
THE PROCEEDINGS OF THE
NEW ZEALAND SOCIETY
OF
ANIMAL PRODUCTION
VOLUME 62 2002

BRIEF COMMUNICATION: Which traits best predict ewe performance and survival the following year on a UK hill farm?

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Keywords: sheep; hill systems; retention; selection; longevity

Introduction

Increasing ewe longevity and reproductive output can improve whole-flock efficiency and reduce environmental impact (Jones et al. 2013). By increasing ewe longevity (the length of productive life), fewer replacements are required, reducing the number of unproductive animals and increasing the number of ewe lambs to sell (Dickerson & Glimp 1975).

Longevity research often looks for genetic indicators of this trait; however, heritability is low, or occasionally moderate (Mekkawy et al. 2009). An alternative approach may be to alter how animals are retained for breeding the following year, allowing animals to reach their potential and not reducing longevity by selling animals that are still productive. To achieve this, it is essential to be able to identify ewes that will survive and be productive. Although most research on longevity concentrates on the whole lifetime of an animal, it may be informative to consider factors that affect just the following years' performance, in order to aid retention decisions, particularly when genetic information is unavailable.

On UK hill farms, flock managers often select ewes to keep or sell based on current appearance pre-mating. Ewe age is also often selected on with ewes typically being sold at 5.5 years of age. This aims to avoid both lower returns from selling older ewes and increased incidence of mouth/teeth problems, resulting in ineffective grazing, but there is little scientific evidence for this concern (McGregor 2011). Ewes have been proven capable of having many more productive years after this age (Dickerson & Glimp 1975), so it should be possible to keep these productive animals longer and thereby improve flock longevity.

Categories of traits for consideration that predict ewe survival and performance the following year include: visual assessment, previous performance and Estimated Breeding Values (EBVs).

Although selection on EBVs can successfully improve production levels in hill systems in the UK (Conington et al. 2004), these can be challenging to obtain for hill breeds such as the Scottish Blackface. There are often a limited number of EBV-recorded rams for sale and conventionally ewes are mated in multi-sire cohorts and lambed on open hills, making parentage recording difficult. Ewe performance data (e.g. weights, litter sizes) could be collected relatively easily at routine handling events, if coupled with Radio Frequency Identification ear tags (now mandatory for UK sheep) and associated recording and weighing technology (Brown et al. 2015). However, in UK hill sheep systems, these handling events are limited (Morgan-Davies et al., 2012). Visual assessment pre-mating (for example: size, state of mouth, evidence of disease, etc.), which requires no knowledge of the ewes' previous performance, is another alternative. This is a current approach for selecting animals to retain in the breeding flock in UK hill sheep systems.

The aim of this study was to identify how these different categories of traits are associated with ewe performance the following year, in order to inform recommendations for ewe retention strategies.

Materials and methods

Scottish Blackface ewe performance data were collected at Scotland's Rural College (SRUC)'s Hill and Mountain Research Centre, in the West Highlands of Scotland. All work involving animals was approved by SRUC's Animal Ethics Committee. The research farm is run as a UK commercial hill farm; although the animals are recorded more frequently (monthly compared to 3 to 5 times per year).

All data were collected or collated at the point of selection (October, pre-mating) over two years. 794 ewes were recorded, with some animals appearing in both years. Ages ranged from 2.5 to 7.5 years old at selection. Commercially available EBVs were generated by Signet Breeding Services. Data were grouped into three categories: 1) appearance pre-mating; 2) recorded performance, during early life and the previous year; and 3) EBVs (Table 1).

Ewes were sold if they met predefined rules. These rules removed animals whose current condition had either already significantly reduced their welfare, or was likely to the following year, or who had repeated reproductive failures. Although it could lead to survival bias, for this study, animals sold were not included in the dataset for analysis.

The appearance traits scored (listed in Table 1) include all traits that flock managers take into account when visually judging which animals to retain. Each ewe was scored by the same flock manager throughout the trial.

The categories of traits were each compared against performance the following year, as defined by number of lambs (NL) and weight of lambs (WL) weaned (as measures of production) and ewe survival (ES). The best combination of traits, within each category, was selected

Table 1 Categories of traits available when deciding which ewes to retain for breeding, to explore performance (number and weight of lambs weaned) and survival of ewes the following year. EBVs: Estimated Breeding Values, values are difference to breed average; BCS: Body Condition Score; PY: previous year.

Category	Trait	Scale	Mean (SD)
Appearance pre-mating	Size	1 (smaller than ideal) - 3 (larger than ideal)[1]	2[4]
	Flatness of back	1 (very saddled back) - 3 (flat level back)[1]	3[4]
	Face colour	1 (lots of white) - 3 (mostly black)[1]	3[4]
	Face shape	1 (North type) -3 (South type)[1]	2[4]
	Fleece colour	1 (lots of brown patches) - 3 (all white)[1]	3[4]
	Fleece length	1 (very woolly) - 3 (short tight wool)[1]	2[4]
	Soundness of feet	1 (any foot not sound) – 2 (all feet sound)[1]	2[4]
	Udder damage	1 (severely damaged) - 3 (sound)[1]	3[4]
	Udder attachment	1 (poorly attached) - 3 (well attached)[1]	3[4]
	Teat size	1 (smaller than ideal) - 3 (larger than ideal)[1]	2[4]
	Sound incisor teeth present	0-8	7.8 (0.6)
	Correctness of legs and motion	1 (problems, legs or movement) - 3 (ideal)[1]	3[4]
	Shepherd's choice	1 (would sell) - 5 (would keep)[1]	3[4]
	Jaw position	-5 (lower jaw 5mm back from upper jaw) - 5 (lower jaw 5mm in front of upper jaw)[2]	1.6 (1.2)
	Tooth angle	−3 (45° forward) - 3 (45° backward)[2]	-0.04 (0.3)
	Tooth length	−2 (very short) - 2 (very long)[12]	0[4]
Recorded performance	Birth weight	kg	3.7 (0.7)
	Dam age	Years	2.5 (1.1)
	Lambing date	Days from start of lambing that year	12 (6.7)
	Wean weight	kg	27.8 (3.3)
	First pre-mating weight	kg	48.3 (5.6)
	First pre-mating BCS	1-5[1,3]	3 (0.2)
	PY pre-mating weight	kg	49.4 (6.7)
	PY pre-mating BCS	1-5[1,3]	2.8 (0.3)
	PY early pregnancy weight	kg	48.1 (5.4)
	PY mid-pregnancy weight	kg	47.2 (5.9)
	PY mid-pregnancy BCS	1-5[1,3]	2.7 (0.3)
	PY weaning weight	kg	53.7 (6.5)
	PY weaning BCS	1-5[1,3]	2.7 (0.3)
	PY lambs born alive	0-3	1 (0.7)
	PY lambs at 8 weeks	0-3	0.9 (0.7)
	PY lambs at weaning	0-3	0.9 (0.7)
	PY weight of lambs at birth	kg	3.7 (2.5)
	PY weight of lambs at 8 weeks	kg	16.1 (13.8)
	PY weight of lambs at weaning	kg	24.4 (21.1)
	Current pre-mating weight	kg	51.3 (6.6)
	Current pre-mating BCS	1-5[1,3]	2.6 (0.5)
EBVs	Eight week weight	kg	0.68 (0.66)
	Scan weight	kg	2.08 (1.38)
	Ultrasound muscle depth	mm	0.85 (0.91)
	Ultrasound fat depth	mm	0.12 (0.19)
	Carcass lean weight	kg	0.79 (0.61)
	Carcass fat weight	kg	0.63 (0.62)
	Mature size	kg	2.62 (2.3)
	Litter size	0-3	0.1 (0.08)
	Maternal ability	kg	0.69 (1.04)

[1]Subjective score, [2]scored according to van Heelsum et al (2006), [3]scored on a 5 point scale with quarter integers according to Russel et al (1969), [4]mean presented as the mode, all scores were expressed.

using step-wise Generalized Linear Regression Modelling in GenStat (Payne et al. 2013). Ewe age was also included in each statistical model.

Results and discussion

Across the two years, recorded ewe mortality was 7%; mean lamb weaning weight was 28.6 kg (SD 4.2); and on average 98 lambs per 100 ewes mated were weaned.

The maximum percentage of variance in performance accounted for by the best models for each category of traits is still relatively low (Table 2). This is not unexpected due to the range of other environmental factors likely to be impacting on these traits.

Table 2 Traits in categories available when deciding which ewes to select to breed from, as required for Generalized Linear Model to predict performance (in terms of number and weight of lambs weaned) and survival of the ewe the following year. EBVs: Estimated Breeding Values; BCS: Body Condition Score (scored on a 5 point scale with quarter integers according to Russell et al, 1969).

	Number of lambs weaned	Total weight of lambs weaned	Ewe Survival
Appearance pre-mating	Ewe age, jaw position*, size*, flatness of back*, fleece colour, udder attachment, soundness of feet, tooth length, face colour and teat size.	Ewe age, jaw position*, size*, flatness of back*, soundness of feet, udder attachment, fleece colour, tooth length, face colour, udder damage, correctness of legs and motion, face shape.	Ewe age, flatness of back, correctness of legs and motion, face shape, number of sound teeth, fleece length.
Adj R2	6.3%	6.4%	7.1%
Recorded performance	Current pre-mating weight*; Previous year: lambs born alive*, wean BCS*, early pregnancy weight*, lambs at weaning, total lamb 8 week weight; Own wean weight.	Current pre-mating weight*; Previous year: number of lambs born alive*, wean BCS*, early pregnancy weight*, lambs weaned, total lamb 8 week weight, pre-mating weight, mid pregnancy BCS; Own wean weight*, first pre-mating weight.	Current pre-mating weight* and BCS*, Ewe age; Previous year: early pregnancy weight*, mid pregnancy BCS*, wean BCS*; Dam age, own birth weight, first pre-mating BCS.
Adj R2	11.1%	12.1%	14.6%
EBVs	Ewe age*; EBV for: litter size*, mature size.	Ewe age*; EBVs for: litter size*, eight week weight, carcass lean weight, maternal ability.	Ewe age; EBVs for: eight week weight*, ultrasound fat depth, scan weight*, carcass lean weight.
Adj R2	3.5%	4.0%	7.5%

*Trait significant to model, $P<0.05$. Percentage of variance accounted for by model (Adj R2) also shown.

Recorded performance data explained the largest amount of variation in WL, NL and ES compared to appearance traits and EBVs. This suggests that flock managers may benefit from using recorded performance data to aid retention decisions and help maximise these variables the following year. However, it is anticipated that long-term selection on EBVs will improve these performance traits across generations in a more predictable and cumulative way in well-recorded flocks. Further work to explore any potential for economic gain in a hill sheep system, from better selection of ewes, is needed. In particular, costs (e.g. labour, equipment, etc.) associated with collecting each category of traits should be considered.

When exploring longevity, most research studies focus on the whole lifetime of the animal (e.g., Mekkawy et al. 2009). Limitations of these datasets are the time-period required to collect the data and changes in flock selection regimes, making it impossible to know the animal's true productive ability (Essl 1998). In this study, decision to sell was based on a strict protocol; identifying animals failing to meet welfare standards or reproductive capabilities. This resulted in animals remaining in the flock after 5.5 years of age, allowing a rare opportunity to track these marginal animals. Although identifying early indicators of longevity would clearly have benefits to breeding strategies, predicting an animal's performance the following year may also provide an applicable and useful tool for a flock manager when selecting which animals to retain.

To conclude, recorded performance data is likely to be more valuable than ewe appearance in developing an objective system to select ewes for breeding the following year in hill flocks. This could be particularly useful when parentage information and EBVs are not available.

Acknowledgements

SRUC receive financial support from the Scottish Government's RESAS 2011-2016 Strategic Research Programme 2 (Food, Land and People).

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