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CDCB
COUNCIL ON DAIRY CATTLE BREEDING

April 2020: Genetic Base Change

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The base for U.S. genetic evaluations will be updated, effective with the April 7, 2020, triannual evaluations.

The genetic bases to which (most) dairy traits are expressed in the United States have been updated every five years since 1980. With the base change, users of genetic evaluations may become aware that the standards they set for choosing service bulls or valuing females in the past may no longer meet the genetic quality to remain competitive, due to genetic progress.

Since 1980, some have suggested that the base should be updated more often. A few have lobbied for a fixed base, or one that's never updated. The reasoning for the latter is that if the best bulls are chosen, the magnitude of the numbers are not particularly important and all evaluations are comparable regardless of when published.

For the last base change in 2015, the average predicted transmitting abilities (PTA) of cows born in 2010 were set to zero. Progress continued to be made for most traits, as shown by Table 1 with the PTAs of cows born in 2015. These milking cows born in 2015 define the new base. With the April evaluations, their PTAs will be set back to zero. Stated differently, the averages in Table 1 will be subtracted from the current PTAs of all animals. These are the changes in PTAs expected in April.

Because gains were made across five years for most traits, most of these PTAs will be lowered by the amount shown. However, if the trends were unfavorable, the PTAs will generally increase. The exceptions can be for somatic cell score (SCS) and the four calving traits which may do the opposite because lower values are preferable for these traits. The average PTAs in the table are the differences in transmitting ability for animals over the five-year period. **A note of caution, these will not be the exact changes coming because all will be recalculated before the April 2020 run using more complete and current data.** Any updates in the traits' variation will also cause these approximations to vary from the estimates presented.

Key progress points demonstrated in Table 1 include:

- Favorable gains are shown for 81 of the 102 traits (excluding conformation), while 18 were unfavorable.
- The most important traits (all lifetime merit indexes) showed genetic improvement for all the breeds; the largest gains were for Holsteins, Jerseys and Ayrshires. Thus, the merit indexes for all breeds will be lowered in April.
- Genetic gains were made in all three yield traits (milk, fat, protein) for all breeds. Gains were particularly impressive for Holsteins and Jerseys; so the base change will reduce PTA milk for these breeds by about 492 and 524 pounds, respectively.
- PTAs for fat and protein will be adjusted down by about 18 to 25 pounds.
- Changes in PTAs for somatic cell score (SCS) will be small (-.01 to +.02) for all breeds except Holsteins which will increase by 0.08 due to their progress in lowering SCSs.
- PTAs for productive life will be reduced by about 0.6 to 1.9 months for Guernseys, Holsteins, Jerseys and Milking Shorthorn due to increasing their genetic capacity for longer life.
- Unfortunately, 13 of the 18 fertility estimates showed unfavorable changes over the five years; only Holsteins improved for all three traits.
- PTAs for cow livability, launched in August 2016, improved for three of the six breeds (0.74 for Holsteins).
- Resistance against diseases in Holsteins improved for five of the six traits.
- PTAs increased for 80 of the 90 breed conformation traits, which indicates that selection has been for the higher scores. In most cases this probably was desirable, but in others, perhaps not. The 10 traits with PTAs that did not increase were ones that had an intermediate optimum.

Table 1. Difference in predicted transmitting abilities (PTAs) of cows born in 2015 compared to those born in 2010. PTAs will decrease by these amounts to implement the 2020 genetic base change[1].

		Breed					
Trait	**Units**	**AY** Ayrshire	**BS** Brown Swiss	**GU** Guernsey	**HO** Holstein	**JE** Jersey	**MS** M. Shorthorn
Milk	Pounds	182	214	150	492	524	36
Fat	Pounds	6	8	6	24	25	2
Protein	Pounds	6	8	4	18	20	2
Somatic cell score (SCS)	Log base 2 units	-.01	.00	.00	-.08	.00	.02
Productive life	Months	.12	.24	.90	1.86	1.54	.63
Daughter pregnancy rate	%	-.47	-.62	-.12	.24	-.99	-.53
Heifer conception rate	%	-.45	-.24	.04	.50	.44	-.20
Cow conception rate	%	-.50	-.74	-.17	.38	-.90	-.50
Early first calving	Days	1.1	0.5	0.5	1.5	1.4	0.0
Gestation length[2]	Days	-.29	-.03	-.04	-.35	.30	.26
Cow livability	%	-.28	-.28	.01	.74	.08	-.06
Displaced abomasum	%	–	–	–	.21	–	–
Ketosis	%	–	–	–	.20	–	–
Mastitis	%	–	–	–	.60	–	–
Metritis	%	–	–	–	.34	–	–
Milk fever	%	–	–	–	-.06	–	–
Retained Placenta	%	–	–	–	.05	–	–
Service sire calv. difficulty[2]	%	–	-0.3	–	-0.4	–	–
Daughter calv. difficulty[2]	%	–	-0.6	–	-1.9	–	–
Service sire stillbirth[2]	%	–	–	–	-0.3	–	–
Daughter stillbirth[2]	%	–	–	–	-1.6	–	–
Final Score	Points	0.5	0.4	0.4	1.0	0.7	0.1
Stature	Points	0.7	0.6	0.1	0.8	0.5	0.2
Strength	Points	0.3	0.2	0.0	0.4	0.0	0.0
Dairy form	Points	0.3	0.3	0.1	0.6	0.4	0.2
Foot angle	Points	0.1	0.1	0.2	0.7	0.1	0.0
Rear legs	Points	-0.2	0.1	-0.1	0.0	0.0	0.0
Body depth		–	–	–	0.4	–	–
Rump angle	Points	-0.1	0.0	-0.1	0.0	0.4	-0.1
Rump width	Points	0.4	0.1	0.1	0.6	0.1	0.1
Fore udder	Points	0.4	0.3	0.5	1.2	0.7	0.2
Rear udder height	Points	0.4	0.3	0.4	1.5	0.6	0.1
Rear udder width	Points	0.4	0.3	0.3	1.4	0.2	0.1
Udder depth	Points	0.3	0.2	0.3	1.0	0.9	0.2
Udder cleft	Points	0.3	0.1	0.2	0.7	0.1	0.0
Teat placement	Points	0.2	0.3	0.4	0.6	0.3	0.1
Teat length	Points	0.2	-0.2	-0.1	-0.2	0.0	-0.2
Lifetime Net Merit	Dollars	121	60	77	231	191	45
Lifetime Cheese Merit	Dollars	123	63	77	239	196	45
Lifetime Fluid Merit	Dollars	117	56	78	219	179	42
Lifetime Grazing Merit	Dollars	108	38	62	207	142	25

[1] *These estimates are traditional genetic predictions prior to modification with genomic data. Positive PTA will be lowered by this amount to satisfy the new base. Conversely, a negative value means the PTA will be raised by this amount. Estimates can change as additional records are added and trait variation is included. The red color for a number indicates there was a loss for that trait between 2010 and 2015. The "–" means a genetic evaluation is not calculated for the trait in this breed.*

Caution: These will not be the precise changes applied in April, because all will be recalculated before the April 2020 run using more complete and current data.

[2] *Completed information for this trait is not available yet for 2015, so it is replaced by the most recent annual average available.*

Performance Differences Attributed to Genetic and Environmental Changes

The PTAs in Table 1 represent only half the genetic change achieved, as each animal only transmits half of their genes to their offspring. Table 2 shows the total changes in performance between cows born in 2015 and 2010 and an indication of how much of the changes were attributed to genetics and environment.

Key points:

- For the milk traits, all breeds but Guernsey revealed a positive contribution from both components.
- Genetic gain for somatic cell score (SCS) was made for three breeds, and Holsteins improved by 0.17. Two breeds were unchanged, and Milking Shorthorn increased by 0.05.
- Environmental trends for SCS and productive life (PL) generally were unfavorable.
- Environmental trends for daughter pregnancy rate (DPR) and cow conception rate (CCR) were favorable.
- For heifer conception rate (HCR), environmental trends were negative for Holsteins, Jerseys and Milking Shorthorn.
- All six breeds showed reduced age at first calving (AFC), particularly via the environment (10 to 26 days). Genetics reduced age at first calving up to three days.
- Phenotypic reductions in gestation length for Holsteins and Jerseys seemed surprising, especially since the genetic component for Holsteins decreased while Jerseys increased.
- Phenotypic changes for resistance to the six health disorders introduced in April 2018 were all positive.

Table 2. Differences in actual (phenotypic) performance between cows born in 2015 and those born in 2010 attributed to genetic (BV=breeding value[1]) and environmental changes.

		Breed					
Trait	**Partitioned Change**	**AY** Ayrshire	**BS** Brown Swiss	**GU** Guernsey	**HO** Holstein	**JE** Jersey	**MS** M. Shorthorn
Milk (pounds)	Phenotypic	696	435	123	1077	1535	259
	Genetic (BV)	363	427	301	984	1049	71
	Environmental	333	8	-178	93	486	188
Fat (pounds)	Phenotypic	48	27	25	71	93	34
	Genetic (BV)	13	17	13	47	51	4
	Environmental	35	10	12	24	42	30
Protein (pounds)	Phenotypic	27	24	14	49	70	13
	Genetic (BV)	12	15	8	36	39	3
	Environmental	15	9	6	13	31	10
SCS (Log base 2 units)	Phenotypic	.08	-.03	.00	-.06	.13	.12
	Genetic (BV)	-.02	.00	-.01	-.17	.00	.05
	Environmental	.10	-.03	.01	.11	.13	.07
Productive life (months)	Phenotypic	-2.25	-.84	-.13	2.66	-.72	-.16
	Genetic (BV)	.24	.47	1.81	3.73	3.07	1.26
	Environmental	-2.49	-1.31	-1.94	-1.07	-3.79	-1.42
Daughter pregnancy rate	Phenotypic	1.3	.3	-.2	2.9	-.6	-.4
	Genetic (BV)	-.94	-1.25	-.23	.49	-1.98	-1.06
	Environmental	2.24	1.55	.03	2.41	1.38	.66
Heifer conception rate %	Phenotypic	1.0	-.1	.9	-.7	-4.3	-2.4
	Genetic (BV)	-.90	-.47	.08	.99	.88	-.40
	Environmental	1.90	.37	.82	-1.69	-5.18	-2.00
Cow conception rate %	Phenotypic	1.5	-.4	1.3	4.4	-1.3	2.3
	Genetic (BV)	-1.01	-1.47	-.34	.77	-1.81	-.99
	Environmental	2.51	1.07	1.64	3.63	.51	3.29
Early first calving (days)	Phenotypic	26.2	18.3	10.6	26.6	28.8	10.8
	Genetic (BV)	2.2	1.0	0.9	3.0	2.8	0.0
	Environmental	24.0	17.4	9.7	23.6	26.0	10.8

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Gestation length (days)[2]	Phenotypic	.18	.75	.11	-1.24	-.80	.09
	Genetic (BV)	-.58	-.06	-.08	-.70	.60	.52
	Environmental	.76	.81	.19	-.54	-1.40	-.43
Cow livability %	Phenotypic	.64	-.17	-.37	.19	-.47	-1.00
	Genetic (BV)	-.55	-.56	.02	1.49	.15	-.12
	Environmental	1.19	.39	-.39	-1.30	-.62	-.88
Displaced abomasum %	Phenotypic	–	–	–	.10	–	–
	Genetic (BV)	–	–	–	.42	–	–
	Environmental	–	–	–	-.32	–	–
Ketosis %	Phenotypic	–	–	–	.31	–	–
	Genetic (BV)	–	–	–	.39	–	–
	Environmental	–	–	–	-.08	–	–
Mastitis %	Phenotypic	–	–	–	.83	–	–
	Genetic (BV)	–	–	–	1.20	–	–
	Environmental	–	–	–	-.37	–	–
Metritis %	Phenotypic	–	–	–	1.09	–	–
	Genetic (BV)	–	–	–	.68	–	–
	Environmental	–	–	–	.41	–	–
Milk fever %	Phenotypic	–	–	–	.11	–	
	Genetic (BV)	–	–	–	-.12	–	–
	Environmental	–	–	–	.23	–	–
Retained placenta %	Phenotypic	–	–	–	.29	–	–
	Genetic (BV)	–	–	–	.10	–	–
	Environmental	–	–	–	.19	–	–
Service sire calv. difficulty	Genetic (BV)	–	-0.6	–	-0.8	–	–
Daughter calv. difficulty %[2]	Genetic (BV)	–	-1.2	–	-3.8	–	–
Service sire stillbirth %[2]	Genetic (BV)	–	–	–	-0.6	–	–
Daughter stillbirth %[2]	Genetic (BV)	–	–	–	-3.2	–	–
Lifetime net merit ($$)	Genetic (BV)	242	120	154	462	382	90
Lifetime cheese merit ($$)	Genetic (BV)	246	126	154	478	392	90
Lifetime fluid merit ($$)	Genetic (BV)	234	112	156	438	358	84
Lifetime grazing merit ($$)	Genetic (BV)	216	76	124	414	284	50

[1] *These changes are based on traditional genetic predictions prior to modification with genomic data. An "–" means a genetic evaluation is not provided for the trait in that breed. A red number indicates there was no phenotypic improvement between 2010 and 2015, but instead apparent deterioration for the trait.*

[2]*Completed information for 2015 not available yet, so it is replaced with the most recent annual average available.*

Impact of Genomics

The genomic revolution initiated in 2008 brought an increase in the rate of genetic improvement, primarily due to a reduction in the generation interval. A small portion of genomic benefits would have been revealed in the previous base change for cows born in 2010, but the current update will reflect all benefits from genomics achieved from 2010 to 2015.

Key points:

- For illustration, 150% would indicate 50% more gain was made than in the previous five-year period.
- Use of genomics is responsible for the accelerated gains for milk traits shown in Table 3 for Brown Swiss, Holsteins and Jerseys, but genomics were not available for Guernseys until 2016. Ayrshires and Milking Shorthorn – having limited use of genomics – show smaller gains in milk traits than during the previous five-year period.
- The benefits of genomics for productive life (PL) were impressive for Holsteins and Jerseys.
- The Guernsey, Holstein and Jersey breeds showed larger gains (43 to 100% more) in the lifetime merit indexes for this base update, than they did during the previous period.

Table 3. Relative size in percentage of the 2020 genetic base changes[1] compared to the base changes five years earlier (2015).

	Breed					
Trait	**Ayrshire**	**Brown Swiss**	**Guernsey**	**Holstein**	**Jersey**	**Milking Shorthorn**
Milk	68	103	124	147	141	13
Fat	72	131	108	162	142	20
Protein	80	107	89	164	150	18
SCS	200	B	A	189	A	AB
Productive life	26	63	102	207	252	142
Daughter pregnancy rate	AB	AB	AB	A	AB	AB
Heifer conception rate	AB	AB	A	550	677	AB
Cow conception rate	AB	AB	AB	A	AB	AB
Cow livability	AB	AB	A	120	29	AB
Sire calving ease[2]	–	A	–	80	–	–
Daughter calving ease[2]	–	75	–	100	–	–
Sire stillbirth[2]	–	–	–	38	–	–
Daughter stillbirth[2]	–	–	–	200	–	–
Lifetime net merit	43	92	145	164	152	58
Lifetime cheese merit	43	94	140	166	153	58
Lifetime fluid merit	43	95	153	162	147	55
Lifetime grazing merit	40	73	200	174	143	47

[1] These approximations are based on the traditional genetic predictions prior to modification with genomic data. Cells showing an A indicate there was no gain between 2005 and 2010 (instead a loss) so the ratio of gain is undefined. Cells with a B indicate there was no gain between 2010 and 2015. The (-) means that a genetic evaluation is not provided for the trait in that breed.

[2]Completed information for 2015 not available yet, so replaced with the most recent annual average available.

Percentage of Change Attributed to Genetics

To answer the question of what is contributing to the phenotypic improvement being made in dairy production traits, Table 4 was derived from the information in Table 2 for traits that have had evaluations initiated since 2008. The genetic contribution averaged 45% but was greater (averaged 69%) for the three traits with the greatest emphasis in net merit index (NM$) and for Holsteins (71%), the breed with the largest population.

Table 4. Percentage of the change in phenotype attributed to genetics for cows born in 2015 compared to those born in 2010 for traits with published evaluations initiated before 2010[1].

		Breed					
Trait	**Emphasis in Net Merit (%)**	**AY** Ayrshire	**BS** Brown Swiss	**GU** Guernsey	**HO** Holstein	**JE** Jersey	**MS** M. Shorthorn
Milk	-1	52	98	100	91	68	27
Fat	27	27	63	52	66	55	12
Protein	17	44	62	57	73	56	23
SCS	-4	100	0	100	100	0	0
Productive life	12	100	100	100	100	100	100
Daughter preg. rate	7	0	0	0	17	0	0
Heifer conception rate	1	0	0	9	100	100	0
Cow conception rate	2	0	0	0	18	0	0

[1] These changes are based on the traditional genetic predictions prior to modification with genomic data. A "0" indicates there was no genetic improvement in five years. A "100" in red indicates there was genetic improvement and the phenotypic change was unfavorable. A "100" in black indicates that the genetic improvement exceeded the phenotypic change. See https://aipl.arsusda.gov/reference/base2014.htm for the previous base change report from December 2014.

When the base is changed every five years, most PTAs are lowered – and the standard deviations (SD) are also updated. In most cases, the variation increases. Yield and SCS records are adjusted for variance within herd and year to keep the same SD as the base year using SD ratios shown in Table 5.

Table 5. Ratio of trait SD for base cows born in 2015 vs. those in 2010. The PTAs will be expanded (or contracted) by these ratios.

	Breed					
Traits	**Ayrshire**	**Brown Swiss**	**Guernsey**	**Holstein**	**Jersey**	**Milking Shorthorn**
Milk, Fat, Protein	1.069	0.998	1.106	1.056	1.090	1.046
SCS	0.957	0.987	0.970	0.963	0.925	1.039

Table 6. Ratio of trait SD for base cows born in 2015 compared to Holsteins. The PTAs will be expanded (or contracted) by these ratios.

	Breed					
Trait	**Ayrshire**	**Brown Swiss**	**Guernsey**	**Holstein**	**Jersey**	**Milking Shorthorn**
Milk, Fat, Protein	1.09	1.12	1.06	1.00	1.02	1.34
SCS	1.10	1.05	1.11	1.00	1.05	1.32

The Bottom Line

Advocates for improving sustainability and eliminating world hunger should be amazed to see the changes in productivity in U.S. dairy.

Greenhouse gases are being reduced per unit of product because of greater production per animal. We are seeing significant changes in the animals' appearance and health as well.

Since we're approaching another base change, this may be a good time to remind dairy producers to adopt genetic selection strategies that could virtually eliminate any complacency of decisions between base changes. For example, if selection is based on standards like percentiles (recalculated every run) or by simply selecting the top-ranked bulls on an economic index of their choice, forward progress would occur, devoid of any delays.

[1] *Dr. H. D. Norman is CDCB Technical Advisor and Industry Liaison, Dr. Paul VanRaden is ARS Research Geneticist (Animals), and Dr. George Wiggans is CDCB Technical Advisor.*