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MODELLING THE ANNUAL LIVEWEIGHT CURVE IN DAIRY CATTLE

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SUMMARY

Three methods for estimating the daily weight change of dairy cattle throughout a lactation were compared with respect to goodness of fit, variability, versatility and interpretation. Estimates of the rate of weight change obtained from a nonlinear quadratic model describing the annual liveweight curve, were found to give a less variable and more realistic description of a cow's changing weight than growth rate estimates which assume *a priori* linear periods of weight change.
Keywords: weight change, liveweight, growth curve.

INTRODUCTION

The 2 most commonly used estimates of the change in weight of dairy cows are the absolute daily weight changes (ADC) obtained by taking the net weight gain over a specified period and dividing by the number of days in the period (this method is also known as the 'by difference' method), and the slope determined from a linear regression (LRC) (Broster *et al.* 1975; Tudor 1972; Goodall and McMurrary 1984). The choice of the periods over which to obtain the ADC and LRC is subjective, and may vary from animal to animal. In many cases both these approaches involve assuming linear relationships across obviously nonlinear subsections of the annual liveweight curve as observed from experimental weighings. Additionally, they provide only an average assessment of weight change over a period, with no indication of the variation that may be occurring from day to day. The use of such averages may be misleading.

This paper describes the fitting of a nonlinear quadratic function to the weight changes of dairy cattle during lactation. It demonstrates how simple mathematical techniques can be used to obtain a continuous expression for the daily weight change.

MATERIALS AND METHODS

The data were obtained from 12 spring calving dairy cows over 2 lactations from 1986 to 1988. Unfasted weights were taken at 2 weekly intervals following normal milking. Linear segments of the liveweight curves were considered as 0–120 days, 120-240 days and 240 days to calving, and average daily weight changes over these 3 periods were obtained using the approximate estimation methods ADC and LRC described above.

A quadratic curve relating liveweight to days in lactation was then fitted to each cow in each year. The fitting was carried out using a least squares procedure on the statistical package GLIM (Baker 1985).

The function to describe the weight change on any given day was obtained as the first derivative of the quadratic equation. This daily weight change (QDC), was of the form given in equation 1.

$$\text{Daily weight change} = b + 2 \times c(\text{days}) \qquad (1)$$

where b and c are constants depending on each individual cow and lactation.

For each cow in each year these weight changes were evaluated for each day and averaged for the specified periods to give a third estimate of average daily weight change. By setting equation 1 to zero, an estimate of the day on which the minimum liveweight occurred was determined. This estimate was compared with the assumed value of 120 days implied in the estimation of AGR and LRS.

RESULTS AND DISCUSSION

An initial idea of the variation which can occur in the weight change for an individual cow during the three assumed linear periods, can be seen from Fig. 1.

The correlation coefficients between the estimates from the quadratic model and the observed data in Fig. 1 were 0.92 and 0.93 for cows A and B respectively. Values for this correlation for the 24 curves ranged from 0.64 to 0.98, with 15 greater than 0.90.

Table 1 gives the estimated daily weight changes for the 2 cows in Fig. 1 for each of the assumed linear periods. Using equation 1, liveweight changes on specified days have been included to give an idea of the range over which each average is assumed to be typical.

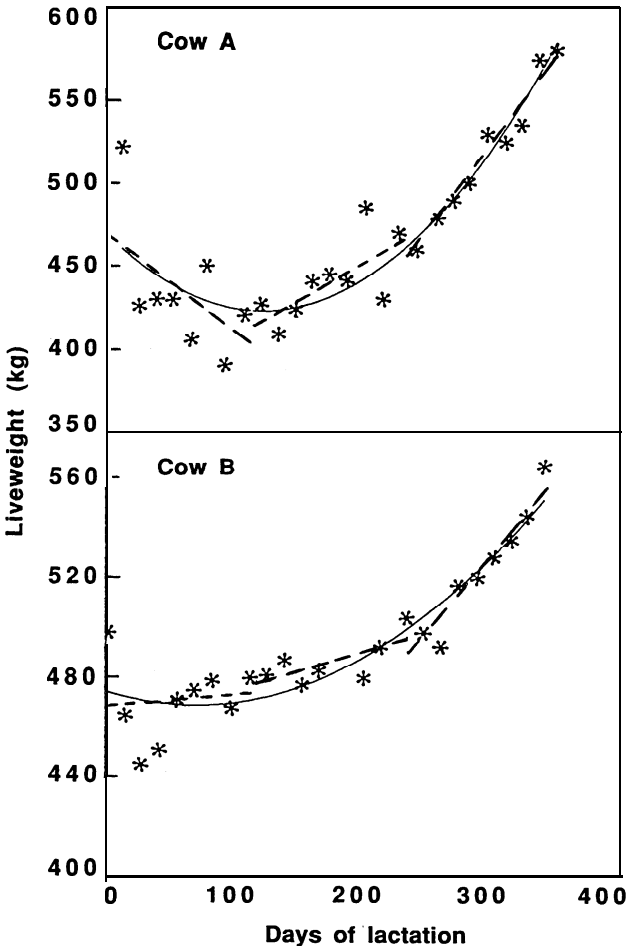

Fig. 1. Change in liveweight for 2 cows showing fitted quadratic curves, observed weights (*) and fitted linear segments (dashed lines).

In the calving to 120 day period, the daily weight change of cow A varied from -0.68 kg to -0.04 kg, yet the averages of -0.84, -0.53 and -0.39 do not reflect the rapid change in rate of weight gain. A similar story is seen for cow B whose daily weight changes from 0 to 120 days vary from -0.13 kg to +0.10 kg, but whose average values for this period are -0.16, +0.04 and -0.02. The averages in the 2 periods 120 to 240 days and 240 days to calving in general provide a somewhat better representation of the daily growth rates. However the LRC of +0.58 kg for cow B in the final period is

Table 1. Daily weight changes (kg/day) on particular days and as averages calculated using ADC, LRC (bold) and QDC (italic) for the three linear segments for cows A and B

	No. of days from calving: 10	20	50	100	120	150	200	240	300	350
Cow A	–0.68	–0.62	–0.44	–0.15	–0.04	0.13	0.42	0.65	1.00	1.29
Average		–0.84	**–0.53**	*–0.39*		0.39	**0.42**	*0.31*	0.87	**0.96** *1.01*
Cow B	–0.13	–0.11	–0.05	+0.06	+0.10	0.16	0.27	0.35	0.48	0.58
Average		–0.16	**+0.04**	*–0.02*		0.19	**0.14**	*0.23*	0.56	**0.58** *0.47*

Table 2. Differences for 12 cows over 2 years between the 3 weight change estimates (mean ± s.d.) ADC, LRC and QDC for the 3 periods: calving to 120 days, 120 to 240 days and 240 days to calving

Period	ADC		LRC		QDC	
	Year 1	Year 2	Year 1	Year 2	Year 1	Year 2
0-120 days	–0.06 ± 0.278	–0.370 ± 0.154	0.070 ± 0.220	–0.28 ± 0.159	0.04 ± 0.088	–0.230 ± 0.156
120–240 days	0.310 ± 0.139	0.220 ± 0.147	0.360 ± 0.105	0.190 ± 0.143	0.240 ± 0.070	0.230 ± 0.052
> 240 days	0.690 ± 0.135	0.440 ± 0.173	0.710 ± 0.128	0.410 ± 0.186	0.670 ± 0.116	0.420 ± 0.139

at the extreme end of the range of daily values, +0.35 to +0.58, and would not reflect the true performance of the cow during this period.

When the mean average daily weight changes for the 12 cows are compared between years, the estimates of QDC have a lower standard deviation than either the ADC or LRC estimates (Table 2).

In year 1, the estimated minimum weight occurred in the period 100-140 days for 10 cows. In year 2, no cows had an estimated minimum weight in the period between 80 and 140 days with 11 of the cows reaching their estimated minimum weight before 80 days. Thus in year 1, the use of 120 days as a terminal point for the initial weight loss period seems reasonable, however in year 2, this was obviously misleading. This variation between years demonstrates the need for a more flexible relationship which does not require an imposed minimum point to identify linear segments. This perceived need is consistent with recent analyses of weight changes in beef cattle (O'Rourke *et al.* 1991).

CONCLUSION

A simple quadratic polynomial provides a reliable and biologically sound functional form to describe the liveweight change of a lactating dairy cow between successive calvings. This nonlinear model can be used to provide daily estimates of weight change over any nominated period, as well as to identify the point of minimum liveweight. The estimates are more precise than those based on linear regression or absolute differences over a fixed time period, and allow a more accurate interpretation of the liveweight performance of the dairy cow.

REFERENCES

BAKER, R. J. (1985) Glim 3.77 Reference guide. *In* 'Glim 3.77 Reference Manual.' (Numerical Algorithms Group, Oxford.)

BROSTER, W. H., BROSTER, V. J., SMITH, T. and SIVITER, J. W. (1975) *J. Agric. Sci., Camb.,* **84:** 173-86.

GOODALL, E. A. and McMURRAY, C. H. (1984) *Anim. Prod. 38:* 341-9.

O'ROURKE, P. K., ENTWISTLE, K. W., ARMAN, C., ESDALE, C. R. and BURNS, B. M. (1992). *Theriogenology,* Vol. 35 pp 839-53.

SAS Institute Inc. (1987). SAS/STAT Guide for Personal Computers, Version 6 Edition. Cary, NC: SAS Institute Inc.

TUDOR, G. D. (1972.) *Aust J. Agric Res., 23: 389-95.*