SAC Paper on BW2022

From: Peter Amer

To: NZAEL Scientific Advisory Committee

Date: October 2021

Re: BW 2022 – SAC endorsement sought

Background

The national breeding objective (NBO) for the NZ dairy industry had its last major review in 2012. Since that time, the economic values in BW have been updated annually. For the 2021 year, a decision was made to postpone updating BW. This was because of time pressures in development of NZAEL 3.0, and because more substantial changes were planned for this year.

Following discussions with breeding industry representatives, along with NZAEL management and board, it was agreed that a major review of the NBO should take place. As part of the review process key industry stakeholders and farmers were engaged to provide input.

Stakeholder consultation occurred via a consultation document, survey and online meetings with plenty of opportunity for shareholders to provide feedback and have input into the direction of the review process. Based on input from stakeholders, a farmer survey was created to get farmer input into trait preferences and thoughts on what the future cow of NZ should look like. There were nearly 500 responses to the farmer survey, with the three key findings being:

1) More selection effort on functional traits desired (especially udders)
2) More gains in fertility desired
3) Appetite for niche indexes, e.g. high cow output, OAD

The results of the farmer survey will be communicated to farmers at an industry workshop planned for 27th October – this will be run online. Results of the farmer survey and the stakeholder survey can be found at the following links –

Stakeholder survey results

link2 (may have to add farmer survey results as appendix?)

The NZAEL 3.0 launch in December of this year will see the introduction of significant modifications to the genetic evaluations for Fertility and Functional Survival as previously reported to the SAC. These modifications have resulted in new trait definitions to fit into BW. There is also strong support from both survey respondents and the NZAEL Farm Advisory Panel to include Udder Overall in BW and for it to have a non-linear weighting that penalises low performing bulls moreso than rewarding high performing bulls. The purpose of this paper is to provide details of the technical calculations underpinning the proposed BW2022, with a view to them being endorsed as technically sound by the SAC.

BW2022 changes

More detailed discussion of economic value changes are provided in Appendix 1. A table comparing new (provisional) and currently used economic values is presented in Appendix 2.

For **Fat, Protein, Liveweight, SCC, BCS**, the existing BW excel spreadsheet model uses identical methodology to what has been used previously. However, two years' worth of new price data has been added. The model typically uses 5-year averages of input variables where possible. Key inputs that have been updated include:

- Milk solids price including 21/22 season forecast.
- The value component ratio (VCR) that values milk fat relative to protein.
- Forage value index calculations of feed costs for 5 seasons (early spring, late spring, summer autumn and winter).
- Cull cow values.
- Bobby prices.
- Farm operating costs and revenues (which drive per cow costs).

Milk Volume was initially changed as Fonterra announced a volume charge reduction of 1 c per litre, to remove a 1 cent per litre. We have been advised unofficially the1 c reduction will be reinstated, in line with the charges from the other companies. Accordingly, at the current time, the milk volume penalty is assumed to be the same as for previous years.

Fertility has two components, each with their own economic weighting (Calving season day in cows, CSD123, and calving season day in heifers, CSD0). The different weightings reflecting a low economic value of a tighter calving pattern in heifers, as they have better inherent fertility and tend to have a tight calving pattern. In determining the economic weight, the cost of empty cows is higher, whereas the value of AI calves is lower, than previous model assumptions. Overall, along with the greater dispersion in the NZAEL 3.0 fertility estimated breeding values compared to NZAEL 2.0, the emphasis on fertility in BW will increase by approximately 70%. Even though the new fertility economic weights will be applied to two underlying EBVs with units of "days into the calving season that the cow calves), it is still planned that a single fertility breeding value will be published with the same units as previously (i.e. CR42, the percentage of cows re-calving within the first 6 weeks from planned start of calving). More details in Appendix 1.

Functional survival is a newly defined trait (probability of surviving from one parity to the next) in contrast to the currently used residual survival. It combines an evaluation of direct survival (excluding culling for fertility or low production) with an index of 4 TOP traits. In addition to the new trait definition, the cost of a replacement heifer has been revised upwards substantially. The net impact on the magnitude of weighting on functional survival is modest, although the new Functional Survival Breeding Values are quite different to the currently used Residual Survival Breeding Values. More details in Appendix 1.

Introduction of udder overall (UO)

AbacusBio has been working with the Farm Advisory Panel (FAP) on the inclusion of udder overall (UO) in BW2022. Reduction in the national herd, and increases in production per cow are putting greater stress on udders than was historically the case. In determining the economic value for UO, the key assumptions leading to the costs associated with bad udders (defined as those cows ranking in the worst 20% of the herd) are:

Category	Key assumptions	Cost
Increased risk of developing clinical mastitis	Economic value of mastitis $102/incidence	
	Increased chance of a cow with a bad udder developing clinical mastitis 30%	$30.50
Cost of wintering a cow whose udder blows out early in the milking season	Total MJME demand for wintering cow 7,831	
	Average weighted feed costs – winter $0.03/MJME	
	Risk of cow with bad udder blowing out at start of milking season 5%	$13.00
Cost of replacements	Net impact of an end of season voluntary cull $1464.61	
	5% of cows with a bad udder (worst 20% of herd) are culled (1% culled for udders across the herd)	$67.50
Total		$111.00

A nonlinear approach to the UO economic weighting has been taken. This means that the bad udder end of the scale gets penalised proportionally more than a good udder gets favoured at the same unit change on the udder overall scale. This will avoid too much sacrifice in progress in other traits to get udders up to a higher standard than necessary, and also reflects some uncertainty about the effectiveness of TOP udder scores in discriminating between young cows scored at the favourable end of the scale.

Both increased adoption of once a day milking and increasing per cow production are placing pressure on udders. However, including UO in BW will involve some double counting because the cost of culling bad udder cows is included in both the UO economic value, and also in the functional survival economic value. While it would be possible to reduce the impact of UO on the indirect functional survival component of the final functional survival estimated breeding value, it is too late to rework this for November 2021 release. The impact of UO on the indirect functional survival breeding value is relatively modest, and once a bull has a number of daughters reaching their 3rd and later parities, indirect functional survival becomes less influential.

Wiki resource for NBO methodology

Technical details related to the NZAEL3.0 evaluation are available on the nzael wiki page (https://wiki.nzael.co.nz/index.php/Main_Page, note login details are required to access this page, if you don't have access please email NZAEL.manager@dairynz.co.nz). Information related to the

National Breeding Objective (NBO) can be found at the following link - https://wiki.nzael.co.nz/index.php/Breeding_objective. The contents of that page are:

Contents

A full list of contents of these pages is in Appendix 4.

Still to be resolved prior to November sign off for implementation in February

- Fonterra milk pricing (capacity adjustment) – results presented here assume a milk volume charge to farmers of 4 cents per litre. We had been assuming a reduction in the penalty based on an indication from Fonterra that they would be removing the capacity adjustment (1 cent per litre) to the milk volume charge, but there is now an unofficial indication it will be reinstated.
- Body condition score (BCS) is directly included in BW, and it was intended from the outset that its inclusion would have been breed neutral. It has transpired that the BCS was not breed neutral in the past, and a separate SAC paper will be presented to recommend the manner in which breed neutrality will be achieved in NZAEL3.0.
- Dispersion of liveweight. This topic will be addressed in another SAC paper. Briefly, the NBO model determines the economic value of 5 year old weight, but the liveweight evaluation is dominated by 2 year old TOP scores and 2 year old weights. The proposed NZAEL3.0 manner for scaling to 5 year old weight was rejected at the last SAC meeting. Here we have increased the within breed dispersion of the current NZAEL 3.0 liveweight EBVs by 15% for index testing purposes, as this creates alignment to the amount of within breed dispersion as for NZAEL 2.0 liveweight EBVs.

Support from Farm Advisory Panel (FAP)

Substantial consultation with FAP has been undertaken. In the September FAP meeting, a number of resolutions were passed as follows:

1. That the increased weighting on fertility is supported by FAP members.
2. That it makes sense to partition the fertility weighting across the two EBVs, given that further refinements are planned, and acknowledgement that poor cow fertility (CSD123) has a greater economic impact than poor heifer fertility (CSD0).
3. That the non-linear approach to Udder Overall is preferred and that full culling costs should be included in the calculation, even though that would result in some very modest double counting with functional survival.

There is a strong level of support and buy in from the FAP for the proposed changes.

Implications for Production Worth (PW) and Lactation Worth (LW)

Production worth is an economic function of producing values, and lactation worth is an economic function of adjusted phenotypes. In the past, for PW and LW there have been special weights for milk, fat and protein, based on more recent prices, rather than the 5-year average used for BW economic values. However, it is unclear what the value of this is. We know that the milk price fluctuates quite a bit, and that VCR is also very unstable. Therefore, it is questionable whether using this year's milk price and VCR are substantially better at predicting the near-term future, compared to using the 5 year average.

Impacts on EBV correlations and 10-year genetic gains

Appendix 3 presents correlations for estimated breeding values of interest, with the new (provisional) BW and current BW indexes. The new index will deliver more genetic gain in milk solids and fertility, at the expense of slightly higher milk volume and slightly higher liveweight. Capacity, Udder Overall, and Legs will have more favourable trends. Gestation length will decrease by between 0.6 and 1.3 days (breed dependent), such that the shortening trend in gestation length is 50% stronger relative to selection on the current BW.

Recommendations

1. The SAC recommend (to the NZAEL board) that the economic weights for Milk, fat, protein, liveweight, body condition score and somatic cell score be updated in line with the standard procedure of taking 5-year averages of key price assumptions.

2. The SAC recommend the new economic weights for the two underlying fertility traits (CSD0 and CSD123) even though a single fertility trait CR42 is the published EBV for fertility.

3. The SAC recommend adoption of the new economic weight for functional survival.

4. The SAC recommend the inclusion of Udder Overall in the BW.

5. The SAC recommend a non-linear economic weight for Udder Overall that penalises poor udders to a greater extent than it rewards good udders.

Appendix 1 – more specific details on BW changes

Documentation of assumptions and approaches to BW calculations is currently a priority for the AbacusBio team. The primary documentation location will be the NZAEL wiki. Additional documentation takes the form of powerpoint presentations to FAP and AB Enrollees, as well as this Appendix, and a paper for the NZAEL Board. This section provides a summary explanation of changes as of 29th September.

Milk price and value component ration (VCR) changes

The table below summarises the time series of milk price assumptions which drive the revenue component of the economic values of fat, protein, and volume. The 5-year average VCR for 2022 is 1.14, compared with a value of 1.16 in BW2020. This is only a modest change, given the current (2020 and 2021) values are lower than 1 in the 5-year average and have replaced values of similar magnitude in 2015 and 2016. The 5-year average CPI adjusted pay-out has however increased significantly from $6.32 to $7.29 (a 15% increase).

At the time of writing of this paper, the capacity adjustment was fully excluded from the milk volume penalty (as opposed to using the 5-year average and only keeping 4/5th of the adjustment). However, pending advice from Fonterra, the full capacity adjustment may need to be reinstated.

Season, CPI ref	Index year	VCR	Pay-out	CPI	Volume charge	Capacity adjustment	CPI adj pay-out
2006/07, 2007Q2	2007	0.39	$4.13	832			$5.20
2007/08, 2008Q2	2008	0.36	$7.37	865			$8.92
2008/09, 2009Q2	2009	0.35	$5.21	882			$6.19
2009/10, 2010Q2	2010	0.49	$6.16	896			$7.19
2010/11, 2011Q2	2011	0.60	$7.36	944	0.0290		$8.16
2011/12, 2012Q2	2012	0.47	$6.40	953	0.0290	0.0100	$7.03
2012/13, 2013Q2	2013	0.46	$5.84	959	0.0290	0.0100	$6.38
2013/14, 2013Q3	2014	0.35	$8.30	968	0.0290	0.0100	$8.98
2014/15, 2014Q4	2015	0.67	$4.65	976	0.0290	0.0100	$4.99
2015/16, 2015Q2	2016	0.93	$4.30	979	0.0298	0.0100	$4.60
2016/17, 2016Q2	2017	1.07	$6.52	983	0.0296	0.0100	$6.94
2017/18, 2017Q2	2018	1.84	$6.79	1,000	0.0296	0.0100	$7.11
2018/19, 2018Q2	2019	1.25	$6.35	1,015	0.0296	0.0100	$6.55
2019/2020, 2019Q2	2020	0.83	$7.14	1,032	0.0296	0.0100	$7.24
2020/2021F, 2020Q2	2021	0.71	$7.55	1,047	0.0296	0.0100	$7.55
2021/2022F, 2021Q2	2022		$8.00	1,047	0.0296	0.0100	$8.00

Why milk has gone up, relative to liveweight

The table below summarises the economic value calculations for liveweight in BW2022 versus BW2020. The final economic values are equivalent, because the higher feed costs of heavier replacement heifers and cows in BW2022 are offset by higher revenues from cull cows and bobbies.

	BW 2022			
Live weight (kg)	Value $	Expressions per cow	Product	
Live weight cow maintenance (per 1 kg increase in cow LW)	-1.19	1.00	-1.19	
Live weight bobby calf value (per 1 kg increase in cow LW)	0.17	0.81	0.14	
Live weight replacement cost (per 1 kg increase in cow LW)	-2.53	0.27	-0.69	
Live weight value change cull cow carcase value (per 1 kg increase cow LW)	1.97	0.18	0.36	
Total				-1.38
	BW 2020			
Live weight (kg)	Value $	Expressions per cow	Product	
Live weight cow maintenance (per 1 kg increase in cow LW)	-1.18	1.00	-1.18	
Live weight bobby calf value (per 1 kg increase in cow LW)	0.17	0.81	0.09	
Live weight replacement cost (per 1 kg increase in cow LW)	-2.44	0.27	-0.66	
Live weight value change cull cow carcase value (per 1 kg increase cow LW)	2.03	0.18	0.37	
Total				-1.38

The milk price (based on 5-year average) has gone up by 15% resulting in 22% higher economic values for fat and protein, while the weighted average feed prices as per forage value index have only gone up modestly (see Table below).

New Zealand weighted average feed prices ($/kg DM) by season for BW2020 and BW2022 economic value calculations

Feed costs by season	2020	2022
Winter	0.35	0.37
Early Spring	0.44	0.47
Late Spring	0.20	0.20
Summer	0.27	0.25
Autumn	0.32	0.30

Fertility

The NZAEL 3.0 fertility genetic evaluation process has a number of improvements over the NZAEL 2.0 system. This includes the inclusion of heifer calving dates, better use of all calving dates, and better data quality filters and controls. Validation has shown that the new approach is significantly better for predicting genetic merit for a tighter calving pattern. However, there is still a strong desire by many stakeholders to progress towards a conception-based definition of the fertility trait, with the expectation that this will reduce the apparent favourable fertility of very short gestation length animals, and better predict the genetic merit of fertility-based culling (i.e. tight calving pattern with which the current trait targets, does not directly translate to less empty cows). Historically, we have not been able to take a conception-based approach, due to the need to obtain pregnancy diagnosis data on a large number of cows.

The changes to the fertility genetic evaluation both now, and in the future, will necessitate spreading the weighting across multiple fertility EBVs. While we are able to use a simple formula to generate a single CR42 EBV with analogous definition to the historic fertility EBV, we are proposing to weight tow of the new fertility traits independently in the calculation of BW. That will involve separate economic weights for heifer calving season day, versus cow calving season day. This separation would likely evolve further during 2022 if planned research on the conception-based fertility trait is progressed.

Further, a number of assumptions going into the fertility economic value have been revised. These include:

1. The genetic regression effects of the CSD123 EBV on survival, and CR42 have been re-estimated using data from the validation study, noting that the data used as the dependent variables were not included in the EBV estimation.
2. The net cost of a cow being culled for fertility has been incorporated with units of percent surviving and using an updated net cost of replacing a cow at the end of the milking season increased from ~$1400 to ~$2000.
3. There is a separate weight on heifer calving season day which considers the value of empty heifers (lower than the cost of an empty cow) and lost milk production from later calving (less milk lost than for later calving cows)
4. The value of AI calves (either for surplus/export sales, or AI beef matings) is substantially lower than it used to be, as the industry size is more stable, and sale of dairy heifers for live export is no longer a significant source of income.

5. The savings in backup bull requirements with higher in calf to AI rates has been included (but the value is very modest).

Functional survival

The methodology for calculating Functional Survival is based on the same methodology principles as previously for Residual Survival. However, it has been modified to account for the change in units (from days surviving, to percent surviving from one parity to the next). The cost of a replacement heifer has increased substantially from $1320 to $1975. The new value is based on a weaner cost of $676, 52 weeks of grazing @$12 per week, $221 to cover interest, deaths, breeding, health and reproductive failure costs to R1, and then 13 weeks and $28 per week through the final winter plus $91 of deaths, animal health and interest.

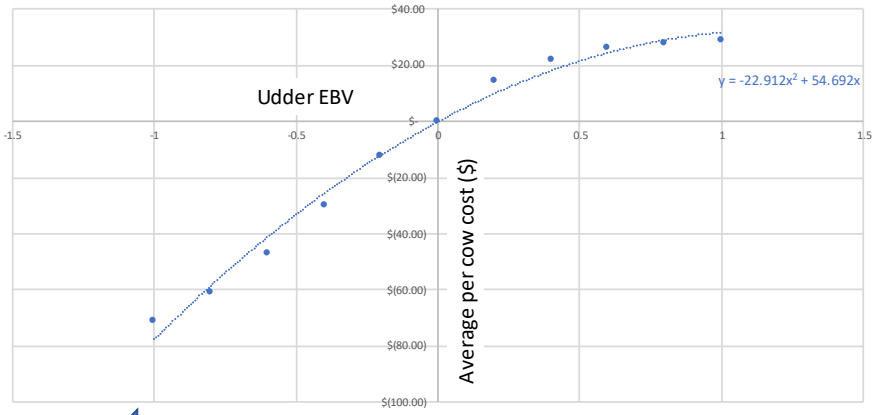
The overall index emphasis on functional survival does not increase, partly because of more weighting on other traits, but also because of the relatively low amount of spread in functional survival breeding values because of low heritability.

Appendix 2. The new set of economic weights

Economic weights of traits for the current BW 2020 and updated BW 2022			
Trait (units)	**Economic Value ($/unit change)**		
	Updated BW 2022	**Current BW 2020**	**% change**
Milk Fat (kg)	5.18	4.25	+22%
Milk Protein (kg)	5.21	4.26	+22%
Milk Volume (litres)	-0.0951	-0.094	-1.1%
Live weight (kg)	-1.38	-1.38	0%
Residual Survival (days of average herd age)		0.11	
Functional Survival (percent surviving)	2.65		
Somatic cell score (log of cell counts cells/ml)	-42.89	-37.11	+16%
Fertility (% calving in first 42 days of caving season)		5.92	
Fertility (Calving Season Day cows)	-8.08		
Fertility (Calving Season Day heifers)	-2.40		
Body condition score (units)	115.40	101.96	+13%

It is planned that a non-linear weighting be applied for udder overall.

Average per cow cost as function of udder overall EBV



Higher chance of actually being in worst 20% of population for a "bad udder"

abacusbio.

Appendix 3 – Impact on correlations of traits with indexes and expected genetic responses by breed for the provisional BW2022 versus the existing BW2020.

Note that the changes in responses and correlations also reflect the changes in estimated breeding values from NZAEL 2.0 to NZAEL 3.0, and all of the changes are measured in terms of NZAEL 3.0 trait definitions.

Correlations for NZAEL 3.0 EBVs with the current index (2020) and the proposed index (2022)								
	Jersey		**Crossbred**		**Holstein Friesian**		**O'Seas Holstein**	
	2020	2022	2020	2022	2020	2022	2020	2022
Milk	0.17	0.27	-0.23	0.01	-0.12	0.06	0.15	0.27
Fat	0.78	0.82	0.64	0.72	0.76	0.83	0.76	0.86
Protein	0.61	0.68	0.05	0.30	0.26	0.44	0.59	0.67
SCC	-0.17	-0.15	-0.15	-0.15	-0.08	-0.09	0.08	0.06
Fertility	0.23	0.33	0.27	0.38	0.20	0.30	0.34	0.39
Gestation length	-0.23	-0.28	-0.11	-0.18	-0.21	-0.30	-0.07	-0.17
Functional Survival (%)	0.50	0.54	0.28	0.31	0.35	0.31	-0.05	-0.03
Body Condition Score	0.28	0.30	0.01	0.08	0.04	0.05	0.23	0.18
Liveweight	-0.04	0.07	-0.37	-0.14	-0.19	0.01	-0.32	-0.23
Capacity	0.39	0.41	0.10	0.19	0.06	0.16	0.10	0.10
Udder overall	-0.01	0.16	-0.04	0.16	-0.06	0.12	-0.22	-0.17
Legs	0.13	0.01	0.18	0.04	0.15	0.05	0.21	0.14

Expected trait unit responses (NZAEL 3.0 EBVs) after 10 years of selection on the current index (2020) and on the proposed index (2022)								
	Jersey		**Crossbred**		**Holstein Friesian**		**O'Seas Holstein**	
	2020	2022	2020	2022	2020	2022	2020	2022
Milk (kg)	59.36	93.96	-129.70	5.93	-57.07	28.35	83.54	148.22
Fat (kg)	14.26	14.84	12.50	14.15	15.24	16.71	14.71	16.72
Protein (kg)	6.98	7.74	0.91	4.91	3.58	5.94	9.35	10.67
SCC	-0.07	-0.07	-0.08	-0.08	-0.04	-0.04	0.03	0.02
Fertility (% CR42)	1.43	2.05	2.16	3.06	1.37	2.04	1.80	2.11
Gestation length (days)	-0.91	-1.14	-0.60	-0.93	-0.92	-1.3	-0.23	-0.58
Functional Survival (%)	1.04	1.12	0.67	0.74	0.69	0.60	-0.09	-0.04

Body Condition Score	0.05	0.06	0.00	0.02	0.01	0.01	0.03	0.02
Liveweight (kg)	-0.98	1.54	-16.38	-6.02	-5.87	0.16	-7.07	-5.06
Capacity	0.18	0.19	0.06	0.11	0.03	0.08	0.04	0.04
Udder overall	0.00	0.09	-0.02	0.10	-0.03	0.06	-0.10	-0.08
Legs (low preferred)	0.02	0.00	0.03	.001	0.03	0.01	0.04	0.03

Appendix 4 – Content of Breeding Objective page on NZAEL wiki