

# A Proposed Scale to Quantify the Extent of White Spotting in Soay Sheep

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## Introduction

The basic genetics of white spotting<sup>1</sup> in colored sheep are quite well defined. Whether or not a sheep will exhibit white spotting, or irregular patches of pure white hair is determined by simple dominant – recessive Mendelian genetics<sup>2</sup>. The question of *how extensive* the white spotting (or marking) will be is far less predictable. I have been examining the genotypic and phenotypic history of a flock of Soay sheep—the Hareknoll flock of Sue Furness in Wales—where intentional breeding over about 23 years for extensive white spotting has led to production of almost completely white Soay sheep. Good records of matings and progeny were kept, including many photographs and a coding system to estimate the extent of white spotting.

My objective is to determine whether the extent of white spotting in parents can be quantified in such a way as to produce a statistical model that predicts the extent of white to be expected in the offspring. Sue Furness, the owner and breeder of the Hareknoll Soay sheep flock in Southern Wales, has over this period developed a sense of what is likely to occur with particular matings of white-spotted parents. I hope here to strengthen those observations with quantifiable measurements and modeling.

In order to build any statistical model of the heritability of white spotting extent one needs to have a numerical expression of the extent. Percentage of the body surface covered in white spotting is a logical choice, however to actually quantify the surface area white coverage is tedious if not impractical. One could use image analysis techniques to assess from photographs the actual percentage white extent, however this level of precision is likely not warranted. Instead, a simple visual estimate of a relatively small number of *classes* of white extent should serve to adequately test whether there is hope of a heritability model. Usually in such models having about 10 classes is sufficient, and it would seem logical to divide the range of zero to one-hundred percent white into 10 equal classes of 10% increments.

After studying a number of white-spotted sheep photos, I conclude that the classes need much better discrimination in the extremes, particularly at the low end, and can tolerate much wider classes in the mid-range without suffering in information content. By this I mean that the first appearances of white spotting in an individual of a group tend to be very small areas, typically at the poll. In particular in NA Soay population where the extent of white is far less that in the Hareknoll flock, these may be less than 1%, but are very important in signaling the presence of homozygous recessive white spotting, *Ss/Ss*. The next level of increased spotting is usually observed a bigger poll spot, and perhaps a forehead spot. These tend to have roughly 1 to 3% of the area in white. By the middle classes, whether the sheep has 30, 40 or 50% white is not terribly important (for purposes of the statistical model), and is in fact more difficult to estimate accurately from visual examination than are cases with either very little white or very little pigment.





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<sup>1</sup> While most may not think of large continuous patches of white on a sheep as a “spot”, in genetics terminology the gene location controlling this trait is named the “Spotting locus”, so here I will use the term ‘spotting’ for *any* white markings other than the *lighter, symmetric areas typically found in the wild pattern on the belly, chin, rump, etc.*

<sup>2</sup> At least one recognized expert, Dr. Phil Sponenberg, asserts that roughly half the sheep that are heterozygous for white spotting *still* exhibit minor white spotting. I hope to determine someday whether or not this is true for NA Soay sheep.

From this rationale I developed a range of 10 classes (which includes zero, meaning no white, up through 9, being almost all white<sup>3</sup>.) Table 1 below shows the classes, names, percentage ranges, and gives examples for most levels. Adherence to ‘historical names’ for white marking are used where known (e.g., ‘twinks’ and ‘wisps’).






**Table 1.** Proposed classes of extent of white spotting to be used in analysis and description of white spotting.<sup>4</sup>

| Extent Name              | % White Range | Label | My Class Code | Example(s) <sup>5</sup>  |
|--------------------------|---------------|-------|---------------|--|
| No White spotting        | 0%            | 0%    | 0             | NA   |
| Wisp or Twink            | 0.01 to 1%    | 0.5%  | 1             | Kvasir, Bunny<br>          |
| Splash                   | 1% to 3%      | 2%    | 2             | Bunny, Pepper<br>         |
| Splashes to Blaze, Socks | 3% to 10%     | 5%    | 3             | Obsidian, Amanda<br>     |
| ‘White Marked’           | 10% to 30%    | 20%   | 4             | Blue Mountain Fiona<br> |

<sup>3</sup> Pure white would logically be class 10, however, that would likely mean a different agouti allele – *Awt*, or dominant white, which does not occur in Soay sheep, so it would mean it had been introduced from some other breed. Thus no class 10 Soay sheep should arise in this study, and indeed in about 125 sheep examined so far, none have.

<sup>4</sup> All Hareknoll Flock Soay photos provided courtesy Sue Furness.

<sup>5</sup> I often choose to show examples on self-colored black sheep only because they show up more clearly, not because there is any believed linkage between white spotting and either Agouti pattern or Brown color loci.

|                    |              |       |   |   |
|--------------------|--------------|-------|---|---|
| Piebald & Skewbald | 30% to 70%   | 50%   | 5 | Primrose, Aurora, Pedro, Hosea, Jessica<br> |
| “Brown Marked”     | 70% to 90%   | 80%   | 6 | Paul<br>                                   |
| “Brown spots”      | 90% to 97%   | 95%   | 7 | Amy, David<br>                              |
| Mostly White       | 97% to 99%   | 98%   | 8 | Jimmy, Joni<br>                           |
| “White”            | 99% to 99.9% | 99.5% | 9 | Diamond, Jewel<br>                        |

These classes have been assigned to approximately 125 Soays from the flock history of Hareknoll and the Woodland Creek Farm flocks, and it seems to be a useful scaling. Current tentative statistical models are capturing roughly 80% of the total variation that is observed, indicating a model that should have reasonable predictive quality.