DEFINITION OF SUSTAINABLE BREEDING GOALS IN DAIRY CATTLE

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INTRODUCTION
Sustainable agricultural production has received increased attention. Therefore, animal breeders should get involved in discussions concerning sustainability (Gamborg and Sandøe, 2005). Key words characterising sustainable animal breeding are product quality, genetic diversity, efficiency, and animal health and welfare (Codefabar, 2004). Breeding goals for dairy cattle are currently moving towards including both milk yield and functional traits such as mastitis resistance and stillbirth (Miglior et al., 2005), which are both related to sustainability. Many production and functional traits have unfavourable genetic correlations. Further, many functional traits have lower herheritabilities than production traits. Therefore, selecting for increased milk yield may result in deterioration of functional traits even when these traits are included in the breeding goal. Deterioration of functional traits cannot be considered sustainable. Sustainability can be included in the breeding goal by weighing traits both by traditional economic values (EV) derived using profit equations and non-market values (NV). The NV can for example represent the value of improved animal welfare, which is not reflected in the current market economy (Olesen et al., 2000). However, avoiding deterioration of functional traits by increasing their weight in the breeding goal will lead to decreased genetic improvement with respect to production traits. Hence, genetic improvement in production traits should be balanced with genetic improvement in functional traits.

The aim was to present a method to define sustainable breeding goals. NV are derived using desired gain indices based on the degree of acceptance for loss in response in milk yield in order to improve functional traits. The method is an extension of the method by Nielsen et al. (2005).

MATERIAL AND METHODS
Breeding goal and assumed genetic, phenotypic and economic parameters. The breeding goal contained the following three traits; milk yield (MY), mastitis resistance (MR), and conception rate (CR). MY was weighted only by an EV, whereas MR and CR were weighted by both an EV and a NV (Olesen et al., 2000):

\[ H = EV_{MY} \times Y_{MY} + (EV_{MR} + NV_{MR}) \times Y_{MR} + (EV_{CR} + NV_{CR}) \times Y_{CR} \]

where, NV + EV is a goal value (GV), and Y is genetic values for MY, MR, and CR.

Only the selection paths of progeny tested sires to breed cows and sires were included. The progeny group per sire was assumed to be 100 daughters and 5% of tested bulls were assumed selected. Applied genetic, phenotypic, (Sørensen, 1999) and economic parameters (Nielsen, 2004) are presented in Table 1.
Table 1. Applied heritabilities (diagonal), genetic correlations (above diagonal), phenotypic parameters (below diagonal) and economic values (EV)

<table>
<thead>
<tr>
<th>Trait</th>
<th>MY</th>
<th>MR</th>
<th>CR</th>
<th>EV[]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Milk yield (MY)</td>
<td>0.28</td>
<td>-0.35</td>
<td>-0.35</td>
<td>148</td>
</tr>
<tr>
<td>Mastitis resistance (MR)</td>
<td>0.03</td>
<td>0.04</td>
<td>0.20</td>
<td>163</td>
</tr>
<tr>
<td>Conception rate (CR)</td>
<td>-0.10</td>
<td>0</td>
<td>0.03</td>
<td>65</td>
</tr>
</tbody>
</table>

\(^a\)Units: milk yield = kg; mastitis resistance = incidence; conception rate = \%. \(^b\)€ per phenotypic standard deviation

Restricting response in milk yield to improve functional traits. NV were derived using desired gain indices with restricted response in MY, corresponding to a given percent loss. Percent loss in response in MY is selection response for MY using a breeding goal with EV and NV for functional traits relative to selection response for MY for a breeding goal with EV only. The desired response for milk yield is then: \((100-x)\times \Delta G_{OPT}\), where \(\Delta G_{OPT}\) is selection response for MY using a breeding goal with EV only, and \(x\) represents different proportions of percent loss in response in MY. \(\Delta G_{OPT}\) is:

\[
\Delta G_{OPT} = \frac{G_{MY}^i b}{\sigma_I}
\]

where, \(G_{MY}^i\) is the covariance between index and additive genotype for MY, \(\sigma_I\) is the standard deviation of the index, and \(i\) is the selection intensity. The desired gain index (Cunningham et al., 1970) is then:

\[
\begin{pmatrix}
P & G_{MY} \\
G_{MY}' & 0
\end{pmatrix}
\begin{pmatrix}
b \\
\lambda
\end{pmatrix}
= \begin{pmatrix}
Gv \\
[(100-x)\Delta G_{OPT} / i]\sigma_I
\end{pmatrix}
\]

where, \(P\) is a phenotypic (co)variance matrix, \(G_{MY}\) is the column of the G-matrix for MY, \(b\) is a vector of selection index weights, \(\lambda\) is a Lagrange multiplier, \(v\) is a vector of EV, and \(G\) is a genetic (co)variance matrix. Total economic response is maximized under the restriction that \(G_{MY}^i b\) equals a given percent loss in MY. Iterations to the fifth decimal were used to find the value of \(G_{MY}^i b\), which yielded the desired response corresponding to a given percent loss in response in MY. Relative GV for MY, MR, and CR were found based on estimated \(b\)-values:

\[
GV = (GG)^{-1}GPb
\]

Absolute GV for MR and CR were derived from relative GV scaled to the original EV for MY (Table 1). Finally, NV were derived as the difference between GV and EV.

Preliminary results showed that selection response for MR increased at a higher rate than selection response for CR. Therefore, NV were also derived using a multiple restriction (Lin, 2005) with simultaneously restricting selection response in MY to a given percent loss and restricting MR to zero response:

\[
\begin{pmatrix}
P & G_{MR} & G_{MY} \\
G_{MR}' & 0 & 0 \\
G_{MY}' & 0 & 0
\end{pmatrix}
\begin{pmatrix}
b \\
\lambda \\
\theta
\end{pmatrix}
= \begin{pmatrix}
Gv \\
0 \\
[(100-x)\Delta G_{OPT} / i]\sigma_I
\end{pmatrix}
\]

where, \(G_{MR}, G_{MY}\) are columns of \(G\) for MR and MY and \(\lambda, \theta\) are Lagrange multipliers. NV were derived in the same way as using the single restriction described above.
RESULTS AND DISCUSSION
The NV for MR and CR increased at the same rate (Figure 1a), using the single restriction with response in MY restricted to a given percent loss. However, selection response was higher for MR than for CR (Figure 1b). Positive response for MR was obtained with 8 percent loss in response in MY, but a loss of almost 36% was needed to obtain positive response for CR.

Figure 1. a) Non-market values (€/phenotypic standard deviation) b) selection response in € for mastitis resistance (Δ), conception rate (□), and total response (+) as a function of % loss in response for milk yield.

The NV for MR and CR and corresponding selection responses when simultaneously restricting response in MY to a given PCTLOSS and restricting MR to zero response, are presented in Figures 2a and 2b. Because restricting response in MR to zero, results in 8 PCTLOSS, NV and selection responses are presented from 8 PCTLOSS. NV for CR increased but NV for MR decreased with increasing PCTLOSS, due to increased NV for CR. To attain positive response for CR, the loss in response in MY was 13% by applying this multiple restriction (Figure 2b) compared to 36% for the single restriction (Figure 1b).

The reason for applying the multiple restriction with zero response in MR (Figures 2a,b) was to obtain more equal responses in MR and CR than using the single restriction (Figure 1a,b). This would especially be an option for a trait with high negative response or for a trait at a critical low level. The disadvantages using this multiple restriction are that one should be willing to loose at least 8 percent in selection response for MY, and that total selection response will be lower than using the single restriction.

Animal breeders and scientists should discuss sustainable breeding with society (Gamborg and Sandøe, 2005). It might be easier to communicate using selection response instead of GV (Kanis et al., 2005), because a GV does not say much about the actual selection emphasis on a trait. Using the present method, it is possible directly to show how much selection response in MY farmers or breeding companies are willing to loose to improve functional traits.
Figure 2. a) Non-market values (NV) for mastitis resistance (Δ) and conception rate (□), as a function of % loss in selection response for milk yield with response in mastitis resistance restricted to 0. b) Total selection response (+) in € and selection response for conception rate (□).

CONCLUSION
This study has shown that it is possible to derive non-market values and define sustainable breeding goals for dairy cattle by quantifying the trade-off between selection response for MY and functional traits using desired gain indices. In order to define sustainable breeding goal, breeding organisations should derive market economic values using profit equations, predict selection responses based on market economic values and add non-market values for traits currently having unacceptable genetic responses.

REFERENCES