



## Sheep breeding: Response to selection

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Genetic improvement programs aim to improve selected traits in a flock through breeding. Their success is measured in terms of the trait's response to the selection.

Response depends on:

- the selection being effective (superior sheep have been identified); and
- the traits being heritable.

**Note:** Refer to Farmnote No. 52/93 'Sheep breeding: Heritability' (Agdex 430/30) for an explanation of heritability.

### The response equation

Response to selection is the product of the average selection differential and heritability. This is shown in the following equation.

Response to selection = heritability x average selection differential

The selection differential is the difference in the selected trait between the selected animals and the average of all animals before selection. It is the average of those for the males and females. Heritability describes the proportion of differences between sheep that are genetic in origin.

#### Example

Of 10 males and 10 females, 3 males and 7 females are required. The top performers for clean fleece weights are selected, as in Table 1.

Identifying and retaining sheep that are superior only for the trait of interest will maximise the selection differential. For example, if the third ram above had been rejected in favour of the fourth, the selection differential would become 0.36, a decrease of 16 per cent.

$$\begin{aligned} \text{Response} &= 0.34 \times (0.17 + 0.43) \div 2 \\ &= 0.102 \text{ kg per generation} \end{aligned}$$

If all the females were selected, or if they were randomly selected, then the average of the whole group and the selected group would be the same. That is, the female selection differential would be zero. The response would then be:

$$\begin{aligned} \text{Response} &= 0.34 \times (0.00 + 0.43) \div 2 \\ &= 0.073 \text{ kg per generation} \end{aligned}$$

**Table 1. Example of the calculation of selection differentials: Clean fleece weights**

	Female	Male
	4.4*	4.8*
	4.2*	4.7*
	4.1*	4.6*
	4.0*	4.4
	3.9*	4.4
	3.7*	4.3
	3.5*	4.2
	3.5	4.0
	3.4	3.8
	3.3	3.5
Average	3.8	4.27
Average of selection	3.97	4.7
Selection differential	0.17	0.43
*Selected.		

Under these circumstances, the response equation is often written as:

Response to selection = 0.5 x heritability x male selection differential

This takes account of the superiority of the selected rams and the half contribution of genes from the male side. The half from the female side is usually average, and so has zero selection differential.

Another way of determining response to selection is to take the average of the male and female estimated breeding values - see Farmnote No. 53/93 'Sheep breeding: Estimated breeding values', Agdex 430/30.

### Potential genetic gains

This example concerns the maximum gains that can be achieved with single trait selection. The exercise uses the following data:

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Flock size:	2000 ewes
Mating ratio:	2%
Effective lambing percentage:	70
Ewe and ram deaths:	5% per year
Ewe age groups:	5
Ram age groups:	3
Clean fleece weight:	4.0 kg
Average fibre diameter:	21.0 microns
Ewe hogget liveweight:	45.0 kg

From these, the following figures were calculated:

Number of ewe replacements required:	440
Number of ram replacements required:	14
Number of ewe replacements available:	700
Proportion of ewes required (440/700):	0.63
Selection differential (clean fleece weight):	0.30
Number of ram replacements available:	700
Proportion of rams required (14/700):	0.02
Selection differential (clean fleece weight):	1.21

Therefore, the response is calculated as follows:

$$\begin{aligned} \text{Response} &= 0.34 \times (0.30 + 1.21) \div 2 \\ &= 0.26 \text{ kg per generation} \end{aligned}$$

This is the maximum rate of gain possible, since all selection pressure has been directed towards clean fleece weight. Table 2 shows the possible responses and percentage gain per year and per generation.

Even though each of these traits has a different heritability, the gain per year is not much different. A reasonable expectation for most traits in sheep is a gain of 1.5 to 2.0 per cent per year.

## Further reading

- Farmnote No. 52/93 'Sheep breeding: Heritability' (Agdex 430/30).
- Farmnote No. 53/93 'Sheep breeding: Estimated breeding values' (Agdex 430/30).
- Farmnote No. 73/2003 'Genetic nomenclature and animal breeding terms' (Agdex 400/30).

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**Table 2. Potential genetic gains from single trait selection**

Trait	Response		
	per generation	% per generation	% per year
Clean fleece weight	0.26	6.5	1.9
Average fibre diameter	1.43	6.8	1.9
Ewe hogget liveweight	2.38	5.3	1.5

**Note:** The data in the table is based on all available selection pressure being applied to the single trait of interest.