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Illustrated Inter-variety Matings

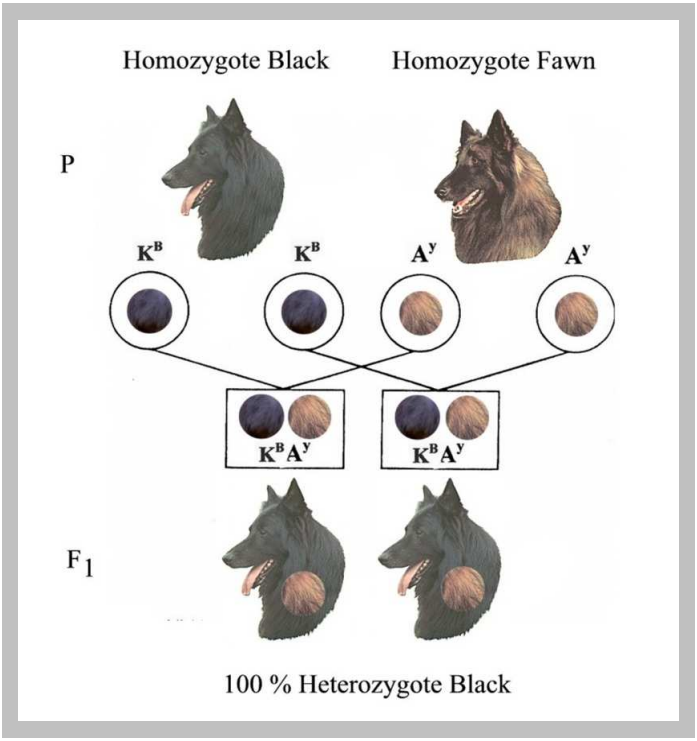
A. Inter-variety matings

“Crossbreeding” is not the exact word when it concerns dogs of the same breed, so we have chosen the expression “inter-variety mating”. In this chapter, we will study the consequences for inter-variety matings between our different variety of coat textures and colours.

a) Matings between long-haired Groenendael and Tervueren.

Knowing that two long–haired will never produce short-haired dogs, the result has to be a Groenendael or a Tervueren, never a Malinois or a ‘Short-haired black’. In other words, the dog is called "homozygote" based on hair length. That is what hair length is about.

Case 1
If we mate two homozygote parents, a Groenendael $\mathbf{K^BK^B}$ (black long hair) with a Tervueren $\mathbf{A^yA^y}$ (fawn long hair), what colour will the offspring be? Taking into account that each allele of one parent forms a pair with one of the two alleles of the other parent, we can expect the following results:



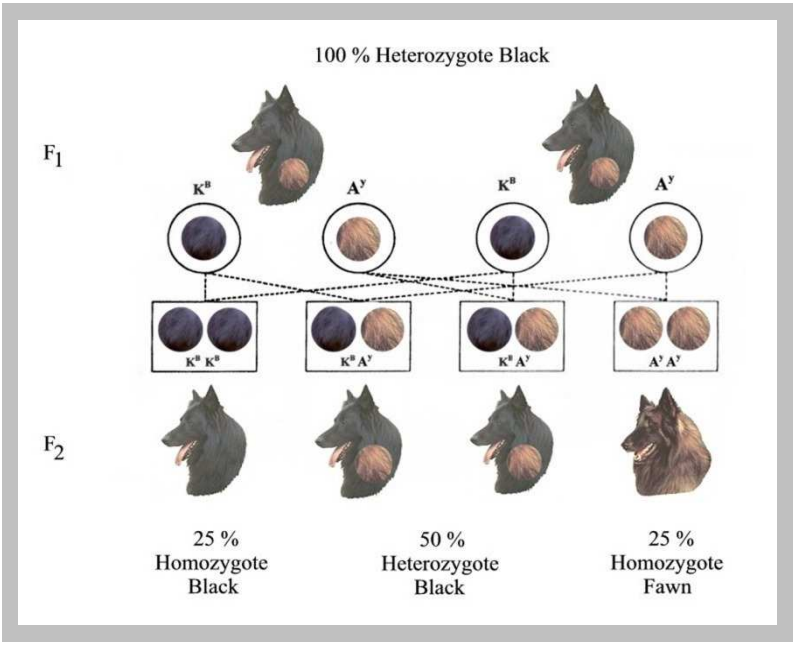
Each new gene is formed as follows: $\mathbf{K^BA^y}$. As $\mathbf{K^B}$ is epistatic over $\mathbf{A^y}$, the offspring will be black but it will carry the allele for fawn colour. This means that they are all heterozygotes.

If parents that differ from each other in just one characteristic are crossed, then the resulting hybrids are uniform in the chosen characteristic. **This is known as the Mendel's first law and is also called the principle of uniformity.**

The parental generation is marked with a P. The first daughter generation is named F1 from Latin 'filia', which means 'daughter'. If two hybrids of the F_1 generation are crossed, then the resulting generation is called F_2, the following generation F_3 and so on.

If just one character is studied, then we talk of a monohybrid crossing. If further characteristics are also regarded, then the crossing is called dihybrid, trihybrid,...polyhybrid.

Case 2



If we mate two heterozygotes from the first litter F_1, what colour will the offspring be? There are four combinations possible from $\mathbf{K^BA^y} + \mathbf{K^BA^y}$ as shown below:

In the F_2 generation, genotypically, there are three types of offsprings. They are

25% $\mathbf{K^BK^B}$ (homozygote black)
50% $\mathbf{K^BA^y}$ (heterozygote black)
25% $\mathbf{A^yA^y}$ (homozygote fawn).

This gives a 1 : 2 : 1 ratio. The mating of heterozygotes results, for the descendants, in the reappearance of the recessive (or the hypostatic) character, in a proportion of one recessive to three dominants. **This is known as the Mendel's second law and is also called the principle of segregation.** It states that the individuals of the F_2 generation are not uniform, but that the traits segregate. This concept of independent traits explains how a trait can persist from generation to generation without blending with other traits. It explains, too, how the trait can seemingly disappear and then reappear in a later generation. It is possible, if we know the parents genotype, to foresee the characters of the next generation.

Case 3

Mating a Groenendael heterozygote $\mathbf{K^B}k^y$, $\mathbf{A^yA^y}$ with a Tervueren homozygote k^yk^y, $\mathbf{A^yA^y}$

The litter will be 50 % Groenendael heterozygotes $\mathbf{K^B}k^y$, $\mathbf{A^yA^y}$ and 50 % Tervueren homozygotes k^yk^y, $\mathbf{A^yA^y}$.

Case 4

As long hair and fawn colour in the Tervueren are all recessive, it is obvious that this dog is homozygote. Mating a Tervueren with another Tervueren will always produce Tervueren. So, with regards to reproduction the Tervueren is a dog without surprises. But not always. Let us study the following case, which certainly appears from time to time:

Case 5

Mating two Tervueren with the following allele combination k^yk^y, $\mathbf{A^y}$a (cells of heterozygote are in grey coloured):

x	k^y, $\mathbf{A^y}$	k^y, a
k^y, $\mathbf{A^y}$	k^yk^y, $\mathbf{A^yA^y}$	k^yk^y, $\mathbf{A^y}$a
k^y, a	k^yk^y, $\mathbf{A^y}$a	k^yk^y, aa

We obtain the genotypical proportion of **1 : 2 : 1**. This is also an exemple of the application of the second law of Mendel. We find a completely black puppy (rarely two), a Groenendael carrier of alleles **aa**. The Tervueren brothers or sisters are either homozygotes k^yk^y, $\mathbf{A^yA^y}$ or heterozygotes k^yk^y, $\mathbf{A^y}$a. The mating of a Groenendael $\mathbf{K^BK^B}$, $\mathbf{A^y}$a with a Tervueren k^yk^y, $\mathbf{A^y}$a or even two Groenendael $\mathbf{K^BK^B}$, $\mathbf{A^y}$a produce also black recessive dogs but it will not be possible to distinguish them between the Groenendael in the litter. On the contrary, in a litter of Tervueren parents, black is always recessive.

Case in which fawn is diluted in sand

In all the cases studied so far, it was clear that all the Tervueren were fawn or carriers the alleles **I** which did not affect fawn colour intensity. But there are also sand Tervueren; these dogs carry the recessive allele i which reduces fawn intensity.

Let us mate two Tervueren $\mathbf{A^yA^y}$ carriers the dilution alleles **Ii.** This example explains why in a litter of Tervueren, we can find fawn with sand.

x	$\mathbf{A^y}$, **I**	$\mathbf{A^y}$, i
$\mathbf{A^y}$, **I**	**AyAy , II**	$\mathbf{A^yA^y}$**, I**i
$\mathbf{A^y}$, i	$\mathbf{A^yA^y}$**, I**i	$\mathbf{A^yA^y}$**,** ii

We find the genotype proportion **1 : 2 : 1** according to Mendel's second law. Among the possible combinations, there is one Tervueren with double allele ii. This is a sand. One other is fawn **II** non-carrier of allele sand and the last two ones are **I**i, who carry the recessive allele like their parents. If a total of 75% are fawns, 2/3 of them are sand allele carriers.

We must remember that the mating of Tervueren sand will only produce sand. This is also true for the Groenendael. If we replace in the table above $\mathbf{A^y}$ with $\mathbf{K^B}$, we will no doubt have all Groenendael as the recessive i does not dilute black colour. But half of the Groenendael are carriers of one allele i and quater has the same allele in pair.

b) Matings between long hair and short hair

Groenendael x Malinois

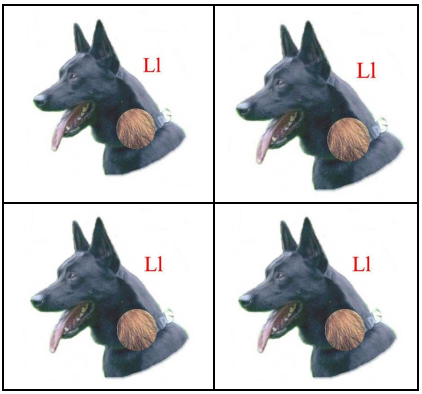
Let us mate a Groenendael ll, $\mathbf{A^yA^y}$, $\mathbf{K^BK^B}$ homozygote with a Malinois **LL**, $\mathbf{A^yA^y}$, kk homozygote for both colour and hair length. This is the simultaneous combining of two pairs of alleles: short and long hair, on one hand, and black and fawn colour, on the other hand. What is the resulting genotype?

x	l $\mathbf{A^y, K^B}$	l $\mathbf{A^y, K^B}$
L $\mathbf{A^y,}$ k^y	**L**l $\mathbf{A^yA^y, K^B}k^y$	**L**l $\mathbf{A^yA^y, K^B}k^y$
L $\mathbf{A^y,}$ k^y	**L**l $\mathbf{A^yA^y, K^B}k^y$	**L**l $\mathbf{A^yA^y, K^B}k^y$

As consequence, we obtain all Black short Hairs **L**l**,** $\mathbf{K^B}k^y$**,** $\mathbf{A^yA^y}$ heterozygotes as well for both colour and hair lenght (**L**l). Indeed,

- all will be black because the allele $\mathbf{K^B}$ is epistatic over $\mathbf{A^y}$,
- all will have short hair **L** as short hair dominates long hair l.

Phenotype appearance:

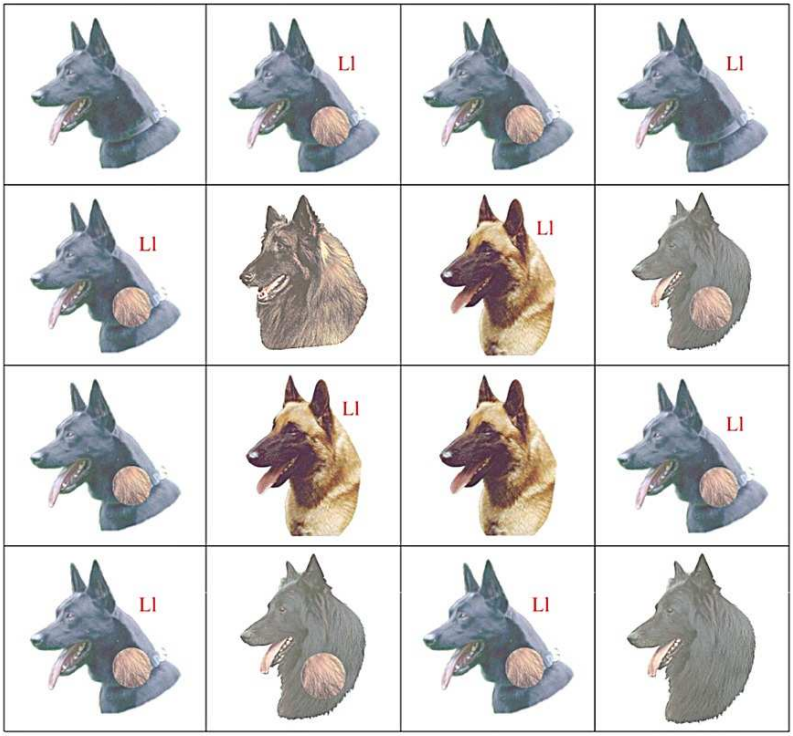


F_1

If we mate two heterozygotes from this first litter F_1, we obtain the following genotype proportion:

x	**L** **A^y, K^B**	l **A^y,** k^y	**L** **A^y,** k^y	l **A^y, K^B**
L **A^y, K^B**	**LL** **A^yA^y, K^BK^B**	**Ll** **A^yA^y, K^Bk^y**	**LL** **A^yA^y, K^Bk^y**	**Ll** **A^yA^y, K^BK^B**
l **A^y,** k^y	**Ll** **A^yA^y, K^Bk^y**	ll **A^yA^y,** k^yk^y	**Ll** **A^yA^y,** k^yk^y	ll **A^yA^y, K^Bk^y**
L **A^y,**k^y	**LL** **A^yA^y, K^Bk^y**	**Ll** **A^yA^y,** k^yk^y	**LL** **A^yA^y,** k^yk^y	**Ll** **A^yA^y, K^Bk^y**
l **A^y, K^B**	**Ll** **A^yA^y, K^Bk^y**	ll **A^yA^y, K^Bk^y**	**Ll** **A^yA^y, K^Bk^y**	ll **A^yA^y, K^B K^B**

The above Punnett's square is converted into a comprehensible or visible illustration below:



From the 16 individuals, 4 are homozygotes: 1 Black Short Hair, 1 Groenendael, 1 Malinois and 1 Tervueren. The other twelve are heterozygotes either because of he hair texture or the colour or for both colour and hair length. The detailed result is the following:

Colours	**Varieties**	**Homo-zygote**	**Heterozygote**		
			Colour & hair	**Colour**	**Hair**
12 black	9 black short hair	1	5	2	1
	3 Groenendael	1		2	
4 fawn	3 Malinois	1			2
	1 Tervueren	1			

We find the genotypical proportion of **9 : 3 : 3 : 1**. We can state that every trait is inherited independently of the others. This means that offspring can possess combinations of genes that neither parent possesses. **This is known as the Mendel's third law and is also called the principle of independent assortment.**

Mating a recessive black homozygote Groenendael ll, k^yk^y, aa with a Malinois homozygote **LL**, k^yk^y,$\mathbf{A^yA^y}$, results in the generation F_1 to be all heterozygotes Malinois (**L**l, k^yk^y, $\mathbf{A^y}$a) for both colour and hair length.

If we mate two heterozygotes from this first litter, what will happen? We will have the mendelian proportion 1 : 2 : 1 as following:

1 homozygote Malinois **LL**, k^yk^y, $\mathbf{A^yA^y}$
2 heterozygotes (for colour and hair) Malinois **L**l**,** k^yk^y, $\mathbf{A^y}$a
1 homozygote Groenendael ll, k^yk^y, aa

Tervueren x Malinois

Mating Tervueren x Malinois produce only fawn colour. In the first generation they will all be short hair Malinois, at least in appearance, but in the second generation, concerning hair length, we have the Mendelian proportion of one homozygote Tervueren ll, two heterozygotes Malinois Ll and one homozygote Malinois **LL**. Remember that the dominance of short-haired on the long-haired is not complete in all cases and can produce semi-long hair.

In the first issue of the magazine (1978/1979) of the *Royal Club Groenendael*, J. Yves Dambrain (kennel: du Maugré) gives us a few interesting points of observation.

With the advice of F.-E. Verbanck, I did an inter-variety mating Tervueren x Malinois. All the puppies of this first offspring were Malinois (heterozygotes for the length of the hair). So, from this first generation, I had often Tervueren in the Malinois litters. At first, too neophyte probably, I could not make the difference between long hair and short hair during the first weeks of their life. When the puppies were three weeks old, the long hair appeared. At four weeks, I could put them in their variety. In time, with meticulous observation, I came to these findings. Tervueren puppies are born darker and remain so until after weaning. They have more mask than the Malinois. From the first week, the hair on the skulls of Tervueren becomes bright when it is not in short hair. I carefully noted these observations.

Some say that Malinois born very dark and it's true, but these puppies have very quick more pale hairs which does not happen in Tervueren. Later, I saw almost all these long-haired in adulthood and I compared them to the short-haired of the same litters. I had to admit that the Tervueren, in great majority, had more mask than their brothers and sisters Malinois; they were generally higher and they were also more big-boned.

Is it by chance? Perhaps, but these observations are over thirty long-haired adults. Other breeders may have done the same or other observations but did not speak out. I noticed that even some Malinois females mated to different males, of various origins, gave birth to excellent long hair while their young with short hair were common. Why?

From this I concluded, probably too hastily, that the long hair gene carried not only the characteristic of the long hair, but

contains an influence on colour and skeleton. More observations will confirm or refute these initial findings.

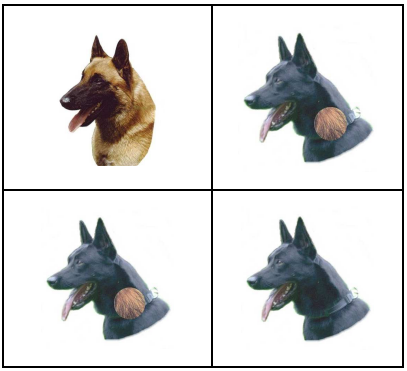
To conclude this chapter, here is an interesting excerpt of the magazine *L'Aboi* dated 1 December 1945 about the mating long hair x short hair, in which G. O'Breen expressed the following:

Of course, the pitfall to avoid is, in the first place, the production of semi-long hair and secondly, to put them in hands of inexperienced breeders. In the shows, judges can penalize dogs with semi-long hair. It should be noted that, for breeding, semi-long hair is not necessarily a bad thing. Issued from families of correct pedigrees, the semi-long hair may be useful in breeding of the long hair or the short hair because it is in itself not lacking in certain qualities; but it must be used carefully and appropriately, what not all breeders are capable of.

C. Matings between short hairs

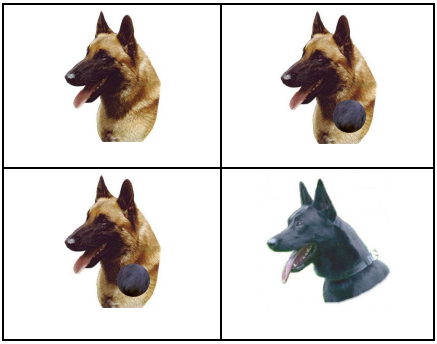
Concerning black short-haired, there are two possibilities:

a) The mating of a homozygote Malinois $\mathbf{A^yA^y}$ with a dominant black short hair $\mathbf{K^BK^B}$ in the first generation produces only heterozygote black short-haired $\mathbf{K^BA^y}$ dogs. In the second generation, there will be one homozygote Malinois $\mathbf{A^yA^y}$ and one homozygote black short-haired $\mathbf{K^BK^B}$ against two heterozygotes black short-haired $\mathbf{K^BA^y}$.



With short hair dominant black ($\mathbf{K^B}$), the two main characters, short hair and black hair, being dominant, can always hide the long hair or the fawn colour without easy detection. Therefore, the combinations are multiple and it is probably one of the reasons why this kind of mating has not been more successful.

b) The mating of a homozygote Malinois $\mathbf{A^yA^y}$ with a recessive black short hair aa produces in the first generation only heterozygote Malinois $\mathbf{A^y}$a. In the second generation, there will be one homozygote Malinois $\mathbf{A^yA^y}$ and one homozygote black short-haired aa against two heterozygotes Malinois $\mathbf{A^y}$a.



With short hair black recessive (aa), the combinations are more simple.

In excommunicating the variety of short black hair, don’t have we sin against the preservation of genetic variability by removing the ability to adapt to a modification of the objectives of the breed? The short black hair, together with the Malinois, could it not be a solution to transfer, by matings well thought, qualities to the Groenendael, today's in difficulty?

d) Matings with rough hair

Rough hair differs completely from other varieties due to hair texture. Except for some very rare cases of black colour, rough hair is only historically present under the fawn colour and the dark ash-grey colour. The dark ash-grey has been extinct for many years because it carried a lethal allele, said F.-E. Verbanck.

In an article published in March 1920, Ch. Huge made some interesting comments with regards to rough hair texture:

In regard to rough hair, reproduction will be easier if we accepted the mating with short hair. First, we can say that this rough hair texture is not definitive. When rough-haired mated rough-haired begin to produce Barbet’s hair, in other words when the undercoat covering the rough hair becomes soft and forms a kind of down, it is time to turn to short hair and preferably to short hair coming from two rough-haired or from a rough-haired mated with short hair or finally from short hair having thick hair.

But it is not advisable to breed rough hair with long hair, as the rough hair always tends to become too long. Short hair with

long hair offers fewer disadvantages, but it is not more officially accepted, in order not to go back to producing too many semi-longs, which would again require careful selection through many generations (in general three before finding the pure family in any of both directions, according to the mendelian theory).

In the same magazine *Chasse et Pêche* from 17 September 1922, Charles Huge even said:

> Concerning hair texture, if there is a mating that should be avoided if possible: it is the mating of long hair with rough hair, which is a waste of time, often three generations, because of the furnishings on the muzzle. It should only be used when necessary in order to benefit from a really extraordinary breeding dog. But short hair, of any colour, is necessary to avoid the rough hair becoming soft. I have always returned to mating after three or four generations as rough hair is not a definitive hair.
> Ask the breeders of Brussels Griffon (fawn rough hair) if the Small Brabant (fawn short hair) is not included in their success?

B. Breedings with a different breed

Attempts to create new breeds are not absent. There are, and there have been many attempts to breed the German shepherd (and also other breeds) with our Malinois. That happens mainly with working dogs.

Certainly, in the first generation, the union of hereditary qualities of two individuals of different breeds often engenders individuals with superior qualities and higher height to their

parents. It is the heterosis phenomenon or hybrid vigour. But then, the obtained qualities retrogress rapidly if we use those crossbred dogs for breeding. In fact, Mendel's characters segregation law will be applied and the heterosis effect will disappear over the next generations.

In the article *Useful breeding and Dangerous breeding* which was published on 17 September 1922 in *Chasse et Pêche*, Charles Huge strongly criticised the danger of breeding between breeds and specially that of the crossbreeding with the German Shepherd who has very different characteristics, so different that the patterns do not fit.

C. The usefulness of inter-variety mating

The Belgian Shepherd is one breed with several varieties. In order for the phenotype and genotype to stay the same among the varieties, inter-variety matings are necessary. The absence of these matings would move the varieties away from each other, with the evident danger of creating individuals of very different types that could have characteristics so distinct that they would no longer be varieties differentiated by hair texture only.

The omission of a global formulation for the colours or for the whole of the varieties, has harmed the uniqueness of the breed. What was the interest to exclude the small varieties? None on a genetic level. On the contrary, by doing so, we eliminate the more or less 50.000 chromosomal "travel companions" found in the dog's genetic heritage. We know that recessive genes cannot be eliminated and the breeders would no longer feel obliged to eliminate the so-called nonconforming puppies.

Charles Huge in "*Useful Breeding and Dangerous Breeding"*:

No, a variety has never going downhill because there were at the same time other colour and hair varieties, with of course, the same general characteristics. That is a concept that the facts have proven wrong after forty years that I attentively examine its evolution; but the opposite has been fatal for all breeds where the choice of coat has been too exclusive. Provided that the colour is tolerable, whatever the colour of its coat, don't hesitate to use it.

Let us also quote F.-E. Verbanck ("*Several varieties but ONLY ONE BREED"* published in the magazine *La Vie Canine* in June 1964) who issues the following warning:

Breeding between different varieties has to be carefully considered attempts, made for a well-defined purpose, knowing full well that it will prove to be a lengthy business, whose positive results will only be obtained after several generations. Our opinion has not changed, on the contrary, breeding between different varieties, performed by serious breeders, have shown their merits. Each time that a regeneration is necessary in one of the varieties of our Belgian Shepherds, it is only in the other varieties that we can find the necessary elements.

The arguments to justify the prohibition of inter-variety matings abound. Regarding the hair texture, mixing long hair, short hair, rough hair gives a quite large variety of patterns due to the phenomenona of incomplete dominance. For the colour we can equally find arguments. As heterozygotes are often less beautiful than homozygotes, breeders, for quality purposes, are interested in selecting the varieties for themselves and to avoid inter-variety matings. That leads to genetic isolation,

morphological and/or temperament differentiation (‘working dog’ on one side, ‘companion dog’ on the other, for example).

So what is the place of the varieties in the genetic management of a breed? There are multiple reasons in favour of a sufficient genetic variability in the Belgian Shepherd dog breed. Some of them are:

- ✓ Preserve good breeding qualities for the Belgian Shepherd (fertility, strength, etc.). As many abnormalities are recessive, the reduction of the genetic variability increases the frequency of heir appearance.
- ✓ Preserve a certain homogeneity among the different varieties. Too evident morphological and temperament differences between the different varieties must be avoided.
- ✓ Preserve the possibilities of evolution or modification for the Belgian Shepherd which imply maintaining a certain variation. The required model at a certain period in time will not necessarily be the model 30 years later.

As conclusion, I do not find any inconvenience in defining well described varieties, nor to prefer them, but I do find many problems that impoverish the breed by depriving it of valuable elements whose only flaw is a question of colour, valued according to criteria that change throughout the years. Let’s use our energy to fight hereditary diseases like epilepsy or sterility, structural defects like hyper-type (light structure, head too long, lack of stop), teeth defects like prognathism and character defects like shyness, the timid dogs which can not look after property or are incapable of

defending their owner. The Belgian Shepherd Dog, before all colour consideration, is or should be a Shepherd dog with all implies its **breed type, gait and temperament**. All that seems to me more important than excluding certain colours which historically and genetically belong to our native breed.

Grey, Sable or Sand?

The FCI General Committee, at its meeting end of July 2009, approved a synopsis of Prof. Bernard Denis's book « *Coat colours in dogs* ». This summary « *Standardized Nomenclature of Coat Colours in dogs* » is to be regarded as the official reference for the description of coat colours in dogs. All amended standards and the new ones should comply with this standardized nomenclature (see the circular 90/2009 on the FCI website). In France, the new nomenclature is already applicable for the pedigrees.

« *The necessity of standardizing the terminology of coat colours in dogs has been felt for a long time,* explains Prof. Bernard Denis. *It is a fact that from one breed to another it happens that he same word designates different colours or, on the contrary, the same coat is given in very different descriptions. Furthermore, traditional nomenclature often deliberately employ imaginative terms to describe a colour*

rather than taking into account the precise nature of the basic coat. »

The « **fawn with black overlay** » is characterized by the presence of bi-pigmented hairs (fawn at the base, black at the end) interspersed with entirely black hairs. It is the colour of the Malinois and the (fawn) Tervueren. « Overlay » alone indicates that it is black. Otherwise, it is necessary to specify the colour. For example « brown overlay ». For the mask also, « mask » implies « black mask ». Otherwise, it is necessary to specify the colour. It is, therefore, necessary to state the extent of overlay (at the least: slight, moderate, heavy); however, if the precision is missing, it can be considered as a synonym for « moderate overlay ». For the Laekenois (rough hair), the standard accepts that the overlay is expressed more discreetly: « *with traces of black overlay* ».

For the Tervueren, the standard accepts the « *grey with black overlay* » and classifies the « *grey* » among the faults. Because of the larger or lesser amount of black overlay on a light background (diluted fawn), we get an impression of a grey colour. « Grey », in genetics, is another phenomenon. Greying is a progressive change resulting in a lightening of the hair coat as the dog gets older. The greying gene occurs on the **G** locus which is not a gene belonging to the Belgian Shepherd Dog. Examples are the « Bouvier des Fandres" or the "Poodle ».

In reality, what is it? Under the action of an allele that decreases the intensity of phaeomelanin (in this case the recessive allele "i" from locus I - Intensity) fawn becomes in « **sand** » (term of the standardized nomenclature) but without diluting the black eumelanin (black overlay, mask, etc.). « Grey with black overlay » becomes « **sand with black overlay** ».

What then is « sable »? It is the French word for « sand » (or “grey” in the actual FCI BSD standard). It is used to indicate the shade of colour that comes only from fawn dilution. But also take into consideration that, in order to denominate all the shades of phaeomelanin colour, English-speaking geneticists often use the word « sable ». To resume:

English-speaking geneticists	FCI BSD standard		FCI Standardized nomenclature	
	French	English	French	English
sable	fauve	fawn	fauve	fawn
	gris	grey	sable	**sand**

In the standard the coat colour of the Groenendael is described as « uniform black ». This is in contradiction with another part of the standard that tolerates a little white on chest and toes for all varieties of the Belgian Shepherd. The term « black » is mentioned in the standardized nomenclature without any other specification.

In conclusion, an update of terms used in the standard in accordance with the standardized nomenclature, and in close relationship with the terminology used in genetics, would mark a major step forward for better accuracy and understanding coat colours in dogs.

March, 2015.