# Fertility Trait Economics and Correlations with Other Traits

*P.M. VanRaden*
*Animal Improvement Programs Laboratory, Agriculture Research Service, United States Department of Agriculture, Beltsville, MD, USA 20705-2350*

## Introduction

National fertility evaluations are computed using greatly differing trait definitions and statistical models. Correlations of fertility traits with other traits within each country can be used to quantify those differences. Procedures analogous to those of Powell and VanRaden (2003) for longevity were used to obtain correlations for fertility traits. Relative emphasis on fertility and longevity in current national selection indexes are compared. Differences in definitions and adjustments can affect economic values of the traits evaluated.

## Methods

International fertility evaluations for Holsteins from the study of Jorjani (2005) were matched with yield, somatic cell score, and longevity evaluations from February 2006. Data from 11 country scales were included for a variety of fertility traits, and evaluations were used for a particular country only if the bull had daughters with milk yield records in 10 or more herds in that country. An exception is that a joint fertility evaluation from Denmark, Finland, and Sweden was tested, and these results were matched with other traits from Denmark and used only if the bull had daughters there.

Correlations of fertility evaluations with birth year and with the other traits within birth year were computed for each country scale. Birth year means were subtracted from the data for each trait. Some scales were reversed to make favorable directions identical across all scales. Scales reversed were Great Britain and Ireland for trait 4 (calving interval) and Canada for trait 2 (calving to first insemination). For SCS, scales were reversed to make high numbers always unfavorable. Trait 3 (cow non-return) evaluations were obtained from run 2 of Jorjani (2006) whereas traits 1 (heifer fertility), 2, and 4 were from run 1. Trait 1 correlations are not listed for France and Israel because their trait 1 input records were duplicates of trait 3. Correlations of fertility traits with birth year measure genetic trend free of units.

## Results

Correlations for fertility traits 1 to 4 of Jorjani (2006) are in tables 1 to 4, respectively. Correlations are consistent and small but always favorable with SCS, larger and always favorable with longevity, and nearly always unfavorable with yield and with angularity or dairy form (DF). Selection for high yield has resulted in moderate to large declines in fertility traits across time.

Birth year trends for cow non-return rate are inconsistent, with some countries reporting large negative trends and others small gains. Differences in genetic trend are associated with large differences in within-year correlations of yield with cow non-return rate. Interbull (2006) survey forms do not indicate that any country except Ireland adjusts fertility traits for yield, but several adjust non-return for interval to first insemination. Genetic trends are somewhat more consistent for traits 1, 2, and 4 than 3. Inconsistent correlations of fertility traits with other MACE traits may explain some of the lower genetic correlations of fertility traits across countries.

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Table 1. Correlations of heifer fertility evaluations with birth year and with other trait evaluations within birth year and country.

| Country | Bulls | Birth yr | Milk | Fat | Protein | Longevity | SCS | DF |
|---|---|---|---|---|---|---|---|---|
| Canada | 2663 | -.09 | -.11 | -.09 | -.14 | .14 | -.10 | -.06 |
| Denmark | 4317 | -.27 | -.23 | -.19 | -.27 | .03 | -.05 | |
| Great Britain | 2819 | -.43 | -.48 | -.22 | -.44 | .13 | -.12 | -.07 |

Table 2. Correlations of evaluations for interval from calving to first insemination with birth year and with other trait evaluations within birth year and country.

| Country | Bulls | Birth yr | Milk | Fat | Protein | Longevity | SCS | DF |
|---|---|---|---|---|---|---|---|---|
| Canada | 2683 | -.01 | -.26 | -.16 | -.21 | .32 | -.12 | -.22 |
| Denmark | 4024 | -.34 | -.42 | -.36 | -.40 | .25 | -.22 | |
| Netherlands | 6762 | -.33 | -.49 | -.46 | -.50 | .04 | -.15 | -.39 |
| New Zealand | 3010 | -.08 | -.29 | -.05 | -.19 | .49 | -.10 | |

Table 3. Correlations of cow non-return evaluations with birth year and with other trait evaluations within birth year and country.

| Country | Bulls | Birth yr | Milk | Fat | Protein | Longevity | SCS | DF |
|---|---|---|---|---|---|---|---|---|
| Canada | 3003 | -.06 | -.07 | -.09 | -.09 | .09 | -.04 | -.03 |
| Germany | 12169 | .06 | -.01 | -.03 | -.02 | .17 | -.04 | -.01 |
| Denmark | 4075 | -.41 | -.43 | -.37 | -.47 | .23 | -.17 | |
| France | 8930 | .09 | .00 | -.02 | .00 | .28 | -.08 | -.17 |
| Israel | 608 | -.06 | -.07 | -.16 | -.27 | .38 | -.15 | |
| Netherlands | 6847 | -.41 | -.39 | -.37 | -.48 | .08 | -.04 | -.02 |

Table 4. Correlations of calving interval, days open, or fertility index with birth year and with other trait evaluations within birth year and country.

| Country | Bulls | Birth yr | Milk | Fat | Protein | Longevity | SCS | DF |
|---|---|---|---|---|---|---|---|---|
| Canada | 3265 | -.06 | -.11 | -.13 | -.13 | .21 | -.06 | -.10 |
| Denmark | 4117 | -.40 | -.31 | -.28 | -.32 | .34 | -.18 | |
| Spain | 845 | -.08 | -.38 | -.29 | -.35 | .38 | -.16 | -.36 |
| Great Britain | 2810 | -.27 | -.36 | -.36 | -.42 | .30 | -.13 | -.40 |
| Ireland | 954 | -.20 | -.40 | -.35 | -.37 | .49 | | |
| Netherlands | 6544 | -.41 | -.52 | -.43 | -.50 | .06 | -.13 | -.43 |
| New Zealand | 3191 | -.11 | -.32 | -.05 | -.21 | .59 | -.10 | |
| United States | 19091 | -.04 | -.21 | -.21 | -.17 | .48 | -.12 | -.31 |

The longevity study of Powell and VanRaden (2003) did not include correlations with fertility because evaluations were not yet available. Correlations of fertility and longevity in tables 1 to 4 are helpful but difficult to compare because fertility definitions differ. To examine a uniform definition of fertility, correlations between US daughter pregnancy rate (DPR) and foreign longevity evaluations for bulls with daughters in 10 or more herds in both countries are reported in table 5. Countries are listed from highest to lowest correlation, along with genetic correlations for longevity from Interbull for comparison. The correlation of DPR evaluations with productive life (PL) for US bulls was .55. Countries such as Finland, France, and Israel whose longevity evaluations have low correlations with DPR also have low correlations with US PL. Longevity evaluations of Ireland and Sweden include more fertility than US PL, and this may have reduced their longevity correlations with the United States slightly. A revision of US PL in 2006 will decrease its correlation with fertility.

Table 5. Correlations of foreign longevity with US daughter pregnancy rate evaluations, and Interbull genetic correlations of foreign with US longevity.

| | Correlation with US | |
|---|---|---|
| Country | DPR | PL |
| Ireland | .66 | .73 |
| Sweden | .64 | .81 |
| Great Britain | .58 | .83 |
| Canada | .54 | .89 |
| Belgium | .52 | .82 |
| New Zealand | .51 | .66 |
| Germany | .46 | .85 |
| Spain | .46 | .72 |
| Italy | .44 | .73 |
| Denmark | .42 | .83 |
| Netherlands | .38 | .80 |
| Switzerland | .35 | .72 |
| Australia | .34 | .67 |
| Finland | .28 | .64 |
| France | .27 | .67 |
| Israel | .22 | .39 |

Total merit indexes place about 20% of selection emphasis on fertility and longevity traits in nearly all of the largest Holstein populations in Interbull. Partitioning emphasis between the two traits is difficult because poor fertility is a main cause of poor longevity. Most countries that select for both place about equal emphasis on each. A few countries have recently implemented fertility evaluations and have not yet included these in total merit. Table 6 compares selection emphasis across countries.

Table 6. Relative emphasis on fertility and longevity traits as percentage of total merit.

| | % of Total Merit Index | |
|---|---|---|
| Country | Fertility | Longevity |
| United States | 7 | 11 |
| Germany | 1 | 25 |
| Netherlands | 10 | 8 |
| France | 13 | 13 |
| Canada | 5 | 7 |
| Italy | | 8 |
| Denmark | 8 | 9 |
| Australia | 9 | 8 |
| New Zealand | 10 | 8 |
| Great Britain | | 17 |
| Sweden | 6 | 10 |
| Ireland | 22 | 18 |

Fertility indexes are reported in many countries instead of the individual traits. When only one combined trait such as DPR from group 4 is used in selection, about twice as much relative emphasis is placed on interval to first insemination as compared to cow non-return rate. Some countries with fertility indexes place more relative emphasis on non-return rate than on interval to first insemination because costs of breeding cows that cycle but don't conceive are higher than costs of remaining open longer for cows that don't cycle.

Predictions of longevity, however, always place more emphasis on interval to first insemination than on cow non-return rate. Combined longevity in Canada includes twice as much emphasis on interval to first insemination as on non-return rate, and predictions in Netherlands only include interval to first insemination. In US data (VanRaden et al., 2004), correlations of PL evaluations were .33 with interval to first insemination vs. only .11 with cow non-return rate. A single fertility index may not sufficiently describe both the economic values of the components of fertility and their values as predictors of longevity.

Adjustment of a trait for another trait can affect relative economic values of both. For example, yield traits are adjusted for current days open in some countries. Pregnancy reduces milk yield near the end of lactation, but the extra milk from high producing cows that have longer lactations also has economic value that should not simply be subtracted. Multi-trait evaluation can be more accurate than phenotypic adjustment of one trait for another, because genetic correlations and heritabilities among the traits also are considered. However, multi-trait models assume linear relationships among traits whereas actual trait relationships may be nonlinear.

## Conclusions

Genetic trends for fertility and correlations with yield traits were generally unfavorable. However, trends for cow non-return rate were slightly positive in two countries and the magnitude of correlations between yield and fertility was not very uniform across countries. Correlations of fertility traits with longevity were always favorable and somewhat more uniform. Correlations with SCS were also favorable and the most uniform but not as large. Correlations with dairy form (angularity) were always unfavorable especially for traits 2 and 4.

Exact economic values for fertility traits may be difficult to determine because of part-whole relationships and high correlations of these with longevity. Combined emphasis on fertility and longevity is now about 20% of total merit in many countries.

## References

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