Homozygous suris in alpaca breeding

Dr Pierre Baychelier

Alcazar Suri Stud – www.alcazar.com.au

First published in: *Alpacas Australia*, Issue 42, Summer 2003, pages 30 to 34

Correspondence to pierre@alcazar.com.au

Abstract

Breeding suris can be achieved using different paths: crossing with huacayas, grading up or breeding pure suris. Whatever the approach, it is extremely important to try to only use homozygous males for mating. This paper briefly reviews the advantages and disadvantages of crossing. It then concentrates on the issue of identifying homozygous suris, either by test mating or by study of their pedigree.

Introduction

It would appear that, almost since the very first introduction of suris into Australia, alpaca breeders have experimented by crossing them with huacayas [8]. From these very early experiments, it gradually became clear that the huacaya and suri phenotypes are more than likely governed by a single gene, with two alleles: S and s [2, 3]. The S allele is supposedly completely dominant over the s allele and the three possible combinations result in the three following phenotypes:

- [SS] suri (homozygous suri);
- [Ss] suri (heterozygous suri);
- [ss] huacaya.

Crossing suris and huacayas: why and why not?

There are advantages and disadvantages in crossing suris and huacayas. These have already been discussed in a previous paper [1] but are repeated below for the reader's convenience.

Advantages of crossing

Cost

Using cheaper female huacayas and crossing them with male suris, you will produce low cost suris. If the male suri you are using is homozygous [SS], you will get 100% suri progeny; if the male you are using is heterozygous [Ss], you will get 50% suri progeny and 50% huacaya progeny.

Hybrid vigour

Hybrid vigour is maximal in the F1 generation. Hybrid vigour translates into concrete advantages for the breeder:

- F1's are quite robust and need little attention; therefore they make ideal commercial animals for fleece production.
- F1's develop well and often have an advantage on the show scene. As only the phenotype is judged, a good F1 should receive a ribbon when competing against poorer pure suris.
- F1's usually have excellent fertility and mothering ability.

Import suri genes in the huacaya population
- Lustre genes
- Low-medullation genes

Import huacaya genes in the suri population
- Density genes
- Colour genes

Disadvantages of crossing

Time consuming
See paragraph below about grading up.

Hybrid vigour is not heritable.
- Two inbred animals can give a vigorous hybrid.

Example: an inbred Peruvian x an inbred Chilean = a vigorous hybrid
- Two vigorous hybrids can give an inbred animal.

Example: 2 F1's (vigorous hybrids) from the same parents, mated together, give an inbred F2.

Hybrid vigour is maximal in F1 then 50% is lost in F2.
If breeding for hybrid vigour is your aim, you should make sure that the F1's are your finished product.

Independent segregation of characters in F2 (Mendel's second law)
- Do not cross F1's together! This will result in unwanted surprises.
- What to do with male F1's? They are heterozygous, not only for the S gene but also for all the other genes that make a suri a good suri. Keep them for fleece production or for showing but do not breed from them.

Crossing may diminish suri hardiness and other typical characteristics.
The suri is suspected to be stronger and more robust than the huacaya and to live longer [5, 7]. The males are more virile and the females breed more readily [5]. Its fleece is much more lustrous and softer, exhibits a lower degree of medullation, is more even for micron over the body [6] and grows 1 to 2 cm longer in a given year [7]. Will all these commercially important characteristics be maintained in hybrids? What we know about such traits in other species, especially sheep, suggests that they are governed by polygenes and are therefore inherited in a quantitative additive manner: This suggests that they would be halved in hybrids.
Note, however, that this last issue comes from a suri breeding point of view only. If you take the huacaya point of view, then it may be a good idea to mate F1's back to the huacaya type, in an effort to obtain improved huacaya fleece.

Grading up

Now that many of the first generation F1's are reaching reproductive age, we are starting to see the second generation on the ground. Many advertising articles refer to the progeny of F1's as F2's. This is not always correct.

An F2 is the product of two F1's mated together:

F1 x F1 = F2

The product of an F1 mated back to a suri (or to a huacaya for that matter) is called a **backcross** in short BC, or more precisely **BC1** for first generation backcross:

suri x F1 = BC1

A BC1 mated again to a suri, gives a backcross 2 or BC2… etc

suri x BC1 = BC2

suri x BC2 = BC3

Typically, when you reach the BC3 stage, you have more than 93% suri blood (15 pure suri great great grand parents, for one huacaya great great grand parent) and can consider that you are back to a pure suri stage. This is called **grading up** [1, 4]. See Figure 1 below.

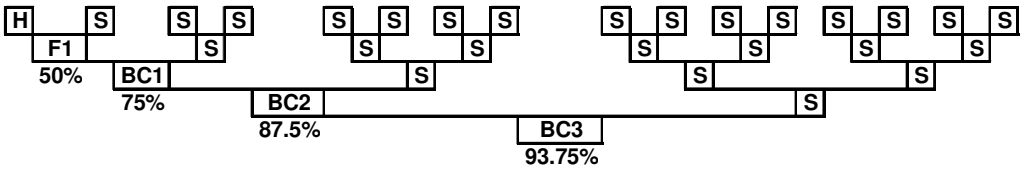

Figure 1 - Pedigree of a backcross 3 – The figures in % represent the % of suri blood (H huacaya, S pure suri, F1 first filial generation, BC1 backcross 1, BC2 backcross 2, BC3 backcross 3) – F1, BC1, BC2 and BC3 exhibit the suri phenotype

The importance of using homozygous suris

Whether you are breeding pure suris, grading up to the suri type or rather interested in producing F1's for fleece production or for showing, **it is of the utmost importance that you use pure suri males, or at least homozygous males [SS], in your breeding programme.** This is easily understood by studying Figure 1 again. Pure suris have a higher probability of being homozygous [4].
The remaining part of this article will discuss how homozygous suris can be identified.

Test mating suris

Testing suris by mating with huacayas

The best method to check if an animal is homozygous or heterozygous is to mate this animal to the recessive homozygous type. This is a Mendelian "recipe" that never fails. In the case of alpacas, the best method is therefore to mate the suri you want to test to a huacaya. In practice, it is easier and quicker to test a suri male by mating him to huacaya females than to test a suri female by mating her to huacaya males, although the principle of testing would essentially be the same in both situations. So test mating is usually only used for males. There are other ways to "test" females (see below).

Table 1 below returns the probability that a suri is homozygous after a given number of matings with huacayas, all producing suri offspring. Of course, as soon as you obtain a huacaya in such test matings, you can be 100% sure that the suri tested is heterozygous [Ss].

Table 1 – Probability that a suri is homozygous [SS], after a given number of matings to huacayas [ss], all producing suri offspring

Number of suri offspring from matings to huacayas	Probability
1	50.0%
2	75.0%
3	87.5%
4	93.8%
5	96.9%
6	98.4%
7	99.2%
8	99.6%
9	99.8%
10	99.9%
11	100.0% *
12	100.0% **

* The exact figure is 99.9512%

** The exact figure is 99.9756%

This is also presented graphically on Figure 2.

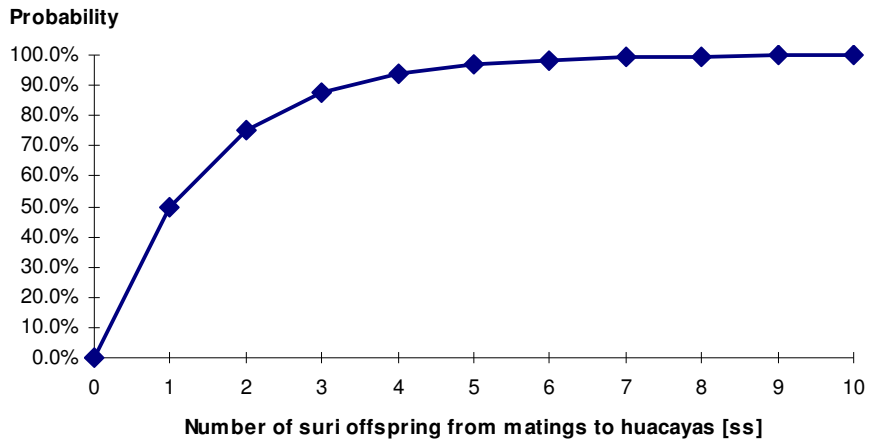

Figure 2 - Probability that a suri is homozygous [SS], after a given number of matings to huacayas [ss], all producing suri offspring

This means that, in practice, you only need to mate an "untested" suri male to 5 huacaya females to be more than 95% sure that the male is homozygous.

Testing suris by mating with suris?

It is easy to understand that it would require more matings to suri females in order to prove that a male suri is homozygous. If you mate the untested suri male to homozygous females, you cannot draw any conclusion. However, if you mate the male to proven heterozygous females then you can still test this male for homozygosity.

The equation used to return the probability is [9]:

$$P = 1 - \prod(P_{BBi} + \tfrac{3}{4} P_{Bbi} + \tfrac{1}{2} P_{bbi})^{ni}$$

This equation is complex and I have simplified it, as follows:

$$P = 1 - (0.5 + \tfrac{3}{4} \times 0.5)^{n1} \times (\tfrac{3}{4})^{n2} \times (\tfrac{1}{2})^{n3} = 1 - (0.875)^{n1} \times (0.75)^{n2} \times (0.5)^{n3}$$

where

P is the probability of the male being homozygous,
$\mathbf{n_1}$ is the number of suri offspring out of randomly chosen suri females,
$\mathbf{n_2}$ is the number of suri offspring out of known heterozygous suri females,
and $\mathbf{n_3}$ is the number of suri offspring out of huacaya females.

Note that, if only matings to huacayas are taken into account, then $n_1=0$ and $n_2=0$ and the equation becomes:

$$P = 1 - (0.5)^{n3}$$

which is the equation used to return the probabilities presented above in Table 1 and Figure 2.

Note also that, in the equation, it is assumed that "randomly chosen" suri females are defined as having a 50% chance of being homozygous (P_{BB}=0.5) and a 50% chance of being heterozygous (P_{Bb}=0.5). This is probably conservative, knowing that the suri population in Australia in year 2000 was made up of approximately 50% F1's [2]. Therefore the proportion of heterozygous females in the Australian suri population is probably higher than 50%.

Example: A suri was mated to 1 huacaya, 2 know heterozygous suris and 5 randomly chosen suris and produced suri offspring only. What is the probability that this animal is homozygous?

The answer is: $P = 1 - (0.875)^5 \times (0.75)^2 \times (0.5)^1 = 0.8557$ or 85.6%.
This probability, obtained after 8 matings, is still low compared to mating to 5 huacayas.

More theoretical results are presented in Figure 3, where it becomes immediately apparent that the most powerful test to use is to mate the unproven suri male to huacayas, as described previously. However, information from other matings, collected for example on the International Alpaca Registry (IAR) database or herd book, can be very useful too.

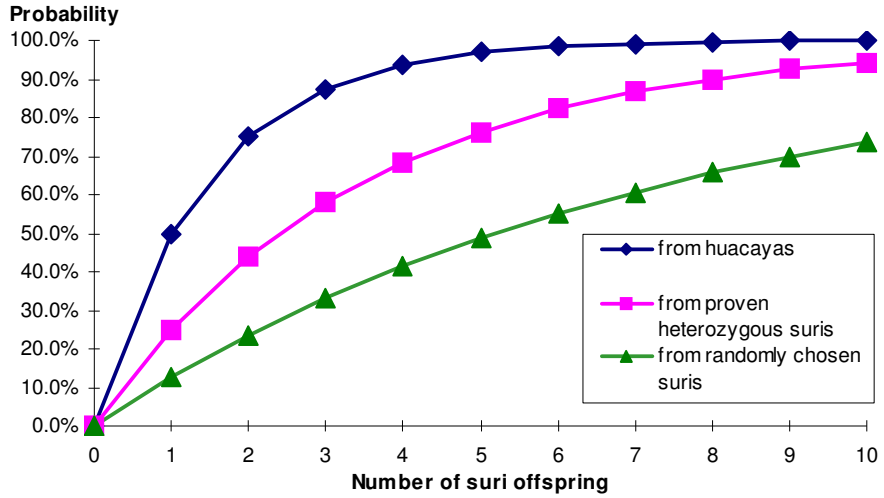

Figure 3 - Probability that a suri is homozygous [SS], after a given number of matings, all producing suri offspring

Using suri pedigrees

Pedigrees can also be used to return a probability of homozygosity and it is sometimes the only method available. This is certainly the case for young

animals that do not have any progeny on the ground ("unproven males") or for females, who typically have fewer progeny than males.

Calculation principle

The calculation principle is very simple and has been explained in a previous article [4]. An example will illustrate the concept. Let us imagine the mating of two F1's. By definition, these two animals are heterozygous [Ss]. The mating will produce:

- a homozygous **suri** [SS] with a 25% probability or 0.25;
- a heterozygous **suri** [Ss] with a 50% probability or 0.5;
- a **huacaya** [ss] with a 25% probability or 0.25.

This means that, if you consider the suri progeny only, the probability that the offspring is homozygous is 0.25 / (0.25 + 0.5) = 0.33 or 33% and the probability that the offspring is heterozygous is 0.5 / (0.25 + 0.5) = 0.67 or 67% (or 1 – 0.33 = 0.67).

Results

Table 2 below returns the probability according to the status of the sire, the maternal grand-sire and the maternal grand-dam. Again, an animal defined as "untested suri" means that there is a 50% probability it is homozygous and a 50% probability it is heterozygous.

Table 2 - Probability that a suri is homozygous [SS] according to ancestry

	Maternal grand-sire				
Sire	proven homozygous [SS]	untested suri *	proven heterozygous [Ss]	huacaya [ss]	**Maternal grand-dam**
proven homozygous [SS] #	**100%**	**88%**	**75%**	**50%**	proven homozygous [SS]
	88%	**80%**	**71%**	**50%**	untested suri *
	75%	**71%**	**67%**	**50%**	proven heterozygous [Ss]
	50%	**50%**	**50%**	**0%**	huacaya [ss]
untested suri *	**75%**	**68%**	**60%**	**43%**	proven homozygous [SS]
	68%	**63%**	**58%**	**43%**	untested suri *
	60%	**58%**	**55%**	**43%**	proven heterozygous [Ss]
	43%	**43%**	**43%**	**0%**	huacaya [ss]
proven heterozygous [Ss]	**50%**	**47%**	**43%**	**33%**	proven homozygous [SS]
	47%	**44%**	**42%**	**33%**	untested suri *
	43%	**42%**	**40%**	**33%**	proven heterozygous [Ss]
	33%	**33%**	**33%**	**0%**	huacaya [ss]

* 50% probability of being homozygous and 50% probability of being heterozygous

To be perfectly correct, from a statistical point of view, a suri can be proven heterozygous, whereas it can never be **proven** homozygous. As soon as a suri has one huacaya in its progeny, one can be absolutely sure that the suri is heterozygous – as long as this is not a registration mistake. However, a suri cannot be proven homozygous. It is only possible to return a **probability** of being homozygous, and this probability never reaches 100%, although it can be very close.

Out of these results, two graphs are presented below. Figure 4 illustrates that the maternal grand-sire and the maternal grand-dam have a similar influence on the outcome. Figure 5 represents the most usual situation, where the maternal grand-dam is of unknown status.

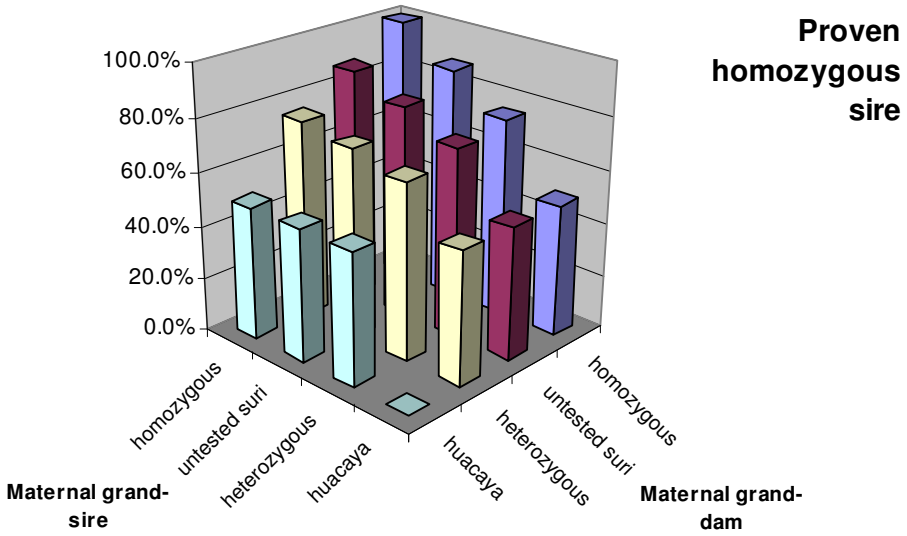

Figure 4 - Probability that a suri is homozygous [SS] according to ancestry, given that the sire is homozygous

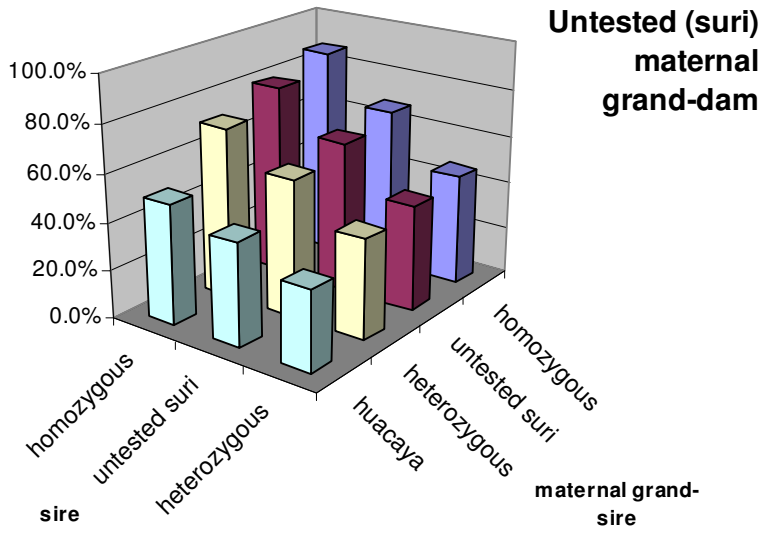

Figure 5 - Probability that a suri is homozygous [SS] according to ancestry, given that the maternal grand-dam is an untested suri

Table 2 only takes into account three of the ancestors. Of course, if you have access to a more detailed pedigree, as we will in the future, you can apply the same calculation principle to the whole series of ancestors and return an even more accurate probability.

Grading up revisited

The reader may have noticed that, in Figure 1, the figures in % represent the **% of suri blood**, not the probability of being homozygous. However, if we assume that all pure suris are indeed homozygous, then this BC3 pedigree can be redrawn and the probability for each backcross being homozygous can be calculated. See Figure 6 below.

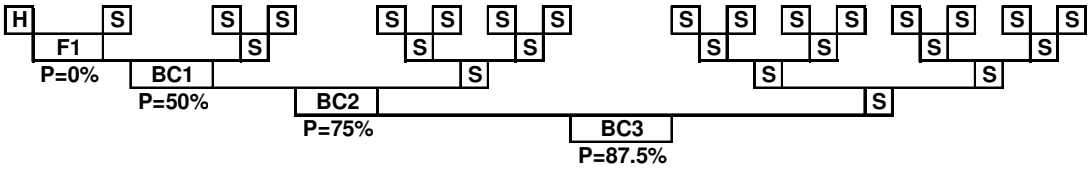

Figure 6 - Pedigree of a backcross 3 – The figures in % represent the PROBABILITY OF BEING HOMOZYGOUS [SS] (H huacaya, S HOMOZYGOUS suri, F1 first filial generation, BC1 backcross 1, BC2 backcross 2, BC3 backcross 3) – F1, BC1, BC2 and BC3 exhibit the suri phenotype

Conclusion

When breeding suris, because the S allele is dominant over the s allele, it is of the utmost importance to use homozygous suri males. The same applies to females but it is not always possible to ensure that the female used is homozygous.
The best way to check that a suri is homozygous is to mate it with at least 5 huacayas (test mating). The results of suri to suri matings can also be used but are not as powerful a tool in returning a meaningful conclusion. Moreover, for young males and females, the use of pedigree can also be of great assistance. This is particularly important when selecting a young animal for purchase.

Acknowledgements

The author wishes to thank Mr Brenton Spehr and Mr Glen Riley for their assistance in the writing of this article.

References

1. BAYCHELIER P. – Crossing huacayas and suris – Newsletter of the Hawkesbury Blue Mountains Region of the AAA, Volume 8, Issue 3, pp 10-11, July 2002.
2. BAYCHELIER P. – Suri and huacaya: two alleles or two genes? - Proceedings of the 2000 Australian Alpaca Association National Conference, Canberra, pp 79 to 85, 2000.
3. PONZONI R.W. et al. – Phenotypes resulting from huacaya by huacaya, suri by huacaya and suri by suri alpaca crossings – Proceedings of the International Alpaca Industry Seminar, Sydney, pp 11-13, 1997

4. BAYCHELIER P. – What is a pure suri? – Alpacas Australia, issue 39, pp 30-33, Summer 2002
5. BILLINGTON W. – Suri Education Day – Cedar House Alpaca Stud, Yass, 16th July 2000
6. HOLT C. - Alpaca Fibre Production Course Notes - International School of Fibres, 2000
7. BARREDA J. – Let's save the Suri – Alpaca International News, pp 7-12, 1994
8. KEANE S. – A pot of gold at the end of the Chilean rainbow? – Alpacas Australia, Issue 28, pp 30-37, 1999
9. BOURDON R.M. – Understanding animal breeding – Prentice Hall, Upper Saddle River, NJ, 1997