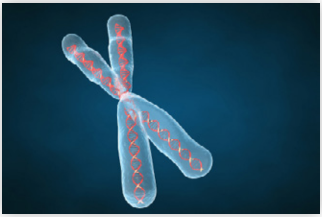
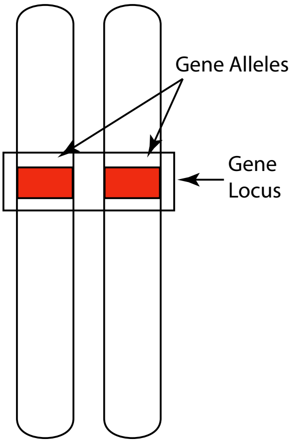
Genetics of the coat: colours and structure

INTRODUCTION TO GENETICS



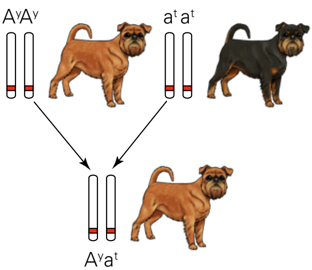
A chromosome

The body of a dog consists of billions of cells. Dogs and humans belong to the **eukaryote** organisms. Eukaryote organisms have cells with a nucleus. Within that nucleus the genetic material or DNA is carried. The nucleus contains long filaments, forming the **chromosomes**. In dogs, the nucleus contains 38 pairs of chromosomes and one pair of sexual chromosomes. This gives a total of 78 chromosomes in dogs (compared to 46 chromosomes in humans).



Chromosomes carry hereditary characteristics where each pair of chromosomes inherits one chromosome from the father and one chromosome from the mother.

A chromosome is divided into segments. A segment of a chromosome is better known as a **locus** and is the location of a particular **gene**.
The same gene can have a number of alternative forms, called **alleles**. A dog with two different alleles is a **heterozygous** dog. A dog with two identical alleles of a gene at a given locus is called a **homozygous** dog.



Combination of 2 homozygous dogs, resulting in a heterozygous dog. The dominant allele determines the appearance of a dog.

In general, a dog that is heterozygous for a colour gene, will have one gene that acts as dominant to the other gene. Only the traits of the **dominant** gene will be visible. The traits of the **recessive** gene will be invisible. To see the traits of a recessive gene, the dog has to be homozygote or needs two identical copies of the recessive alleles.

A gene whose influence may mask the influence of a gene at another locus is called **epistatic**. E.g. K^B is epistatic over A^y. The masked gene is called **hypostatic**. Dominant alleles are written with a capital letter, recessive alleles are written in lower case. For example: A^y for fawn, a^t for black with fawn markings.

PIGMENTS

Coat colours in dogs are created by two pigments: **eumelanin** and **phaeomelanin**. Eumelanin is a dark pigment (varying from black to brown), phaeomelanin is a light pigment (varying from red to yellow). Eumelanin and phaeomelanin is produced by **melanocytes**.

White colour is no colour: at places in the skin where the pigments are absent, the translucent hair cortex is filled with air, making the hairs look white.

Translucent hair cortex.

THE LOCI THAT DETERMINE THE COAT COLOUR

We summarize the loci and their alleles that are of importance for the coat colour in the breed. Every dominant allele is written with an uppercase.

A-locus (Agouti)

$\mathbf{A}^{y}$: *sable, fawn*, fawn with dark overlay, red with black tips, yellow

The colour ranges from red fawn to dark fawn to orange fawn and to pale fawn.

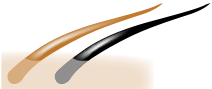
The Agouti locus is named after a rodent. The different alleles at the A-locus have the effect of altering the extension of eumelanin and phaeomelanin on the hair and the entire coat. On the hair this can have the effect of a fawn colour with black tips (bi-colour) or a fawn colour with dark bandings, both leading to the typical "black overlay". Fawn with black overlay is the most common coat in the canine species. There are several gradations in the overlay: varying from a very slight to a moderate and to a heavy overlay.

Dark fawn with black hair tips.

Fawn with dark bandings.

a^w: *wild boar, wild type, wolf-grey. Probably NOT in the Griffon Bruxellois breed.*

a^t: tan points




The dog is black with tan (phaeomelanin) markings on the muzzle, eyebrows, chest, belly, feet and under the tail.

a: recessive black (this allele is NOT in the Griffon Bruxellois breed)
The order of dominance at the A-locus is: $A^y > a^w > a^t > a$.

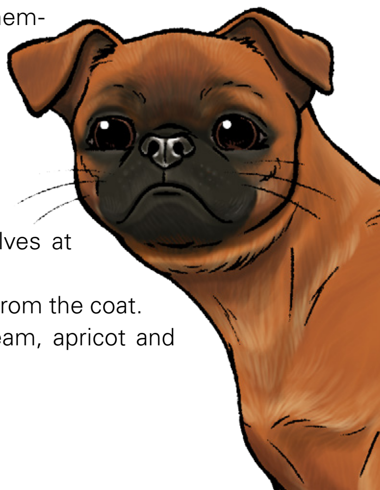
B-locus (Brown)

Brown is a type of eumelanin pigment. The black eumelanine allele B is dominant to the brown eumaline alleles b. When a black&tan dog has 2 recessive b alleles, the dog will appear as chocolate and tan, which is not allowed in the breed standard.
B: black eumelanine
b: brown eumelanine


Black Petit Brabançon with a dominant B-allele and a brown Petit Brabançon with 2 recessive b-alleles. The brown colour is not allowed in the breed standard.

D-locus (Dilution)

Melanophiline gene (MLPH). Causes a dilution of eumelanine (to blue or grey) and phaeomelanine (to liver or chocolat).
D: normal colour, no dilution, it lets the genes express themselves at other loci
d: diluted colour, dilutes both eumelanin and phaeomelanin



E-locus (Extension)

E^m: black mask (melanistic mask), it may also cause black hairs on the chest
E: normal hair colour. It let's the genes express themselves at other loci, e.g. A, B.
e: recessive red, "neutralizes" any black hair or eumelanin from the coat. Noses can dilute in winter. Gives yellow, lemon, red, cream, apricot and sometimes white.

E^g: grizzle phenotype, occurs in a^ta^t dogs (until now only found in the Saluki and Afghan breeds) only when there are no K^B and E^M alleles.
E^h: this allele has been identified very recently in English and American Cocker Spaniels as being responsible for "dirty red" or "sable" in these breeds.

Dogs with two recessive e-alleles have a solid red or solid yellow colour due to phaeomelanine production or the removal from eumelanine from the coat. Sometimes this is (wrongly) described as "clear red" or "clear sable".

When E is present in a dog, it usually has some black or brown in its coat because of the production of eumelanin. The E allele is dominant to the e allele. Although the e/e genotype is the most recessive at this locus, it is epistatic or masks other genotypes at other loci, such as the K and A locus.

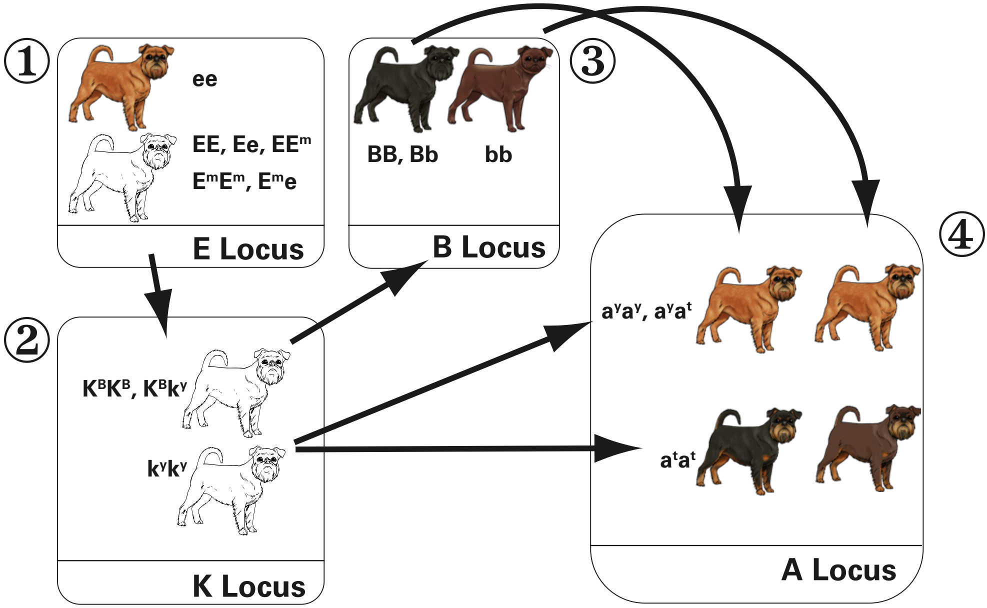
K-locus (Black)

With molecular DNA studies it is recently shown that "dominant black" is not caused by an agouti allele. "Dominant black" is a genotype that is epistatic to fawn/sable agouti phenotypes and which occurs at another locus, K (for blacK).

K^B: Dominant black. Masks all the red and black&tan colours and is therefore epistatic over the A-locus. The dog is black when he has the domi- nant "B" allele at the B-locus.
k^{br}: causes the "brindle" pattern. In some texts about the Griffon Bruxellois "brindle" is sometimes wrongly used to describe the colour "black mixed with red-brown". The brindle allele is NOT present in Griffon Bruxellois. The colour "black mixed with red-brown" belongs to the red fawn colour range A^y and is the same as "fawn with dark overlay".
k^y: allows phaeomelanin (red/yellow) pigment to show. All black-and-tan dogs or dogs with tan points are homozygote k^y/k^y! All fawn or sable dogs are homozygote k^y/k^y, whether they have a melanistic mask or not. Red dogs that have an e/e genotype however, can have any genotype at the K locus.

HOW THE A, B, E AND K LOCI AFFECT EACH OTHER IN DETERMINING COAT COLOUR IN GRIFFON BRUXELLOIS

The graphic below helps to illustrate the interactions of the genes at these four loci in a hierarchy in terms of their role in coat colour. If a dog is filled with colour, it means the colour of the dog has been determined at that point. If a dog is still white, it means information about an additional gene is required.



First, we look at the **E locus**. The gene at this locus is responsible for black masks when present as well as most shades of yellow and red. Any dog that is "ee" will be some shade of yellow to red, and everything happening at the A, B, and K loci will be hidden until the next generation. If the dog has any E or Em alleles, then it will not be yellow and we must look next at the K locus.

There are three versions, or alleles, of the **K locus:** K^B, k^{br}, and k^y where k^{br} is not in Griffon Bruxellois and is removed from the graphic. If a dog has even a single copy of K^B (K^BK^B, K^Bky) it will be solid coloured in the pigmented areas, and we go directly to the B locus to determine colour. Everything happening at the A locus in these dogs is hidden until the next generation. If a dog is k^yk^y, we go next to the A locus to see which alleles are expressed.

The **A locus** has at least four alleles. Reccive black - a - is not in Griffon Bruxellois and is removed from the graphic overview. Any dog which has at least one copy of A^y

(and no K^B) will be fawn or sable. Any dog that is a^ta^t (and no K^B) will have tan points. The next stop is the **B locus**. Any dog which is "bb" will have brown fur in those areas that would otherwise be black. This holds true for both solid colored and agouti-patterned animals.

The **D locus** (not shown in the diagram) can alter the intensity of pigment. Animals which are "dd" exhibit grey or blue fur in place of black, and light tan or "Isabella" in place of brown. This tan is similar to some A^Y shades but lacking any banding or black tips on individual hairs.

The **E locus** is responsible for the black mask seen in many breeds, and more significantly, for the presence of the yellow to red coats of many dogs. The gene involved is known as MC1-R, which has at least three versions affecting the appearance of the dog, E, E^m, and e. Dogs with two copies of e will be yellow, orange or red in their pigmented coat regardless of their genotype at all the other loci.

Animals with a single copy of E^m can produce offspring with or without a mask, while those with two copies will only produce masked offspring.

The **B locus** is responsible for the presence of brown, chocolate, or liver animals. It is also responsible for nose color. The gene associated with this locus is known as TYRP1. In breeds where the A locus does not come into play, any animal that has at least one B allele (and is not "ee"), will be black in pigmented coat. Those dogs, which have two copies of any of several b alleles will be brown. There are at least three such b alleles. Regardless of other loci, any animal with at least one B allele will have a black nose and pads, while those with any two b alleles will have a liver nose and pads.

The **K locus** plays a pivotal role in coat color. This locus is a relative newcomer in our understanding of canine color, and includes traits formerly attributed by some to other genes.

The dominant allele in the series is K^B, which is responsible for self-coloring, or solid colored fur in pigmented areas. This trait was formerly attributed to the Agouti (A) locus as A^S, but recent breeding studies had shown this not to be the case.

There are two other alleles, k^{br}, and k^y. K^B is dominant to both k^{br} and k^y, while k^{br} is dominant only to k^y. The recessive allele, k^y, allows the basic patterns of the A locus to be expressed.

Any animal with at least one K^B allele will be self-colored.

Any animal with two k^y alleles will show agouti patterns (see A locus).

THE LOCI THAT DETERMINE THE COAT STRUCTURE

In 2006 Donna Housley and Patrick Venta published that the gene causing hair length in several breeds of dogs was *Fibroblast Growth Factor 5* (FGF5).
In 2009 Edouard Cadieu published a paper that expanded the breeds studied to 80. Among these, many breeds were all long-haired or all short-haired.
They indicate that the mutation causing long is recessive, but the length of the “long” hair is variable within individuals and across the breed. “L” is used for the dominant allele for short hair and “l” is used for the recessive long hair gene. In our breed, it’s assumed that all the varieties are homozygous “L” carriers (short hair), although there are still carriers today of the recessive genes for long hair that were once infused by the King Charles Spaniel! It depends on the situation at the W-locus if the short hair appearance will be expressed (the dominant allele “W^h” causes “rough hair”, the recessive allele “w^h” causes “no rough hair”).

Cadieu discovered that the “*R-spondin 2*”-gen (RSPO2) is responsable for rough hair. Many wirehaired dogs also have “facial furnishings” or a beard. It is quite likely that shorthaired wire coats feel more wirey than longhaired wire coats. Winge (1950) postulated that wire (W^h) is dominant to non-wire (w^h). This was supported in the study by Cadieu et al. (2009). The gene for rough hair “W^h” is epistatic to the gene for short hair (“L”). The short haired coat (LL or Ll) is expressed if a dog has two recessive genes for no rough hair (w^hw^h). The Petit Brabançon is of the “w^hw^h LL” genotype, the Griffon Bruxellois or Griffon Belge is of the “W^hW^h LL” or “W^hw^h LL” genotype. Our breed is supposed to be homozygote for short hair (LL), although there are still some living examples that carry the gene for long hair (“l”) from the King Charles Spaniel and sometimes long haired puppies are still born!

Overview of the coat structure in Griffon Bruxellois/Belge and Petit Brabançon:

Locus	**Allele**	**Coat**	**Visual**
L Locus	L	Short hair	
	l	Long hair	
Wh Locus	W^h	Wire hair	
	w^h	Smooth hair	

The dominant gene is written first and in uppercase for every locus.

THE PUNNETT SQUARE

One of the most valuable and easiest tools to predict the probability of inheritance is the **"Punnet Square"**. The square was invented by the English genetecist Reginald Punnett early in the 20th century. It's a simple graphical way to determine the potential combinations of genotypes.

genetic contribution of one parent

genetic contribution of the other parent

	A^y	a^t
A^y	Ay A^y	A^y a^t
a^t	A^y a^t	a^t a^t

offspring genotype possibilities

The genotype of one parent is written accross the top and that of the other parent down the left side of the Punnett square. It doesn't matter which parent is on the top or on the left side of the square. But in general, the male is written on top, and the female on the left.
Next, we have to fill in the grey boxes by copying the row and column-head letters across or down into the empty squares. This gives us the predicted frequency of all of the potential genotypes among the offspring each time reproduction occurs.

In the example, 1/4 will be homozygote A^y/A^y (red), 2/4 will be heterozygote A^y/a^t (red, carrying a gene for black&tan) and 1/4 will be homozygote a^t/a^t (black&tan). Phenotypically, 75% will be red, 25% will be black&tan.

When more traits have to be evaluated at once, the Punnet Square can become too complicated. In these cases it's better to use another method as in the example below:

Sire:	*Genotype*:	$W^h w^h$ $a^t a^t$ $k^y k^y$
	Gametes:	W^h a^t k^y - w^h a^t k^y
Dam:	*Genotype*:	$W^h W^h$ $a^t a^t$ $k^y k^y$
	Gametes:	w^h a^t k^y

	W^h a^t k^y	**w^h a^t k^y**
w^h a^t k^y	$W^h w^h$ $a^t a^t$ $k^y k^y$	$w^h w^h$ $a^t a^t$ $k^y k^y$

Result: 50% black&tan/rough, 50% black&tan/smooth
(W^h is the allele for wire-hair, w^h for "no wire-hair")

With all the previous knowledge, it will now be possible to give an overview of the genotypes for all varieties within the Griffon Bruxellois breed.

GENOTYPE GRIFFON BRUXELLOIS AND RED PETIT BRABANÇON:

A-locus	a^ya^y or a^ya^t
B-locus	BB of Bb
D-locus	DD of Dd
E-locus	E^mE^m (melanistic mask) E^mE (melanistic mask) E^me (melanistic mask) EE (no melanistic mask) Ee (no melanistic mask) ee (no melanistic mask and no black hair)
K-locus	k^yk^y

The red Petit Brabançon and the red Griffon Bruxellois can also carry the genes for "black&tan" (a^t). These dogs are phenotypical red, because a^y (red) is dominant over a^t (tan points).

The black mask is desired for the red Petit Brabançon, but can also appear in the Griffon Bruxellois.

GENOTYPE GRIFFON BELGE (BLACK&TAN) AND PETIT BRABANÇON (BLACK&TAN)

A-locus	a^ta^t
B-locus	BB or Bb
D-locus	DD or Dd
E-locus	E^mE^m (melanistic mask) E^mE (melanistic mask) E^me (melanistic mask) EE (no melanistic mask) Ee (no melanistic mask)
K-locus	k^yk^y

In theory, two heterozygote (E/e or E^m/e) black&tan parents can produce recessive red (e/e) puppies. If this occurs, it's advised to have them DNA-tested. Black&tan and red is always homozygous k^yk^y!

GENOTYPE GRIFFON BELGE (BLACK) AND PETIT BRABANÇON (BLACK)

A-locus	a^ya^y or a^ya^t or a^ta^t
B-locus	BB or Bb
D-locus	DD or Dd
E-locus	E^mE^m (melanistic mask) E^mE (melanistic mask) E^me (melanistic mask) EE (no melanistic mask) Ee (no melanistic mask)
K-locus	K^BK^B or K^Bk^y

The black colour is caused by the dominant K^B allele. Dominant black masks all other colours, but the alleles at the K-locus are suppressed (or hypostatic) when the dog has two recessive red "e" alleles at the E-locus! Heterozygous black K^Bk^y is not always pure black, sometimes one can see some reddish hairs in their black coat.

Let’s look at some practical intervariety crossings and their phenotypical results by using trihybrid Punnett-charts. We can “predict” the phenotypical appearances easily, but the amounts or percentages are just statistiscal indications. In practice, those numbers and percentages can be totally different!

Some examples:

1 Griffon Belge (bt/r) x Petit Brabançon (bt/s):

Sire: Ch. St Johns The Ratcatcher (bt/s)

Genotype: $w^hw^h\ a^ta^t\ k^yk^y$

Gametes: $w^h\ a^t\ k^y$

Dam: Ch. Leo Belgicus Well-Marked (bt/r)

Genotype: $W^hW^h\ a^ta^t\ k^yk^y$

Gametes: $W^h\ a^t\ k^y$

	$w^h\ a^t\ k^y$
$W^h\ a^t\ k^y$	$W^hw^h\ a^ta^t\ k^yk^y$

Result:

100% black& tan/rough. These 8 puppies can produce smooth offspring.

Offspring:

Leo B. Leonic Unlimited (bt/r)

Leo B. Linus Unlimited (bt/r)

Leo B. Laban Unlimited (bt/r)

Leo B. Lord Lexus Unlimited (bt/r)

Leo B. Lucifer Unlimited (bt/r)

Leo B. Luna Unlimited (bt/r)

Leo B. Lotje Unlimited (bt/r)

Ch. Leo B. Lilla Unlimited (bt/r), see photo to the right.

Important note here: when one of the parents is homozygote for rough hair, every litter will always result in all rough haired puppies!

2 Griffon Belge (bt/r) x Petit Brabançon (bt/s):

Sire: Ch. Leo Belgicus Paso-Doble (bt/r)

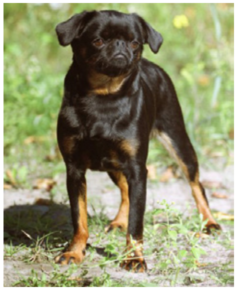
Genotype: $W^h w^h\ a^t a^t\ k^y k^y$

Gametes: $W^h\ a^t\ k^y$ - $w^h\ a^t\ k^y$

Dam: Ch. Leo Belgicus Coup de Ciel (bt/s)

Genotype: $w^h w^h\ a^t a^t\ k^y k^y$

Gametes: $w^h\ a^t\ k^y$



	$\mathbf{W^h\ a^t\ k^y}$	$\mathbf{w^h\ a^t\ k^y}$
$\mathbf{w^h\ a^t\ k^y}$	$W^h w^h\ a^t a^t\ k^y k^y$	$w^h w^h\ a^t a^t\ k^y k^y$

Result:
50% black&tan/rough
50% black&tan/smooth

Offspring:
Leo Belgicus Espoir (bt/r), Leo Belgicus Esprit (bt/s),
Leo Belgicus Esperanto (bt/s), Leo Belgicus Espérance (bt/s)

Ch. Leo Belgicus Esperanto

3 Griffon Belge (b/r) x Griffon Bruxellois (r/r):

Sire: Ch. Liamford Black For Good To Marquant (b/r)

Genotype: $W^h w^h a^y a^y K^B k^y$

Gametes: $W^h a^y K^B$ - $W^h a^y k^y$

$w^h a^y K^B$ - $w^h a^y k^y$

Mother: Ch. Polcot Portia (r/r)

Genotype: $W^h w^h a^y a^y k^y k^y$

Gametes: $W^h a^y k^y$ - $w^h a^y k^y$

	$W^h a^y K^B$	**$W^h a^y k^y$**	**$w^h a^y K^B$**	**$w^h a^y k^y$**
$W^h a^y k^y$	$W^h W^h a^y a^y K^B k^y$	$W^h W^h a^y a^y k^y k^y$	$W^h w^h a^y a^y K^B k^y$	$W^h w^h a^y a^y k^y k^y$
$w^h a^y k^y$	$W^h w^h a^y a^y K^B k^y$	$W^h w^h a^y a^y k^y k^y$	$w^h w^h a^y a^y K^B k^y$	$w^h w^h a^y a^y k^y k^y$

Result:

37,50% black/rough (b/r)
37,50% red/rough (r/r)
12,50% black/smooth (b/s)
12,50% red/smooth (r/s)

Or: 75% rough, 25% smooth
50% red, 50% black

Offspring:

Ch. Debmar Go For Gold (r/r)
Ch. Debmar Dressed In Black (b/s),
(photo see page 119)
Ch. Debmar Lucky For Some (b/r)
Ch. Debmar Go For Golf (r/r)

Ch. Debmar Go For Gold

4 Griffon Belge (b/r) x Griffon Bruxellois (r/r):

Sire: Ch. Ekselent Choice (r/r)

Genotype: $W^hw^h\ a^ya^t\ k^yk^y$

Gametes: $W^h\ a^y\ k^y$ - $w^h\ a^y\ k^y$
$W^h\ a^t\ k^y$ - $w^h\ a^t\ k^y$

Dam: Ch. Janna d'Ark Iz Gusarskoy Ballady (b/r)

Genotype: $W^hw^h\ a^ya^t\ K^Bk^y$

Gametes: $W^h\ a^y\ K^B$ - $W^h\ a^y\ k^y$
$W^h\ a^t\ K^B$ - $W^h\ a^t\ k^y$
$w^h\ a^y\ K^B$ - $w^h\ a^y\ k^y$
$w^h\ a^t\ K^B$ - $w^h\ a^t\ k^y$

	$W^h\ a^y\ k^y$	**$w^h\ a^y\ k^y$**	**$W^h\ a^t\ k^y$**	**$w^h\ a^t\ k^y$**
$W^h\ a^y\ K^B$	$W^hW^h\ a^ya^y\ K^Bk^y$	$W^hw^h\ a^ya^y\ K^Bk^y$	$W^hW^h\ a^ya^t\ K^Bk^y$	$W^hw^h\ a^ya^t\ K^Bk^y$
$W^h\ a^y\ k^y$	$W^hW^h\ a^ya^y\ k^yk^y$	$W^hw^h\ a^ya^y\ k^yk^y$	$W^hW^h\ a^ya^t\ k^yk^y$	$W^hw^h\ a^ya^t\ k^yk^y$
$W^h\ a^t\ K^B$	$W^hW^h\ a^ya^t\ K^Bk^y$	$W^hw^h\ a^ya^t\ K^Bk^y$	$W^hW^h\ a^ta^t\ K^Bk^y$	$W^hw^h\ a^ta^t\ K^Bk^y$
$W^h\ a^t\ k^y$	$W^hW^h\ a^ya^t\ k^yk^y$	$W^hw^h\ a^ya^t\ k^yk^y$	$W^hW^h\ a^ta^t\ k^yk^y$	$W^hw^h\ a^ta^t\ k^yk^y$
$w^h\ a^y\ K^B$	$W^hw^h\ a^ya^y\ K^Bk^y$	$w^hw^h\ a^ya^y\ K^Bk^y$	$W^hw^h\ a^ya^t\ K^Bk^y$	$w^hw^h\ a^ya^t\ K^Bk^y$
$w^h\ a^y\ k^y$	$W^hw^h\ a^ya^y\ k^yk^y$	$w^hw^h\ a^ya^y\ k^yk^y$	$W^hw^h\ a^ya^t\ k^yk^y$	$w^hw^h\ a^ya^t\ k^yk^y$
$w^h\ a^t\ K^B$	$W^hw^h\ a^ya^t\ K^Bk^y$	$w^hw^h\ a^ya^t\ K^Bk^y$	$W^hw^h\ a^ta^t\ K^Bk^y$	$w^hw^h\ a^ta^t\ K^Bk^y$
$w^h\ a^t\ k^y$	$W^hw^h\ a^ya^t\ k^yk^y$	$w^hw^h\ a^ya^t\ k^yk^y$	$W^hw^h\ a^ta^t\ k^yk^y$	$w^hw^h\ a^ta^t\ k^yk^y$

Example: Ch. Chervovy Kozyrnoy Iz Gusarkoy Ballady (bt/s)

Result:

37,50% black/rough (b/r)
28,125% red/rough (r/r)
9,375% black&tan/rough (bt/r)
12,50% black/smooth (b/s)
9,375% red/smooth (r/s)
3,125% black&tan/smooth (bt/s)

Or: 75% rough, 25% smooth
50% black, 37,50% red,
12,50% black&tan

5 Petit Brabançon (bt/s) x Petit Brabançon (r/s):

Sire: Ch. Beauview Nothing To Wear (bt/s)

Genotype: $w^hw^h\ a^ta^t\ k^yk^y$

Gametes: $w^h\ a^t\ k^y$

Dam: Alma Of Baluchistan (r/s)

Genotype: $w^hw^h\ a^ya^y\ k^yk^y$

Gametes: $w^h\ a^y\ k^y$

	$\mathbf{w^h\ a^t\ k^y}$
$\mathbf{w^h\ a^y\ k^y}$	$w^hw^h\ a^ya^t\ k^yk^y$

Result:
100% red/smooth (r/s)

Offspring:
Grace Of Baluchistan (r/s)

All the puppies from this combination are phenotypically red and can produce reds and black&tans in the next generation.

Ch. Grace Of Baluchistan

6 Petit Brabançon (bt/s) x Griffon Bruxellois (r/r):

Sire: Ch. Sam I Am Of St John (bt/s)

Genotype: $w^h w^h \; a^t a^t \; k^y k^y$

Gametes: $w^h \; a^t \; k^y$

Dam: Ch. Red Hot Hottentot's Faye Dunaway (r/r)

Genotype: $W^h w^h \; a^y a^y \; k^y k^y$

Gametes: $W^h \; a^y \; k^y$ - $w^h \; a^y \; k^y$

	$w^h \; a^t \; k^y$
$W^h \; a^y \; k^y$	$W^h w^h \; a^y a^t \; k^y k^y$
$w^h \; a^y \; k^y$	$w^h w^h \; a^y a^t \; k^y k^y$

Result:
50% red/rough (r/r)
50% red/smooth (r/s)

Offspring:
Leo Belgicus Bon-Aparte (r/s)
Leo Belgicus Bon-Amie (r/r)
Leo Belgicus Bon-Appétit (r/r)
Ch. Leo Belgicus Bon-Fire (r/r)

Ch. Leo Belgicus Bon-Fire. Clear red Griffon Bruxellois from red rough and black&tan smooth parents!

7 Griffon Belge (b/r) x Griffon Belge (b/r):

Sire: Ch. Marquant Wil Smith (b/r)

Genotype: W^hW^h a^ya^y K^Bk^y

Gametes: W^h a^y K^B - W^h a^y k^y

Mother: Marquant Ultra Violet (b/r)

Genotype: W^hW^h a^ya^y K^Bk^y

Gametes: W^h a^y K^B - W^h a^y k^y

	W^h a^y K^B	W^h a^y k^y
W^h a^y K^B	W^hW^h a^ya^y K^BK^B	W^hW^h a^ya^y K^Bk^y
W^h a^y k^y	W^hW^h a^ya^y K^Bk^y	W^hW^h a^ya^y k^yk^y

Result:

75% black/rough (b/r)

25% red/rough (r/r)

Offspring:

Ch. Marquant Infatuation (r/r)

Ch. Marquant Infatuation
[Photo: Ian Francis, Photocall UK)

References:

Website dr. Sheila Schmutz: http://homepage.usask.ca/~schmutz/dogcolors.html

Bernard Denis: *"Coat colours in dogs"*

VetGen: http://www.vetgen.com


Brussels Griffon
Sensitive
Intelligent
Alert
Affectionate
B.L
©'92'