Basrah J. Agric. Sci., 18 (1) 2005

ESTIMATION OF BODY WEIGHT OF LOCAL GOATS FROM BODY SIZE MEASUREMENTS

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SUMMARY

The aim of this study was to evaluate the use of hip height and width and relevant demographic information to predict body weight (BW) of local goats. Seven regression models were developed from 220 records of 154 goats. Parity, hip height, hip width, and age were consistently related with BW. The coefficients of multiple determinations varied from 80 to 89%. The number of significant factors and parameter estimates of the models differed among groups of goats. These differences were due to locations and feeding regimen. This study indicate that a reliable model for estimating BW of goats maintained in a wide range of environments can be developed using body measurements, demographic information, and measurements of hip height and hip width. However, for management purposes, substantial improvements can be obtained by developing models for each location.

INTRODUCTION

The body weight (BW) of goats is important for several management purposes, including assessment of feed efficiency, the value of culled goats, and the efficiency of rearing replacement nannies. However, BW measurements are complicated to interpret because statistically, they are multidimensional (mass per unit of volume, Bonczek, *et al* 1992). But biologically, they are composites, e.g. size (skeletal development), fatness, and gut fill are major determinants of BW. For several management and research applications, these components of BW should be separated. Fluctuations in gut fill are usually irrelevant for monitoring production and for research purposes. For practical reasons, BW is difficult to obtain regularly in typical goat herds. Heart girth measurement, a widely used indicator for BW, because they are easier to measure but has the same interpretation problems as BW. In addition, heart girth measurements can be difficult to perform uniformly because the positioning of the goat during measurement can easily affect the results. There is a growing interest in body condition scoring regularly (Markusfeld-Nir, 1996), and research (Heinrichs, *et al* 1992, Enevoldsen, *et al* 1996, Lin, *et al* 1988, Markusfeld and Ezra. 1993, Yerex, *et al* 1988) has shown that a body size measurement such as height is a potentially important determinant of the gross production, production efficiency, and health of dairy cows. Such measurements are routinely collected in some intensively managed herds (Markusfeld and Ezra. 1993 and Markusfeld, 1996), and more widespread use is strongly recommended (Enevoldsen, *et al* 1996). Consequently, body size measurements may be available from ongoing production and health management programs in the future. The value of such measurements can be evaluated in terms of BW, and these measurements may provide a convenient option to assess BW. Wither height, hip height, and hip width are indicators of skeletal development (body size) that are relatively easy to obtain precisely because the anatomical locations for measurement are easy to identify. These measurements can also be made from behind the cow, which is practical in most housing systems. Another advantage is that height and width measurements represent two extremes with respect to skeletal development. The objective of this study was to evaluate the use of hip height, hip width body length, chest circumference and hip circumference to predict BW in dairy cows. Parity, DIM, age at first calving, and current milk production were included in the analyses as covariates.

MATERIALS AND METHODS

Data were collected from April 2004 to December 2004 from seven commercial goat herds. Data included the following measurements: BW (kilograms), height at the highest point of the hip (measured in centimeters using a vertical standard equipped with a crossbar and level), and width of the hip (measured in centimeters using a standard equipped with two crossbars). Information about parity, age at first calving was obtained using animal teeth. All BW and body size measurements in a herd were obtained using the same technician on a single day. Days in milk were calculated as the number of days postpartum when BW and body measurements were obtained. Measurements were taken in April or early May from 154 goats in seven herds (one recording in each herd). All goats had been fed preserved forages and concentrate. Measurements were repeated in July or early August and in December.

The data (220 records) were analyzed using multiple regressions according to the procedure of SPSS (1998). The main effects in the analyses were herd, parity, age at first calving, hip height, and hip width. Categorical variables (herd and parity) were recorded as dummy variables (0 or 1). A statistical model that used a stepwise strategy was applied as follows. First, complex models were specified for each of the all data (full models). The full models for each of data files contained herd, parity, age at first calving, hip height, hip and width and quadratic and cubic effects for age at first calving, hip height and hip width as main effects. Finally, all possible two factor interaction terms were included. Significance of interactions that involved herd was tested in the full models by fitting these terms last. Squared and cubic terms and interactions were the same as those that were described previously. Second, the full models were simplified by removing the least significant terms one by one. This strategy could not be used for the data file 5 because the file contained few observations and because distribution of the data was unbalanced with respect to parity and DIM. Instead, most interaction terms were tested using a forward inclusion strategy. Herd was maintained as a main effect in the models, regardless of significance. Models were reduced until all terms (except herd) were significant at $P = 0.01$ (Type III sums of squares F test). The intercepts and regression coefficients from the model fitted to data files 1 and 7 were finally used to calculate predicted BW (or expected BW based on observed values of body measurements and BCS) for all seven data files. Therefore, the model fitted to goats that had been barn fed was used to calculate expected BW for goats that were allowed to graze (the parameter estimate for herd was set to 0). The relationships among these predictions and the measured BW were assessed through calculation of simple product moment correlation coefficients, which were squared to allow comparison with the R^2 values obtained from the multiple regression analyses. Model 1 was chosen for prediction because data represented goats that were exposed to relatively stable housing and feeding conditions. Application of that model to the same type of goats that were switched to very different feeding and management conditions (i.e., grazing) should allow an assessment of the difference in BW caused by that switch (primarily because of changes in gut fill). Model 7 was chosen for prediction because data represented extremes related to body size and a broad spectrum of housing and management conditions. Such a model should be valid for a wide range of herds. Comparison with models that were specific to each data file allowed evaluation of the precision of model 7.

RESULTS

Table 1 shows the data stratified by parity (1 to 5). The data presented for goats contained more than one observation per animal.

TABLE (1). Data characteristics, regression coefficients, and predictive ability of the final models for the estimation of BW of goats.

MODEL	1	2	3	4	5	6	7
Goats, no.	30	29	13	15	22	19	26
Season of recording	Spring	Spring	Summer	Fall	All year	all year	Spring
Feeding regimen	Barn4	Grazing	Grazing	Barn	Various5	Various5	Barn
Mean BW (observed), kg	35	27	25	34	30	29	33
Model residual SD (MSE), kg	34	26	30	26	18	25	38
CV (MSE/Mean BW), %	6	5	5	4	5	5	7
R2, %	80	89	84	85	89	86	85
Regression coefficients							
Intercept	492	2571	–1642	622	–111	–814	–479
Herd	6	0	0	0	0	0	. . . . . .
Age at calving, d							
Linear	NS	NS	6.4	–1.0	–0.4	NS	. . .
Quadratic	NS	NS	–0.009	–0.001	NS	NS	. . .
Cubic	NS	NS	0.000003	NS	NS	NS	. . .
DIM, d							
Linear	0.2	–2.2	0.2	0.1	–0.5	NS	0.1
Quadratic	NS	NS	NS	NS	0.003	NS	NS
Cubic	NS	NS	NS	NS	–0.00001	NS	NS
ECM7 Production, kg/d	NS	–15	NS	NS	NS	NS	. . .
Hip height, cm	4.2	2.0	4.8	4.7	4.2	5.7	5.9
Hip width, cm							
Linear	–29.2	–76.2	–19.7	–15.0	4.5	8.0	2.8
Quadratic	0.3	0.6	NS	NS	NS	NS	NS

The means, standard deviations, and 5th and 95th percentiles (90% of observations were included in this interval) are given for each variable for each stratum. Most of the differences among lactations appeared to be unimportant. However, values for BW, ECM, and hip width appeared to be smallest for first and second parity cows. Age at first calving and DIM were similar for different parities. Hip height appeared to be smallest for cows of parities 2 to 4. The DIM was quite different for lactation groups in data file 5. The coefficients of variation for the models (residual standard deviation of the model/ mean of the dependent variable) were 4 to 7%, and the R^2 were 80 to 89%. Parity, DIM, hip height and hip width consistently were important predictors for BW in all data files. The number and combinations of polynomial and interaction terms differed among models. No interaction or higher order terms were important for the model describing the BW of data file 6. Interactions existed between DIM and hip height and between parity and hip width in Model 2. In Model 3, there was an interaction between age at first calving and hip width. In Model 4, age at first calving was included in interactions with both parity and hip width. In Model 5, there was also an interaction between age at first calving and parity.

TABLE (2) Data characteristics, regression coefficients and predictive ability of the final models for the estimation of BW.

Model 1 2 3 4 5 6 7
Interactions between age at first calving and parity
1 NS NS NS 0.4 0.5 NS NS...
2 NS NS NS 0.3 0.5 NS NS...
3 NS NS NS 0.4 0.4 NS NS...
4 NS NS NS 0.5 0.1 NS NS ...
5 NS NS NS 0.0 0.0 NS NS...
Interaction between age at first calving and hip width
NS NS 0.03 0.03 NS NS NS
Interaction between stage of lactation and hip height
NS 0.02 NS NS NS NS NS
Interactions between hip width and parity
1 NS 15 NS NS NS NS NS
2 NS 11 NS NS NS NS NS
3 NS 10 NS NS NS NS NS
4 NS 12 NS NS NS NS NS
5 NS 0 NS NS NS NS NS
Model predictions of BW9 and correlation with observed BW
Predicted BW using model 1
Mean 32 36 33 31 28 29 31
r2 (versus observed, ´100) 81 76 76 77 53 81 79
Predicted BW using model 7
Mean 33 34 31 32 30 26 27
r2 (versus observed, ´100) 74 79 77 77 62 81 85

Agreement between predicted and observed BW was assessed with the squared correlation coefficient. Important estimates in data file 1 included herd, parity, DIM, hip height and hip width (linear and quadratic). For these data, the difference between first parity goats and goats in fifth or greater lactation for BW was 12 kg, and, for each additional 10 DIM, there was a corresponding increase of 1.5 kg of

BW. A 1-cm increase in hip height was associated with a 2.1-kg increase in BW. The relationship between hip width and BW was curvilinear. ECM was significant in model 2 only. The *P* values of interactions that involved herd (data not shown) only approached significance for the interaction between hip width and herd in Model 4 (P = 0.02) and for the interaction between ECM and herd in Model 1 (P = 0.05). Table 2 also provides mean BW predictions as determined by Models 1 and 7 for each of the seven data files. Agreements between predicted and observed BW were assessed by means of squared correlation coefficients. Predictions from Model 7 were more valid and precise than predictions from Model 1 (means of predicted and observed BW were more similar, and correlation was higher in general). However, Model 7 did not fit the data file 5 as well as it did the other data files.

DISCUSSION

The goal of this observational study was to develop tools that could provide more precise and meaningful descriptions of lactated goats to support management decisions. Consequently, the associations that were revealed cannot and should not directly be regarded as causal (Enevoldsen, *et al* 1996). The number of observations was relatively limited in this study compared with the number of observations in other studies but was relatively large compared with those of most experimental studies. Compared with many other observational studies, measurements in this study were relatively exact, and the applied statistical significance values were low. Consequently, spurious associations were unlikely to occur. The data in Table 1 show that goats included in this study were approximately the recommended size and weight at first calving (Ayied, 1996), but these measurements were attained at approximately 12 mo of age in contrast to the recommended 9 mo of age. Mean height was numerically lower for goats in their third or greater lactation than for younger goats. Data from bucks showed that the mature height (and also other size measurements) is attained at approximately 52 wk of age (Ayied, 1996). The pattern of greater mean height for younger goats in the current data files might have been due to an increased emphasis of nutrition. Because several studies (Koenen and Groen. 1996 and Yerex, *et al* 1988) have shown that smaller cows are more efficient, smaller cows might be less likely to be culled (culling rate in these herds was approximately 40%). The unadjusted correlation indicated that hip width was the strongest single predictor for the estimation of BW, which should have been expected because hip width is the body dimension that is developed last (Pieniak-Lendzionl, 2004) and thus exhibits the most variation. However, the regression analyses showed that the relationships between body measurements were very important predictors of BW, and, together with demographic data, these two factors allowed a relatively precise estimation of BW (model coefficients of variation decreased to less than half that of unadjusted means). In this study, herd was included as a covariate, which allowed evaluation of the consistency of the effects of body measurements across different herd conditions (test for significance of interaction terms). Such interactions with herd were not significant ($P > 0.05$), but the main effect was significant. Therefore, measurements from different herds cannot be compared directly because of the effects of technician and other herd factors. The ranking of BW for cows based on a set of covariate values is unlikely to differ, however. If the results of this study were to be applied across herds (e.g., for selection purposes), this herd effect would pose no problems. If, in contrast, the results were to be applied within a specific herd, some knowledge about that particular herd must be obtained (a validation study within the herd), or wider confidence intervals of target recommendations must be presented. A validation study is obviously inconvenient for extension purposes, but the same problem applies to the application of almost all results of research. Omission of the herd effect or inclusion of herd as a random effect in this analysis would not have solved this fundamental problem. Results thus indicated that different models may be needed to predict BW in different environmental conditions and breeds. The BW estimation model for data file 5 was especially different from the other models. Further development of this model is needed in other herds with considerably more cows. However,

Model 7 provided predictions that correlated well with the predictions that were specific to a particular group of cows, although BW clearly was overestimated for cows that were grazing. A biologically plausible explanation could be that gut fill is substantially reduced during grazing. Therefore, application of Model 1 to data file 2 probably provides a reliable estimate of the change in gut fill caused by the switch to grass feeding (8.3 kg = 38.8 kg – 30.5 kg). The current approach to the estimation of BW may more appropriately reflect the net BW because the approach is less influenced by random fluctuations in gut fill. Precision was poorer for young goats (small size and weight). These animals are smaller or their skin is thinner. Also, DIM likely explains more variability in BW in small goats (the simple correlation between BW and DIM was relatively high). The high correlation indicated that the simple Model 7 ranked the goats satisfactorily compared with predictions from the models that were specific to a particular group of goats. For use in the field by managers, a simple model, such as Model 7, might be preferred because few input data are needed and the validity of the model is acceptable for a relatively broad spectrum of feeding and management conditions. Ideally, similar data would be collected and parameters specific to each herd would be estimated for each herd to which the proposed model would be applied.

CONCLUSIONS

Measurements of hip height, hip width and readily available information about age at first calving, parity, DIM, and current milk production were used in several models to predict the BW of individual animals. Agreement between actual and predicted BW showed that body size measurements can be used to provide valid and precise estimates of BW for use in field studies and management of the dairy herd.

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تقدير وزن الجسم في الماعز المحلي من مقاييس الجسم

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الخلاصة

تهدف الدراسة الحالية إلى تقييم استخدام ارتفاع الجسم و عرض المؤخرة و بعض مقاييس الجسم الأخرى للتنبؤ بوزن الجسم للماعز المحلي . استخدام سبعة نماذج للانحدار طورت باستخدام 220 سجل لـ 154 معزة . حللت هذه البيانات إحصائيا لمعرفة تأثير كل من تسلسل الولادة ارتفاع المؤخرة و عرضها و عمر المعزة على وزن الجسم . تراوح معامل التحديد من 80-89 % اختلف عدد العوامل ذات التأثير المعنوي مع اختلاف القطعان و النماذج تعود هذه الاختلافات إلى موقع و نوع التغذية . و يستنتج من هذه الدراسة أن هناك نموذج دقيق للتنبؤ بوزن الجسم للماعز المربى تحت بيئات متباينة يمكن تطويره باستخدام مقاييس الجسم و المعلومات الديموغرافية و مقاييس ارتفاع و عرض مؤخرة الجسم و لكن ولأغراض الإدارة بالامكان الحصول على تحسن واضح عند تطوير نماذج خاصة لكل موقع .