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Relationship of condition/fat score with liveweight in ewes

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Background

Within the Sheep CRC, a number of management decisions have been identified that would be assisted by assessing body condition from liveweight. Liveweight change of itself is seen as inadequate in that it does not have the capacity to account for differences in frame size. This is particularly relevant for managing the breeding ewe flock. A combination of information on liveweight and condition score deals with the frame size issue.

Australian feeding standards (SCA 1990) have been the basis for a number of Decision Support Systems (eg Grazfeed and Grassgro, Freer *et al*. 1997) and other tools developed to assist in the management of ruminant livestock. An important relationship is that of liveweight with condition score (0-5 scale, as per Jefferies 1961), which currently has been set at 0.15 of the standard reference weight (SRW, the fleece free liveweight at condition score 3) for mature animals. This relationship has been included in tools such as the Maternal Weight calculator developed within the Sheep CRC for estimating the body condition of pregnant ewes.

Ideally, the question of how much liveweight change is required to achieve a unit shift in condition score would be resolved using within animal relationships (ie using repeated measurements on individuals). However, there is dearth of published data with multiple liveweight and condition score records for individual sheep, and hence the data establishing the relationship used in publications of SCA (1990), and subsequently Freer *et al* (2007), are based on between-animal relationships. The sheep data available to SCA (1990) is summarised in the Appendix (Table 7).

Introduction

This report presents the results of analyses of the relationship of condition/fat score with liveweight for a number of data sets sourced from across Australia. The primary consideration in selecting those data sets was that both liveweight and condition/fat score had been recorded on the same adult animals on at least two occasions so that the within-animal relationship could be determined.

Fat scores are also used widely, similarly to condition scores, for ewe management. For this reason data sets with repeated records of liveweight and fat score were also included in these analyses.

The study sought to determine:-

- the relationship of liveweight with condition score as practised in a number of studies of adult breeding ewes from across Australia where repeated measurements (of individuals) over time were available,
- the extent to which the within- and between-animal relationship of liveweight with condition score might differ, and if appropriate,
- quantify the within-animal relationship of liveweight with condition score.

Methods

A total of seven data sets containing liveweight and condition or fat score recorded on multiple occasions from individual ewes were available from a number of sources across Australia. They are listed below the two headings of condition score and fat score.

I Condition score

Source 1. Data were available for 3 years with all ewes replaced each year, although some ewes present in year 1 were used again in year 3. Body condition scores were assessed by the one scorer over the three years

Source 2. The data included information collected over 3 years with Merino ewes replaced each year.

Source 3. The data were collected in one year from 561 Merino ewes located at 6 sites, with 2 assessments of liveweight and condition score conducted by one assessor.

Source 4. Data from a 3 line selection experiment were available for 6 years (1992, 1994-1998) and comprised (2830 annual records) from 1044 Merino ewes (2-6 years of age, mean 8.9 liveweights with condition scores per year). Body condition scores were allocated by a number of assessors over the period. The ewes were sourced from 21 locations.

II Fat score

Source 5. The data were collected in one year from 2 year-old Merino ewes located at 3 sites, with scores by a different assessor at each site. The bloodline at each site also differed.

Source 6. Based on their fibre diameter and liveweight, 1912 ewes (3-8 years of age) were grouped as being suitable for joining to meat or wool type sires, with liveweight and fat scores being collected in one year (same assessor throughout)

Source 7. 118 Border Leicester x Merino ewes with liveweight and fat scores collected 6 months apart, and scored by the same operator.

Statistical analyses

For all analyses reported, any liveweights collected during pregnancy and lactation were excluded to ensure that liveweights, and the relationships derived, were representative of “dry” animals.

Comparison of the within- and between-animal relationship of liveweight with condition/fat score. For each of the datasets, a bivariate analysis of liveweight and condition/fat score was used to estimate the within- and between-animal variances and co-variances (within ASReml, Gilmour *et al.*, 2002), after adjustment for “structural” factors within the data (e.g. year, age, property and genotype). These factors were fitted as fixed effects and the “animal” term was fitted as a random effect. Because each of the sites from *Source 5* represented a different genotype, scorer and location, each site was analysed separately for the purposes of estimating the within- and between-animal relationship of liveweight with condition/fat score. The respective variances and co-variances were use to estimate the within- and between-animal correlations of liveweight with condition/fat score, and the coefficients of regression of liveweight on condition/fat score. The repeatability (t, Turner and Young, 1969) for each trait was also estimated as:

$$t = \sigma_B^2 / (\sigma_B^2 + \sigma_W^2)$$

Within-animal regression of liveweight on condition/fat score. Liveweights from each of the data sets were analysed separately using ASReml (Gilmour *et al.*, 2002) fitting condition score (linear covariate), design factors (e.g. site, year of measurement) and their interaction with score as fixed effects and animal, spline(score) and the interaction of design factors with spline(score) as random effects. Non-significant terms were sequentially deleted.

To allow for differences in frame size of the groups of ewes, and consistent with the approach used by APC (1990), the regression coefficient estimated above was expressed as a proportion of the standard reference weight (liveweight at score 3) of the group. The standard reference weight (Freer *et al.*, 1997) for each group of animals was estimated from the sum of the intercept and three times the estimated regression coefficient.

Results

The mean liveweight and condition/fat score for each of the data sets are included in Table 4. The range in mean condition/fat scores of the data sets were within 0.6 units of 3, except for the *Source 7* data with a mean of 4.2. These data also had the lowest coefficients of variation for both liveweight and fat score.

Comparison of the within- and between-animal relationship of liveweight with condition/fat score

The analyses of the variances and co-variances clearly indicate differences between the within- and between-animal relationships of liveweight with condition/fat score.

The repeatability of condition/fat score (range 0.09 to 0.48) was less than that for liveweight (range 0.37 to 0.71) in all data sets except *Source 1* which were both 0.45 (Table 4).

Table 1 Mean, standard deviation (sd) and repeatability of liveweight and conditions/fat score in breeding ewes

Source		Liveweight kg			Score		
		mean	sd	Repeatability	mean	sd	Repeatability
1	Merino	48.3	6.8	0.45	2.9	0.5	0.45
2	Merino	53.6	8.4	0.71	2.4	0.7	0.48
3	Merino	47.2	8.0	0.60	2.6	0.7	0.41
4	Merino	59.0	9.5	0.44	3.1	0.6	0.17
5.1	Merino	44.6	7.3	0.45	2.5	0.6	0.32
5.2	Merino	44.1	5.5	0.46	3.1	0.6	0.26
5.3	Merino	50.5	6.3	0.59	3.0	0.6	0.09
6	Merino	46.1	7.5	0.55	3.3	0.7	0.28
7	XB	81.5	8.0	0.43	4.2	0.6	0.33

Table 2 Between- (B) and within-animal (W) variances (σ^2), and the respective correlations (r) and regression coefficients (b) for liveweight on condition / fat score in breeding ewes

Source	Liveweight		Score					
	σ_B^2	σ_W^2	σ_B^2	σ_W^2	r_B	r_W	b_B	b_W
1	23.8	28.8	0.148	0.179	0.64	0.61	8.17	7.71
2	45.4	18.4	0.187	0.207	0.74	0.46	11.60	4.30
3	18.3	12.3	0.191	0.271	0.67	0.43	6.53	2.88
4	28.3	36.7	0.042	0.209	0.57	0.50	14.82	6.59
5.1	27.6	30.1	0.106	0.222	0.77	0.66	12.41	8.20
5.2	15.3	17.7	0.095	0.265	0.45	0.43	5.65	3.49
5.3	21.9	15.2	0.034	0.333	0.63	0.36	16.05	2.45
6	28.6	23.6	0.140	0.352	0.51	0.56	7.29	4.60
7	27.6	36.0	0.113	0.233	0.28	0.58	4.41	7.19

The between-animal correlations ranged from 0.28 to 0.77, and the within-animal from 0.36 to 0.66. For 7 of the 10 analyses, the between-animal correlation of liveweight with condition/fat score exceeded that for within-animal. Of the remaining 3 analyses, 2 represented the crossbred ewe data sets which also had among the higher condition scores (Table 5).

The between-animal regression coefficients of liveweight on condition/fat score for 8 of the 9 data sets (including all 8 Merino ewe data sets) were greater than the within-animal relationship, and substantially so for most (7) of them (Table 5). The data set in which the within-animal regression was greater was *Source 7* (4.41 and 7.19 kg/ score, between- and within-animal, respectively), also having the highest mean fat score and lowest coefficient of variation.

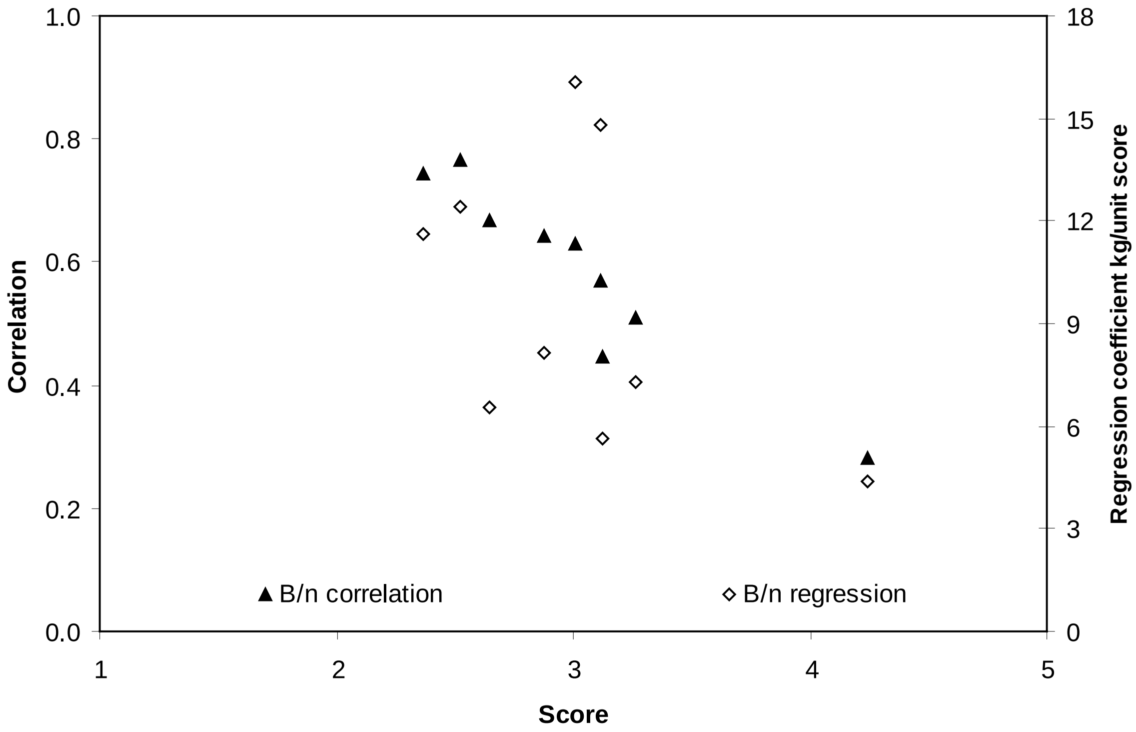

Figure 1 The association of group mean condition/fat score with the between-animal correlations and regression coefficients of liveweight on condition/fat score

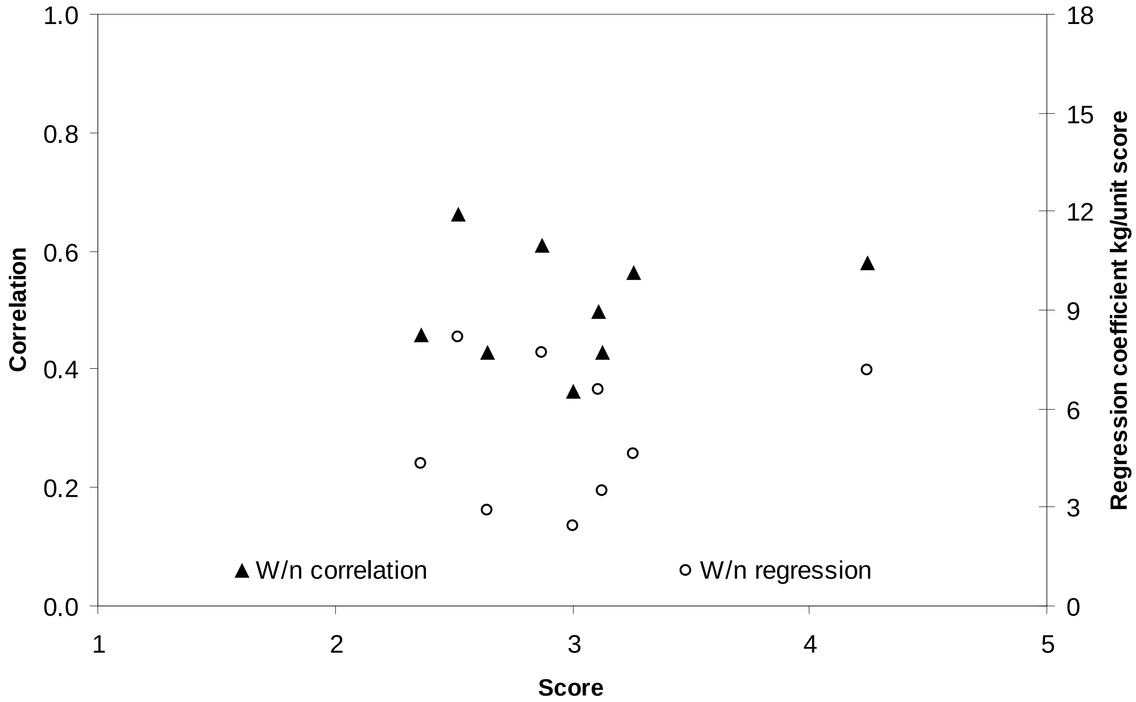

Figure 2 The association of group mean condition/fat score with the within-animal correlations and regression coefficients of liveweight on condition/fat score

There is a clear trend for the between-animal regression of liveweight on condition/fat score to decline with the mean score of the group, but the association of the group score with the between-animal regression coefficient is less distinct (Figure 5).

The with-animal correlations and regression coefficients of liveweight on condition/fat score each appear to be independent of the group mean condition/fat score (Figure 6).

Within-animal regression of liveweight on condition/fat score

Condition score

Table 6 indicates the rate of change in liveweight for each unit change in condition score for each of the data sets. The range in estimates of the slope was 1.3 to 7.4 kg liveweight / unit condition score.

Although there were effects of year and selection line within the *Source 2* and *4* flocks, respectively, there was no interaction with condition score and hence the relationship was constant within the flocks: 6.0 and 5.7 kg /condition score, respectively. Consequently, the slope expressed in relation to the SRW was 10.1-11.1 and 9.2-9.6%, respectively. The slope within the *Source 1* data differed between years, ranging from 5.9 to 7.4 kg/condition score, representing 12.7-15.5% of the SRW. However, the greatest variation existed within the *Source 3* data where the slope varied between properties and ranged from 1.3 to 5.8 kg/condition score (3.0 – 12.3 % of the SRW).

Table 3. Within-animal regression of liveweight and condition score (scale 0-5) of, estimated from data containing multiple records per animal.

Score	Source	Breed		n	Wt @ cs=0	Slope kg/ score	SRW[†]	Slope as % SRW
Condition	1	Merino	Year 1	669	25.1	7.3	47.0	15.5
		Merino	Year 2	686	28.9	5.9	46.7	12.7
		Merino	Year 3	757	28.3	7.4	50.5	14.6
	2	Merino	Year 1	320	36.4	6.0	54.6	11.1
		Merino	Year 2	400	41.9	6.0	60.0	10.1
		Merino	Year 3	500	38.0	6.0	56.2	10.8
	3	Merino	Property 1	91	46.0	4.7	60.0	7.8
		Merino	Property 2	101	37.7	2.5	45.3	5.6
		Merino	Property 3	96	29.8	5.8	47.2	12.3
		Merino	Property 4	91	38.6	1.3	42.3	3.0
		Merino	Property 5	88	29.5	4.7	43.6	10.8
		Merino	Property 6	94	38.6	4.2	51.1	8.1
	4	Merino	Line 1	342	45.0	5.7	62.2	9.2
		Merino	Line 2	354	43.5	5.7	60.7	9.4
		Merino	Line 3	348	42.5	5.7	59.7	9.6
Fat	5	Merino	Site 1	800	24.4	7.1	45.8	15.6
		Merino	Site 2	911	33.9	3.4	44.1	7.7
		Merino	Site 3	967	44.0	2.9	52.9	5.6
	6	Merino	Meat	963	37.8	3.6	48.5	7.3
		Merino	Wool	953	29.7	5.1	45.0	11.3
	7	XB		118	53.2	6.7	73.2	9.1

[†] Standard Reference Weight; Liveweight estimated at condition/fat score 3, assuming the ewes are mature.

Fat score

Across the fat score data sets (*Sources* 5-8), the range in the slope estimates (2.9 to 7.1 kg / unit fat score, Table 6) was of a similar magnitude as that for the condition score data sets.

“Meat” ewes, within the *Source 6* data, required at a significantly (P<0.05) smaller change in liveweight to affect a unit change in fat score than did the “wool “ewes (3.6 *vs.* 5.1 kg/ score).

Discussion

Comparison of the within- and between-animal relationship of liveweight with condition/fat score

Measurement errors and changes between measurements would both have been contributing influences on the repeatability estimates in this report. If measurement error is negligible and the relationship between liveweight and condition/fat score is linear, the repeatability of liveweight and of score will be the same. However, for all but 1 data set, the repeatability of liveweight of score was less (often substantially) than that of liveweight. This is to be expected given the small within-animal variance in liveweight measurement that can be achieved (Lee *et al.* 2008), and the subjective nature of scoring, even with training.

Lower regression coefficients indicate a greater sensitivity of score to changes in liveweight at the within-animal level than between animals. While the between-animal relationship may be useful in describing animals within a flock at a given time, for the purposes of managing the condition score of animals the within-animal relationship is appropriate. The analyses of variances and co-variances indicated that there are differences in the relationship of liveweight with condition/fat score at the between-animal and within-animal levels.

Within-animal regression of liveweight on condition/fat score

The analyses indicated considerable variability in the relationship of liveweight and condition/fat score. Possible factors behind that variability include operator and genotype. However, the structure of each of the data sets makes attributing reasons for the variation extremely difficult, with little comparative information available. Both the *Source* 1 and 2 flocks comprised one bloodline each, and were scored by one operator across all 3 years. The 3 selection lines within *Source 4* were each based on sheep from multiple sources, although little variation between the selection lines was evident. The *Source 5* data represented three different Merino genotypes, which were confounded by geographical location and operator. The *Source 3* data set, assessed by just the one operator, showed significant differences in the relationship between properties, although reasons for those differences are not obvious given available information but may include a genotype effect.

Only 1 data set gives direct guidance as to differences in the condition (fat) score / liveweight relationship. The *Source 6* data set allows a legitimate comparison of two groups differing in their rankings on fibre diameter and liveweight (**“**meat” or “wool” types) as they were both scored by the same operator. “Meat” types had a smaller regression coefficient (3.6 *vs* 5.1 kg/score), and although they had a slightly higher estimated SRW, one score represented only 7.3 % of SRW (*cf.* 11.3 % for “wool” types). This is consistent with the suggestion that “meat” type sheep have a higher proportion of their fat partitioned to the carcass (including the subcutaneous depot) and less in the abdominal depots compared with “non-meat” types (Butterfield *et al.* 1985).

To test the factors behind the great variation in the condition (fat) score / liveweight relationship would require a small study that:

- repeatedly measuring liveweight and condition/fat score over time with,
- diverse genotypes managed at one site
- a number of independent scorers, and
- managed differences in liveweights between measurements.

Conclusion

- Comparisons of the between and within-animal relationship of condition/fat score with liveweight indicated that the relationship within-animal is more sensitive (lower slope)
- There was considerable variation in the LW/score relationship across the data sets, but the range in estimates of the regression coefficient was similar for condition score and fat score.

- But little explanation for that variability. The indication from one source was that fat score of “meat” Merinos was more sensitive to liveweight than “wool” Merinos
- Very limited data was available for non-merino sheep.
- A longitudinal study, using a range of diverse genotypes, with repeated liveweight and scoring observations, and manipulation of liveweight changes in a pre-designed manner, would assist in resolving reasons for variation in the LW/score relationship, and the need for “constants” that reflect genotype differences.
- While considerable variation was evident in the within-animal relationship of liveweight with condition/fat scores, the current constant of 0.15 of the SRW appears to be at the high end of the range. Until reasons for the variability are available, a constant of 0.1 of SRW per unit condition score might be more appropriate.

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Appendix

Table 4. Regression of liveweight on condition score (0-5) from SCA (1990) and its relationship to estimated standard reference weight

			n	Intercept	Slope kg LW/ unit CS	SRW[†]	Slope as % SRW
Dry							
Polwarth x SA Merino	adult	C	47	33.1	6.3	52.0	12.1%
	maiden	C	60	21.3	7.3	43.2[#]	16.9%
Saxon Merino	adult	C	44	29.9	5.6	46.7	12.0%
	maiden	C	42	17.6	7	38.6[#]	18.1%
Scottish blackface	adult	B	30	33.3	10.6	65.1	16.3%
Lactating							
SA Merino		C	10	35.3	5	50.3	9.9%
Saxon Merino		C	10	29.4	5.5	45.9	12.0%
Corriedale		C	10	18.9	11.9	54.6	21.8%
Dorset		A	62	20.6	11.8	56.0	21.1%
Wethers							
Polwarth x SA Merino		C	54	18.3	11.8	53.7	22.0%
Saxon Merino		C	58	16.1	10	46.1	21.7%
Saxon Merino		C	90	33.2	7	54.2	12.9%
Weaners							
Polwarth x SA Merino	Wethers	C	46	5.6	11.3		
	Ewes	C	45	6.5	10.1		
Saxon Merino	Wethers	C	37	7.3	9.3		
	Ewes	C	42	11.8	7		

[A] KG Geenty and M Abrahamson (unpublished), [B] Russel *et al*. (1969), [C] RL Thomson and JZ Foot (unpublished)
[†] Calculated Standard Reference Weight; intercept plus 3 times slope
[#] Assuming maturity