Genetic analysis of body weight in Black and White dairy cattle

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1. Introduction

Mature body weight (BW) of dairy cattle has a negative economic value; marginal costs associated with increased energy requirements for raising female stock and increased maintenance requirements for lactating cows exceed marginal revenues from increased BW of disposed young female stock and lactating cows (Dempfle, 1986; VanRaden, 1988; Groen, 1989; Steverink *et al.*, 1993; Visscher *et al.*, 1994). Economic value of BW might become even more negative if more stringent environmental restrictions are imposed (Steverink *et al.*, 1993). Reports from New Zealand (Dempfle, 1986) and from The Netherlands (Steverink *et al.*, 1994) evaluated the economic impact of inclusion of BW in the breeding goal with production traits. Expected increase in profitability was 2 to 4% when BW was negatively included in the breeding goal and in the selection index. However, at present BW is not included in field recording in most breeding programmes. Several issues have to be considered before including BW in a breeding scheme. First, body weight is influenced by effects of growth, gestation and lactation (Korver *et al.*, 1985; Hietanen and Ojala, 1995). When using field data, adequate corrections for these effects must be made. The repeatability of BW over different periods in lactation might indicate optimal frequency and period of measurement. Secondly, for practical reasons information about mature BW is needed early in a cows life. For example, BW at an immature stage (e.g., BW at first calving) might be used to select for mature BW. Inclusion of BW at first calving in a selection index is useful when the genetic correlation between BW at first calving and mature BW is high. Thirdly, estimating BW might be facilitated by using indirect measurements of BW, e.g., body measurements such as hearth girth and height (Gravir, 1967; Heinrichs *et al.*, 1992).

January 1995, a PhD study was started at Wageningen Agricultural University to study several questions about including BW in dairy cattle breeding programmes. Aims of this study are (1) to estimate genetic parameters of BW; (2) to estimate the systematic effects of growth, lactation and pregnancy on BW; (3) to estimate the genetic relation of BW at immature stages with BW at maturity; (4) to estimate the relation between body measurements and BW. This paper briefly gives results obtained sofar, and describes research in progress.

2. Growth patterns in heifers

The genetic relationship between weight at calving and weight at maturity was evaluated by Koenen and Groen (1996). In this study, data on 767 Dutch Black and White heifers until the age of 600 days along with BW at first calving were available. Animals were weighed monthly. The Von Bertalanffy function and a two-phase logistic function were evaluated for fitting the growth patterns of individual heifers. The two-phase logistic function was better for fitting the growth patterns than the than the Von Bertalanffy function. The following two-phase logistic function, based on the summation of two partly overlapping sigmoidal curves (Koops, 1986) was fitted for each animal:

$$Y_t = \frac{a_1}{1 + e^{-km(t-b_1)}} + \frac{a_2}{1 + e^{-km(t-b_2)}}$$

where

Y_t	:	BW (kilogram) at age t(days),
a_1	:	asymptotic maximum BW during the first phase (kilograms),
b_1	:	age at the first inflection point (days),
km	:	maturation rate,
a_2	:	asymptotic maximum BW during the second phase (kilograms), and
b_2	:	age at the second inflection point (days).

(Figure 1). Total BW is estimated by summing the two partly overlapping sigmoidal curves. Asymptotic mature BW is estimated by (a_1 + a_2). The km parameter of the two-phases logistic function equals four times the maximum increase in maturity.

Estimated parameters (per animal) were analysed statistically using DFREML (Meyer, 1991). Estimated heritability of BW at first calving was 0.48. Estimated heritability of mature BW was 0.26. Estimated genetic correlation of actual BW at first calving with estimated mature BW was 0.74, whereas the genetic correlation of estimated BW at calving with estimated mature BW was 0.93. These high genetic correlations indicate that BW at first calving can be effectively used as an index trait for selection on mature BW.

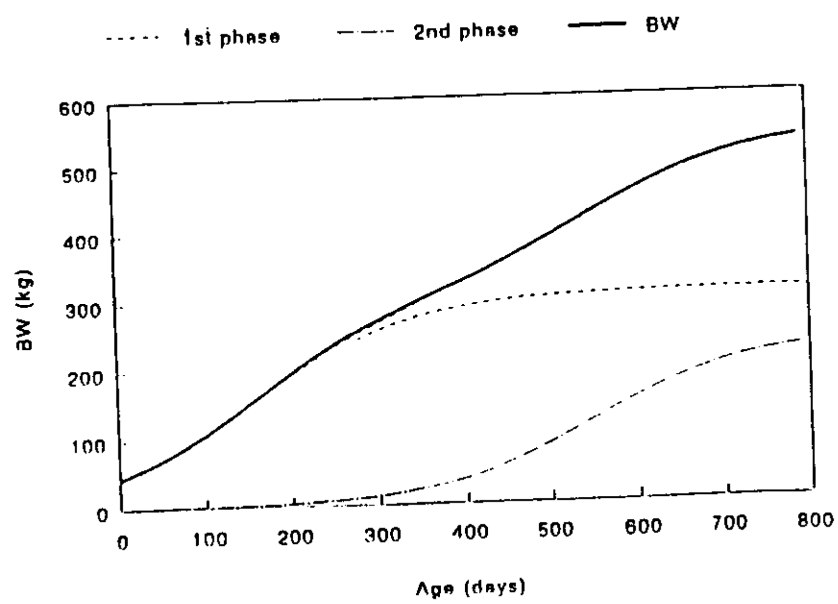

Figure 1
Mean body weight of growing heifers of the two phase logistic function.

3. Effects of lactation and pregnancy on body weight

To estimate the effects of growth, lactation and pregnancy accurately, frequent longitudinal observations on BW are required. At the experimental farm "Schöthorst", all lactating animals were weighed twice daily in the period January 1989 through August 1994. Weekly average weights of 399 individual animals (1160 lactations) were available. To describe BW changes caused by the effects of growth, lactation and pregnancy non-linear mathematical formulas were applied (Wood *et al.*, 1980; Korver *et al.*, 1985).

When averaging all observations on all heifers (n=229), a clear pattern was found: weight loss occured in early lactation and increased weight late in lactation (Figure 2). This mean curve can adequately be described by non-linear functions. In this dataset, heifers lost on average 53 kg and minimum weight was observed at 35 days in lactation. However, when these functions were fitted to animals individually, 22% of all heifers showed no systematic reduction of BW during the first two months of lactation. This agrees with findings of Berglund and Danell (1987) who found no obvious weight loss in about 25% of the animals. Differences in weight loss patterns and stage of lactation with minimum weight depend on feeding (Korver *et al.*, 1985), parity, and breed (Berglund and Danell, 1987). Berglund and Danell (1987) found a large variation between cows in weight changes and energy deficits. Available data will be further analyzed to quantify variation among animals in weight changes during early lactation, and to estimate relationships between weight, weight changes, and milk production.

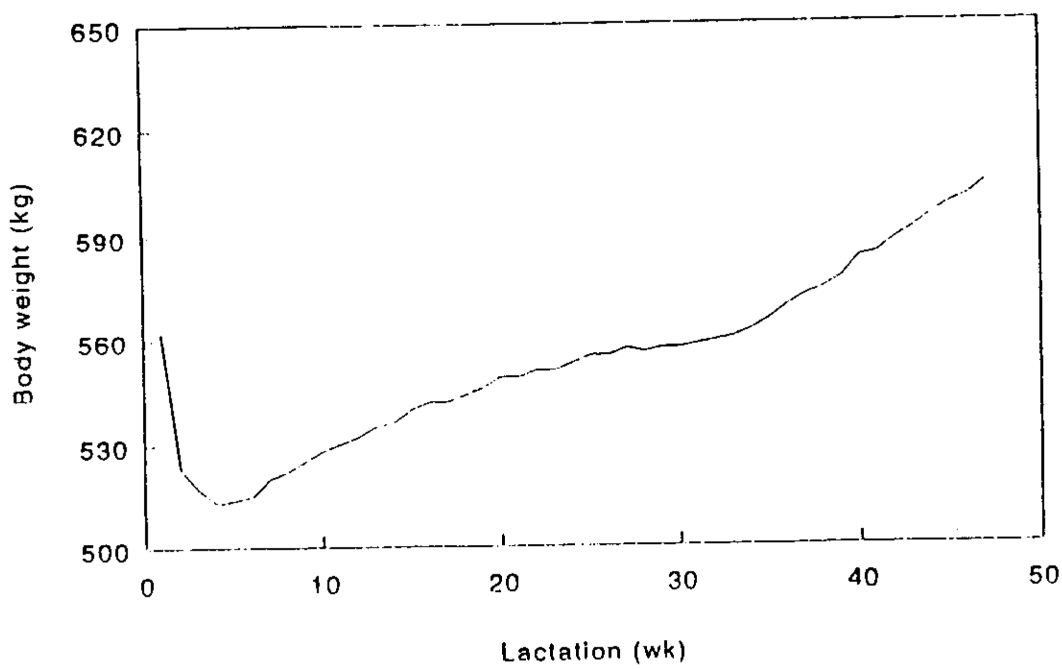

Figure 2
Mean body weight of heifers during lactation.

4. Body weight and body measurements

In the period Sept. 1995 through Jan. 1996 observations on BW, height, and heart girth for 7500 lactating heifers in 600 herds were collected. Heifers were also scored for conformation (Dutch national linear scoring system) on the same day of collecting the body measurements. Production data from the NRS is available for all heifers included.

Data will be analyzed to quantify genetic parameters (heritabilities and correlations) for body measurements. The results of the study on effects of lactation on body weight will be considered to develop different alternatives for correction for stage of lactation will be compared. Possibilities of predicting BW from wither height, heart girth and linear conformation traits will be studied. The genetic relation of BW with production traits will be studied as well.

5. Discussion

Including BW in the breeding programme requires knowledge on genetic correlations with milk production and feed intake capacity. Estimated genetic correlations between BW and production are non-consistent. When the whole lactation period was considered Ahlborn and Dempfle (1992) and Hietanen and Ojala (1995) found a positive correlation between milk production and body weight. However, Van Elzakker and Van Arendonk (1993) showed that the estimates of the genetic correlation depend on the stage of lactation. In their study the genetic correlation changes during the lactation from 0.29 in week 2 to -0.25 in week 13.

Feed intake is positively related with BW (Korver *et al.*, 1991; Nieuwhof *et al.*, 1992). Inclusion of BW in the breeding goal in a negative manner might have a negative influence on energy intake. According to Veerkamp (1994), reduction in energy intake of smaller cows is larger than the decreased maintenance requirements: thereby increasing the negative energy balance in early lactation. Schmidt and Schönmuth (1995) also found significant relations between body measurements and feed-intake. Relations between body measurements, body weight and feed intake are required to find an optimal selection strategy fo BW.

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