stimulate egg production in the UBC strain was inevitable. Following extensive inquiry, two particularly outstanding strains were selected in 1930 from which to secure breeding males. Both of these strains had been developed with remarkable success under combined exhibition and bredto-lay breeding programs. The productive capacity achieved from subsequent matings and succeeding generations showed a favourable increase, several females producing over three hundred eggs in their pullet year in the early 1930's. In addition, the introduction of these 'blood lines' served to increase appreciably the vigor and ruggedness of the UBC strain.

In 1935 a program of selection for improvement in feathering, growth rate and meat type in the RIR and BPR flocks was instituted. Such selection was adapted to conform as far as possible to the growing demand for a "quick-growing, early feathering, 'streamlined' chicken"<sup>31</sup> by the broiler

<sup>31.</sup> Lloyd, E.A., "Breeding for Meat and Egg Production", <u>Proc. Seventh World's Poultry Congress and Exposition</u>, Cleveland, Ohio, 1939, p. 484.

market which, even at that time, constituted "an important source of revenue"<sup>32</sup> for the west coast poultry industry.<sup>33</sup>

Critical observationswere made and five arbitrary classifications<sup>34</sup> were adopted. Selection of breeding stock from the early feathering<sup>35</sup> classification failed to produce marketable broilers by eight weeks of age.

At this time, McRae (Milwaukie, Oregon) was successfully obtaining completeness of feathering in some families of his RIR strain at four weeks of age. In 1937 the University imported some baby chicks of this strain and the following year an outstanding male was selected from these and mated to females of the UBC strain. All of the progeny resulting from this mating were "very early feathering at

32. Lloyd, E.A., op. cit., p. 484.

- 33. The demand for this type of chicken was, at this time, of a seasonal nature and largely confined to the west coast areas of Canada and the United States. It arose initially from the fact that weather conditions in this region favoured earlier hatching than was possible elsewhere and, consequently, early production of broilers. At this time the so-called Japanese method of chick sexing was just beginning to make its appearance in America and, certainly, was not being used to any extent along the west coast where the White Leghorn predominated throughout the flocks. This fact necessitated the retant-ion of the male chicks for some time in order to permit sex determination and profitable disposal was a major concern in reducing the overhead costs of the industry. Thus, in spite of the relatively poor quality of such broilers, the local poultrymen were able to avail themselves of this opportunity to dispose of their male chicks at a profit by concentrating upon earlier hatching.
- 34. Early, medium early, medium, medium late and late feathering.
- 35. See footnote 15 re. connotation.

six weeks of age",<sup>36</sup> indicating that the UBC strain was lacking in a dominant character for rapid feathering in their genetic constitution. During the next few years intensification of this characteristic was incorporated into the breeding program. Unfortunately this was accompanied by an increasing susceptibility to fowl paralysis. Decreasing fertility and hatchability in some family lines also became a major problem.

In an effort to stem these unfavourable trends, the introduction of another 'blood line' was decided upon. To this end a breeding male was secured from a strain the record of which was very impressive not only in regard to these factors but, also, in regard to egg production, color, vigor and type. The results obtained were so satisfactory that this 'blood line' has since been highly infused in the UBC strain during which period the flock has remained "closed". However, the enforced concentration upon characteristics other than feathering quality has resulted in an appreciable loss of early fullness of feathering which, in a large measure, had been secured via the McRae strain. While continued selection for the early-feathering sex-linked gene has achieved homozygosity of this characteristic to such a degree that the UBC strain today is noteworthy because of its extreme tail length, the problem of securing rapid fullness and of eliminating the unfavourable "bareback" is yet to be solved.

36. Lloyd, E.A., op. cit., p. 487.

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### (b) Method of Feathering Classification

As previously noted, five arbitrary classifications were adopted in 1935, based upon the degree of feathering at eight weeks of age. For the sake of brevity in use, these classifications were soon referred to as Types 1 to 5, signifying the order of regression of feathering quality. With the introduction of the McRae 'blood line' and the resultant increase in early fullness of feathering, recognition was given to such a characteristic by classifying the birds so feathered as Type FF (full feathering).

Beginning in 1940, more attention was given to the tail development when "typing" the birds and the suffixes LT, MT and ST (long, medium and short tail) were adopted as modifiers of the above classifications. As far as possible, and with increasing annual frequency, breeding stock was selected from among those birds exhibiting long tails at six weeks of age. All breeding stock now used is of this phenotype, the long tail characteristic being assumed to result from the recessive sex-linked early-feathering gene in homozygous form. Such birds are now classified as EF <sup>38</sup>

- 37. See footnote 34.
- 38. This classification includes a well-represented median dorsal feather tract, because the consistency of its appearance in conjunction with a long tail would seem to indicate that it could justifiably be concluded to arise from the possession of the sex-linked early-feathering gene. The similarity of this phenotypic description to that of the "retarded" phenotype reported by McGibbon and Halpin is discussed later in this paper.

(early feathering). If a bird also exhibits fullness of feathering at this age it is classified EFFF; if it exhibits a deficiency of feathering on the back it is classified EFBB (bareback). Typical birds of these classifications, both male and female, at six and eight weeks of age, are shown in Plates III, IV and V. It will be noted that, due to sexual dimorphism in the rate of feathering - which characteristic is quite evident in the UBC strain - an EFFF male resembles an EF female and an EF amle resembles an EFBB female. Thus extremes in feathering are, by and large, represented by an EFFF female and an EFBB male.

Comparison of present classifications with photographs of those originally adopted in 1935<sup>39</sup> suggest that the following general phenotypic modifications have evolved:

1935 Classification	Present Classification
Early (Type 1) or Medium ) Early (Type 2) )	plus long tail Type EFFF
Medium (Type 3) or Medium ) Late (Type 4) )	Plus long tail Type EF
Late (Type 5)	plus long tail Type EFBB
Early (Type 1) or Medium ) Early (Type 2) )	Types 1 MT (FFMT), 1 (FF or FFST)
Medium (Type 3)	Type 1-2
Medium Late (Type 4)	Type 2
Late (Type 5)	Туре З

For practical purposes, it may be stated that all birds are now classified as either EFFF, EF or EFBB. However,

39. See footnote 34.

examination of the accompanying tables will show that a few birds still failed to fall into one of these classifications in the observations made during the last two years -- 26 (all males) out of a total of 589 in 1948 and 24 (18 males) out of a total of 790 in 1949. In view of the fact that the majority of these birds were progeny of birds known to be homozygous for the early-feathering gene, it would seem that their appearance requires an explanation other than that they possess the dominant allele for slow feathering and consequent lack of tail development.

In the light of the multiple allelic series, known to exist in White Leghorns, the above results might be analyzed on the basis of heterozygosity, in both the dam and the sire, for the "tardy" gene. Such would result in 1/4 of the progeny being homozygous "tardy" and, therefore, slow feathering and tailless. While such a possibility cannot be overlooked as at least a partial explanation, the writer is inclined to the belief that, in view of experimental results outlined in this paper, other genetic factors are also responsible for the appearance of such birds in the U.B.C. flock.

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#### Preliminary Observations - 1948

As an initial step in the investigation of the "bareback" problem, observations were made of the feathering characteristics of the RIR chicks hatched in 1948. All males used in the 1947-48 breeding pens were EFFF. The eggs were set biweekly and five hatches were made during March and April.

Unfortunately, following the selection of the breed-

ing stock for this season, the feathering data on the birds hatched in 1945 was lost so that such information was unavailable for this study. Thus definite classification of nine females (E56-000 series) could not be stated. These females, together with two others from the 1944 hatch (G56-000 series) on which feathering data were lacking, are noted as "unknown" in the accompanying tables, and the tabulated results of the feathering characteristics of their progeny are recorded separately (see 1948 matings 3a, 3b, 3c, 4a and 4b -Tables 4 and 5).

Three females, remaining from the 1943-44 hatch (D49-000 series), were retained for preliminary experimental matings: one Type EFBB, one Type FF(ST) and one Type 2 (see 1948 matings 5, 6 and 7 - Table 6). Classification of the progeny of these three females over a three-year period (1946-48 inclusive) is shown in Table 7.

A general observation of the feather data suggested that the phenotypic differentiation of feathering characteristics of the breeding stock, at least insofar as the EFFF and

EF types were concerned, was of little value in determining the feathering characteristics of the progeny. While the number of EF females used was small (three), the data on their progeny were quite comparable to those obtained on the progeny of the EFFF females mated to the same EFFF males. While this would seem to indicate similarity of genetic constitution, the fact that male H35-507 produced better feathered progeny than did H35-501 in the overall picture and, also, that certain females individually exhibited appreciable variance in their progeny, suggest that insufficient differentiation was being made in classifying birds EFFF. Mating 3 also lends weight to the latter point of view and is perhaps even more indicative in this regard as it shows the results of the progeny of the same females when mated to different EFFF males. Thus, while the possibility existed that genetic differences may be masked and, therefore, not evident in the phenotype, it was decided to be more rigid in the classification EFFF the following year.

Two major observations were made regarding the experimental females. First, although two of these birds were phenotypically slow-feathering (see matings 5 and 7), both of them produced early-feathering male progeny, as had been noted also during the previous two years. While the three-year totals (see Table 7) are not sufficiently large to be conclusive, it is interesting to note that the FF(ST) female produced <u>all</u> early-feathering male progeny while the

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Type 2 female produced only one male chick (out of 25) which was not early-feathering. As all their male progeny would be phenotypically slow-feathering, had these dams been of "tailless" classifications because of the possession of the dominant late-feathering gene, it would appear that they must be genotypically early-feathering and that the expression of this character was genetically suppressed at the time they were originally typed.

The second observation was to the effect that the majority of the male progeny from the EFBB female (all of them in 1947 and 1948) were tailless and that most of these were, in turn, barebacked (Type 2). With the exception of one FF(ST), which might quite possibly have been an error in view of the number involved (31), neither characteristic appeared in the female progeny. The assumption that the appearance of tailless progeny resulted from heterozygosity for the "tardy" gene in both sire and dam (which would result in 1/4 of the progeny being homozygous "tardy" and, therefore, tailless) can scarcely be said to donstitute a satisfactory explanation for the high incidence of tailless male progeny and the absence (bar one) of tailless female progeny. Evidence presented seems highly indicative that the tailless condition of the (male) progeny is due to the barebacked aspect of the dam. The possibility of sex-linkage of this characteristic is thus suggested.

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### Table 1.

CLASSIFICATION OF THE FEATHERING DATA OF THE 1948 FLOCK OF U.B.C. RHODE ISLAND REDS

				Clas	ssifi	cati	Lon of	Featl	nerin	g of I							
Dam			N	Tales	3					Fe	_	Total Known	Total Unknown				
	EFFF	EF	EFBB	1	1-2	2	Total	efff	EF	EFBB	1	1-2	2	Total			
					(	1) N	Mating	: EFI	FF of 2	k EFFI	ŗ f						
						(											
G56-513	0	6	1	0	Ö	0	7	3	5	4	0	0	0	12	19	4	
G56-525	0	2	8	0	0	0	10	0	3	1	0	0	0	4	14	1	
G56-532	0	3	6	0	0	0	9	8	5	9	0	0	0	22	31	8	
G56-539	0	2	2	0	0	0	4	10	2	1	0	0	0	13	17	1	
G56-545	0	0	5	0	0	0	5	2	4	2	0	0	0	8	13	5	
G56-547	1	0	3	0	0	0	4	2	3	1	0	0	Q	6	10	0	
G56-558	0	6	7	0	0	0	13	6	5	3	0	0	0	14	27	4	
G56-578	2	4	1	0	0	0	7	4	8	2	0	0	0	14	21	2	
Total	3	23	33	0	0	0	59	35	35	23	0	0	0	93	152	25	

Note: The following dams shown in the above mating are full sisters:

G56-532 and G56-545

G56-539 and G56-547

1 28 1

## Table 2.

CLASSIFICATION OF THE FEATHERING DATA OF THE 1948 FLOCK OF U.B.C. RHODE ISLAND REDS

				Clas	ssifi	cati	on of	Featl	nerina	g of I	Prog	eny				
Dam			N	lale	3					Fe		Total	Total Unknown			
	EFFF	EF	EFBB	l	1-2	2	Total	EFFF	EF	EFBB	1	1-2	2	Total		
					()	.) Me	ating:	EFFF	o x I	EFFF ç	2					
	۲.	-					) o <sup>*</sup> :	H35-5	507	······································	-					
G56-516	8	2	2	0	0	0	12	12	1	3	0	0	0	16	28	5
G56-534	3	6	0	0	0	0	9	10	4	0	0	0	0	14	23	4
G56-556	9	4	2	0	0	0	15	18	3	0	0	0	0	21	36	3
G56-576	2	0	0	0	0	0	2	4	0	0	0	0	0	4	6	1
G56-596	2	9	5	0	0	0	16	5	5	5	0	0	0	15	31	7
G56-614	1	1	0	0	0	0	2	2	0	0	0	0	0	2	4	0
G56-636	7	5	2	0	0	0	14	11	1	1	0	0	0	13	27	3
Total	32	27	11	0	0	0	70	62	14	9	0	0	0	85	155	23

Note: The following dams are full sisters: G56-556, G56-576, G56-614 & G56-636 G56-534 and G56-596 -29

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# Table 3.

## CLASSIFICATION OF THE FEATHERING DATA OF THE 1948 FLOCK OF U.B.C. RHODE ISLAND REDS

				Cla	ssifi	lcat:	ion of	Feat	nerin	g of I	rog	eny					
Dam			Ν	<b>Male</b>	3					Fe		Total Known	Total Unknown				
	EFFF EF EFBB 1 1-2 2 Total EFFF EF EFBB 1 1-2 2									2	Total						
					(	2) 1											
						-	(a) 🖋										
G56-543	3	6	5	0	0	Ó	14	3	6	6	0	0	0	15	29	5	
G56-558	0	6	7	0	0	0	13	6	5	· 3	0	0	0	14	27	4	
Total	3	12	12	0	0	0	27	9	11	9	0	0	0	29	56	9	
							(b) <u>o</u>	: H35-	-507								
<b>D</b> 49-184	1	0	1	0	0	0	2	0	0	1	0	0	0	1	3	3	
							· · · · · · · · · · · · · · · · · · ·				· · · · ·						
Grand Total	4	12	13	0	0	0	29	9	11	10	0	0	0	30	59	12	

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 $\frac{\text{Table 4}}{(3) \text{ Mating: EFFF } \sigma \text{ x Unknown } \frac{2}{7}}$ (a)  $\sigma \text{ H35-518}$  (b)  $\sigma \text{ H35-518 & G30-365}$  (c)  $\sigma \text{ G30-365}$ 

	S	Classification of Feathering of Progeny													· · ·		
Dam	l r			<u> </u>	ales	3					Fe	male	s			Total	Total
	0	efff	EF	EFBB	lmt	1-2	2	Total	efff	EF	EFBB	lmt	1-2	2	Total	ТПОМП	OHAHOWH
E56-027	a b c	0 1 0	0 2 0	0 0 0	0 0 0	0 0 0	0 0 0	0 3 0	4 1 0	1 0 0	0 0 0	0 0 0	0 0 0	0 0 0	5 1 0	5 4 0	2 0 0
E56-038	a b c	2 0 1	0 2 0	2 1 0	200	0 0 1	0 1 2	6 4 4	ଷ ଷ ଷ	0 0 3	2 0 1	000	0 0 0	0 0 0		11 7 10	2 0 2
E56-052	a b c	000	0 0 0	2 4 4	0 0 0	0 0 0	0 0 0	2 4 4	4 1 1	3 1 2	2 0 1	0000	0000	0 0 0	8 2 4	10 6 8	0 0 2
E56-066	a b c	0 0 1	0 0 2	1 0 2	0000	0 0 0	0 0 0	1 0 5	0 0 1	104	1 0 2	0 0 0	0 0 0	0 0 0	2 0 7	3 0 12	1 0 2
E56-074	a b c	0 0 0	0000	0 0 0	0 0 0	00	0 1 5	0 1 6	୦	000	0 0 0	0 0 0	0 0 0	0 0 0	0 2 2	0 3 8	0 1 2
E56-083	a b c	0 1 2	0 1 0	0 0 0	0 0 0	0 0 0	0 0 0	0 2 2	2 1 4	0 0 1	1 0 3	0 0 0	0000	0 0 0	3 1 8	3 3 10	0 0 2
E56-087	a b c	0 0 0	0 1 0	1 1 0	0 0 0	0 0 0	0 0 0	1 2 0	0 1 0	0 0 0	0 0 0	0 0 0	0 0 0	0 0 0	0 1 0	1 3 0	1 0 0
Total	a b c	2 2 4	0 6 2	6 6 6	2 0 0	0 0 2	0 2 7	10 16 21	13 9 10	5 1 10	5 0 7	0 0 0	0 0 0	0 0 0	23 10 27	33 26 48	6 1 11

 $\phi$  - Male J66-833 used for experimental breeding 1949-50.

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### Table 5.

CLASSIFICATION OF THE FEATHERING DATA OF THE 1948 FLOCK OF U.B.C. RHODE ISLAND REDS

				Clas	ssifi	icat:	ion of	Featl	nerin	g of I	Prog	əny				
Dam			р	Males	3					Fe	emal	es			Total Known	Total Unknown
	EFFF	EF	EFBB	1	1-2	2	Total	EFFF	EF	EFBB	1	1-2	2	Total		
						(4)	Mating	g: EFI	FF o	x Unkr	nown	9		· .		
							(a) <u>ơ</u>	: H35	5-501							
G56-501	0	2	5	0	0	0         0         7         5         7         1         0         0         1           1         0         8         11         3         1         0         0         1									20	3
G56-555 <sup>8</sup>	1	2 <sup>b</sup>	4 <sup>C</sup>	0	1	0	8	11	3	1	0	0	0	15	23	2
Total	1	4	9	0	1	0	15	16	10	2	0	0	0	28	43	5
							(b) <u>o</u>			$\sim$						
E56-047 <sup>8</sup>	4 <sup>d</sup>	4 <sup>8</sup>	2	0	0	0	10	11	3	0	0	0	0	14	24	4
E56-076	0	0	0	0	1	2	3	9	1	2	0	0	0	12	15	4
Total	4	4	2	0	1	2	13	20	4	2	0	0	0	26	39	8
										-					• · · · · · · · · · · · · · · · · · · ·	
Grand Total	5	8	11	0	2	2	28	36	14	2	0	0	0	54	82	13
				a - b - c - d -	oo u inc inc inc	used Lude: Lude: Lude:	for bi s J66-8 s J37-2 s J66-8 s J66-8	reedin 336 us 221 us 335 us	ng in sed for sed for sed for sed for	1949 or bre or bre or bre	als eedi eedi eedi	o. ng in ng in ng in	n 19 n 19 n 19 n 19	49. 49. 49.		

1 32 1

### Table 6.

### CLASSIFICATION OF THE FEATHERING DATA OF THE 1948 FLOCK OF U.B.C. RHODE ISLAND REDS

				Clas	ssifi	cati	lon of	Feath	nerin	g of E	rog	eny				
Dam			N	ales	3					Fe	emal	es		•	Total Known	Total Unknown
-	efff	EF	EFBB	1	1-2	2	Total	EFFF	EF	EFBB	1	1-2	2	Total		
						(5)	Mating	g: EFI	FF of	x FFSI	' Q					
						• •		: H35	5-50 <b>7</b>		<u> </u>				!	
								- 100								
D49-124	1	0	0	0	0	0	. 1	3	0	0	0	0	0	3	4	0
						(6)	Matin	z: EFI	FF of :	x EFBI	<sup>3</sup> <del>2</del>			х. 		
D49-154	0	0	0	0	2	7	9	4	2	0	0	0	0	6	15	0
						(7)	Mating									
D49-166	1	4	3	0	0	0	8	3	3	1	0	0	0	7	15	2

### Table 7

CLASSIFICATION OF THE FEATHERING DATA OF PROGENY OF FOUR FEMALES OVER A THREE-YEAR PERIOD

			-	CO	ass	ifice	atio	n of Fe	eather	ing	of Pro	gen	У				
Dam	Yr.	•		Ma]	es						Feme	les				Total Known	Total Unkn.
		EFFF	EF	EFBB	1	1-2	2	Total	EFFF	EF	EFBB	l	1-2	2	Total		
D49-124 (FFST)	'46 <sup>8</sup> '47 <sup>0</sup> '48 <sup>6</sup>	2	42	- ***			2	6 2 1	16 1 3	3 7		1 3		-	20 11 3	26 13 4	5 <sup>g</sup> 7 <sup>k</sup> 0
D49-154 (EFBB)	146 <sup>1</sup> 147 <sup>0</sup> 148 <sup>6</sup>	3	3		2 3	2 2	13 5 7	23 8 9	11 9 4	5 12 2		1			16 22 6	39 30 15	10 3 0
D49-166 (Type 2	146 <sup>k</sup> 147 <sup>0</sup> 148 <sup>e</sup>	2 <sup>h</sup> 1	8 2 4	4 3	1		-	14 3 8	11 5 3	4 4 3	1				15 9 7	29 12 15	13 31 2
D49-184 (EF)	1460 1470 1481	10 <sup>j</sup> 2	4		1			10 7 0	12 3	3 6		l			16 9 0	26 16 0	71 0 0

Three-year Totals by Dam

D49-124	3	6					9	20	10		4		34	43	12
D49-154	3	3		5	4	25	40	24	19		1		44	84	13
D49-166	3	14	. 7	1			25	20	11	1			31	56	18
D49-184	12	4		1			17	15	9		1		25	42	7

See following page regarding subscripts.

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#### Table 7 (Cont'd) - Subscripts

a - Sire E39-266. Feathering type unknown (lost data).

b - Sire E39-708. Feathering type unknown (lost data).

c - Sire E39-195. Feathering type unknown (lost data).

d - Sire G30-330. Feathering type EFFF.

e - Sire H35-507. Feathering type EFFF.

f - Not used for breeding in 1948.

g - Including Male G56-555 used for breeding in 1948 & 1949.

h - Including Male G30-333 used for breeding in 1947.

i - Including Male G30-331 used for breeding in 1947.

j - Including Males G30-355 & G30-357 used for breeding in 1947.

1

S

1

k - Two Type 1 and one Type EF.birds included.

1 - Type EF birds but sex unknown in all cases.

#### Table 8.

#### SUMMARY OF 1948 PROGENY TOTALS RESULTING FROM VARIOUS MATINGS

				Clas	ssifi	.cati	ion of	Feath	erin	g of I	roge	eny				
Mating Number			D	lales	3					Fe	male	s			Total	Total Unknown
	EFFF	EF	EFBB	lmt	1-2	2	Total	EFFF	EF	EFBB	lmt	1-2	2	Total		Unitiowi
# la	3	23	33	0	0	0	59	35	35	23	0	0	0	93	152	25
# 1b	32	27	11	0	0	0	70	62	14	9	Ó	0	0	85	155	23
# 2a	3	12	12	0	0	0	27	9	11	9	0	0	0	29	56	9
#2d	1	0	1	0	0	0	2	0	0	l	0	0	0	1	3	3
# 3â	2	0	6	2	0	0	10	13	5	5	0	0	0	23	33	6
# 3b	2	6	6	0	0	0	16	. 9	1	0	0	0	0	10	26	1
# 3c	4	2	6	0	2	7	21	10	10	7	0	0	0	27	48	11
# 4a	11	4	9	0	1	0	15	16	10	2	0	0	0	28	43	5
# 4b	4	4	2	0	1	2	13	20	4	2	0	0	0	26	39	8
<b>#</b> 5	1	0	0	0	0	0	_ 1	3	0	0	0	0	0	3	4	0
# 6	0	0	0	0	2	7	9	4	2	0	0	0	0	6	15	0
#7	1	4	3	0	0	0	8	3	3	1	0	0	0	7	15	2
Totals	54	82	89	2	6	18	251	184	95	59	0	0	0	338	589	93

For parental feathering types see following page.

1

#1a - 0"H35-501 x 8 EFFF 00	#3c - o'G30-365 x 7 Unknown oo
#1b - 0"H35-507 x 7 EFFF qq	#4a - o H35-501 x 2 Unknown oo
#2a - 0"H35-501 x 2 EF 00	#4b - o H35-507 x 2 Unknown oo
#2b - 0"H35-507 x 1 EF q	#5 - o H35-507 x 1 Type 1 p
#3a - 0"H35-518 x 7 Unknown oo	#6 - 0"H35-507 x 1 EFBB Q
#3b - oo H35-518 & G30-365 x 7 Unknown oo	#7 - 0"H35-507 x 1 Type 2 p

Note: The oo in Matings 3a, 3b and 3c are the same. of H35-518 died during the regular breeding season and was replaced by o G30-365. Hence the paternal parentage of the progeny shown in Mating 3b is uncertain as these chicks were hatched from eggs laid during the time interval required to be observed for definite sperm replacement under ROP regulations. 1

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All of noted above are EFFF.

Observations - 1949

All three phenotypes were represented in the males used during the 1949 breeding season - one EFFF, two EF and one EFBB - which afforded the opportunity of observing the effect of a male's reathering characteristics on those of his progeny. As in the previous year, five biweekly hatches were made, the first occurring February 28th and the last April 25th.

The decrease in the number of birds classified EFFF this year was, of course, a direct result of more rigid selection decided upon following analysis of the 1948 data. An interesting point, though perhaps of little consequence, was that, in spite of using all three phenotypes in the sires, the percentages of male and female progeny classified EFFF closely retained the same relative proportion as the previous year, roughly a 1:3 ratio:

	Males	Females
1948 -	21.5% (54/251)	54.4% (184/338)
1949 -	12.8% (46/359)	36.9% (159/431)

A very noticeable feature of this year's data was the absence of EFFF male progeny, and the very limited number of EFFF female progeny (20%), resulting from the mating of the EFFF male to three EFFF females. This is particularly striking in view of the EFFF progeny obtained from the other three males when mated to females of this classification, both EF males producing approximately 20% males and 40% females while the EFBB male produced 8% and 36% respectively. As the EFFF

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male, when mated to three EF females, produced approximately 1/3 EFFF progeny, both male and female, results did not consistently substantiate the assumption of insufficient differentiation in the EFFF category, although such a hypothesis could explain the results of individual cases in a satisfactory manner.

A decided decrease in the number of birds classified EFBB also was observed. To a large degree, this could probably be explained as a result of continued selection for better feathering quality in the past plus a probable fortunate choice of breeding stock. The increased attention paid to the appearance of this type is probably reflected here also. While the percentage of male and female birds of this type in the 1948 hatch was in the ratio of 2:1, the number of females secured in the 1949 hatch was not sufficiently large to be indicative in this regard:

			Males	F	emales
1948	-	35.3% (	89/251)	17.5%	(59/338)
1949		319% (	14/359)	0.9%	(4/431)

c

The observation of most interest, however, was that the EFBB male produced both tailed and tailless progeny when mated to EFFF females (see 1949 mating 6). While it is to be admitted that both partially bailless (Type 1MT) and completely tailless (Types 1-2 and 2) progeny were not secured from any one individual female, the overall result of this mating is similar to that obtained in the progeny of the EFBB female (Experimental, 1948) over a three-year

-39-

period (see Table 7) except that, in this latter instance, these types appeared only in the male progeny. (Although both of these types were not produced by this female in 1948, reference to Table 7 will show that they were produced in each of the preceding two years. This fact favours the assumption that the same results could have been expected from the EFBB male had the numbers of his progeny been sufficiently large). Aside from this, however, this observation served as an additional indication that the bareback characteristic of the breeding stock gave rise to taillessness in the progeny and, too, that possibly there was sexlinkage of the factor(s) involved.

The fact that one of the EF males used (J66-836) also produced tailless progeny (male only in the EFFF and FF matings; both male and female in the EF mating - see 1949 matings 3b, 4b and 5) can probably be explained on the grounds that this bird had been incorrectly classified at six weeks of age and was, in reality, Type EFBB. Such an error could quite possibly arise from two sources. First. it should be remembered that the three phenotypic classifications used are purely arbitrary and that, while the majority of the birds are relatively easy to type according to these categories, there are, nevertheless, several individuals which constitute "borderline" cases and which, therefore, may be incorrectly classified. In this regard, environmental, nutritional and other non-heritable factors which affect feathering quality may also lead to improper

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classification. It should be noted here, too, that lateness in season also has been observed to militate against both the rate of feathering and rate of growth via a higher incidence of parasitic infestation which, in turn, is due to the fact that, as the season advances, weather conditions become more favourable to parasitic development. Where confinement rearing is not practised, such as is the case at the University, infestation of this type can become quite detrimental. A second reason, of equal or possibly more importance, is the fact that the exact mode of inheritance involved in the case of the "bareback" is not known and that, therefore, it is not impossible for the responsible gene (s) to be masked in the Indeed it would seem that only by way of such a phenotype. possibility could the appearance of bareback progeny from non-bareback stock be explained.

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### Table 9.

CLASSIFICATION OF THE FEATHERING DATA OF THE 1949 FLOCK OF U.B.C. RHODE ISLAND REDS

			_	Clas	sifi	.cat	ion of	Feath	ering	g of I	Proge	eny				
Dam			N	lales	3					Fe	emale	es			Total Known	Total Unknown
	EFFF	EF	EFBB	IMT	1-2	2	Total	efff	EF	EFBB	lMT	1-2	2	Total		
					(	1)	Ma <b>ti</b> ng:	EFFF	o x	EFFF	ę					
						÷.	O <sup>A</sup> :	J66-	835							
H57-365	0	7	0	0	0	0	7	0	4	0	0	0	0	4	11	1
H57-416	0	4	0	0	1	0.	5	2	2	0	0	0	0	4	9	7
G56-534	0	13	0	0	0	0	13	1	6	0	0	0	0	7	20	7
Total	0	24	0	0	1	0	25	3	12	0	0	0	0	15	40	15
						2)	Mating	EFFF	ox	EF ç						
							of a	: J66-	835							
H57-399	1	1	1	0	0	0	3	3	3	1	0	0	0	4	7	0
H57-457	0	6	1	0	0	0	7	0	7	0	0	0	0	7	14	1
H57-470	5	6	0	0	0	0	11	4	5	0	0	0	0	9	-20	2
Total	6	13	2	0	0	0	21	7	13	0	0	0	0	20	41	3

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# Table 10.

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CLASSIFICATION OF THE FEATHERING DATA OF THE 1949 FLOCK OF U.B.C. RHODE ISLAND REDS

				Clas	ssifi	.cati	lon of	Feath	nerin	g of I	Prog	eny				·
Dam			N	lales	3					Fe	emal	es			Total Known	Total Unknown
	EFFF	EF	EFBB	lmt	1-2	2	Total	EFFF	EF	EFBB	lmt	1-2	2	Total		onknown
					(	3) 1	Mating:	भेज ।	Tx El	০ স্থন্দ						· · · ·
						(	(a) <u>o</u> :	J66-	811	···· ¥						
H57-306	0	2	1	0	0	0	3	4	5	0	0	0	0	9	12	6
H57-372	2	8	1	0	0	0	11	5	14	2	0	0	0	21	32	6
H57-379	1	4	0	0	0	0	5	1	1	0	0	0	0	2	7	3
H57-398	5	13	0	0	0	0	18	5	9	0	0	0	0	14	31	5
H57-417	2	1	0	0	0	0	3	6	0	0	0	0	0	6	9	1
H57-461	0	12	1	0	0	0	13	5	5	1	Ö	0	0	11	24	0
H57-465	1	9	0	0	0	0	10	6	6	0	0	0	0	12	22	4
Total	11	49	3	0	0	0	63	31	40	3	0	0	0	75	138	25
						(	(b) <u>o</u> .	J66-	-836							
H57-335	2	4	0	0	0	0	6	2	0	0	0	0	0	2	8	2
H57-359	1	3	0	0	0	,Q	4	3	3	0	0	0	0	6	10	0
H57-391	4	8	1	0	1×	0	14_	3	9	0	0	0	0	12	26	4
H57-444		12	0	<u> </u>	1	<u>l</u>	15	3	10			0	0	13	28	9
TOTAL	8	27	<u> </u>	<u> </u>	2		39		22	0	0	0	0	33	72	15

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Table 11.

				Clas	sifi	cat	lon of	Feath	erin	g of I	roge	eny				
Dam			N	ales	3					Fe	emale	es			Total Known	Total Unknown
	EFFF	EF	EFBB	lMT	1-2	2	Total	EFFF	EF	EFBB	lmt	1-2	2	Total		
					(	(4) N	Mating	EFC	X E	Fç						
							(a) <u>o</u>	<b>.</b> J66-	. <u>811</u>							
H57-384	. 0	6	0	0	0	0	6	1	8	0	0	0	0	9	15	11
					(b) $\underline{\sigma': J66-836}$											
H57-309	1	17	1	0	0	0	19	8	10	0	0	0	0	18	37	2
H57-358	0	8	0	0	1	1	10	2	9	0	0	1	0	12	22	1
H57-436	0	3	0	0	0	0	3	1	5	0	0	0	0	6	9	3
H57-472	1	10	1	0	0	0	12	3	13	0	0	1	0	17	29	1
H57-481	0	11	0	0	0	0	11	5	4	0	0	0	0	9	20	4
Total	2	49	2	0	1	1	55	19	41	0	0	2	0	62	117	11
			1			<b></b>	1 <del></del>			<del> </del>	r			1		
Grand Total	2	55	2	0	l	l	61	20	49	0	0	2	0	71	132	22
					(	(5) N	Mating	EFC	x F	Fç						
			<u>.</u>			-	0	<u>J66</u> -	836							
H57-402	0	12	0	0	2	0	14	3	5	0	0	0	0	8	22	10

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Table 12.

				Clas	ssifi	cati	lon of	Feath	erin;	g of I	roge	eny			met a 1	met al
Dam			Δ	ales	3					Fe	emale	es.			Known	Unknown
	EFFF	EF	EFBB	lmT	1-2	2	Total	EFFF	EF	EFBB	lMT	1-2	2	Total		
					(	6) <u>I</u>	Mating:	EFBI	3 <b>d x</b>	EFFF	<u> </u>					
							<u> </u>	J37-	221							
H57-302	3	6	1	0	0	0	10	12	10	0	0	0	0 C	22	32	15
H57-332	0	2	0	0	0	0	2	2	11	0	0	0	0	13	15	10
H57-422	0	2	0	la	0	0	3	3	7	0	0	1	0	11	14	7
H57-423	1	9	1	18	0	0	12	2	7	0	1	0	0	10	22	6
H57-427	0	12	1	0	0	0	13	3	12	0	0	0	0	15	28	6
H57-438	0	7	0	10	0	0	-8	6	8	1	0	0	0	15	23	13
H57-451	0	1	0	0	0	0	1	3	1	0	0	0	0	4	5	0
H57-458	0	4	0	0	0	0	4	6	14	0	0	0	0	20	24	8
H57-467	1	7	0	0	2	0	10	0	8	0	0	1	0	9	19	3
H57-705	1	8	1	0	0	0	10	11	2	0	la	0	0	14	24	2
Total	6	58	4	3	2	0	73	48	80	1	2	2	0	133	206	70
					a	. Mec	lium Te	ail.	b. R	unt.						· .
					(	7) 1	<b>Mating</b> :	EFBI	3 d'x	EFQ						
						-	<u>d</u> :	J37-	-221	<b>T</b>						
H57-325	3	9	0	0	0	0	12	7	2	0	0	0	0	9	21	6
H57-328	2	10	1	0	0	0	13	8	9	0	0	0	0	17	30	3
H57-368	1	8	1	0	0	0	10	4	8	0	0	0	0	12	22	5
H57-447	3	0	0	0	0	0	3	4	5	0	0	0	0	9	12	8
Total	9	27	2	0	0	0	38	23	24	0	0	0	0	47	85	22

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## Table 13.

### CLASSIFICATION OF THE FEATHERING DATA OF THE 1949 FLOCK OF U.B.C. RHODE ISLAND REDS

	Classification of Feathering of Progeny															
Dam			Л	lales	3			-		Fe	emale	95			Total	Total
	EFFF	EF	EFBB	lMT	1-2	2	Total	EFFF	EF	EFBB	lmt	1-2	2	Total	Known	Unknown
				·	(	(8) Mating: EFFF or x Unknown qq										
		-				d: J66-835										
H57-349	1	4	0	0	0	0	5	1.	2	0	0	0	0	3	8	3
G56-555	0	11	0	0	1	0	15	10	5	0	0	0	0	15	30	7
E56-038	0	0	0	0	2	l	3	2	8	0	0	0	0	10	13	2
E56-047	0	1	0	0	0	1	2	0	1	0	°O	0	0	1	3	7
Total	4	16	0	0	3	2	25	13	16	0	0	0	0	29	54	19

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### Table 14.

#### SUMMARY OF 1949 PROGENY TOTALS RESULTING FROM VARIOUS MATINGS

f1												* **			i	·
				Clas	ssifi	cat	lon of	Featl	nering	g of I	Proge	eny				
Mating			р	lales	3			Females							Total	Total
Number	EFFF	EF	EFBB	1MT	1-2	2	Total	EFFF	EF	EFBB	lmt	1-2	2	Tot.	Known	Unknown
# 1	0	24	0	0	1	0	25	ື	12	Ĩ	0	0	0	15	40	15
# 2	6	13	2	0	0	0	21	7	13	0	0	0	0	20	41	3
# 3a	11	49	3	0	0	0	63	32	40	3	0	0	0	75	138	25
# 3b	.8	27	1	0	2.	1	39	11	22	0	0	0	0	33	72	15
#4a	0	6	0	0	0	0	6	1	8	0	0	0	0	9	15	11
# 4b	2	55	2	0	1	1	61	20	49	0	0	2	0	71	132	22
<b>#</b> 5	0	12	0	0	2	0	14	3	5	0	0	0	0	8	22	10
# 6	6	<b>5</b> 8	4	3	2	0	73	<b>4</b> 8	80	1	2	2	0	133	206	70
# 7	9	27	2	0	0	0	38	23	24	0	0	0.	0	47	85	22
<b>#</b> 8	4	16	0	0	3	2	25	13	16	0	0	0	0	29	54	19
Totals	46	281	14	3	11	4	359	159	261	4	2	4	0	431	790 .	201

### For parental feathering types see following page.

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# Table 14 (Cont'd.)

#1	-	EFFF	(J66-835)	x	3	EFFF 1	Females
#2	-	efff	(J66-835)	x	3	EF	Ħ
#3 <b>a</b>	-	EF	(J66-811)	x	7	EFFF	11
#ЗЪ	-	EF	(J66-836)	x	4	EFFF	ŧt
#4a	-	EF	(J66-811)	x	1	EF	11
#4b		EF	(J66-836)	x	5	EF	11
#5	-	EF	(J66-836)	x	1	FF	11
<b>#6</b> -		EFBB	(J37-221)	x	10	) EFFF	17
#7	-	EFBB	(J37-221)	x	4	EF	11
#8	-	EFFF	(J66-835)	x	4	Unkno	wn "

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## An Accounting of the "Unknowns" of the 1949 Flock

1. Early Mortality - This group includes all birds known definitely to have died prior to the recording of data regarding sex and feathering classification.	<u>Number</u> 93
2. No Record - This group includes all birds on which no data were obtained other than the fact that they were wing-banded. Birds whose lost wing bands were not retrieved are included as is also mortality due to preying animals and birds. In this group, too, are birds which wander astray from their respective houses and excape detection until such time as they are useless for re- cording desired data.	77
3. Lost Wing-bands - Includes those birds whose lost wing-bands are retrieved for identification.	9
4. Sex Only Noted - Due to oversight at the time no feathering data was noted at the time of observation	4
5. Sex Not Noted In some cases sex identification at the time of gathering the data was too indecisive to be considered reliable.	18

Total -

201

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Experimental Matings and Observations - 1949 and 1950 1. Reciprocal Matings of the Regular 1949 RIR Breeding Pens

In order to investigate the extent of possible error arising from incorrect classification at six weeks of age and, also, to investigate more thoroughly the effect of the male's feathering characteristics upon those of his progeny, it was decided to interchange the males of the 1949 breeding pens, to continue such breeding for a three-week period (allowing the last two weeks in which to collect hatching eggs) and to adopt a method of classification (additional to that normally used at six weeks) which would give greater recognition to variability in the rate of back feathering.

For comparative purposes, the EFFF and EFBB males were interchanged as were also the two EF males, one of which could now be assumed to be a possible EFBB bird. The progeny of these matings were hatched on July 25th and 26th, an incubation period of 22 days being allowed in order to secure as large a hatch as possible. It is interesting to note that all seven of the additional chicks secured in this manner showed good viability as they all survived the full 12-week period prior to the hatch being marketed. The sex ratio was normal (four males, three females) as was also the variation in feathering characteristics exhibited when compared with the remainder of the hatch (males: one EFMS, two EFNS, one EFNSBB; females: one EFFF, one EFMS, one EFNS -- see explanation of classifications here employed later on). They did, however, show a slight tendency towards lower weights at

eight weeks of age (males: 1.26 lbs.; females: 1.11 lbs.).

As all available facilities for floor brooding were already in use with the regular season's hatch, these chicks were reared in confinement. Multi-tier electric brooders were used for the first four weeks, holding cages for the second four weeks, while floor rearing was used for the final four-week period prior to marketing. While such a method unfortunately involved a change of environmental factors and their consequent effect on the rate of feathering, it, nevertheless, allowed observations of feather development under conditions which closely simulated those normally encountered in the commercial broiler industry.

An attempt was made to classify these birds in the light of the multiple allelic series found to exist in White Leghorns.<sup>40</sup> Observations carried out at the 1-day, 10-day and 3-week periods did not indicate the presence of this series of genes in the University strain of Rhode Island Reds. The range in development of secondary flight feathers and tails encountered in this hatch is shown in Plate I. These three birds are the male members of a typical family (3 males, 4 females) which is shown in Plate II at four, six and eight weeks of age. (The fact that all three birds selected for photographing at ten days of age were males is purely coincidental.) While the birds shown in Plates Ib and Ic may

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<sup>40.</sup> Phenotypic descriptions as noted by Jones and Hutt were used for guiding purposes in this investigation. See Jones and Hutt, <u>Multiple Alleles</u>, pp. 197-199.

be said to approach the phenotype of a "retarded" Leghorn, 41 insofar as secondary flight feather development is concerned, the degree of retardation shown (in the Rhode Island Red) is of such little consequence in contrast to that exhibited by a "retarded" Leghorn that it could not be considered sig-Two other considerations substantiate this connificant. clusion. First, while not to the same degree as shown in Plate Ia, both of these birds exhibited fair tail development at this age. This fact is not too noticeable in the photographs mainly because the tail feathers had not unsheathed at this age but were, rather, in the pin stage of development. Thus, in spite of having attained an appreciable length, they are not inclined to show too distinctly in the photographs. A "retarded" Leghorn chick at this age has "no sign of a tail" according to Jones and Hutt, which fact would not indicate that these birds are of the retarded phenotype. Second, it must be remembered that Rhode Island Reds do not feather out as rapidly and fully as do White Leghorns in the same length of time. No chick in this hatch showed feather development equal to that of a normal-feathering Leghorn although a few such as the male shown in Plate Ia, approached this degree. On the other hand, all of the chicks exhibited development superior to that of a "retarded" Leghorn. On the assumption that a "retarded" Rhode Island Red chick would show even less 41. Jones and Hutt, op. cit., Fig. 23, p. 198. 42. Ibid., p. 199.

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development than a "retarded" Leghorn does at this age, such would seem to indicate that all of the chicks of this hatch were "normal" insofar as this terminology is used relative to the multiple allelic series.

The above, however, is not to be interpreted as precluding variation in the feathering quality throughout the hatch. Rather, it is offered as evidence that factors other than those of the allelic series are responsible for the gradations in fullness of feathering noted at later stages of development. Actually, as noted by Darrow (1941), variations in tail development were found to serve as excellent criteria for prediction of fullness of feathering of the back at eight weeks of age. At this time, the males shown in Plate Ia, Ib and Ic were classified EFWS, EFNS and EFNSBB respectively, thus covering the extremes in fullness of feathering noted in a parallel manner to which extremes in tail development were observed at ten days of age. Plate IIc, showing these birds at eight weeks of age, illustrates this pointvery well.

A major observation was that all of the progeny from these four matings were early-feathering. In the light of previous results obtained, it would appear that this fact can only be interpreted as coincidental. Such a situation, however, could not serve as a basis upon which to formulate any hypotheses relative to the inheritance of the bareback characteristic.

A further observation was made to the effect that

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there was no deficiency of male progeny, such as was noted in both the 1948 and 1949 data. All of the chicks which died before sex could be determined visually with certainty were "posted" to insure accuracy in this regard. In the face of such evidence it would seem that much of the discrepancy previously observed was due to incorrect classification at the time this information was gathered. As the tendency of such errors would admittedly be in this direction, this possibility presented itself as a rather disturbing feature in view of the importance placed upon sex in the analysis of the data of the preceding two years.

As previously noted, the chicks were classified in the usual manner at six weeks of age on the basis of three phenotypes. At eight weeks of age they were re-classified into five groups, based upon the extent of the back feathering as noted below:

(EF)FF - Fully feathered back
(EF)WS - Wide median dorsal streak
(EF)MS - Medium width median dorsal streak
(EF)NS - Narrow unbroken median dorsal streak
(EFNS)BB - Narrow broken median dorsal streak or bare back.

It is to be noted that the bracketed portions of these classifications do not appear in Table 9 showing the results of these two methods of classification. These were omitted solely for the purpose of enabling a single-page presentation of the data. Reference to this table will show the relative inadequacy of the normal manner of classifying the birds into three categories at six weeks of age, as shown

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by the extensive internal variation in each of these categories ateight weeks of age. This evidence probably explains much of the difficulty previously encountered in attempting to secure differentiation in classification of the progeny on the basis of the feathering characteristics of the parental stock. The results, also, would seem to indicate the feasibility of classifying feathering characteristics at eight weeks of age rather than at six weeks although consideration must be given here to the fact that classification on the basis of five types rather than three was not used at this latter age. In view of the parallelism noted between eightweek feather development and 10-day tail development it would seem such a system of classification could be used at six weeks with equal success. However, as the data presented in Table 9 would appear to indicate a lack of uniformity of feather development between six and eight weeks throughout the entire hatch, the later age may be said to be preferable.

Data on the results of the four matings are presented in Table 10, being grouped together according to sire and feathering classification at eight weeks of age at which time 148 of the 163 chicks originally hatched still survived. Both the combined and average weights of the individuals within each group are also shown. These data were secured in an attempt to correlate eight-week feather development with eightweek body growth, the existence of which is a debatable point in view of conflicting conclusions resulting from investigation in this field. It will be noted that, within each family,

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Ta]	le	15.

Classifica	ation	Cla	ssi	fi	cat	ior	1 of Fe	eatl	leri	lng	at	8 1	Veeks	
Mating Feather	ering		M	Ial	es					Fe	emal	les		TOTAL
Male Female W	Veeks F	ŦW	is M	IS I	NS	BB	Total	FF	ws	MS	NS	BB	Total	
EFFF x EFFF EFFF x EF EF(a) x EFFF EF(a) x EF EF(a) x FF EF(b) x EFFF EF(b) x EF EFBB x EFFF EFBB x EF EFBB x Unkn	CFFF		2	ľ	-		0 2 0 0 0 0 0 0 1	4 1 2 3	5 242	ର ର			11 0 1 2 2 0 2 7 2	11 0 3 1 2 2 0 2 7 3
Group To	otal	0	3	0	0	0	3	11	13	4	0	0	28	31
EFFF x EFFF EFFF x EF EF(a) x EFFF EF(a) x EF EF(b) x EF EF(b) x EF EFBB x EFFF EFBB x EF	EF		2	1	1	3 1	4 0 2 3 0 1 1	1	3 1 4 1 1	1 1 2	1		4 1 2 6 1 2 1	8 1 4 9 1 3 2
Group To	otal	0	ะ	3	2	4	11	2	10	5	1	0	18	29
EFFF x EFFF EFFF x EF EF(a) x EFFF EF(a) x EF EF(a) x FF EF(b) x EFFF EF(b) x EF EF(b) x EF EFBB x EFFF EFBB x EF EFBB x Unkn	IFBB		3 1 1 3	74 2 244	4 1 1 2	52 718	19 6 1 3 1 7 1 10 6 9		2 1 1	2 11 312	2 2 1 1	3	90 a a 0 5 a 4 0 1	28 6 3 5 1 12 3 14 6 10
Group To	otal	0	82	3	9	23	63	0	4	10	7	4	25	88
GRAND TOTALS	5	01	.3 2	6]	12	27	77	13	27	19	8	4	71	148

Note: All of the progeny of the above matings were early-feathering.

EFFF Male - J66-835 EF(a) Male - J66-811 EF(b) Male - J66-836 EFBB Male - J37-221 FF - Fully feathered back

WS - Wide median dorsal streak

MS - Medium median dorsal streak

NS - Narrow median dorsal streak

BB - Bare back

<u>Table 16</u> <u>WEIGHT OF RHODE ISLAND REDS AT EIGHT WEEKS OF AGE CLASSIFIED ACCORDING TO FEATHERING GROUP</u>

Feathering			Si	e's Nur	nber and	l Feath	ering Ty	7pe			
Gr	oups	J66-8	35 EFFF	J66-8	ll EF	<b>J66-</b> 8	36 EF	J37-22	21 EFBB	Total	
of P	rogeny	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
efff	No. Birds Total Wt. Average		4 5.17 1.29		6 7.48 1.25				3 4.50 1.50		13 17.15 1.32
efws	No. Birds Total Wt. Average	5 7.37 1.47	11 13.89 1.26	3 4.87 1.62	2 2.48 1.24		5 6.76 1.35	5 8.33 1.67	9 11.75 1.31	13 20.57 1.58	27 34.88 1.29
EFMS	No. Birds Total Wt. Average	12 17.33 1.44	5 5.96 1.19	3 4.13 1.38	3 2.67 .89		7 8.71 1.24	11 16.68 1.52	4 4.45 1.11	26 38.16 1.47	19 21.79 1.15
EFNS	No. Birds Total Wt. Average	5 6.76 1.35	2 2.36 1.18	3 4.45 1.48			4 4.95 1.24	3 4.60 1.53	2 2.45 1.23	11 15.81 1.44	8 9.76 1.22
EFNSBB	No. Birds Total Wts Average	7 9.53 1.36	3 3.18 1.06			11 16.86 1.53		9 12.91 1.43	1 1.40 1.40	27 39.30 1.45	4 4.68 1.17
Totals by Male	No. Birds Total Wt. Average	29 40.99 1.41	25 30.56 1.22	9 13.45 1.49	11 12.63 1.14	11 16.86 1.53	16 20.42 1.28	28 42.52 1.52	19 24.55 1.29	77 113.82 1.48	71 88.16 1.24

See text regarding feathering classifications of progeny

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There is an increase in weight between the two extremes in fullness of feathering but that progressive increase in fullness between these extremes were not consistently accompanied by increases in weight. Unfortunately the unbalance of the table, arising from several unrepresented groups, made a correlation analysis impossible. Too, the numbers involved could scarcely be said to be sufficient to permit definite conclusions in any case. The general indication of the data, however, might be said to at least allow the possibility of correlation between these two factors.

#### 2. Type EFBB Male x Type EFBB and Slow-Feathering Females

In order to investigate further the effect of the bareback characteristic, it was decided to mate an EFBB male with poor-feathering females and observe the feathering of the resulting progeny. As there was a distinct shortage of such females remaining in the Rhode Island Red flock, it was necessary to utilize females of other breeds and also to use pullets. The consequent mating was composed of pullets of the following breeds and types:

Breed	Number	Type
Rhode Island Red	2 3	EFFF
Barred Plymouth Rock	1 3	efbb 1-2
New Hampshire	1 1	EFBB 2

Note: The EFFF females were included for control purposes.

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This mating was made at the same time as the reciprocal matings (just discussed) and the progeny of all five matings were reared under identical conditions. As was the case also with the other four matings only small families were secured which left little scope for individual analysis. The relatively small number of chicks was primarily due to the fact that the birds were rapidly going into a molt and consequently "off the lay" to an unfavourable degree. No chicks whatsoever were secured from four of the females in this particular mating - including both of the control birds. The classification of the chicks hatched is shown in Table 17.

No early-feathering male chicks were observed among the progeny of the slow-feathering Barred Plymouth Rocks which, insofar as the number of progeny permitted, indicated that these females possessed the dominant latefeathering sex-linked gene. It is interesting to note that, aside from the above, there was a fairly evenly distributed and extensive variation in the progeny of these females. The progeny of the slow-feathering New Hampshire also tended to a similar distribution, probably limited only by the few number of chicks in her family.

The three "Rock" males classified as FF- were fullfeathering birds with the modifying aspect of retardation in the development of the feathers on the back and wing bows. This effect was most marked at the six-week age and can be plainly seen on one of the male progeny in the family of female J64-717 at this age by referring to Plate IX, showing

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### Table 17

### Classification of the Feathering Characteristics at Six Weeks

of the Progeny of Experimental Mating #2

### Rhode Island Red Male #J66-833 - Type EFBB

Breed and Type of Dam	Rì	node Re	Isla ed	and			Barred Plymouth Rock								Ne H'st	w nire
Dams' Nos.	ן א	Туре		EFBB		EFBB				'ype	1-2				Tÿpe	) 2
Feathering &	J64-466		J64-485		J64-638		J64-690		J64-702		J64-717		Total		J64-	-801
Sex of Progeny	O M	Ŷ	0	<b></b>	O a	<b>9</b>	· 0*	Ŷ	0×	<b>e</b>	. 0	Ŷ	0ª	Ŷ	0	<u> </u>
EFFF EF EF- EFBB	1 <sup>a</sup>	1		lþ	1			2		l		16		1 1 2		2 <sup>h</sup>
FFMT FFST FF-							1 1 1	:	1	2	1 <sup>f</sup> 2		3 1 3	2	lj lk	2 <sup>i</sup>
1-2 2 3	3	1° 1 <b>¤</b>	1 <sup>đ</sup> 1			2	2		1	1		l lg	2 1	2 1	1 <sup>1</sup> 1	
Total	1	3	2	1	1	2	5	2	3¢	4	3	3	11¢	9	4	4
X - RumplessØ - Including one unknown early-feathering)											10WN	(not				

See following page for other subscripts

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# Table 17 - Subscripts

່ສ	-	Male	#231	-	Туре	EF	 See	Plate	IVa
b	-	Female	#236	-	Туре	EFBB	 See	Plate	Vc
C	-	Female	#232	- -	Туре	1-2	 See	Plate	VIC
đ	-	Male	#235	-	Type	1-2	 See	Plate	VIa
8	-	Female	#257	-	Туре	efff	 See	Plate	XP
f	-	Male	#258	-	Туре	FFMT	 See	Plate	XID
g		Female	#260	454	Туре	2	 See	Plate	XIIa
h	-	Female	#267		Туре	efff	 See	Plate	XIVc
i		Female	#268	-	Туре	FFMT	 See	Plate	XVD
j	-	Male	#264	-	Туре	FFMT	 See	Plate	XVID
k	-	Male	#266	-	Туре	FFST	 See	Plate	XVIIC
1	-	Male	#263	-	Туре	2	 See	Plate	XVIIIC

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this family at four, six and eight weeks of age. (The other male chick of this family which was similarly affected was lost through accident prior to taking the photograph at six weeks.) This observation was in keeping with the high degree of correlation between feather development of the back and wing bow areas noted generally throughout this experimental work. The fact that the tail development in these birds was appreciably delayed suggested the possibility that the retardation noted in the back feathering had been extended posteriorly to include feather development of the tail also. However, while such development in all three cases was appreciably inferior to that of the FF(ST) individuals, it was not uniformly expressed in the birds so affected. The retarded feathers of the back and wing bow made normal appearance as pin feathers but thereafter developed very slowly and in a very different manner to normal feathers. They did not attain normal fullness prior to molting, at which time they were replaced by normal feathers, but retained their characteristic narrowness and tightness even after reaching maturity. They were also observed to possess a yellow-brown tinge in pigmentation which gave them a very faded appearance in contrast to the remainder of the birds' plumage. As both the color variation and retardation of feather development may be assumed to have arisen from the sire, such a combined effect in the progeny suggested a possible close linkage in the Rhode Island Red breed between the factors for color and for the bareback characteristic.

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The family produced by dam #J64-717 was typical of the wide variation of feathering characteristics resulting from the Red-Rock cross. Extensive use was made of this family and that of the slow-feathering New Hampshire in photographically recording progressive stages of feather development of most of the various classifications noted up to eight weeks of age (see Plates IX to XII inclusive re the Rock cross and Plates XIII to XVIII inclusive for the Hampshire cross). It should be noted that one female of the Rock family (Plate X) and two females of the Hampshire family (Plate XIV) exhibited fullness of feathering to an extent found impossible of attainment with the University strain of Rhode Island Reds even when using Type EFFF breeding stock. Thus it would seem that this fullness must have been inherited from the dams in question and that the genes responsible were masked in these females by the possession of the dominant allele for slow feathering. Allowance might also be made for the possibility of the presence of an inhibition factor, the homozygous form of which constitutes a normal function of the "bareback" Rhode Island Red type of feathering, which lost its suppressive action in heterozygous condition in the progeny. Should such be the case, however, the fact that slow-feathering female chicks were also observed in these families would seem to suggest that more than one inhibitory factor was involved, that such factors did not uniformly express themselves in the phenotype, and that they were independently inherited. The appearance of female chicks of the FF group in the families of the Type 1-2 Rock dams and the Type 2 New Hamp-

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shire dam might be viewed as lending evidence to such a possibility. In this regard, too, it should be noted that the EFFF female chick of the Rock family, while extremely full in feathering, nevertheless distinctly showed the very pointed tips of the secondary flight feathers which was observed throughout this experiment as being indicative of the presence of inhibitors in a bird's genetic constitution (see Plate X). Be it as it may, some aspect of the elusive phenomenon termed "hybrid vigor" for want of a better explanation would seem to be expressing itself in the appearance of these females. Certainly their appearance cannot be explained solely on the basis of the possession of the sex-linked early-feathering gene inherited from the sire as all of the female progeny must be assumed to possess this factor. Indeed, observations would seem to indicate that the sexlinked alleles are not in themselves too important, particularly when attention is directed to the relative fullness of feathering secured in some of the males (those classified in the FF group in Table 17) which must be assumed to have inherited the dominant gene for slow feathering from their respective dams (see Plates XI, XVI and XVII). Aside from the possession of this dominant gene, the genetic constitution of these dams is of a very uncertain nature if only, as noted above, by way of the probably masking effect exerted by this gene over the normal expression of other factors affecting feathering. Thus, as the maternal portion of the genetic constitution of the progeny is of necessity

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unknown, the extent to which the bareback characteristic of the sire is reflected in the variations of feathering of the progeny cannot be analyzed satisfactorily.

While only three chicks were secured from one of the Rhode Island Red Type EFBB females, and four from the other, both early and late-feathering individuals were represented in each of the families. Although the number of progeny was insufficient to permit any conclusion being reached relative to the distribution of these types, it might be allowed that a 1:1 ratio was indicated. Retardation of back feathering of the "early" chicks similar to that already described in the FF-Rock males, was observed (see Plate IV). Due to the limited size of these families, no definite conclusion could be made regarding the absence of chicks of the FF group, although the possibility of a homozygous inhibitory condition in the "bareback" genotype, as previously expounded, may be offered by way of explanation.

It is of interest to note that one of the slowfeathering chicks (a female) was not only tailless but lacking a pygostyl entirely. The fact that this bird was of extremely poor feathering quality (even aside from this rumpless aspect) plus, also, the observation that the retarding effect of the bareback characteristic appeared to extend posteriorly to affect tail feather development, raised the question of the possibility of a cumulative, inhibitory, somal effect being responsible for such a malformity.

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#### 3. Type EFBB Rhode Island Red Males x White Leghorn Females Homozygous for Early and Normal Feathering

This investigation was instigated primarily by the 43 report of McGibbon and Halpin (1946) in which reference is made to the existence of the "retarded" gene in the strain of Rhode Island Reds at the Agricultural Experiment Station in Madison, Wisconsin. This reference is noted in full below:

> "Another variation, encountered in S.C.R. I. Reds at this station, and tentatively designated as 'retarded' due to its similarity with that first described by Warren in Leghorns, is likewise the result of a single autosomal recessive gene substitution in comparison with normal. This character, too, may be recognized in the day old chick, but with greater certainty at 2 weeks, and at 6 weeks is expressed by a narrow band of feathers on the back while the tail feathers approximate in length those of normal early feathering chickens." 44

The similarity of the six-week descriptions here reported for the "retarded" phenotype and elsewhere reported in this paper for the "EF" phenotype of this University will be noted immediately. Efforts to substantiate the existence of such a gene in the University strain by means of various matings over the past two years were quite unsuccessful, as has been seen by the results of such matings reported in this paper in tabulated form. More detailed observations made in this regard (at 1-day, 10-day and 3-week periods)

44. Ibid., p. 406

<sup>43.</sup> McGibbon, W.H., and Halpin, J.G., "Three Alleles Affecting Completeness of Feathering in the Chicken", <u>Poultry</u> <u>Science</u>, 1946, Vol. 25, pp. 406-407 (Abstract only).

and discussed elsewhere in this paper (see Experimental Mating 1) also failed to indicate that the variations noted in feathering resulted from the action of a multiple allelic series of genes such as is inferred here. The investigation herein reported was made in an effort to eliminate any degree of uncertainty still held relative to these findings.

For preliminary investigation, pen matings of one week's duration were used. All three Rhode Island Red phenotypes were utilized in these matings - one EFFF (#J66-835), one EF (#J66-811) and one EFBB (#J66-833). Feathering classification on the basis of flight feather development - long, medium and short - did not prove to be a very reliable method of prediction of future development except in the extremes and then only with certain reservations. At ten days of age fairly clear-cut differentiation was noticeable and at this time the chicks were classified into five groups, El to E5 (experimental), differentiation being based upon flight feather development and tail development as noted below:

<u>Type El</u> - This type exhibits normal Leghorn feathering with seven long well-developed primaries and an equal number of long secondaries forming a continuous arc with the wing outstretched. The tail is very promient with the feathers well unsheathed. (See Plate XIXb)

<u>Type E2</u> - Only the first four or five primaries show good development but these lack much of the length of Type E1. The secondaries show uniformity of length which

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approximates that of the covert feathers. The tail is in very short pins under the down. (See Plate XXa) <u>Type E3</u> - This type shows both shortened primary and

secondary flight feathers which, like Type El, form a continuous arc with the wing outstretched. The tail development, while inferior to Type El, is actually not as retarded as it might appear due to the fact that the feathers are, by and large, just beginning to unsheathe and, therefore, do not show individual fullness exhibited by an unsheathed feather. (See Plate XXIa)

Type E4 - This type is difficult, if not impossible, to

differentiate from Type E2. As flight feather development is similar in both types, the only basis of differentiation is in tail development, none of which is evident in this type. However, as such development in Type E2 is extremely limited, such a basis cannot be considered too reliable at this age. Differentiation in this regard becomes very obvious within the following few days. (See Plate XXIIb)

<u>Type E5</u> - Extreme retardation of flight feather development

would seem to permit fairly reliable classification of this type even at one day of age. By ten days this feature is very noticeable. Much doubt regarding the actual existence of this type arose from the fact that only one chick (a female) was observed in the entire hatch. Further observations, however, allowed its acceptance as a distinct

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type and gave evidence that the severe retardation noted was heritable in origin and not physiological in nature as was originally suspected. (See Plate XXIIIa)

On the basis of the above feathering classifications the results of the three matings are shown below.

	Fea	rs										
Sire	Type El		Type E2		Type E3		Type E4		Type E5		Total	
	C M	f	ď	Ŷ	0	Ŷ	o	Ŷ	ď	Ŷ	0	Ŷ
EFFF	3	3			1	4					4	7
EF	1	2			2	7					3	9
EFBB	4	3	7	1	1	2	2	3	0	1	14	10

Table No. 18

By four weeks of age much of the significant difference in flight feather development between Types El and E3 had been lost. At this age the former type had seven long primaries and ten long secondaries whereas the latter had only six long primaries and nine long secondaries. The disparity in flight feather lengths had disappeared entirely. However, differences in the development of both the median dorsal feather tract and the tail were quite noticeable, the difference in the latter being largely one in fullness of the individual feather rather than in the actual number of feathers present.<sup>45</sup> At this age Type E2 exhibited a rather sparse and spindly tail each feather of which was decidedly pointed. Apparent lack of barbules on this distal portion

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gave each feather a very frayed appearance. Both of these characteristics may be noted in Plate XXb. By this time the secondary flight feathers were almost of normal length although they still retained uniformity of length as noted earlier. Type E4 exhibited rudimentary tail growth while Type E5 was still quite tailless. Both of these types showed abnormal secondary flight feather development, the tip of each feather appearing quite pointed in the early growth stage and developing a "droplet" formation by four weeks of age.

By six weeks of age Types El and E3 had lost any significant difference in feather development. At this time Type E2 showed appreciably poorer development of tail, back and wing bow development. Type E4 exhibited mostly pin feathers in the dorsal feather tract, a few of which were in the process of unsheathing, and no tail development. Type E5 was still quite bare on the back and wing bows and, of course, showed no tail growth whatsoever.

45. It should be noted here that Male #944 (See Plate XIXc) at this age showed rather superior feathering for Type El whereas by this time some of the birds classified as Type E had developed better feathering than Male #948 (See Plate XXIb) so that the overall type differences were actually not as great as the photographs accompanying this paper might suggest. However, in order to depict continuity of growth and development of the birds originally selected as good examples of their respective types, it was decided to use the same individuals as previously for photographic purposes. Plate XXIIb is an exception to the above, a bird of a later hatch being used to fill the four-week vacancy in this series of photographs which arose from the fact that Female #919 (See Plate XXIII) had not been accepted at this time as representative of a separate classification.

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At eight weeks Types El, E2 and E3 were for all practical purposes indistinguishable from one another in fullness of feathering. Type E4 showed good back and wing bow feathering although not all the pin feathers in these areas had completely unsheathed. The tail feathers were still very short and mostly in the pin stage. Type E5 exhibited little advancement in feathering and presented essentially the same appearance as at six weeks. No tail development was observed in this bird until twelve weeks of age.

As the above-noted results warranted further investigation, both of the Type EFBB males previously used in this experimental work were mated to Leghorns which were trapnested for progeny identification purposes. Two hatches were secured from these matings, the first on January 2nd and the second on January 21st of this year. The resulting chicks were subjected to rigorous observation and two classifications, additional to the five previously reported, were adopted to permit finer distinction in variation of feather development -Type E1-2 and Type E4X. The former was adopted in order to allow for variation previously included in Types E1 and E3, while the latter similarly took into consideration variation previously included in Type E2.

Type E1-2 gave independent classification to those chicks which exhibited a more rapid decrease in length of the secondary flight feathers proximal to the body than was noted in others (which retained the classification E1) in a manner similar to that previously discussed in connection with the

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Rhode Island Red chicks (see Plate 1 - b and c). Such a tendency is, of course, quite normal to a certain degree as a result of the progressive manner in which these feathers make their appearance in plumage development (see Plate XIXa) and, because of the rigid specifications demanded for Type El in classifying these chicks, it was considered quite probable that many, if not all, of those typed El-2 may have been normal-feathering birds. Certainly none exhibited the severe degree of retardation described by Warren <u>et al</u> as the expression of the "retarded" gene in Leghorns.

The introduction of Type E1-2 may be considered to be the main reason for the lack of representation (with the exception of one male chick) of Type E3 in the results of these matings, as shown in Tables 19 and 20. Too, it must be remembered, as noted previously, that by four weeks of age the significant differences between Types El and E3 have largely disappeared. While an appreciable number of chicks were classified this type at two days of age, this number had decreased rapidly by ten days of age, had practically disappeared by three weeks and had been reduced to one by four weeks. About two-thirds of those originally so calssified underwent a transition in typing to Type E1-2 (some of which subsequently had been classified Type El by four weeks), the remaining one-third directly from Type E3 to E1. While some doubt may be harboured regarding the actual existence of this classification in the light of its elusiveness and unpredictable development, such characteristics may be explained by

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the possibility that the errects of the causative factor(s) may be of very limited duration. It should be noted, too, that sex may possibly be involved in this particular type as males seemed to be more prone than females, both in representation and duration of this phenotypic classification.

As noted above, Type E4X in effect gave further differentiation in feather development between Types E2 and E4. Observations carried out would seem to indicate that these three classifications represent a series of progressive degrees of inhibition in feather development, particularly In regard to this latter aspect, they that of the tail. exhibit identical development of the individual feather in the manner previously described for Type E2, differing only in the time of appearance. All exhibit a peculiar physiological abnormality in feather development which suppresses eruption and early growth after which the effect disappears. This characteristic would seem to be directly related to the aberrant formation of the tips of the tail feathers and those of the secondary flight feathers in these particular feather Following this initial stage of suppression, developtracts. ment is quite rapid although all three types continue to show progressive stages of tail feather length up to ten weeks of The resultant type of feather differs very markedly age. from the "juvenile" type of tail feather of Types El, El-2 and E3, being guite broad in physical dimension and resembling adult plumage in contrast to the smaller and narrower feather of these latter types.

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Г	a	b	1	e	19	

# Progeny of Rhode Island Red Sire J66-833 - Experimental Mating #3

	Feathering Classification at 4 Weeks															
Dam	E	El		E1-2		E3		E2		E4X		<b>E4</b>		<sup>L</sup> E5		Cal
	<b>O</b>	Ŷ	0*	Ŷ	0 <sup>M</sup>	f	o	f	d	Ŷ	ď	Ĥ	ď	f	0ª	Ŷ
381	1		1	1								1			2	2
804				1		•					1.				1	1
H13-236										1	1 <sup>0</sup>				1	1
H13-256		1	2	1			1		1	3	1				5	5
H13-262		1		2			1					1			1	4
J65-820	2	1	2	1			1	2	3	1		1	2		8	6
J65-838		2	4 <sup>C</sup>	lb					2	1		1		2d	6	7
J65-849		1	2						30	2					5	3
J65-879	1		3d		1							2			5	2
J65-881	3		2						3	3		2			8	5
J65-884	2	2	3				2		1	1					8	3
J65-956		1		1								1			0	3
J66-066	2						1		1						4	0
J66-115		2					1					2ª		1°	1	5
Total	11	11	19	8	1	0	7	2	14	12	3	11	0	3	55	47

See Table 20 re subscripts

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# Table 20

# Progeny of Rhode Island Red Sire J37-221 - Experimental Mating #3

	Feathering Classification at 4 Weeks									Tatal						
Dam	E.	El F		-2	E3		E2	E2		IX.	E4		E	5		
	0	Ŷ	ď	<b>9</b> .	്	Ŷ	UC	Ŷ	ð	Ŷ	ď	Ŷ		Ŷ	ď	Ŷ
340		1												-	0	1
445	1		3	1			la								5	1
H13-345	×		1ª	la				1 <sup>a</sup>							1	2
J65 <b>-834</b>	2	1	2	2											4	2
J65-872	2	2	3b	3 <sup>b</sup>											5	6
J65-893	1			2											1	2
J65-991	2	3	2	4											4	7
J66-055	2.	2	4	1								!			6	3
J66-092	2	1		2											2	3
Total	12	10	15	16	0	0	-1	1	0	0	0	0	0	0	28	27
<u>ج</u>	Subscripts a - "Retarded back" at 8 weeks   applicable b - Including one "retarded back" at 8 weeks   to c - Including one "bareback" at 8 weeks   Table 19 d - Including two "barebacks" at 8 weeks															

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A major dominant inhibitor would appear to be responsible for the appearance of these classifications which, inclusive of Type E5, represented fifty per cent of the progeny not only on an overall basis (52/102) but also relative to sex distribution (24/55 males, 28/47 females). Such results indicated the male bird to be heterozygous for such an inhibitor. Further differentiation, represented by these four classifications, would seem to be indicative of the presence of additional inhibitory modifiers acting in a cumulative manner in suppressing tail development. The fact that Type E5 was represented only by female chicks, plus the further observation that the percentage of females increased with each progressive stage of suppression, would suggest that

these latter inhibitory modifiers were also equal in their distribution between the sexes but that a further inhibitory factor, of a recessive sex-linked nature and capable of expression only in the heterogametic female, was superimposed upon this genetic background to give the results obtained. Reference to Table No. 19, showing the classification of the progeny of Male J66-833, will graphically illustrate this point. It is to be noted that a similar distribution in the progeny of this sire resulting from the preliminary mating was secured (see Table No. 18).

Assuming the possibility of the existence of such a series of inhibiting factors, analysis of the results of this mating would seem to indicate a further possibility of such factors being independently inherited and, in the absence of the major dominant factor, to be responsible for the

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variations in feather development in the early-feathering classifications of feathering characteristics.

It will be immediately noticed that the variations in the feathering of the progeny of Male J37-221 did not parallel those observed in the other mating just discussed. The results of this mating are shown in Table No. 20. The lack of similarity in the overall results of the two matings would seem to indicate that the two males, while both of the same phenotype (EFBB), were, nevertheless, different in their genetic constitutions. Assuming the possibility of the cumulative action of a series of inhibiting factors as noted above, it would appear that this latter male was lacking the major dominant inhibitor supposedly possessed by the former but that, nevertheless, possession of the modifiers was sufficient not only to present the phenotypic "bareback" classification of the bird himself but also sufficient to foster a genetic condition in his progeny, dominant to the autosomal "normal" Leghorn type of feathering, by the cumulative action of such factors. As only Type E2 slow-feathering chicks were observed, this hypothesis would not appear to be improbable as such a phenotype might be considered to represent the maximum inhibitory action possible in the absence of the major dominant factor. The fact that only two chicks of this type were observed (out of a total of fifty-five) might also be viewed as supporting such a theory and, in addition, as a further indication of independent inheritance. Furthermore, such a cumulative effect, in conjunction with the assumed

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sex-linked inhibitor, might be offered as a causative factor of the difference noted in the percentages of the two sexes which exhibited slow feathering in the progeny of Male J66-833 (male 24/55 - 44%; female 28/47 - 60%).

While there appeared to be some correlation between back feathering and tail development the modus operandi was quite obscure. Retardation, where noticed, was similar in appearance to that previously described when discussing the Red-Rock cross and was observed to extend posteriorly to similarly suppress development of the central tail feathers. Usually only the central pair of feathers was so affected. Retardation was most noticeable at six weeks of age and had largely disappeared by nine weeks. Barebacked birds, on the other hand, usually showed only a narrow streak of pin feathers in the median dorsal tract at eight weeks of age and are not fully feathered by twelve. Both retardation of back feathering and bareness of back appeared in a rather promiscuous manner throughout the progeny of Male J66-833 while only the former was observed in the chicks from the other mating. This would seem to indicate the possible necessity of the presence of the major dominant inhibitor at least in order to completely suppress back feathering in the chicks of this cross. An exception to this assumption was the appearance of bareness in three of the Type E1-2 male progeny from the other male which might be explained on the basis of cumulative inhibitory factors such as noted earlier. The

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fact that these barebacked progeny appeared in the earlyfeathering group of chicks would also seem to support the theory that different genetic constitutions may give rise to the EFBB phenotype as presupposed earlier, these chicks apparently having inherited all inhibitory factors from the sire and effectively representing the same phenotype.

#### Discussion

The foregoing results of this experimental work have shown that aberrations in the feathering characteristics of the progeny of early-feathering barebacked RIR's indicate the expression of genetic factors which cannot be explained on the basis of past research relative to feathering in the domestic fowl. To the extent that inter-breed matings were utilized in securing these results, it is not possible to state definitely the degree to which they are inherent in the RIR breed in general and in the bareback characteristic in particular. Certainly inter-breed matings would appear to inject modifications into the overall feathering characteristics of the resulting progeny. The writer is of the opinion that to assume similarity of genetic constitutions of various breeds may prove to be very misleading in interpreting resultant data. A rather pertinent point in this regard is the phenomenon of the sexually dimorphic aspect in the rate of feathering of the American breeds in contrast

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to the uniformity of feathering found in the Mediterranean breeds. The distinct possibility of major genetic variations in different breeds is, perhaps, too readily overlooked in research in this field, particularly in the relatively indiscriminatory manner in which crossbreeding has been utilized in fostering genetic theory relative to feathering. While much information relative to the origin of the various breeds has been lost in antiquity, there is still sufficient evidence available to permit the assumption that anything resembling a common ancestor must, in many cases, be relegated to the very distant past. Thus it would seem that major genetic changes may have evolved in the intervening period. Certain feathering characteristics of the RIR, for example, are attributable to its Red Malay Game ancestry among which, aside from color, is undoubtedly its closeness or tightness of plumage. Quite presumably, too, other heritable factors affecting feathering may be traced to such an origin. Just how close an ancestral link exists between the Red Malay Game and, say, the White Leghorn, is, however, a matter of much conjecture. Analysis of the data in this paper would 'suggest that much of the inhibitory aspect of the RIR's genetic constitution arises from the Red Malay Game. The action of the assumed major inhibitor in suppressing tail development in the inter-breed mating with Leghorns homozygous for both early and normal feathering, while not similarly expressing itself in the Rhode Island Red

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phenotypes, may be considered to be indicative in this regard.

On the basis of the data obtained in this experimental work, it would seem permissible to postulate a "Theory of Inhibitors" relative to the Rhode Island Red breed. While further research is admittedly required to obtain definite proof of the existence of such inhibitors and, subsequently, their mode of inheritance and other genetic properties, the results of this work indicate the presence in this breed of four inhibiting factors - one major and two minor inhibitors of an unknown nature insofar as their sexlinked or autosomal properties are concerned, and a fourth which appears to be a recessive sex-linked gene. The major inhibitor would seem to be a normal complement of the Rhode Island Red's genetic constitution and to be dominant to the normal type of Leghorn feathering in suppressing tail development when associated with the homozygous form of the sexlinked recessive early-feathering gene. At any rate it is not similarly expressed in the Rhode Island Red phenotypes which are also homozygous for the early-feathering gene. The two minor inhibitors are capable of independent or cumulative action, either in the presence or absence of the major factor. Their cumulative action is apparently equal to that of the major inhibitor in giving rise to the Type E2 (FFMT) phenotype in inter-breed matings, but the extreme rarity of appearance of this type of feathering in the Rhode Island Red flock would seem to indicate that they do not express

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themselves in a like manner in intra-breed matings. It may be possible, however, that their action is responsible for the variations found in secondary flight and tail feather development noted in this paper. In a somewhat similar manner the data indicates that their independent action is expressed in the E1-2 and E3 feathering classifications, while in conjunction with the major gene they appear to give rise to the E4X and E4 classifications in the Leghorn cross. The fourth inhibitor is believed to be primarily responsible for the appearance of the retarded type of back feathering in individual action, and of the bareback phenotype when associated either with the major inhibitor or the two minor inhibitors.

It would appear that the apparent tendency of the major and minor inhibitors to be "masked" to at least an appreciable degree, plus the apparent recessiveness of the sex-linked inhibitor, has played a prominent role in the difficulty that has been experienced in eliminating the poor feathering quality of the Rhode Island Red and in the persistence of the militating aspect of the "bareback".

#### Conclusions

1. Inhibiting factors, possibly peculiar to the Rhode Island Red and arising from its Red Malay Game ancestry, were indicated in the genetic constitution of this breed; these factors give rise to the "bareback" characteristic.

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- 2. A major inhibiting factor, apparently not expressed in Rhode Island Red feathering phenotypes, is dominant to homozygous early-feathering normal Leghorn type of feathering. In such a cross it expresses itself by retarding tail development in a specific manner. It exerts a physiological action in the early development of secondary flight and tail feathers in suppressing eruption and early growth after which its action seems to cease. Its effect can be noted by the malformation of the tips of these feathers.
- 3. Two minor inhibitors, capable of independent or cumulative action either in the presence or absence of the major factor, are also indicated in the Leghorn cross. Their cumulative action is equal to that of the major inhibitor when the latter gene is not present. It is believed that their action in conjunction with the major factor probably is responsible for the variations in secondary flight and tail development noted in Rhode Island Red chicks.
- 4. Experimental work was insufficient to demonstrate whether these three genes are autosomal or sex-linked in nature.
- 5. A fourth inhibiting factor appeared to be a recessive sex-linked gene and to be primarily responsible for retarded back feathering when acting alone and for the "bareback" when acting in conjunction with the major inhibitor or the two minor inhibitors.
- 6. Further research work is required to definitely ascertain the existence of these genes and their mode of inheritance.

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# PLATE I



Showing the normal range in feather development observed throughout the flock at ten days of age



Plate Ib Male #272

Plate Ic Male #274



#### PLATE II



Plate IIa - 4 weeks of age

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A typical Rhode Island Red family showing normal feather development found throughout the flock at four, six and eight weeks of age. Note that wingband numbers are in consecutive order from left to right as noted in Plate IIa, the females constituting the upper row in Plate IIc.



Plate IIb

6 weeks of age

Plate IIc

8 weeks of age



# PLATE III

Type EFFF - Typical male and female development noted at six and eight weeks of age



Plate IIIa

Male at 6 weeks



Plate IIIb

Male at 8 weeks



Plate IIIc

Female at 6 weeks

Plate IIId

Female at 8 weeks



## PLATE IV

Type EF - Typical male and female development noted at six and eight weeks of age



Plate IVa

Male at 6 weeks



Plate IVc Female at 6 weeks

Plate IVd

Female at 8 weeks



## PLATE V

Type EFBB - Typical male and female development noted at six and eight weeks of age



Plate Va

Male at 6 weeks



Plate Vb

Male at 8 weeks



Plate Vc

Female at 6 weeks

Plate Vd

Female at 8 weeks



# PLATE VI

Type 1-2 - Typical male and female development noted at six and eight weeks of age



Plate VIa

Male at 6 weeks



Plate VIb

Male at 8 weeks



Plate VIc Female at 6 weeks

Plate VId Female at 8 weeks



#### PLATE VII



#232 (1-2 ?) - #236 (EF ?) - #237 (1-2 d) - #231 (EF d)

Showing typical Type 1-2 and Type EF chicks resulting from the EFBB x EFBB mating - see Experimental Mating 2 in text

Note: Birds in the same order in all three pictures

Plate VIIa - 4 weeks of age



Plate VIIb

6 weeks of age

Plate VIIc

8 weeks of age



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# PLATES VIII TO XII

INCLUSIVE

## PLATE VIII



Plate VIIIa - 4 weeks of age

Showing the family of Type EFBB BPR dam #J64-638 (one Type EF male, two Type 2 females) at four, six and eight weeks of age.

Sire: Type EFBB RIR #J66-833 (See Experimental Mating #2)


Plate VIIIb

6 weeks of age



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### PLATE IX

Plate IXa - 4 weeks of age



Showing feathering types resulting from the inter-breed mating using a BPR Type 1-2 dam (#J64-717) and a RIR Type EFBB male (#J66-833) at four, six and eight weeks of age.

Note that the birds in Plates IXb and IXc are in the following order reading from left to right: #256 - Type 1-2 female #258 - Type FFMT male #257 - Type EFFF female #259 - Type FF- male #260 - Type 2 female



Plate IXb 6 weeks of age





PLATE X



Plate Xa - 4 weeks of age

Type EFFF (El) Female #257 showing an extreme fullness of feathering found impossible of attainment in the U.B.C. strain of Rhode Island Reds. Note the degree of fullness at four weeks in contrast to its full sisters (Plates IX and XII).



Plate Xb 6 weeks of age

Plate Xc



PLATE XI



Plate XIa - 4 weeks of age

Type FFMT (E2) Male #258 showing the type of feathering commonly found in Orpingtons and New Hampshires (see Plate XVIIIA). Note (a) suppression of tail and back feathering and also the uniformly short secondary flight feathers at four weeks (b) pointed tips of secondary flight feathers and (c) relative fullness of feathering at eight weeks of age.



Plate XIb

6 weeks of age

Plate XIc



## PLATE XII

Type 2 - Female #260 (see Plate IX). Typical female development noted at six and eight weeks.



Plate XIIa

6 weeks of age



Plate XIIb

FEATHER DEVELOPMENT IN THE RHODE ISLAND RED AND NEW HAMPSHIRE CROSS

# <u>PLATES XIII TO XVIII</u> <u>INCLUSIVE</u>

#### PLATE XIII

Plate XIIIa - 4 weeks of age



#261 <b>7</b>	#262 of	 #263 8	-	#264	660	#265 <del>}</del>	#266 of	-	#267 <del>-</del>	#268 <del>-</del>
EFFF	3	2		FFMT		FFMT	FFST		EFFF	FFMT

The family of Type 2 New Hampshire dam #J64-801, showing extreme variation in its feather development as noted above. Note lower row of birds in Plates XIII b and c are females in the following order left to right: #267, #265, #268 and #261. Males in XIIIb in the same order are #264, #262, #263 and #266, while in XIIIc are #263, #264 and #262.

(#266 dead at eight weeks of age.)

Sire: Type EFBB RIR Male #J66-833.



## PLATE XIV

Feather development of Female #257 - Type EFFF



Plate XIVa

10 days of age



Plate XIVb



Plate XIVc

6 weeks of age

Plate XIVd



## PLATE XV

Feather development of Female #268 - Type FFMT

Plate XVa - 10 days of age



Note that this female shows the feathering phenotype normally associated with the presence of the sex-linked late-feathering gene in spite of the fact that its sire was homozygous for the early-feathering gene. In this case it would appear that the retardation of feather development must have arisen from the genetic factors presumably associated with the bareback characteristic of the sire. Feather development in this bird was identical to that of Male #264 (see Plate XVI). In this latter case, however, such development could normally be assumed to have been caused by the presence of the late-feathering gene inherited from the slow-feathering Type 2 New Hampshire dam.



Plate XVb

6 weeks of age

Plate XVc



#### PLATE XVI

### Feather development of Male #264 - Type FFMT



Plate XVIa - 4 weeks of age

Typical Type FFMT (E2) feathering commonly found in New Hampshires. For 10-day development see Plate XVa. Note comparative fullness of feathering at eight weeks of age in spite of presumed presence of the late-feathering gene inherited from the dam. Note, too, that by four weeks of age the uniformly short secondaries are almost normal in length although exhibit the aberrant tip formation associated with inhibition of development of feathering.



Plate XVIb

6 weeks of age

Plate XVIc



#### PLATE XVII

Feather development of Male #266 - Type FFST

<image>

Plate XVIIa - 10 days of age

Note that this male exhibits retardation of feather development of a more extreme nature than #264 (Plate XVI) yet of an appreciably less severe degree than #263 (Plate XVIII). Inhibitory action in this case is not only shown in the aberrant tip formation of the secondaries but also can be observed to have affected development of the primary flight feathers in a similar manner. Note rapidity of feather development between four and six weeks of age. By this latter age this type resembles closely Type FFMT in spite of the very appreciable difference exhibited by these two types at four weeks of age. By six weeks, however, Type 2 feathering still shows extreme retardation (Plate XVIIIc) and even at eight weeks is tailless, relatively bare on the wingbows & back, and still exhibits short secondary flight feathers (Plate XVIIId).



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Plate XVIIb



## PLATE XVIII

Feather development of Male #263 - Type 2





Plate XVIIIc

6 weeks of age





#### PLATE XVIIIA



Plate XVIIIA - 8 Weeks of age

Hampbar Male #390 at eight weeks of age showing the typical Type FFMT (E2) feathering commonly found in Orpingtons and New Hampshires. Note the looseness and fluffiness of this type of feathering compared to that found in the Rhode Island Red. Note, too, that this bird is not earlyfeathering but, nevertheless, is full-feathered at 8 weeks. FEATHER DEVELOPMENT IN THE RHODE ISLAND RED <u>AND</u> <u>WHITE LEGHORN</u> <u>CROSS</u>

# <u>PLATES XIX TO XXIII</u> <u>INCLUSIVE</u>

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#### PLATE XIX

Plate XIXa - 2 days of age



Male showing Type El (EFFF) feathering as observed in Leghorns homozygous for the sex-linked early-feathering gene & the autosomal normal-feathering gene of the multiple allelic series. Note that the tail development at four weeks is not clearly shown in the photograph as the bird had its tail drawn in closely to the body at the time.



Plate XIXb 10 days of age

# PLATE XX

Type E2 (FFMT) feathering.



# PLATE XXI

Type E3 feathering.



Plate XXIa

10 days of age

Plate XXIb



## PLATE XXII

Type E4 feathering.

Plate XXIIa - 2 days of age



Note (a) early differentiation from Type El, (b) similarity to Type E2 up to ten days of age, after which period genetic differences reflect themselves in feather development, (c) retarded development & abnormal tip formation of secondary flight feathers revealing the presence of inhibitory factors in the bird's genetic constitution. See Plate XXb for characteristic development of the tail which makes its appearance later.



Plate XXIIb

l0 days of age

Plate XXIIc



# PLATE XXIII

# Type E5 feathering.



Plate XXIIIa

10 days of age



Plate XXIIIb

<u>ADULT</u> <u>FEATHER DEVELOPMENT</u> <u>IN</u> <u>RHODE ISLAND RED</u> <u>AND</u> <u>NEW HAMPSHIRE</u> <u>COCKERELS</u>

# PLATES XXIV TO XXV INCLUSIVE

## PLATE XXIV



Plate XXIVa - 31 weeks of age - Male J266-374

Plates SSIV and XXV show the correlation between the "pin-feathery" aspect of retarded hackle development and delayed growth of the tail feathers in the adult plumage of some Rhode Island Red and New Hampshire cockerels. Plates XXIVa and XXVa respectively show normal development in these two breeds. Plates XXIVb and XXIVc show progressive stages of development in the Rhode Island Reds at 25 and 31 weeks respectively.



Plate XXIVb

25 weeks of age

Male J266-414

Plate XXIVc

31 weeks of age

Male J269-410



PLATE XXV

Plate XXVa

31 weeks of age

Male J266-059





Plate XXVb

28 weeks of age

Male J266-795