Coat Colour Inheritance in the PWC

By Juliana du Pree

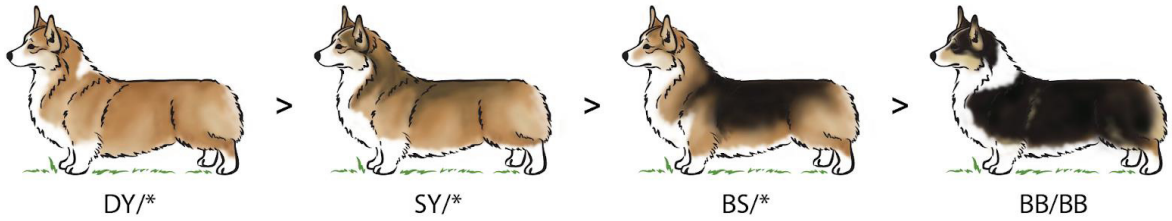
Coat colour genetics in the PWC is relatively straightforward once you have a handle on the basics. That said, the basics can be pretty daunting unless you have a background in the sciences or a somewhat masochistic streak like I must since I'm an artist, not a scientist! Bear with me, it does get easier to understand. Refer to the glossary of terms at the end of this article for more information on the terms used here. As I'm no expert, apologies for any errors, omissions or misunderstandings.

The colour genes of the Pembroke falls primarily on the A (Agouti) Locus and does not have any other notable locus interactions that affect the outcome of their primary colour as Cardigans do with Merle (M Locus), Brindle (K Locus), and Clear red (E Locus). The only exception to this is Dilute (D Locus) which causes bluies. Generally a Pembroke will be **homozygous EE KyKy BB DD mm**, thus allowing the A locus genes to show through – this means we can focus only on one locus and not worry about the others. This makes it relatively easy to determine what alleles each puppy in your litter might be carrying.

The A Locus controls what yellow/red pigment (pheomelanin) or black pigment (eumelanin) is produced and where it is on the body. New research, published in 2021, gave more insight into how the Agouti ASIP (Agouti Signaling Protein) alleles control these pigments. ASIP alleles associated with a yellow/red colour are dominant to black.

Listed in order of dominance

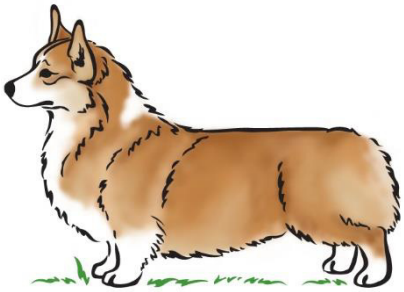
Gene	**Genetic Term**	**PWC Breed Term**
$ASIP^{DY}$	Dominant yellow or clear red/sable (DY)	Red or Fawn
$ASIP^{SY}$	Shaded yellow or shaded sable (SY)	Sable
$ASIP^{AG}$	*Agouti (AG)*	*Wolf Sable (not present in PWC)*
$ASIP^{BS}$	Black Saddle (BS)	Red Headed Tricolour
$ASIP^{BB}$	Black back (type 1, 2, 3) (BB)	Black Headed Tricolour
$ASIP^{a}$	*Recessive black (a)*	*black with no tan (not present in PWC)*



The basics of colour in the PWC:

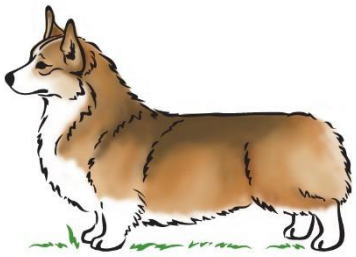
With each main colour, there is variation in expression based on other factors including: the intensity of red (almost white to irish setter), the boundary locations of red and black on a tricolour, whether or not there is a mask on the muzzle/head, and irish spotting (white markings) can cover any of these areas, thus hiding the pattern.

Red (ASIP^{DY}- Dominant yellow or *clear red/sable*)
Clear red is a red & white dog with no obvious black hairs, though some may be present in the coat in small quantities. Red is dominant over all other colours and the secondary colour gene is not visible. A dog only needs one copy DY to be visibly red.



Sable (ASIP^{SY}- Shaded yellow or *shaded sable*)
Shaded sable is what we describe as sable & white. The sable can vary from a light sprinkling, to a heavy coverage of black that almost makes a dog appear tricolour. The amount of sabling present is likely dependent on the secondary colour gene the dog carries. Sable hair is banded - red at the base, black at the tip due to the red and black pigments turning on and off at certain points in the growth cycle.

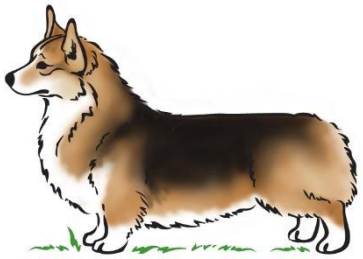
Pure for sable (SY/SY)



Sable, RHT factored (SY/BS)

Sable, BHT factored (SY/BB)

Red Headed Tricolour (ASIP^{BS}- Black saddle)
Black with tan point genes are recessive to Red (DY) and Sable (SY). A dog must have 2 copies of this gene to appear to be tricolour. In the case of a RHT the tan will creep over the lifetime of the dog and create a black saddle, how much is determined partly by which secondary colour gene the dog carries. A dog that is BS/BS will creep more than a dog that is BS/BB.



Red Headed Tri (BS/BS)

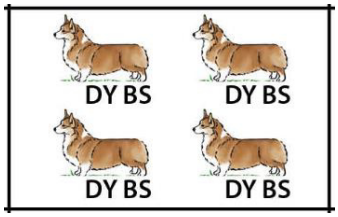
RHT, BHT factored (BS/BB)

Black Headed Tricolour (ASIP^{BB}-Black Back)
What we term a Black Headed Tricolour (BB) is the traditional black with tan point pattern – showing tan on cheeks, eye pips, elbows and hocks. The insides of the ears will remain black. It is is the most recessive gene on the A locus. A dog must have 2 copies of this gene to appear to be BHT (BB/BB). The BHT pattern does not change over the course of the lifetime of the dog.

Punnett Squares

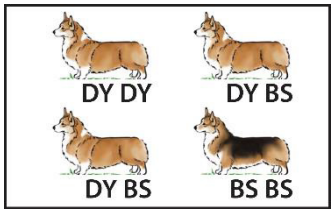
Going back to High School Biology class: every dog has two primary colour genes that they receive, one from each parent. Thus for each puppy there are 4 possible outcomes.

Example #1: Starting off simple. Sire: Pure for Red (DY/DY). Dam: RHT (BS/BS). Each parent can only give a single option since they are both homozygous for their colours, thus every puppy will have one red gene and one RHT gene.



	DY (red)	**DY (red)**
BS (RHT)	DY/BS	DY/BS
BS (RHT)	DY/BS	DY/BS

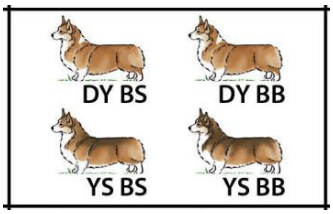
Example #2: Sire: Red dog that carries RHT (DY/BS), Dam: Red bitch that carries RHT (DY/BS).



	DY (red)	**BS (RHT)**
DY (red)	DY/DY	DY/BS
BS (RHT)	DY/BS	BS/BS

In this case, each puppy has a 50% chance of being red, carrying RHT (DY/BS), a 25% chance of being pure for red (DY/DY), and a 25% chance of being RHT (BS/BS).

Example #3: Sire: Red dog that carries Sable (DY/YS), Dam: RHT bitch that carries BHT. (BS/BB).



	DY (red)	**SY (sable)**
BS (RHT)	DY/BS	YS/BS
BB (BHT)	DY/BB	YS/BB

In this case, each puppy has a 25% chance of being red, carrying RHT (DY/BS), a 25% chance of being red, carrying BHT (DY/BB), a 25% chance of being Sable, carrying RHT (YS/BS), and a 25% chance of being Sable, carrying BHT (YS/BB)

For quick reference of all the possibilities, please see the Matrix.

Clear as mud? Just remember the order of dominance is the same as it's always been (Red > Sable > RHT > BHT) and that there is a big variation in the degrees of expression. There is still so much we don't know about colour genetics and how all the genes interact to give us the range of shades and patterns in our breed. Hopefully we will see more research being done to help demystify it in the future.

Glossary of Terms:

- Genes: genes control all the info stored in DNA.
- Alleles: variants of genes, in pairs - one from each parent.
- Locus/Locii: the position of a gene on the chromosome
- Genotype: an individual's collection of genes.
- Phenotype: is the observable characteristics or traits.
- Eumelanin: black pigment present everywhere on a dog, from coat, to nose leather.
- Pheomelanin: Red pigment present only on the coat. This does not affect nose, eye rims etc.
- Dominant vs Recessive: Every dog carries two alleles at each locus. The dominant gene is the one we observe phenotypically, the recessive is not observed but is present genotypically.
- Heterozygous: pair of genes where the two genes are different.
- Homozygous pair of genes where the two genes are the same.

Further reading:

Dog Coat Colour Genetics - one of the best sites available to learning about colour genetics.
*Not totally up to date with the available research on the A Locus

- Dog colour patterns explained by modular promoters of ancient canid origin - 2021 study on Agouti (ASIP)
- UC Davis A locus testing
- PWC colour outcome matrix