



FRENCH BULLDOG COAT COLOUR GENETICS - FEB 2008

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This is a very interesting field that is undergoing some changes as the actual genes that affect colour are beginning to be located on the chromosomes.

DNA specific tests can now be carried out for the presence of most of the colour alleles, particularly where one wants to know if there are unwanted dilution factors hiding within individuals. While it can look very complicated, try to understand the subject and thus produce the colours you want from matings, and not waste litters with incorrect colours. Knowledge of your proposed breeding pairs' colour genetics can help maximise desired colour combinations.

General information

Melanocytes are the cells that produce skin and hair colour and they are derived from neural crest cells. These cells arise along the back very early in foetal development and then give rise to a number of cell types, including a large proportion of the peripheral nervous system. If there is a decrease in the number of neural crest cells, other cell types are favored, leading to a reduction in melanocyte formation (see below). The melanoblasts (immature colour cells) migrate from the dorsal midline over the surface of the body, so the last areas to be reached are the feet, chest and muzzle (ie where you are more likely to see white toes, etc).

Neural crest cells also form part of the nervous system for the inner ear and eye. Animals selected for extreme white spotting (eg. Dalmatians) can have hearing and/or vision problems in other extreme white patterns (merle series). Dalmatian deafness is

thought to be as a result of the absence of melanocytes in the stria vascularis of the inner ear.

Melanocytes produce melanin by the action of alpha MSH. Large amounts of MSH results in Eumelanin (mainly Tyrosine) which produces black or derivatives of black (blue, chocolate, brown, liver). Restricted amounts of MSH result in Pheomelanin (contains varying amounts of cystine and tyrosine) which produces reddish brown or yellowish tan.

#Control of melanocyte function is intricate and many loci(genes) have mutations which affect components of melanogenic control mechanisms.

Colour Genes

There are about 10 recognised "**loci**" of different colour genes. Each locus can have a variable number of **alleles** that can influence the colour outcome (dilution, pattern, dominant or recessive effects).

All dogs carry these genes, many of which are in a fixed (homozygous) form eg. Gordon Setters, Elkhounds etc. In these breeds virtually all loci are fixed and there is very little colour variation across the breed. In other breeds some loci are fixed, while others have a degree of variation (number of alleles) present at other loci. **Not all breeds carry all the possible alleles at each locus.**

Current research - Many of the colour loci are being extensively studied to precisely locate the position of the various genes on the correct chromosome, and further, which alleles actually occur at that site and how they affect the colour outcomes available. From this, DNA markers may be developed, and thus allow DNA colour testing in various breeds prior to mating. The DNA research that is being done at this time is going to continue to change our understanding of colour genetics - its a fairly dynamic field - it is certainly not fixed in concrete.

Gene / allele designation - The way I write the alleles is to put the loci first as a capital. If only 2 alleles occur (dominant and recessive) then eg. D means the dominant allele, d the recessive allele. Where there are more than 2 alleles for a loci, I find it easier to keep the capital as the indicator for the loci, followed by a smaller letter indicating the allele. (If one has a fancy typewriter/computer, one could do the allele in smaller letters above the series loci letter.) If there are several alleles at a loci, these are usually written in decreasing order of dominance (according to current knowledge).

The French Bulldog is supposed to be homozygous for B, C, D, g, m and usually t.

A series (Agouti) Pattern locus affects colour of individual hairs, banding.

Supposedly only AyAy – dominant red/yellow (fawn) – which restricts dark pigment distribution. AyAy is associated with fawns, with or without masks.

Aw and At – sable and black and tan – not supposed to be in the general Frenchie population, nor is 'a' solid black. However, Aw may be present in the breed giving a black tipping to fawn hairs creating a "sable" effect in some fawns and fawn peds.



Fawn (with mask)



Fawn (without mask)



Fawn (red)



Fawn (sable)

B series permits black (pigment locus) - affects all dark pigmented areas – nose, eyes, skin, hair.

B – permits black to be formed – black noses, lips, eye rims.

B fully dominant to b. BB – no liver.

Frenchies are supposed to be BB (ie. no liver).



Liver (also referred to as Chocolate)



Chocolate Pied

C or Albino series (pigment locus) – affects hair

C allows melanin to be formed. – affects the depth of pigment formed (intensity) – rich red.

Cch – chinchilla – has more effect on tan – colour paling – pale yellow coats.

Cd – white coat, black noses and dark eyes

It is possible to have C.ch C.ch creating white if other ee present or ay, and would still have a black nose.

It is highly probable that the Cch and Cd are present in the Frenchie which probably accounts for the diluted fawns (creams) seen so often in the USA. Otherwise should be CC.



Cream

D – dilution series(pigment locus) – affects skin, eyes, nose, hair.

D – intense pigment – if present, the colour will be determined by other loci present.

D allows black pigment to form

d – dilution of pigment.

If dd, the colour will be diluted depending on the other modifying factors > blue

Frenchies are not supposed to carry dilute (dd ie. blue) in the standard and should all be DD. Black eye rims and noses are called for in the standard and therefore dilutes such as blues and livers cannot be exhibited. However, this dilute is present in the breed in England and the USA, rarely seen in Australia.



Blue



Blue Brindle



Blue Pied

E series – extension series (pattern locus) – relates to dark pigment rather than tan, affects only the hair, subject to incomplete dominance, plus and minus factors. Restricts location of dark pigment (MC1R)

Em allele (Masking) = super extension with dark mask

This allows agouti to bind some of the time and cause fawn pigment to be made on the body and the melanocyte stimulating hormone to bind on the face instead. Because of this, any fawn dog with a mask cannot be ee at MC1R because an Em is required for the melanistic mask (black, brown, blue). Colour patterns of s series (pied) can make it impossible to see the mask.

E – extension without dark mask (does not permit dark mask) – allows for self coloured dogs, depending on the action of alleles at A locus.

– permits black pigment to be formed in the coat as well as black noses and dark eyes.

e – restriction gene – ee = dysfunctional MC1R and are unable to make black hairs anywhere on the body **ee = fawn** – does not permit black to be formed in the coat – the dog may still carry black at the B loci, but cannot carry black in the coat when present as ee. Eg.fawn/tan/red.)

Em dominant to E and e; Kbr (brindle) recessive to ee.

Em – masking - variable in Frenchies.

E series affected by the S (recessive white genes)

Effect of e series on c.ch – possible that ee and c.ch could cause such dilution of colour as to give white or yellowish white dogs.

Frenchies can carry Em, E, ee.

Em – as EmEm, Em E, Em e together with ayay and kk – fawns with black masks.

E – as EE – without masks – can be fawn if kk, brindle if Kbrk.

If ee – if carrying Kbr k, can hide brindle



Fawn (with black mask)



Fawn (without mask)

K series – new. – (pigment locus) dominant black – different loci to agouti.

Brindle – suggestion that Br is possibly in the K (black) series. This series then becomes:-

K black (dominant) – solid dark dogs

Kbr recessive (partial extension)

k = non dark, non brindle

The brindle gene is located on a different chromosome to the MC1R (E locus). Br is dominant, so long as the other genes which interact are of the correct genotype. Br seems to require particular alleles at more than 1 locus. There is a suggestion that Br initiates suppression of agouti. If Br is not an extension allele, then it appears not to need the MC1R protein.

Brindle must have either Em (mask) or E in order to make black hairs on the body . It means ee dogs can carry brindle, but it cannot be expressed.

If Em and K Br – brindle expressed

If ee plus KBr – no mask, brindle hidden, fawn dog – ie can hide brindle.

If fawn with shading from top to bottom, most likely EE Ay Ay – as E allows expression of brindle, no hidden carriers.



Dark Brindle



Brindle



Tiger Brindle



Reverse Brindle (with mask)

Frenchies appear to only have Kbr and k – no dominant black (K)

Brindles therefore have 1 or 2 copies of Kbr,

Fawns carrying brindle are eeKbrk (no mask)

S series – spotting – (recessive white locus)

Likely there are 2 or more loci involved with incomplete dominance between alleles.

S – self colour or totally pigmented surface

= full colour with no more than 10% white (toes, chest).

The recessive Alleles – restrict full pigment of the dog in an orderly fashion.

ie. in order to be pied, need 2 s genes present – therefore, there are hidden carriers of pied genes.

si - irish spotting involving a few definite areas of white – feet, lower legs, tail tip, white undersides, white blaze, and usually white collar. Usually in a symmetrical pattern. Hooded pattern to head quite often. = 10-30% white, recessive to S range and overlaps S and sp allele.



Brindle & White – irish spotting



Fawn & White – irish spotting

sp – piebald spotting – random spots of colour on a white background – can be few or very many.

= 20-80% white, wide range of colour percentage and location of pigmented areas. Individuals with full collar, blaze, white legs, belly and tail tip to individuals who have only head and tail root colour.

Reported to be less symmetrical than si, can be wide range of phenotypes.

S when combined with sp can create dogs who look like si (pseudo irish).



Brindle Pied – piebald spotting



Fawn Pied – piebald spotting

sw – extreme white piebald.

= <10% pigment. If pigment present, confined to the parts of the head, tail root. Typically no body patches (except perhaps at tail root) and a cap of colour on the head around the ears and/or eyes.. Incomplete dominant allele when combined with S or si to produce dogs who appears as spsp individuals in phenotype (pseudo irish or pseudo boston dogs) as in the Boxer.



Extreme White Brindle Pied



Extreme White Fawn Pied

In Frenchies - S Series – all 4 alleles are present, a few tickings are common in most peds.

Pieds - Brindle and Fawn peds:-

Markings most likely Si – extensive mantle, ?solid/nearly solid on head,(?mantle pattern present in Frenchies)

Sp – piebald – multiple patches of colour, hooded effect on head

Sw – extreme white piebald – only one or 2 patches of colour.

All peds **should** carry black pigment on eyes, nose and mouth, but with swsw may lack mouth, eye, nose pigmentation.

Extreme white fawn (ee) peds may be affected by Cch. and can lack pigment round eyes, nose, mouth.



Extreme pied lacking pigment

As the pied genes are recessive to S (solid colour) – need a combination of either:- Ssp; Ssw; sisi; spsi; spsp, swsw – these would be affected by Kbr, k and Em, E and ee.

Note - Brindles - if carrying e or pied - often have paler nails
Brindles and fawns - if carrying pied – often small splashes of lack of pigment on vulva, genitals, belly when born.

Bostons probable ayay BB CC DD EE gg KbrKbr mm SiSi tt

British Eme fawn black mask EeKbrk brindle no mask , ay,at CC most fully pigment but c.ch may be present to account for paler tans.

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References – from all over the net but mostly from:-

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