

PREDICTION OF BODY COMPOSITION IN LIVE ANIMALS

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Summary

Merino and Border Leicester x Merino ewe and wether weaners within the bodyweight range of 20 to 40 kg were slaughtered and body composition determined. Highly significant relations were established between full bodyweight or empty bodyweight and weights of skin, head, blood, internal organs, carcass weight and carcass composition. Total protein, fat and energy in the animals were also significantly related to full bodyweight and empty bodyweight. Significant differences existed in some of these relations between sexes and breeds. The data are compared with other published results.

I. INTRODUCTION

Most available techniques for predicting body composition in the live animal are either tedious or difficult to use in the field, e.g. tritium dilution technique (Panaretto 1963; Panaretto and Till 1963), antipyrine and N-acetyl-4-aminoantipyrine (Wellington *et al.* 1956; Panaretto 1962; Bensadoun *et al.* 1962, 1963), and with urinary creatinine as a predictor of body protein (Van Niekerk *et al.* 1963). Other techniques, though promising, are still in the developmental stage, e.g. body fat from specific gravity determined by air displacement (Beeston 1964).

Precise regression relations between parameters of the live animal and parameters of the composition of either the empty (ingesta-free) body or the carcass would have wide application. There has been little interest in such studies because the amount of ingesta in the intestinal tract is large and variable. It can range from 5 to 30% of the total weight of the body. Bensadoun *et al.* (1963), however, found good relations between the weight of the wool-free, empty body of sheep (EBW) and their "shrunk" (18-20 hour fast, water allowed) full bodyweight (FBW) when a comparatively wide variety of diets and body compositions were used ($r = 0.994$, S.E. of the estimate 3.8% of the mean shrunk weight of 41.62 kg). After re-examining published work, Tulloh (1963) reported **that in the sheep** EBW and carcass weight are highly correlated with dissected carcass composition. He points out that carcass composition in sheep is more closely related to FBW than to age. Tallis, Turner and Brown (1964) report a 0.95 correlation between liveweight before slaughter and weight of edible meat in seven-month old Merino wethers. Gardner, Hogue and Bensadoun (1964) report good rela-

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tions between wool-free empty body composition and the weight of the wool-free EBW of lambs.

The present report details various regression relations obtained for **pasture-fed Merino** and **Border Leicester x Merino** weaner ewes and **wethers** relating FBW and EBW to body composition.

II. METHODS

Twenty-four **9-month-old Merino** and **Border Leicester x Merino** sheep were used. Six ewes and six **wethers**, paired for bodyweight within breeds, were selected from the flock to give as wide a range in bodyweight as possible (Merinos 20-31 kg, Border Leicester x Merinos 24-40 kg). The sheep were fasted for 36 hours, weighed and slaughtered.

Weights of blood, head, feet, skin, internal organs and **carcasses** were obtained. The skins were dried and shorn and the weight of wool recorded. The head and feet, internal organs and half of each **carcase** were minced separately. Minced samples were analysed for moisture, protein, fat and calorific value. The other half of each **carcase** was dissected into muscle, fat, bone and waste. Water content was determined on the separate parts. Edible meat was calculated as muscle plus fat plus waste.

Linear regression of FBW and EBW on fresh weights, dry weights and chemical composition values of body and **carcase** components was done. The data showed no evidence of non-linearity. The mean linear regression and homogeneity of regression was tested. The four groups were compared using covariance. In this paper only the relations between FBW and EBW and body composition on a fresh basis are described.

III. RESULTS

Table 1 gives the estimated composition of animals with **FBW's** of 24 and 31 kg for each breed and sex group. The components of the **carcasses** given in Table 1 were each determined from an equation relating it to FBW. **FBW's** of 24 and 31 kg cover the range common to all treatments. Analyses of variance, correlation coefficients of mean regressions and standard deviations of mean residuals are given in Table 2.

FBW was significantly linearly related to all components measured at the 0.1% level of probability. Correlation coefficients varied from 0.745 for weight of head to 0.995 for EBW.

There were no significant differences in the slopes of regression lines for sexes and breeds for any parameter except bone. But for skin, head, **carcase** and total body water weights there were significant differences in the adjusted means. Thus, at the same FBW all groups had the same EBW, weight of blood, internal organs, edible meat and total calories. Merinos had heavier skins and lower **carcase** weights than Border Leicester x Merinos; the latter was due to less bone. **Wethers** had heavier heads than ewes.

The only difference between groups in total body water was that Merino ewes have significantly less than other groups.

TABLE 1
Fresh weights of parts of body and composition of carcase and total empty body

FLW (X) (kg)			Treat- ment					Parts of Body (Y)					Composition of Carcase (Y)					Empty Total Body (Y)				
								Blood (kg)	Skin (kg)	Head (kg)	Feet (kg)	Internal Organs (kg)	Carcase (kg)	Edible Meat (kg)	Muscle (kg)	Fat (kg)	Bone (kg)	Empty Bodyweight (kg)	Body Water (kg)	Calories (megacals)	Ether Extract (kg)	Crude Protein (kg)
24	1	Merino ewes						1.23	1.65	1.51	.53	4.09	9.61	8.16	6.12	1.73	1.42	21.18	11.86	57.67	2.90	4.01
	2	Merino wethers						1.23	2.09	1.66	.59	4.09	10.60	8.16	6.12	1.73	1.67	21.18	13.07	57.67	2.90	4.01
	3	BL x M ewes						1.23	1.54	1.50	.54	4.09	10.44	8.16	6.12	1.73	1.60	21.18	13.15	57.67	2.90	4.01
	4	BL x M wethers						1.23	0.88	1.71	.60	4.09	11.11	8.16	6.12	1.73	1.76	21.18	12.45	57.67	2.90	4.01
	31	1 Merino ewes						1.51	2.41	1.59	.64	5.27	13.31	11.05	7.78	2.96	1.70	27.22	14.63	77.83	4.29	5.10
		2 Merino wethers						1.51	2.74	1.81	.70	5.27	14.24	11.05	7.78	2.96	2.20	27.22	16.82	77.83	4.29	5.10
		3 BL x M ewes						1.51	2.05	1.50	.65	5.27	14.70	11.05	7.78	2.96	2.14	27.22	16.30	77.83	4.29	5.10
		4 BL x M wethers						1.51	1.61	1.82	.71	5.27	14.44	11.05	7.78	2.96	2.07	27.22	16.26	77.83	4.29	5.10
Rate of change g/kg*								39.7	95.2	20.5	15.7	170	532	413	238	161	59.8	862	456	2880†	198	155

*i.e. slope of regression line.

†Kilocalories/Kilogram

TABLE 2

Analysis of variance and of covariance of fresh weight of parts of the body, composition of carcase and total empty body (Y) on fasted liveweight (X)

	Parts of Body (Y)				Composition of Carcase (Y)					Empty Total Body (Y)				
	Blood (g)	Skin (g)	Head (g)	Internal Organs (g)	Carcase (g)	Edible Meat (g)	Muscle (g)	Fat (g)	Bone (g)	Empty Body- weight (g)	Body Water (g)	Calories (kilocal)	Ether Extract (g)	Crude Protein (g)
<i>Analysis of variance</i>														
F value for regression	53.71 ***	47.02 ***	16.95 ***	56.80 ***	518.58 ***	337.22 ***	197.80 ***	243.25 ***	176.59 ***	1225.16 ***	444.59 ***	286.02 ***	97.39 ***	99.51 ***
F value for differences in slopes	1.36	0.37	1.02	1.50	0.24	0.028	1.95	0.60	4.93 *	0.93	2.54	0.12	0.30	0.30
<i>Analysis of covariance</i>														
F value for differences in treatments	0.69	10.64 ***	4.26 *	2.88	8.02 **	2.49	1.53	2.50	7.81 **	0.90	6.48 **	1.35	1.69	2.49
Correlation coefficient	0.884	0.867	0.745	0.864	0.987	0.977	0.962	0.969	0.961	0.995	0.982	0.971	0.927	0.929
Standard deviation (g)	133	316	109	553	521	554	415	276	111	605	627	4183	466	383
Conservative LSD†														
5%		429	148		714						851			
1%		587			977						1165			
.1%		796												

“r-Conservative — Least favourable in respect to the size of the ($X_i - X_j$) component of LSD’s

* $P < 0.05$
 ** $P < 0.01$
 *** $P < 0.001$

IV. DISCUSSION

These data show that the composition of the live animal may be predicted with high precision from the FBW. Precision is slightly improved by using EBW — as seen from the correlation coefficients and residual standard deviations in Table 3. With the exception of internal organs, the differences between types of animals were the same when predicted by EBW or FBW. It is important that a fasted weight be taken because of the variability in weight of ingesta between animals or treatments (Large 1964). In this study, a 36-hour fast was used giving a correlation coefficient of 0.995 with a S.D. $\pm$ 605 g for FBW on EBW. This compares with 0.994 by Bensadoun et al. (1963) for an 18-20 hour fast.

Large (1964) reported the relations between body parts and EBW for Suffolk x Halfbred ewe lambs aged 1-1 6 weeks (4-40 kg EBW). There is good agreement between his regression lines and ours only for the carcass weight of Border Leicester x Merino sheep. Our Merino data has a parallel, but lower, regression line relating carcass weight to EBW. This suggests a true breed effect operates since the disagreement is difficult to explain on an age or nutrition basis (Tulloch 1963).

Y (Carcass weight in kg)

$$= 0.549 \times -0.348 \text{ (Border Leicester x Merino)}$$

$$= 0.602 \times -2.580 \text{ (Merino)}$$

$$= 0.595 \times -0.719 \text{ Large (1964)}$$

where X = EBW in kg.

Gardner, Hogue and Bensadoun (1964) reported relations between body chemical composition and EBW for Hampshire x Rambouillet-Columbia ewe and wether lambs on different planes of nutrition, slaughtered at 13 weeks (17-37 kg EBW). Their correlation coefficients for total protein, fat and calories were slightly lower than reported in the present study. The regression equations differed considerably as shown.

TABLE 3

Comparison of relationships between body composition and full or empty bodyweight

Body Component	Full Bodyweight		Empty Bodyweight		Empty Bodyweight	
	r	Residual S.D. (g)	r	Residual S.D. (g)	Residual S.D. (g)	(Large 1964)
Blood	0.884	133	0.883	138	61	
Skin	0.867	316	0.878	303	148	
Head	0.745	109	0.735	111	59	
Internal organs	0.864	553	0.907	510		
Carcass	0.987	521	0.989	414	416	
Water	0.986	563	0.995	307		
Protein	0.929	383	0.943	342		
Fat	0.923	494	0.943	504		
Calories	0.973	4183*	0.972	4210		

*Kilocalories

Energy in whole animal (megacals)

(Y) = 3.307×-12.247 . This paper

(Y) = 4.733×-47.47 Gardner, Hogue and Bensadoun (1964)

Protein in whole animal (kg)

(Y) = $0.1816 X + 0.16$. This paper

(Y) = $0.1197 \times +0.92$ Gardner, Hogue and Bensadoun (1964)

where X = EBW in kg

There was no difference between the breeds in whole animal calorific value. Merinos had more energy in skin and other organs which balanced the lower total energy from smaller carcasses.

Bensadoun *et al.* (1963) showed that FBW (18-20 hour fasting, but water access) was highly correlated with empty body water up to 55 kg EBW or for animals not containing more than 30% fat. These workers proposed a system whereby the energy value of the sheep body *in vivo* can be calculated from knowledge of the empty body water and the FBW.

For certain body components, a single regression equation describes the relations with FBW, but for others it does not. It was found in this and other studies (Gharaybeh, Arnold and McManus, unpublished data) that the fresh weight of edible meat differs very little at the same FBW or EBW between a wide range of breed, sex and grazing management treatments.

It is concluded that the FBW (36-hour fasted) of sheep is a good predictor of body composition and the relations shown have special significance for field investigations. More evidence is needed to show whether a general prediction equation covering a wide range of FBW, breeds, ages and nutritional histories of animals can be established. Preliminary information indicates that this is unlikely (Gharaybeh, Arnold and McManus, unpublished data).

It is difficult to compare the precision of the regression relations reported here with the most accurate chemical technique (tritium dilution) because different workers present error terms in different ways. Use of residual standard deviation in all such studies would permit uniform comparisons to be made.

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