Appaloosa Genetics
And the Contributions and Benefits of our Solid lp/lp Horses
By Sharon January

Can you cross an Appaloosa mare that looks like this:

SPR Special Secret F3-2738

Smoky Black Varnish Roan Filly

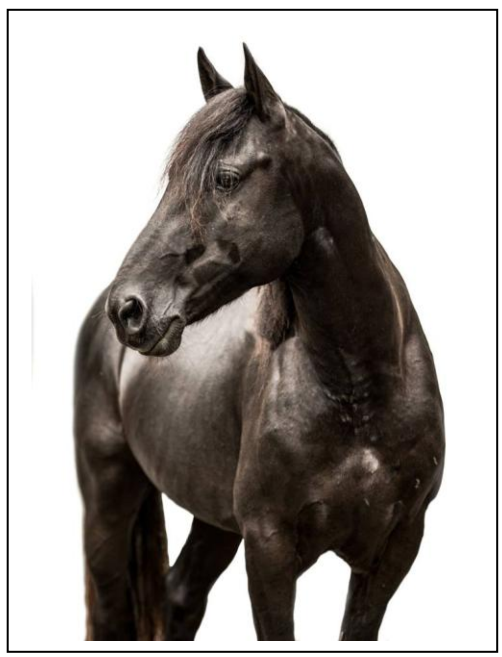
←

To a stallion that looks like this:

CTR Turn and Burn F4N-2745

Solid Black Stallion

→



And get a foal with a coat pattern like one of these?

FVF Wind Serenade F3-2658

BCA Chats Tsumago F5-2701

The answer is yes. In fact, ALL resulting foals from this particular cross theoretically should have a coat pattern like the leopard foal or the near-leopard foal above 100% of the time. You might ask, "How is this possible?"

While most people seem to know that you always get a coat pattern of some kind from a fewspot or snowcap, many do not understand the genetics behind this. In this article, I'll try to connect the dots for those who do not understand Appaloosa genetics.

To start with, let's go over a few Appaloosa basics. LP is the “Appaloosa gene”, or the “leopard complex” gene. This gene is what creates the characteristics (white sclera, striped hooves, and mottled skin), the varnish roaning, and the spots. It is expressed in test results as LP.

There are other genes that create the coat pattern of the Appaloosa, called pattern genes. Currently, there is only one pattern gene that has been discovered and can be tested for, although they feel there are many, which explains the vast array of coat patterns we see. The only one they can currently test for is PATN1. This is the pattern gene that creates leopards and near-leopards (the white coat patterns covering 65% to 100% of the horse's body). The pattern genes require the LP gene to “light them up"; to be expressed. A horse that is not carrying LP can still carry and pass on PATN1 (and the other pattern genes) but they will be solid, with no coat pattern, as the pattern genes will not be expressed without the LP.

Every horse always carries two base color genes. They CAN carry one or two LP genes, one or two of a particular pattern gene, one or two agouti genes (this gene restricts black, if the horse is carrying a black gene, to the points and so creates a bay), one or two of a particular dilution gene such as dun or cream, etc. If a horse carries two of the exact same gene they are said to be homozygous for that gene. If they are carrying only one gene of a particular color or pattern, they are said to be heterozygous for that color or pattern. Some genes are dominant and some are recessive. There are only three base colors in horses; red, bay, and black. Black is dominant and red is recessive, so if a horse carries both a red gene and a black gene, the horse will be black (or bay, depending on agouti). ALL other horse colors are a creation of other genes at work on those three colors. So as not to confuse, as color is not the topic being written about except for a brief education on how genetics work, the intention was to only use black and red here. However, since we will be using real horses in this article, with real genetics, there has to be a dilution gene added to the mix since the mare carries one cream gene.

The hard and fast rule is that the sire and dam will each throw one of their two color genes to their foal, which then gives the foal its two color genes; one from each parent. This will determine the foal's base color. If a horse is heterozygous (carrying one red gene and one black gene), it has a 50% chance of throwing the black gene and a 50% chance of throwing the red gene to its foal. Each new breeding is a new roll of the dice with the same 50/50 chance. If a horse is homozygous for black, carrying two black genes, then it will always throw black 100% of the time. If it is homozygous for red, carrying two red genes, then it will always throw red 100% of the time. In genetic terms, black is stated as E and red is stated as e. Capital letters mean a gene is dominant and lowercase letters indicate that it is recessive. A homozygous black horse would be stated as EE, a homozygous red horse would be stated as ee, and a heterozygous black horse would be stated as Ee.

And so, the Appaloosa genetics work the same. If a horse is homozygous LP, stated LP/LP, they will throw an LP gene to their offspring 100% of the time. For reasons we do not understand, when a horse is homozygous for LP, it somehow suppresses the spots, so LP/LP horses do not have any spots (hence your most well known snowcaps and fewspots, and less known varnish roans and other coat patterns that do not have any spots). LP/LP horses also have CSNB (Congenital Stationary Night Blindness; not to be confused with moonblindness). The reason these horses are known as color producers is because they will throw that LP gene 100% of the time, just as a homozygous black horse will always throw a black gene. A heterozygous LP horse is stated as LP/lp (or sometimes LP/n, depending on the testing facility; n means negative for a particular gene, and lp means negative for the LP gene). These LP/lp horses always have spots and are the most colorful and sought after of Appaloosas because of those spots. Like explained with a heterozygous black horse, an LP/lp horse will throw that LP gene 50% of time. The other 50% they will not, as there is no other LP gene to throw (like the dilution and agouti genes, they may only be carrying one of this particular gene and they'll either throw it or they won't; it's a 50/50 chance). If a foal does not get the LP gene from either parent (which is always a possibility when breeding two heterozygous horses together or a solid and a heterozygous horse together) then the foal will be solid and said to be lp/lp (not carrying any LP gene).

The pattern genes create the white coat pattern behind the spots. As stated earlier, the PATN1 gene creates leopards and near-leopards, but there are many other pattern genes as well. So a heterozygous LP horse (LP/lp) that is also carrying PATN1 is going to be a colorful leopard or near-leopard with spots. Other pattern genes with LP/lp will create a vast array of coat patterns, such as a blanket with spots.

A horse that does not get any pattern gene, but does get the LP gene, will be your varnish roans without any white coat pattern. If the horse is LP/lp, you will likely not see any spots when they are born, as they will generally be born phenotypically (i.e.; the appearance) solid, but as they roan with age, the roaning will go around the existing but previously invisible spots and the lighter the horse gets with age from roaning, the more the spots will show up and the more colorful the horse will become. If these horses not carrying any pattern genes are LP/LP, they will not have spots to roan around, and so will only be varnish roans.

So, back to the original question of the cross between the first two horses pictured. These two horses are real ICAA horses with the actual genetics stated below. Below you will see what is known as a Punnett Square. They were (before computerized reports were available), and still are at times, used to determine all possible outcomes of crosses between certain animals and plants if you know their genetics. They can be very large depending on how many genetic variables and possibilities there are. The first one shown below is very basic for this particular cross as their genetics are simple and only their base color, one dilution gene, and two pattern genes (LP and PATN1) are listed. Both of these horses are carrying agouti in its recessive form, so this is not listed for simplification.

Stallion: CTR Turn and Burn is a solid black Appaloosa stallion with the genetics EE, lp/lp, PATN1/PATN1. Knowing what you learned above, he is homozygous for black so he will always throw a black gene, he does not carry any LP gene to throw to his offspring, but he is homozygous for the PATN1 gene so he will always throw the pattern gene that creates leopards and near-leopards to his offspring.

Mare: SPR Special Secret is a smoky black varnish roan Appaloosa mare with the genetics Ee, Cr/n, LP/LP, and is n/n (negative) for PATN1. Knowing what you learned above, she is heterozygous for her base color; she is phenotypically smoky black but she is carrying a red gene, so she can throw either a red or a black gene to her offspring. She is also carrying one cream gene (Cr), a dilution gene that creates palomino, buckskin, and smoky black, depending on the base color and if agouti is present. So she has a 50% chance of throwing that cream gene and a 50% of not throwing it. She is homozygous for LP so she will always throw an LP gene. She is not carrying any pattern genes, which we know because she not only tested negative for PATN1, but she is not showing any white coat pattern at all. She is currently young and is only starting to roan, but she will eventually be a varnish roan with no spots.

The Punnett Square below: The sire, CTR Turn and Burn, is on top, with all possible combinations of what he can throw (in his case it is always the same; PATN1, lp, and E, 100% of the time, so there are only two square), and the dam, SPR Special Secret, is on the left, with all of her possible combinations that she can throw (she can throw LP and E; LP and e; LP, E and Cr; or LP, e, and Cr). All possible combinations of this cross and the results of their offspring are in each square.

	PATN1 lp E	PATN1 lp E
LP E	LP/lp n/PATN1 EE	LP/lp n/PATN1 EE
LP e	LP/lp n/PATN1 Ee	LP/lp n/PATN1 Ee
LP E Cr	LP/lp n/PATN1 EE Cr	LP/lp n/PATN1 EE Cr
LP e Cr	LP/lp n/PATN1 Ee Cr	LP/lp n/PATN1 Ee Cr

So as you have learned about basic color and Appaloosa genetics from the article, any resulting foals from this particular cross should be 100% leopards or near-leopards, with 50% being black and 50% being smoky black. All resulting foals would have the genetic makeup of EE, LP/lp, n/PATN1; or Ee, LP/lp, n/PATN1; or EE, Cr/n, LP/lp, n/PATN1; or Ee, Cr/n, LP/lp, n/PATN1. All would be sought after for their colorful coat patterns and there would be no risk of getting a solid foal nor an LP/LP foal without any spots that would have CSNB.

Below is another Punnett Square that shows the more common cross of a stallion and mare that are both heterozygous for PATN1 and for LP. I'm using homozygous black with no agouti for both the mare and the stallion. If I used heterozygous black or bay, this Punnett Square would be much larger, as I would have had to add squares for all of those possible color combinations along with the pattern genes. Homozygous red would have the same results for red. So the stallion and the mare in this hypothetical cross would both read as EE, LP/lp, n/PATN1. All of the possible combinations of the genes that each could throw to their offspring is listed, with the stallion on the top and the mare on the left. Remember, in this cross, both the mare and the stallion will always throw E. Each will throw LP 50% of the time and each will throw PATN1 50% of the time. In this hypothetical cross, we do not know if either horse is carrying another pattern gene in addition to PATN1.

	PATN1 lp E	PATN1 LP E	lp E	LP E
PATN1 lp E	PATN1/PATN1 lp/lp EE	PATN1/PATN1 LP/lp EE	n/PATN1 lp/lp EE	n/PATN1 LP/lp EE
PATN1 LP E	PATN1/PATN1 LP/lp EE	PATN1/PATN1 LP/LP EE	n/PATN1 LP/lp EE	n/PATN1 LP/LP EE
lp E	n/PATN1 lp/lp EE	n/PATN1 LP/lp EE	lp/lp EE	LP/lp EE
LP E	n/PATN1 LP/lp EE	n/PATN1 LP/LP EE	LP/lp EE	LP/LP EE

The squares have been colored in only for ease of counting the results. So as you have learned about basic Appaloosa genetics from the article, resulting foals from this particular cross would be as follows (but remember, each breeding is a new roll of the dice and the below odds would always be the same with each foal):

25.00% chance foal would be solid black (blue squares)
37.50% chance the foal would be black leopard or near-leopard, with spots (light green squares)
12.50% chance the foal would be black with other or no coat pattern, with spots (could be varnish roan, have a blanket, or other white pattern; purple squares)
18.75% chance the foal would be black fewspot or near-fewspot, with no spots (orange squares)
6.25% chance the foal would be black with other or no coat pattern, with no spots (could be varnish roan, a snowcap, or other coat pattern; gray square)

As you can see, there are many different genetic combinations that you could get from this cross, and this does not count all of the pattern genes that cannot currently be tested for, but phenotypically you would have the results below:

The theory of 25% lp/lp (solid) holds true
The theory of 25% LP/LP (no spots and carrying CSNB) holds true (18.75% + 6.25%)
The theory of 50% LP/lp (with spots) holds true (37.50% + 12.50%)