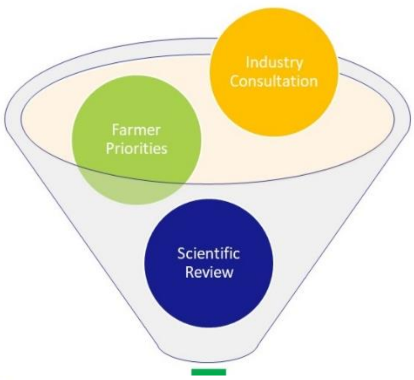
National Breeding Objective 2020

Options Paper

Your herd. Your asset. Your future.

V2: Additional indices added 27 May 2020



DataGene
Solutions for Herd Development

Contents

Acknowledgements

Prepared by Michelle Axford, Lee-Ann Monks, Gert Nieuwhof, Matt Shaffer, DataGene on behalf of the Genetic Evaluation Standing Committee

The Genetic Evaluation Committee: Simone Jolliffe (chair), Joanne Dickson, Patrick Glass, Tim Humphris, Rohan Sprunt, Trevor Saunders, Rohan Butler, Peter Thurn, Bruce Ronalds, Christian Hickey, Vaughn Johnston, Steph Bullen, Janet Auchterlonie, Trevor Parrish, Jennie Pryce, Gert Nieuwhof, Michelle Axford, Matt Shaffer

This research was conducted by Michelle Axford, Gert Nieuwhof, Matthew Shaffer (DataGene), Jennie Pryce, Jo Newton (Agriculture Victoria), Katarzyna Stachowicz, Peter Amer, Cheryl Quinton, Bruno Santos and Sam Harburg (Abacus Bio).

We are pleased to acknowledge the inputs of the following people into this project:

- Peter Williams, DataGene
- Caeli Richardson, Agriculture Victoria
- John Droppert, Sophia Omstedt, Vanessa Fischer, Matt Harms, Mick Harvey and the Dairy Farm Monitor Project Team for their assistance in compiling data.
- Dairy Australia, Regional Development Programs, Australian Dairyfarmers Ltd for their support of NBO consultation activities
- Holstein Australia, Jersey Australia, Australian Red Dairy Breed for their support of NBO activities
- Data processing centres, breed organisations and herd recording farmers for providing data.
- All survey participants.

DataGene
Solutions for Herd Development

Context

The National Breeding Objective (NBO) supports genetic selection pressure for an agreed group of desirable traits, providing direction for both bull and cow breeding across the country.

The current NBO for the Australian dairy industry is aimed at increasing net farm profit. It is expressed through the three breeding indices – Balanced Performance Index (BPI), Health Weighted Index (HWI) and Type Weighted Index (TWI).

DataGene has a policy to review the NBO every five years, to ensure it keeps pace with the evolving needs of dairy businesses, new knowledge and breeding technologies. The previous review, undertaken in 2014, resulted in the introduction of the three indices (BPI, HWI, TWI) in 2015. Since then there has been a there has been a positive and sustained increase in the utilization of Australian indices. This review is seen as an update rather than a review that concludes with wholesale change, with the following purposes.

- to ensure the NBO which is aimed at driving on-farm profit still remains relevant, and
- to develop an index (or indexes) based on strong scientific principles which are in line with farmer preferences and meet the agreed NBO.

Appendix 1 outlines 2019/20 review process, which is guided by DataGene's Genetic Evaluation Standing Committee. DataGene co-ordinates the review activities which involve consultation with industry stakeholders and scientific analysis by a team from Agriculture Victoria and Abacus Bio. Implementation is planned for December 2020.

This document outlines options and recommended changes based on the findings from consultation activities and scientific review. It provides a foundation for industry discussion and decision.

Different stakeholder groups are involved in different stages of the process.

Stage	Timing	Stakeholders involved
Identify key themes	July 19	Genetic Evaluation Standing Committee
Discussion Paper	Oct 19	Genetic Evaluation Standing Committee
Data collection; scientific review	Nov 19 – Jan 20	Agriculture Victoria – Dr Jennie Pryce and Dr Jo Newton Dairy Australia Trade & Strategy Group and Farm Team Abacus Bio DataGene staff
Circulate discussion paper and request responses to NBO survey	Dec 19 – Jan 20	Farmers, breed organisations, bull company managers, herd improvement service providers, Regional Development Programs, DataGene social media
Analyse results; prepare options paper	Feb – Apr 20	Review team
Stakeholder discussion of options	May 20	Genetic Evaluation Standing Committee, bull company managers breed organisations, Dairy Australia Farm team
Stakeholder agreement	May -June 20	Genetic Evaluation Standing Committee
Development & testing of algorithms; updating GESNP	June-Nov 20	DataGene ABV Team and external testers
Implementation	Dec 20	Rollout to industry via public ABV release

Survey Summary

A total of 307 people voluntarily participated in the NBO Survey through December 2019 and January 2020, of which 196 were farmers and mainly herd owners. About two thirds of participants are located in Victoria.

In relation to farmers, the main breed for half the participants was Holstein while Jerseys represented 16%, two-way cross and three-way cross was about 10% each. About half of farmers had a split calving system, 31% were seasonal and 18% were year round. 42% of farmers did not register animals with a breed association.

71% of participants named the BPI as the most useful index with 24% favouring HWI and 16% favouring TWI. Participants could select more than one index. Of participants, 24% did not use BPI, HWI or TWI sighting the following reasons

- I am not convinced that Australian dairy indexes are a useful tool (31 people)
- I use other countries' or companies' indexes to select bulls (30 people)
- Australian breeding indexes are not an accurate indication of the quality of my herd (18 people)

There was a higher prevalence of index dissatisfaction amongst farmers with cross-bred cattle. The survey results do not provide clarity on the reasons for this or the traits that are seen to be missing. Further research is warranted in this area.

Participants were asked to rank traits of importance. Overall, Daughter Fertility was significantly more important than any other trait. There was no significant difference between protein, protein %, temperament, fat, fat %, survival/longevity, somatic cell count, mastitis resistance, calving ease and type traits. Next in the order of priority were milking speed, likeability, milk L and feed saved with no significant difference between this group. Gestation length and heat tolerance were ranked lowest.

The survey asked questions directly related to the NBO Discussion paper and the analysis of this information provided direction for the options presented in the following paper.

Options Summary

During the NBO Review, researchers applied updated economic and physical parameters to a bio-economic model that is used to calculate the weighting applied to each trait in an index. A summary of parameters is included in Appendix 2. Of note, the value of fat, protein, feed and labour have all risen. The updated values will increase or decrease the value of each affected trait which is why the economic weights are different in the options presented compared to the current indices. The impact of increasing or decreasing values depends on the relationship between traits with a population.

The starting point in this project was to apply updated parameters to the existing three indices. These are known as BPI20, HWI20 and TWI20. Compared to current indices, the main changes include the introduction of Mastitis Resistance and Survival traits. From there, several options have been developed, tested and presented below. The options explore the themes developed in the early consultation period of the project and take on board the feedback collected through the NBO survey. For each option, the economic weights, response to selection and percent emphasis are presented below. The logic behind the options is discussed in more detail later in this report.

The options considered in this review are

Label	Option	Pros	Cons
BPI19	BPI19 – current BPI	The best BPI for fertility	
BPI20	BPI20 – the current BPI with updates made to the values of fat, protein, feed, labour and other economic parameters. As per 2015, feed saved is at half the actual value of feed.	Mastitis resistance and Cell Count Survival Mammary System and Type traits	Similar to BPI19 for fertility
BPIFP88	BPIFP88 – BPI with a change to the fat:protein price ratio. The ratio changes from 0.5 (current) to 0.88 which means a higher value attributed to fat.	Fat More concentrated milk Survival Mastitis resistance and Cell Count Mammary system and overall type	Protein
BPIFP108	BPIFP108 – BPI with a change to the fat:protein price ratio. The ratio changes from 0.5 (current) to 1.08 which means a much higher value attributed to fat.	Fat More concentrated milk Survival Mastitis resistance and Cell Count Mammary system and overall type	Protein
BPIfeed100	BPIfeed100 – BPI with feed fully costed	Similar to BPI20 for production and health traits Best BPI option for feed saved	Give up some mammary system and type traits
BPI_fert150	BPI20 with an additional 50% weight on daughter fertility	Strong response for fertility and still economically efficient.	
BPI_fert200	BPI20 with an additional 100% weight on daughter fertility	Strongest response for fertility	Moving too close to HWI
BPI_fert150fs	BPI_fert150 with 0 contribution for Feed Saved and addition of udder depth	Good option for Jerseys where the goal is to increase liveweight.	For Holsteins, reduces improvement in feed saved. Limited response to the addition of Udder Depth
BPI_fert150milk	BPI_fert150fs with a smaller penalty on milk and addition of udder depth	In line with Jersey goal to increase response for milk L	Not a profit-based index Lower response in fertility. Negative impact on feed saved in Holstein Limited response to the addition of Udder Depth
TWI19	TWI19 – current TWI		Not sufficiently different to BPI19
TWI20	TWI20 – the current TWI with updates made to the values of fat, protein, feed, labour and other economic parameters. As per 2015, feed saved is at half the actual value of feed.	Mastitis resistance and Cell Count Survival Mammary System and Type traits	Fertility Feed Saved Not sufficiently different to BPI

Label	Option	Pros	Cons
TWImilk	TWImilk – TWI with much lower penalty for milk volume and liveweight (through lower economic value of feed saved)	Strongest for protein and more milk L Fat Survival Mastitis resistance and cell count Strongest for overall type and mammary system, fore udder attachment	Weakest for fertility Weakest for feed saved. Taller stature (this may be a pro or con)
TWIfeed100	TWIfeed100 – TWI with feed fully costed	Best TWI option for feed saved Mastitis resistance and cell count Best TWI option for fertility	Poorest TWI option for mammary and overall type
TWItype200	TWI20 with double the weighting on Overall Type and Mammary System	Strong response for Overall Type and Mammary System	Fertility Feed Saved in Holstein Bigger Holsteins
TWItype300	TWI20 with triple the weighting on Overall Type and Mammary System	Strongest response for Overall Type and Mammary System	Fertility Feed Saved in Holstein Bigger Holsteins Protein Fat Mastitis Resistance
HWI19	HWI19 – current HWI		Not sufficiently different to BPI19
HWI20	HWI20 – the current HWI with updates made to the values of fat, protein, feed, labour and other economic parameters.	Survival Fertility Mastitis resistance and Cell Count Feed Saved	Protein and Fat Not sufficiently different to BPI
HWI130fert	HWI130fert – HWI with a 30% higher weighting on fertility	Strongest for fertility Survival Mastitis resistance and cell count Feed Saved Lower liveweight	Type Protein Fat
HWI150fert	HWI150fert – HWI with a 50% higher weighting on fertility	Strongest for fertility Survival Mastitis resistance and cell count Feed Saved Lower liveweight	Type Protein Fat
HWI200fert	HWI200fert – HWI with twice the weight on fertility	Strongest for fertility Survival Mastitis resistance and cell count Feed Saved Lower liveweight	Type Protein Fat
HWIfeed100	HWIfeed100 – HWI with feed at double the weight	Extreme Feed Saved Fertility Mastitis resistance and cell count	Slight decline in type

The economic weights for each index tell us the multiplier used in the index calculation. Use this number **across** the indices to see where there is more or less emphasis on each trait. This isn't a useful number to compare between traits within an index because each ABV trait group has a different scale and range.

Table 1 Economic weights for Index options. Options that are bolded with a clear background indicate the current recommendation.

	BPI									TWI						HWI					
Trait	BPI19	BPI20	**BPI_fert150**	BPI_fert200	BPI_feed100	BPI_fp88	BPI_fp108	BPI_fs	BPI_milk_fs	TWI19	TWI20	TWI_Milk	TWI_feed100	TWI_type200	TWI_type300	HWI19	HWI20	HWI_fert130	HWI_fert150	**HWI_fert200**	HWI_feed100
PROT	6.92	6.76	**6.76**	6.76	6.76	4.99	4.33	6.76	6.76	6.23	6.08	6.08	6.08	6.08	6.08	4.46	4.36	4.36	4.36	**4.36**	4.36
FAT	1.79	2.08	**2.08**	2.08	2.08	3.54	4.09	2.08	2.08	1.61	1.87	1.87	1.87	1.87	1.87	1.16	1.35	1.35	1.35	**1.35**	1.35
MILK	-0.1	-0.11	**-0.11**	-0.11	-0.11	-0.11	-0.11	-0.11	-0.04	-0.09	-0.1	-0.04	-0.1	-0.1	-0.1	-0.06	-0.07	-0.07	-0.07	**-0.07**	-0.07
SURV	0	7.2	**7.2**	7.2	7.2	7.26	7.27	7.2	7.2	0	7.2	7.2	7.2	7.2	7.2	0	7.2	7.2	7.2	**7.2**	7.2
FERT	6.94	5.3	**7.96**	10.61	5.3	5.33	5.33	7.96	7.96	4.86	3.71	3.71	3.71	3.71	3.71	6.94	7.06	9.17	10.59	**14.11**	7.06
SCC	1.07	0.69	**0.69**	0.69	0.69	0.69	0.69	0.69	0.69	1.07	0.69	0.69	0.69	0.69	0.69	1.07	0.69	0.69	0.69	**0.69**	0.69
MAS	0	6.75	**6.75**	6.75	6.75	6.77	6.78	6.75	6.75	0	6.75	6.75	6.75	6.75	6.75	0	6.75	6.75	6.75	**6.75**	6.75
MSPEED	4.9	5.02	**5.02**	5.02	5.02	5.02	5.02	5.02	5.02	4.9	5.02	5.02	5.02	5.02	5.02	4.9	5.02	5.02	5.02	**5.02**	5.02
TEMP	3.51	3.6	**3.6**	3.6	3.6	3.6	3.6	3.6	3.6	3.51	3.6	3.6	3.6	3.6	3.6	3.51	3.6	3.6	3.6	**3.6**	3.6
MAMM	2.29	2.76	**2.76**	2.76	2.76	2.76	2.76	2.76	2.76	2.52	2.99	2.99	2.99	5.98	8.97	2.97	3.59	3.59	3.59	**3.59**	3.59
UDDEP	0.82	0	**0**	0	0	0	0	0.82	0.82	0.9	0	0	0	0	0	0.82	0	0	0	**0**	0
OTYPE	2.26	1.36	**1.36**	1.36	1.36	1.37	1.37	1.36	1.36	6.15	3.7	3.7	3.7	7.41	11.11	2.26	1.36	1.36	1.36	**1.36**	1.36
PINSET	1.28	0.78	**0.78**	0.78	0.78	0.78	0.79	0.78	0.78	1.41	0.85	0.85	0.85	0.85	0.85	1.28	0.78	0.78	0.78	**0.78**	0.78
FOREA	0	0	**0**	0	0	0	0	0	0	3.22	1.34	1.34	1.34	1.34	1.34	0	0	0	0	**0**	0
FEEDEF	0.1488	0.1927	**0.1927**	0.1927	0.3853	0.1927	0.1927	0	0	0.1488	0.1927	0.1541	0.3853	0.1927	0.1927	0.2975	0.3853	0.3853	0.3853	**0.3853**	0.7707

The most important consideration when comparing indices is the outcome that is expected based on the population of cows and the AI bulls used to produce the herd's next generation. The change in traits that is expected based on genetic selection for each index is illustrated in tables 2 and 3. These tables are presented in ABV units. For example, the BPI20 is expected to produce an additional 2.68 kg in a 10 year period in Holsteins.

The response to selection shows the change that is likely to be made by using each index as the main breeding index in a population of cows over a period of ten years. These tables are presented in ABV units. For example, the BPI20 is expected to produce an additional 2.68 kg protein in a 10 year period in Holsteins.

Each breed has its own population of breeding stock that contributes towards the next 10 years of progress. The response to selection for each index is presented for Holstein, Jersey and Red Breed populations.

Table 2 Response to selection for index options in Holsteins (ABV units)

	BPI19	BPI20	BPI_fp88	BPI_fp108	BPI_feed100	BPI_fert150	BPI_fert200	BPI_fert150fs	BPI_fert150milk	TWI19	TWI20	TWI_feed100	TWI_milk	TWI_type200	TWI_type300	HWI19	HWI20	HWI_fert130	HWI_fert150	HWI_fert200	HWI_feed100
PROT	3.36	2.68	1.79	1.48	2.36	2.27	1.89	2.42	3.69	2.77	2.41	2.11	3.68	2.09	1.78	1.86	1.08	0.83	0.69	0.39	0.43
FAT	6.13	6.01	7.30	7.68	5.44	5.29	4.62	5.58	5.62	5.85	5.87	5.34	5.92	5.45	4.94	3.89	3.40	2.93	2.66	2.06	2.11
MILK	14.19	15.20	-17.17	-27.91	0.13	5.58	-2.54	19.58	111.59	39.17	29.41	13.94	121.44	46.86	57.86	6.76	0.50	-6.57	-10.15	-18.07	-26.87
SURV	1.74	2.12	2.04	1.99	2.03	2.17	2.18	2.26	2.35	2.05	2.29	2.22	2.37	2.33	2.28	2.05	2.35	2.33	2.32	2.27	1.98
FERT	2.75	2.54	2.39	2.31	2.67	3.09	3.51	2.92	2.58	1.79	2.03	2.20	1.69	1.52	1.08	3.41	3.36	3.69	3.87	4.21	3.31
SCC	11.06	12.82	12.42	12.17	12.54	13.05	13.08	13.23	13.31	11.56	13.23	13.08	13.19	12.58	11.64	13.10	14.24	14.09	13.97	13.58	12.49
MAS	1.15	1.80	1.75	1.72	1.75	1.77	1.72	1.78	1.71	1.17	1.84	1.81	1.75	1.70	1.53	1.29	1.88	1.82	1.78	1.68	1.63
MSPEED	0.35	0.37	0.41	0.42	0.33	0.33	0.30	0.38	0.37	0.50	0.45	0.41	0.44	0.50	0.52	0.35	0.33	0.29	0.27	0.23	0.21
TEMP	0.43	0.53	0.52	0.52	0.47	0.46	0.40	0.51	0.56	0.58	0.61	0.56	0.66	0.64	0.64	0.39	0.43	0.38	0.35	0.28	0.29
MAMM	0.79	1.11	1.14	1.14	0.88	0.94	0.79	1.19	1.37	2.13	1.79	1.57	1.96	2.56	3.03	0.99	1.11	0.96	0.87	0.68	0.60
OTYPE	0.39	0.55	0.59	0.60	0.25	0.38	0.24	0.69	0.86	1.89	1.31	1.00	1.48	2.12	2.63	0.38	0.38	0.24	0.18	0.02	-0.20
FEEDEF	-2.34	-2.77	-3.76	-4.07	9.77	-0.55	1.32	-12.13	-16.22	-12.75	-7.93	5.08	-14.49	-14.98	-19.57	13.05	13.02	13.84	13.83	14.26	34.60

Table 3 Response to selection for index options in Jerseys

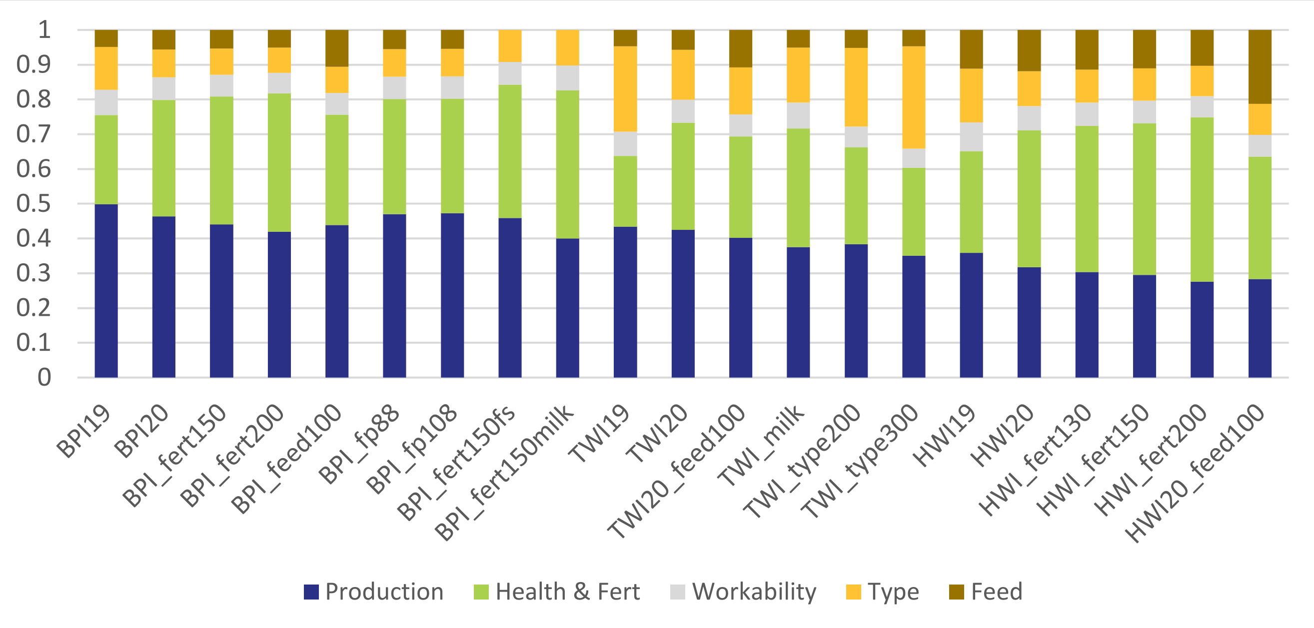
	BPI19	BPI20	BPI_fp88	BPI_fp108	BPI_feed100	BPI_fert150	BPI_fert200	BPI_fert150fs	BPI_fert150milk	TWI19	TWI20	TWI_feed100	TWI_milk	TWI_type200	TWI_type300	HWI19	HWI20	HWI_fert130	HWI_fert150	HWI_fert200	HWI_feed100
PROT	5.82	5.35	4.53	4.20	5.09	5.02	4.65	5.07	6.35	5.20	5.09	4.90	6.16	4.70	4.26	4.66	3.92	3.57	3.35	2.78	3.04
FAT	7.85	7.30	8.18	8.44	7.04	6.96	6.55	7.03	6.85	6.34	6.51	6.32	6.33	5.19	4.14	5.88	5.04	4.67	4.43	3.81	4.05
MILK	64.73	60.14	20.65	6.55	48.60	47.77	35.47	56.98	154.71	101.17	82.33	72.01	165.52	106.93	118.75	67.88	49.84	37.70	30.35	12.65	21.11
SURV	1.25	1.64	1.54	1.50	1.51	1.60	1.56	1.76	1.87	1.86	1.95	1.84	2.01	2.10	2.12	1.46	1.79	1.72	1.68	1.55	1.37
FERT	0.53	0.34	0.37	0.37	0.47	0.71	1.06	0.59	0.27	-0.19	-0.06	0.07	-0.32	-0.46	-0.70	0.91	0.89	1.21	1.41	1.83	1.12
SCC	6.72	6.89	7.17	7.21	7.12	7.37	7.74	7.41	7.07	6.24	6.58	6.89	6.19	4.73	3.34	8.86	8.73	9.00	9.13	9.30	8.54
MAS	1.01	1.36	1.33	1.31	1.42	1.40	1.43	1.34	1.21	0.87	1.28	1.35	1.15	1.02	0.81	1.19	1.57	1.58	1.58	1.56	1.57
MSPEED	0.38	0.44	0.45	0.45	0.41	0.39	0.33	0.40	0.39	0.50	0.51	0.49	0.49	0.57	0.58	0.38	0.39	0.33	0.30	0.22	0.30
TEMP	0.42	0.54	0.41	0.37	0.45	0.44	0.35	0.51	0.67	0.85	0.77	0.70	0.90	1.02	1.14	0.47	0.51	0.41	0.35	0.21	0.28
MAMM	1.07	1.47	1.20	1.10	1.25	1.23	0.99	1.45	1.81	2.89	2.46	2.27	2.69	3.56	4.14	1.54	1.70	1.44	1.29	0.90	1.08
OTYPE	1.19	1.53	1.30	1.21	1.23	1.31	1.09	1.61	1.96	2.94	2.46	2.20	2.71	3.42	3.91	1.45	1.55	1.32	1.18	0.84	0.79
LWT	0.28	0.29	0.27	0.26	-0.14	0.19	0.08	0.61	0.76	0.82	0.57	0.15	0.78	0.86	1.02	-0.27	-0.31	-0.40	-0.44	-0.55	-1.22
FEEDEF	-4.97	-5.28	-4.80	-4.60	2.67	-3.35	-1.48	-11.10	-13.96	-15.06	-10.43	-2.72	-14.19	-15.76	-18.60	5.05	5.80	7.51	8.21	10.15	22.45

Table 4 Response to selection for index options in Aussie Reds (breed code UUUU)

	BPI19	BPI20	BPO_fert150	BPI_fert200	BPI_feed100	BPI_fp88	BPI_fp108	BPI_fert150fs	BPI_fert150milk	TWI19	TWI20	TWI_feed100	TWI_milk	TWI_type200	TWI_type300	HWI19	HWI20	HWI_fert130	HWI_fert150	HWI_fert200	HWI_feed100
PROT	7.11	6.59	6.23	5.77	6.33	5.97	5.71	6.18	7.48	6.27	6.13	5.99	7.32	5.35	4.43	5.52	4.49	4.08	3.81	3.14	3.52
FAT	7.67	7.72	7.02	6.23	7.26	8.49	8.72	7.21	8.27	7.72	7.72	7.40	8.64	7.42	6.76	5.73	5.00	4.29	3.83	2.74	3.61
MILK	135.98	127.36	112.33	96.15	121.73	112.60	106.55	110.39	180.99	122.86	121.33	118.11	185.97	110.30	95.36	101.47	76.86	62.19	52.88	31.42	58.55
SURV	0.41	0.72	0.65	0.57	0.62	0.73	0.73	0.78	0.72	0.72	0.90	0.80	0.83	1.02	1.06	0.40	0.67	0.59	0.54	0.41	0.39
FERT	0.88	0.32	0.89	1.41	0.45	0.17	0.11	0.71	0.35	0.13	-0.14	0.01	-0.41	-0.49	-0.75	1.38	1.10	1.58	1.87	2.44	1.21
SCC	8.46	10.83	10.41	9.83	11.08	10.87	10.80	10.12	9.28	8.76	11.27	11.80	10.14	9.99	8.41	10.74	12.67	11.95	11.42	10.02	11.63
MAS	0.67	1.15	1.11	1.05	1.16	1.16	1.16	1.09	0.97	0.74	1.23	1.26	1.07	1.11	0.95	0.89	1.37	1.30	1.24	1.09	1.23
MSPEED	0.47	0.42	0.43	0.43	0.42	0.41	0.41	0.42	0.34	0.47	0.42	0.43	0.34	0.37	0.30	0.53	0.45	0.45	0.44	0.42	0.39
TEMP	0.37	0.39	0.36	0.32	0.33	0.40	0.40	0.40	0.43	0.48	0.45	0.40	0.48	0.51	0.52	0.36	0.33	0.30	0.27	0.22	0.18
MAMM	-0.20	0.32	0.08	-0.15	0.17	0.54	0.61	0.32	0.24	0.92	0.93	0.78	0.80	1.70	2.22	-0.04	0.36	0.13	-0.01	-0.32	0.02
OTYPE	-0.38	-0.49	-0.55	-0.59	-1.01	-0.40	-0.36	-0.02	0.00	0.78	0.11	-0.46	0.22	0.97	1.61	-0.97	-1.19	-1.22	-1.20	-1.17	-2.07
LWT	-0.06	-0.10	-0.20	-0.29	-0.72	-0.04	-0.01	0.45	0.45	0.86	0.38	-0.30	0.50	1.03	1.50	-0.87	-1.04	-1.11	-1.11	-1.14	-2.14
FEEDEF	1.11	1.85	3.72	5.40	13.18	0.69	0.26	-8.08	-8.09	-15.59	-6.83	5.58	-9.10	-18.72	-27.21	15.91	19.11	20.30	20.41	20.85	39.07

A popular way to compare indices is to look at the percent emphasis of a trait or trait group. The relative emphasis of each trait group is shown in Figure 1. Compare the emphasis placed on trait groups in each index with the current BPI, HWI, TWI. This study analysed a wide range of options. For example the relative percent emphasis for production varies between 28 and 50%.

Figure 1 Relative emphasis of each trait



Options for discussion

The Genetic Evaluation Standing Committee identified the following themes for discussion in this NBO Review: Base change, Fat : Protein ratio ratio, Longevity, fertility, feed efficiency, new traits, multiple indices.

Updating the base (also known as the average)

ABVs are relative measures that can be compared to each other or to an average (known as the base).

The last base change occurred in 2014 following a period of annual base adjustments. The current policy links base reviews with the five yearly NBO review.

Globally, there is an inconsistent approach to base policy. There isn't a right/wrong answer from a scientific point of view. Keeping a constant base from year to year improves market stability as it avoids annual ABV adjustments. However, over a period of time, the base can lose some relevance as the animals are no longer in Australian herds.

The based is highly linked to the marketability of ABVs. For example, bulls are very difficult to market if they fall below a threshold such as 100 for Type (domestic semen market) or 0 for milk (export semen market). However, the base also needs to provide a clear benchmark from which ABVs can be compared.

In Australia, the base includes cows that are now 9-13 years of age. Maintaining a relatively young group of cows in the base means that the next generation are only a bit better so ABVs aren't very large. This provides clarity about the sort of expected improvement a farmer is likely to achieve in his/her herd. When comparing an ABV to ‘average’, it is easier to picture current cows that are still milking in herds rather than a group of old cows that are long gone.

An older base has the benefits of showing the new animals to be quite a lot better than the older animals for most, but not all, traits.

Lastly, there may be a desire to apply a different base to each breed so that there is more uniformity in the scale of the top BPI animals in each breed. While ABVs cannot be compared between breeds, it can be confusing to see the top bulls in one breed have a BPI of 400 while another breed may be only 100.

Should the base be adjusted to a more modern base, even though it will mean ABVs drop for most traits?

Should there be a different base for each breed so that the top bulls of each breed are more similar in BPI?

> *From the survey…..*
>
> *Maybe need to roll back the figures*
>
> *The base needs to be changed, especially daughter fertility. Bulls that are 102 are now below average and need to be identified as such.*

Options

The following are a series of viable options

	Description	Pros	Cons
1. Base update	Update to create a new group in April 2020. Base animals would be daughters of NASIS bulls born 2014-2018 for yield, feed saved and conformation and NASIS bulls born 2007-2011 for fertility, mastitis, workabilities	The 'average' remains a modern cow. Maintains current policy.	It looks like animals have 'dropped' for many traits because the values are lower.
2. Base update with improved breed	Update to create a new group in April 2020. Base animals would be daughters of NASIS bulls born 2014-2018 for yield and conformation and NASIS bulls born 2007-2011 for other trait groups. Add a filter so that animals in the base group have a consistent breed of sire, maternal grand sire and maternal great grand sire (ie FFFF, JJJJ)	The 'average' remains a modern cow. Crossbred animals are removed. This is especially important for the Jersey base. Maintains current policy.	It looks like animals have 'dropped' for many traits because the values are lower.
3. Don't roll the base but improve breed	Maintain the current base for another 5 years. Base animals would remain daughters of NASIS bulls born 2009 - 2013 for yield and conformation and NASIS bulls born 2002-2006 for other trait groups. Add a filter so that animals in the base group have a consistent breed of sire, maternal grand sire and maternal great grand sire (ie FFFF, JJJJ)	The 'average' remains a modern cow. Crossbred animals are removed. This is especially important for the Jersey base. Jerseys would see an increase of +16 BPI. A sudden change in ABVs, caused by a base change, is avoided.	The 'average' is no longer a modern cow. It is a stable group of cows that are historical.
4. Base update but add back the gains.	Update to create a new group in April 2020. Base animals would be daughters of NASIS bulls born 2014-2018 for yield and conformation and NASIS bulls born 2007-2011 for other trait groups. Add back the gains made in BPI, HWI, TWI. Add a filter so that animals in the base group have a consistent breed of sire, maternal grand sire and maternal great grand sire (ie FFFF, JJJJ)	The 'average' remains a modern cow. A sudden change in ABVs, caused by a base change is tempered.	Considerable work is required to implement. BPI = sum (ABV*economic weight) plus a factor. It makes it difficult to show the BPI calculation.
5. Split red breeds group into 4	Separate each Red breed into its own base group. There will be a base group for Aussie Red, Ayrshire, Illawarra, Dairy Shorthorn	A more marketable set of ABVs for Ayrshire, Illawarra, Dairy Shorthorns	Considerable work is required to implement. It is more challenging for farmers with multiple red breeds to compare animals Red animals returned from Interbull are assumed to be Ayrshire. A proportion of these are likely to be wrong. At the moment, there is little consequence as the breeds share a common base. In the future, it will be more important to fix the breed for animals of interest. Least stable
6. Split red breeds group into 2	There will be a base group for Aussie Red and then a combination of Ayrshire, Illawarra, Dairy Shorthorn	A more marketable set of ABVs for Ayrshire, Illawarra, Dairy Shorthorns. Maintain	Considerable work is required to implement.

DataGene
Solutions for Herd Development

	Description	Pros	Cons
		a larger base group for 3 breeds.	It is more challenging for farmers with multiple red breeds to compare animals Less stable
7. Split red breeds group into 3.	There will be a base group for Aussie Red, Ayrshire, and combined Illawarra/ Dairy Shorthorn	A more marketable set of ABVs for Ayrshire, Illawarra, Dairy Shorthorns. There are very few Dairy Shorthorns so it is practical to combine with Illawarra.	Considerable work is required to implement. It is more challenging for farmers with multiple red breeds to compare animals Least stable
8. Breed based factors	Add an arbitrary figure to the average BPI of each breed so that the top bulls of each breed have a similar BPI	The top bulls have a similar BPI.	Depending on the rate of genetic gain between breeds, the equality between breeds will break down in a few years. Breeds cannot be compared. Having similar numbers may encourage invalid between breed comparisons.
9. Across breed base	Work towards an across-breed base in the 21/22 AOP (Implementation December 2021 or later).	All animals (especially crossbred animals) can be fairly compared. This is quite useful for cross-bred herds wanting to select the best replacements for a herd.	Breeds with slower rates of genetic gain will appear disadvantaged. Significant programming is required to re-work.

Fat: Protein Ratio

The Balanced Performance Index is an economic index built from a detailed analysis of input costs and farmgate returns for milk and stock. Milk price is a vital component of the analysis. The current analysis utilises component pricing based on a four-year historic average plus one-year forecast, supplied by Dairy Australia. As farmgate returns for protein yield have been historically stronger compared to fat yield, indices have reflected this, as shown in the figure.

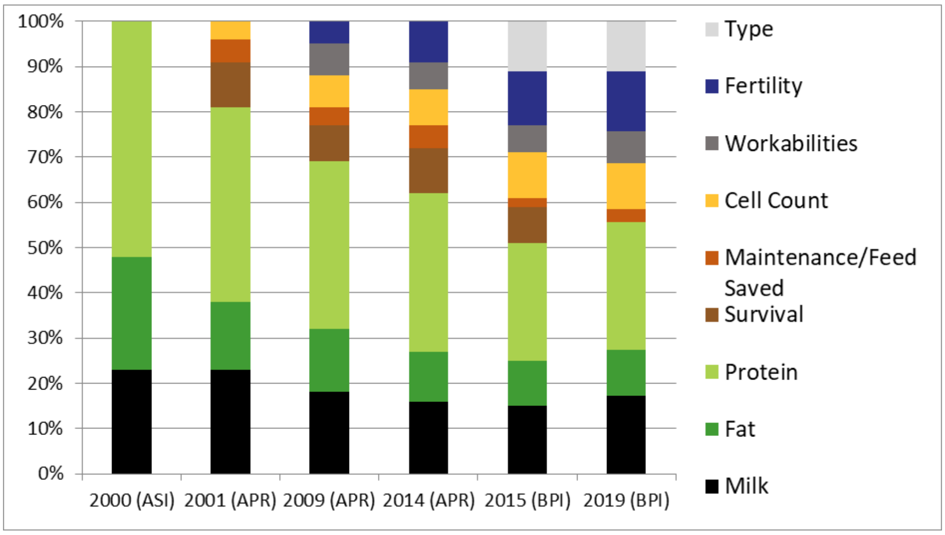


Figure 4 : Percent emphasis on traits in Australian indices from 1996-2019

If the relative price paid for fat to protein changes then it is appropriate for breeding indices to reflect this change using the same methodology. However, if there is a forecasted shift in the value of fat, compared to protein, then consideration should be given to a different methodology for calculating the economic weights for fat and protein.

Is the existing policy for establishing economic weights appropriate; where values are based on 4 years of historical data plus 1 year forecast?

- Survey result: 78.2% of respondents agree that weighting on milk production traits should adapt to long-term shifts in international demand for Milk, Fat and Protein -.

From the survey…..

I know I can compensate for any perceived loss of per cow production by increasing feeding and/or running extra cows. I know I can't control for any 'lost production' if the cow is empty and culled.

More is not always better! This point has been missing from the genetics discussion for ever.

Move about 8% weighting off asi And move the weighting onto fert scc feed save

Ideally I don't want to trade off any milk protein to achieve those objectives.

Butterfat to be more relevant

Considerations

Dairy Australia data suggests a stable fat:protein price ratio paid to Australian farmers over the past four years, as shown in Figure 5. The ratio of 0.5 is lower compared to the commodity price ratio that has moved between 0.7 and 1.7 during the same period.

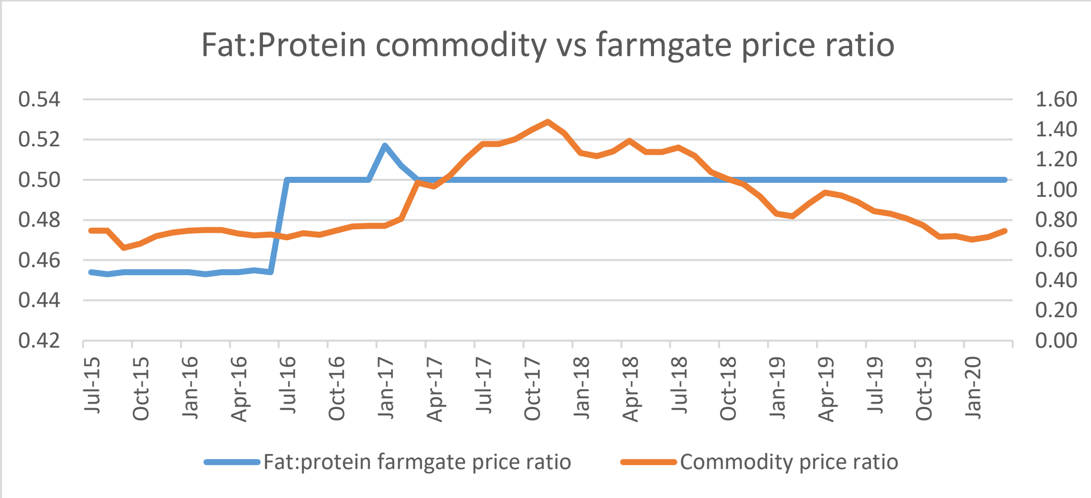


Figure 5 Fat:Protein commodity vs farmgate price ratio, Dairy Australia, 2020

An analysis of three fat:protein price ratios was conducted.

1. The current farmgate fat:protein price ratio of 0.5 (known as BPI20)
2. The commodity fat:protein price ratio over the last 6 years of 0.88 (known as BPI88)
3. The commodity fat:protein price ratio over the last 4 years of 1.08 (known as BPI108)

Table 5 shows the economic weights for protein, fat and milk under each of the three options. Changing the fat:protein price ratio to 0.88 would lower the value of protein by 1.77 and increase the value of fat by 1.46. The correlation between BPI2020 at 0.5 and BPI2020 at 0.88 is 0.98 suggesting moderate re-ranking amongst a large group of bulls. The response to selection analysis shows gains for fat at the expense of protein with most other traits expected to have similar responses.

Some processors will offer different payment structures that would make a difference to an individual farm. However, there is little evidence of the national shift in farmgate price ratio to justify an increase in the price ratio applied to the index model.

Table 5 Economic weights for protein, fat and milk under three fat:protein price ratios (AbacusBio, 2020)

Trait	**BPI20**	**BPI88**	**BPI108**
PROT	6.76	**4.99**	**4.33**
FAT	2.08	**3.54**	**4.09**
MILK	-0.11	-0.11	-0.11

Breeding for Longevity

The two most important determinants of a dairy bull's genetic merit for profitability are milk yield and survival. Survival – also known as longevity or productive herd life – refers to a bull's ability to produce daughters that last in the herd for many lactations.

Survival is a significant contributor to overall profitability on dairy farms in Australia because:

- Fewer replacements are needed, which means lower heifer rearing costs (or greater income as surplus heifers are sold).
- The herd is more mature – more mature cows have greater milk yields than younger cows.
- A greater proportion of the culling decisions can be based on yield, resulting in an increase in the average yield of the herd.

The economic value of Survival in the BPI, is distributed amongst traits that influence survival. For example, yield, fertility, cell count and type. There is a component of survival, known as residual survival, that includes traits we don't currently measure, such as lameness and metabolic disorders; while avoiding double counting those traits already included in the indices. Residual survival was removed from Australia's breeding indices in April 2019, based on the following rationale. Residual Survival had proven challenging to implement and had caused some instability from run to run. This had led to larger than expected movements of bulls between runs so the Genetic Evaluation Standing Committee requested its removal from the indices.

This NBO review aims to resolve how Survival is best accounted for in indices. It could be by:

1. Applying the economic value of survival to its contributing traits. This means no direct weighting on Survival.
2. Applying some of the economic value of survival to the trait itself and the rest to its contributing traits. This will likely mean some double counting that could over-emphasise traits linked to survival.
3. Applying all of the economic value of survival on the trait itself. This would reduce the weightings on fertility, cell count, type and other traits.

Is it important that Survival/Longevity has its own place in an index, rather than indirect emphasis through other traits?

Survey results show strong support for survival: strong signal to include Survival/Longevity in the indexes (81%) especially among Jersey and crossbreed farmer and to a lower, but still important, extent among Holstein farmers. Furthermore, Survival/Longevity appears in a second order of importance in desired emphasis

From the survey…..

Given pressures globally on antibiotics & animal welfare health & survival needs to be in front of mind, not production. I think production based systems have by in large bred cows to partition more energy to milk rather than looking after them selves to the point where production is not our issue within breeds it is survival

Considerations

Given the strong support for survival in the survey, only one option was considered. It is proposed that all of the economic value of survival is placed on the trait itself. This option means that there may be some double counting of traits like fertility, somatic cell count and mastitis resistance. However, these are considered economically important traits for which double counting is acceptable. In the past, some of the value of survival was distributed amongst fertility and overall type and it is proposed that this is reversed which lowers the economic value placed specifically on these two traits. The overall weight on the health and fertility group has increased. The overall weight of the type group has decreased. This doesn't mean that type is less important, it just means that some of the value of overall type in delivering longer lasting cows has been counted directly on survival.

Survival has strong and positive correlations with Fertility, Somatic Cell Count, Mastitis Resistance, Temperament, Mammary System, Overall Type, amongst other traits as shown in Table 6. Including an economic value on survival has positive benefits for all these traits. A full list of trait correlations is included in Appendix 3

Table 6 Correlations with Survival ABV in Holsteins

	Survival		**Survival**		**Survival**
Protein	0.03	**Fertility**	0.48	**Overall Type**	0.36
Fat	0.11	**Somatic Cell Count**	0.64	**Mammary System**	0.45
Milk	0.25	**Mastitis Resistance**	0.41	**Udder Depth**	0.72
Feed Saved	-0.14	**Milking Speed**	0.17	**Pin Set**	-0.02
		Temperament	0.30	**Fore Udder Attachment**	0.49

Breeding for fertile cows

The Daughter Fertility ABV provides a genetic estimate of the percentage of a bull's daughters that will be pregnant by six weeks after the mating start date compared to the average. For year-round calving herds, this is equivalent to the percentage of daughters pregnant by 100 days after calving. The economic value of fertility and its associated index weight has steadily increased over the past decade. The BPI has the heaviest weighting on fertility compared to its predecessors. However, the HWI goes even further to add extra emphasis on fertility to meet the needs of farmers wanting to put more focus on health traits.

The economic value for fertility is derived from longer survival, costs associated with re-breeding, value of extra AI calves and lost milk associated with longer calving intervals.

This review aims to:

1. Check for further sources of economic value for fertility.
2. Determine if the genetic gains for daughter fertility are considered acceptable.
3. Determine if the HWI, should shift further away from an economic index to a desired gains index with a more extreme position on health traits.

Is the rate of genetic gain in daughter fertility fast enough? Should the HWI shift further away from the BPI by putting even more emphasis on health traits?

Survey results show Fertility is the No 1 priority for farmers.
Most people (76%) support that HWI should have even more emphasis on Fertility and Health traits. Note that industry services support this position more than farmers and non-registered farmers more than registered farmers. Farmers from Northern Victoria and Southern Riverina are the less supportive to increase emphasis on Fertility and Health traits. Also Jersey breeders support it more than other breeders.

From the survey…..

The BPI is good but there is not enough emphasis on daughter fertility and too much emphasis on milk production traits in the BPI

Focus on Fertility.. and seasonality.. cows in calf to a season

Considerations

In the BPI options presented, the economic weight placed on fertility relies solely on the value of fertility alone because the component related to survival has been placed directly on survival. As a result, the economic weight for fertility is lower compared to the current BPI in most of the options presented. The impact is a slightly lower response to selection for fertility in the BPI options.

An additional BPI option was tested that added another 50% to the economic weight for fertility. This option has a positive response to selection, stronger than the current BPI. The high correlation with BPI20 suggests that this remains an economically efficient option. A further, more extreme option, doubled the weight on fertility in order to understand the variation in response.

The HWI has been pushed further with options presented for an additional 30%, 50% and 100% weight on fertility that results in a corresponding increased response to selection for fertility.

The TWI options include the same economic weight for fertility as BPI, however the antagonistic relationship with both milk litres and type mean a lower response to selection. The TWI options are expected to deliver the slowest response to selection for fertility.

Breeding for Feed Efficiency

The Feed Saved ABV was introduced in 2015 to quantify genetic differences in feed efficiency between animals. Australia was the first country in the world to produce a genetic evaluation using residual feed intake information. The Feed Saved ABV allows farmers to breed cows with reduced feed requirements for the same amount of milk produced. The Feed Saved ABV was introduced at 50% of the true economic value for this trait in the BPI. The cost of feed is based on the historical marginal cost of feed over the past four years with a 1-year forecast. During this review, it is appropriate to review both the feed costs as well as the 50% discount that was applied to this new trait.

Are we ready to count feed saved at its full weight?

Survey result: Industry does not seem to fully support this. Feed saved desired emphasis is low. However, a relevant proportion of the respondent (35%) supported the increase of Feed Saved emphasis within the indexes. There are differences among regions.

Considerations

Options are presented that include feed saved at both 50% and 100% of the model's economic value. A further HWI model presents an option that is 200% of the economic value. In most of the options the expected response to selection for feed saved is negative meaning that there is a continual decline in feed efficiency in all but HWI and options valuing feed saved at 100%.

New traits

Since the last NBO review, there are several new traits that are/will be evaluated, including heat tolerance and mastitis resistance.

Heat Tolerance

Heat Tolerance**,** another global first, was developed by DairyBio and released by DataGene for the first time in 2017. Heat Tolerance identifies animals with a greater ability to tolerate hot, humid conditions with less impact on milk yield. The economic value of Heat Tolerance will vary according to the location of the farm; it will have a greater economic value in locations where there are more hot and humid days and nights.

As there are hot and humid days in nights in virtually all regions, should the index include a base value for Heat Tolerance? Farmers who want to apply more pressure are supported through tools like the Good Bulls App where filters can be applied to screen out animals with a Heat Tolerance ABV below a nominated threshold.

Is there support for generating a different index for hotter regions that would have a much greater emphasis placed on Heat Tolerance?

Survey result: The importance of Heat Tolerance is low when compared with the rest of traits, however there is quite large support to include Heat Tolerance in the indexes (50% of respondents) and a lower but still relevant support (30%) to create a specific index for hotter regions.

> *From the survey…..*
>
> *All traits should be considered but unreliable traits should not have too much weighting on the overall index.*

Considerations

The addition of Heat Tolerance is considered unsuitable for a general index as its value varies by climate – it is more highly valued in hotter and more humid clients. Tools such as the Good Bulls App provide farmers with options to prioritise this trait to meet the demands of their local climatic conditions. As a result, no options that include heat tolerance are presented.

Mastitis Resistance

The Mastitis Resistance ABV was released in April 2020. This new ABV utilizes a multi-trait model that includes clinical mastitis records, udder conformation traits and cell count to evaluate genetic differences in clinical cases of mastitis. Although highly correlated, Mastitis Resistance ABV is not the same as Cell Count ABV. Cell Count ABV uses only cell count information from herd recording but has a higher reliability than Mastitis Resistance.

Should Mastitis Resistance be included in indices, in addition to Cell Count ABV? The economic value that is currently applied to Cell Count ABV would be spread across both traits.

Survey result: There is strong signal to include Mastitis Resistance as a separate trait to SCC (80% of supporters). Furthermore, Mastitis Resistance appears in a second order of importance in desired emphasis.

Considerations

Given the strong support from the survey to include Mastitis Resistance combined by the significant economic benefit to improving this trait, all options include Mastitis Resistance ABV. The economic weights for Mastitis Resistance are higher in TWI and HWI compared to BPI. The economic weight for Somatic Cell Count has been adjusted to focus solely on the economic benefit of lower cell counts so that the benefit of lower incidence of mastitis can be placed directly on mastitis resistance. In all options presented, the response to selection for Mastitis Resistance is expected to be higher compared to current indices.

Multiple indices

Australia's three breeding indices reflect the range of preferences identified in the 2015 NBO Review. All three indices account for the traits that affect profit and longevity in the herd. The difference is in the emphasis given to specific traits. Analysis of marketing materials used to promote bulls shows the BPI is most popular, followed by HWI. The TWI is less often used in marketing material. If the TWI is no longer relevant, we have the option to discontinue it to focus attention on BPI and HWI.

Is there still a role for the Type Weighted Index?

Survey results

- Type Weighted index is the least used by the respondents; just 16% use it and mostly in combination with the other indexes. 4% solely use TWI.
- Jersey and registered farmers as well as farmers from Northern Victoria and Southern Riverina seem to be the ones that most support TWI.

From the survey…..

I believe there is not enough difference in the way BPI HWI and TWI are calculated, for example if I pick 5 bulls they are usually ranked in the same order on all 3 lists, meaning that I may as well just use bpi

If the Type weighted index is not used extensively then stop using it. Encourage those who want to emphasise to filter on type traits.
Too many major indices can be confusing.

Too much information! Keep it concise 🐄

The BPI needs to be on science based on sound economics for the commercial dairy farmer, if the want Type , put that into the TWI at a higher rate and leave it out of the BPI so as a commercial dairy farmer I have the confidence that the BPI is structured to suit me and not pandering to the "Show Ring" side of the industry.

Generally far too much emphasis as an industry on production at expense of health & survival traits. Type traits are over emphasised in my view and are based on "opinion for show ring" rather than just enough for a functional cow.

Dump TWI and HWI. Focus on one index and select for type and health within that index.

STOP constantly changing the criteria

Considerations

BPI, HWI and TWI with updated economic and physical parameters are included for consideration. However, it appears as though the relationships between these indices have become stronger which means there is less difference between each index. Using the 2020 NBO Survey results alongside an understanding of the breeding preferences of Australian farmers (Martin-Collado, 2015), the HWI and TWI were modified to more closely reflect the motivations of each. The impact of the additional options is a lower correlation with BPI.

In addition to the updated BPI, HWI, TWI, additional options presented in this paper include:

- BPI, HWI, TWI with double the value on feed saved
- BPI with fat:protein ratios of 0.88 and 1.08 compared to the current 0.5
- HWI with an additional 30% higher fertility weighting
- HWI with an additional 50% higher fertility weighting
- TWI with 40% of the milk weighting (lower penalty on milk) and 80% of the feed saved weighting (lower weighting on feed saved)

Jersey specific index

The Jersey breed is the second largest breed in the country. While Jersey data is combined with data from all other breeds to generate the BPI, HWI and TWI, breeders have asked for a breed-specific index. A breed specific index would be based on Jersey-based inputs, where information is available.

Would dairy producers with Jersey and Jersey cross animals be better off with a Jersey specific index?

Would dairy producers select Jersey bulls on the basis of a Jersey specific index rather than the BPI or the index from another country?

Survey results

- Jersey farmers would give more emphasis (than Holstein or crossbred) to Temperament, Fat (kg), Milking Speed and Likeability and would give less emphasis to Daughter Fertility and Calving Ease

From the survey…..

I just want the biggest Jersey cow I can breed at 10% solids and 7000lt milk. Stature 110+ and upward swing in production and components. Type and Mammary System as high as I can.

Get back to basics. Breed a low maintenance commercial herd cow for Australian conditions and systems.

Considerations

While not specifically a Jersey index, the TWIMilk is included that achieves higher production, a larger cow with better overall type and temperament in the Jersey population. This option emphasises production with less penalty on milk and substantially lower value for feed saved. This option has higher values for overall type and mammary system compared to the BPI20. It's values are similar for survival, somatic cell count and mastitis resistance but lower emphasis on fertility.

Further Jersey-style options were tested with a BPI base. Feed Saved does not include Residual Feed Intake for non Holstein breeds. As a result, Feed Saved is comprised solely of liveweight. As Jersey breeders have indicated the desire to increase liveweight, rather than hold or decrease it, an option was added that places zero weight on Feed Saved. This is known as BPIfert150_fs.

BPIfert150_fs_milk tests the option of reducing the negative weighting on milk L, in response to survey data supporting a stronger emphasis for more milk amongst participants breeding Jersey cattle. This option shows a much stronger response for milk but at the expense of fertility.

Based on consultation with Jersey Australia, Udder Depth was added to BPI150_fs and BPI150_fs_milk at the same level it appeared in the BPI. This over emphasises the weighting on Udder Depth in new index options as it is a trait included in the multi-trait Mastitis Resistance model. Its impact on the index options is negligible.

As breeds are different populations and have different underlying assumptions, the predicted impact of an index will vary from breed to breed. For this reason, all of the index options were re-assessed using both Holstein and Jersey-based assumptions so that the impact of each index is clearer to farmers and industry.

Formative reports

This options paper draws upon detailed reports prepared during this review process.

- Abacus report
- NBO discussion paper, November 2020
- Fat:Protein price ratio, Dairy Australia (published in June)

- Analyzing the heterogeneity of farmers' preferences for improvements in dairy cow traits using farmer typologies

Appendix 1: National Breeding Objective review

The National Breeding Objective (NBO) describes the collective breeding priorities for Australian dairy herds. Its purpose is to enable farmers to breed herds that meet the future needs of the Australian dairy industry.

While Australian Breeding Values (ABVs) express a bull or cow's genetic potential for a single trait such as fertility or protein kilograms most farmers want to improve more than one trait in their herd.

The NBO supports genetic selection pressure for an agreed group of desirable traits, providing direction for both bull and cow breeding across the country.

The current National Breeding Objective for the Australian dairy industry is aimed at increasing net farm profit. It is expressed through the three breeding indices – Balanced Performance Index (BPI), Health Weighted Index (HWI) and Type Weighted Index (TWI) – see box.

Reviewing the NBO

The National Breeding Objective must evolve over time in response to the changing needs of dairy businesses, new knowledge and breeding technologies. As the NBO evolves, so do the indices. DataGene has a policy to review every five years the NBO and the index formulated to meet this objective.

The last review, undertaken in 2014, resulted in the release of the three indices in April 2015. The BPI aligns directly to the top priorities established through Australia's Longest Farmwalk and Farmer Survey in 2014.

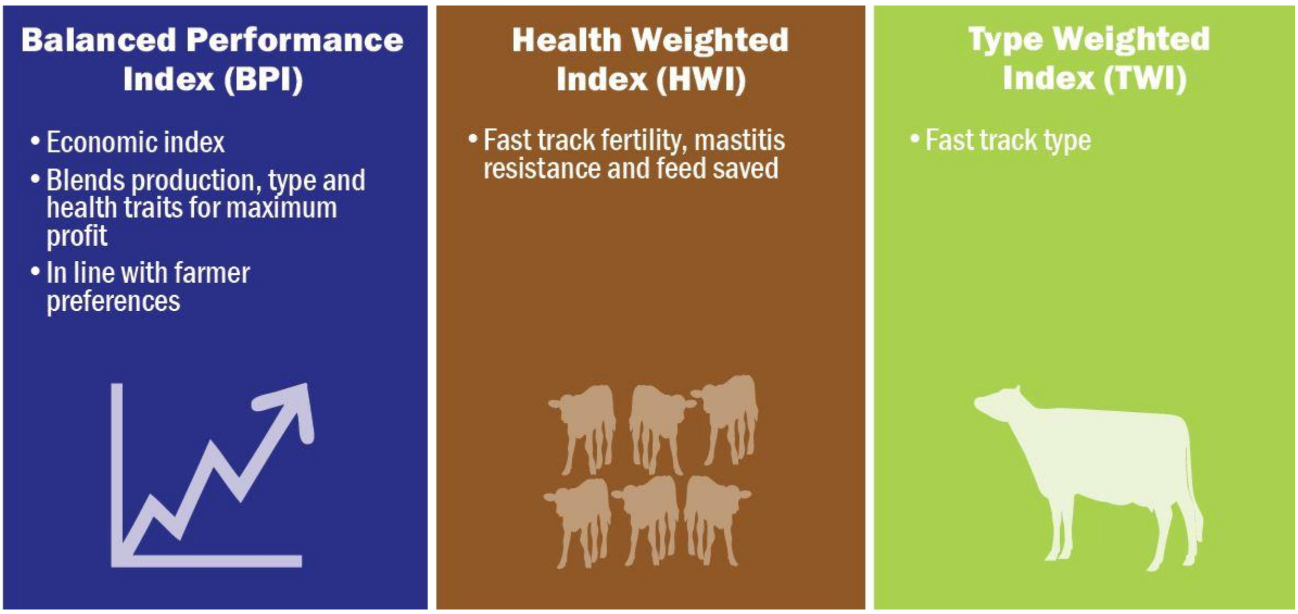
Figure 1: Australia's three breeding indices

Australia's three breeding indices (BPI, HWI, TWI) are used to rank bulls, cows and herds so that superior genetics can be identified and used in breeding programs.

These indices combine the traits that drive on-farm profit, with different weightings to reflect different farmer breeding preferences.

The BPI is an economic index that reflects most farmer preferences.

It drives net profit through a balance of functionality, type and yield. The Health Weighted Index puts extra emphasis on traits like fertility and cell count. The Type Weighted Index puts extra emphasis on traits like overall type and mammary system.

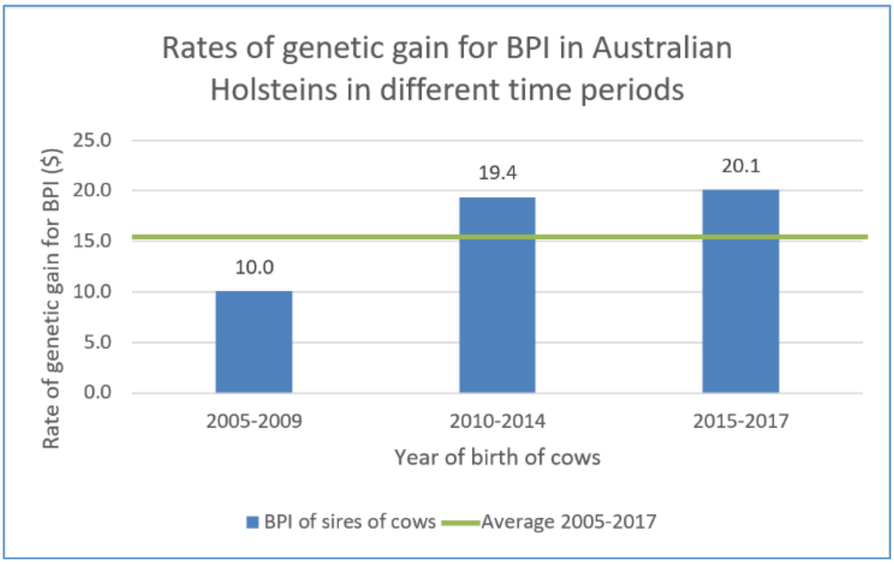


2019/20 NBO review

The purpose of the 2019/20 NBO review:

- to ensure the NBO which is aimed at driving on-farm profit still remains relevant, and
- to develop an index (or indexes) based on strong scientific principles which are in line with farmer preferences and meet the agreed NBO.

Since the introduction of the BPI, HWI and TWI, there has been a positive and sustained increase in the utilization of Australian indices. The combination of an increased awareness in BPI, use of genomics to select young bulls based on BPI and implementation of the Good Bulls Extension strategy have worked together to double the rate of genetic gain in the sires used to produce Australian cows, as shown in the graph. This means that this review is seen as an update rather than a review that concludes with wholesale change.



Review process

Australian indices make a difference on the next generation of Australian dairy herds so a collaborative process involving farmers, scientists, processors, herd improvement organisations and farm advisors is key.

The NBO review is guided by DataGene's Genetic Evaluation Standing Committee that includes farmers, scientists, breed association, semen reseller and bull company representatives who have been nominated by Australian Dairy Farmers, National Herd Improvement Association, Dairy Australia or the DataGene Board.

DataGene leads the review process which also involves a team of scientists from Agriculture Victoria and Abacus Bio.

The process and timelines for the National Breeding Objective Review are outlined in Figure 1. This document is the Options Paper which provides a framework for industry discussion and decisions. Implementation is planned for December 2020. The timing of the implementation is planned around the main breeding seasons with a December release the most practical option for farmers and commercial organisations.

Different stakeholder groups are involved in different stages of the process.

Stage	Stakeholders involved
Identify key themes	Genetic Evaluation Standing Committee (July 2019)
Discussion Paper	Genetic Evaluation Standing Committee (October 2019)
Data collection; scientific review	Agriculture Victoria – Dr Jennie Pryce and Dr Jo Newton Dairy Australia Trade & Strategy Group and Farm Team Abacus Bio DataGene staff
Circulate discussion paper and request responses to NBO survey	Farmers, breed organisations, bull company managers, herd improvement service providers, Regional Development Programs, DataGene social media
Options paper and discussion	Genetic Evaluation Standing Committee Bull company managers Breed organisations Dairy Australia Farm team
Stakeholder agreement	Genetic Evaluation Standing Committee
Development & testing of algorithms; updating GESNP	DataGene ABV Team and external testers

Appendix 2: Key parameters used in the models

Table 6 selected physical and economic inputs used in the models and compares them to 2015.

Parameter, unit	Value 2015	Value 2020
Milk fat price, A$/kg	3.22	3.63
Milk protein price, A$/kg	7.77	7.26
Milk volume charge, A$/L	0.03	same
Milk price, A$/L	0.42	0.46
Payment on milk solids, A$/kg of milk solids	5.71	6.18
Average milk fat percentage	4.11	4.09
Average milk protein percentage	3.34	3.38
Average milk lactose percentage	4.9	same
Energy requirements for fat, MJ of ME/kg of fat	59.5	same
Energy requirements for protein, MJ of ME/kg of protein	38.3	same
Energy requirements for lactose, MJ of ME/kg of lactose	25.8	same
Feed costs, A$/MJ of ME	0.025	0.032
Average energy content of feed, MJ of ME/kg of DM	11.9	same
Average feed price, A$/kg of DM	0.286	0.396
Number of herd recorded dairy cows per region		
Victoria	433,383	358,822
New South Wales	99,919	92,904
Queensland	38,587	25,953
South Australia	46,928	38,774
Tasmania	58,766	56,472
Western Australia	30,236	24,432
Cull cow average price, A$/kg of cow BW by lactation	2.68	same
Cull cow average dressing out, %	55.6	same
Breed percentage of herd recorded dairy cows:		
Holstein-Friesian	72	same
Jersey	12	15
Crossbreed and others	16	13
Average herd recorded cow milk production per lactation, L	6,788	6925

Change in SCC ABV for a 50,000 increase in cell count	-31.25	same
Proportion of cows per calving system		
Split calving	0.416	0.425
Year-round calving	0.234	0.211
Seasonal calving	0.35	0.363

Parameter, unit	**Value 2015**	**Value 2020**
Percentage of farmers producing surplus heifer calves	75	same
Calf mortality, %	5	same
Replacement heifer cost, A$/head	1606	1650
Genetic merit differential of AI calves over natural mating calves, A$	62.7	same
Price differential of AI calves over natural mating calves, A$	435	935
Price of beef bull sired female calf, A$/calf	100	same
Price of beef bull sired male calf, A$/calf	30	same
Bobby calf average value, A$	54.3	same
Lactation length, d	322	same
Proportion of heifers in an average herd	0.22	same
Extra labour required by a bad temperament heifer, minutes per heifer per milking	0.48	same
Extra labour required by a bad temperament cow, minutes per cow per milking	0.33	same
Number of milkings per cow	644	same
Proportion of heifers with bad temperament	0.096	same
Proportion of cows with bad temperament	0.01	same
Standard deviation of temperament ABV in bulls	2.14	2.76
Extra time spent with bad behavior heifers or cows every milking during the first 4 wk of lactation, min	2	same
Extra time spent with bad behavior heifers or cows every milking during the rest of the lactation, min	0.33	same
Number of milkings when a heifer is badly behaving during the first 4 wk of lactation	56	same
Number of milkings when a heifer is badly behaving during the rest of lactation	588	same

Average hourly labor cost, A$/h	30	36.75
Extra labor required by low milking speed cow, min per cow per milking	1.5	same
Proportion of low milking speed cows	0.015	same
Standard deviation of milking speed ABV in bulls	2.41	3.20
Extra time spent with low milking speed cow	2	same
Overall slippage labour cost, A$/slippage lactation	1.6	$1.96
Proportion of slipping events due to poor udder cows	0.019	same
Incidence of mastitis caused by slippage, % of mastitis cases	15	same

Appendix 3: ABV correlations

Understanding the relationships between ABVs is helpful when comparing index options. For example, there is a moderate unfavourable relationship between production and fertility and also overall type and fertility. These traits pull against each other. This helps to explain why more pressure on one trait doesn't necessarily translate into faster progress. It's about finding the right balance that achieves the National Breeding Objective.

Table 7 correlations between ABVs in recent Holstein bulls with daughter records (NASIS Bulls born 2011-2015, ABV Daughter Fertility >=60, N=9283)

	PROT	FAT	MILK	SURV	FERT	SCC	MASTITIS	MILK SPEED	TEMP	MAMM	UD DEPTH	OTYPE	PINSET	FOREA	LWT	FEED SAVED
PROT	1.00	0.34	0.68	0.03	-0.17	-0.02	-0.03	-0.02	0.15	0.01	-0.19	0.00	-0.05	-0.22	0.13	-0.22
FAT	0.34	1.00	0.10	0.11	-0.13	0.08	0.08	0.13	0.21	0.13	-0.07	0.10	-0.10	-0.03	0.15	-0.26
MILK	0.68	0.10	1.00	0.25	-0.16	0.13	0.01	0.01	0.17	0.22	0.05	0.19	-0.05	0.03	0.18	-0.24
SURV	0.03	0.11	0.25	1.00	0.48	0.64	0.41	0.17	0.30	0.45	0.72	0.36	-0.02	0.49	0.04	-0.14
FERT	-0.17	-0.13	-0.16	0.48	1.00	0.40	0.24	-0.03	-0.09	-0.12	0.36	-0.20	-0.07	0.04	-0.32	0.18
SCC	-0.02	0.08	0.13	0.64	0.40	1.00	0.65	-0.15	0.11	0.23	0.51	0.16	-0.13	0.27	-0.02	-0.05
MASTITIS	-0.03	0.08	0.01	0.41	0.24	0.65	1.00	-0.07	0.13	0.16	0.29	0.08	-0.10	0.15	0.02	-0.07
MILK SPEED	-0.02	0.13	0.01	0.17	-0.03	-0.15	-0.07	1.00	0.26	0.24	0.21	0.14	-0.10	0.21	0.08	-0.13
TEMP	0.15	0.21	0.17	0.30	-0.09	0.11	0.13	0.26	1.00	0.24	0.09	0.22	-0.03	0.20	0.15	-0.19
MAMM	0.01	0.13	0.22	0.45	-0.12	0.23	0.16	0.24	0.24	1.00	0.51	0.73	-0.16	0.71	0.34	-0.31
UD DEPTH	-0.19	-0.07	0.05	0.72	0.36	0.51	0.29	0.21	0.09	0.51	1.00	0.40	-0.20	0.67	0.11	-0.12
OTYPE	0.00	0.10	0.19	0.36	-0.20	0.16	0.08	0.14	0.22	0.73	0.40	1.00	0.02	0.65	0.57	-0.44
PINSET	-0.05	-0.10	-0.05	-0.02	-0.07	-0.13	-0.10	-0.10	-0.03	-0.16	-0.20	0.02	1.00	-0.18	0.06	0.02
FOREA	-0.22	-0.03	0.03	0.49	0.04	0.27	0.15	0.21	0.20	0.71	0.67	0.65	-0.18	1.00	0.22	-0.14
LWT	0.13	0.15	0.18	0.04	-0.32	-0.02	0.02	0.08	0.15	0.34	0.11	0.57	0.06	0.22	1.00	-0.81
FEED SAVED	-0.22	-0.26	-0.24	-0.14	0.18	-0.05	-0.07	-0.13	-0.19	-0.31	-0.12	-0.44	0.02	-0.14	-0.81	1.00

Table 8 correlations between ABVs in recent Jersey bulls with daughter records (NASIS Bulls born 2011-2015, ABV Daughter Fertility >=50, N=1067)

	PROT	FAT	MILK	SURV	FERT	SCC	MAS	MSPEED	TEMP	MAMM	UDDEP	OTYPE	PINSET	FOREA	LWT	FEEDEF
PROT	1.00	0.54	0.70	0.22	-0.25	-0.04	0.09	0.14	0.30	0.19	-0.33	0.24	0.25	-0.18	0.23	-0.23
FAT	0.54	1.00	0.12	0.12	-0.18	0.09	0.10	0.21	0.01	-0.05	-0.17	0.02	0.19	-0.12	0.18	-0.18
MILK	0.70	0.12	1.00	0.30	-0.28	0.05	-0.02	0.05	0.37	0.33	-0.08	0.36	0.24	0.03	0.23	-0.23
SURV	0.22	0.12	0.30	1.00	-0.02	0.31	0.18	0.23	0.37	0.52	0.48	0.60	0.38	0.57	0.33	-0.33
FERT	-0.25	-0.18	-0.28	-0.02	1.00	0.28	0.22	-0.27	-0.37	-0.37	0.16	-0.37	-0.17	-0.08	-0.29	0.29
SCC	-0.04	0.09	0.05	0.31	0.28	1.00	0.54	-0.20	-0.15	-0.13	0.46	-0.06	0.02	0.30	-0.08	0.08
MAS	0.09	0.10	-0.02	0.18	0.22	0.54	1.00	-0.05	-0.03	-0.03	0.10	0.00	0.05	0.10	-0.14	0.14
MSPEED	0.14	0.21	0.05	0.23	-0.27	-0.20	-0.05	1.00	0.38	0.35	-0.09	0.30	0.15	0.09	0.15	-0.15
TEMP	0.30	0.01	0.37	0.37	-0.37	-0.15	-0.03	0.38	1.00	0.62	-0.14	0.59	0.15	0.28	0.32	-0.31
MAMM	0.19	-0.05	0.33	0.52	-0.37	-0.13	-0.03	0.35	0.62	1.00	0.08	0.90	0.20	0.56	0.32	-0.32
UDDEP	-0.33	-0.17	-0.08	0.48	0.16	0.46	0.10	-0.09	-0.14	0.08	1.00	0.17	-0.08	0.64	0.06	-0.06
OTYPE	0.24	0.02	0.36	0.60	-0.37	-0.06	0.00	0.30	0.59	0.90	0.17	1.00	0.23	0.60	0.46	-0.46
PINSET	0.25	0.19	0.24	0.38	-0.17	0.02	0.05	0.15	0.15	0.20	-0.08	0.23	1.00	-0.02	0.27	-0.27
FOREA	-0.18	-0.12	0.03	0.57	-0.08	0.30	0.10	0.09	0.28	0.56	0.64	0.60	-0.02	1.00	0.28	-0.28
LWT	0.23	0.18	0.23	0.33	-0.29	-0.08	-0.14	0.15	0.32	0.32	0.06	0.46	0.27	0.28	1.00	-0.996
FEEDEF	-0.23	-0.18	-0.23	-0.33	0.29	0.08	0.14	-0.15	-0.31	-0.32	-0.06	-0.46	-0.27	-0.28	-0.996	1.00

Table 9 correlations between ABVs in recent Aussie red bulls with daughter records (NASIS Bulls born 2011-2015, ABV Daughter Fertility >=50, N=699)

	PROT	FAT	MILK	SURV	FERT	SCC	MAS	MSPEED	TEMP	MAMM	UDDEP	OTYPE	PINSET	FOREA	LWT	FEEDEF
PROT	1.00	0.72	0.82	0.09	-0.16	0.07	0.00	0.03	0.11	-0.14	-0.28	-0.03	0.11	-0.29	0.08	-0.08
FAT	0.72	1.00	0.62	0.13	-0.31	0.09	0.04	0.02	0.15	0.09	-0.09	0.06	-0.05	-0.09	0.15	-0.15
MILK	0.82	0.62	1.00	0.07	-0.27	0.06	0.01	-0.04	0.16	-0.04	-0.27	0.02	0.08	-0.24	0.06	-0.06
SURV	0.09	0.13	0.07	1.00	-0.21	0.25	0.25	0.11	0.12	0.45	0.54	0.18	0.27	0.37	0.29	-0.29
FERT	-0.16	-0.31	-0.27	-0.21	1.00	-0.05	-0.04	0.04	-0.07	-0.40	-0.18	-0.13	0.04	-0.19	-0.20	0.20
SCC	0.07	0.09	0.06	0.25	-0.05	1.00	0.81	-0.31	-0.06	0.12	0.23	-0.18	0.03	0.12	-0.12	0.12
MAS	0.00	0.04	0.01	0.25	-0.04	0.81	1.00	-0.26	-0.04	0.11	0.20	-0.13	0.02	0.14	-0.07	0.07
MSPEED	0.03	0.02	-0.04	0.11	0.04	-0.31	-0.26	1.00	0.21	0.01	0.02	-0.05	0.07	0.04	-0.01	0.01
TEMP	0.11	0.15	0.16	0.12	-0.07	-0.06	-0.04	0.21	1.00	0.13	-0.05	0.13	-0.01	0.05	0.15	-0.14
MAMM	-0.14	0.09	-0.04	0.45	-0.40	0.12	0.11	0.01	0.13	1.00	0.51	0.22	-0.19	0.66	0.21	-0.21
UDDEP	-0.28	-0.09	-0.27	0.54	-0.18	0.23	0.20	0.02	-0.05	0.51	1.00	0.03	-0.19	0.59	0.16	-0.16
OTYPE	-0.03	0.06	0.02	0.18	-0.13	-0.18	-0.13	-0.05	0.13	0.22	0.03	1.00	-0.06	0.23	0.80	-0.81
PINSET	0.11	-0.05	0.08	0.27	0.04	0.03	0.02	0.07	-0.01	-0.19	-0.19	-0.06	1.00	-0.25	0.02	-0.03
FOREA	-0.29	-0.09	-0.24	0.37	-0.19	0.12	0.14	0.04	0.05	0.66	0.59	0.23	-0.25	1.00	0.19	-0.19
LWT	0.08	0.15	0.06	0.29	-0.20	-0.12	-0.07	-0.01	0.15	0.21	0.16	0.80	0.02	0.19	1.00	-0.997

FEEDEF	-0.08	-0.15	-0.06	-0.29	0.20	0.12	0.07	0.01	-0.14	-0.21	-0.16	-0.81	-0.03	-0.19	- 0.997	1.00

Appendix 4: Estimated base adjustment

The estimated impact of a base adjustment is shown in the following tables. This is an estimate that is based on genetic trends but is subject to final confirmation once the full analysis is complete.

Note that for traits with positive genetic trends, the base adjustment is a move down. For example Rear Teat Placement in Holsteins. A bull that was 100 becomes 99. For traits with a negative genetic trend, the base adjustment is an upward move. For example Teat Length in Holsteins, a bull that was 100 becomes 101.

Base increase for traits that employ a cow base

For example, if the following base adjustment was made, the BPI of Holsteins would drop by 57 units. The BPI of Guernsey bulls would drop by 22 units.

BREED	BPI	HWI	TWI	ASI	FAT	FATP	MILK	PROT	PROTP
Brown Swiss	15.4232	10.1744	13.3632	15.0888	1.4676	-0.0176	46.7588	2.4826	0.0342
Holstein	57.5016	47.17	55.3488	29.2032	5.0304	0.0164	91.437	4.2378	0.0336
Guernsey	22.1188	14.7544	26.9902	21.3614	5.1894	0.0274	88.5902	3.025	0.01
Jersey	43.5544	32.135	49.9962	31.2642	5.0138	0.016	77.8186	4.3426	0.0368

For example, if the following base adjustment was made, the Overall Type of Jerseys would drop by roughly 3 units. A bull that was 100 would become 97.

BREED	OTYPE	MAMM	PINSET	PINW	REAR_AH	REAR_AW	RLEG	RSET	STAT
Holstein	1.4616	2.5676	-0.4854	0.604	2.8992	0.2938	0.6358	0.0876	2.1268
Guernsey	0.24115	1.821	-2.2993	0.3951	0.17165	2.43715	0.11055	0.31335	0.50525
Jersey	3.403	3.8556	1.477	1.3872	2.4086	2.6218	0.6694	-1.045	2.022

BREED	TEAT_L	TEAT_PF	TEAT_PR	UD_DEP	UD_TEX	CENT_L	FORE_A
Holstein	-1.0012	1.3	0.9014	2.4716	1.2744	1.8884	1.4724
Guernsey	-0.24265	2.12365	0.33565	0.27045	-0.5881	0.08845	1.0796
Jersey	-0.9394	2.3182	3.0304	1.4378	2.5712	2.2396	2.1544

BREED	ANGUL	BODY_D	BONE	CHEST_W	FOOT_A	LOIN	MUZW	BODY_L	RUMP_L
Holstein	-0.933	-1.549	1.296	-1.029	-0.5132	-0.682	-1.0462		
Guernsey	0.19915	-0.17085	-0.669	0.26935	0.6176	0.01195	-0.3883		
Jersey	2.2556	0.2668	1.777	0.4036	1.4002	2.0032	1.74	2.2178	2.2142

Base increase for traits that employ a bull base

BREED	EASE	FERT	SCC	SURV	LIKE	MSPEED	TEMP
Brown Swiss		0.0516	3.5434	0.3314	0.4816	-0.3876	-1.7842
Holstein	1.0168	0.0732	15.7786	3.0298	0.9022	0.4682	0.444
Guernsey		0.4292	-5.9912	-2.0706	1.51625	-0.5705	1.15825
Jersey		-0.3806	8.6026	3.0036	1.8622	1.2496	1.4036

DataGene
Solutions for Herd Development