Genetic Selection for Reproduction: Current Reproductive Status of the National Herd; Application of Selection Indexes for Dairy Producers

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INTRODUCTION

In 1990, an ad hoc committee of the American Association of Bovine Practitioners developed a set of proposed standards for measuring reproductive performance on U.S. dairy farms (Fetrow et al., 1990). The committee considered overall reproductive performance, intensity of estrous detection, conception efficiency, pregnancy losses, culling because of reproductive failure, and natural-service reproductive efficiency. Those categories included traits such as days open (**DO**), calving interval, number of services, and conception rate (**CR**). The committee's intent was to provide a basis for analyzing reproductive performance with practical and accurate approaches to the calculations with consideration given to the availability of on-farm data, its electronic storage, and limitations of the computing environment. The traits adopted by the dairy industry have evolved over the last 15 yr as reproductive events reported through the Dairy Herd Information (**DHI**) system increased and as statistical methodology and computer technology advanced.

CURRENT REPRODUCTIVE STATUS OF THE NATIONAL HERD

Bull Fertility

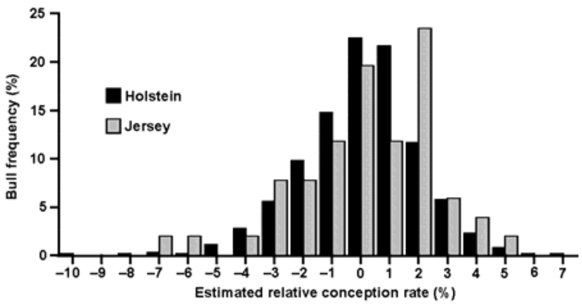
Since the early days of artificial insemination (**AI**), service bulls have been evaluated for their ability to impregnate cows by individual AI organizations. The fertility measure was usually the 60- to 90-d nonreturn rate (**NRR**) for first breeding; a 30-d range was included to accommodate tabulations after the end of the calendar month. Unfortunately, any bull with semen that was used exclusively early in the month had more time for his mates to be rebred than a bull with semen used later in the same month; that is, some bulls were measured with a 60-d NRR; whereas others approached a 90-d NRR. The advent of readily available electronic data storage made it more convenient to calculate NRR for a fixed interval. Although the reporting of individual inseminations through DHI and technician records provided strong support for defining NRR on a fixed interval, several AI organizations continued to use a 30-d range to measure fertility because they continued to receive data once a month.

In 1986, Dairy Records Management Systems (**DRMS**; Raleigh, NC) initiated a fertility evaluation for service sires based on breeding records supplied by producers enrolled in DHI (Clay, 1987). Estimated relative conception rate (**ERCR**) was provided as a comparison across AI organizations. This phenotypic evaluation of bull fertility is based on a fixed 70-d NRR (Animal Improvement Programs Laboratory, 2006). First-service inseminations that were reported by DRMS, AgSource (Verona, WI), and Minnesota DHI through AgriTech Analytics (Visalia, CA) during the last 3 yr are included.

Implementation of ERCR provided dairy producers with a fertility evaluation for any AI bull with an adequate number of inseminations regardless of which AI organization controlled the bull. The use of DHI data simplified the use of a fixed interval for tabulating NRR because data were readily available and updated continuously. Data from bull mates that left the herd or were in herds that discontinued DHI testing prior to completing that fixed interval could be excluded from the bull's fertility evaluation. Although initially the AI industry was concerned that the availability of ERCR would destroy marketing potential for AI bulls with low fertility, AI organizations began to rely on ERCR information as the number of inseminations through technician service decreased and the demand for reproductive information by dairy producers increased. The process of calculating ERCR was transferred from DRMS to USDA in 2006 (Kuhn et al., 2006).

The current distribution of 641 Holstein and 51 Jersey AI bulls for ERCR is shown in Figure 1. Only AI bulls with ≥ 300 inseminations during the last 3 yr have an ERCR evaluation released. In this evaluation, all bulls sum to 0 (whether or not they have a sufficient number of inseminations to receive an evaluation released). Standard deviation for ERCR was 2.0 % for Holsteins and 2.4 % for Jerseys. The percentage of Holstein bulls that had an ERCR of zero was 22.5; percentages between ± 1 %, ± 2 %, and ± 3 % for ERCR were 59.0, 80.5, and 91.9 %, respectively. Jerseys showed more fluctuation, most likely because of the limited number of bulls.

Figure 1. Frequency of Holstein and Jersey artificial-insemination bulls for estimated relative conception rate in August 2007.



AgriTech Analytics also initiated the Western Bull Fertility Analysis in 2003. That evaluation is based on 75-d veterinary-confirmed CR rather than NRR and considers up to 5 services between 40 and 300 d postpartum/cow/lactation (Weigel, 2006). The total breeding history for each bull is included in his evaluation; that is, the fertility outcome is not restricted to a fixed number of recent years. The evaluation is based on data from on-farm computers and uses available pregnancy-check codes.

The AI organizations continue to obtain information on the breeding success of their bulls by calculating evaluations from technician breeding receipts or through breedings recorded through DHI (one organization). A telephone survey of the major AI organizations that operate in the United States was completed to learn more about how they determine the bull fertility ratings that they provide to the public. The survey questions included:

- Does your organization rate bulls on fertility from field data?
- Where do you obtain the data you use to evaluate them?
- How long a time period is included in your evaluation?
- What do you publish?
- How many nonreturn days are in your calculation?
- Is your evaluation derived from first or all services?
- Do you eliminate cows sold before a specific number of days after inseminating?
- Do you eliminate cows in herds that go off test before a specific number of days after inseminating?
- Is information on services from natural service bulls that follow AI breedings available to you to document failures of those AI breedings?

All AI organizations that were surveyed had programs to monitor bull fertility, but few relied completely on in-house information to determine the fertility rating provided to the public. Most received some information from technician breedings, but one organization purchased breeding records from a dairy records processing center. Another obtained breeding records directly from its cooperating herds. The most common fertility measure was NRR, which varied from 59 to 90 d for first breeding; however, some organizations still used a range of days in their NRR evaluations. One organization based fertility on CR because they had access to pregnancy-check records. The time period for data included in a bull's fertility evaluation varied from 1 yr to no limit. An equal number of organizations included first services only compared with all services. Those organizations that obtained data from technician breedings did not adjust for cow departures because of culling or when a herd discontinued production testing. They also did not have access to data that showed when a natural service mating followed an AI mating. The survey revealed opportunities for improving service-sire fertility evaluations. An evaluation with considerably higher accuracy will be available early next year from USDA (M. T. Kuhn, Animal Improvement Programs Laboratory, ARS, USDA, Beltsville, MD, personal communication).

The most important factor in obtaining an accurate fertility evaluation for a bull is to have many inseminations. The new USDA evaluation for bull fertility will be more accurate because it will include insemination data from most of the United States, as well as for all services (not just first), and will be based on CR rather than NRR. Additional model effects will be included that are not used in ERCR. Preliminary results from the developmental research have been reported at dairy industry meetings.

Cow Fertility

Many producers have expressed concern about the fertility of today's milking herds. A review of studies on reproductive efficiency by Lucy (2001) confirmed the validity of that concern. Washburn et al. (2002) reported large declines in reproductive

Table 1. Averages for reproductive traits of Holsteins and Jerseys by breeding year.

Year bred	Calving to first breeding (d)		70-d nonreturn rate for first service (%)		First-service conception rate (%)		Services per lactation[1] (no.)	
	Holstein	Jersey	Holstein	Jersey	Holstein	Jersey	Holstein	Jersey
1996	89	82	54	57	36	39	2.1	2.0
1997	91	84	55	57	34	37	2.1	2.1
1998	91	85	54	56	32	36	2.2	2.1
1999	92	85	53	55	31	35	2.3	2.1
2000	90	84	53	55	31	35	2.3	2.1
2001	92	85	52	56	31	36	2.3	2.1
2002	88	81	50	53	29	35	2.5	2.2
2003	88	83	48	53	30	36	2.5	2.3
2004	86	84	48	53	31	36	2.5	2.3
2005	86	84	46	52	30	35	2.6	2.4
2006	85	83	…	…	…	…	…	…

[1] Average number of breedings recorded during a lactation for all cows with Dairy Herd Information lactation records except for cows sold for dairy purposes without a recorded breeding and cows with terminated lactations with no confirmed reproductive status (not coded as pregnant or open).

performance in southeastern herds during the 1990s. Average DO increased from 122 d for Jerseys and 124 d for Holsteins in the late 1970s to 152 d for Jerseys and 168 d for Holsteins in the late 1990s. The corresponding increase in number of services per conception was from 1.9 to 2.9 for both breeds. Oseni et al. (2003) analyzed DO of Holsteins that calved between 1997 and 2002 by state and region. Average DO for the United States was 142 with 137 d for the Southwest, 140 d for the Northwest, 141 d for the Northeast, 142 d for the Midwest, and 155 d for the Southeast. De Vries and Risco (2005) reported that average annual pregnancy rate (**PR**) declined from 22 % in the late 1970s to 12 % in the early 2000s for Holsteins that calved in Georgia and Florida.
Parity averages for those traits are in Table 2 for cows that were bred in 2005. Older Holsteins tended to have longer periods from calving to first breeding (85 d for parity 1 compared with 92 d for parities > 5). For Jerseys, the period from calving to first breeding decreased from parity 1 (85 d) to parity 3 (82 d) and then increased through parities > 5 (88 d). For Jerseys, 70-d NRR declined across parity (5 %); however, for Holsteins, it declined only from parity 1 to parity 2 (3 %) and then remained constant. Conception rate declined across parities for both breeds (7 %). Number of services/lactation remained reasonably constant for Holsteins across parities (2.6 to 2.7), but increased slightly for Jerseys (from 2.3 to 2.5).

The 70-d NRR declined with the number of subsequent services for both Holsteins and Jerseys (Table 3). However, either no or only a small decline (3 %) in NRR was found across parities. For example, NRR for Holsteins declined 9 % between first (Table 2) and fifth services after first parity. However, across parities, NRR declined only 3 % for first (Table 2) and second services (Table 3) and not at all for third through fifth services. Declines for Jersey NRR were 15 % between first and fifth services, but only 5 % across parities for first service (Table 2), 3 % for second service, 2 % for third service, and 1 % for fourth and fifth services.

Conception rate declined with parity (Table 4). Conception rate was slightly higher (1 to 2 %) for

Table 2. Averages for reproductive traits of Holsteins and Jerseys that were bred in 2005 by parity.

Parity	Calving to first breeding (d)		70-d nonreturn rate for first service (%)		First-service conception rate (%)		Services per lactation[1] (no.)	
	Holstein	Jersey	Holstein	Jersey	Holstein	Jersey	Holstein	Jersey
1	85	85	48	54	32	37	2.6	2.3
2	85	83	45	52	29	36	2.7	2.3
3	87	82	45	52	29	35	2.6	2.4
4	88	84	45	50	28	34	2.6	2.4
5	90	85	45	51	27	32	2.6	2.4
> 5	92	88	45	49	25	30	2.7	2.5

[1] Average number of breedings during a lactation for all cows with Dairy Herd Information lactation records except for cows sold for dairy purposes without a recorded breeding and cows with terminated lactations and not confirmed as pregnant or open.

Table 3. Averages for 70-d nonreturn rate (NRR) for subsequent services after first for Holsteins and Jerseys that were bred in 2005 by parity.

Parity	70-d NRR for second service (%)		70-d NRR for third service (%)		70-d NRR for fourth service (%)		70-d NRR for fifth service (%)	
	Holstein	Jersey	Holstein	Jersey	Holstein	Jersey	Holstein	Jersey
1	46	49	43	46	41	43	39	39
2	43	48	41	45	40	40	38	41
3	44	47	42	43	41	41	39	37
4	44	48	43	46	41	40	39	39
5	43	47	42	42	41	42	40	39
> 5	43	46	43	44	41	42	39	38

Table 4. Averages for conception rates for subsequent services after first for Holsteins and Jerseys that were bred in 2005 by parity.

Parity	Second-service conception rate (%)		Third-service conception rate (%)		Fourth-service conception rate (%)		Fifth-service conception rate (%)	
	Holstein	Jersey	Holstein	Jersey	Holstein	Jersey	Holstein	Jersey
1	33	39	31	35	29	32	26	28
2	30	37	29	34	28	30	26	29
3	30	36	30	32	28	29	26	30
4	30	35	29	34	27	28	26	25
5	28	34	28	31	26	28	25	25
> 5	26	32	26	31	25	26	25	24

second service than for first regardless of breed or parity. All differences were statistically significant for Holsteins ($P < 0.001$) and three of the five differences were significant ($P < 0.05$) for Jerseys. Conception is impacted by days in milk, and second services occur at a more favorable breeding time. After second service, CR generally declined (1 to 11 %) through fifth service (the last breeding examined). Jersey CR declined to the Holstein average after parity 3. Within individual service, CR generally declined across parities. For example, first-service CR (Table 2) decreased from 32 % for parity 1 to 25 % for parities ≥ 5 for Holsteins and from 37 to 30 %, respectively, for Jerseys. Corresponding declines for later services (Table 4) often were smaller.

To document the extent of synchronized breeding (ovulation synchronization followed by timed AI) in the United States, Miller et al. (2007) developed a method to identify herds using synchronization based on deviation of observed frequency of first inseminations by day of the week from an expected equal frequency and by the maximum percentage of cows that were inseminated on a particular day of the week. Based on that method, Miller et al. (2007) categorized U.S. herds according to likelihood of synchronized breeding: none, possible, probable, and definite. The proportion of herds with synchronized breeding (probable and definite) at first service has grown from 2 % of herds and cows in 1996 to almost 20 % of herds and 35 % of cows in 2005. Over all years, synchronized herds had 17 d fewer to first breeding, 9 d fewer open, and

Table 5. Averages for reproductive traits of Holsteins that were bred in 2005 by herd status for synchronized breeding (ovulation synchronization followed by timed artificial insemination).

Synchronization status	Calving to first breeding (d)	70-d nonreturn rate for first service (%)	Conception rate (%)	Services per lactation[1] (no.)	Pregnancy rate[2] (%)
None	90	46	30	2.6	20.2
Possible	78	40	27	2.9	21.8
Probable	74	38	27	2.9	22.4
Synchronized	72	35	25	3.1	21.7

[1] Average number of breedings recorded during a lactation for all cows with Dairy Herd Information lactation records except for cows sold for dairy purposes without a recorded breeding and cows with terminated lactations with no confirmed reproductive status (not coded as pregnant or open).
[2] Pregnancy rate = 0.25 (233 − days open).

0.2 services more per cow than did herds with traditional estrous detection. For Holsteins bred in 2005 (Table 5), synchronized herds had 18 d fewer to first breeding and 0.5 services more per cow compared with herds with traditional estrous detection; synchronized herds also were 11 % lower for 70-d NRR for first service and 5 % lower for CR. Herds designated as nonsynchronized had the lowest PR (20.2 %). Herds designated as synchronized and possibly synchronized had higher PR (21.7 and 21.8 %, respectively), but herds with probable synchronization had the highest PR (22.4 %). Although synchronization raised PR, the economic impact of its additional cost was not investigated.

Pregnancy Rate as a Measure of Cow Fertility

Pregnancy rate allows herd managers to measure how quickly cows become pregnant again after having a calf. It is defined as the percentage of nonpregnant cows that become pregnant during each 21-d period. Many reproductive specialists prefer PR to DO as a measure of reproductive success because of several advantages (VanRaden et al., 2004). Pregnancy rate is easily defined, and information from cows that do not become pregnant is included in those calculations more easily. In addition, larger rather than smaller values are desirable.

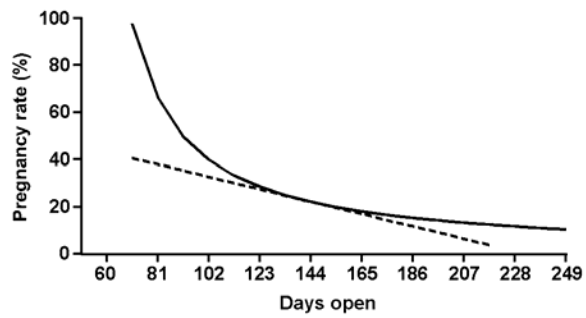
The nonlinear formula to convert from DO to PR (VanRaden et al., 2004) is PR = [21/(DO – voluntary waiting period + 11)]100. The voluntary waiting period occurs at the beginning of the lactation and is the period when the cow is not inseminated because of herd management practices; it is assumed to be 60 d so that comparisons can be made across herds. The factor of +11 adjusts to the middle day of the 21-d cycle so that cows that conceive during the first cycle receive 100 % credit on average. For example, a herd that averages 133 DO would have a PR of 25 % as compared with 20 % for a herd with 154 DO.

Daughter Pregnancy Rate (DPR) as a Genetic Measure of Cow Fertility

The genetic effect of a bull on the fertility of his daughters can be estimated, and herd fertility can be improved through genetics. Although calving interval and DO have been available from DHI data for many years, routine genetic evaluations were not developed for those or other fertility traits because of their low heritability (less than 5 %). Unfortunately, the erroneous assumption that improving reproductive traits through selection was futile led to the belief that within-herd management was the only way to achieve satisfactory herd reproductive performance. What was overlooked was that genetic variation for DO is greater than for milk yield because of the extreme phenotypic variation for some reproductive traits.

Pregnancy rate and DO are almost the same trait genetically. Although the formula for PR is not very linear when graphed across the whole range of DO, the curve can be approximated by a straight line across the smaller changes in daughter averages that result from sire genetic differences (Figure 2; VanRaden et al., 2004). For calculation of genetic evaluations, DO are converted to PR with a linear formula: PR = 0.25 (233 − DO). A 1 % higher PR equals 4 d fewer open.

Figure 2. Comparison of nonlinear (**–**) and linear (**--**) formulas for converting days open to pregnancy rate (VanRaden et al., 2004).



Pregnancy rates calculated by USDA's Animal Improvement Programs Laboratory are often somewhat higher than those reported by dairy records processing centers and reproductive specialists (VanRaden et al., 2004). The USDA calculations exclude additional cycles after 250 d in milk (**DIM**) and exclude lactations with no reported inseminations, if the cow was sold during that lactation for reasons other than reproduction. Pregnancy status after 250 DIM is used, but records are set to a maximum of 250 DO. For cows that become pregnant before 50 DIM, a minimum of 50 DO is used. Records in progress and records with unverified pregnancies are included in national genetic evaluations for DPR but receive less weight than complete and verified records.

Current breed averages for DO and PR based on the USDA national database (Animal Improvement Programs Laboratory, 2007) are in Table 6. Average DO ranged from 127 d for Jerseys to 157 d for Guernseys. Breed averages for PR, which is reversed in direction from DO, ranged from 19 % for Guernseys to 26 % for Jerseys; the average PR for

Table 6. Breed averages for days open, pregnancy rate, gestation length, and calving interval.

Breed	Pregnancy rate[1] (%)	Days open[1]	Gestation length[2] (d)	Calving interval [3] (d)
Ayrshire	23.2	140	281.7	422
Brown Swiss	20.3	152	287.5	440
Guernsey	19.1	157	285.8	443
Holstein	22.0	145	279.5	425
Jersey	26.4	127	280.0	407
Milking Shorthorn	24.8	134	281.3	415

[1] Cows born during 2003; pregnancy rate = 0.25 (233 − days open).
[2] Cows bred after February 1998 that calved before January 2006; parities 2 through 5.
[3] Days open plus gestation length.

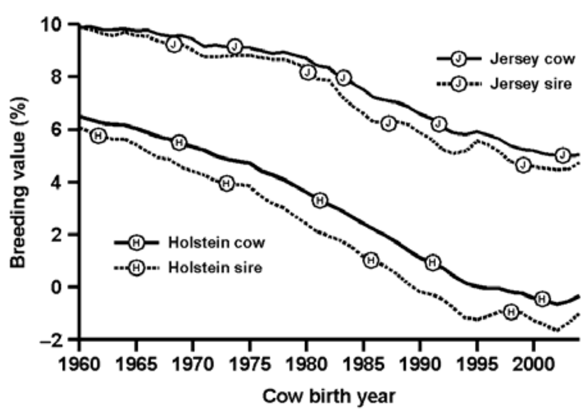
Holsteins was 22 %. Breed differences also exist for gestation length (Table 6). Norman et al. (2007) reported that Holsteins had the shortest average gestation length (279.5 d) and Brown Swiss the longest (287.5 d). Calving intervals (the sum of DO and gestation length) were shortest for Jerseys (407 d) and longest for Guernseys (443 d).

In the United States, genetic evaluations for DPR began to be provided by USDA in 2003 (VanRaden et al., 2004). Current U.S. predicted transmitting abilities (**PTA**) for DPR are calculated with an all-breed animal model (VanRaden et al., 2007) and expressed as deviations from a base PR across breeds, which is then adjusted to a within-breed base. The statistical model (VanRaden et al., 2004) is the same as that used for yield traits, productive life (**PL**), and somatic cell score (**SCS**); which accounts for management group (herd-year-season), the interaction of parity and calving age, inbreeding, permanent environment, and the interaction of herd and sire. Holstein management groups also account for registry status. A heritability of 4 % is assumed for DPR.

The PTAs for DPR are reported as percentages. A PTA DPR of 1 implies that a bull's daughters are 1 % more likely to become pregnant during that estrous cycle than if the bull had a PTA DPR of 0. Each increase of 1 % in PTA DPR is equivalent to a decrease of 4 d in PTA DO, and PTA DO can be approximated as PTA DPR multiplied by −4 (VanRaden et al., 2004). Thus, a bull with a PTA DPR of +2.0 would have a PTA DO of −8. A primary reason that DPR was chosen instead of DO as a genetic measure for cow fertility is the benefit of having a trait for which selection can be in a positive direction (such as for milk yield).

Genetic trends for DPR are shown in Figure 3 for Holsteins and Jersey cows and their sires. The lower DPR for sires than for cows for individual cow birth years indicated that the decline in bull genetic merit for DPR preceded the decline for cows. Breed differences in genetic merit for DPR also are evident, which indicates that genetic improvement of cow fertility is possible. The Holstein genetic trend for DPR has stopped declining since 1995, but the environmental trend continues downward (VanRaden and Multi-State Project S-1008, 2006). The implementation of genetic evaluations for PL in 1994 (VanRaden and Wiggans, 1995) probably helped to reverse the genetic decline in fertility because of the relationship between reproductive traits and longevity (genetic correlation of −0.59 between DO and PL; VanRaden et al., 2004).

Figure 3. Trend in breeding value for daughter pregnancy rate for Holsteins (H) and Jerseys (J) on the August 2007 all-breed base.

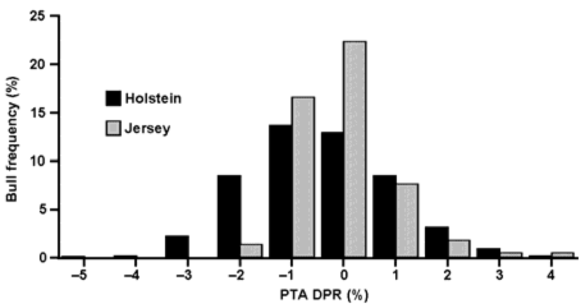


Selection for Cow Fertility

Based on the current distribution of 684 Holstein and 112 Jersey AI bulls for PTA DPR (Figure 4), AI bulls are available with the genetic potential to improve herd fertility. About 6 % of Holstein bulls and 3 % of Jersey bulls have a PTA DPR over 2.0 % and thus could raise average herd PR from 22 % to at least 24 % for Holsteins and from 26 to at least 28 %

for Jerseys. A 2 % increase in herd PR is an improvement of 9 % (2/22 = 0.09) for Holsteins and 8 % (2/26 = 0.08) for Jerseys in the percentage of open cows that become pregnant within 21 d after the voluntary waiting period of 60 d. Because a 1 % increase in PR is equivalent to a decrease of 4 DO, those top Holstein and Jersey bulls for PTA DPR could reduce DO by at least 8 d in the average herd because their daughters would conceive earlier. Two consecutive generations of high-DPR bulls could shorten DO in a herd by at least 12 d.

Figure 4. Frequency of Holstein and Jersey artificial-insemination bulls for predicted transmitting ability (PTA) for daughter pregnancy rate (DPR) adjusted to breed base in August 2007.



What would the impact on overall herd performance be from selecting service sires based solely on PTA DPR rather than on an overall genetic-economic index as recommended by most traditional animal breeders? Among the 684 Holstein AI bulls currently in active service, the 41 bulls with a PTA DPR of ≥ 2.0 % compared favorably (Table 7) with other bulls for genetic merit for SCS (slight decrease) and PL (increase of 3.1 mo). Naturally, genetic merit for daughter fertility was much higher for bulls with high PTA DPR (2.5 %) than the overall average for active AI bulls (–0.4 %). However, genetic merit of high-DPR bulls was 551 lb. less for milk, 18 lb. less for fat, and 8 lb. less for protein compared with all active AI bulls. In spite of lower genetic merit for yield traits, high-DPR bulls were superior for lifetime net merit by $104. Ironically, current semen prices (National Association of Animal Breeders, 2007) were only $1 different between an average active AI bull ($24) and average high-DPR bull ($25).

Because most producers are more selective than just choosing an average bull, PTA averages for the top 50 % of Holstein active AI bulls based on lifetime net merit were compared with the top 50 % of high-DPR bulls. The 20 highest DPR bulls still had nearly the same advantage over the top net-merit bulls for DPR (3.0 %), but the loss in genetic merit for yield traits was even greater (946 lb. milk, 30 lb. fat, and 18 lb. protein). The highest DPR bulls continued to excel for PL (2.3 mo) but no longer had an advantage for lifetime net merit ($7 lower). A comparison of current semen prices (National Association of Animal Breeders, 2007) showed that the highest DPR bulls were less expensive ($21) than the top bulls for lifetime net merit ($25). In addition, average daughters of the highest DPR bulls would have 12 fewer DO compared with average daughters of the top half of bulls for lifetime net merit.

Table 7. Genetic merit for production and fitness traits of Holstein bulls with high genetic merit for daughter pregnancy rate (**DPR**) compared with other Holstein artificial-insemination (**AI**) bulls based on August 2007 predicted transmitting abilities (**PTA**).

Trait	All active AI bulls	Active AI bulls with PTA DPR of ≥ 2.0 %	Top 50% of active AI bulls based on lifetime net merit (> $245)	Top 50% of active AI bulls with PTA DPR of ≥ 2.0% based on PTA DPR (> 2.3 %)
Bulls (no.)	684	41	342	20
PTA milk (lb)	838	287	1,125	179
PTA fat (lb)	32	14	43	13
PTA protein (lb)	25	17	34	16
PTA somatic cell score	2.94	2.86	2.88	2.84
PTA productive life (mo)	1.1	4.2	2.1	4.4
PTA DPR (%)	–0.4	2.5	–0.1	2.9
PTA days open (derived)	1.6	–10.0	0.4	–11.6
Lifetime net merit ($)	242	346	357	350

APPLICATION OF SELECTION INDEXES FOR DAIRY PRODUCERS

Lifetime Merit Indexes

Many traits have been added to USDA genetic-economic indexes since the 1971 introduction of predicted difference dollars, which included only milk and fat yields. The current lifetime net merit index places an emphasis of 23 % on both fat and protein yields, 17 % on PL, –9 % on SCS, 6 % on udder, 3 % on feet and legs, –4 % on body size, 6 % on calving ability and 9 % on DPR (VanRaden and Multi-State Project S-1008, 2006).

Cow fertility is a major component of longevity and was first included in lifetime merit indexes in 2003 (VanRaden and Seykora, 2003). Current relative emphasis on DPR in lifetime merit indexes varies from 9 % for net merit to 8 % for fluid merit to 7 % for cheese merit (VanRaden and Multi-State Project S-1008, 2006). Lifetime net merit is suitable for most producers. Fluid merit is appropriate for producers who receive no payment for milk protein, and cheese merit was designed for producers who are paid on cheese yield pricing.

Additional benefits associated with DPR that are not included in genetic estimates of PL are additional calves produced, decreased units of semen needed per pregnancy, decreased labor and supplies for estrous detection, inseminations, and pregnancy checks, and higher yields because more ideal lactation lengths are achieved (VanRaden and Multi-State Project S-1008, 2006). Semen price ($15/unit) and insemination labor costs ($5/unit) are multiplied by 0.025 units/day open to estimate a cost of $0.50/day open. Estrous detection labor and supplies ($20/lactation) multiplied by a 0.5 % increase/day open result in a cost of $0.10/day open. Labor costs for pregnancy checks ($10/exam) are multiplied by 0.012 exams/day open for a cost of $0.12/day open. Reduced profit from lactations longer or shorter than optimum are estimated to be $0.75/day open.

The loss of about $1.50/day open is converted to a lifetime value by multiplying by 2.6, which assumes that cows have 2.8 lactations, no breedings are attempted for half of the cows during their final lactation, and heifer fertility is also included with a correlation of 0.3 to cow fertility (2.6 = 2.8 – 0.5 + 0.3). That economic loss for 1 day open is then converted to DPR by multiplying by –4, which results in a DPR value of $16/PTA unit. Also, the number of calves born increases with both DPR and PL. At a constant PTA PL, 1 % higher DPR results in about 1 % more calves per lifetime with an average value of ($150 + $450)/2, an extra $3/PTA unit of DPR. Poor fertility is correlated with other unmeasured health expenses, and $2 is added to account for those for a total value of $21/PTA unit in USDA genetic-economic indexes for lifetime merit.

Holstein Total Performance Index

In May 2007, Holstein Association USA changed the name of its Type-Performance Index to Total Performance Index to reflect an increased emphasis on health and fertility traits (Holstein Association USA, 2007). Emphasis on early breeding is 19 %, which includes PL (10 %), DPR (8 %), and dairy form (–1 %). The correlation between USDA lifetime net merit and the Holstein Total Performance Index is high (95 %; T. J. Lawlor, Holstein Association USA, Brattleboro, VT, personal communication). More emphasis is placed on type traits in the Holstein index; whereas the USDA lifetime merit indexes often have new fitness traits added as soon as evaluations and estimates of their economic value become available.

CONCLUSIONS

Using service sires with higher CR returns a profit fairly quickly. However, the heritability of bull fertility after AI organizations remove bulls with inferior fertility based on sperm morphology is essentially 0. Thus, little genetic improvement in male fertility is expected over time. Pecsok et al. (1994) reported that a premium of $2 could be paid for semen per 1 % improvement in fertility. Thus, a unit of semen from a bull with an ERCR of +2 would be worth $8 more than a unit from a bull with an ERCR of –2. Clay and McDaniel (2001) recommended using bull fertility as a secondary selection trait after production traits, profit traits, and profit indexes.

Selection for improved cow fertility is possible and recommended, but most benefits are delayed for 2 yr or more. Most breeders should select service sires for overall lifetime merit that includes daughter fertility rather than for daughter fertility alone. However, producers with herd fertility problems may choose to emphasize DPR extensively; which can be done with little loss in overall net merit.

The benefits of enhanced reproductive efficiency are the same whether they are achieved through superior bull or cow fertility. Those benefits include:

- lower semen cost,
- improved ability to optimize lactation and lifetime yields,
- reduced culling due to delayed or failed conception, and
- more herd replacements.

The extent that dairy producers should emphasize fertility depends on their management system. All producers would be wise to consider service-sire fertility and DPR when choosing herd sires. However, those traits are especially important for grazing herds with seasonal calving. By using a few bulls that average 3.0 % for PTA DPR (equivalent to a decrease of 12 DO), much of the genetic decline in fertility from using high producing bulls for 40 yr could be recovered in one generation.

Genetic evaluations for DPR can make a difference to dairy producers that need to improve herd fertility. Selection for improved reproduction is possible and can be extremely effective. However, the general recommendation still is to select for overall merit based on a genetic-economic index appropriate for the current milk market.

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