

Puli Coat Color DNA Study

an update and information page for the owners of Puli who have contributed DNA brushes to the study

This pdf was prepared in January 2021 from a webpage last updated on December 3, 2007 by Sheila Schmutz, PhD

We are grateful to Linore Cleveland for coordinating the samples, photos, consent forms, etc. for this study. The first DNA brushes arrived at our lab in Saskatoon in May, 2005. Susan McConnell has agreed to present an update about this study at the 2005 specialty.

DNA analysis was conducted in the lab of Sheila Schmutz at the University of Saskatchewan, Saskatoon. Interpretation is a collaborative effort with Dr. Sue Ann Bowling, Alaska who initially suggested studying this breed.

Puli Colors

The most common color for Puli is black. They also occur in white. Fako is a Hungarian term used to describe Puli of other pale colors. Some Puli are called apricot. Colors other than black and white are not allowed to be shown in all countries.

Useful references on Puli color were provided by Sue Hopgood of Great Britain. She had saved an article entitled "Coat Colour and Pigmentation and Its Inheritance" from a breed club magazine. A book entitled "The History of the Puli" written by Arany Csaba in 1998 was particularly helpful. This book mentions pale pups born to two black parents and black pups born to two black parents, which implies that either Puli have two forms of black or two forms of fako.

Some black Puli gray with age. Whether this is the progressive graying similar to Poodle silver or whether it is more that some white hairs gradually occur amongst the black ones, is not clear.

Libbye Miller is a vet who has worked with us on a color study in Belgian Sheep Dogs. She co-owns a white Puli too. She noted: "Since they don't shed, the cords grow continuously and it takes them about 5 years to reach the ground. The cords are like a little diary of the changes in their coat color over the years. And if you let the white Puli work in a field with those purple poke berries...you'll have to hear about that for years too!". This is certainly not typical of most other dogs breeds and may affect the way color is "seen" in Puli.

E* or *MC1R

There are 3 common alleles at this locus. *E*, *e*, and *E^M*. At the time this DNA study was done, only these were known, but since then other alleles that are more rare have been identified in other breeds. "Melanistic Mask" is caused by the *E^M* allele and results in eumelanin pigmented hairs on the muzzle. *E^M* is the top dominant allele at the E locus. In other words, *E^M* > *E* > *e* in its effect on phenotype. We had found both the *E* and *e* alleles in Puli in the original study.



Danka and Dalia as pups



Dalia, as an adult

Although the Puli pups above, Danka and Dalia, appear to have melanistic masks, unless these persist into adulthood, it is not considered a mask. Chows and Akitas are all typically born with dark muzzles, but in Chows they all fade as they age. Whereas in Akitas, those dogs without an *E^M* allele fade, and those with at least one such allele, remain.

Dalia is a male Puli with an *E/E* genotype. His coat color is known as fako, often called masko fako. Puli do not seem to have a full melanistic mask caused by the *E^M* allele. Instead, like Chows, their puppy mask fades as they grow into adulthood. Fako may encompass more than one color, but we don't know that yet. Dalia is a "fawn" dog with a genotype *a^y/a^y*. In Hungary, fako seems to be used for any pale color, including gray.



The photo above shows a cord from Dalia and his sibling Danka, as adults. Note that the reddish hairs have faded to cream but the few black hairs are still black.



Sadie, a black dam with an *E/e* genotype, had a litter of one reddish pup named Hector (hiding behind Blizzard in the photo), one white pup named Blizzard, and two black littermates, Raz and Madeline. Their sire was Corin, a black Puli.

The photo, above right on the previous page, shows a cord from Blizzard as an adult. In the photo below, note that the reddish hairs Hector had as a pup have also faded to a cream shade almost, but he is not as white as Blizzard. Neither Blizzard nor Hector have any black hairs. This is typical of dogs with an *e/e* genotype.



Hector, at the left retained more reddish pigment as an adult than Blizzard, middle. However, Hector faded somewhat since he was a pup. Both have *e/e* genotypes. Raz, one of their black littermates, left, has an *E/e* genotype as does the dam, Sadie.

White

Some Puli are *e/e* at *MC1R* and in the case of these dogs, one can not predict their genotype at the *K* locus. Such *e/e* dogs could be *K^B/K^B* or *KB/ky* and still not be black, since the *e/e* genotype prevents black pigmentation of hairs in dogs (but not nose leather or pads). This is an example of "epistasis".



Macintosh, above, is a white Puli with an *e/e* genotype. Therefore one cannot predict his genotype

at *K*. He had white parents, and although he has had a black pup, this pup was born to a black dam.

White appears to be inherited as a recessive to black, according to breeder experience and "The History of the Puli". If *e/e* is required for white to occur in pups from *K^B/-*, *E/-* black dogs, then it would appear to be inherited as a recessive.

Note that Blizzard is another white Puli with an *e/e* genotype. So far these are the only two white Puli we have tested, and both are *e/e*.

In 2019, Hédan et al. published that the mutation that caused dogs that were expected to be red, to be cream/white instead, is in the *MFD12* gene. Cream dogs, including the Puli in their study, are homozygous for this mutation. The "white" dogs Blizzard and McIntosh were both *C/C*, whereas the fako dog Hector was *T/T* (see their photos on p. 4)

Because it only pales phaeomelanin, such dogs can still have a black mask instead of a pale gray mask, although masks do not occur in Pulis.

Hédan B, Cadieu E, Botherel N, Dufaure de Citres C, Letko A, Rimbault M, Drogemüller C, Jagannathan V, Derrien T, Schmutz S, Leeb T and André C. Identification of a Missense Variant in *MFS12* Involved in Dilution of Phaeomelanin Leading to White or Cream Coat Color in Dogs *Genes* 2019, 10, 386; doi:10.3390/genes10050386



Black

Dogs may be black by two different genetic mechanisms. Dogs that have two "a" alleles at the agouti locus inherit black as a recessive trait. They are unable to make red pigment since their agouti gene is not functional. The "a" allele occurs in Puli and several other herding breeds. Kasa, above, is "a/a" in genotype.

Black that is inherited as a dominant, is caused by having at least one copy of the K^B allele, plus at least one copy of the E or E^M allele. This black may also occur in Puli since most breeders consider black dominant to white and fako. Kasa is E/E and K^B/k^y . Therefore, Kasa is black by both genetic mechanisms!

Keddi, a black dog with a white dam and black sire, tested E/e at *MC1R*. He is also "a/a" so would be black, even if he inherited no K^B . However his genotype is also K^B/k^y .

Proof that black can be caused by both genetic mechanisms in Puli is beautifully illustrated by Raz and Madeline, two black littermates. Raz is "a/a", but Madeline has only one copy of "a". Therefore Raz is an "a/a" black and Madeline is a K^B/K^B , E/E black.

Gray



Linda Hall took the photos of some of her grey Puli over the years and has shared them. The photo above illustrates that Puli have "progressive greying". These dogs were all born black. She refers to

them as "graying", "silver" and "black". Not all the Puli continue to go to the pale silver color. Some stay a darker grey.

As of January 2021, the gene causing progressive graying has not been identified. *G* was reported to cause this phenomenon in dogs by C.C. Little and he suggested it was a dominant allele to *g*.



Linda Hall took the photos above of Spot at 5 weeks, 12 weeks and one year of age. She says that not all Puli begin the graying process this young however.

Links

Dog Coat Color Genetics Main Page

<http://munster.sasktelwebsite.net/DogColor/dogcolorgenetics.html>

COLOUR IS A CHALLENGE TO US ALL - thoughts about the heredity of maszkos fakó colour

Article published in Unkarinpaimenkoirat magazine 4/2002

<http://www.puli.fi/maszkosfakoeng.html>

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