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CROSSBREEDING IN TURKEYS

***II. Summary of Studies
on Hatchability, Growth,
and Body Characteristics***

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WEST VIRGINIA UNIVERSITY AGRICULTURAL EXPERIMENT STATION

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Crossbreeding in Turkeys

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West Virginia University Agricultural Experiment Station

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CROSSBREEDING IN TURKEYS

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T. B. Clark

Introduction

CROSSBREEDING is fascinating to most poultry breeders. There is always the chance that the cross may uncover some desirable characteristics even though the hybrid offspring usually are no better than the parents. The task of crossbreeding in chickens is easier and less expensive than with turkeys. For these reasons the effects of crossbreeding have been studied more with chickens than with turkeys and relatively little is known about crossbreeding in turkeys.

Crossbreeding, as used here, refers to matings between individuals of different breeds or, strictly speaking, varieties of turkeys. Outcrossing is used to describe matings of unrelated members of the same variety. Unlike crossbreeding, outcrossing is regularly used by turkey breeders. Each year new blood is introduced from different strains of the same variety to prevent inbreeding.

If hybrid vigor is obtained from crossbreeding, the hybrid offspring will be superior to either parent. The existence of this phenomenon in chickens may manifest itself by increases in hatchability, egg production, or growth rate. Generally, the more distant the relationship, the greater the hybrid vigor resulting from the cross.

Prior to 1938 the crossing of varieties of turkeys was practiced in West Virginia by a few growers to improve rate of growth and breast plumpness. The Standard Bronze and Bourbon Red varieties were commonly used for this purpose. The practice was continued until the Broad Breasted Bronze was introduced to West Virginia about 1940. A series of matings were made at the West Virginia University Agricultural Experiment Station to study the results from different crosses, especially when a Broad Breasted Bronze parent is used in the cross.

Review of Literature

HATCHABILITY

Crossbreeding is not a method of mating designed to permanently improve the reproductive qualities of purebred turkeys. It is only a method of bringing together the good qualities of each variety.

Crossbreeding has usually been found to improve hatchability of the fertile eggs in chickens unless the hatchability of the parent stock was high. For instance, Byerly, Knox, and Jull (1934) reported that if the breeds crossed had hatching averages of 80 per cent or more, little or no improvement occurred.

Marsden and Knox (1937) reported the results of one of the first extensive studies of mating systems with turkeys. This was conducted with Bronze and covered a 5-year period. These workers reported that the out-bred turkeys had an average hatchability of 67.6 per cent. With mild to close inbreeding the hatchability of the matings averaged about 52 per cent. In matings having inbreeding coefficients of 50 to 67.2 per cent, the hatchability averaged 34.9 per cent. A wide variation was obtained within the groups. Some matings between the highly inbred turkeys hatched as well as the outbred controls.

When the experimental work to be reported here was started, hatchability was not one of the principal objectives for study. It soon became apparent, however, that the eggs from the crossbred matings were hatching better than those from the purebred matings. (In other words, an increase in hatchability of the fertile eggs was affected by the male with which the hens were mated.) These observations were reported by Clark, Runnels, and Livesay (1944). The report covered a summary of the data obtained for a 5-year period. It was found that crossbreeding affected hatchability significantly. The average differences in favor of the crossbreds were 8.2 percentage points for the fertile eggs and 10.7 percentage points for the total eggs set.

Crossbreeding did not affect fertility significantly in this experiment. However, the average fertility of the crossbreds was 5.3 per cent higher than that obtained for the purebreds. This increase probably affected an increase in fertile eggs hatched. The eggs were candled on the tenth day but were not broken open to determine the accuracy of the test.

Jull and Phillips (1946) found no great difference in hatchability between crossbred, outbred, and moderately inbred matings. Matings of outbred Blacks resulted in a hatch of 81.6 per cent of fertile eggs; matings of outbred Beltsville Small Whites gave a 91.9 per cent hatch; while a cross of the two varieties resulted in 84.4 per cent hatch. The breeding qualities of the parents seemed to be more important than the form of breeding tested in these matings. On the basis of the results with chickens reported by Byerly, Knox, and Jull (1934) *loc cit.*, very little if any improvement would be expected from these cross matings inasmuch as the hatchability of eggs from the parent stock was high.

Walter and Hoffman (1947) compared reciprocal crosses of Broad Breasted Bronze and Beltsville Small Whites with purebred matings of these varieties. The Beltsville Small White and reciprocal crosses gave higher percentages of fertile eggs and live poults than did the Broad Breasted Bronze matings. Crossbreeding did not reduce the percentage of dead germs. The authors concluded that the crossbreeding resulted in an increased fertility alone.

Marsden and Olsen (1950) studied the differences in fertility and hatchability of eggs from matings of Beltsville Small White, Broad Breasted Bronze, and reciprocal crosses of these varieties. The fertility was lower for the crossbreds than for the purebreds, a common occurrence when turkey varieties of different colors and sizes are mated. The hatchability of fertile eggs for three years was 69.1 per cent for the Beltsville White and 62.1 per cent for the Broad Breasted Bronze. The reciprocal crosses each averaged about 44 per cent. The authors concluded that hatchability is not altered by the male with which the females are mated. On the other hand, it should be noted that low fertility and low hatchability of fertile eggs are occasionally related.

GROWTH AND OTHER BODY CHARACTERISTICS

The crossing of breeds of chickens frequently results in hybrid vigor as measured by viability and growth. Little or no work had been reported on crossbreeding in turkeys in regard to hybrid vigor when this experiment was started.

Clark, Runnels, and Livesay (1940) reported on the first two years (1938-39) of this study. No increased vigor or heterosis, as exhibited by increased growth, was found. Later these same authors, Clark, Runnels, and Livesay (1944), compared the viability of purebreds and crossbreds in a period covering five years, 1938-43. They found a mean difference in viability to four weeks of age of only 1.98 per cent in favor of the crossbreds. This value was not significant.

Asmundson (1942) reported on a limited series of crosses involving the Black, Lilac, and Bourbon Red. These varieties attained about the same adult body weight. Crossing the Bourbon Red and Lilac males on the Black females resulted in F_1 offspring that exhibited heterosis. These hybrid offspring exceeded both parents at eight weeks and after in body weight. Crossing the Black males on White- and Black-winged Bronze females did not result in heterosis. The offspring only exceeded the smaller parent in body weight.

Knox and Marsden (1944) studied the inheritance of breast type, body weight, and shank length in turkeys. They crossed Beltsville Small White toms with Broad Breasted Bronze hens and compared the hybrids

in the F_1 and F_2 with the purebreds used in this cross together with the standard Bronze and White Holland varieties. All three quantitative characteristics showed a blending inheritance. The F_1 progeny was intermediate and closer to the smaller parent. This indicated dominance of genes for small body size. The authors found sufficient relationship between the phenotype and genotype to predict a successful outcome from individual selection. From experience they suggested that by selection within a period of at least five years one can influence the three characteristics within the observed range of variation. The factors for small body size and short shanks were found to show some dominance.

In 1947, Walter and Hoffmann reported studies on Reciprocal Crosses between Broad Breasted Bronze and Beltsville Small Whites which were compared with the two purebreds used. The average body weight of both sexes was 14.92 pounds for the Broad Breasted Bronze, 11.25 for the Beltsville Small White, and 13.25 for the reciprocal crosses. The body weight of the crossbred toms was intermediate between the two purebreds. Body weight of crossbred and Broad Breasted Bronze females was similar. Purebred Beltsville Small Whites were poorer in fleshing but the crossbreds were as well fleshed as Broad Breasted Bronze. No differences were found in fat grade, feathering, or mortality. The authors suggested that broadness of breast seemed to be dominant.

Asmundson (1945), in studying the inheritance of breast width in turkeys, crossed strains of Bronze differing significantly in width of breast. The hybrid offspring were intermediate in breast width. This quantitative character seemed to be determined by more than one pair of autosomal genes. Dominance of wide breast was not evident.

Asmundson (1944) reported that strain differentiation of the Broad Breasted Bronze variety at 24 weeks of age could be accomplished by comparing the breast width at one or two centimeters above the keel. Shank length, keel length, or body depth were found inadequate for the differentiation of the strains studied.

In 1948, Asmundson reported on the results from crossing two strains of Bronze differing in body weight and width of breast. These results agreed with the previous paper by this author in that at 24 weeks of age large body size was dominant to small size and wide breast was not dominant over narrow breast. The length of shank seemed to be determined by general size factors. The two strains did not differ in keel length. The F_1 progeny were intermediate in width of breast and there was no difference in the progeny from reciprocal matings.

El-Ibiary and Jull (1948) studied the relation of breast width, body depth, keel length, and shank to body conformation at 28 weeks of age. They decided that each of these showed strain differentiation. All of

these characteristics could be used in selecting for over-all body conformation at market age. In selecting for desirable breast conformation these workers suggested that turkeys be selected for shallow bodies, long keels and short shanks. These results are not in agreement with those obtained by Asmundson (1948). Disagreement in results could be due to differences in age when observations were made. In a re-analysis of the data El-Ibiary (1948) found that those with the wider breasts are likely to have slightly shorter shanks than narrower breasted birds of the same weight.

Asmundson and Pun (1954) reported data from the crossing of two strains of Bronze differing in body weight at 24 and 26 weeks of age. The F_1 progeny tended to exceed the larger parents in weight to 16 weeks of age. After this age the F_1 males weighed more and the F_1 females less than the larger parents. The differing rates of growth of the F_1 poults to 16 weeks of age indicated heterosis. Correlation studies suggested that weight at market age was determined to a large extent by differences in rate of growth to eight weeks of age.

Experimental Work

GENERAL PLAN OF MATINGS

The principal objective of this project was to study the relative value of purebred and crossbred turkeys from comparisons of body weights and live and dressed market grades. The plan was to start with standard Bronze and Bourbon Red varieties. These were commonly used when the comparisons were started in 1938. Other varieties included later for study were Black, Broad Breasted Bronze, and the Beltsville Small White.

The general plan of the matings reported herein is shown in Table 1 (see Appendix).^{*} The design for the original studies was to make reciprocal matings between the standard Bronze and Bourbon Red. In the first three years, ten hens of one variety and five of the other were mated with each tom. In 1940 no effort was made to use definite numbers in each pen. In 1942 about equal numbers of hens of each variety were used in each pen.

DESCRIPTION OF MATINGS

Single male matings were used the first four years with the exception of pens 3 and 4, 1941, in which two brothers of each strain of Broad Breasted Bronze were used and rotated between these pens daily to improve fertility. Two brothers also were in each pen similarly in 1942.

^{*}The Appendix may be found on page 22.

All pens were fed and managed alike within years. The hens were trapped and the poultts were pedigree-hatched. In the first two years four hatches were made at 14-day intervals starting in April. The following years, two additional hatches were made in June. The eggs were held not longer than 14 days, shipped about 150 miles to Morgantown for incubation and the poultts were then returned to the branch station.*

The poultts from each hatch were brooded in one lot. Shipping the eggs may have had some effect on fertility and hatchability but since all pens were represented in each hatch, the effects should be equalized.

The results obtained the first two years from the standard Bronze and Bourbon Reds and the reciprocal crosses of these varieties are comparable since the matings were similar. The Bronze used in 1938 were from a strain purchased in 1936. The Bourbon Reds used in 1938 were the result of crossing two distinct strains in 1937. In 1939, a Bronze tom from an outcross was used in Pen 1 but the purebred strains were the same as the previous year. The purebred strains used in 1939 were the same as in the previous year except that an outcrossed tom headed Pen 1. The cross-mated hens of each variety were not closely related in 1938. In 1939 Bourbon Red sisters were divided between Pens 1 and 2 and Bronze sisters between Pens 3 and 4.

The purebreds used in 1940 were practically the same as those used the previous year. The F_1 hens in Pens 1 and 2 were out of a Black-Bourbon Red Cross. It had been planned to use F_1 hens in Pens 3 and 4 from a Black-Bronze cross but insufficient numbers prevented this and F_1 hens out of Pens 1 and 2 were used instead.

The plan of the matings for 1941 differed from that of previous years. Broad Breasted Bronze were tested for the first time. The birds in Pens 2 and 6 are from different strains. A pair of toms from each of these strains was rotated daily between Pens 3 and 4. The Bourbon Reds in Pen 5 were an outcross, the tom being from a widely different strain.

The plan of mating was changed again in 1942. Two males were used in each pen to remove the effects of a single male. The number of hens was nearly equal in each pen so as to remove the unequal weighting of numbers between purebred and crossbred matings used in previous years. A different strain of standard Bronze was introduced in 1942. The toms were used in Pen 1 and the hens in Pen 2. Likewise a different strain of Bourbon Reds was introduced, the hens being used in Pen 3 and the toms in Pen 4. Thus, these purebred matings in Pens 1 and 4 were outcrosses.

*University Experiment Farm, Kearneysville, West Virginia.

The two strains of Broad Breasted Bronze out of Pens 2 and 6, 1941, were crossed in Pens 2, 3 and 5. Thus, outcrosses of strains can be compared with crosses of different varieties.

The Beltsville Small White turkeys used in Pen 3 in 1943 were purchased from the U. S. Department of Agriculture the previous year. The Broad Breasted Bronze hens were out of strain crosses made in Pens 2, 3, and 4 in 1942. The Black hens were from some brother-sister matings. Two brothers were used in each pen in 1943.

Only one crossbred mating out of four had sufficient fertile eggs to consider in 1944. The Beltsville Small Whites were from three matings in 1943. Two brothers were used in Pen 7.

In 1945, two brothers were again used in each mating. The Beltsville Small Whites were from Pen 7 in 1944. The Broad Breasted Bronze hens were from families of average hatchability.

METHODS OF WEIGHING AND MEASURING

The body weights were recorded to the nearest tenth of a pound on a 60-lb. milk scale that was calibrated accurately. The measurements of body depth, keel length, and shank length were obtained with a caliper designed to read in centimeters (*cm*). The breast width for the first three years was obtained by bending a piece of solder wire across the anterior of the keelbone at an angle towards the wing joints. The wire was then transferred to a calibrated chart and the width between the two ends measured at a distance of one and one-half inches from the apex (Figure 1).

During the succeeding years the breast was given a grade according to Marsden and Martin (1939).

Methods of Analysis

The methods used in analyzing the data on the hatchability of the eggs and viability of the poults to four weeks of age were given for the first five years by Clark *et al.*, (1944). The statistical treatment consisted of testing the significance of the "t" values for the differences between two varieties of hens which were mated to the same tom or pair of toms. The percentages within pens were paired so that differences due to years were eliminated. Throughout these studies, all eggs laid from March through May each year were incubated. However, only 600 to 800 poults were grown to maturity each year for the growth studies.

The data obtained on growth and the body measurements have been subjected to a similar analysis. The statistical significance of the mean differences in Tables 9 and 10 was determined by calculating "t"

FIGURE 1. Measurements of body depth (A), keel length (B), and shank length (C) were obtained with a caliper designed to read in centimeters. Breast width for the first three years of this research work was obtained by bending a piece of solder wire across the keelbone at an angle towards the wing joints. The wire was then transferred to the callibrated chart (D).

from pooled sums of squares. The mean square values used in these determinations were derived from differences between the crossbreds and purebreds hatched from each pen. The data were taken from two hatches made four weeks apart during the first three years (1938, 1939, 1940). In the following years the data were taken from four hatches, each two weeks apart so as to have offspring from as many hens as possible. The numbers varied between hatches in all years and all differences were weighted.

The s^2 values used in calculating the values of "t" for determining the significance of the differences between each type of crossbred and purebred mating were obtained from the pooled mean squares of "years" and "sires in years." The "sires in years," Table 8, was used in calculating the "t" test of the over-all differences between reciprocal crosses and for testing the differences between purebreds. Appropriate s^2 values, calculated from the 1938-40 data, were also used for making the comparisons in the following years.

A significant mean square for "years" (Table 8) suggests that differences between crossbreds and purebreds were not the same in all years and that an interaction occurred between years and type of breeding. A significant mean square for "sires in years" signifies an interaction between type of breeding and sires. The testing error for "years" was "sires in years," and for "sires in years" was "hatches in sires and years."

Results and Discussion

FERTILITY AND HATCHABILITY

The results obtained from the purebred and crossbred matings are given in Table 1. The additional results for the years 1943-45 are included in this table with those for the first five years published by Clark *et al.* (1944).

These authors concluded that "crossbreeding did not affect fertility significantly, the average difference in favor of the crossbreds being 5.32 percentage points. Crossbreeding did increase hatchability significantly, the average difference in favor of the crossbreds being 8.2 percentage points for the fertile eggs and 10.7 percentage points for the total eggs set."

The data for the additional three years were obtained from crosses involving the Broad Breasted Bronze, Black, Bourbon Red, and Beltsville Small White varieties. The fertility was so low in the reciprocal matings of the Beltsville Small Whites that the results are not reported here.

In these matings the crossbred eggs did not hatch as well as the purebred eggs. However, the average difference of 4.53 percentage points for the pooled results is not significantly in favor of the purebreds. The lack of an increase from crossbreeding as found in the previous years is probably due to the females and the direction of the crosses. In Pen 5 (1943), only three Black females were used. In Pen 6, the purebreds and crossbreds hatched alike. In all other matings, Beltsville Small Whites were the purebreds, which normally hatched better than the Broad Breasted Bronze. The hatchability percentages of the purebred Beltsville eggs are high in all cases.

VIABILITY

The average per cent viability of the poults to four weeks of age for each of the matings studied is also given in Table 1. A large part of the mortality occurred during the early life of the poults. In the first report it was decided to study the records during the first four weeks which included more than half of the mortality for the entire growing period.

The report by Clark (1944) showed that the viability of the purebred and crossbreds to four weeks of age did not differ significantly. The mean difference in favor of the crossbreds was 1.98 percentage points. These results showed that the Broad Breasted Bronze lived as well as the other varieties.

In the final three years the numbers were limited and another variety, Beltsville Small White, was introduced. The average difference for the 6 lots was 6.5 percentage points (Table 1). Growing the poults together as was done may have given the larger poults a better advantage. The poults from Broad Breasted Bronze hens were larger from day-old to the end of this period. It will be seen that in all cases the poults out of Broad Breasted Bronze hens had a higher per cent livability whether purebred or crossbred than did those from the Beltsville Whites.

BODY WEIGHTS AND MEASUREMENTS FOR 1938, 1939, 1940

The results for the initial matings during the first three years are given in Tables 2 and 3. These live weights and measurements are for the progeny from purebred Bronze and Bourbon Reds and the reciprocal matings for 1938 and 1939. In 1940, Cross 2 was a 3-way cross in which the Black variety was introduced. Cross 4 was $\frac{3}{4}$ Bourbon Red and $\frac{1}{4}$ Bronze. Both were backcrossed to the original parent stock.

In the statistical analysis, all crosses during the first three years were considered alike. The significance of the mean differences between the various groups for all years are given in Tables 9 and 10. As previously explained these were derived from an analysis of variance given in Table 8. The ‡ signs before the mean differences in Tables 9 and 10 show that the purebreds had larger average values.

The analysis of variance in Table 8 suggests that the crossbreds and purebreds sired by the same male did not react alike in all years for shank length and breast width. The differences for the body weights and other measurements were alike in all years. In only one case is there a significant mean square for weight under "sires in years."

Table 9 shows that for Cross 1 the differences between purebreds and crossbreds did not differ significantly in either males or females. However, in the Cross 2 males the crossbreds significantly exceeded the purebreds in weight, depth, and breast width. No differences were significant for the females.

Some evidence of heterosis occurred in the first two years where the F_1 s exceeded the larger parent in body weight. However, it was not significantly greater. The statistical significance of the mean differences (Table 9) was determined by computing "t" values from Table 8. Comparing all purebreds and crossbreds shows that male crossbreds exceeded the purebreds only for keel length. The crossbreds did not differ among themselves significantly in weight or for any measurement.

The purebreds, on the other hand, differed among themselves in all but keel length (Table 9). The Bourbon Reds averaged less in body weight, depth, and shank length than the standard Bronze. However,

the Bourbon Reds had exceedingly plump breasts for turkeys at that time; the average width was significantly greater than that for the Bronze. As was noted previously the average breast width of Cross 2 exceeded that of the parent. This may have resulted largely from the 1939 matings (outcrosses).

The averages for the year 1941 are summarized in Table 4. The Broad Breasted Bronze used for the first time were from different strains. A pair of toms from each of the strains was mated to each variety of hens and rotated between the pens daily. The cross was made primarily to test the effect on hatchability.

Statistical tests revealed that the only significant mean differences were for body weight in males.

The Broad Breasted Bronze toms-Standard Bronze female cross averaged almost two pounds larger than the crossbred toms when the Bourbon Red hens were used. Occasionally the crossbred toms approached the larger parent in body size. The hens did not differ significantly. This suggests that one sex was influenced more by one cross than another.

Here again keel length of the Broad Breasted Bronze-Bronze crossbred toms exceeded that of the Broad Breasted Bronze purebred toms but unlike the first three years it did not occur in the hens. However, there was a highly significant difference in breast grade of the hens used for the remainder of these crosses.

The 1942 matings were made to correct some of the objections to the previous years' matings. The averages for these matings are given in Table 5. The reciprocal crosses can be compared with the purebreds as shown by the mating plan in Table 1. The purebred matings are all outcrosses so this is a critical test between crossbreds and purebreds using the same sire.

The mean differences and the significance of the differences for the 1942 matings are given in Table 9. In only two pens, 1 and 4, did the toms differ significantly in body weight and in Pen 2 for depth. The hens differed significantly in all pens for body weight. This was expected since the crossbred hens did not approach the larger parents as the crossbred toms tended to do. The mean differences between the purebred and crossbred hens are highly significant in all but one mating.

Large body size seems to be dominant to small body size. The average body weight of the F_1 s approached the average body weight of the larger parent, the Broad Breasted Bronze.

The differences between the breast grades in Table 10 are all highly significant in both toms and hens. This result was expected since the

comparison was made with Broad Breasted Bronze. The breast grades were obtained by an objective method suggested by Marsden and Martin (1939). Grade 5 was considered average for healthy turkeys with smaller values, 4 down to 2, indicating a better fleshed breast. Narrow breasted turkeys varied from 5 up to 9.

These grades, though probably not as accurate as the wire measurement for the front of the breast, reflect the breast shape at both the front and rear. The significant differences for the breast grades show that the Broad Breasted Bronze purebreds or crossbreds in Table 5 exceeded the breast grades of the other varieties in both toms and hens.

The results given here show that in the F_1 offspring where the Broad Breasted Bronze was one parent, the breast width was about intermediate in grade (shape) between the two parent stocks. Dominance of wide breast is not apparent.

The single cases of significant differences, one in the toms for depth, Pen 2, and the other in the hens for keel, Pen 1, are isolated occurrences. Both occurred in reciprocal crosses between Broad Breasted Bronze and Bronze. The depth and keel length of the purebred Bronze averaged less than that for the crossbreds.

The results for these crosses agree with those of Asmundson (1948) at 24 weeks of age although our results for the weights and measurements were obtained at 28 weeks of age.

The Beltsville Small White varieties were introduced into the study in 1943. The reciprocal crosses are not given in Table 1 involving the Beltsville Small Whites because of the extremely poor fertility. In fact the offspring from Pen 3 could only be obtained when artificial insemination was used.

As shown in Table 10, the main significant difference for Pen 3 was for weight in the toms. The breast grades show negative signs indicating that the purebreds were better than the crossbreds, although these values do not differ significantly. The differences between the breast grades were highly significant in Pen 6 for toms. This was a poor strain of Bourbon Reds and did not have a plump breast like the strains used in 1938 and 1939. The other differences are not consistent.

Only one pen in 1944 and two in 1945 are reported here to compare the Beltsville Small White purebred with the Beltsville Small White X Broad Breasted Bronze crossbred. In the latter year the pens are averaged for the "t" test computed from Table 10. The crosses and purebreds are averaged according to varieties and type of cross.

Only small numbers are available for this study because of low fertility. The results, however, are fairly consistent with Pen 3 in 1943 and Pen 7 in both 1944 and 1945. As would be expected, the wide

differences in physical features, weight, depth, keel, and shank show up in the crosses. The latter, of course, is longer only in the crossbred toms. The other consistent result is the lack of a significant difference in breast grade between the crossbreds and purebreds. Negative signs again appear as in 1943 for the mean differences indicating that the purebred averages were significantly higher than those for the crossbreds. This means that the crossbreds had a slightly plumper breast because the lower the number the better the grade.

FAT GRADES—NUMERICAL AVERAGES

The turkeys were dressed and graded as soon as possible after they were weighed and measured at 28 weeks of age. The U. S. grades were transferred to numerical values as suggested by Marsden and Martin (1939, pp. 554-55). For example, grade 4 is average and corresponds to U. S. Grade A. Grade 3 corresponds to A-plus or one grade above average, while 5 is A-minus, a grade below average. The grouped averages for the lots are given in Table 11.

SUMMARY OF FAT GRADES

The numerical grades for the females in all lots are smaller than those for comparable lots of males. Thus the females carried more fat at this age than did their brothers.

In the first three years the Bourbon Reds and the crosses involving this variety had better fat grades than the standard Bronze. For the most part the grades for the crossbreds were about intermediate between the two purebreds.

The grades for the following three years are grouped together because the Broad Breasted Bronze are involved in all crosses. This variety was used in the crosses for the first time in 1941. The fat grade was considerably better than the averages for either the Bronze or Bourbon Red. In all crosses except the one with Beltsville White, the use of the Broad Breasted Bronze male had a beneficial effect on fat grade.

At 28 weeks of age the Beltsville Small White turkeys in these trials were very fat. Normally this small variety is marketed before this age. However, the fat grade of the few turkeys obtained from the cross between the Beltsville Small White variety and the Broad Breasted Bronze was better than that obtained for the Broad Breasted Bronze variety alone.

The results obtained here suggest that fat deposition and growth are influenced in a similar manner in these varieties by crossbreeding. The average fat grade obtained objectively was about midway between that of the two parent stocks used in each cross.

Summary and General Conclusions

BROAD BREASTED BRONZE X STANDARD BRONZE MATINGS

The crossbred hens did not attain the body weight of the larger parent (Broad Breasted Bronze) as the crossbred toms tended to do. The main differences between these purebred and crossbred hens were highly significant for all but one mating of these varieties. Large body appeared to be dominant to small body size since the average body weight of the F_1 s approached the average body weight of the larger parent—the Broad Breasted Bronze.

When this experiment was started several producers of turkeys in West Virginia were crossing two varieties of turkeys hoping to obtain some beneficial effects such as improvement in growth, finish, and fleshing. To do this they had to maintain two varieties. These producers generally used the standard Bronze and Bourbon Reds with sharp keel bones and generally poor body conformation as we know turkeys today. The present experiment was started by using these varieties. Luckily a strain of Bourbon Reds was secured that was unusually plump breasted for turkeys at that time. The results secured from these first crosses are shown in Tables 1 and 2. These comparisons were conducted in 1938, 1939, and 1940 and the results are given in Tables 1 and 2. Tables 8 and 9 list results for body weight and body measurements and Table 11 lists results for fat grades. The only evidence that heterosis occurred was found in the F_1 crossbreds from the Bronze X Bourbon Red cross. The crossbred toms exceeded the purebred toms in body weight, body depth, and breast width and for keel length in both sexes.

Now that we have a superbly fleshed variety like the Broad Breasted Bronze, the crossbreeder would naturally consider it as one parent for a cross. The Broad Breasted Bronze, however, has a serious fault; it has poor reproductive ability. Every strain tested in this experiment exhibited low fertility and poor hatchability as compared with the Standard Bronze.

No evidence was found in this experiment to show that benefits from crossbreeding are great enough to justify the additional work and expense involved in carrying two varieties of turkeys for crossbreeding purposes.

Interest is increasing in white feathered turkeys and the turkey breeder would be ahead to secure a strain of well-fleshed white feathered turkeys. There are strains available now which are the result of crossbreeding White Hollands and/or Beltsville Small White with Broad Breasted Bronze grading up.

GROWTH AND FEED EFFICIENCY

When the turkeys were old enough to live without supplemental heat they were moved from the brooder houses to a well-grassed growing range of Kentucky blue grass, orchard grass, and alfalfa. Orchard grass proved to be satisfactory and a better range crop than the other crops used under conditions at this Station. Growth, when plotted on curves for either absolute or relative rates, was about the same for all groups of turkeys. As would be expected, the feed efficiency (pounds of feed consumed per pound of gain in body weight) varied only slightly between purebreds and crossbreds.

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APPENDIX

TABLE 1. THE MATINGS, FERTILITY, HATCHABILITY, AND VIABILITY OF PUREBRED, OUTCROSSED, AND CROSSED TURKEYS

PEN No.	MATINGS				EGGS SET	FERTILE EGGS		FERTILE EGGS HATCHED		VIABILITY TO 4 WEEKS
	Male	Female	Type	Hens		Number	Per Cent	Per Cent	Per Cent	
1938										
1	Bronze	Bronze Bour. Red	Purebred Crossbred	10 5	258 80	86.1 95.8	67.1 72.1	71.4 87.7		
2	Bronze	Bronze Bour. Red	Purebred Crossbred	9 5	181 105	86.4 90.7	71.8 81.6	81.1 84.7		
3	Bour. Red	Bour. Red Bronze	Purebred Crossbred	10 5	185 74	98.4 80.8	70.2 64.6	93.5 93.9		
4	Bour. Red	Bour. Red Bronze	Purebred Crossbred	10 4	160 102	96.0 97.0	70.2 67.1	94.9 80.0		
1939										
1	Bronze	Bronze Bour. Red	Purebred Crossbred	10 5	272 128	73.6 98.7	62.9 69.4	86.3 98.1		
2	Bronze	Bronze Bour. Red	Purebred Crossbred	9 4	255 83	73.6 94.9	62.7 66.2	93.3 94.1		
3	Bour. Red	Bour. Red Bronze	Purebred Crossbred	10 4	221 119	92.5 94.9	72.5 79.3	91.4 90.9		
4	Bour. Red	Bour. Red Bronze	Purebred Crossbred	8 5	170 119	89.1 80.8	55.4 81.9	88.4 85.4		
1940										
1	Bronze F ₁	Bronze Black X Bronze	Purebred Crossbred	10 5	174 112	79.1 92.2	56.8 79.6	86.2 95.4		
2	Bronze F ₁	Bronze Black X Bronze	Purebred Crossbred	8 5	187 98	78.5 82.6	65.2 76.9	96.9 92.8		
3	Bour. Red F ₁	Bour. Red Blk. X Bour. R.	Purebred Crossbred	9 5	193 106	90.1 91.0	68.1 75.8	91.1 97.8		
4	Bour. Red F ₁	Bour. Red Blk. X Bour. R.	Purebred Crossbred	10 4	202 101	87.6 90.9	64.3 63.6	95.6 100.0		

1941

1	Bronze	Bronze	Inbred	13	213	88.2	47.6	88.9
2	B.B.Br.	B.B. Bronze	Purebred	8	194	88.7	59.2	99.0
3	B.B.Br.	Bronze	Crossbred	11	219	93.5	67.4	93.5
4	B.B.Br.	Bour. Red	Crossbred	15	279	96.1	75.6	98.0
5	Bour. Red	Bour. Red	Outcrossed	11	174	89.1	61.6	92.0
6	B.B.Br.	B.B. Bronze	Purebred	5	114	91.6	53.3	91.7

1942

1	Bronze	Bronze	Outcrossed	8	250	89.9	66.8	98.9
		B.B. Bronze	Crossbred	8	262	85.9	64.0	96.3
2	B.B. Bronze	B.B. Bronze	Outcrossed	8	269	71.8	49.3	95.6
		Bronze	Crossbred	9	220	89.6	65.8	100.0
3	B.B. Bronze	B.B. Bronze	Outcrossed	6	201	72.6	50.9	97.7
		Bour. Red	Crossbred	8	267	90.6	58.9	97.5
4	Bour. Red	Bour. Red	Outcrossed	8	205	70.9	62.2	95.1
		B.B. Bronze	Crossbred	6	177	69.1	71.3	97.9
5	B.B. Bronze	B.B. Bronze	Outcrossed	8	219	91.3	69.4	98.7
		Black	Crossbred	7	186	92.5	85.5	97.3

1943

3	B. White	B. White	Purebred	8	354	94.1	79.9	86.81
		B.B. Bronze	Crossbred	9	285	51.9	71.6	92.45
5	B.B. Bronze	B.B. Bronze	Purebred	17	617	80.1	69.2	89.13
		Black	Crossbred	3	82	95.1	65.4	84.61
6	B.B. Bronze	B.B. Bronze	Purebred	14	517	79.1	67.7	97.43
		Bour. Red	Crossbred	6	287	56.1	67.1	94.11

1944

7	B. White	B. White	Purebred	12	391	70.58	83.69	73.08
		B.B. Bronze	Crossbred	6	216	56.48	80.33	82.61

1945

7	B. White	B. White	Purebred	10	293	86.68	77.55	77.77
		B.B. Bronze	Crossbred	6	182	46.70	74.11	96.15
8	B. White	B. White	Purebred	10	204	75.00	78.43	76.66
		B.B. Bronze	Crossbred	6	137	42.34	70.68	90.47

TABLE 2. PUREBRED AND CROSSBRED BODY WEIGHTS AND MEASUREMENTS—
28 WEEKS OF AGE

LOTS	No.	BODY		KEEL LENGTH	SHANK LENGTH	BREAST WIDTH
		WEIGHT	DEPTH			
		<i>pounds</i>	<i>cm</i>	<i>cm</i>	<i>cm</i>	<i>inches</i>
Males — 1938						
Bronze	44	20.06	24.11	18.73	20.26	2.25
F ₁ — Cross 1	28	20.26	23.83	19.31	20.08	2.24
F ₁ — Cross 2	17	20.02	23.98	19.19	19.79	2.29
Bourbon Red	61	19.44	23.35	18.60	19.29	2.44
Males — 1939						
Bronze	62	18.37	23.37	17.24	19.84	2.26
F ₁ — Cross 1	30	18.50	23.27	17.81	19.77	2.34
F ₁ — Cross 2	32	18.43	23.43	17.61	19.76	2.41
Bourbou Red	55	16.67	22.62	17.37	19.31	2.48
Males — 1940						
Bronze	37	20.01	24.41	18.10	20.73	2.25
F ₁ — Cross 3	33	19.93	24.24	18.63	20.08	2.10
F ₁ — Cross 4	33	18.98	23.89	18.17	20.10	2.25
Bourbon Red	61	17.57	23.22	17.77	19.73	2.40

TABLE 3. PUREBRED AND CROSSBRED BODY WEIGHTS AND MEASUREMENTS—
28 WEEKS OF AGE

LOTS	No.	BODY		KEEL LENGTH	SHANK LENGTH	BREAST WIDTH
		WEIGHT	DEPTH			
		<i>pounds</i>	<i>cm</i>	<i>cm</i>	<i>cm</i>	<i>inches</i>
Females — 1938						
Bronze	49	12.27	18.70	15.62	15.99	2.43
F ₁ — Cross 1	31	11.81	18.27	15.75	15.80	2.49
F ₁ — Cross 2	29	12.25	18.66	15.96	15.69	2.59
Bourbon Red	45	11.56	18.19	15.71	15.26	2.69
Females — 1939						
Bronze	50	11.64	18.72	14.88	15.60	2.48
F ₁ — Cross 1	23	12.09	18.93	15.34	15.90	2.59
F ₁ — Cross 2	22	11.68	18.64	15.19	15.77	2.54
Bourbon Red	52	11.11	18.20	15.01	15.28	2.59
Females — 1940						
Bronze	34	12.53	19.49	15.33	16.19	2.48
F ₁ — Cross 3	26	12.23	19.21	15.78	16.06	2.57
F ₁ — Cross 4	39	11.91	19.08	15.51	15.94	2.60
Bourbon Red	50	11.44	18.71	15.28	15.82	2.65

Cross 1 — Bronze males X Bourbon Red females.

Cross 2 — Bronze Red males X Bronze females.

Cross 3 — Bronze males X (Black X Bourbon Red) females.

Cross 4 — Bourbon Red males X (Bronze X Bourbon Red) females.

cm — Centimeters.

TABLE 4. PUREBRED AND CROSSBRED BODY WEIGHTS AND MEASUREMENTS—
28 WEEKS OF AGE

LOTS	No.	BODY		KEEL LENGTH	SHANK LENGTH	BREAST GRADE
		WEIGHT	DEPTH			
		<i>pounds</i>	<i>cm</i>	<i>cm</i>	<i>cm</i>	
Males — 1941						
Bronze	37	19.84	24.35	17.65	19.32	6.59
Bourbon Red	47	19.64	23.18	18.49	18.60	5.68
B. B. Bronze ¹	61	23.78	24.17	18.58	19.33	3.66
B. B. Br. ² X Bronze	59	23.69	24.26	18.88	19.78	4.74
B. B. Br. ² X Bour. Red	67	21.94	23.65	18.39	19.41	4.70
Females — 1941						
Bronze	32	12.16	19.12	14.79	15.15	6.00
Bourbon Red	37	11.63	18.56	15.79	14.90	5.35
B. B. Bronze ¹	68	15.62	19.41	15.73	15.23	3.06
B. B. Br. ² X Bronze	44	14.21	19.39	15.51	15.56	4.61
B. B. Br. ² X Bour. Red	68	13.56	18.99	15.59	15.35	4.59

¹Broad Breasted Bronze: Average of two strains.

²Males are listed first.

TABLE 5. PUREBRED AND CROSSBRED BODY WEIGHTS AND MEASUREMENTS--
28 WEEKS OF AGE

LOTS	No.	BODY		KEEL LENGTH	SHANK LENGTH	BREAST GRADE
		WEIGHT	DEPTH			
		<i>pounds</i>	<i>cm</i>	<i>cm</i>	<i>cm</i>	
Males — 1942						
Bronze	45	20.58	24.27	17.93	19.87	6.62
Bourbon Red	28	20.01	23.39	18.65	19.38	5.71
B. B. Br. ¹	94	24.42	23.75	18.94	19.60	3.57
B. B. Br. X Bronze ²	69	22.94	24.36	18.83	19.88	5.03
B. B. Br. X Bour. Red ³	68	23.09	24.26	19.62	19.42	4.71
B. B. Br. X Black ⁴	33	22.81	24.70	19.66	19.74	5.42
Females — 1942						
Bronze	31	11.84	19.25	14.98	15.69	6.13
Bourbon Red	27	11.89	18.85	15.66	15.40	5.30
B. B. Br. ¹	65	15.22	19.34	15.86	15.57	2.72
B. B. Br. X Bronze ²	63	13.82	19.10	15.51	15.47	4.06
B. B. Br. X Bour. Red ³	51	13.84	19.18	16.22	15.36	4.02
B. B. Br. X Black ⁴	30	13.05	19.36	16.11	15.57	4.63

¹Broad Breasted Bronze.

²Reciprocal crosses of Broad Breasted Bronze and Bronze.

³Reciprocal crosses of Broad Breasted Bronze and Bourbon Red.

⁴Males are listed first.

TABLE 6. PUREBRED AND CROSSBRED BODY WEIGHTS AND MEASUREMENTS—
28 WEEKS OF AGE

LOTS	No.	BODY		KEEL LENGTH	SHANK LENGTH	BREAST GRADE
		WEIGHT	DEPTH			
		<i>pounds</i>	<i>cm</i>	<i>cm</i>	<i>cm</i>	
Males — 1943						
B. B. Br. ¹	118	23.63	23.98	18.79	19.35	3.53
Beltsville White	37	16.85	21.46	16.33	17.54	4.73
Beltsville White ²	}	33	21.88	19.08	19.40	4.84
Bourbon Red						
Beltsville White	}	24	22.37	19.01	19.46	4.28
B. B. Bronze						
Females — 1943						
B. B. Br.	99	14.58	19.53	15.89	15.58	3.14
Beltsville White	43	9.76	16.81	13.97	13.76	4.01
Beltsville White	}	27	12.74	15.86	15.44	4.62
Bourbon Red						
Beltsville White	}	25	12.97	15.64	14.90	3.86
B. B. Bronze						

¹Broad Breasted Bronze.

²Males are listed first.

TABLE 7. BODY WEIGHTS AND MEASUREMENTS OF BELTSVILLE WHITES AND
CROSSES WITH BROAD BREASTED BRONZE—28 WEEKS OF AGE

LOTS	No.	BODY		KEEL LENGTH	SHANK LENGTH	BREAST GRADE
		WEIGHT	DEPTH			
		<i>pounds</i>	<i>cm</i>			
Males — 1944						
Beltsville White	7	15.56	20.31	15.27	16.39	4.29
Beltsville White ¹						
B. B. Bronze ²	8	20.54	22.85	17.39	18.40	4.12
Females — 1944						
Beltsville White	15	9.08	16.02	12.91	12.91	3.53
Beltsville White ¹						
B. B. Bronze ²	8	12.27	17.78	14.31	14.14	4.00
Males — 1945						
Beltsville White	9	17.06	20.49	16.58	16.93	4.20
Beltsville White ¹						
B. B. Bronze ²	14	22.72	22.71	19.34	18.88	4.21
Females — 1945						
Beltsville White	11	9.79	15.44	13.20	12.55	4.03
Beltsville White ¹						
B. B. Bronze ²	9	12.91	17.69	14.62	13.64	3.40

¹Males are listed first in crosses.

²Broad Breasted Bronze.

TABLE 8. ANALYSIS OF VARIANCE OF DIFFERENCES BETWEEN GROUPS Sired
BY SAME MALES FOR YEARS 1938, 1939, 1940

PENS	SOURCE OF VARIANCE	DEGREES OF FREEDOM	MEAN SQUARES				
			BODY		KEEL LENGTH	SHANK LENGTH	BREAST WIDTH
			WEIGHT	DEPTH			
			<i>pounds</i>	<i>cm</i>	<i>cm</i>	<i>cm</i>	<i>inches</i>
Males							
1 and 2	Years	2	2.6448	1.0409	6.8935	4.8307*	0.0926*
	Sires in years	3	1.7347	1.8249	0.8231	0.2610	0.0049
	Hatches in sires and years	6	4.3065	0.7821	0.3887	0.2625	0.0412
	TOTAL	11	3.3029	1.1136	1.6899	1.0927	0.0407
3 and 4	Years	2	56.0216	13.8316	9.0816	5.4262*	0.3565†
	Sires in years	3	8.6836	2.2789	2.2500	0.3877	0.0066
	Hatches in sires and years	6	6.6037	1.9180	0.7224	1.3122	0.0478
	TOTAL	11	16.1560	4.1825	2.6588	1.8081	0.0927
Females							
1 and 2	Years	2	3.0783	1.6934	2.1552	0.8238	0.1455*
	Sires in years	3	3.8752*	0.4855	0.5918	0.4200*	0.0148
	Hatches in sires and years	6	0.7054	0.4459	0.1477	0.0677	0.0041
	TOTAL	11	2.0013	0.6835	0.6338	0.3012	0.0327
3 and 4	Years	2	4.7367	2.7255	1.3775	2.4080	0.1475*
	Sires in years	3	4.2314	0.8561	0.6676	0.4739	0.0049
	Hatches in sires and years	6	1.4764	0.4126	0.5054	0.1935	0.0270
	TOTAL	11	2.8206	0.9541	0.7082	0.6726	0.0429

*Significant at the 5 per cent point.

†Significant at the 1 per cent point.

TABLE 9. MEAN DIFFERENCES AND SIGNIFICANCE OF THE DIFFERENCES BETWEEN THE VARIOUS GROUPS IN BODY WEIGHT AND BODY CHARACTERISTICS

SOURCE OF VARIANCE	DEGREES OF FREEDOM	BODY		KEEL LENGTH	SHANK LENGTH	BREAST WIDTH
		WEIGHT	DEPTH			
		<i>pounds</i>	<i>cm</i>			
				<i>cm</i>	<i>cm</i>	<i>inches</i>
Differences Between						
Purebreds and Crossbreds						
Males — 1938, 1939, 1940						
In Cross 1	10	‡0.09	‡0.19	0.51	‡0.31	‡0.00
In Cross 2	10	1.37*	0.71*	0.53	0.45	0.11*
All Purebreds & Crossbreds	10	0.64	0.26	0.52*	0.07	0.05
All Crossbreds	8	0.20	0.09	0.31	0.09	0.01
All Purebreds	8	1.76†	0.93†	0.23	0.83†	0.16†
1942						
Crossbreds - Pens 1,2,3 & 4	8	‡0.18	0.17	‡0.75	0.47	0.30†
Between Purebreds	8	‡0.20	0.22	‡0.73	0.18	0.45†
Females — 1938, 1939, 1940						
In Cross 1	10	‡0.16	‡0.17	0.29	‡0.07	0.08
In Cross 2	10	0.41	0.32	0.21	0.27	0.07
All Purebreds & Crossbreds	10	0.12	0.08	0.25*	0.10	0.07*
All Crossbreds	8	0.06	0.04	0.07	0.13	0.01
All Purebreds	8	0.62*	0.49*	0.17	0.47*	0.18†
1942						
Crossbreds - Pens 1,2,3 & 4	8	0.08	0.28	‡0.42	0.35	0.04
Between Purebreds	8	‡0.34	0.24	‡0.29	0.13	0.51†

*Significant at the 5 per cent point.

†Significant at the 1 per cent point.

‡Signs before mean differences show purebreds had larger values.

TABLE 10. MEAN DIFFERENCES AND SIGNIFICANCE OF THE DIFFERENCES
BETWEEN PUREBREDS AND CROSSBREDS. (10 DEGREES OF FREEDOM)

PENS	YEAR	BODY		KEEL LENGTH	SHANK LENGTH	BREAST GRADE
		WEIGHT	DEPTH			
		<i>pounds</i>	<i>cm</i>	<i>cm</i>		
Males						
3 and 4	1941	1.76 ^o	0.53	0.45	0.46	0.02
1	1942	2.24*	0.12	0.81	‡0.06	1.51*
2	1942	‡0.40	1.56*	0.46	0.49	1.50†
3	1942	‡1.51	0.15	0.57	‡0.25	1.50†
4	1942	3.21†	0.86	0.80	0.12	‡1.09†
5	1942	‡1.93	0.46	0.56	0.02	1.35†
3	1943	5.60†	1.74	1.68	0.89	‡0.42
5	1943	0.61	0.44	1.64	0.09	0.84†
6	1943	‡1.56	‡0.17	0.31	‡0.07	1.01†
7	1944	4.98*	2.54*	2.12	2.03*	‡0.17
7	1945	5.26	2.94	1.91	2.14	0.01
Females						
3 and 4	1941	0.61	0.35	0.08	0.19	0.18
1	1942	2.22†	0.35	0.75*	0.12	1.97†
2	1942	‡1.50*	‡0.20	‡0.18	0.08	1.36†
3	1942	‡2.22	‡0.26	0.32	‡0.30	1.46†
4	1942	2.27†	0.54	0.60	0.06	‡1.26†
5	1942	‡2.31	0.34	0.06	‡0.19	1.67†
3	1943	2.66	1.64	0.88	0.85	‡0.40
5	1943	‡1.24	‡0.29	0.53	‡0.35	0.93
6	1943	‡1.50	‡0.35	‡0.72	‡0.12	1.20
7	1944	3.19†	1.76†	1.40*	1.23*	‡0.47
7	1945	3.01*	1.25	1.30	0.90	‡0.17

*Significant at the 5 per cent point.

†Significant at the 1 per cent point.

‡Signs before mean differences show purebreds had larger mean weights and measurements.

TABLE 11. AVERAGE FAT GRADES OF DRESSED TURKEYS

LOTS	NUMBER	NUMERICAL GRADE	NUMBER	NUMERICAL GRADE
	MALES		FEMALES	
1938 — 1939				
Bronze	107	5.25	99	5.07
F ₁ Cross 1	59	4.05	54	4.02
F ₁ Cross 2	49	5.52	39	3.99
Bourbon Red	116	4.92	97	3.51
1940				
Bronze	38	4.82	36	3.46
Cross 3	34	4.44	30	2.38
Cross 4	36	4.64	40	2.58
Bourbon Red	62	4.60	53	3.08
1941 — 1942 — 1943				
Bronze	82	5.21	77	4.77
Bourbon Red	76	5.45	64	4.57
Broad Breasted Bronze	260	3.95	229	3.49
B. B. Br. X Bronze ¹	60	4.65	44	3.88
B. B. Br. X Bourbon Red	68	4.89	68	3.86
(B. B. Br. X Bronze) ²	69	4.14	63	3.31
(B. B. Br. X Bourbon Red) ²	68	3.83	51	3.14
B. B. Br. X Black ¹	42	3.53	41	3.32
Beltsville White	20	2.74	30	2.43
Beltsville White X B. B. Br. ³	18	3.19	16	3.17

¹Broad Breasted Bronze Males listed first.²Reciprocal Crosses.³Males listed first.