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Prediction of liveweight of cows from type traits and its relationship with production and fitness traits

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ABSTRACT

Liveweight (LWT) data for Australian Holstein cows was predicted from different type traits based on actual LWT and type data of 932 cows collected from 20 different herds over a 3-yr period. In addition to LWT measured using scales, visual estimates of LWT were also available on 90% of the cows with LWT data. The future predictive ability of different models was assessed using 10-fold cross-validation. The relationships between LWT and selected type traits, including body condition score (BCS), were also calculated to assess the usefulness of various traits to predict LWT genetically. The relationships of predicted LWT measures with production and fitness traits were also estimated in an attempt to assess the consequence of continuous selection on an economic index that includes predicted LWT with a negative economic value. The heritability of LWT was 0.4. Among type traits, stature, chest width, bone quality, BCS, udder depth, central ligament, and muzzle width were correlated with LWT both genetically and phenotypically and were used to predict LWT of cows. Predicted LWT measures, using several sets of traits and visually estimated LWT were genetically highly correlated with each other (>0.73). Phenotypically, visually estimated LWT of cows was slightly more correlated with actual LWT than that predicted from type traits, but genetically both approaches gave the same accuracy. The predicted estimates of LWT were also positively genetically correlated with energy-corrected milk yield and had near zero correlation with survival. The correlations of different measures of LWT with fertility traits were unfavorable or near zero, suggesting that selection for reduced LWT may not cause deterioration in fertility traits. However, it may be useful to consider broadening the breeding objective to include traits that are associated with energy balance, particularly if traits such as BCS and bone quality are included in the set of traits used to predict LWT. Based on the results from this study, the inclusion of predicted LWT with negative economic values into the breeding objective would have no negative effect on fitness traits.
Key words: liveweight, type traits, fitness, production, genetic correlation

INTRODUCTION

Selection for increased milk production in most countries favors large cows that produce and eat more than smaller cows (Visscher et al., 1994; VanRaden, 2004) because the same maintenance feed cost is assumed for all cows of the same breed and age in some herd models used to determine economic values. Some exceptions can be found in the economic selection index in New Zealand (Harris et al., 2007), which includes liveweight (**LWT**) or measures of body or frame size in Australia (Valentine et al., 2000) and the United States (VanRaden, 2004). Both in Australia and the United States, the use of some measure of body size instead of LWT is justified due to the lack of LWT data and because measures of skeletal, or frame size, such as stature and heart girth, are more associated with differences in maintenance cost of LWT rather than LWT itself (Hoffman et al., 1996). Furthermore, selection for reduced LWT that includes BCS may actually increase health and fertility disorders because of the association between BCS and energy balance (Coffey et al., 2003). Veerkamp (1998) suggested that dairy cows, particularly at the beginning of lactation, mobilize body tissue and are in negative energy balance because the increase in feed intake does not cover the extra requirements for milk yield. So, selection for reduced LWT may exacerbate the extent of negative energy balance and, thus, health and fertility problems. Possibly for this reason, economic indices in some countries include LWT EBV with positive economic values (VanRaden, 2004), perhaps to increase energy intake and also improve energy balance. A recent study by Frigo et al. (2010) showed that heavier cows experience less ketosis, metabolic, infectious, and other diseases than lighter cows.

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However, in contrast, Hansen et al. (1999) observed that the herd life and fertility of small-sized Holstein cows was actually better than large cows in the United States. Selection for increased milk yield traits without the concomitant increase in LWT has been part of the New Zealand dairy cattle breeding objective since 1996, where the negative economic value of LWT is relatively high compared with other countries because of the high reliance on pasture in New Zealand production systems (Harris et al., 2007). In Australia, since 2004, EBV for predicted LWT have been included in the national breeding objective, the Australian Profit Ranking (**APR**), with a negative economic value. Recent analyses of the Australian data show a small downward genetic trend in chest width and BCS, possibly as a result of selection on APR (Haile-Mariam et al., 2013).

There is a renewed interest in improving efficiency of feed utilization as a means to increase profitability (Grainger and Goddard, 2004) and address the environmental impact of dairy production (de Haas et al., 2011). Optimizing the relationship between LWT and maintenance feed costs is one approach that can contribute to overall savings on feed costs. In Australian dairy cattle, the proportion of feed energy requirement for maintenance is about 50 and 25% of the total during the growth and lactation period, respectively (Bell et al., 2013). In these circumstances, it will be useful to test if continued selection for milk yield traits with constraint (i.e., less increase in LWT relative to the increase in milk yield traits) on LWT could have a negative consequence on fitness traits. The LWT of cows is a function of body size and BCS, so defining maintenance requirements as a variable that is less related to BCS may have fewer negative effects on fitness traits (Collard et al., 2000). This can be tested by predicting LWT considering all the available type traits (including those highly correlated with BCS) as well as type traits that only predict frame size, such as stature, and assessing the effect of selection for reduced LWT or frame size on fertility and health traits.

In Australia, as in many other countries, LWT data are not recorded and, thus, it is predicted from type traits. Currently, stature, chest width, and body depth are used to predict LWT (Valentine et al., 2000), although their accuracy and relevance in the current cow populations has not been investigated. Furthermore, in Australia because insufficient data are collected on fitness traits, survival from the current to the next lactation is used as a proxy for health traits. Similarly, calving interval (**ClvI**), lactation length (**LL**), calving to first service interval (**CFS**), and pregnancy rate (**PR**) are used as proxies for fertility. Other traits, such as fat-to-protein ratio (de Vries and Veerkamp, 2000; Negussie et al., 2013) can be used as an indicator of negative energy balance. This may be particularly useful to test if small-sized cows that produce relatively more milk yield with limited capacity to consume adequate feed are more prone to larger (unfavorable) ratios compared with larger cows.

The aim of this study was to assess the relationship of type traits related to body size, including predicted LWT with milk production and fitness traits in Australian Holstein dairy cattle. The specific objectives of this study were to (1) identify type traits that are correlated with LWT and estimate their relationship with performance traits, including milk yield, fertility, and survival; (2) predict LWT of cows from type traits and estimate the correlations of these predicted LWT measures with milk production, fertility, and survival traits in Australian Holstein dairy cattle; and (3) estimate the phenotypic and genetic trend in predicted LWT.

MATERIALS AND METHODS

Data

In Australian Holstein dairy cattle, all type traits are scored on a scale of 1 to 9, except overall type, which is scored on a scale of 1 to 15. Body condition score is recorded on a scale of 1 (thin) to 8 (fat) according to Earle (1979). All classifications are carried out by Holstein Australia (**HA**, Hawthorn BC, VIC, Australia) classifiers once during the first lactation. Although type data of cows that calved between 1994 and 2012 were used for this study, BCS data were available for cows that were type scored between 1999 and 2012. In total, about 430,000 cows, of which 45% had valid BCS data, were included. The 98% of type classifications were carried out by 33 classifiers, whereas 28 classifiers with less than 100 cows each accounted for the remaining 2% of the classifications. Type classification data of these 28 classifiers were excluded from the analyses. Days in milk at classification ranged from 1 to 500 d, but for most analyses reported in this study, classification after 365 d were set to missing. Data editing on age at classification and age at calving also removed cows classified after 49 mo of age or cows that first calved after 38 mo of age.

To achieve the objectives of the current study different data sets were used. First, type and LWT records of cows from 20 Holstein herds were used for calibrating the phenotypic prediction of LWT. Liveweights on 932 first-parity cows were recorded at the time of type classifications by HA between 2009 and 2011. Close to 90% of the cows were also visually assessed and their LWT estimated by the HA classifiers immediately before they were weighed, using standard portable weigh scales. Second, to obtain improved estimates of genetic