The Genetics of Weimaraner Coat Color. . .Blue and Gray

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In studying the genetics of Weimaraner coat colors, we must always keep certain things uppermost in mind. The basic theory of genes and dominance is relatively readily understood; but unfortunately, very few things are controlled by one simple pair of genes. Also, simple dominance and recessiveness are not all that is involved, many other factors enter -- partial dominance, modification of the action of one pair of genes by another, multiple alleles, penetrance, expressivitiy, etc.

Genetics is also a science of probability. There are so many genes and so many combinations of these genes that the variations are astronomical.

All that is known for certain is that all is not known.

Let us remember this in the following discussion. While we do not know everything, we might as well take advantage of what we think we do know. We should use what we have until something better comes along.

Of the thousands of genes in a Weimaraner, the coat color -- not including length or texture, just color -- is believed to be controlled by *ten* pairs of genes. I strongly believe that there are more that haven't yet been identified. Even though there may be more, these ten do a fairly good job of explaining what we see in reality.

Actually, there are more than ten coat color genes, but only ten pairs of them appear in a single dog. One authority lists 24, and another 30 genes from which these ten are chosen.

> Visualize ten chairs and 24 or 30 people. Only ten can sit at once. Not only that, but each chair is reserved for a particular family of genes and only members of that family can sit in that chair. each chair must be occupied.
>
> For actual example, one chair might be reserved for the "S" family of genes. In this family, we know four genes:
>
> S--which gives solid coat, no white
>
> s^i--which gives some spotting, little white
>
> s_p--which gives piebald spotting, much white
>
> s
> sw--which gives extreme piebald
> s

Only one of the four can be present in any row of ten chairs.

Each dog actually has two rows of ten chairs--one from the dam and one from the sire. As a result, any two of the S or any other family can be present.

Let's look at these genes as they are believed to be in the Weimaraner coat.

DOG 1

Sire: Row 1 A^SbCdEgmPSt

Dam: Row 2 A^SbCdEgmPSt

This could be an actual case, but it would be unusual because the selection of ten from the dam and ten from the sire was identical. Suppose, instead, we had this case:

DOG 2:

Sire: Row 1 A^SbCdEgmPSt

Dam: Row 2 a^tbCdEgmPSt

where the dam contributed a^t instead of A^S, another gene of the same family. a^t happens to be the gene for black and tan markings--"dobe marks", and A^S is the gene for even color distribution. As A^S is dominant to a^t, then a^t has no effect and Dog 2 would *look* just like Dog 1. Actually, if A^S were not completely dominant to a^t, some markings might show-- this *could* explain "dobe marked" Weimaraners. Whether it does or not, I don't know and can't prove one way or the other.

Let's now look at the whole series of coat color "chairs again.*

Sire: A^SbCdEgmPSt

Dam: A^SbCdEgmPSt

Of these, some are not pertinent to the blue-gray question since *all* Weimaraners must have them whether they are blue or gray. These are:

- A^s distributes whatever dark pigment there may be from other genes over the whole body. Examples of alternate family are a^t, Doberman marks; a^y, Basenji marks.
- E similar to A^s except examples of alternates are e^{br}, brindle; E^m, fawn with black mask; e, fawn without black mask.
- g does not gray with age as opposed to G, the graying of Kerry Blues and Bedlingtons.
- m no dapple or merle opposed to M, merle or dapple.
- P delicate shading nuances -- studied in mink, not considered by some writers in dogs.
- S solid coat, no white, as opposed to spotting of several types. See before.
- t no ticking as opposed to T, ticking, as in Shorthairs and English Setters.

These genes describe a dog that is a solid color, without ticking, spotting, dappling, or black and tan markings that does not gray with age. So far it fits the Weimaraner.

This leaves us with fewer factors pertinent to the question, namely:

Sire bCd

Dam bCd

Let us look at the C series. There are thought (by Little) to be three (possibly four) genes that exist. Although there is not general agreement, these are thought to produce the different lighter or darker shades of gray we see in the gray Weimaraner -- the difference between what is described as silver gray, mouse gray, dark gray, etc.

This does not bear directly on the problem at hand.

The C series then added to the previously-excluded group defines the same dog--solid color without ticking, spotting, dappling, or black and tan that does not gray with age but also says that the shades of whatever color it may be can vary somewhat from darker to lighter. It still fits the Weimaraner.

This leaves the genes b, d, and their family members, B and D. b is recessive to B, and d is recessive to D.

- D causes a dog to be intensely pigmented.
  A Black Labrador is certainly D.
  An Irish Setter is certainly D.
- d causes pastel shades -- diluted colors.
  The Weimaraner is certainly d.
- B produces black pigment.
- b does not allow black, thus producing a color variously described as brown, chocolate, liver, and others, depending on the rest of the gene complex.

There can be four combinations of them:

- BD would be black
- bD would be brown-liver-chocolate-other
- Bd would be dilute black -- blue
- bd would be dilute brown-liver-chocolate-other; Weimaraner color, mouse or silver gray, driftwood color.

Since we don't have black or brown Weimaraners, let's discard BD, black, and Bd, brown, and see what would be expected in offspring from Bd, blue, and bd, gray parents.

Let's review for a moment. Each dog has two genes for each characteristic -- one inherited from each parent. Sire and dam have equal effect. Using the B-b family for an example:

> A dog having Bb could by chance pass to his pup either B *or* b at random. A dog having BB could pass either of the B's, but it wouldn't make any difference to the pup; either way he gets a B. A dog having bb could pass either b to a pup, but again, the pup can get only b.
>
> Suppose both a sire and dam were Bb. Then the sire could pass B or b and the dam B or b.
>
> If sire passed B and dam passed B, pup is BB
> If sire passed B and dam passed b, pup is Bb
> If sire passed b and dam passed B, pup is Bb
> If sire passed b and dam passed b, pup is bb
>
> If B is completely dominant to b, then the BB and Bb pups would *look* just alike even though they are actually different. The BB pup can never sire a bb pup regardless of the dam. The Bb pup could sire a bb pup with the proper dam.

From Sire Bd
From Dam Bd — *BLUE*, easier to write BBdd

From Sire Bd
From Dam bd — *BLUE*, easier to write Bbdd

From Sire bd
From Dam Bd — *GRAY*, easier to write BBdd

Okay, then suppose we mate--

1) Blue x Blue
BBdd x BBdd
We know all pups will be blue, BBdd.

2) Blue x Blue
BBdd x Bbdd
We know all pups will be BBdd or Bbdd, all blue.

3) Blue x Blue
Bbdd x Bbdd

* Capital letter indicates a dominant gene, lower case a recessive gene.

We could get B *or* b from either parent.
The pups could be, by chance:

BBdd, blue
Bbdd, blue
bbdd, gray

According to the laws of chance, we would expect in a large number of litters and average of one gray to three blue pups.

4) Blue x Gray
BBdd x bbdd
All pups would be Bbdd, blue.

5) Blue x Gray
Bbdd x bbdd
Pups could be:
Bbdd, blue
bbdd, gray
Chance again dictates an average over a large number of litters. This time, half blue, half gray.

6) Gray x Gray
bbdd x bbdd
Pups can only be bbdd, gray.

It is interesting to note that while various experts disagree on the exact action of some of the genes involved in coat color, they† are unanimous that the pastel gene, d, acting on the black, produces blue.

For example, Winge says, 'Black dogs with dd become "blue'." David and Snyder say, "The recessive gene responsible for the diluting has been designated d. The pigment granules become clumped in the hair cells and the color is thus diluted. Fur that would otherwise be black becomes blue . . .other colors are correspondingly paler." Hutt and Little speak in similar terms. Burns states that there are only three coat color genes about which there seems to be no debate, the B (black) and b (chocolate), the M and m merle family, and the gene for 'blue dilution'," d, and its other family member, D. She also states, "in a dog that lacks D, i.e., has the genetic formula dd, the pigment granules are clumped into very distinct agglomerations. . .the effect on black pigment gives the familiar 'blue' of Greyhounds and Great Danes . . .".

She also observes that we do not know what causes the different shades of blue, but guesses that it depends on the gene complex as a whole, as is often the case.

The real puzzle is what color an "unpastelled" gray Weimaraner (bD) would be. The literature is vague on just what color "brown-liver-chocolate-others" is.

Now we can answer some questions on the above information and see that the answers resemble what we see in the real world.

1. **Q. Can gray pups come from blue parents?**
A. Yes.

2) **Q. Can blue pups come from gray parents?**
A. No.

3) **Q. Can gray pups from blue parents throw blue?**
A. No, they have no B to give.

4) **Q. Could there be a blue parent who would throw only blue pups – no grays?**
A. Yes, a BBdd would have only B to throw, and all pups would be blue. Not that the pups might be BB or Bb depending on the other parent, and therefore, if Bb, the pups could throw gray.

5) **Q. What would you expect from a Weimaraner x Shorthair or Weimaraner x Labrador cross?**
A. Since Labrador and Shorthair are D, we would mask the recessive d and pups should be intense colors --such as black or liver.

6) **Q. If gray Weimaraners ar bb and blue ones have B, where did the B come from?**
A. Who knows? Perhaps from a mutation; perhaps from a cross in the original formation of the breed; perhaps from a cross later in the breed history.

One could speculatively suspect a cross to a black Doberman somewhere because of the apparent existence of B as well as the existence of so-called "dobe marks" where a gene called a^t would substitute for A^s. On the other hand, is it important where B came from or when? Of importance is the probable fact that it exists in Weimaraners.

7) **Q. What explains the existence of darker and lighter shades of gray or blue?**
A. Not known, possibly the C family or combination of the gene complex as a whole.

8) **Q. Isn't a recessive trait an undesirable one?**
A. No. The terms recessive and dominant have only to do with which gene masks the effect of the other and has nothing to do with whether we like or dislike the results.

9) **Q. Since the Weimaraner has been bred for gray for such a long time, wouldn't the gray become dominant instead of recessive?**
A. No.

10) **Q. If genetics is an "exact" science, why are there so many apparent contradictions?**
A. Many reasons, such as:

Genetics is very complex--a little understanding comes in a few moments; real understanding not only requires years of study, but also an understanding of the mathematics of probability.

Probability applies to large numbers of happenings quite exactly, but cannot predict in small numbers of happenings (like Weimaraner litters) with nearly the same degree of confidence.

Explanations based on insufficient understanding are often incomplete or wrong. Simplified articles (like this one) can't give all the whereas's, if's and but's without becoming book length.

Sufficient accurate data is hard to get because larger, slower-reproducing animals like dogs are difficult to experiment with because of the long time and expense involved. Also, breeder's records are notoriously inaccurate and incomplete and prone to "Kennel Blindness." In horses and cattle, where millions of dollars are at stake, much more is known.

11) **Q. One hears occasionally about a blue pup born to two gray parents. How would this be explained?**
A. All such occurences I have checked have turned out to be in error. However, it would not be surprising for this to happen at rare intervals. Hutt states "to some of us viewing with wonder the complex models of the DNA molecule and realizing the infinite number of times it is reproduced, the thing most marvelous is not that mutations occur, but that they do not happen more often."

Of those genes which can be studied individually, mutation rates are quoted varying from 1 in 2,000 to 1 in many millions. With about 6,000 Weimaraners being registered each year, an event of this nature every few years would be well within these boundaries.

This article has tried to deal with questions of fact. It has not rendered a judgement as to the desirability or propriety of blue *vs.* gray and will not do so. If it has to the extent of present day knowledge and belief, objectively defined the rules by which blue and gray reproduce, this can allow others to render subjective judgements as to the desirability of each.

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