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Body condition score as a candidate trait in the breeding worth dairy index

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ABSTRACT

Body condition score (BCS) has been proposed for inclusion in the New Zealand national dairy index, Breeding Worth (BW), to account for replenishment of body tissue. Currently, the breeding objectives model positively accounts for body tissue mobilisation (through extra yield), but not the negative cost of replenishing body tissue. Two methods have been proposed: 1) Including BCS directly into BW by calculating and assigning an economic value to BCS and 2) Adjusting liveweight Breeding Values (BVs) for BCS, which would mean that liveweight BVs would be expressed at a constant BCS (indirect method). Energy equations were used to calculate the direct economic value for BCS and included a sensitivity analysis. With an economic weight of \$25, the percentage emphasis of BCS in BW would be 3.4%. Including BCS in BW, either directly or indirectly, had little impact on sire rankings (rank correlations with and without BCS within breed were >0.99) and would only have a small impact on the economic response of BW (\$0.02 net /cow/annum) and the improvement in BCS (0.006 BCS units/cow/annum). It is concluded that there would be little benefit to including BCS as an independent trait in BW. Body condition score is already included as a predictor in the genetic evaluation of fertility and breeding values for BCS will be estimated routinely from the fertility model.

Keywords: body condition score, selection index

INTRODUCTION

Body condition score (BCS) is commonly used as a method to assess body energy reserves and consequently aid in management decisions. In recent years there has been considerable interest in assessing the potential use of BCS in dairy cattle breeding programmes, primarily as an indicator of fertility (Veerkamp *et al*., 2001; Berry *et al.,* 2003). In New Zealand, we have identified three potential roles for BCS in the national breeding objective 1) as a predictor of fertility; 2) as a predictor of energy replenishment requirements in the dry period due to body tissue mobilisation during lactation; 3) as a predictor of lactation length, since BCS is often used in decision rules to dry off cows. BCS has already been included as a predictor of the fertility breeding value and breeding values for BCS are estimated in that process (Harris *et al.,* 2006). The Breeding Worth (BW) index currently accounts for body tissue mobilisation (through extra yield), but not the cost of replenishing body tissue. However, including both 2 and 3 in a prospective economic value of body condition score is inappropriate, as they both account for tissue replenishment during the dry period.

A dairy cow requires energy for maintenance, activity, milk production, growth, body tissue gain and pregnancy. Some energy is also dissipated as heat, or lost as faecal energy, urine energy or combustible gases. Equations to predict energy requirements for maintenance, activity and milk production are well documented (e.g. Tyrell and Reid, 1965; Hulme *et al.,* 1986; AFRC, 1993; NRC, 2001). Energy requirements to replenish BCS are not so well documented, but can be derived by assuming that mobilised BCS is equivalent to a proportional amount of liveweight; for example by calculating the amount of liveweight expected to be mobilised per unit of BCS, Holmes *et al.* (2002) estimated ME requirements per unit of BCS for Jerseys and Holstein-Friesians of 1439 MJ ME and 2303 MJ ME respectively. The energy value of a kilogram of true body mass is dependent on the relative proportions of fat and protein in tissue and their respective heat of combustion (NRC, 2001). Provided that this can be determined, and with an assumed amount of liveweight per BCS unit, the approximate amount of energy per unit of BCS can be calculated and then the equivalent cost derived. An alternative method is to genetically adjust liveweight for BCS. Liveweight is already included as a breeding goal trait in Breeding Worth, but, currently liveweight BVs do not account for different levels of condition. Adjusting liveweight genetically for BCS would mean that liveweight breeding values could be expressed at the same level of body condition. Thus, BCS would be included indirectly. This method does not require the calculation of an economic value. One would expect the liveweight BVs of a low BCS animal to be adjusted upwards, which would result in more of a negative contribution into BW, thus reflecting the cost of replenishing BCS.

The aim of this study was to account for BCS in BW with regard to body tissue replenishment, through either calculated energy requirements or by genetically adjusting liveweight for BCS.

MATERIALS AND METHODS

Energy calculations

An economic value for BCS, which could be included in a prototype version of BW, was estimated by calculating the costs of replenishing one unit of BCS and included: 1) calculated net energy (NE) requirements 2) the corresponding calculated metabolisable energy (ME) requirements 3) the corresponding amount of feed, and 4) the cost of that feed. A sensitivity approach was taken to model "high", "medium" and "low" levels of the economic value.

First, an estimate of the amount of liveweight equivalent to one unit of BCS was required. This differs between breeds and strains (Holmes *et al.,* 2002), but based on published estimates in Holmes *et al.* (2002) and regression of BCS on liveweight using the data set described by Pryce *et al.,* (2005) which includes sire proving scheme first parity animals in New Zealand, a range of 30kg/BCS unit to 50kg/BCS unit were chosen as they were believed to be at the extremes of what one unit of BCS might be considered to be in the NZ dairy cow population. The net energy value for liveweight change in dairy cows is predicted to be 19MJ/kg (AFRC, 1993). Thus, the net energy in one BCS unit is estimated to be between 570MJ and 950MJ.

ME requirements were calculated by dividing the NE requirements by the efficiency of converting feed into body tissue (k_g). The value of k_g was assumed to vary between 0.33 and 0.55, the range of k_g used in this study should cover differences in the efficiency of converting pasture to body tissue arising through seasonal and lactational effects (Holmes *et al.,* 2002). Feed metabolisable energy was assumed to vary between 10 and 11 MJ ME/kg, to account for different pasture qualities that might be used when body tissue replenishment generally occurs (Autumn/Winter). Using these values, the equivalent kg of feed could be calculated. The cost of feed was assumed to range between \$0.10 and \$0.20 per kg. Using the assumptions listed above, the approximate "high", "medium" and "low" costs for raising BCS by one unit were \$10, \$25 and \$60. Three new indexes were calculated that included the addition to current BW of BCS BVs obtained from Animal Evaluation multiplied by \$10, \$25 and \$60.

Accounting for BCS in BW by adjusting liveweight genetically for BCS

BCS BVs were expressed as z-scores within contemporary group (CG) (having a mean of 0 and standard deviation of 1). Liveweight breeding values were estimated using the same model as currently used in Animal Evaluation, but with a genetic adjustment made for BCS BV (regression of BCS BV on liveweight). An index was calculated that was the same as BW, but included liveweight BVs adjusted for BCS instead of liveweight BVs (the economic value of liveweight was the same as currently used in BW).

Evaluating the methods

The two methods were evaluated by calculating rank correlations of BW with an index that included BW and the addition of BCS BVs multiplied by the "high", "medium" and "low" economic values, or with BW altered to include the liveweight BV adjusted genetically for BCS.

When BCS was included as an additional trait in an index, annual responses to selection were calculated at an industry level using selection index theory, assuming selection decisions are made on the basis of multivariate trait evaluation. It was assumed that genetic improvement is achieved through three main pathways of selection: males to breed males, males to breed females and females to breed males. Genetic parameters and economic values for all traits currently in BW (fat, protein, volume, liveweight, survival, fertility and somatic cell count) in addition to BCS were used to construct the matrices required for the selection index calculations. The proportion of animals selected were 3.6%, 5% and 0.5% for males to breed males, males to breed females and females to breed males (within male and female populations). The selection intensity in the females to breed females pathway is negligible. Genetic lags were assumed to be six years for sires, four years for cows to breed bulls and five years for cows to breed cows. Reliabilities of 1st proof male and average cows were obtained for each trait.

RESULTS

The rank correlations between current BW and the BW that included BCS either as a trait or an adjustment to the liveweight BV were >0.99 in all cases. This indicates that the addition of BCS into BW would not affect sire ranking.

Including BCS at various economic weights in the selection index reduced the direct emphasis on other traits (Table 1). Assuming an economic value of $10, BCS would have 1.3% of the emphasis in BW. Increasing the economic weight on BCS to $25 and $60 would result in increasing the emphasis on BCS in the index to 3.4% and 7.4%. At 7.4%, BCS would have a greater emphasis than fat yield, somatic cell count and survival in the index.

TABLE 1: Percentage of emphasis on traits in BW and BW including BCS BVs multiplied by a "low", "medium" and "high" economic weight

Trait	BW	BW + BCS "low"	BW+BCS "medium"	BW+BCS "high"
Fat	7.2	7.1	6.9	6.6
Prot	37.9	37.4	36.6	35.1
Vol	16	15.8	15.5	14.8
Lwt	18	17.7	17.4	16.6
Fert	9.1	9	8.8	8.4
SC	7.2	7.1	6.9	6.6
Surv	4.7	4.7	4.6	4.4
BCS	0	1.3	3.4	7.4

Responses to selection on BW are presented in Table 2. The current version of BW results in a small positive effect on BCS, predominantly through a favourable correlated response in fertility. Increasing the emphasis on BCS in BW would result in modest genetic gains in BCS and also had a modest effect on overall economic response to selection. Responses to selection for the version of BW that included liveweight adjusted for BCS would be close to the responses to selection for the "medium" index, as the indirect economic value which is attributable to BCS in the liveweight adjusted BW is around $33.

Based on the results presented in Table 2 and using the "medium" economic value as an example, the annual economic benefit of having BCS in BW with an economic value of $25 is (0.0056-0.0018)*25 = $0.10 per cow. The net cost of the increase in liveweight would be $0.08. Thus, the net benefit of including BCS in BW when its effects on LW and BCS only are considered would be $0.02 per cow annually. When all traits are considered in the index, the economic response of including BCS in BW is $11.82 (medium economic weight), while without it the economic response of the aggregate genotype is $11.67 (Table 2). Most of the economic response arises because of the genetic correlation between BCS and fertility.

TABLE 2: Responses to selection on BW and three indexes that include BCS weighted by "low","medium" and "high" economic values in units of measurement

Trait	BW	BW + BCS "low"	BW+BCS "medium"	BW+BCS "high"
Fat (kg)	1.98	1.98	1.98	1.97
Prot (kg)	1.81	1.81	1.80	1.78
Vol (kg)	37.6	37.3	36.86	35.9
Lwt (kg)	0.20	0.24	0.30	0.39
Surv (d)	28.4	29.0	29.7	30.8
Fert (d)	0.34	0.36	0.39	0.44
SC	-0.024	-0.024	-0.024	-0.023
BCS	0.0018	0.0034	0.0056	0.0093
$Total	**11.67**	**11.72**	**11.82**	**12.08**

DISCUSSION

Two methods of incorporating BCS into BW to account for body tissue replenishment were tested. Based on low economic responses and high rank correlations between existing BW and BWs that incorporated BCS into BW (either as an adjustment to liveweight BV or as an independent trait), there is little advantage in including BCS for the purpose of accounting for body tissue replenishment currently. Breeding values for BCS are currently published by Animal Evaluation, as BCS is used as a predictor of fertility. Thus, BVs for BCS are publicly available should they be required.

A sensitivity analysis was used in the first part of this study to evaluate the likely impact of BCS on BW, when different assumptions were made. Even when a very generous (and possibly unrealistically high) economic weight was placed on BCS, there was little impact of BCS on bull rankings and responses to selection. Should BCS have had an impact in this respect, it would be necessary to get more robust estimates of the variables used in the calculation of the economic value of BCS.

Research is required to obtain data relevant to grazing systems and genotypes in New Zealand on which to base the amount of metabolisable energy required to raise BCS. As demonstrated in the present study, there are several assumptions through which errors can be introduced. For example, the extremes used in this study for the amount of liveweight equivalent to one unit of BCS differed by 20kg, which is logical when different breeds and stages of maturity are considered, but have large impacts on the aggregate result, as there was a 6-fold difference between "low" and "high" economic values. Using available data from the sire proving schemes of Livestock Improvement and

Ambreed (from Pryce *et al.,* 2005) to estimate the regression of liveweight on BCS gave an estimate of 30kg/BCS unit. However, although this data set is likely to represent the breed-mix currently present in New Zealand, it does not represent the age structure, as liveweight and BCS records were available on two year-olds only. The next assumption is assuming the amount of energy equivalent to one unit of BCS (or kilogram of liveweight), which can only be obtained with accuracy using slaughter analysis, such as the New Zealand study by Gregory *et al.* (1998). However their study was limited by the number of cows available and the fact they were all cull cows and likely to be at the end of lactation. Existing estimates of the amount of energy equivalent to 1 kg of liveweight are based on studies from other countries and are often old and may not necessarily equate to New Zealand genetics and systems (e.g. AFRC, 1993). Another assumption that impacted on the estimated economic value was the k_g factor used; which was assumed to vary between 0.33 and 0.55, the difference arising because of differences in converting feed to body tissue in Autumn versus Spring pasture, and in-milk versus dry cows (Holmes *et al.,* 2002).

Genetically adjusting liveweight breeding values for BCS was used as an alternative strategy for incorporating BCS into BW, as it avoided the necessity of calculating an economic value for BCS and would allow the maintenance costs of cows to be compared at a constant BCS. This index did not affect sire rankings either and it was a technically unsatisfactory method. Using changes in BCS to assess body energy stores is preferable to using changes in liveweight, as changes in liveweight may not reflect true changes in stores of tissue energy. For example, in experiments where body energy stores were assessed using serial slaughter analysis there were differences in energy content of as much as 40% in cows of similar live weight (Andrew *et al.,* 1994), demonstrating that body mass can vary in energy density

The model used here to calculate responses to selection should be viewed as approximate as it assumed that genetic evaluation of New Zealand dairy cattle is via a multivariate animal model that would include simultaneous genetic evaluation of all traits. In reality, an 8 trait multivariate model is used to predict fertility (two fertility measures per lactation for lactations 1-3 inclusive in addition to BCS and milk volume in lactation one; Harris *et al.,* 2006), while univariate models are used to evaluate all other traits. However, responses to selection are useful to quantify the gains that can be made through enhancing selection indexes.

It is concluded that there would be little benefit in including BCS as an independent trait in BW. BCS is already included as a predictor of the fertility BV, and body condition score BVs will be routinely estimated from the fertility model.

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