Coat and Colors of the Belgian Shepherd

by
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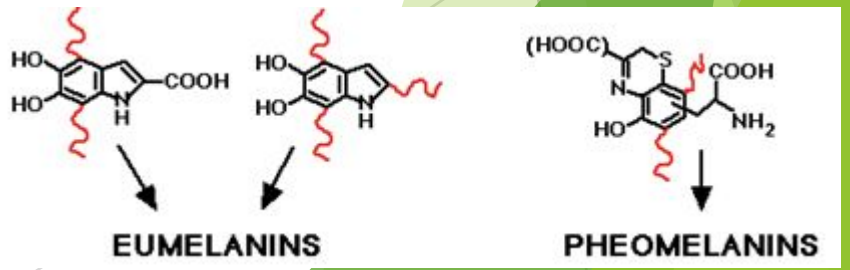
Pictures courtesy of Brigitte Broeckx, Dave Vesely, Kadi Thingvall, Kate Hogan & Saskia Vermeylen

Origins of Color

- There are 2 types of pigment that result in all the different colors found in dogs
  - Eumelanine: Black Pigment
  - Phaeomelanin: Red Pigment
- There are different genes that influence the expression of Eumelanine and Phaeomelanin which in turn results in the different coat colors we see
- In this presentation we will only limit ourselves to the genes that can be found in the Belgian Shepherd.
- The biggest challenge with colors is that every breed has their own way of describing the colors in their breed.



Some basics of genetics

- Each gene receives its own letter
- Each dog receives for each gene one copy from its mother and one copy from its father
- If both copies for a certain gene in 1 dog are the same, we call the dog homozygous
- If both copies for a certain gene in 1 dog are different, we call the dog heterozygous
- For each gene, there are multiple possibilities (usually between 2 to 5) called alleles
- There is an order of dominance in these alleles.
  - If the allele is dominant, a capital letter is used, then only 1 copy of the allele is needed, to be the color (or trait) that is visible in the dog
  - If the allele is recessive, a small letter is used, then 2 copies of the allele are need to be visible

Color Genes: B Locus, B is for Black

- The gene at the B locus codes has 2 different alleles.
  - In dominant form, B, the dog has a black base color
  - In recessive form, b, the dog has a brown base color (b)
- Almost all Belgians have a black base color although brown based Belgians have been known. For the rest of the presentation we will only talk about black Belgians.
- Black base color means that e.g. the mask is black, the nose is black etc. With a brown base color, you have a brown mask and a brown nose like the brown based Belgian shown in the picture.

Brown based Belgian Shepherd. It is clear from the mask and the brown nose color.

Black based Belgian Shepherd with their black mask and black nose.

B for Black – Inheritance Patterns

Different genetic possibilities:

Genetic Formula	Visual Description
BB and Bb	The dog has a black base color
Bb	The dog has a brown base color

Inheritance scheme:

		Male		
		Black (BB)	Black (brown carrier) (Bb)	Brown (bb)
Female	Black (BB)	100% Black (BB)	50% Black (BB) 50% Black (brown carrier) (Bb)	100% Black (brown carrier) (Bb)
	Black (brown carrier) (Bb)	50% Black (BB) 50% Black (brown carrier) (Bb)	25% Black (BB) 50% Black (brown carrier) (Bb) 25% Brown (bb)	50% Black (brown carrier) (Bb) 50% Brown (bb)
	Brown (bb)	100% Black (brown carrier) (Bb)	50% Black (brown carrier) (Bb) 50% Brown (bb)	100% Brown (bb)

Color Genes: K Locus is also for Black

- Frequently referred to as “Dominant Black”, the gene at the K locus has 3 different alleles. In order of dominance
  - K^B: Dominant; this allele codes for the black base color and hides all other alleles
  - k^{br}: Recessive; this allele codes for the brindle pattern and allows the color coded for by the A-gene to be seen
  - k^y: Recessive; this allele allows us to see the color coded for by the A-gene
- Although rarely seen today, brindle Belgian Sheperds do exist but often labs cannot differentiate between a heterozygous black dog and a brindle

K^B resulting in the black color being spread all over the body

k^{br} resulting in a brindle pattern

k^y allow us to see what is on the A-gene

K for Black – Inheritance Patterns

Different genetic possibilities:

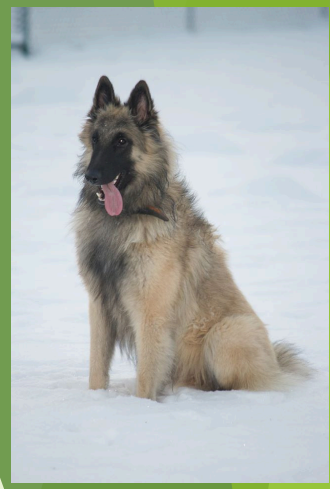
Genetic Formula	Visual Description
K^BK^B, K^Bk^{br}, K^Bk^y	The dog is solid black
$k^{br}k^{br}$, $k^{br}k^y$	The dog has a brindle pattern
k^yk^y	The color of the dog is determined by the A-gene

Inheritance scheme: Due to rareness of the brindle in the BSD, it has not been included in the inheritance scheme

		Male		
		Solid Black (K^BK^B)	Solid Black (Red carrier) (K^Bk^y)	Red (k^yk^y)
Female	Solid Black (K^BK^B)	100% Solid Black (K^BK^B)	50% Solid Black (K^BK^B) 50% Solid Black (Red carrier) (K^Bk^y)	100% Solid Black (Red carrier) (K^Bk^y)
	Solid Black (Red carrier) (K^Bk^y)	50% Solid Black (K^BK^B) 50% Solid Black (Red carrier) (K^Bk^y)	25% Solid Black (K^BK^B) 50% Solid Black (Red carrier) (K^Bk^y) 25% Red (k^yk^y)	50% Solid Black (Red carrier) (K^Bk^y) 50% Red (k^yk^y)
	Red (k^yk^y)	100% Solid Black (Red carrier) (K^Bk^y)	50% Solid Black (Red carrier) (K^Bk^y) 50% Red (k^yk^y)	100% Red (k^yk^y)

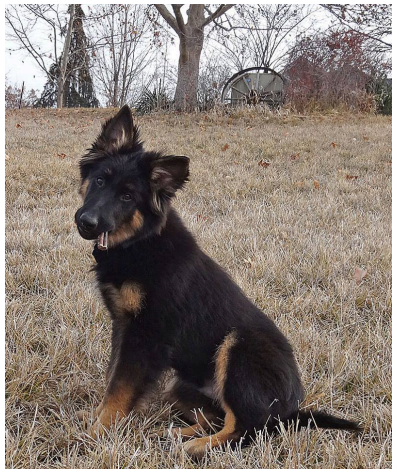
Color Genes: A for Agouti

- For the colors coded by this gene to be visible, the K gene has to be $k^y k^y$.
- Sometimes a recessive color bleeds through.
- The gene at the A locus has 4 different alleles. In order of dominance
  - A^y: Dominant; Codes for a red (fawn/fauve) or sable color
  - a^w: Recessive; Codes for the wild color
  - a^t: Recessive; Codes for the black and tan color
  - a: Recessive; Codes for recessive black, the dog is completely black, but can produce different colored offspring; can only be differentiated from a K^B- dog by a genetic test.



A fawn colored on the left and a sable colored on the right

A wild colored puppy and his mother who should be fawn colored but her wild color is bleeding through



A Black & Tan dog

A solid black born in a fawn litter, this dog must be recessive black

A for Agouti – Inheritance Patterns

Different genetic possibilities:

Genetic Formula	Visual Description
A^yA^Y, A^ya^w, A^ya^t, A^ya	The dog is fawn/sable color
a^wa^w, a^wa^t, a^wa	The dog is wild color
a^ta^t, a^ta	The dog is black & tan color
aa	The dog is black

Inheritance scheme: due to rareness of the Wild and Black & Tan in the BSD, it has not been used for the inheritance scheme

		Male		
		Fawn/Sable (A^yA^Y)	Fawn/Sable (Black carrier) (A^ya)	Black (k^yk^y)
Female	Fawn/Sable (A^yA^Y)	100% Fawn/Sable (A^yA^Y)	50% Fawn/Sable (A^yA^Y) 50% Fawn/Sable (Black carrier) (A^ya)	100% Fawn/Sable (Black carrier) (A^ya)
	Fawn/Sable (Black carrier) (A^ya)	50% Fawn/Sable (A^yA^Y) 50% Fawn/Sable (Black carrier) (A^ya)	25% Fawn/Sable (A^yA^Y) 50% Fawn/Sable (Black carrier) (A^ya) 25% Black (aa)	50% Fawn/Sable (Black carrier) (A^ya) 50% Black (aa)
	Black (aa)	100% Fawn/Sable (Black carrier) (A^ya)	50% Fawn/Sable (Black carrier) (A^ya) 50% Black (aa)	100% Black (aa)

Color Genes: E for Extension

- For the results of the E gene to be visible, the K gene can not be K^B
- The mask may cover the tan points found in the black & tan
- The E locus has 4 different alleles. In order of dominance
  - E^m: Dominant; Mask present
  - E^g and E^h: Recessive; Grizzled or domino mask, not found in Belgian Shepherds
  - E: Recessive; No mask
  - e: Recessive; Red mask (Irish setter color), not found in Belgian Sheperd

Mask vs No mask

E for Extension – Inheritance Patterns

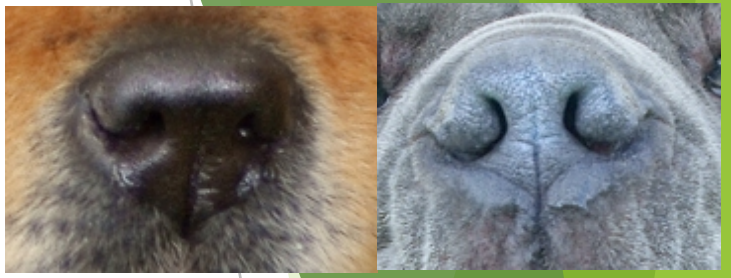
Different genetic possibilities: Since E^g, E^h and e are not found in the Belgian Shepherd, they will not be considered below

Genetic Formula	Visual Description
E^mE^m, E^mE	The dog has a mask
EE	The dog has no mask

Inheritance scheme:

		Male		
		Mask (E^mE^m)	Mask(No mask carrier) (E^mE)	No mask (EE)
Female	Mask (E^mE^m)	100% Mask (E^mE^m)	50% Mask (E^mE^m) 50% Mask(No mask carrier) (E^mE)	100% Mask(No mask carrier) (E^mE)
	Mask(No mask carrier) (E^mE)	50% Mask (E^mE^m) 50% Mask(No mask carrier) (E^mE)	25% Mask (E^mE^m) 50% Mask(No mask carrier) (E^mE) 25% No mask (EE)	50% Mask(No mask carrier) (E^mE) 50% No mask (EE)
	No mask (EE)	100% Mask(No mask carrier) (E^mE)	50% Mask(No mask carrier) (E^mE) 50% No mask (EE)	100% No mask (EE)

Color Genes: D for Dilute



The gene also influence the color in other parts of the dog like the nose, eye rim etc

- The D locus is responsible for changing the color black to a “dilute” slate grey color which is called Blue
- The gene at the D locus has 2 different alleles. In order of dominance
  - D: Dominant; Codes for black
  - d: Recessive; Codes for a dilute, slate grey color

A black longhaired and his blue counterpart

D for Dilute – Inheritance Patterns

Different genetic possibilities:

Genetic Formula	Visual Description
DD, Dd	The dog has normal black in both the base color and charbon (remains able to produce black)
dd	All black becomes a slate grey (the dog is unable to produce black)

Inheritance scheme:

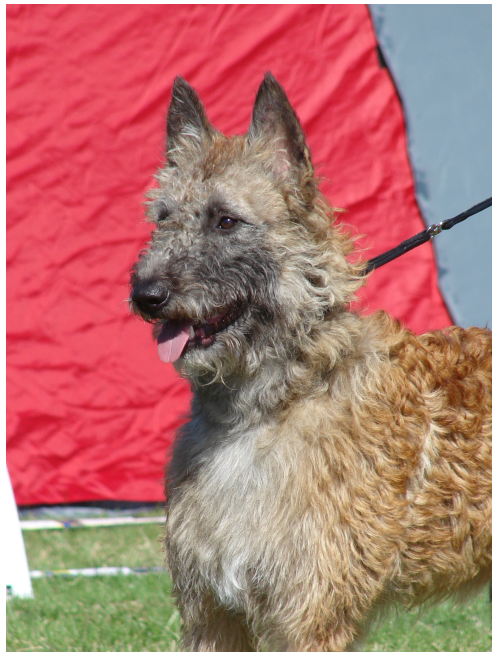
		Male		
		Black (DD)	Black(Blue carrier) (Dd)	Blue (dd)
Female	Black (DD)	100% Black (DD)	50% Black (DD) 50% Black(Blue carrier) (Dd)	100% Black(Blue carrier) (Dd)
	Black(Blue carrier) (Dd)	50% Black (DD) 50% Black(Blue carrier) (Dd)	25% Black (DD) 50% Black(Blue carrier) (Dd) 25% Blue (dd)	50% Black(Blue carrier) (Dd) 50% Blue (dd)
	Blue (dd)	100% Black(Blue carrier) (Dd)	50% Black(Blue carrier) (Dd) 50% Blue (dd)	100% Blue (dd)

Color Genes: I for Intensity

- The gene cause the difference between fawn and sable
- Currently it is not known how many alleles there are for this gene or how they interact so there is also no genetic testing possible
- In older literature you will find this on the C-gene (c^{ch}).

Coat genes: Improper furnishings, RSPO2 Gene

- Don’t be fooled by the name. The “improper” simply means there are no furnishings
- In Belgian Shepherds, only the rough haired Laekenois is supposed to have furnishings. All others do not have these longer hairs on the head
- The furnishings gene has 2 different alleles. In order of dominance
  - F: Dominant; Codes for furnishings, Laekenois
  - I: Recessive; Codes for no furnishings, Malinois, Groenendael or Tervueren



A laekenois with furnishings i.e. longer hairs around the eyes and muzzle

A malinois without furnishings

Improper furnishings – Inheritance Patterns

Different genetic possibilities:

Genetic Formula	Visual Description
FF, Fl	The dog has furnishings
ll	The dog has no furnishings i.e. smooth face

Inheritance scheme:

		Male		
		Furnishings (FF)	Furnishing (smooth carrier) (Fl)	Smooth (ll)
Female	Furnishings (FF)	100% Furnishing (FF)	50% Furnishing (FF) 50% Furnishing (smooth carrier) (Fl)	100% Furnishing (smooth carrier) (Fl)
	Furnishing (smooth carrier) (Fl)	50% Furnishing (FF) 50% Furnishing (smooth carrier) (Fl)	25% Furnishing (FF) 50% Furnishing (smooth carrier) (Fl) 25% Smooth (ll)	50% Furnishing (smooth carrier) (Fl) 50% Smooth (ll)
	Smooth (ll)	100% Furnishing (smooth carrier) (Fl)	50% Furnishing (smooth carrier) (Fl) 50% Smooth (ll)	100% Smooth (ll)

Coat genes: Long Haircoat, FGF5 Gene

- The name is straight forward. The gene influences the length of the hairs in the coat.
- The long haircoat gene has 2 different alleles. In order of dominance
  - G: Dominant; Codes for short hair, Malinois
  - T: Recessive; Codes for long hair, Groenendael or Tervueren

Long Coat – Inheritance Patterns

Different genetic possibilities:

Genetic Formula	Visual Description
GG, GT	The dog has a short coat
TT	The dog has a long coat

Inheritance scheme:

		Male		
		Short (GG)	Short (long carrier) (GT)	Short (TT)
Female	Short (GG)	100% Short (GG)	50% Short (GG) 50% Short (Long carrier) (GT)	100% Short (Long carrier) (GT)
	Short (long carrier) (GT)	50% Short (GG) 50% Short (Long carrier) (GT)	25% Short (GG) 50% Short (Long carrier) (GT) 25% Long (TT)	50% Short (Long carrier) (GT) 50% Long (TT)
	Short (TT)	100% Short (Long carrier) (GT)	50% Short (Long carrier) (GT) 50% Long (TT)	100% Long (TT)

Coat genes: Shedding, MC5R Gene

- Determines the amount of shedding
- Dogs with funishings tend to be light shedders regardless of the fact that they code for heavy shedding
- The MC5R shedding gene has 2 different alleles – C and T, Dogs having at least 1 T gene, tend to shed less.

Heavy shedding

Tor has 1 T gene and sheds less than the other dogs in the family

Shedding – Inheritance Patterns

Different genetic possibilities:

Genetic Formula	Visual Description
CC	The dog has heavy shedding
CT	The dog has intermediate or moderate shedding
TT	The dog has light shedding

Inheritance scheme:

		Male		
		Heavy (CC)	Moderate (CT)	Light (TT)
Female	Heavy (CC)	100% Heavy (CC)	50% Heavy (CC) 50% Moderate (CT)	100% Moderate (CT)
	Moderate (CT)	50% Heavy (CC) 50% Moderate (CT)	25% Heavy (CC) 50% Moderate (CT) 25% Light (TT)	50% Moderate (CT) 50% Light (TT)
	Light (TT)	100% Moderate (CT)	50% Moderate (CT) 50% Light (TT)	100% Light (TT)

Coat genes: Curly Coat, KRT71 Gene

- Determines whether a dog has a wavy/curly coat or a straight coat
- The KRT71 curly coat gene has 2 different alleles – C and T, Dogs having at least 1 T gene, have curly coats.
- Dogs having 1 T gene, usually have less tight curls than dogs with 2 T genes.

Curly Coat – Inheritance Patterns

Different genetic possibilities:

Genetic Formula	Visual Description
TT	The dog has a curly coat
CT	The dog has a wavy coat
CC	The dog has a straight coat

Inheritance scheme:

		Male		
		Curly (TT)	Wavy (CT)	Straight (TT)
Female	Curly (TT)	100% Curly (TT)	50% Curly (TT) 50% Wavy (CT)	100% Wavy (CT)
	Wavy (CT)	50% Curly (TT) 50% Wavy (CT)	25% Curly (TT) 50% Wavy (CT) 25% Straight (CC)	50% Wavy (CT) 50% Straight (CC)
	Straight (TT)	100% Wavy (CT)	50% Wavy (CT) 50% Straight (CC)	100% Straight (CC)

Thank You

- All the members of the FB Groups, “Embark Belgian Shepherds” and “DNA Testing of Belgian Shepherds”, and the newly formed “Belgian Shepherd Health Project, Core Team”
- Saskia Vermeylen, Analysis
- February, 2019
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