The Inheritance of Color and Horns in Blue-gray Cattle II

By John M. Evvard, P. S. Shearer, E. W. Lindstrom and A. D. B. Smith

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SUMMARY

This bulletin is a sequel to Research Bulletin No. 30 published in 1916. It contains information and a discussion concerning the progeny from the original stock subsequent to that date.

The work of the previous investigators, their results and the conclusions drawn therefrom, are retabulated without details. Additional data are added showing that the recessive whites obtained from the F₂ breed true.

The nature of the roan in the Shorthorn is considered. While it is recognized that Wright's criticism of the hypothesis used (Wentworth's) rendered it improbable, yet the fact that two whites when mated to self-colored bulls threw self-colored calves, seems to disprove the hypothesis that roan is the simple heterozygote between self-pigmented and white. Accordingly no conclusions are drawn with respect to roaning.

The relation of these whites with dark points to the similarly marked Wild White Park Cattle of Great Britain is discussed, and the conclusion is drawn that they are of a different genetic composition, the former being recessive and the latter dominant to most colors. It seems probable that the only coat color difference between these whites with dark points and the white Shorthorn lies in the degree of pigmentation in the points. The presence of pigment in the ears shows dominance over the almost complete lack of it.

A white with red points was obtained, as demanded by Lloyd Jones' and Evvard's theory.

Matings of the white with dark points to the almost white Ayrshire reveal that there is no genetic similarity between the two types of white. Data were obtained from these matings, but not in a quantity sufficient to advance or prove any hypothesis.

Detailed tables and descriptions of the new individuals are presented.
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BY JOHN M. EVVARD, P. S. SHEARER, E. W. LINDSTROM AND A. D. B. SMITH

The earlier genetic results of an experiment primarily designed to investigate the economic value of the famous blue-gray cattle were published in 1916 by O. Lloyd-Jones and John M. Evvard as Research Bulletin No. 30 of the Iowa Agricultural Experiment Station. Since 1916 some additional data have been acquired that seem to merit discussion.

From the original cross of purebred Galloway cows with a purebred white Shorthorn bull, in which the $F_1$ animals were blue-gray, the following $F_2$ generation was produced from mating five blue-gray $F_1$ cows with one blue-gray $F_1$ bull:

1 Black  
11 Blue-Gray  
3 White with black points  
5 Red (including one red and white)  
1 Roan (red)

Fig. 1. A typical blue-gray calf. Notice not only the uniformity of the roaning, but also the evenness of the fleshing.
The inheritance of the polled-horned condition proved to be governed by a single pair of genes, and no evidence was obtained that sex is in any way connected with this character.

To explain the coat color results, a trihybrid hypothesis was put forward involving a dominant factor \((B)\) for black and its recessive allelomorph \((b)\) for red. The roan condition was accounted for by a dominant factor \((N)\) which sprinkled white hairs throughout a pigmented coat. An extension factor \((E)\), whose dominance permitted the pigment to cover the whole coat, and in its recessive condition \((e)\) restricted it to the "points," such as the muzzle, ear and hoof, was assumed.

With such a hypothesis the breeding formulae for the original cross and the subsequent progenies may be arranged as follows:

\[
\begin{align*}
\text{P}_1 & \quad \text{Shorthorn Bull, White x Galloway Cows, Black} \\
& \quad b\,b\,e\,e\,N\,N \quad B\,B\,E\,E\,n\,n \\
\text{F}_1 & \quad \text{Blue-Gray} \\
& \quad B\,b\,E\,e\,N\,n \\
\text{F}_2 & \quad \text{Phenotype} \quad \text{Description} \quad \text{Ratio} \quad \text{Obtained} \quad \text{Calculated} \\
& \quad 27\,B\,E\,N \quad \text{Blue-Gray} \quad 27 \quad 11 \quad 9 \\
& \quad 9\,B\,E\,n \quad \text{Black} \quad 9 \quad 1 \quad 3 \\
& \quad 9\,b\,E\,N \quad \text{Red-Roan} \quad 9 \quad 1 \quad 3 \\
& \quad 3\,b\,E\,n \quad \text{Red} \quad 3 \quad 5 \quad 1 \\
& \quad 9\,B\,e\,N \quad \text{White with black points} \quad 12 \quad 3 \quad 4 \\
& \quad 3\,B\,e\,N \quad \text{White with red points} \quad 4 \quad 0 \quad 1 \\
\end{align*}
\]
While the data do not fit this working hypothesis well ($P = .002$), it is retained merely to aid in reporting the results. It is evident that the number of experimental animals was too limited to afford any conclusive test of the genetic basis for color.

Altho the $F_2$ data afforded no conclusive evidence on the complete inheritance of Shorthorn color, they did permit an analysis of the various pairs of hereditary factors involved. For example, the black color (B) of the Galloway proved to be a simple dominant to the red (b) of the Shorthorn. This situation was analogous to that reported in the Angus breed by Cole and Jones (4) and in the Holstein-Friesian breed by Campbell (3). A summary of the various matings from Bulletin 30, involving these colors, has been arranged in table I:

### Table I. Summary of the Matings Involving Black and Red Colors.

<table>
<thead>
<tr>
<th>Mating</th>
<th>Offspring obtained</th>
<th>Expected</th>
<th>Dev.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Black</td>
<td>Red</td>
</tr>
<tr>
<td>$Bb \times Bb$</td>
<td>20</td>
<td>6</td>
<td>19.5</td>
</tr>
<tr>
<td>$Bb \times b$</td>
<td>7</td>
<td>5</td>
<td>6.0</td>
</tr>
<tr>
<td>$Bb \times BB$</td>
<td>9</td>
<td>0</td>
<td>9.0</td>
</tr>
<tr>
<td>$bb \times bb$</td>
<td>0</td>
<td>7</td>
<td>7.0</td>
</tr>
</tbody>
</table>

All progenies showed a remarkable agreement with the expectation on the basis of a single factor difference between black and red pigment in the Galloway x Shorthorn cross, proving that the roaning from the latter breed does not disturb the inheritance of these basic colors.

It was also shown that the fundamental distribution of color could be explained successfully on a single factor basis in which the extended (E) or spread condition of the color (black or red) was completely dominant to the restricted (e) condition. Data to substantiate this appear in table II.

Accordingly, the assumption that the Galloway and White Shorthorn cattle differ by a sin-

Fig. 3. The head of a typical blue-gray steer, "Tama Jim." He is of the $F_1$ generation and made a good steer. The blue-gray roaning on his head does not extend to the ears. The same is the case in the roan Shorthorn. Notice the polled condition.
TABLE II. SUMMARY OF MATINGS INVOLVING EXTENSION AND RESTRICTION OF COAT COLORS.

<table>
<thead>
<tr>
<th>Matings</th>
<th>Offspring obtained</th>
<th>Expected</th>
<th>Dev.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Extended</td>
<td>Restricted</td>
<td>Extended</td>
</tr>
<tr>
<td>E e x E e</td>
<td>22</td>
<td>7</td>
<td>21.7</td>
</tr>
<tr>
<td>E e x e e</td>
<td>2</td>
<td>3</td>
<td>2.5</td>
</tr>
<tr>
<td>e e x e e</td>
<td>0</td>
<td>5</td>
<td>0</td>
</tr>
</tbody>
</table>

A single heredity factor that spreads the pigment over the body on the former and restricts it on the latter seems to be justified. This factor is genetically different from any ordinary spotting factor, as for example, that found in the Holstein and Ayrshire breeds.

The mode of inheritance of the roan condition derived from the Shorthorn breed was not satisfactorily explained by this experiment. These experimental data acquired under controlled conditions do not afford complete substantiation of the monohybrid explanation of roaning. As a matter of fact, the F2 data proved to give a better approximation when fitted to the dihybrid hypothesis. For example, the complete F2 results from roan by roan matings consisted of 12 roan and 9 non-roan. On a monohybrid basis there should be equal numbers of each type. The deviation in this case is 1.5, which is just as large as its probable error. With the dihybrid hypothesis (9 roan : 7 non-roan), the expected numbers are exactly 12 roan and 9 non-roan.

A series of roan by roan matings, however, using other than F1 animals (see table in Appendix of Bulletin 30) showed 6 roans and 6 non-roans, a result entirely compatible with the monohybrid situation.

![Fig. 4. Typical specimens of the F2 generation from mating of the blue-gray F1 bull with the blue-gray F1 cows. From left to right, No. 208 is a white heifer with black points. No. 207 is a red heifer with considerable white marking and No. 204 is a practically solid red steer showing only a little white on the underline. He is a full brother to the red bull used in 1909-10 (see fig. 8 in the previous bulletin). Note the segregation of color and markings.](image-url)
The backcross progenies resulting from matings of roan by non-roan are not directly explainable on either hypothesis. Of 27 offspring from such matings (including those reported in Bulletin 30 plus a few new ones described herein), 7 were roan and 20 non-roan. These results deviate noticeably from the 1:1 ratio expected on the simple monohybrid basis, the deviation of 6.5 being practically four times as large as its probable error. A similar expectancy is obtained on the dihybrid basis if the matings were made entirely at random. The fewness of such matings render this unlikely, however, and it becomes idle to fit the data to any such distribution.

Perhaps the most interesting observation arising from a study of such backcross data is that gained by considering the matings of roan by solid colored animals separately from matings of roan by white. The former matings produced 4 roans and 16 non-roans, whereas the latter gave 3 roans and 4 non-roans. Here is a strong suggestion that white acts differently with roan than does a solid color, a clue that may perhaps be of assistance to future investigators. At present, no simple hypothesis is available for solving this phase of the problem. A few new observations made by the authors seem to be worthy of discussion. In 1918 Wright (16) showed that the hypothesis temporarily adopted in Bulletin 30 was not adequate. He noted that this hypothesis accounted for discrepancies from the one factor hypothesis (roan as the simple heterozygote) at the expense of the general facts since in a population breeding at random, figures from a dihybrid hypothesis are obtained which would be in distinct variance from those actually found.
Fig. 6. Recessive back-cross to red. This is the other back-cross, the sire of these calves was a red Shorthorn bull; their dams were F₁ blue-gray cows. They were both red in color.

Nevertheless, Wright does not attempt to explain a fact mentioned by Lloyd-Jones and Evvard, namely that Whitehall Sultan, a white Shorthorn bull, got 59 calves out of red cows, 15 of which, practically one-fourth, were not roan but red. Martini (7) showed the same to be the case with Maxwalton Sultan, a son of Whitehall Sultan, also white, which, out of 54 matings with red cows, produced 13 red calves, a significant number. This tendency seems to have been maintained in two other of Whitehall Sultan’s white calves, Fair Acres Sultan and Snowbird’s Sultan, twins, both of which when mated with red cows produced a significant number of red calves (unpublished data).

At the time Bulletin No. 30 was published, there had not come into prominence an English breed called the “Blue Albions,” a society of its breeders having been formed in 1920. According to Wallace (13) the breed originated in Derbyshire, England, and possesses strong resemblances to the Shorthorn. He suggests that it arose from a cross of the Shorthorn with the Black Welsh. It has been bred in the hills for a considerable time and claims are made that it breeds true, or that it throws no significant number of black or white calves. The junior author, A. D. B. Smith, has seen specimens of this breed in England. He is inclined to disbelieve the statement that these cattle breed reasonably true to the roan condition. In appearance their roaning is, save for the color, in every way similar to that of the Shorthorns and in photographs they would be difficult to distinguish save for the black muzzle of the Blue Albion. Blue-gray breeds are said to occur in Belgium in the Race Belge Bleue and the Race du Condroz. Buche (2) has reported La Race Bleue du Nord as a blue-gray breed in France. This blue-gray would seem also to occur on the banks of the Nile, and the Bundelkhand blue-gray humped...
breed in India is reported by Wallace (13) as having been derived from a cross of a black and white breed of Zebu cattle. The present writers have never heard of a true breeding red-roan breed.

In view of the facts that the experimental data do not completely support the simple monohybrid hypothesis and that certain white Shorthorns mated to red produce red, it seems inadvisable to build further upon it. In support of this second fact it may be noted that in the course of this investigation two such exceptional white animals were observed. The first, a white Shorthorn cow, No. 105, to the service of No. 148 F₂ red bull, dropped one roan and one red calf. The second, a white with black points (F₂ cow No. 208) mated to a red Shorthorn bull, gave birth to a black calf, No. 1115. This calf had considerable white marking, but as his sire was similarly marked no stress can be laid on this point.

Save for these two not unimportant cases the monohybrid hypothesis of roan as the heterozygous condition fits the observed facts as well as the dihybrid. Altho the evidence produced regarding this point is conclusive for neither theory, it seems worth recording and may be of use to future investigators.

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Fig. 7. The sire of the white with red points. Royal Crest (379410), the white Shorthorn bull which is the sire of much of the produce recorded here and in particular of calf No. 1133, the long expected white with red points.

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1In a more recent publication Smith (11) the junior author makes note of the fact that in correspondence with the political agent in the Bundelkhand, India, "it has been ascertained that white and black cattle exist alongside the blue mentioned by Wallace, and that the blues throw solid colors."
Fig. 8. Fourth generation back-cross to Shorthorn. Heifer 1128, by the white Shorthorn bull. Her dam, a white with black points, was the product of a sire-daughter mating, being sired by the F₁ blue-gray bull out of No. 146F₂, a blue-gray which was herself sired by the F₁ blue-gray bull.

The Relation of the Wild White Park to the Whites With Dark Points

In their discussion on the various types of Wild White cattle, as bearing on the hereditary constitution of the white F₂ animals in this experiment, the authors of the previous bulletin distinguished between the Wild White of the Chillingham herd and of the Pembroke cattle, the former being dominant and the latter, they said, recessive. Further investigation would appear to contradict this claim. Wallace (13) writes of the Pembroke White Cattle at Lamphey Court: "The difficulty of procuring at all times stud bulls good enough to keep up the standard of a small number of cattle is got over by the use of a choice black bull when a white is not available. A large proportion of his progeny takes after the mothers in being white with black points, and those that are born black are transferred to the black cattle herd." This and the fact that in Volume II of the Park Cattle Society Herd Book, both the Dynevor herd and the Solva Herd, an offshoot of the Dynevor, threw solid black calves tends to show that the white of the Pembroke Wild Cattle is dominant.

Notwithstanding this evidence it can now be shown that the white color of these Iowa cattle is recessive in its action, and, indeed, save for the pigment of their "points" they behave as do the white Shorthorns. Two cows of this description of blue-
gray parentage (208 and 215) mated to red or Ayrshire (fig. 11) bulls produced 7 pigmented calves, all blue-gray save one, which was black with white markings.

Furthermore, mated to a white Shorthorn bull (fig. 7) these white cows with black points (208, 215 and A1110) bred true for the restriction factor, producing 4 whites with black points and 1 white female with red points (table III). The official description of this last heifer runs: "Horned, white, excepting end points as follows: Inner edge or border of both ears reddish hairs, rather heavy fringe. All four hoofs show red, the left front and two hind ones show about 1/2 to 1 inch of red with laminae running up and down. The right forward hoof shows some red tho not as marked and definite as the other three. Tail white,

TABLE III.

<table>
<thead>
<tr>
<th>Matings White x White, ee x ee</th>
<th>White Shorthorn x White with Black Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sire</td>
<td>Dam</td>
</tr>
<tr>
<td>------</td>
<td>-----</td>
</tr>
<tr>
<td>bbeeNN</td>
<td>No. 208 B(B)ee Nn</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>No. 215 B(B)ee NN</td>
</tr>
<tr>
<td></td>
<td>No 1110 Bbee N(N)</td>
</tr>
</tbody>
</table>
no red perceptible. On our black-pointed white cattle some of their hoofs are partly black as the above's are red.

It would seem probable that the only difference between the normal white Shorthorn and this calf is that the pigmented area of the former is more restricted than that of the latter. That the more extensive pigmentation is dominant, and possibly due to a single factor, may be seen from the fact that the mating, white Shorthorn by white-with-black-points gave five whites-with-points. It would seem safe to say that it would have been only a matter of routine to have recovered a plain white of the Shorthorn type by mating one of these offspring back to the white Shorthorn grandparent.

In this connection it might be noted that Storer (12) draws distinctions between herds that had highly pigmented ears and those with pigment only inside. He also mentions a cross with white Shorthorns where both calves had pigmented ears. That black is dominant to red in the ears may be gathered from the evidence of Bewick quoted by Storer to the effect that in the Chillingham herd, since the keeper destroyed the black-eared cattle, no more appeared. Concerning the Chartley herd Storer writes: "It is somewhat singular that these white-eared ones are all descendants of one cow which was pointed out to us—her own ears were lighter in color than most of the others but not as light as those of the calves." The Park Cattle Society in its standard requires the entire ear to be pigmented, designating any animal not completely so as "Weak-marked." In

![Fig. 10. Typical Park Cattle marking. Bull calf No. 1132, which was twin with the heifer No. 1131. Both were this color, white with black "points". This color of these calves would meet the requirements of the Park Cattle Society in England.](image-url)
Volume II of the Park Cattle Herd book (1921) in the Somerford herd, a White Shorthorn bull mated to three typical cows produced two typical calves and one all white.

Inasmuch as the Wild White Park cattle, therefore when mated to most of the other breeds throw calves of their own coloration and marking, and inasmuch as within the breed itself black calves appear (Miss Pitt (10) sums up this evidence) this white must be a dominant white, due possibly to an inhibitor. The evidence presented here shows the lack of dominance in the Iowa white animals of Wild Park coloration.

**WHITE AND AYRSHIRE MATINGS**

As will be seen from the tables (Table IV and Appendix table) four matings of these white cattle with dark points were made to an Ayrshire bull (fig. 11) white, with red spots. These are interesting, the only other carefully observed and reported matings involving a cross between the Ayrshire and other breeds being those described in a paper by Gowen (6) dealing with the Ayrshire and Guernsey, Jersey, Holstein-Friesian and Aberdeen Angus breeds. The evidence presented here bears out what was previously a strong presumption, that these two kinds of white are different. The white Ayrshire bull which had only a little red marking on the head and buttocks, mated to cows 208 and 215, both the products of blue-gray parents, gave four blue-gray calves (1134, 1135, "Y" and "Z"). The genotype of the Ayrshire bull might be considered as $(bb EE nn)$. He would be

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Fig. 11. Willowmoor Robin Hood 19th (15339), Ayrshire bull, the sire of four interesting calves. He is almost as white as the cows with black points to which he was mated, but his is a different kind of white, due to extreme spotting. The mark over his buttocks was reproduced in one of his offspring, No. 1134. This calf took her color markings largely from her sire save that the pigment was black and showed some Shorthorn roaning.
homozygous for the extension of pigment, his apparent lack of it being due to selection in what is a recessive condition of spotting involving multiple factors. (See the work of Dunn, Webb, and Schneider (5) who demonstrated this to be the case in the Holstein-Friesian breed). Mated to cows of the genotype $B (B) ee N (N)$, the result is $Bb Ee Nn$ the genotype for the blue-gray, the red-roan and solid black or red might also have appeared. Four blue-grays were obtained from this mating, thereby establishing the different genetic composition of these two breeds. The exact descriptions of these four individuals are interesting. Two of them were practically solid blue-gray. The other two approximated rather an Ayrshire type of spotting.

The two solid colored animals were No's 1135 out of cow No. 215 and "z" out of cow No. 208. No. 1135 is described: "Practically all black roan excepting belly and flanks which are white. The roan was especially well marked over rump and thighs, forehead and face and heart girth. Over neck and sides were a few white hairs among almost solid black loin covering. The tail brush was white and the balance roan. It may be called a very dark blue-roan. The fore hoofs and fetlocks are black, but the rear are white with white fetlocks. The eyes and nose are black, the tongue light colored."

"Z" is described: "Practically solid blue-gray, nearly black with white and gray hair scattered in the black. The blue-roan color is the most prominent about the head, neck and shoulders. White on underline, but legs are black. Tongue black and hoofs are black. There is a reddish brown tinge on the edge of the ears."

TABLE IV. MATINGS OF AYRSHIRE WHITE BULL X WHITE WITH BLACK POINTS.

<table>
<thead>
<tr>
<th>Sire</th>
<th>Dam</th>
<th>Offspring</th>
</tr>
</thead>
<tbody>
<tr>
<td>bbEEnn</td>
<td>No. 208 B(B)eeNn</td>
<td>1134, Blue-gray (Light-Spotted) BbEeNn</td>
</tr>
<tr>
<td>bbEEnn</td>
<td>No. 208 B(B)eeNn</td>
<td>&quot;Z&quot;, Blue-gray (Solid) BbEeNn</td>
</tr>
<tr>
<td>bbEEnn</td>
<td>No. 215 B(B)eeNN</td>
<td>1135, Blue-gray (Solid) BbEeNn</td>
</tr>
<tr>
<td>bbEEnn</td>
<td>No. 215 B(B)eeNN</td>
<td>&quot;Y&quot;, Blue-gray (Spotted) BbEeNn</td>
</tr>
</tbody>
</table>

The two spotted blue-grays were calf No. 1134 out of cow No. 208 and "Y" out of cow No. 215. The following description is given of No. 1134: "Largely white with black roan marking, shows considerable Ayrshire spotting. Most parts of the spotted regions are blue-roan. Roan is most evident over rear thighs and over forehead. Black tannish color resembling the Galloway and is also sometimes seen in Holsteins. Eyes and muzzle are black. The tongue is light colored. The neck region is heavily pigmented with very slight traces of the roan condition. The feet show clear black markings on leg above hoof and blending with the hoof in all cases. The hoofs are black. The belly is
Finally, calf "Y" was, "Blue-gray with white irregular markings over body and legs. The legs are white as is also the underline. The white and gray hairs scattered in black areas were most noticeable about the head, neck and shoulders, although present over the entire black area except in a lesser degree. There is a red fringe in the ears. The tongue is white, also the hoofs."

Thus two of these calves have the solid blue-gray characteristics of their maternal grandparents. Of the two spotted animals, "Y" apparently has some of the spottedness of one of the grandparents, 146 F₂, which is described, "Blue-gray, white underline, white buttocks and inside of hocks." It is, however, the other calf, No. 1134, that is the most interesting in that she bears to a remarkable degree the markings of her sire, the white Ayrshire, who had pigment on his head and thighs in the usual Ayrshire spots. The description of this daughter is: "Roan is most evident over rear thighs and forehead." The fact that the spotting in the calf is typically Ayrshire with the blue-roan modification is also of interest.

Other noteworthy points shown by these four matings are the nature of the black, the pigmentation of the hoof, the color of the tongue and the "reddish brown tinge on the edge of the ears."

While several interesting hypotheses might be evolved to account for these different points, in view of the paucity of facts it is not considered that theorizing is warranted.
APPENDIX

This table shows the produce subsequent to the publication of bulletin No. 30. In the genetic formulae the parenthesis about a letter indicate inability to classify the animal definitely concerning that character. A star (*) indicates the animal "has some white," and a dagger (†) that it has already been recorded.

<table>
<thead>
<tr>
<th>Cow No.</th>
<th>Sire of Cow</th>
<th>Dam of Cow</th>
<th>Color</th>
<th>Horns</th>
<th>Genetic Formula</th>
<th>Mated to bull</th>
<th>No. of calf</th>
<th>♂</th>
<th>♀</th>
<th>Color ¹</th>
<th>Horned</th>
<th>Polled</th>
</tr>
</thead>
<tbody>
<tr>
<td>208</td>
<td>No. 1 Blue-gray F₁</td>
<td>No. 45F₁</td>
<td>White—black ears</td>
<td>Polled</td>
<td>B(B)eeNnPp</td>
<td>White Short-horn</td>
<td>†1126 x</td>
<td>x</td>
<td>White—black ears</td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>White Short-horn</td>
<td>1131 x</td>
<td>x</td>
<td>White—black ears</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>White Short-horn</td>
<td>1132 x</td>
<td>x</td>
<td>White—black ears</td>
<td>x</td>
<td></td>
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<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Ayrshire bull</td>
<td>1134 x</td>
<td>x</td>
<td>Blue-gray*</td>
<td>x</td>
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<td></td>
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</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Ayrshire bull</td>
<td>&quot;Z&quot; x</td>
<td>x</td>
<td>Blue-gray</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>215</td>
<td>No. 1 Blue-gray F₁</td>
<td>No. 146F₂*</td>
<td>White—black ears</td>
<td>Horned</td>
<td>B(B)eeN(N)pp</td>
<td>White Short-horn</td>
<td>1128 x</td>
<td>x</td>
<td>White—black ears</td>
<td>x</td>
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</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Ayrshire bull</td>
<td>1135 x</td>
<td>x</td>
<td>Blue-gray</td>
<td>x</td>
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<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Ayrshire bull</td>
<td>&quot;Y&quot; x</td>
<td>x</td>
<td>Blue-gray*</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>146</td>
<td>No. 1 Blue-gray F₁</td>
<td>No. 109F₁</td>
<td>Blue-gray*</td>
<td>Horned</td>
<td>BbEeNapp</td>
<td>White Short-horn</td>
<td>1130 x</td>
<td>x</td>
<td>White—black ears</td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1110</td>
<td>No. 1 Blue-gray F₁</td>
<td>No. 53F₂</td>
<td>White—black ears</td>
<td>Polled</td>
<td>Bbee(NN)P(P)</td>
<td>White Short-horn</td>
<td>1133 x</td>
<td>x</td>
<td>White—red ears</td>
<td>x</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

¹No black, red-roan, nor red calves produced from these matings.