The Colours of The Brittany

(The Genetic Transmission)

by Pierre Willems

I AM NOT A GENETICIST!.... but I am very curious, and as we, poor Frenchmen, dispose of very few popularizing literature about the subject, a few years ago, being unable to find someone who could help me with the mystery of colour inheritance, I undertook an investigation in the works of some writers in your language, and after a lot of reading and investigations, I wrote an article about the subject, that has been printed - in French, of course - in the Club de l'Epagneul Breton magazine in 1991.
Since then I went on investigating ... and, as I believe many of you have as little knowledge as I had, I hope that this article will help you understand how things work for our specific breed. Before starting to "teach", a few words more:
For those who do not know yet, the French standard admits five colours, with or without roan:

Orange and white (OW)
Black and white (BW)
Liver and white (LW)
Tricolour black (Black + white + orange: BT)
Tricolour liver (Liver + white + orange: LT)

It is impossible to try and explain genetic transmission without some preliminaries. Even avoiding the technical or trying not to take myself for a scientist, a minimum of knowledge is indispensable:
Any dog of any breed, even mongrels, possess the entire panel of the genes existing in the species. Whether it is physically visible or not in a specific dog is another question, but the fact that a gene is not physically visible does not mean that it is not present!

Most of the visible characteristics of a dog (the "phenotype") are under the influence of genes, present in the chromosomes, and so inherited from the parents. Some are not as they depend much of the way the dog is raised: weight, coat thickness, occasionally also height, musculature, etc. ....
Genes are always present in pairs, one of the elements of the pair coming from the father, the other one from the mother, due to the division of the cell at the time the embryo is created. To give a rough example: If the father's genes are imaged by "PP", and the mother's genes by "MM", the offspring will carry "PM" genes.

Those genes may exist as several varieties (the alleles) for a same gene, whose influence varies accordingly in its effect as well as strength. We distinguish DOMINANT genes, and RECESSIVE ones. (This notion of genetic dominance must not be confused with the "dominance" of a temperament. "Dominance" is a word for the genetician, white "domination" involves social characteristics). By convention, a dominant gene is designated by a capital letter, white a recessive gene is designated by a small letter.

The existence of a dominant gene is ALWAYS evident, visible; people say that the gene is expressed. Even if the pair of genes consist for one half by a recessive, and for the other half by a dominant, it is only the latter that will be in evidence, and not some intermediate between the two genes! On the contrary, for a recessive gene to be expressed, this one will have to be present in double ("homozygous"). In short:

Dominant + dominant = evidence of the dominant;
Dominant + recessive = evidence of the dominant;
Recessive + recessive = evidence of the recessive.

1. THE "B" GENE (the Black series)

This is the gene that gives the black colour, and also the liver one! Both colours are due to the same pigment (eumelanin) and the size of its particles determines whether it is seen as black or liver. The gene for black is designated by "B" (=dominant), while the one for liver is designated by "b" (=recessive).
If we have parents ... father=BB (=black) ... mother = bb (=liver), all their offspring will be uniformly "Bb".

As we explained above, the dominant gene masks the expression of the recessive, so this first generation offspring will be uniformly black, all the puppies carrying a "Bb" gene sequence.
If we mated the first generation pups to each other, the offspring in this second generation would each show one of these combinations:

Bb + Bb = BB which is black (homozygous)
Bb + Bb = Bb which is black too (heterozygous)
Bb + Bb = equivalent to the above line
Bb + Bb = bb which is liver (homozygous)

BB and Bb are "phenotypes" (physically black but there is no guarantee of the genetic combination), while "bb" is a "genotype" (liver is ALWAYS and ONLY of "bb" type).

Also it should be noted that, statistically, a mating as above (Bb+Bb) will produce 75% black coated offspring, and 25% liver. However, on a small amount of offspring, it may not be true, of course! (For another characteristic - tricolour - when I bred together a dog and a bitch both carrying the tri gene, I had to wait until their third liter to obtain tri-colours!)
Hard to understand? Sorry, but if you did not follow, please read again, otherwise the next steps will be unintelligible.

2. THE "A" GENE (the Agouti series)

There are several forms of this gene, several "alleles", but we are fortunate in that our breed only involves two of them: "As" and "at". (Although one expert thinks there is a possibility for a third allele for "A" in the brittany. Despite my investigations, I could not find any evidence of this theory, while my conclusions appeared to be correct, after a check on about 500 brittanys!)

"As" which is dominant, gives solid colours, while "at", which is recessive, involves the "tan point" that gives the ticking at the end of the legs, around the anus, on the eyebrows, and on the cheeks. In short, it qualifies our tricolour dogs, while the "As" gene concerns the non-tri's.
As seen before, the combination of the two genes give:

As + As = ASAS = plain colour (homozygous)
As + at = Asat = plain colour (heterozygous)
at + at = atat = tricolour (homozygous)

Depending what the "B" gene allows, we will obtain:
BB/AsAs = black
Bb/AsAs = black
bb/AsAs = liver
BB/Asat = black
bb/Asat = liver
BB/atat = black tricolour
Bb/atat = black tricolour
bb/atat = liver tricolour

3. THE "E" GENE (the Extension series)

It is the gene that permits orange (the true name being "fawn"). Or, more exactly, the "E"

(dominant) allows the other genes in the "B" series to express themselves.
The heterozygous recessive form "ee" FORBIDS the evidence of the black (B-) or the liver (bb) ...The "ee" form is called "epistatic" to "B".

So, an orange and white brittany is ALWAYS a carrier of "ee", regardless of what he may hide on the "B" or "A" gene!! ... and so, it is obvious that a mating involving two OW dogs will only produce OW offspring. On the reverse "other colours" will give a variety of colour, as very often, they carry a heterozygous "E" gene.

If your "other colours" both present an "Ee" structure, they will give you "ee" (=OW) offspring as well as "EE" or "Ee" (=BW or LW or Tris)... and, similarly, if mating an OW to any "other colour", provided the later is not homozygous for "EE", as this would allow BW and LW but FORBID OW!

THE COATS OF THE BRITTANYS

We know enough now to put our dogs' coats in codes, thus allowing us to extrapolate what colour possibilities any mating will offer:

The minimum formulae are as follows: ("-" is conventionally used to denote that the gene is undetermined)

	"B" gene	"A" gene	"E" gene
Orange and white	-	-	ee
Black and white	B-	As-	E-
Liver and white	bb	As-	E-
Black tricolour	B-	atat	E-
Liver tricolour	bb	atat	E-

And it gives the following panel:

FATHER:		OW	BW	LW	BT	LT
M	OW	OW	ANY COLOR	ANY COLOR	ANY COLOR	ANY COLOR
O	BW	ANY COLOR	ANY COLOR	ANY COLOR	ANY COLOR	ANY COLOR
T	LW	ANY COLOR	ANY COLOR	O/W, L/W, LT	ANY COLOR	O/W, L/W, LT
H	BT	ANY COLOR	ANY COLOR	ANY COLOR	O/W, BT, LT	O/W, BT, LT
E	LT	ANY COLOR	ANY COLOR	O/W, L/W, LT	O/W, BT, LT	O/W, LT
R						

4. WHITE, THE "S" GENE (the Spotting series)

The white in the coat is not easy to understand, as our eye, and subsequently our brain, has the reflex to "read" a combination of a colour and white as COLOUR ON WHITE, may be due to the fact that we are used to writing with dark ink on white paper!?

Well, our dogs are not "white + something", but "something + white".

Do not forget that the original colour of the "wild" dog was fawn, and it is only due to mutations along the centuries that black appeared, and then white .

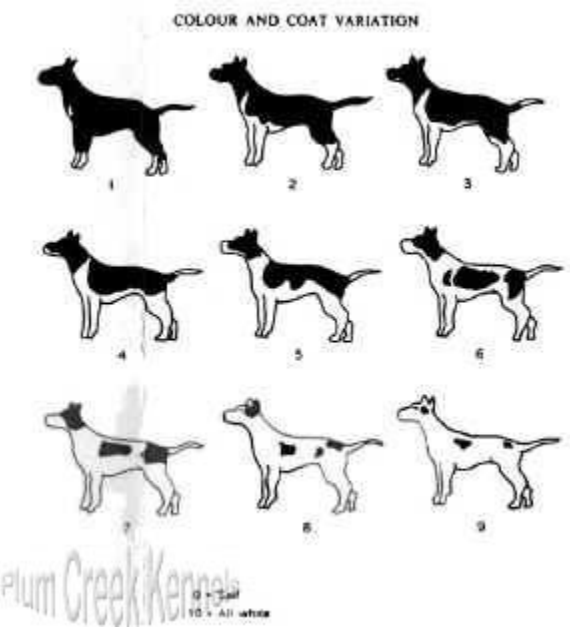
Consequently, the existence or the absence of white IS NOT BOUNDED TO THE SURFACE OF

THE COLOUR! Contrary to what happens in painting, white is not an element of a palette that can be mixed according to wish, and so accentuating or reducing the pigmentation. That part of white appearing on the coat of brittanys is dependent on a gene known as "S" (for spotting) - or "s" for the recessive alleles.
These genes can be present under four declensions:

"S+" giving a coat almost entirely colored, nearly without any white (e.g. Labrador, Gordon setter).
"si" the "Irish" spotting (because of the origin of the rats who were used for the study, and not because of the Irish setter!).
"sp" (p = piebald) giving a coat with irregular spotting or ticking (e.g. cocker, English setter).
"sw" (w = white) concerns coats almost completely white, with "invading" white spotting (e.g. Westie, Pyrenean Mountain, Dogo Argentina).

Roy Robinson, a geneticist of great reputation, classifies the different types of spotting in ten grades as below:

"S+" (not shown) corresponds to "0 white" with 100% coloured,
"1" to "3" corresponds to "si"
"3" to "9" corresponding to "sp"
"9" and "10" being "sw".



Remember that, in what is written above, white areas are considered in opposition to coloured areas, disregarding any ticking, flecking, or roan, which are under the influence of another gene that we will explain later on.

As you will notice, the coats showing white all depend on recessive genes...which means that, to be expressed, the are supposed to exist in an homozygous form!...and so, if you want to breed dogs with a lot of white, you will have to "extract" the combination "spsp" from the parent's genes.

But here we have two problems to face. As the standard of the brittany allows it since it exists, all this gene capital has been mixed up along the generations, and, as the domination between the recessive gene - though being in the order listed (i.e.: S+ - si - sp - sw) - is very incomplete, there is no "mathematical" way to obtain a given result.

But one thing is sure: the genes "S+" and "sw" do not exist in our breed. Being dominant, the presence of S+ would be evident in the first generation, while "swsw" implicates white spots on the ears, eyes in a white area, such characteristics which are FORBIDDEN by the standard, and so they do not allow brittanys in France to be confirmed. (In France, confirmation by a breed expert is compulsory to obtain the registration of a pedigree), and so this gene should be expelled from our breed since the very beginning

of its existence!

White on ears or eyes, or a coat with no white would indeed imply a crossing with another breed. And so, it also means that, however dark your brittany's coat may be, it will always show at the same time Colour+white without risk of deviating to "all colour" or "all white".

Of course, a good knowledge of the appearance of your dog's parents will help you in reaching your goals! The important thing to understand is that, once again we are not in possession of a palette that allows us to spread the colour as the painter does!

5. THE "T" GENE (the Ticking series)

Well, we approach the end of my attempt to explain our dogs' coats. Thank you if you followed me so far! Do not worry, this one will be short!

Firstly, it could be useful to remind you that ticking/flecking/and so on concerns the small spots of uniform colour that appear in the white
parts of the coat, disregarding the true spots, of much larger size, while roan applies only to an intimate mix of coloured hair and white hair.

The coats with ticking are under the influence of the "T" gene which is dominant. Conversely, the coats with no ticking are determined by the recessive allele "t", so the "tt" type has uniform white between/around the colour spots.

It should be noted that it appears that this dominance of "T:on"tt" is not total, and also it seems that "tt" is involved in majority of dogs of "spsp" type, rather than "sisi" ones.

....and roan??? Well, as far as I know, experts are still guessing about the existence of a "R" gene, or if roan is just an extreme expression of "T".. and I will not tell you more than they do!

What must be remembered is that ticking is independent from the extension of the coloured area, and, here too, it is not a painter's brush spreading the ticking so much that is becomes a spot!!

You are still here? What patience!! Thank you for having been so attentive to my words!

I hope your knowledge, or better, your understanding about the colours in our breed has been improved... But never forget that a brittany is not just a lovely coat, as it is a working dog, with a very balanced temper, and this is much more important to the welfare of the breed than any "clothing" consideration!

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References: Robinson's "Genetics for dog breeders 1982"
Willis' "Genetics of the dog 1989"
Whitney's "How to breed dogs 1971"
Pr. Denis' "Les couleurs de robe chez le chien 1982"

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