Selecting Sires Other Than For Milk Production

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Dairy producers in the U.S. have dramatically increased milk production per cow over the last 30 years. Increases in herd production are the result of improved management as well as improved genetics. In recent years, average genetic improvement for milk production in the U.S. has been approximately 210 pounds per cow per year (Van Raden et al., 1996). Because the majority of dairy producers in the U.S. make their income from the sale of milk, production traits receive primary selection emphasis in most breeding programs.

Cow profitability, however, depends not only on how much milk a cow produces each lactation, but also on how many lactations she produces. As production per cow continues to climb to new, higher levels, the stress that high production has on a cow is of greater concern to dairy producers. Additionally, semen price has an impact on breeding expense and needs to be considered. This presentation will address those areas that should be considered in a breeding program besides production in order to maximize herd profitability.

Table 1: Genetic correlation between 1st lactation SCC and Holstein type traits[1].

trait	correlation with SCC
udder depth	-.42*
thurl width	-.21*
fore attachment	-.41*
dairy form	.18*
front teat placement	-.31*
stature	-.11
teat length	.20*
rump angle	.08
rear udder height	-.19*
strength	-.06
rear udder width	-.15
body depth	-.05
udder cleft	-.12
rear legs, side view	-.10
foot angle	-.06
final score	-.30*

**: Genetic correlations larger than 2X their standard error*

1: Rogers et al, J. Dairy Sci. 74:1087.

Correlated Response: A Concern For The Future?

Selection for higher production has been effective in developing cows with greater genetic merit for production. However, has selection for increased production been all positive? What has been the correlated response observed in other traits as a result of heavy selection emphasis for milk production?

Several studies (Bertrand et al., 1985; Hansen et al., 1979; Jones et al., 1994; Shanks et al., 1978) indicate that health costs tend to increase as production increases. Results would suggest that cows producing higher volumes of milk are under more physiological stress than lower producing cows. Increased health costs have been associated with higher producing cows for traits such as mastitis, reproductive disorders, and ketosis.

Emanuelson et al. (1988) reported a positive genetic correlation of .20 between mastitis and production. Genetic correlations between Somatic Cell Count (SCC) and production range from .16 to .25. (Banos and Shook, 1990; Boettcher et al., 1992). These results suggest that continued selection for milk production will result in slow deterioration for mastitis resistance. Maintaining good udder health in the high producing herd will be necessary to maximize profitability.

Several studies (Hansen et al., 1983a; Oltenacu et al., 1991; Raheja et al., 1989) have shown a negative genetic relationship between milk production and reproductive performance in cows, suggesting that continued selection for production will result in poorer reproductive performance in cows. Getting cows bred back is a major concern for the high producing herd and is likely to become even greater as herd averages climb.

The increased health costs associated with high production cows is a growing concern with consumers. Consumers will not accept drug residues in milk and meat products from dairy operations. Efforts to breed for healthier cows so as to minimize the need to treat cows for diseases will bolster consumers confidence when buying dairy products.

Selection Tools To Consider

Udder health. Genetic estimates for somatic cell score (SCS) have been calculated by AIPL/USDA since January 1994. Daughters from bulls with low PTAs for SCS are predicted to have less problems with mastitis than daughters from bulls with high PTAs for SCS. One of the challenges with incorporating PTA SCS data into breeding programs is that the heritability of SCS is assumed to be about 10% (Wiggans et al., 1994). This means that most of the differences observed between daughters of bulls are due to management and environment and not genetics. The general recommendation is not to base selection decisions on PTA SCS independent of other traits. Instead, the best approach is to incorporate PTA SCS into a selection index. One such index that includes PTA SCS is Net Merit. Net Merit will be discussed in more detail later on.

Udder conformation also affects SCS and mastitis. Table 1 (Rogers et al., 1991) shows that cows with deeper udders, loser fore attachments, wider front teat placement, longer teats, and lower rear udder attachments tend to have higher levels of somatic cells. Selection emphasis for more shallow, tightly-attached udders would improve udder health. Part of the dilemma, however, is that important udder traits such as udder depth have a negative correlation with milk production. Higher producing cows tend to have deeper udders. Putting too much selection emphasis on udder depth will have a negative impact on milk yield. Moderate depth to the udder may be the most logical compromise. Extremely deep udders are susceptible to injury and mastitis, whereas extremely shallow udders are usually associated with cows that don't give enough milk. As such, both extremes are usually detrimental the cow's herd life. High production from shallow udders is the ideal, but more realistic is high production from moderately deep udders that pose minimal management challenges.

Dairy producers tend to avoid bulls that are minus for udder traits. For example, Holstein bulls with minus STA values for udder traits as calculated by the Holstein Association are often avoided. However, the genetic differences between bulls for udder traits may be less than some realize. For example, Holstein bulls with an STA of -3 for udder depth have mature daughters with an average udder depth that is approximately .4 inches above the hock, whereas Holstein Bulls with an STA of +3 for udder depth have mature daughters with an average udder depth that is approximately 1.8 inches above the hock (see Holstein Type-Production Sire Summaries, July 1996, p. 13). The difference in average udder depth between these two extreme bulls is less than one and a half inches.

What many breeders many not realize is that STA rankings do not reflect the dramatic improvement the Holstein breed has made for udder traits in the past 25 years. Even though the STA rankings accurately rank the bulls for udder depth, the breed as a whole has improved to the point that even low ranking bulls for udder depth tend to sire udders that are above the hock. Breeders should be cautious about automatically excluding minus udder bulls from breeding programs.

Table 2: Correlation between PTA Productive Life (PL) and various performance traits[1].

trait	correlation with PTA PL
PTA Milk	.51
PTA Protein	.51
PTA SCS	-.19
PTA Type	.31
TPI	.56
STA Udder Comp.	.35
STA Foot & Leg Comp.	.16
STA Stature	.02
STA Dairy Form	.28
STA Strength	-.19

1: Based upon 2,722 Holstein bulls from July 1996 Sire Summary, with PTA PL Rel. >75%

Longevity. As discussed previously, dairy producers want cows that can produce high volumes of milk over several lactations. In July 1994, AIPL/USDA began publishing a genetic estimate for Productive Life (PL). Productive Life is based on the months that a cow is in milk (up to a maximum of 10 months per lactation) until the cow dies or reaches 84 months of age (Wiggans et al., 1994). For living cows, predicted months of productive life are used. Predictions are based upon the cow's current age and lactation number and the production and linear-type profile of her sire. Productive life reflects a cows ability to resist culling for all reasons: production, reproduction, mastitis, disease resistance and so forth. As such, low PL values indicates which bulls tend to have daughters that do not stay in the herd very long, regardless of reason.

Table 3: Confidence Range (CR) for PTA Protein at three levels of Reliability (*R*)

Trait = PTA Protein

Genetic Standard Deviation for PTA Protein = 20 lbs.

CR = $\sqrt{(1-R)} \times (GSD)$

R	$(1-R)$	$\sqrt{(1-R)}$	$\sqrt{(1-R)} \times (GSD) = CR$ (lbs.)
.36 (young sire)	.64	.8	16
.84 (1st crop proven)	.16	.4	8
.99 (2nd crop proven)	.01	.1	2

Table 2 shows the relationship between PTA PL and several other genetic measures for 2722 Holstein bulls from the July 1996 evaluation that had reliabilities greater than 75% for PTA PL. As expected, high producing cows tend to stay in the herd a long time. There was also a positive relationship between udder composite and PL and between feet and leg composite and PL. Daughters of bulls with high production, good udders, and good feet and legs tend to have higher PL.

Perhaps surprisingly, there was almost no relationship between stature and PL. Above average stature was no more associated with PL than below average stature. Results from Table 2 suggest that short cows with high production, good udders, good feet and legs, and low SCS are just as likely to stay in the herd as tall cows with high production, good udders, good feet and legs, and low SCS. Results would suggest that stature is probably a personal preference trait.

The heritability used by AIPL/USDA to compute PTA PL is 8.5%. Reliabilities for PTA PL will be below 60% for most AI proven bulls based on initial first-crop daughters. Producers should exercise caution before selecting bulls independently for PTA PL. A better recommendation is to use a selection index which incorporates PL into the calculation, such as Net Merit.

Reproduction. One of the greatest management challenges facing the high producing herd is getting cows bred back. The reproductive performance of a herd is a complex interaction between management, especially nutrition, and genetics. High producing cows lose body weight early in the lactation, as the cow can not consume enough dry matter to meet her production and maintenance needs during this time period.

Is it possible that certain growth genes have an impact on production and reproduction at the same time? For example, Hansen et al. (1983a) showed a negative genetic correlation between cow reproductive performance and production, similar to the research results of others. High producing cows have inferior reproductive performance. However, Hansen et al. (1983b) also reported a positive genetic correlation between reproductive performance in virgin heifers and the heifer's subsequent first lactation milk production. Prior to the stress of production, heifers that had higher genetic merit for milk production had superior reproductive performance. Heifers with desirable growth genes may be the healthiest, most aggressive heifers and also have superior reproductive performance. The desirable growth genes may also be responsible for the higher milk production in these heifers after calving. The growth genes may be involved with aspects of nutrient partitioning that ultimately lead to reduced reproductive performance in lactating cows.

Although the underlying genetics for reproduction may have improved as a result of selection for production (as the heifer data would suggest), the improvement may be completely overshadowed by the stress of production in lactating cows.

Heritability estimates for most reproductive traits are very low, less than 5% in most cases (Berger et al., 1981; Hansen et al., 1983a; Schaeffer and Henderson, 1972). Response to genetic selection for improved reproductive performance would be slow. Dairy producers should concentrate on management for improved reproductive performance, particularly in the area of nutrition to reduce the impact of negative energy balance early in lactation, rather than attempt to breed

Table 4: Economic comparison of an average young sire (57th percentile Net Merit) with a top proven bull (95th percentile Net Merit)

	random young sire	proven bull
Net Merit percentile	57th	95th
Net Merit (per lactation)	$123	$179
Net Merit (3 lactations)	$369	$537
semen price/unit	$3	$12
# units to get milking daughter	6 units*	6 units
semen cost to get milking daughter	$18	$72
Young Sire Benefits		
birth report: 2 calves from 6 units @ $8	$16	
milking daughter: 1 @ $40	$40	
INCOME		
Net Merit (3 lactations)	$369	$537
birth report	$16	
milking daughter	$40	
subtotal income	***$425***	
EXPENSES		
semen cost	$18	$72
INCOME LESS EXPENSES	**$407**	**$465**

**: The number of units of young sire semen to obtain a milking daughter is typically close to 15 units.*

directly for improved reproductive performance in cows.

Even though the heritability estimates for reproductive traits are low, any genetic differences that may exist between bulls for reproduction should be reflected in PL. As mentioned above, rather than select on PL directly, the preferred approach would be to use Net Merit, which incorporates PTA PL.

General Health. Although the United States does not have a systematic recording system for disease traits, other countries do. Denmark and Sweden are two countries which have extensive records for disease traits and have also imported a large amount of U.S. genetics over the past 25 years. Recent research (Gary Rogers, personal communication) has compared PL evaluations from the U.S. with genetic evaluations for disease traits for the same bulls in Denmark and Sweden. The most striking result is the strong negative correlation between STA dairy form from U.S. data and diseases other than mastitis from Scandinavia data. One interpretation is that extreme dairy form cows (extreme angularity) are under the most stress and are most susceptible to disease. Surprisingly, strength had little relationship with diseases other than mastitis. This study would suggest that high producing cows that don't look very angular may have less problems with disease than high producing cows that are very angular. In other words, cows that do not look like they are working too hard (when they actually are) are the cows more desired. Although the results are not yet published, this is likely to be an area that receives additional research attention in the future. How do we breed cows to maximize production and at the same time minimize metabolic stress?

Net Merit. Since July 1994, PTAs for PL and SCS are combined with PTA for Milk, Fat, and Protein Dollars (MFP$) into an economic index called Net Merit (Wiggans et al., 1994). The PTA MFP$ is multiplied by .7 to account for feed costs. The relative emphasis on discounted PTA MFP$, PTA PL, and PTA SCS in Net Merit is 10:4:-1, respectively. The negative weight for PTA SCS is because lower values are preferred for this particular trait.

Net Merit considers those traits of known economic importance to most dairy producers. Results are expressed on a per-lactation basis in dollars. Differences between bulls reflect the expected differences in income per lactation, prorated over the expected lifespan of the bull's daughter. High ranking bulls for Net Merit should transmit a balanced combination of high production per lactation, the ability to stay in the herd for multiple lactations, and good udder health.

Table 5: Net Merit semen values index for 7 bulls at the 90th percentile or higher for Net Merit.

Bulls ranked by Net Merit

bull	Net Merit	semen price	Net Merit value index
Action	$210	$30	$450
Bucko	$205	$20	$495
Credit	$195	$18	$477
Dollars	$185	$16	$459
Epic	$180	$15	$450
Franco	$175	$8	$477
Junior	$164*	$3	$474

Bulls ranked by Net Merit Semen Value

bull	Net Merit	semen price	Net Merit value index
Bucko	$205	$20	$495
Credit	$195	$18	$477
Franco	$175	$8	$477
Junior	$164*	$3	$474
Dollars	$185	$16	$459
Action	$210	$30	$450
Epic	$180	$15	$450

**: PTA Net Merit for Junior prior to adjustment for pedigree slippage = $184.*

Economic Considerations

Purchase decision are seldom made based on genetic merit alone. Other factors include semen price and reliability. In other words, the selection decision considers income potential (genetic merit), expense (semen price) and the amount of risk the producer is willing to take (reliability).

Risk. Risk management can be addressed with reliability. AI bulls can be grouped into 3 basic risk categories: young sires, proven bulls with first-crop daughters, and proven bulls with second group daughters. The reliabilities associated with each category are approximately 35% for young sires, 75-85% for proven bulls with first-crop daughters, and 99% for proven bulls with second-crop daughters.

Reliability is expressed as a percentage value and is therefore unitless. An equivalent value that expresses reliability in the same units as the trait of interest is called confidence range.

Confidence range is a direct function of reliability.

Confidence range is calculated by taking the square root of 1 minus reliability and multiplying this by the genetic standard deviation for the trait. Table 3 is an example of confidence ranges for three bulls with reliabilities of 36%, 84%, and 99% for the trait protein yield. Figure 1 is a graphic representation of confidence range. Confidence range allows us to visualize the amount of risk that we take when using bulls of various reliability. The larger the confidence range, the greater the opportunity for the true breeding value of the bull to still go up, or to still go down. Figure 2 is a graphic representation of the confidence range associated with three bulls with PTA (or Parent Average (PA) for a young sire) Protein of 60 pounds and with reliabilities of 36%, 84%, and 99%.

A.I. progeny-test bulls are a popular choice for many producers due to their good genetic merit and low semen price. However, the low reliability associated with progeny-test bulls means that the genetic estimate (PA) is still subject to rather large changes. To minimize the risk, the general recommendation is to use only a few units of progeny test semen from any one young sire, and to use a several young sires to balance out the frequency of young bulls that will be lower than parent average (one-half of the bulls) with the frequency of young bulls that will be higher than parent average (the other half). Unfortunately, at the time of progeny testing, we don't know which bulls are the half that will be above PA after their daughter proofs and which half will be below PA after their daughter proofs, hence the need for progeny testing.

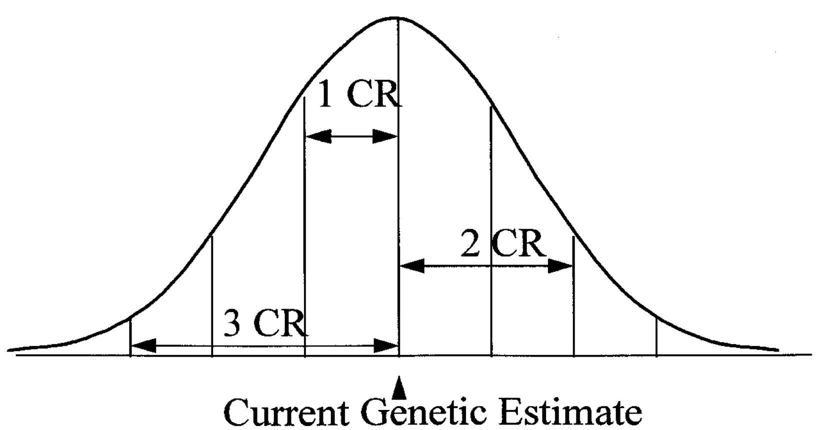
Genetic merit of A.I. young sires compared to proven bulls. How do young sires, as a group, compare to proven bulls? One point that is sometimes overlooked is that young sires usually end up with PTA values slightly lower than their PA. The probable explanation for this is that cow indexes for many bull dams are slightly overestimated. This may be more a reflection is typical management (most producers usually pay close attention to their best cows) than intentional bias, but the fact remains that the average PTA for progeny test bulls after their daughter proofs is slightly less than their PA at time of sampling. For protein yield, PA overestimates PTA by

Figure 1. Graphic representation of Confidence Range (CR).

± 1 CR = 67% of the time, true genetic estimate will be in this range when animal is at 99% Reliability

± 2 CR = 95% of the time, true genetic estimate will be in this range when animal is at 99% Reliability

± 3 CR = 99% of the time, true genetic estimate will be in this range when animal is at 99% Reliability



about 4 pounds. For milk yield, PA overestimates PTA by about 100-150 pounds. When comparing PTAs of proven bulls with PA of progeny test bulls, a slight adjustment for this "pedigree slippage" should be included.

Young sires do not receive a daughter proof until 4 years after their semen is distributed as young sires. Of interest is to compare the daughter proofs of young sires with the proven bulls that were available 4 years previously when semen from the young sires was first distributed for testing. Recent research at Virginia Tech (Weigel et al., 1995) indicates that the average PTA MFP$ for AI young sires, relative to proven bulls available at the same time the young sire semen was distributed, is at the 57th percentile ranking.

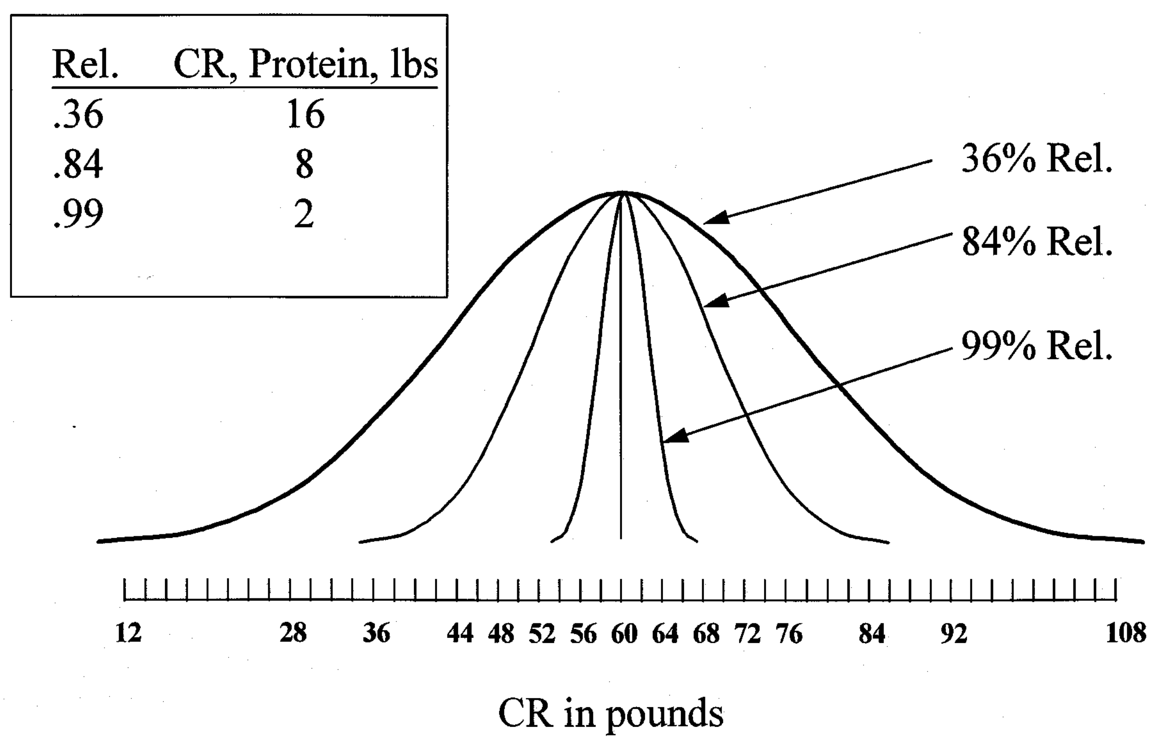
It is also important to use young sire semen as soon as possible. The genetic merit of young sires is determined at conception. Young sires are the most competitive with proven bulls at their youngest age. By the time a young sire finally gets a daughter proof at about 41/2 to 5 years of age, the genetic merit of the young sires has declined to about the 12th percentile for PTA MFP$ relative to the most recent group of proven bulls in Active AI.

The Virginia Tech study demonstrates that the average young sire is of higher genetic merit than the average proven bull if used when the young sire is just over 12 months of age. Producers using only average proven bulls could make greater genetic progress by using young sires only. However, there are still many proven bulls that are of higher genetic merit (at higher levels of reliability) than the average young sire. Breeders using 100% AI young sires are almost certainly not maximizing their genetic progress since they are not maximizing the higher reliability proven bulls of high merit.

There are other advantages proven bulls have over young sires. Proven bulls provide a greater opportunity to use known calving ease bulls on heifers if calving difficulty is a management concern. Fertility rankings are available for most proven bulls, so high fertility proven bulls may be logical choices on hard breeding cows or during summer heat stress. Type proofs on proven bulls are useful for breeders using mating programs.

Semen price must yet be considered. Semen prices for AI young sires are usually low, generally $5 or less

Figure 2. Confidence Range (CR) for 3 bulls with PTA (or PA) Protein of +60 pounds at 3 different levels of Reliability.



per unit. Additionally, AI young sire programs usually offer various incentive payments for offspring data. For example, the herd owner may receive payments if calving ease information is reported and if the herd owner has one of the first milking daughters of the bull.

Table 4 is an economic comparison of an average young sire compared to a proven bull at the 95th percentile for Net Merit. The Net Merit value used for the young sire was $127, which is equal to a current Active AI Holstein bull that would be at the 57th percentile for Net Merit. In this example, the proven bull's daughter is expected to generate $58 more profit than the young sire's daughter, even after semen prices and incentives have been considered. The table can be easily modified into a spreadsheet so that herd owners can alter prices and genetic merit of young sires and proven bulls as needed.

Net Merit is probably the best index to use for producers wanting a balance of high production, longevity, and udder health. Net Merit does not consider semen price, however. A simple index that considers both Net Merit and semen price is as follows:

Net Merit Semen Value Index =
3*Net Merit - 6*Semen Price.

Net Merit is expressed on a per lactation basis. The multiplication factor of 3 for Net Merit assumes a daughter will stay in the herd for 3 lactations. This corresponds to a 33% cull rate. The number of lactations in easily calculated by dividing 1 by the cull rate percentage. For example, the average number of lactations for a herd with a 40% cull rate would be 2.5 lactations. Because the genetics are also transmitted to future generations, a multiplication factor of 3 is fairly robust even if cull rate is slightly higher than 33%.

The multiplication factor of 6 for Semen Price assumes that it takes approximately 6 units of semen to get a milking daughter in a well managed herd and the semen is used judiciously to get pregnancies. In reality, young sire semen is often used on difficult breeding cows or in the summer months when conception rates are lower. Assuming 6 units per daughter is probably too generous for the young sire, but if no adjustment is made for incentives, a value of 6 comes close to approximating overall income and expense for young sires and keeps the formula simple.

Many times the PA for Net Merit of young sires is not printed in bull books. Also, even if PA is listed, a minor adjustment to account for pedigree slippage should be included. General guidelines to follow are:

1. If PA Net Merit is available, subtract 20 points to account for pedigree slippage. For example, if a progeny test bull has a PA Net Merit of $180, use $160.

2. If PA Net Merit is not available, multiply PTA MFP$ by .7 to arrive at an approximate PA Net Merit. In this case, do not subtract an additional 20 points. The pedigree slippage is already included in the .7 multiplication factor. For example, if a progeny test bull has a PA MFP$ value of $200, use $140 as an estimate of the bull's eventual Net Merit.

Table 5 is a comparison of 7 bulls. Six of the bulls are proven bulls, and the 7th bull (Junior) is a progeny test bull. In July 1996 bulls that had Net Merit values of greater than $164 were in the 90th percentile and above. All of these bulls, including the young sire, would be in the 90th percentile group, so this is an outstanding group of bulls. In the case of Junior, $20 was subtracted from his PA Net Merit to account for pedigree slippage.

Table 5 also lists semen price. Using the Net Merit Semen Value index, we see that the top 3 value bulls are Bucko, Credit, and Franco, followed by the young sire Junior. The three lower value bulls in this example are Dollars, Action, and Epic. Although all of these bulls are extremely good values, the second high bull for Net Merit (and second high bull for semen price) actually has the highest value after accounting for semen prices.

Conclusions:

When selecting bulls for the herd other than production, the simplest approach is to use an overall economic index such as Net Merit which accounts for factors such as longevity and udder health. If and when more health and fitness information is available for U.S. proven bulls, these values can easily be incorporated into an index similar to Net Merit. Young sires continue to be a good value relative to the average proven bull, but as a group the young sires are probably not as high in genetic merit as the best proven bulls. Because the best proven bulls are more expensive than young sires, consider calculating a Net Merit Semen Value index for bulls to determine best overall value.

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Notes