

Coat Colour Inheritance for the Belgian Shepherd Dog

Summary

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This is a work in progress. Genetics is a rapidly evolving field, and updates will be made.

Genes are all tied into a long strand of DNA. Each point on this strand of DNA is called a locus (plural = loci). Each locus is occupied by two doses of each gene, one inherited from each parent. The variant forms of the gene are called **alleles**. Alleles are identified by letter names; the letter name may include a superscript, as in A^y. The several alleles present at a given locus are called a series.

If both alleles on the same locus are identical, the trait will be homozygote (homo = same, zygote = egg). If both alleles on the same locus are different, the trait will be heterozygote (hetero = other). Which of the alleles is expressed, depend on dominance. The most dominant allele will always be the one that is expressed. A recessive allele is one that is less dominant. In most cases, a heterozygous dog will express whichever of its alleles is the most dominant. While the conception of dominance involves an interaction between alleles located on the same locus, epistasis (i.e. action of one gene on top of another) involves an interaction between alleles of different loci.

There are two types of pigment:

- **Eumelanin** that determines the coat, nose, lips and eyes with **black** colour or **brown/liver/chocolate** colour;
- **Phaeomelanin** that determines only the coat with **yellow/red** colour that covers everything from deep red (like Irish Setters) to light cream.

It is only in very recent years that research in molecular genetics has begun to identify the genes responsible for colour. Until now, using DNA, alleles are known to exist at 8 genes or loci (see website: <http://homepage.usask.ca/~schmutz/dogcolors.html>). To make things easier, we don't take into account the loci without influence on the colour of our Belgian Shepherd. So, for all Belgian Shepherds producing only black eumelanin and not brown/liver/chocolate eumelanin, we don't detail the B locus. All the alleles at each locus are listed in order of dominance of alleles. The alleles known to exist, using DNA, are preceded with a full black dot.

A. The three loci that determine the coat colour

a) **A locus** (Agouti) determines the **distribution** of eumelanin and phaeomelanin. This is a pattern locus that allows for the increasing distribution of eumelanin pigment over yellow/red (phaeomelanin) in a recessive manner. The agouti series is composed of the following alleles:

- **A^y: Fawn** - restricts eumelanin pigment distribution; that determines a pattern of fawn coats with black overlay (fawn hairs with darker tips with some solid black hairs intermingled amongst fawn hairs). *This is the dominant allele for the short hair Malinois, the long hair Tervueren and the rough hair Laekenois.*

In July 2009, the FCI approved a standard nomenclature for coat colour. The words "fawn" and "sable" (for diluted fawn colour) are mentioned. The translation into French of "fawn with black overlay" and "sable with black overlay" are "fauve charbonné" and "sable charbonné". "Sable", in French, means "sand" and is used to indicate the shade of colours that come from phaeomelanin dilution (see locus I).

- **a^w: Wild** - agouti "wild-type" allele: gives wolf-grey colouration. The colour is characterized by a pattern of banded hairs, typically black at the tip, with a light central band, and a dark base. This allele is not associated with the Belgian Shepherd.

- **a^t: Tan points** - dark body with red, tan, or beige on muzzle, chest, eyebrows and legs. It is only dominant over recessive black (below), so a dog needs to be homozygous for tan points in order to express them (or heterozygous for recessive black and tan points and the recessive black). This pattern is not associated with the Belgian Shepherd.
- **a: Recessive black** - uniform (or solid) black coat with no phaeomelanin in the coat at all, except for white markings. Is present in some herding breeds. *Present in some Groenendael (long hair) and the Black Short Hair. Many Schipperkes are recessive black. This allele belongs to the historical genetic heritage of the Belgian Shepherd dog.*

b) K locus (Black) determines eumelanin. The series for this locus is composed of three alleles:

- **K^B: Dominant Black** – uniform (or solid) black coat, except for white markings. K^B is epistatic over the A locus. In other words, any genes on the A locus will not be visible. *Most of the Groenendael have this allele.*
- **k^{br}: Brindle** - black stripes on a phaeomelanin background. k^{br} is dominant over k, so a dog only needs one k^{br} in order to be brindle. Black stripes are epistatic over the allele A^y. Has become fairly rare in the Belgian Shepherd Dogs, although it sometimes still appears.
- **k^y**: a k^yk^y dog will express whichever alleles are on its A locus.

c) E locus (Extension) determines **extension** of eumelanin. The extension series is composed of three alleles that are epistatic over A and K loci:

- **E^m: Black mask** – the mask can vary greatly, covering anything from just the end of the muzzle to the whole of the muzzle, eyebrows and ears. Black mask may also cause black hairs on the chest and/or back and tail. A black mask is not visible on a black dog. This is why Tervueren from Groenendael without mask (a priori, impossible to know) inherit a light face or lack of mask. *Tervueren from Groenendael parents often do not carry the full masking. For the Malinois and the Tervueren, the mask has become obligatory (Standard of 1978). A dog needs only one E^m allele to have a mask.*
- **E: Neutral** – no restriction of pigment. Usually written with a capital letter, is recessive to E^m.
- **e: Recessive phaeomelanin** – uniform red coat, except for white markings. An ee dog is unable to produce any eumelanin (black) in its coat. However, the colour of the eyes, nose and lips are unaffected. Allele not associated with Belgian Shepherd dogs.

B. The two loci that could affect the colour intensity

a) D locus (Dilution) affects the intensity of pigmentation. For this locus, there are two alleles:

- **D: Normal pigment.** No dilution. *All the varieties of the Belgian Shepherds are DD.*
- **d: Diluted pigment.** When homozygous (dd), it dilutes the black colour of eumelanin to blue/slate/grey. The dilution will override all alleles for black (dominant or recessive) and change all eumelanin pigments on the dog. It affects skin/hair colour simultaneously (nose is slate). (on website: www.belgiandogs.info - article about the “The Blue invade our Malinois”)

b) I locus (Intense) - (locus or gene not yet identified) It only affects the intensity of the phaeomelanin pigment. For this locus, there are two alleles:

- **I = intense red**, not diluted.
- **i = co-dominant**, so i/i dogs are paler than I/i dogs. *This is the case for the Tervueren sable (incorrectly called “grey” – black overlay on a pale base coat gives the illusion of “grey”).*

C. White markings

Any of the above colours and patterns can be accompanied by white markings that are present from birth. White is not a colour in itself, but an absence of pigment. It is a lack of both eumelanin **and** phaeomelanine. The presence of white markings is very frequent amongst all the Belgian Shepherd varieties, and it sometimes shows some hairs on the chest and on the toes. Many breeds tolerate a white marking on the chest or on the toes.

Because melanocytes migrate from the spinal column downwards during fetal development, any delay of the may result in small white areas on the chest, toes or underbelly. Such delays could be due to nutrition, position in the womb, etc. These small patches of white are not considered to be an inherited spotting trait, though the rate of melanocyte migration may be.

D. Genotype and phenotype

A dog's colour **genotype** describes the genes that contribute to its colour. A dog's colour **phenotype** is what we see.

Varieties	Coat colour			Colour intensity		Phenotype (1)
	Locus A	Locus K	Locus E	Locus D	Locus I	
Groenendael dominant black	A ^y A ^y or other alleles	K ^B K ^B or K ^B k ^y	E ^m E ^m or E ^m E or EE	DD	II or Ii or ii	Total or uniform black
Groenendael recessive black	aa	k ^y k ^y	E ^m E ^m or E ^m E or EE	DD	not applicable	Total or uniform black
Malinois or Tervueren	A ^y A ^y or A ^y + one other allele	k ^y k ^y	E ^m E ^m or E ^m E	DD	II or Ii	Fawn mask with black overlay
Tervueren sable	A ^y A ^y or A ^y + one other allele	k ^y k ^y	E ^m E ^m or E ^m E	DD	ii	Sable mask with black overlay
Laekenois	A ^y A ^y or A ^y + one other allele	k ^y k ^y	E ^m E ^m or E ^m E or EE	DD	II or Ii	Fawn with traces of black hairs

(1) for all varieties, a small amount of white is tolerated on forechest and toes

The “Black Short Hair” variety (incorrectly called “Black Malinois”) is a rare variety that still exists but since 1974, is no longer recognized by the *Société Royale Saint-Hubert* and the *FCI*. It has exactly the same coat colour genotype as the dominant and recessive long hair Groenendael. The “Short Hair Sable” (very rare and not longer recognized) has the same coat colour genotype as the long hair Tervueren sable.

This is a summary of a more extensive article about the Varieties (history, coat colour and texture inheritance, inter-variety matings).

