Inheritance of coat colour in the Nova Scotia Duck Tolling Retriever

Claire Wade

The standard for the Nova Scotia Duck Tolling Retriever describes the breed as having the coat and colour characteristics outlined below:

Coat and Colour

The Toller was bred to retrieve from icy waters and must have a water-repellent double coat of medium length and softness with a softer, dense undercoat. The coat may have a slight wave on the back, but is otherwise straight. Some winter coats may form a long, loose curl at the throat. Featherings are soft at the throat behind the ears and at the back of the thighs, and forelegs are moderately feathered. While neatening of the ears and feet is permitted, the Toller should always appear natural. Colour is various shades of red or orange with lighter featherings and underside of tail, and usually at least one of the following white markings — tip of tail, feet (not exceeding beyond the pasterns), chest, and blaze. A dog of otherwise high quality is not to be penalized for lack of white. The pigment of the nose, lips and eye rims should match, and be flesh coloured, blending with coat, or be black.

-http://www.toller.ca/standard.html

Coat colour in dog breeds is heavily influenced by several different genes. The limitation that the Nova Scotia Duck Tolling Retriever should be red or orange surprisingly still allows variation at several of these genes to influence what we see.

The Agouti locus (commonly termed the A-locus)

Fig 1.

http://jon-atkinson.com/Canada_Wildlife.html

The “agouti” coat colour is the colour that we frequently see on wild animals i.e. a brownish grey with variation of colour along the length of the hair (Fig 1.). During domestication of many animals, humans have selected them to differ from this basic colour to distinguish them from the wild counterparts. The gene that causes the agouti colour is called ASIP (Agouti-signalling protein).

In other breeds, colours affected by the A-locus are: a. solid (also known as non-agouti or self-colour) (lower-case a), b. sable (Ay), c. saddle pattern (As) and d. tan points (at) (Fig 2.)

In the toller we only see the effects of the Agouti locus if a dog is not clear red (more about this later). Agouti tollers are typically brown sable or brown with tan points (similar to dogs b. and d. in the pictures in Fig. 2, but with brown replacing the black). On sable dogs, the darker tips of hairs typically become lighter over time and so an adult Ay sable toller is often indistinguishable from a clear red toller. In Fig. 3, the pup second from the right is a sable and possibly the one behind also. The most obvious distinguishing feature in pups is a “widow’s peak”. Typically the tips of the ears and the tip of the tail are darker. Typically the nose is darker (brownish rather than a true flesh colour) and remains so. Some brown tipping may remain into adulthood. If the main underlying fur colour is black then the tipping can be black. In Australia, a well-known black-tipped sable dog is Gundi (Lidlriva Onyx Gundi). In tollers, the sable coat is most common (even if you are unable to observe it because of clear red) and this is dominant over the tan-pointed coat. This means that a

dog needs to inherit tan points from both parents to have tan-points and that this will only be seen if the toller is not clear red (EE or Ee at the E locus).

The Brown locus (B-locus)

Fig 2.

a. b. c. d.

The nose colour in all tollers and the hair tipping colour in the agouti tollers is controlled by the b-locus. The gene coded by this locus (called Tyrosinase Receptor protein 1 TYRP1) is thought to alter the shape of the pigment granule in the hair which changes the way the hair refracts light. The effect is to alter a black coat to brown. This is the major gene that changes black Labrador retrievers to brown. The brown version of the gene is the most common in tollers and it is recessive. In some breeds (such as the Australian Kelpie) the brown dogs are called red. Names for the same phenotype are red, brown, chocolate, and liver. The brown gene is recessive (you need two brown genes to see it), therefore to get a black-nosed toller, you need to breed with at least one black-nosed parent. In tollers there are at least three different versions of this gene that seem to code for flesh-coloured nose (most common), medium dark nose (common in the Glenmave bitches) and a very dark nose (Edlyn Seastar Dodge N Burn, Lidlriva Delphi). To avoid black tipped sables and black and tan tollers, avoid breeding a black nosed dog with a sable bitch or vice versa.

Fig 3. Clear red and sable toller pups at Tolleron kennel

The Extension locus for "clear red" (E-locus)

The most common red that we see in tollers is driven by the extension locus. The gene in this case is the same one that makes red-hair in people and chestnut in horses. The name of the gene is melanocortin-receptor 1 MCR-1) and it is recessive (two copies are needed to observe it). If you

breed clear red with clear red then you will always get clear red. Because there is no tipping on the fur, you can get a clear red dog with a black nose without any off-standard colours. In Fig. 3 four of the pups are clear red.

In hair there are two types of pigment. Black and brown hues are driven by a pigment called eumelanin, while red and yellow hues are caused by a different pigment pheomelanin. Agouti visible dogs (Ee or EE) produce both types of pigment in their hair, whilst clear red dogs (ee) are only capable of producing red or yellow tones (the eumelanin doesn't work). The hue of red that we see in the toller is related to two different loci.

The intensity locus (KITLG-Related)

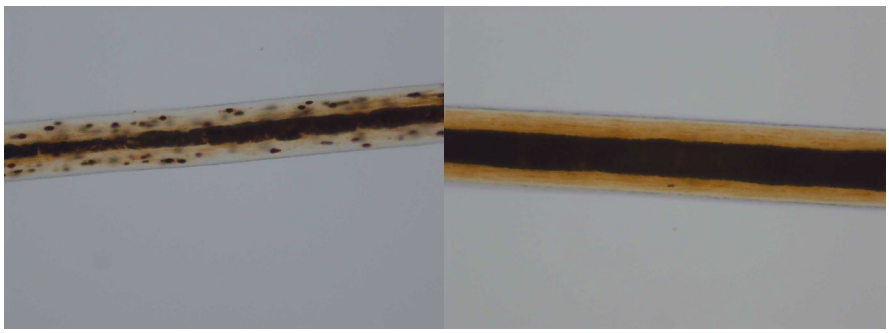
This locus, first described by Danika Bannasch's team in 2020 is comprised of a segment of DNA that interferes with a pigmentation gene close by called KIT-Ligand (KITLG). Danika is a toller breeder with the prefix Aqeus and is also a Professor of Genetics. The insertion has a variable number of copies. The more copies, the darker the pigment. This might be quite challenging to test for as copy number events in DNA can grow and shrink with some amount of randomness. However, if the dog has only a single copy, this will usually be faithfully replicated and the toller will be a paler shade of red but not buff (e.g. GMH CH Foxgrove's Annie Get Your Gun WCX, CD https://www.k9data.com/pedigree.asp?ID=763928) who is the mother of Foxgrove's Afterburner who has been used in Australia.

The dilution locus (D-locus or buff)

The gene causing buff dilution in tollers is recessive. Therefore buff tollers have two copies of the dilute version of the gene (dd) and it must be inherited from both parents. This gene affects the transport of pigment granules into the hair shaft. When the recessive allele is present in two copies, the pigment enters the hair shaft in clumps rather than as a smooth flow. This affects the refractive quality of the hair making it appear both lighter and to have a mauve/silvery tint (think Weimeraner which is a dilute brown dog). A very dark red toller genetically that is dilute at this locus can be nearly indistinguishable from a lighter red non-dilute toller. In some breeds, dilute coat colour is associated with other skin problems which are caused by the clumps fracturing the hair shaft and creating a "shaving rash" effect that fosters skin infections. Luckily this does not seem to occur in tollers, possibly because the hair is soft. Weimeraners also seem unaffected by this problem.

Fig. 4 Dilute and normal toller hair

a. eedd b. eeD? (? means d or D)



White markings

The major gene causing white markings in dogs is called MITF (Melanocyte inducing transcription factor). But it is very likely that other genes may also play a role. It is not the protein coding from this gene that affects the patterning of white on the dog, but it is the switches that control how often and how fast this gene is used. The switches control how far the pigment travels around the embryo and this begins at the spine (which is why it is the tips of the toes, nose and tail that often miss out on pigment) and is mainly active before a pup is born, but there must be some activity that remains after that because it is not uncommon to see the amount of white on a toller "shrink" as it ages, so that a mismark may be reduced to just a few hairs. In tollers, there are at least five different variants of this gene, and each has a subtle effect on the markings. There is some degree of chance also. It is possible for two dogs with the same genes for white markings to have a different distribution of white. Clear red dogs will typically have more white than sable dogs in the same way that chestnut horses typically have more white than bays.

Glossary

Gene: a piece of DNA that is interpreted by the body to be the template for a particular protein

Locus: a place in the animal's chromosomes (usually where a gene is located that influences a trait we care about)

Genotype: the combination of variants for a particular gene

Allele or variant: different versions of the same gene

Recessive gene: two copies of the same variant are needed to see the effect of the variant for two variants at the E locus (E -> not clear red variant) (e -> clear red variant). We inherit one variant for each gene from each parent.

		Sire (looks sable) genotype is Ee	
		E	e
Dam (looks sable) genotype is Ee	E	EE (not clear red – can see the effect at the A locus)	Ee (not clear red)
	e	eE (not clear red)	ee clear red

Sample Toller genotypes and appearance (phenotype):

	A locus	B locus	E locus	D locus
Clear red with flesh nose	?? (could have anything here)	bb	ee	D? (not dilute)
Clear red with dark nose	?? (could have anything here)	B? (has at least one big B)	ee	D? (not dilute)
Buff with flesh nose	??	bb	ee	dd
Buff with bluish nose	??	Bb	ee	dd

Sable with brown tips and dusky or flesh nose	Ay?	bb	E?	D?
Sable with dark tips and very dark nose	Ay?	B?	E?	D?
Brown and tan	atat	bb	E?	D?
Black and tan	atat	B?	E?	D?

Brancalion, L., Haase, B., Wade, C.M. (2021) Canine coat pigmentation genetics: a review. Anim Genet :, 2021. Pubmed reference: 34751460. DOI: 10.1111/age.13154.