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NON-LINEAR CALVING DIFFICULTY WEIGHTINGS IN THE IRISH DAIRY INDUSTRY

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SUMMARY

The genetic evaluation of calving difficulty in Ireland is currently based on farmer reported scores. The predicted transmitting abilities (PTAs) can then be converted using non-linear regression on phenotypic calving difficulty for high reliability bulls to an estimate of the percentage of difficult calvings for Dairy Cows and Dairy Heifers. A non-linear penalty is proposed to account for the risk that a low reliability bull may have a much higher percentage of difficult calvings than initially predicted. In addition to this penalty, a non-linear weighting is proposed for calving difficulty within a dairy beef index to reflect that a 1% increase in calving difficulty at a level that is already considered high has a larger economic impact than a 1% increase at a lower level.

INTRODUCTION

Calving difficulty is a trait of economic importance in cattle, with costs including loss of calf, loss of milk for dairy cows and veterinary costs incurred by difficult labour (Dekkers, 1994). Work carried out by Amer *et al.* (2001) determined the economic weighting of calving assistance in the Ireland and incorporated this economic value into breeding objectives for beef. Currently, prototype genetic evaluations for dairy calving difficulty traits are computed by the Irish Cattle Breeding Federation (ICBF) for "Dairy Heifer" (DH) and "Dairy Cow" (DC) matings. While all data (including data from beef matings on dairy cows) is simultaneously used in the multi-trait evaluation, the evaluation produces separate PTAs for heifers and cows. The genetic evaluation system uses calving category scores as input phenotypes in a way that was found to optimise the heritability of the traits and the stability of the evaluation system. However, the resulting PTAs need to be transformed from the underlying 4 point score scale (defined as 1 = no assistance, 2 = some assistance, 3 = considerable difficulty, 4 = veterinary assistance), to a percent difficult scale (defined as percentage of scores 3 and 4), in order to align with economic value calculations and to make more sense to farmers. The translation is undertaken using a non-linear function, separately for each type of calving (e.g. DH versus DC), and is based on comparing PTAs for high reliability bulls with the actual number of difficult calvings in their daughters.

MATERIALS AND METHODS

Two levels of non-linear weightings were integrated into the transformed calving difficulty PTAs, firstly incorporating a non-linear penalty for low reliability bulls and secondly applying a non-linear weighting for percentage of difficult calvings in an index for dairy beef suitability.

Non-linear reliability penalty. The conversion of PTAs from the underlying genetic evaluation scale to the percent difficult scale involves fitting a quadratic to the PTAs for high reliability bulls using their progeny percentage of difficult calvings for DH and DC as the independent variable. However, the direct conversion to a PTA based on percentage of difficult calvings does not take account of the downside risk associated with getting a high percent difficult bull, which is not completely offset by the upside risk of the bull turning out to have lower than expected difficulty. For this reason, an adjustment calculation has been made to translate the raw PTA into a weighted average expected level of percent difficulty.

To do this, each quadratic function was combined with an assumed normal distribution of uncertainty around the PTA. This distribution has a standard deviation combining the breed specific genetic variance (σ^2) calculated from de-regressed PTAs, by breed, and the reliability (ρ^2) of the bull's own PTA. In order to get the expected average percentage of calving difficulty that takes into account the uncertainty of the calving difficulty PTAs, the estimates were weighted by the normal distribution around the point using the integral in the following equation, where x is the PTA.

$$\int_{-\infty}^{\infty} N(x,\mu,\sqrt{\sigma^2(1-\rho^2)})\cdot f(x)\ dx \rightarrow \int_{-\infty}^{\infty} \frac{1}{\sqrt{\sigma^2(1-\rho^2)}\sqrt{2\pi}} e^{-\frac{(x-\mu)^2}{2\sigma^2(1-\rho^2)}}\cdot(ax^2+bx+c)\ dx$$

This integral simplifies to the following weighting function: $f(x, \sigma^2, \rho^2) = ax^2 + bx + c + a\,\sigma^2(1-\rho^2)$ where the intercept of the quadratic changes depending on the breed specific genetic variance of calving difficulty and reliability of a particular bull of interest. This gives a penalty function of a $\sigma^2(1-\rho^2)$ which can be applied to the transformed PTA. Using this adjustment adds larger weight to PTAs with lower reliabilities in breeds with a high amount of variability, as they have a larger spread, which represents higher risk.

Non-linearity in utility of calving difficulty. A linear weighting on calving difficulty within an index suggests that at any level of calving difficulty, an additional increase of 1% in calving difficulty has the same negative impact for farmers. However, in reality it is more likely that farmers would be more averse to an increase in calving difficulty when the mean level is already high compared to at lower levels. This suggests a non-linear economic weighting transformation would be appropriate for calving difficulty. The justification for this transformation is that with the high rates of assistance, a significant proportion of the herd is compromised in their health and rebreeding success, and a large amount of this cannot be compensated for as easily as a small amount. Barwick *et al.* (2001) investigated employing non-linear selection emphasis on calving ease EBVs in beef and determined that the method was useful in responding to the different levels of calving ease found in beef cattle.

Three non-linear weighting function options for calving difficulty were compared with a traditional linear economic weight derived based on the economic cost involved in the increased stockman hours, veterinary interventions, cow mortality, disposal and infertility as well as loss in milk sales as originally calculated by Berry *et al.* (2005). These economic weights were combined into an index designed to identify profitable beef bulls for use in Irish Dairy herds that combines calving difficulty, calf value incorporating a mortality adjustment and gestation length (McHugh *et al.* 2012).

RESULTS AND DISCUSSION

Non-linear reliability penalty. Figure 1 shows the penalty function as reliability increases from 0 to 1 (0 to 100%) for three different levels of variation which were equivalent to the variances observed in a trial data set of raw Angus (0.05), Charolais (0.09) and Belgian Blue (0.18) bull PTAs from ICBF. When the reliability was low (<0.1), the penalty in the high variability breed was around 3-3.5%, so the percentage of difficult calvings was inflated by the penalty of 3-3.5% to account for the risk that, due to the poor reliability of the PTA, the bull produces more difficult calvings than expected. The risk is lower in the breeds with less variability as the spread in potential PTAs is smaller at the same reliability.

Table 1 shows the genetic variance by breed for the dairy heifer and dairy cow PTAs as derived from the initial set of AI bulls from ICBF. The average penalty applied by breed to these AI bulls is also shown for dairy heifers and dairy cows, along with the average penalty applied to a dataset of young bulls that do not have any progeny records. Table 1 shows that the breeds with

the highest variance in the dairy heifer PTAs were Herefords, Belgian Blue and Simmentals, although of these three breeds only Belgian Blues also had a large variance in the dairy cow PTAs. The variance for the Angus PTAs was reasonably low for both dairy heifer and dairy cow PTAs, and thus the average adjustment was fairly low, with an average of 0.37-0.44% additional in the AI sires, and 0.52-0.63% additional in the young bulls. In comparison, the average adjustment for the Belgian Blue sires was around 1.3% in the AI sires and around 2% extra in the young bulls.

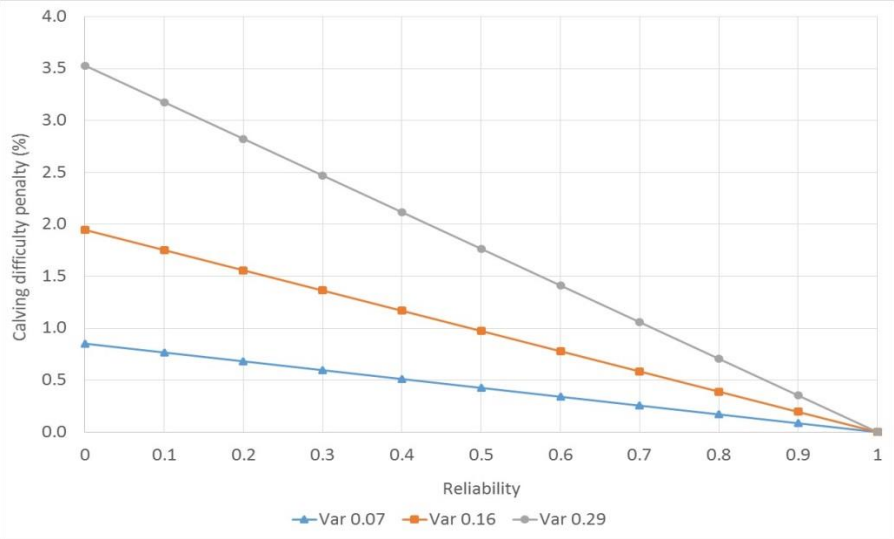

Figure 1. The additional penalty applied in percentage calving difficulty as the PTA reliability increases from 0 to 1 for three different levels of within breed variance.

Table 1. The derived genetic variance, average penalty for an initial set of AI bulls and the average penalty for a set of young bulls with no progeny records, by breed for both dairy heifer and dairy cow evaluations.

Breed[1]	Dairy heifer			Dairy cow		
	Genetic var	Avg sire penalty %	Avg young bull penalty %	Genetic var	Avg sire penalty %	Avg young bull penalty %
AA	0.05	0.37	0.52	0.05	0.44	0.63
AU	0.06	0.54	0.61	0.02	0.17	0.20
BA	0.08	0.60	0.81	0.02	0.19	0.28
BB	0.18	1.37	1.88	0.16	1.30	2.03
CH	0.09	0.69	0.96	0.04	0.29	0.46
HE	0.34	3.40	3.46	0.05	0.58	0.58
LM	0.07	0.40	0.65	0.03	0.15	0.30
PI	0.06	0.58	0.66	0.02	0.17	0.21
PT	0.07	0.61	0.75	0.02	0.19	0.25
SA	0.04	0.29	0.42	0.01	0.10	0.17
SH	0.07	0.66	0.73	0.02	0.28	0.32
SI	0.12	0.90	1.17	0.04	0.36	0.53

[1]Angus (AA), Aubrac (AU), Blonde D'Aquitaine (BA), Belgian Blue (BB), Charolais (CH), Hereford (HE), Limousin (LM) Piedmontese (PI), Parthenaise (PT), Saler (SA), Shorthorn (SH).

Non-linearity in utility of calving difficulty. The three proposed non-linear economic weightings place moderate, strong and very strong non-linear penalties on high calving difficulty bulls (Figure 2). The weighting functions showed a widening difference between the linear and quadratic indexes as the percentage difficulty increases, with bulls whose calving difficulty was greater than 20% being severely penalized by the non-linear index equations. In the linear index formulation some of the bulls with high calving difficulty percentages were being balanced out (at the overall index level) by a high calf value, so the non-linear transformation applies a harsher weighting to these bulls, meaning that they have low index values. While the non-linear index is successful in applying a stronger negative weighting at higher levels of calving difficulty, the trade-off between calf value and calving difficulty at low versus higher levels of calving difficulty is not known. A survey has been designed for Irish farmers to try and quantify the trade-off between calf value and calving difficulty in both dairy cows and heifers, with the strength of the non-linear index weighting that ultimately gets applied in the industry to be determined by the results of the survey.

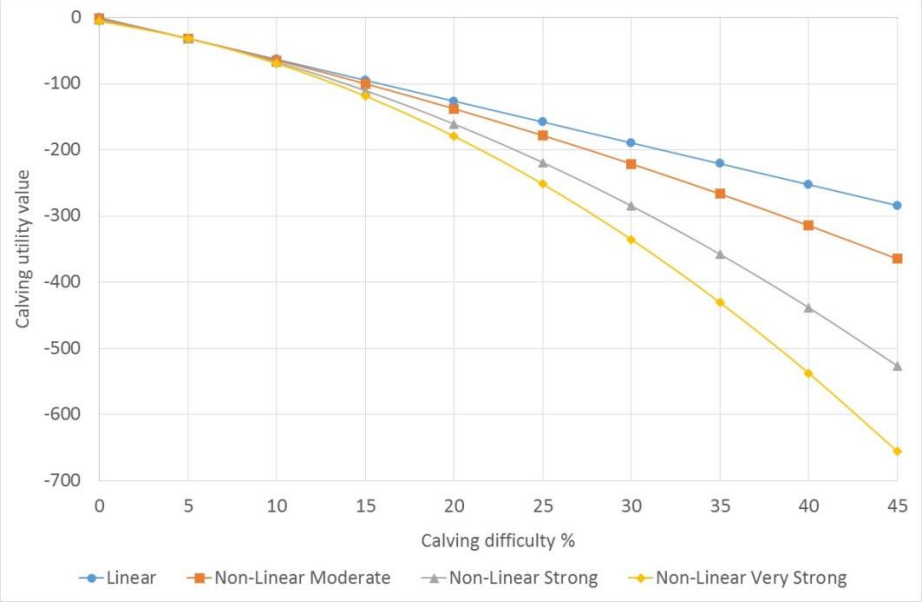

Figure 2. The linear and non-linear index transformations for calving difficulty percent.

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