Dr. John L. Fuller  
Jackson Memorial Laboratory  
Bar Harbor, Maine 04609

Dear Dr. Fuller:

Attached for your review is my report on coat color genetics as it possibly relates to the Briard. The report is based upon Dr. Little's fine book and your generous assistance during our phone conversations and the discussion in your office on July 19, 1969. This is submitted to you in the hope that I have not misinterpreted or misunderstood the materials or your very helpful explanations.

The report is only intended as an hypothesis and this must be emphasized since an extensive genetic study of the Briard coat color has never been made. The report is necessarily based upon the very limited data currently available. The details are therefore difficult to analyze accurately.

If you find this report to be soundly formulated in theory, it will be presented to the Briard Club, hopefully to help overcome some misconceptions being discussed and to inspire an interest in a more complete, scientific study of the Briard coat color.

The Briard Club of America and the French Club des Amis du Briard are grateful for the guidance you have given us. It has offered us a more scientific approach to our breeding problems and we wish to extend our thanks for your interest and kind contributions.

Sincerely,

Diane McLeroth  
Standard Committee  
Briard Club of America
Mrs. John K. McLeroth  
3030 Rockwood Drive  
Fort Wayne, Indiana 46805

Dear Mrs. McLeroth:

I think you have done a very fine piece of work on the report on coat color in the Briard. As you state, because the necessary extensive genetic experiments have not been performed for this breed, one must in some way present hypotheses.

I am quite sure that your statements regarding the A and B locus are accurate. I am not as sure that we can definitely state that C and c<sup>ch</sup> are both present in the Briard, but it is quite possible that they are. As you rightly say, the greatest problem is concerned with the possible variations at the E locus. I am basing my opinion that both A<sup>y</sup> and e are present in the breed by your statement that occasionally dark puppies come from the mating of two light Briards. As for the G locus, I think it would require matings between Kerry Blue and the Briard to be certain if the graying effect in maturity is produced by the same locus in these two breeds. Since the phenomenon occurs in the Briard, it is quite conceivable that indeed the G locus is active.

You make a very good point in the discussion that excluding one expression of a gene while encouraging its expression on other backgrounds is illogical. It could potentially cause damage to the breed. There may be a few exceptions to this principle; in particular, instances where the expression of a heterozygote is desired, but I don't think any of these apply to the Briard.

Again, let me congratulate you for putting together such a readable article.

Sincerely,

John L Fuller  
Senior Staff Scientist

JLF:jfr
The following genetics discussion is based primarily upon the extensive study of coat color by Drs. C.C. Little, J.P. Scott and J.L. Fuller at Jackson Laboratory. Their study was applied to the Briard with the generous help and guidance of Dr. John L. Fuller, Associate Director and Senior Staff Scientist of the Jackson Laboratory, Bar Harbor, Maine.

This study was made for the Briard Club of America with the hope it may, in some way, help to overcome some of the misunderstandings and controversies that always seem to plague the Briard in this country. The report uses the same gene names and symbols as those used for decades of research at the Jackson Laboratory.

The report briefly outlines the basic genes identified to date, that influence the coat color of dogs and compares these influences to the Briard as non-technically as possible. It does not pretend to cover all aspects of this vast subject and due to very limited data on the Briard, it is necessarily a generalized discussion of colors. New data could reveal unexpected influences and a detailed scientific study would be required to determine more definitely, the effects of these genes on the coat color of the Briard.

***

TEN BASIC GENES have been identified as influencing the coat color in dogs. These basic genes are believed to be transmitted to the offspring, independent of each other, each carried on a different chromosome. Therefore they are not considered "linked". (Genes that are linked are located on the same chromosome and tend to remain together as they are transmitted from one generation to the next.)

EACH OF THE TEN BASIC GENES HAS TWO OR MORE FORMS. Not all forms of each gene are present in every breed and this varies from breed to breed. Some forms of a basic gene have a more dominant (epistatic) influence and can mask or hide a recessive gene paired with it. This dominant/recessive relationship is not always perfect and the recessive form can modify the effect of the dominant in certain cases. A gene form that does not normally influence a breed can occur, upon rare occasion, by mutation (an unexpected change in the forms of the genes that are normally present). The various forms of a basic gene which occupy the same locus (location or site) on a chromosome are called alleles of one another. Allele means “another form of”.

EVERY DOG OWES ITS COAT COLOR TO ONE PAIR OF EACH OF THE TEN BASIC GENES. One member of each gene pair is inherited from the sire, the other member of that gene pair comes from the dam. If the two members of the pair are not alike (heterozygous), the more dominant form of that pair will have more influence on the coat color of that dog. If both members of the gene pair are alike (homozygous), the influence of that pair can be intensified. Either member of a dog’s gene pair can be transmitted to its offspring.

THERE ARE TWO BASIC PIGMENTS IN DOGS: DARK pigment expressed as black or brown; and LIGHT pigment which is expressed as red, yellow or tan. These two pigments vary from breed to breed and modifiers can also affect its expression. Various other genes control the amount, extent and distribution of these two pigments.
Some genes actually produce pigment, the other basic genes only influence its depth, intensity, extension or uniformity, but do not themselves produce that pigment.

The different forms of each basic gene will be listed in the (epistatic) order of dominance with the most dominant listed first.

1. The A BASIC GENE (also called the A locus or A Series of Alleles) determines the amount and location of the dog’s two basic pigments (DARK and LIGHT), in each individual hair and in the coat as a whole. The A gene series produce BOTH pigments.

\( A^s \) is the symbol for the gene form that produces DARK pigment throughout the coat.

( self-color, black)

\( a^s \) is the symbol for the gene form that restricts the formation of DARK pigment, leaving LIGHT. (sable, tawny)

\( a^l \) is the symbol for the tan-point pattern. This is the most recessive gene form and restricts the formation of the DARK pigment in the pattern areas, leaving them light or tan, hence the name "tan-point". Areas which may be involved are the feet, legs, chest, sides of the muzzle, eyebrows or sometimes the entire underside of the body and tail. The extent of the pattern area can vary considerably from dog to dog, with only a slight indication of pattern on the legs of one dog, to a more typical pattern on another dog, or a dog will have only a dark "saddle" or a dark dorsal streak remaining. The DARK pigment can appear black, brown or tan, depending on which modifying genes are present. If the pattern is present, the dog is of \( a^l a^l \) construction, regardless of the background color (black, gray or tawny) or the extent of the pattern.

The A SERIES OF GENES ARE THE BASIC COAT COLOR GENES of the Briard

The A series is the primary pigmentation factor of the Briard with all forms of this gene creating the colors. This produces the wide range of colors from black through the many shades of tawny, and the various degrees of the tan-point pattern seen in the breed. This A series has a wide degree of expression because of the interaction among the A series gene forms, as well as their modification by the other gene series.

Every dog has a pair of each type of gene. In a homozygous pairing (both members of a gene pair are alike) the effect of that gene can be intensified, while the heterozygous pairing (a dominant paired with a recessive) can have a modifying affect on the color produced. For example, the gene for black, paired with a recessive \( A^s a^l \), could explain the reddish cast sometimes seen in the blacks, whereas, paired with itself \( A^s A^s \), would produce a richer black. When \( a^l / \) tawny is paired with the recessive \( a^l / tan \) point, it can produce a coat which appears darker because of the presence of more DARK pigmented hair, tending to a pattern (overlay).

The A series of genes does not produce any spotting and is not believed to be linked to any deleterious affects or degeneration.

The dog with tan-points on black and the dog with tan-points on tawny have the same \( a^l a^l \) primary pigmentation gene pair. Independent modifiers allow or restrict the black pigment produced by this gene, giving the different base colors.

Like all recessives, the tan-point gene must be paired with itself to produce the pattern in the coat. The tan-point dog, whether the base color is black or on tawny, can therefore only transmit this tan-point gene to its offspring.
Note: a" is the symbol for "wild-color" which at one time was discussed as part of the A series. However, further studies have indicated that it is not part of the A series of genes, but is a separate genetic influence. The two basic pigments form alternate bands or rings of DARK and LIGHT pigment on an individual hair giving the appearance of gray. Banded hairs are often found in the coats of A series animals.

The possible parings of the A basic genes in the Briard are:

- \( A^Aa^A = \text{Black} \)
- \( A^Aa^a = \text{Black} \)
- \( A^a a^A = \text{Tawny} \)
- \( a^a a^a = \text{Tawny} \)

Genes that modify the pigment can change the appearance of these colors.

2. THE B BASIC GENE (B locus) is a simple pair that either produces or restricts only DARK/black pigment. It has no affect on the LIGHT/tawny pigment.

- \( B \) produces black pigment with black pigmentation of the nose, pads of the feet, nails, lips, rim of the eye, etc.
- \( b \) is the recessive to \( B \) and inhibits the amount of DARK pigment, giving liver or brown with brown noses, etc. Type: American Water Spaniel

The B basic gene in the Briard

- \( B \) is clearly the genetic influence in the color of the Briard, giving black in the coat and black pigmentation to the nose, pads and nails. \( b \) appears to be totally lacking. Briards do not have brown noses. The appearance of a brown nosed Briard would be indicative of a mutation. It would of course be rejected by the Standard and by the responsible breeder.

The only paring of the B basic genes in the Briard is: \( BB \)

3. THE C BASIC GENE (C locus) influences the DEPTH of pigment formed but does not in itself produce pigment.

- \( C \) allows the full depth of pigment to develop in the coat.
- \( c^{eh} \) reduces the LIGHT (red, yellow) pigment by allowing fewer and smaller pigment granules to be formed in each hair. This gene has little or no influence on the DARK (black) pigment and can only be seen in LIGHT pigmented areas of the coat.
- \( c^e \) is albinism (pink eye) and all pigment is absent. Albinism is extremely rare in dogs and is primarily of theoretical interest rather than of practical concern.
- \( c^e \) produces extreme dilution of color. It is not only very rare in dogs, but difficult to identify. It is the most recessive form of the C series. Type: West Highland White Terrier.

The C basic gene in the Briard

- Only the first two forms of this gene appear to be present in the Briard gene pool. The \( C \) for full depth of pigment is the highly desirable form, since it allows the deep, rich colors called for by the Standard. The \( C C \) (homozygous) gene pair is needed to produce the rich “fauve chaud” or red-gold tawny. Other genes need to be present for that tawny to be clear and uniform.

- \( c^{eh} \) which reduces the LIGHT pigment with little affect on black may be responsible for "light" or "faded" tawny. This is evidenced by the light tawny dog with scattered black hairs or the black tan-point dog with pale tawny points. This effect is also seen in the dog with a dark
overlay on pale tawny. When there is little or no dark pigment in the coat, the dog would be just light, washed out tawny. This lightening influence is not believed to be degenerative. However, it is not desired by the Standard.

The affects of $c^a$ or $c^e$ are unknown in Briards. They would be easily recognized since their influence is very pronounced.

The possible pairings of the C Series of genes in the Briard are: $CC =$ Full depth of pigment in the coat; $C c^e h =$ Possibly a lessened depth of tawny color; and the $c^e h c^e h =$ Pale Tawny with diminished depth of pigment.

4. **THE D BASIC GENE** (D locus) influences the DENSITY of the pigments produced by other genes.

- $D$ is dominant and allows the full density of pigment. (most dogs)
- $d$ produces dilution as seen in the "blue" Great Dane.

The D basic gene in the Briard

$D$ is undoubtedly present in the Briard. In recent years the $d$/dilution recessive has also been produced in the breed. In the search for the “gray” coat, it has become fashionable to produce the $dd$/gray-born-gray. This is difficult to do and still conform to the Standard’s requirement for dark eyes and a black nose. Unfortunately, the dark pigmentation of the nose and eyes is also diminished $dd$/dilution reduces black pigment to silver-blue and causes the tawny to be a pale, flat, silvery color. This dilution of the pigment is evident at birth with the characteristically dull, flat color in both blacks and tawnies.

The possible paring of the D/basic genes are:
- $DD =$ Full density of pigment in the coat;
- $Dd =$ dense pigment in the coat;
- $dd =$ Dilution of pigment of the coat, eyes, nose and nails.

5. **THE E BASIC GENE** (E locus) influences the EXTENSION of the DARK pigment present in the coat.

- $Em$ is the mask pattern, an extension of DARK pigment on the muzzle, ears and sometimes down onto the back. (Some studies propose that the mask pattern may not actually be part of the E Series.)
- $E$ allows the full extension of DARK/black pigment over the entire body surface.
- $e^br$ produces brindle. Dark hairs are scattered through the coat. Hairs are sometimes banded but this may be difficult to detect. In the presence of $a^y$/tawny or $a^l$/tan-point, it can cause bands or stripes of dark hair in the coat, as seen in the Mastiff. The effects are very complex and can be difficult to identify since they vary from breed to breed.
- $e$ prevents the formation of DARK pigment, leaving only LIGHT.

The E basic gene in the Briard

This gene series is difficult to analyze because of its complex variations and modifications. Yet, it is of primary interest in the Briard because of its influence on the A series pigments. All known forms of E appear to influence the coat color of the Briard.

- $Em$ produces the dark mask as seen on the tawnies and extends dark pigment in the black.
- $E$ Extension of pigment produces the black coat in the presence of $A^y$/black. $E$ in the presence of $a^l$/tan-point, gives the black coat with tan points. With $a^v$/tawny, little DARK pigment remains for $E$ to extend and the coat is tawny although it may mixed with varying amounts of dark hairs.
**e**/brindle is very difficult to identify in a long haired breed (as are many genes). It could produce scattered dark hairs as seen on many of the tawnies, although other genes can also cause this affect. Further study might show an influence that is more widespread than suspected. **e**/brindle produces a coat that appears to be black in some Scottish Terriers.

**e** prevents the formation of DARK pigment. In the presence of the **A**/black, the ee coat would not be black but would be a deep reddish-gold, tawny color. This type of tawny (which is genetically a “restricted black” dog) when bred to a normal **a**/tawny carrying the **E**/extension gene, could produce the black puppies which are occasionally reported from tawny to tawny matings.

**EXAMPLE:** 
Sire: Tawny **A**A**e**e <br> Dam: Tawny **a**a**E**E <br> would yield a reconstructed black -- **A**a**E**e <br> - **A** and **e** from the sire <br> - **a** and **E** from the dam

The **A**A**e**e type of tawny would not have a mask or any dark hairs scattered in the coat.

**e** in the presence of **a**/tan-point restricts the DARK pigment and the ground color of the dog would be tawny-- the tawny-tan-point. The difference between the pattern areas and the ground color can be very slight, making this tan-point difficult to identify.

**ee** in some combinations can produce a light tawny. In some breeds, **ee** in the presence of **e** has been shown to considerably reduce tawny pigment, and has caused coats that are very pale cream. Since there are indications that the Briard has both ee and **e**/present, this type of very pale coat is certainly possible.

The **E** series of genes has the following possible pairings in the Briard: **E**m**E**m and **E**m**E**=Masked if tawny; **E**m**e**/br=Masked brindle; **E**m**e**=Masked if tawny; **EE**=Extension of black pigment throughout the coat; **E**e**br**= Extension of black; **e**br**e**=Brindled tawny; **e**br=Brindle; **ee**=Restricts black pigment from forming, leaving tawny.

6. **THE G BASIC GENE** (G locus) influences the GRAYING of black coat color from birth to maturity or throughout life. 

**G** is a partial dominant and a puppy with this gene form is born black will clear more and more to gray as it grows older. Type: Kerry Blue and Bedlington Terriers and in Poodles. (This is NOT the gene series that produces the “Noire Ardoise”, a black with some white hairs throughout the coat.)

**g** The coat color remains constant, without graying.

The **G** basic gene in the Briard

There are Briards born black, which turn increasingly gray in color with age. This is probably produced by the **G**/graying gene. This is based on observation since no scientific studies (out crossing to other breeds) have been done.

The gray born black is considered a true gray, and is not a dilution as is produced by the dd/dilution or the M/merle genes.

The possible genetic pairings of the **G** series in Briards are: **GG**=Born Black and Graying; **Gg**=Born Black perhaps with some graying; **gg**=Born black and remains black.

7. **THE M BASIC GENE** (M locus) influences the UNIFORMITY of the pigment present.
M is dominant and produces merled coats. Irregular patches of dark pigment are distributed on lighter patches of that same pigment, often leaving areas of the coat without any pigment (white). The iris of the eye is often spotted, china or wall-eyed. This gene is deleterious and can be lethal. Type: Merled Collie, Old English Sheep Dog and Harlequin Great Danes.

m the recessive, allows uniform pigmentation, without merle.

The M basic gene in the Briard

Although the merled coat used to be present in the Briard, it no longer appears to be an influence. It was common in the early 1900s and as late as post World War II. It is carefully excluded by the Standard with the disqualification of spotted eyes, or coat. M/merle, being a dominant is seen in the coat of the dog that carries it and therefore isn’t difficult to eliminate. As a rule today, the occurrence of merle in the Briard would indicate a mutation or an outcross.

Briards are mm/ non-merled in genetic construction.

8. THE P BASIC GENE produces the rare "pink eye" dilution and is so rare in dogs it is not considered of practical concern.

P allows ordinary color (most dogs)
p is dilute and restricts DARK pigment giving very pale color. Black is lilac and the eye is ruby or pink.

The Briard is PP in genetic construction.

9. THE S BASIC GENE is the white SPOTTING series

S allows full pigmentation (solid colors) without white or spots. Minus modifiers can influence this gene form allowing scattered white hairs in the coat (the “Noire Ardoise” in Briards) or a white spot on the chest, in animals that are SS in construction.

s₁ produces Irish spotting. Type: Basenji. This allows areas of white on the toes, chest, neck, tail tip, face, etc.

sₚ is piebald spotting. As little as 15 to 20 percent of the coat is pigmented with the remainder white.

sₜ is extreme piebald spotting where the entire coat is white, sometimes with one or two patches of pigment remaining.

The S basic gene in the Briard

White or spotting is not permitted in the Briard and the breed is SS/non-spotted in construction. Minus modifiers explain the scattered white hairs allowed by the standard and the small white spot occasionally seen on the chest. All genetic influences can have many degrees of affect, like a rheostat on a light fixture, which changes the amount of light gradually. Selective breeding can strengthen the influence of a gene.

The recessive spotting genes are believed to be linked to degenerative characteristics such as blindness, deafness, etc.

The S series genetic pair in Briards is SS.
10. **THE T BASIC GENE** is responsible for ticking (flecks of color on white areas of the coat)

   \[ T \] allows ticks of color to be formed in white areas of the coat.

   \[ \text{† White areas are clear of ticking.} \]

The **T** basic gene in the Briard

Since white is not allowed in the Briard, this gene is not of concern to breeders.

The gene pair for Briards is **TT**.

----------

**Further Clarification:**

Each Briard is born with a pair of each of the ten basic genes. One member of the pair comes from the sire, the other member of the pair comes from the dam. The following chart lists the possible forms of each basic gene in the Briard. **Each dog has two from each series.**

<table>
<thead>
<tr>
<th>A*</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E*m</th>
<th>G</th>
<th>m</th>
<th>P</th>
<th>S</th>
<th>T</th>
</tr>
</thead>
<tbody>
<tr>
<td>a*</td>
<td>-</td>
<td>C^ch</td>
<td>d</td>
<td>E</td>
<td>g</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>A*</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>e^w</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>--</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>ee</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

The **A series** coat colors of the Briard and their modifications by the **C/depth** of pigment, **E/extension** of pigment, **G/Graying**, and now the **D/density** series are the ones of interest to Briard breeders. For the most part, degenerative or deleterious color genes do not appear to be present in the Briard.

A dog will transmit either member of each gene pair to each puppy. This tends to follow a genetic ratio which shows up more clearly when large numbers of puppies are included. One example:

A black sire = \[ A^* a^* \] bred to a black dam = \[ A^* a^* \] produces the following:

- \[ A^* \] (black) from the Sire / paired with/ \[ A^* \] (black) from the Dam
- \[ A^* \] (black) from the Sire / paired with/ \[ a^* \] (tawny) from the Dam
- \[ A^* \] (black) from the Dam / paired with/ \[ a^* \] (tawny) from the Sire
- \[ a^* \] (tawny) from the Sire / paired with/ \[ a^* \] (tawny) from the Dam

One - \[ A^* A^* \] (black); two- \[ A^* a^* \] (black); and one - \[ a^* a^* \] (tawny) = giving the genetic ratio of 75% black and 25% will be the more recessive tawny. This is the ratio when both dogs have the same heterozygote gene pair.
The genetic ratio changes when other genes are involved in the paring. For example:

A black sire = $A^b a^y$ bred to a tawny dam = $a^y a^y$ produces the following:

- $A^b$ (black) from the Sire paired with $a^y$ (tawny) from the Dam
- $A^b$ (black) from the Sire paired with the other $a^y$ (tawny) gene from the Dam
- $a^y$ (tawny) from the Sire paired with $a^y$ (tawny) from the Dam
- $a^y$ (tawny) from the Sire paired with the other $a^y$ (tawny) gene from the Dam

The genetic ratio for this type of breeding is 50% black and 50% tawny. There are ratios for every type of breeding, and the math can become more complicated when more than one gene pair is included.

An example of this is the black dog carrying the tan-point gene mated to an tawny carrying the tan-point gene. There are now three different forms of the $A$ series genes.

A black sire = $A^b a^t$ bred to a tawny dam = $a^t a^t$ produces the following:

- $A^b$ (black) from the Sire paired with $a^t$ (tawny) from the Dam
- $A^b$ (black) from the Sire paired with $a^t$ (tan point) from the Dam
- $a^t$ (tawny) from the Dam paired with $a^t$ (tan-point) from the Sire
- $a^t$ (tan-point) from the Sire paired with $a^t$ (tan-point) from the Dam

A caution: It is difficult to make an accurate analysis of coat color genetics by looking at a few dogs or litters. Scientific studies and accurate records for large numbers are required for responsible conclusions. For Briards these data don’t exist. And so we must depend upon the studies of other breeds and basically, we guess. A litter and even a dozen litters are simply too limited in numbers to provide the needed data.

Knowledge of genetics also varies and a limited knowledge can cause confusion. Emotion can cloud observations and discussions. The results of breeding can easily be misinterpreted and the conclusions are too often influenced by a desire to prove or disprove certain hypotheses. It is as important to develop objectivity, recognize limitations and enlist expert advice, as it is to become familiar with the genetic principals involved. Otherwise, the conclusions will be confused and useless.
In the tan-point, we deal with a primary color of the Briard gene pool. It isn’t deleterious and it doesn’t lead to merling or spotting as the French once believed. The pattern can also be obscure against a tawny background. Since $\text{A}/\text{tan point}$ is the most recessive form of the $\text{A}$ series, it together with the $\text{ee}$ restriction of black pigment would explain the abnormally low genetic ratio of black dogs with tan points in Briards.

Attempting to exclude one expression of a gene but encourage that same expression in other circumstances is genetically illogical. A disqualification is written to prevent or eliminate an undesirable trait, but the causative gene(s) will NOT be eliminated if bred in order to produce another trait. Some breeders destroy puppies with undesired colors or traits but no progress is made toward eliminating those colors or traits.

In closing I’d like to emphasize that the coat color of the Briard is mostly esthetic and is an ever-changing fashion. It has nothing to do with the dog’s construction or it’s ability to perform it’s intended work. A dog with a beautiful coat which lacks chest, strength, angulations, balance or correct temperament is not what the Briard is meant to be.

The time-honored rule for breeding is to “Always Respect the Standard”. If you respect the Standard, you respect the Breed. Certainly there can be variations of interpretation, but a fault is a fault and a disqualification is a disqualification, regardless of whether the judge in a show ring recognizes it or not. The responsibility to respect the Standard and to protect the quality of the Briard lies first and foremost with the breeder.

Respectfully submitted,

Diane McLeroth