Genetics of sheep health traits

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Objective

To quantify :
1. Genetic variation in health traits
2. Relationship between health and performance traits

Phenotypes

1. Foot lesion scores
2. Fecal egg count (FEC)
3. Dag scores

Methods

- 20,581 lamb health events across 29 flocks

Lamb performance data
- o 40 day weights
- o Weaning weights
- o Ultrasound fat and muscle depth
- o 120 day weight

(Co)variance components
- Estimated using linear animal mixed model

Fixed effects
- Litter size (single, twin, triplet, quadruplet)
- Rearing rank (single, twin, triplet)
- Gender of lamb
- Ewe parity (1, 2, 3, 4, ≥5)

Random Effects
- Animal
- Contemporary group (flock-date of recording)

Pedigree
- Assigned based on breed groups

Results

- 7% lambs were recorded with footrot
- Less incidence of foot problems in:
  - o Females
  - o Texel and Belclare breed
- 5% lambs moderately to very daggy
- Greater dag scores recorded in twins

Heritability estimates (Table 1)
- Low to moderate h^2 recorded for all health traits

Table 1. Heritability estimates (diagonal), phenotypic (above diagonal) and genetic (below diagonal) correlations between the health traits ($\pm$ SE)

	Foot Score	FEC	Dag Score
Foot Score	**0.08 ± 0.01**	0.05 ± 0.03	-0.003 ± 0.01
FEC	0.50 ± 0.34	**0.18 ± 0.04**	-0.02 ± 0.03
Dag Score	-0.02 ± 0.16	0.01 ± 0.28	**0.08 ± 0.01**

Correlations between health traits (Table 1)
- Lambs genetically susceptible to foot problems were also susceptible to high FEC
- Very weak correlation recorded between FEC and dag score

Genetic correlations between health and performance traits (Table 2)
- Higher foot lesion scores was associated with:
  - o Lower lamb weight
- Lower FEC was associated with:
  - o Superior lamb conformation and fat score
- Lower dag scores with associated with:
  - o Higher lamb live-weights

Conclusions

- Ample genetic variation exists for foot lesion score, FEC and dag score
- Health traits included in Irish national sheep breeding objectives in 2015

Acknowledgements

Phenotypes

Foot Lesion Scores

Use: indication of lameness in sheep
Scale 0 to 4

0. Absence of foot problems

1. Mild interdigital dermatitis or scald
2. More extensive scald
3. Mild footrot
4. Severe footrot

Fecal Egg Count (FEC)

Use: the presence of gastro-intestinal nematode parasites
Scale 4 to 10

McMaster technique
1 egg = 100 eggs/ gram
Data transformed to $\log_e(x+100)$

Dag Score

Use: indication of susceptibility to flystrike
Scale 0 to 5

Build up of fecal material around a lambs' hindquarter
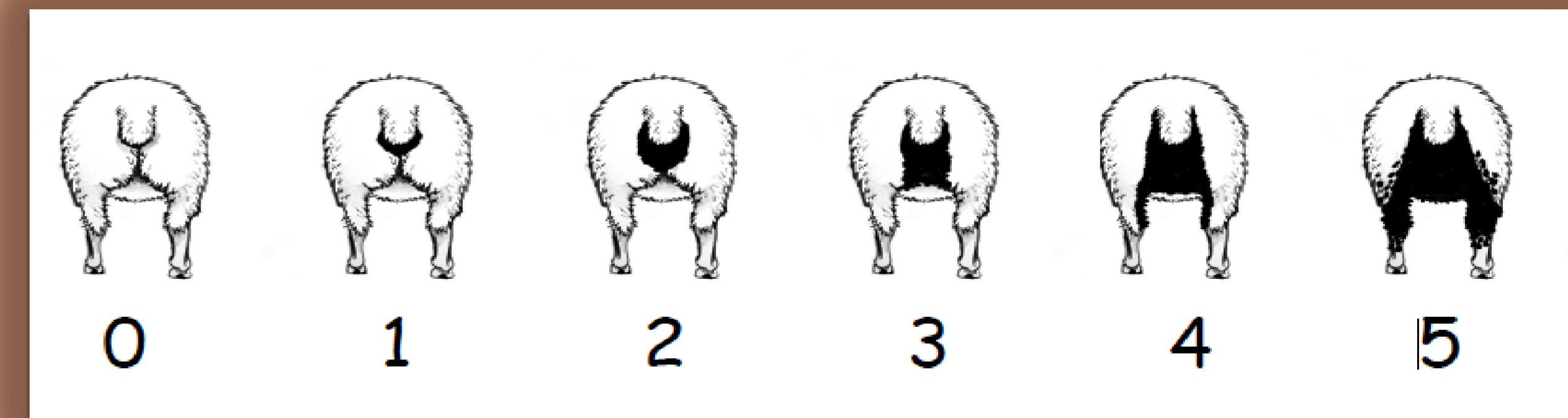
0. No visible dags
to
5 . Very daggy

0 1 2 3 4 5

Table 2. Genetic correlations (± standard error) between health and lamb performance traits.

Trait	Foot Lesion Score	FEC	Dag Score
Live weight at 40 days	-0.04 ± 0.16	0.42 ± 0.20	-0.13 ± 0.14
Live weight at weaning	-0.01 ± 0.14	0.88 ± 0.13	-0.01 ± 0.14
Live weight at 120 days	-0.49 ± 0.02	0.37 ± 0.26	-0.04 ± 0.18
Ultrasound muscle depth	0.32 ± 0.22	-0.11 ± 0.29	0.15 ± 0.18
Ultrasound fat depth	0.65 ± 0.18	-0.30 ± 0.32	0.38 ± 0.17

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ABSTRACT: The objective to this study was to quantify the genetic variation in foot lesion scores, fecal egg count (FEC) and dag score of lambs, and to examine the relationship between lamb health and performance. Lamb health events (n=20,581) were recorded across 29 crossbred flocks. Lamb performance data were also recorded. Low heritabilities were recorded for foot lesion scores (0.08 ± 0.01), FEC (0.18 ± 0.04) and dag score (0.08 ± 0.01). With the exception of the genetic correlation between foot lesion scores and FEC, phenotypic and genetic correlations recorded between the health traits were weak and close to zero. Negative genetic correlations were recorded between feet lesion score and lamb weights. Unfavorable genetic correlations were recorded between FEC and lamb weights; in contrast favorable genetic correlations were recorded between ultrasound and FEC data. The genetic correlations between dag score and lamb weight were weak but negative.

Keywords:

sheep

health

genetics

Introduction

One of the major constraints to long-term sustainability of livestock is susceptibility to infectious diseases (Bishop and MacKenzie (2003)). To mitigate from this risk many countries worldwide have commenced to breed for less susceptible animals through the inclusion of health traits in their breeding objectives (Bishop and Morris (2007)). Lameness, gastro-intestinal nematode parasites and flystrike are some of the major health traits that determine sheep productivity and profitability but are also of growing welfare concern internationally. Footrot has been highlighted as a huge cause of economic loss and as one of the major welfare problems in sheep (Bishop and Morris (2007)). With the evolution of anthelmintic resistant nematodes, an alternative sustainable approach to gastro-intestinal nematode infections is required (Good et al. (2006)). Flystrike is the most common ectoparasite disease that affects Northern Europe (Bisdorff and Wall (2008)). Dag score refers to the build-up of fecal material around a lamb's hindquarter and has been shown to be strongly correlated with flystrike (Greeff and Karlsson (2009)). However dag score is an important trait in itself for Irish producer's lambs since excessive daggy animals incur financial penalties at the point of slaughter. Current methods for the control and prevention of these diseases are not only costly to the sheep industry but also require substantial labour input. There is considerable scope for the exploitation of genetic variation in sheep health traits

through the use of the trait itself or through the use of predictor traits: lameness- through the use of foot lesion scores (Nieuwhof et al. (2008)), gastro-intestinal nematode parasites – through the use of fecal egg counts (FEC; Bishop and Morris, 2007); and flystrike- through the use of dag scores (Greeff and Karlsson (2009)) and therefore it is possible to select for sheep with genetically superior health attributes. However, to date no health traits have been included in the Irish national genetic evaluations. The objective to this study was to quantify the genetic variation in foot lesion scores, FEC and dag score in Irish sheep, to examine the relationship between lamb health and performance traits and to investigate whether these health traits should be incorporated into the national genetic evaluations.

Materials and Methods

A total of 20,581 lamb health events from 29 crossbred flocks across the years 2010 to 2013, inclusive were available from the Sheep Ireland database (www.sheep.ie). The three health traits considered in the present study were foot lesion scores, fecal egg counts and dag score.

Foot Lesion Scores. Foot lesion scores were recorded by a trained technician on a scale from zero to four as described by Conington et al. ((2008); 0= absence of foot problems, 1= mild interdigital dermatitis or scald, 2= more extensive scald, 3= mild footrot, and 4= severe footrot). Only one overall score was assigned to each individual animal on each scoring date. Only lambs scored between 50 and 250 days were included in the analysis.

Fecal Egg Count. FEC were determined using a modified McMaster technique (Whitlock (1948)), with each egg observed representing 100 eggs per gram of faeces. No differentiation was made between the genera of the eggs in the counting of the eggs. Only FEC scored on animals between 145 and 315 days were included in the analysis. FEC values were transformed to logarithms $\log_e(x+100)$ to stabilise the variance.

Dag Score. Dag score was scored on a six point scale ranging from 0 (no dag) to 5 (very daggy) by trained technicians (Figure 1). In the current study dag scores were measured on lambs ranging in age from 50 to 250 days of age.

Figure 1: Criteria used for the scoring of dag scores on each animal individually.

0   1   2   3   4   5
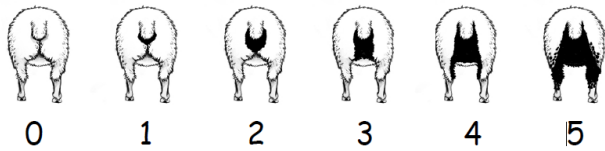
Lamb Performance. Forty day weights, weaning weights, ultrasound measures (measured at approximately 140 days of age) of fat (UFD) and muscle (UMD) depth and weight at ultrasound scanning were also available. Only animals with forty day weights recorded between 20 and 65 days and weighing between 12 and 30 kg at the forty day weight were retained. Weaning weight records between 20 and 55 kg of lambs aged between 66 and 130 days were retained. Ultrasonic scan records were retained on lambs aged between 85 and 170 days of age at date of measurement and weighing between 25 and 65 kg, with muscle depth scores between 18 and 40 mm and fat depth scores between 0 and 4 mm.

Data analyses. Across all traits animals were discarded if sire, recording date, flock of recording or ≥50% of their breed fraction were unknown. Ewes with parities >8 were discarded and ewe parity was categorized as 1, 2, 3, 4, ≥5 or missing. Litter size was defined as the number of lambs born (alive or dead) per lambing event; only litter sizes between one (singles) and four (quadruplet) were retained for analysis. Rearing rank was defined as the number of lambs weaned per ewe; rearing rank was coded as 1 (reared as singles), 2 (reared as twins), 3 (reared as triplets) or missing. Contemporary group for the lesion score, FEC and dag score was defined as flock-date of scoring for each trait separately. Following all edits 4,934 foot lesion scores, 7,097 day scores and 1,167 FEC records remained from mainly Belclare, Suffolk, Texel, and Charollais crossbred lambs.

Statistical analyses. Phenotypic and genetic (co)variance components for foot lesion scores, dag score and FEC were estimated using a linear animal mixed model in ASReml (Gilmour et al. (2012)).

Phenotypic and genetic covariance components between the lamb health traits and lamb performance were estimated using linear sire mixed models in ASReml (Gilmour et al. (2012)).

Fixed effects considered for inclusion in the model were litter size (single, twin, triplet, quadruplet), rearing rank (single, twin, triplet), gender of lamb, ewe parity (1, 2, 3, 4, ≥5 and missing), and the heterosis and recombination loss coefficients for each animal. Fixed effects and interactions of biological interest between the fixed effects were tested in the model using forward-backward regression, where P=0.05 was the threshold significance levels for entry and exit of variables into/from the model. Across all traits animal and contemporary group of flock-date of scoring were included as random effects.

The pedigree of all animals was traced back to the founder population where founder animals were allocated to breed groups based on breed composition.

Results and Discussion

On average 58% of the lambs had no incidence of foot problems, 35% had some incidence of scald (25% mild and 10% severe) and 7% were recorded with footrot (5% mild and 2% severe). Male lambs were more likely to suffer from foot lesion scores relative to female lambs (P<0.05). Less incidence of foot problems were recorded in the Texel and Belclare breeds whereas the greatest incidence of foot problems were recorded for Vendeen lambs. A score of zero (i.e. no visible dags) was recorded on 32% of the scored lambs; 5% of the lambs were classed as moderately to very daggy (dag score four or five). Lambs reared as twins were more likely to have greater dag scores relative to triplets and singles (P<0.05). The lowest levels of dag scores were recorded for the Belclare and Texel breeds and highest dag scores were recorded for the Suffolk lambs. Relative to a lamb born to a third parity ewe highest FEC were recorded for a lamb born second parity ewe (0.30 ± 0.11; P<0.05). Similar to previous Irish results lower worm burdens were observed in Texel lambs compared to Suffolk bred lambs (Good et al. (2006)).

Low to moderate heritability estimates were recorded for the three health traits investigated in the present study (Table 1.). The current heritability recorded for foot lesion scores (0.08 ± 0.01) was within the range of heritabilities estimated by Nieuwhof et al. (2008) for the Scottish Blackface and Mule breeds. FEC had the highest heritability estimate (0.18 ± 0.04) recorded across the three health traits and was similar to those reported in the New Zealand sheep population (Pickering et al. (2012)). The heritability recorded for dag score (0.08 ± 0.01) were lower than those reported in New Zealand (Pickering et al. (2012)) but collaborates previously reported heritability estimates for Australian Merinos by Smith et al. (2009).

Table 1. Heritability estimates (diagonal), phenotypic (above diagonal) and genetic (below diagonal) correlations between the health traits (± standard error).

	Foot Lesion Score	FEC	Dag Score
Foot Score	0.08 ± 0.01	0.05 ± 0.03	-0.003 ± 0.01
FEC	0.50 ± 0.34	0.18 ± 0.04	-0.02 ± 0.03
Dag Score	-0.02 ± 0.16	0.01 ± 0.28	0.08 ± 0.01

The phenotypic correlations between the health traits were close to zero and ranged from -0.02 ± 0.03 (FEC and dag score) to 0.05 ± 0.03 (foot lesion score and FEC). Lambs that were genetically susceptible to foot problems were also susceptible to high worm burden as indicated by the moderate genetic correlation recorded between foot lesion score and FEC (0.50 ± 0.34). The observed

phenotypic and genetic correlations recorded between dag score and FEC in the present study, are contrary to the industry held view that excessively daggy lambs are suffering from a high worm burden and therefore require treatment.

In general weak phenotypic correlations were recorded between the health and lamb performance traits. The phenotypic correlations between foot lesion scores and lamb performance data were weak and ranged from -0.07 ± 0.02 (ultrasound scan weight) to 0.02 ± 0.02 (UMD). Weak to moderate phenotypic correlations were also recorded between FEC and lamb performance traits and ranged from -0.07 ± 0.06 (UMD) to 0.41 ± 0.51 (weaning weight). Negative phenotypic correlations were recorded between lamb weights and dag score whereas weak positive correlations were recorded between ultrasound data and dag score.

The genetic correlations between health traits and lamb performance traits are reported in Table 2. Moderate to weak negative genetic correlations were recorded between foot lesion score and lamb weights. In contrast, however positive genetic correlations were recorded between foot lesion score and ultrasound measures indicating that although foot lesion scores had a negative effect on lamb weight performance this did not have a knock-on effect on the animal's conformation or fat cover (Table 2).

Unfavorable (positive) genetic correlations were recorded in the present study between FEC and lamb weights and although higher than previously reported (Wolf et al, 2008; Pickering et al., 2012), large standard errors were associated with the current correlations. Favorable (negative) genetic correlations were recorded between ultrasound and FEC data indicating that low worm burdens is more likely to result in superior lamb conformation and fat score but does, however, result in large weight losses.

The negative genetic correlations recorded between dag score and lamb weight mean that selecting for less daggy lambs will result in selection for lambs of higher live-weight.

Table 2. Genetic correlations (± standard error) between health and lamb performance traits.

Trait[§]	Foot Lesion Score	FEC	Dag Score
40d WT	-0.04 ± 0.16	0.42 ± 0.20	-0.13 ± 0.14
WWT	-0.01 ± 0.14	0.88 ± 0.13	-0.01 ± 0.14
Scan WT	-0.49 ± 0.02	0.37 ± 0.26	-0.04 ± 0.18
UMD	0.32 ± 0.22	-0.11 ± 0.29	0.15 ± 0.18
UFD	0.65 ± 0.18	-0.30 ± 0.32	0.38 ± 0.17

[§]40d WT = forty day weight, WWT= weaning weight, Scan WT = weight of lamb at ultrasound scanning; UMD = ultrasound muscle depth, UFD = ultrasound fat depth.

Conclusion

Results from this study indicate that ample genetic variation exists for foot lesion score, FEC and dag score and allows for the inclusion of health traits in the Irish national sheep breeding objectives. Genetic correlations between the health traits and lamb performance traits were weak to moderate and knowledge of these correlations will allow for simultaneous selection on greater lamb performance while improving Irish sheep health attributes.

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