DID YOU KNOW?

WHY ARE BLACK CONNEMARA'S SO RARE AND WHAT COLOURS CAN THEY PRODUCE?

Using DNA hair samples of the black Connemara stallion Kippure Lancelot, the Animal Genetics.eu colour calculator and research publications we share the inner complexities of achieving the genetic colour Black.

Kippure Lancelot's Genetic Colour as reported by Animal Genetics UK using DNA samples.

Result	What this means
EE	Homozygous Black
aa	Homozygous Agouti
gg	Negative for the grey gene
nn	Negative for the cream gene

"BUT WHAT DO THESE RESULTS ACTUALLY TELL US?"

Understanding colour genetics

Every horse has a base colour, which can be black, bay, or red. This is controlled by the Extension (Red/Black Factor) and Agouti genes. It is very important to understand that dominant means to have power and influence over others and recessive means to take a backseat where the dominant gene is present. Homozygous means to have two identical genes and heterozygous means to have two different forms of the same gene, an Allele is a version of a gene.

Red/black factor

The Extension gene controls the production of black or red pigment throughout the coat. The allele for black colour (E) is dominant over the red allele (e), so a horse only needs one copy of the black allele to appear black-based.

E/E	Black	Only the black factor detected. The horse tested homozygous for black pigment. It cannot have red foals regardless of the colour of the mate. The basic colour of the horse will be black, bay or brown unless modified by other colour modifying genes.
E/e	Black	Both black and red factors detected. The horse tested heterozygous for the red factor. It can pass on either E or e to its offspring. The basic colour of the horse will be black, bay or brown unless modified by other colour modifying genes.
e/e	Red	Only the red factor detected. The horse tested homozygous for red pigment. The basic colour is chestnut unless modified by other colour modifying genes.

Agouti gene
The Agouti gene can then modify black pigment by pushing it to the points of the horse, creating a bay. The Agouti gene is dominant, so a black pigmented horse only needs one copy of the Agouti gene (A) to appear bay. Agouti does not have any effect on red pigment.

A/A	Bay	Only dominant allele detected. Black pigment distributed in point pattern. The horse cannot have black foals regardless of the colour of the mate. The basic colour of the horse will be bay or brown in the absence of other colour modifying genes
A/a	Bay	Horse tested Heterozygous for Agouti. Black pigment distributed in point pattern. The horse can transmit either A or a to its offspring. The basic colour of the horse will be bay or brown unless modified by other colour modifying genes.
a/a	Black	Only recessive allele was detected. Black pigment distributed uniformly. The basic colour of the horse will be black in the absence of other colour modifying genes.

Why is Kippure Lancelot Black when his parents are not Black?
Kippure Lancelot derives from the Grey Stallion Frederiksminde Hazy Merlin and Bay mare Kippure Kim. We don't know the genetic colour of his parents but we do know that Lancelot has inherited a black factor allele and a recessive agouti allele from both his sire and his dam. Working backwards using the colour calculator at animal genetics.eu I have calculated that the highest probability of Lancelot's parents producing black was 12.5% with some options in between that and of the lowest chance at 2.93%. Another way to look at those probabilities is between a 1 in 8 chance and a 1 in 34 chance. There was a far greater 50% chance that he would be grey but he did not inherit the fate of the grey gene.

What did we learn about colour genetics and producing black offspring?
We need at least 1 dominant black allele and 2 recessive agouti allele to produce black. Recessive allele can be hidden to the eye behind 1 dominant agouti allele. Recessive allele can only be seen by the eye in their homozygous state (two copies of the same allele/absence of a dominant allele) but they can also be hidden in the case of homozygous carriers of the red gene… are you keeping up? It can be tricky one to grasp. The reason black is rare is due to the need of recessive allele which are so often cancelled out by dominant allele making the chances far slimmer to produce black.

Question: Using the above information can you calculate the colour possibilities of offspring when you have a black sire and a black dam?
Try not to think of the answer by using Kippure Lancelot's DNA but by using the red/black factor and agouti tables to calculate the different variations that can create black and then calculate the ways those genes can present themselves if one gene from each parent is passed on in each scenario and finally don't forget the rule of dominant and recessive to get your prediction.

Not every horse is Black, Bay or Chestnut why is that?
Within the DNA responsible for colour there can be additional genes passed onto offspring called modifying genes, these genes can alter the base colour. A common one within the Connemara is the cream dilution gene. This gene affects both red and black pigment and is responsible for 'diluting' the carrying horse. The Cream dilution is the gene responsible for palominos, buckskins, cremellos and smoky blacks.

Horses which carry one copy of the cream gene are identified as single dilutes; they are heterozygous for the cream dilution gene. In the simplest case, a bay horse with a single copy of cream is known as a buckskin, a single dilute black horse is known as a smoky black and a single dilute chestnut horse is known as a palomino. Single dilute horses have a 50% chance on passing the cream gene on to its offspring.

Horses which carry two copies of the cream gene are referred to as double dilutes; they are homozygous for the cream dilution gene. A bay horse with two copies of cream is known as a perlino. A black horse with two copies of cream is known as a smoky cream and a chestnut horse that carries two copies of cream is known as a cremello. Double dilute horses will always pass on a copy of the cream gene to its foals.

Why is my Connemara going grey?
Grey is the dominant gene responsible for the gradual and progressive de-pigmentation (fading) of the carrying horse. Grey cannot be considered a base-colour, or a dilution, but rather a gene which slowly removes pigment from the coat. Grey is considered to be the 'strongest' of all coat modifiers, and acts upon any base-colour regardless of the carrying horse's phenotype. The fading process itself may last for years, but once hair is de-pigmented, the horse's original colouring will never return.

Since grey is a dominant gene, where it is present it is expressed. However, the final colour of the carrier will vary from horse to horse. Some grey horses fade to full de-pigmentation (almost pure white) whereas others may be 'fleabitten'. Fleabitten refers to grey horses with tiny non-faded spots or 'fleabites.' The grey carrying horse may also experience de-pigmentation of the skin itself, and before skin is fully faded may display 'mottling'.

Colour probabilities of offspring sired by Kippure Lancelot out of mares of different colours.
The only way to truly predict the colour of offspring is to know the genetic colour of the mare. In the table on the next page there are some examples of what colours can be produced when crossed with the colour genetics of Kippure Lancelot. It must be noted that we are looking only at base colour and the inclusion of the crème gene here, there is a further table regarding the presence of the grey gene which is often found in Connemara's.

Mare Colour	Mare Genetic Colour	Offspring probabilities
Bay	Ee and Aa EE and Aa	50% Bay 50% Black
	Ee and AA EE and AA	100% Bay
Chestnut	ee and aA	50% Bay 50% Black
	ee and aa	100% Black
	ee and AA	100% Bay
Buckskin/Palomino	Ee, Aa and nCr EE, Aa and nCr ee, aa and nCr ee, Aa and nCr ee, AA and nCr	25% Black 25% Smoky black 25% Bay 25% Buckskin
	Ee, AA and nCr EE, AA and nCr	50% Bay 50% Buckskin
Perlino	AA, Ee and CrCr AA, EE and CrCr	100% Buckskin
	Aa, Ee and CrCr Aa, EE and CrCr	50% Buckskin 50% Smoky Black
Cremello	aa, ee and CrCr	100% Smoky Black
	Aa, ee and CrCr	50% Smoky Black 50% Buckskin
	AA, ee and CrCr	100% Buckskin

Kippure Lancelot offspring probabilities where the grey gene is present.

Mare DNA	Definition of DNA result	Outcome with Kippure Lancelot
gg	Negative for grey gene	Colour possibilities as above
gG	Positive for the dominant grey gene, carrying one copy (Heterozygous). Heterozygous grey horses statistically will pass on the grey gene to 50% of their progeny.	Colour possibilities outlined above reduce by 50% despite the base colour if the grey gene is passed on the offspring will ultimately go grey, if the grey gene is not passed on the offspring will remain the base colour unless any other modifying genes are present.
GG	Positive for the dominant grey gene, carry two copies (Homozygous). Homozygous grey horses statistically will pass on the gene to 100% of their progeny	Colour possibilities outlined above reduce by 100% despite the base colour the offspring will receive one copy of the grey gene from the mother and the offspring will ultimately turn grey.

Discussion limited to common colours within the Connemara gene pool. There are other variants possible with the inclusion of additional colour patterning found in different breeds.

Answer: 75% Black 25% Chestnut