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A Study of Weights and Body Dimensions of Lambs and the Prediction of Weights using Some Linear Dimensions

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While it is easy to determine body weights on farms where scales are available, it may be difficult to do so on ranges, where animals are scattered over a wide area distributed among many shepherds, and scales are either not available or not readily transportable.

In this study an attempt has been made to predict birth and 120-day weights of lambs by two quick and simple measurements of linear dimensions. These measurements can be accomplished in a short time with little risk of error and they require no special experience.

Similar work was done by Brookes and Harrington (1960) on beef steers for the period from birth to eight months of age. They found that among all measurements considered singly, chest girth was most closely related to live weight at all ages. They also reported that height at shoulder was the measurement which, as a second variate in the regression equation, led to the greatest increase in the accuracy of the prediction of live weight. On the other hand, Flock *et al.* (1962) working on beef calves, did not recommend any linear body measurements as selection criteria to improve prediction of weaning performance. Working on sheep, Katada and Takida (1958) gave six measurements (including length and heart girth) from which live weight could be predicted by multiple regression. Galal *et al.* (1965) studied the simple and multiple correlations between six birth measurements and weaning weight. They showed that from a practical point of view, little information was gained when considering other measurements besides the birth weight for predicting the weaning weight. They also reported that *metacarpus* lateral width at birth was highly correlated with both birth and weaning weights, and in the absence of birth weight this measurement alone, or with hook width, could be used for predicting weaning and birth weights.

MATERIALS AND METHODS

The results of this study were obtained from all the single lambs born in the 1963–64 lambing season at Ras El-Hekma Desert Research Station located in the North Western Coastal Desert. Equal numbers of males and females were taken at random in each breeding group, all the breeding groups of that season being represented. These breeding groups were: three purebreeds, Barki (B), Merino (M) and Awassi (A); two first crosses of Barki with both Merino and Awassi (MB) and (AB), respectively; two backcrosses one to the Merino ($\frac{3}{4}$ M) and one to the Barki ($\frac{1}{4}$ M); and finally two second backcrosses, $\frac{3}{8}$ Merino $\frac{5}{8}$ Barki ($\frac{3}{8}$ M) and $\frac{5}{8}$ Merino $\frac{3}{8}$ Barki ($\frac{5}{8}$ M). Data represented 454 birth records and 396 weaning records.

Birth measurements were taken within 24 hours of birth, birth weight was taken to the nearest 10 g. The two other measurements were the extended length from the upper part of the shoulder to the hook bone over the vertebral column, and heart girth. Body dimensions were measured to the nearest centimetre. Lambs were weighed at biweekly intervals and the 120-day weights were estimated by interpolation between the nearest two weights.

Lambs were kept with their mothers until weaning at an age averaging about 120 days.

For the analysis of the linear measurements the following model was assumed:

$$Y_{ijk} = \mu + s_i + b_j + (sb)_{ij} + e_{ijk}$$

where Y is the linear measurement at birth, i.e. body length and heart girth, μ is an effect common to all lambs, s_i is an effect common to all lambs having the ith sex, males and females, b_j is an effect common to all lambs of the same breed group $j = 1, 2, 3, \ldots 9$, $(sb)_{ij}$ is an effect common to all lambs of the ith sex in the jth breed group and e_{ijk} is a random element with $e \simeq NID\ (0, \sigma^2 e)$.

For the analysis of the birth and 120-day weights the following model was assumed:

$$Y_{ijk} = \mu + s_i + b_j + (sb)_{ij} + \beta_1 X_{1\,ijk} + \beta_2 X_{2\,ijk} + e_{ijk}$$

The symbols in this model are as above, with X_1 and X_2 being two concomitant variables representing the extended length and heart girth taken at birth, while β_1 and β_2 are the partial regressions of body weight on these two measurements, respectively. All elements in the model were assumed to be fixed except for the es which were assumed as being $NID\ (0, \sigma e^2)$.

Duncan's multiple range test (DUNCAN, 1955) was used to detect significant differences among means.

RESULTS AND DISCUSSION

The analysis of variance of the two body dimensions, length and heart girth, is presented in *Table 1.* Breed of the lamb was found to cause a highly significant difference in both dimensions. This result is generally in agreement with those reported by ASKER *et al.* (1954), YOUSSEF (1952) and ABOUL-NAGA (1966) working on Egyptian breeds of sheep. Among breeds, the (MB) group had the highest mean (*Table 2*) followed by ($\frac{5}{8}$ M) in length and ($\frac{3}{4}$ M), ($\frac{5}{8}$ M) and (A) in heart girth. The differences among these groups were, however, non-significant. Other breeds comparisons are represented in *Table 2* in which a line connecting any two means refers to a non-significant difference between them. The superiority of the (MB) group in heart girth was also observed by FAHMY (1964). Sex was found to have a

Table 1. Analysis of variance

Source of variation	length DF	length MS	heart girth DF	heart girth MS	birth weight DF	birth weight MS	120-day weight DF	120-day weight MS
Sex	1	3·00	1	27·00*	1	2·28**	1	185·30**
Breed	8	8·38**	8	21·50**	8	0·52*	8	58·28**
Sex × breed	8	1·00	8	9·25	8	0·30	8	10·97
Due to regression					2	39·06**	2	390·98**
due to length, b_1					1	7·13**	1	285·13**
due to heart girth, b_2					1	54·29**	1	264·74**
Residual	436	2·29	436	5·97	434	0·16	376	10·07

* denotes significance at $P < 0{\cdot}05$
** denotes significance at $P < 0{\cdot}01$.

Table 2. Significant differences among group means (Duncan's test) $P < 0{\cdot}05$

Length, cm	*n*	32	26	34	58	24	180	26	52	22
	$\bar{X}$	19·50	18·92	18·56	18·53	18·46	18·26	18·04	18·02	17·95
	breed	*M B*	$\frac{5}{8}$ *M*	$\frac{3}{8}$ *M*	*M*	$\frac{3}{4}$ *M*	*B*	$\frac{1}{4}$ *M*	*A B*	*A*
Heart girth, cm	*n*	32	24	26	22	180	34	52	26	58
	$\bar{X}$	36·25	36·25	36·15	35·77	34·87	34·82	34·75	34·73	34·29
	breed	*M B*	$\frac{3}{4}$ *M*	$\frac{5}{8}$ *M*	*A*	*B*	$\frac{3}{8}$ *M*	*A B*	$\frac{1}{4}$ *M*	*M*
Birth wt, kg	*n*	32	24	22	26	26	180	52	34	58
	$\bar{X}$	4·10	4·10	4·07	3·92	3·74	3·63	3·62	3·59	3·59
	breed	*M B*	$\frac{3}{4}$ *M*	*A*	$\frac{5}{8}$ *M*	$\frac{1}{4}$ *M*	*B*	*A B*	$\frac{3}{8}$ *M*	*M*
120-day wt, kg	*n*	28	26	164	46	22	22	24	34	30
	$\bar{X}$	22·42	21·74	20·99	20·15	20·13	19·46	19·42	19·00	18·92
	breed	*M B*	$\frac{1}{4}$ *M*	*B*	*A B*	*A*	$\frac{3}{4}$ *M*	$\frac{5}{8}$ *M*	*M*	$\frac{3}{8}$ *M*

NOTE: The solid line denotes a non-significant difference among the underlined means. The broken line denotes significant differences through the range on non-significant differences caused by the greater number in certain classes, thus lower variance of the mean of these groups, i.e. $\frac{5}{8}$ *M*, is not significantly different in length from any group except AB group.

significant effect on heart girth but not on length. This is in contrast with the findings of ABOUL-NAGA (1966).

The effect of breed, sex, interaction and the regression of length and heart girth on birth and 120-day weights are presented in *Table 1.* Sex of the lamb was found to have a highly significant effect on both birth and 120-day weights. Similar results were also observed by ASKER *et al.* (1952) and KARAM (1959), while different results were observed by ABOUL-NAGA (1966) on both weights.

While breed was a highly significant source of variation at 120-day weight, it was only just significant at birth. These results are generally in agreement with those reported by FAHMY (1964) and ABOUL-NAGA (1966). The greater difference in weaning weight may be attributable to the differential degree of adaptation of these breeds. Any differences in birth weights may be accelerated at weaning by the different effects that the prevailing environmental factors may have on different breeds. For instance, while Barkis ranked non-significantly lower than the Merinos in birth weight, they ranked significantly higher in 120-day weight. This is thought to indicate the better adaptation quality of the native Barki as compared to the Merino.

The mean differences among breed groups are presented in *Table 2.* At birth, the (MB) group was the heaviest followed by ($\frac{3}{4}$ M) and (A) groups. However, the differences among these groups were non-significant. No significant differences could be observed among the four lightest breed groups, i.e. (B), (AB), ($\frac{3}{8}$ M) and (M). Otherwise, all differences in birth weight were significant at the five per cent level. At 120-day weights, the (MB) group was again the heaviest followed by ($\frac{1}{4}$ M), (B), (AB) and (A) groups. On the other hand, the two second backcrosses ($\frac{5}{8}$ M) and ($\frac{3}{8}$ M) together with the Merinos showed the lightest weights at 120 days.

The general superiority of the (MB) group may be attributed to heterosis. Although the (AB) group is a direct result of crossing two different breeds, yet a negative heterosis was observed in both birth weight and heart girth, where the average of the two parents exceeded that of the cross. At 120 days, the average weight of the (AB) group was intermediate between (A) and (B) groups. Likewise was length at birth. The highest heterosis in the (MB) group as compared to that in the (AB) group may be attributed to the fact that the two parental groups (M) and (B) are more widely genetically different than the difference between (A) and (B) groups (Awassi and Barki are coarse wool breeds, while Merino is a fine wool breed). Merino lambs showed the poorest performance and, except for length, they ranked last in heart girth and birth weight and last but one in 120-day weight. This

Table 3. Simple correlation coefficients between characteristics

	120-day wt	*length*	*heart girth*
Birth weight	0·33**	0·40**†	0·68**†
120-day weight	—	0·33**	0·34**
Length	—	—	0·30**

** Denotes significant at $P < 0{\cdot}01$ (D.F. = 378).
† Denotes D.F. = 436.

relatively poor performance of Merino lambs indicates their poor adaptation to the adverse environmental conditions in the desert. The poorer performance of Merino lambs relative to the native ones was also reported by Fahmy (1964) and Aboul-Naga (1966). Other crosses took an intermediate position.

The simple correlation coefficients among the four measurements studied are presented in *Table 3.* Heart girth was the measurement most highly correlated with both birth and 120-day weights. This result is similar to that reported by Brookes and Harrington (1960) on beef calves. The lowest correlation was that between the two body dimensions, length and heart girth at birth, yet it was highly significant. The simple correlation coefficient of birth and 120-day weights was 0·33, which is less than the value of 0·57 reported by Galal *et al.* (1965), but close to one of 0·32 (between birth and 140-day weights) reported by Butcher *et al.* (1964) and greater than that reported by Karam (1959) as 0·21 on Rahmani sheep.

To predict the birth weight of a lamb (Y_1) from its body length (X_1) and heart girth (X_2), the following relationships were found:

$$\hat{Y}_1 = -3{\cdot}16 + 0{\cdot}088\, X_1 + 0{\cdot}150\, X_2$$

From this equation the multiple correlation of X_1 and X_2 with Y_1 (R=0·72) is significantly higher than the simple correlation of Y_1 with X_1 (0·40),

though it does not differ significantly from the simple correlation of Y_1 with X_2 (0·68). Thus the heart girth alone is almost as good a predictor for birth weights as both heart girth and body length together.

As weaning weight (Y_2) was the trait most economically important in the study, an attempt was made to predict it from birth weight alone, in the case of its availability, from the linear measurements alone (X_1 and X_2) or from both birth weight and the linear measurements. The following prediction equations were obtained:

$$\hat{Y}_2 = 13{\cdot}67 + 1{\cdot}81\, Y_1 \qquad (1)$$
$$\hat{Y}_2 = -5{\cdot}29 + 0{\cdot}608\, X_1 + 0{\cdot}413\, X_2 \qquad (2)$$
$$\hat{Y}_2 = -3{\cdot}34 + 0{\cdot}514\, X_2 + 0{\cdot}317\, X_2 + 0{\cdot}84\, Y_1 \qquad (3)$$

To evaluate the relative efficiency of these three equations, correlation estimates (Rs) were made for the three equations and were found to be 0·33, 0·41 and 0·43 for equations 1, 2 and 3, respectively. No significant differences could be detected among these estimates. Weaning weight can therefore be predicted from any of the equations, depending on the data available.

SUMMARY

A total number of 454 lambs was used to study the predictability of birth and 120-day weights from body extended length and heart girth. Breed groups studied were: three pure breeds, Barki, Merino and Awassi: two first crosses, $\frac{1}{2}$ Merino $\frac{1}{2}$ Barki and $\frac{1}{2}$ Awassi $\frac{1}{2}$ Barki; two first backcrosses, $\frac{1}{4}$ Merino $\frac{3}{4}$ Barki and $\frac{3}{4}$ Merino $\frac{1}{4}$ Barki and two second backcrosses, $\frac{3}{8}$ Merino $\frac{5}{8}$ Barki and $\frac{5}{8}$ Merino $\frac{3}{8}$ Barki.

The model used to analyse the linear measurements included sex of the lamb, breed, and the interaction between them, while for the analysis of body weights the linear measurements were added as continuous variables in the model.

Analysis of variance of the two body dimensions showed a highly significant effect due to breed. Sex was a significant source of variation only in heart girth. Birth weight and 120-day weight were significantly affected by breed, sex and the two linear dimensions. Breed differences among the means of the four characters studied showed that the first cross, $\frac{1}{2}$ Merino $\frac{1}{2}$ Barki was the highest among all breed groups, while the Merino group was the lowest in almost all the characters studied.

Prediction equations were estimated as follows:
Predicted birth wt = − 3·16 + 0·088 (length) + 0·150 (heart girth)
Predicted weaning wt = − 5·29 + 0·608 (length) + 0·413 (heart girth)
If birth weight was available, 120-day weight could be predicted as follows:
Predicted 120-day wt = 13·67 + 1·81 (birth wt)
Predicted 120-day wt = − 3·34 + 0·514 (length) + 0·317 (heart girth) + 0·843 (birth wt)
Differences among the three equations in predicting 120-day weight were found to be non-significant.

The simple correlation coefficients among the four characters were all positive and highly significant. The highest correlation was 0·68 between

birth weight and heart girth at birth, while the lowest one was 0·30 between the two linear measurements at birth.

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