Genetic evaluations for fitness and fertility in the United States and other nations

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"A key priority in research and education should be to identify those traits that really affect cost of producing milk and concentrate selection on them" (McDaniel, 1976).

Selection

Dairy cattle breeders in the US and many other countries have benefited from the advice of McDaniel and others at previous workshops, such as "The first change needed is to get more daughters on each bull's original progeny test. Among the reasons for the larger number are: … improved accuracy of evaluations for non-yield traits (SCS, Productive Life, etc.) that have lower heritabilities than those for yield" (McDaniel, 1995). Today, more accurate evaluations for more traits affecting profit are readily available.

Genetic progress is the product of accuracy, intensity, and genetic standard deviation (SD) divided by generation interval (Dickerson and Hazel, 1944). Fitness and fertility traits may have received too little selection because breeders focused too much on the heritabilities of traits rather than the accuracies now possible with modern progeny testing. Also, trait reliabilities are reported to the public, but accuracies (the square root of reliability / 100) give a higher and more realistic view of potential progress. Potential progress is greater for traits that have large genetic SD as percentages of trait means. Genetic and phenotypic coefficients of variation are greater for fitness and fertility traits than for most yield and type traits (Table 1).

Table 1. Genetic and phenotypic coefficients of variation (CV) for traits of interest.

Trait	Mean	Phenotypic SD	Phenotypic CV	Genetic CV
Protein (lbs)	692	91	13	7
Stature (in)	57	1.6	3	2
Productive Life (mo)	24	13	54	16
Daughter Pregnancy Rate (%)	23	15	65	13

Fitness and fertility traits have only recently been included in most national selection programs. Table 2 summarizes the beginning dates for US data recording and for genetic evaluation of each trait. Some of the earliest recorded traits such as milk yield and final score for type may not deserve direct selection today because breeders can apply selection to the individual components within these traits instead. Accuracy is increased because each individual trait is evaluated with its own heritability, and evaluations can consider correlations among traits. Similarly, selection for the components of productive life, such as fertility and mastitis, might result in more genetic progress than direct selection for longevity. However, overall traits are easier to select for and may contain some economic value not measured by individual components.

Table 2. History of traits recorded and evaluated in the United States.

Trait	Milk and fat	Final score type	Protein	Calving Ease	Linear type[1]	Productive Life	Somatic Cell Score	Calving Interval[2]
Collected since:	1908	1929	1975	1977	1983	1908	1987	1908
Evaluated since:	1935	1964	1977	1978	1983	1994	1994	2003

[1] Breeds other than Holstein began collecting and evaluating linear type during 1979-82.
[2] Evaluations are expressed as daughter pregnancy rate.

Most breeders understand the recorded traits in their own national database but are less familiar with foreign evaluations. Traits with the same name may have different genetic expression or interact differently with environments of other countries. Table 3 provides average genetic correlations among all countries for a variety of traits (Mark, 2003) and average correlations of the US evaluations with other countries' evaluations. For all traits, US correlations are higher on average than the average of other countries with each other, which may be surprising because most countries included in the Interbull evaluations are geographically close together in Europe. Environments and trait definitions should be similar but apparently are not.

Table 3. Average genetic correlations among all countries and of US with other countries as reported by Interbull.

Trait	Protein	Stature	Fore Udder	Somatic Cell Score	Long-evity	Sire Calving Ease	Daughter Calving Ease
Countries included	27	21	21	20	14	10	10
Average correla-tion with USA	.89	.90	.79	.86	.74	.86	.64
Average of all correlations	.87	.89	.75	.85	.59	.83	.58

Correlations are lower for new traits than those evaluated for some time, as might be expected. Reasons for low longevity correlations may be differing adjustments for yield (Powell and VanRaden, 2003) and difficulty in modeling changes in culling risk across the cow's life. Daughter calving ease correlations may be low because this trait includes direct and maternal effects in some countries and only maternal effects in others. Global progress could be higher with increasing trait harmonization.

Fertility

Cow fertility traits are officially evaluated by at least 13 other countries. Data, methods, and genetic parameters used in most of these national evaluations are documented in standard survey forms available from Interbull (2003). Original research publications are also referenced in the surveys and will not be duplicated here.

Fertility trait definitions differ greatly across countries. Only Ireland subtracts regressions on yield traits from their fertility evaluations. This is surprising given that most countries provide functional longevity evaluations, in which regressions on yield traits are subtracted from longevity. Several countries including Germany, France, Israel, Norway, and the Czech Republic evaluate only first-insemination conception or non-return rate, which are traits that have very low heritability (1 to 3%). Two countries evaluate whether the cow was inseminated (New Zealand) or became pregnant (Australia) early in lactation as binary traits.

Like the United States, several other countries evaluate overall reproductive success, which includes variation caused by ability to cycle, ability to conceive, and other factors such as embryo loss. Several countries measure interval traits such as days to first breeding, days open, or calving interval, which tend to have higher heritability (4 to 6%) but may take longer to obtain complete data. The Netherlands, Denmark, Sweden, and Switzerland evaluate more than one fertility trait and recorded more information than the United States did until our database was expanded this year. Some use only first lactation fertility records of cows, while others also evaluate heifer fertility. With low heritability and repeatability, including more records is very important. Several countries evaluate bull and cow fertility effects, which are nearly uncorrelated, together in the same model. Advantages of joint analysis may be small.

In February 2003, a US national evaluation of cow fertility began (VanRaden et al, 2003). The Net Merit formula was then revised to include daughter pregnancy rate (DPR) and also service sire calving ease and daughter calving ease beginning in August 2003. Evaluations of cow fertility traits have high reliabilities only after hundreds of daughters are recorded. For bulls with only first-crop daughters, reliabilities average about 60%, and parent averages still provide much of the information. Methods to include records in progress for DPR (Kuhn and VanRaden, 2003) will be implemented in November 2003. Reliabilities for new bulls increase by about 6% because records are used at 130 rather than 250 days in milk. Accuracy could be further increased by using multi-trait methods.

Correlations of fertility evaluations in the United Kingdom with those of 8 other countries were reported by Wall et al (2003). Of those that provided either calving interval or overall fertility indexes, the highest correlation (.76) was for US DPR with UK calving interval, indicating that DPR should be useful to foreign breeders. Correlations of DPR with other fertility traits of other countries are not yet available.

Pregnancy rate and days open (DO) in the United States are almost the same trait genetically, and a 1% higher pregnancy rate equals 4 fewer DO. Selection for high yield over several generations contributed to longer calving intervals because of the well-known unfavorable genetic correlation between yield and DO of about 0.35. Biologically speaking, “The stress of production seems to delay reproduction” (Freeman, 1986). Selection for productive life, which is highly correlated with fertility, has slowed the decline in fertility, but direct selection for fertility should increase potential progress and profit.

Conclusions

Researchers should continue to follow the advice from McDaniel (1976). A key priority should be to help breeders decide what traits deserve selection by further examining economic values. This job is now more difficult because many countries have developed successful breeding programs and each evaluates a variety of different traits. Actual selection will become easier if international evaluations such as those provided by Interbull for yield, conformation, and somatic cell score are provided also for fitness and fertility traits, so that different measurements can be compared on the same scale. Genetic selection has improved greatly both nationally and internationally. Recent inclusion of more fitness traits in US selection programs allows breeders to reduce the costs of infertility and difficult births while continuing to increase production, income, and profit.

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