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Technical Series ^{Issue 22}

Genetic improvement

Demystifying the black box

DairyNZ 

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In this issue of the *Technical Series...*

This *Technical Series* focuses on two central pillars of New Zealand dairy farming – genetic improvement in dairy cattle and ryegrass.

New Zealand's dairy farming history includes detailed animal records, herd testing and assessment of animals' physical conformation. These have provided a great resource of phenotypic data for artificial breeding.

This phenotypic data adds greatest value when converted to genetic merit indices such as breeding values, breeding worth and production worth.

To create economically relevant genetic indices for dairy cattle, excellent data capture, databases, economic values and animal evaluation models are required. New Zealand has a world-leading reputation in this area.

This is due to the dairy industry's investment and support, and many recognised experts working in New Zealand.

This issue of the *Technical Series* describes the genetic evaluation system for dairy cattle – from on-farm identification, recording and measuring, to genetic estimation. It also focuses on crucial elements where farmers can maintain and enhance genetic gains.

The value of genetic improvement is demonstrated in productivity, efficiency and environmental impacts through to farm profit.

To realise the largest profitability gains from better animal genetics, improvement is also needed in pasture plant genetics, especially in ryegrass, the predominant pasture species.

The new DairyNZ Forage Value Index for perennial and short-term ryegrasses has been a true collaborative effort.

While the Forage Value Index is in its build phase, the animal breeding worth system is an ongoing evolution. New genetic traits such as lameness and facial eczema are being explored, along with strengthening the estimates of existing traits, such as fertility.

To support the development of the DairyNZ Forage Value Index and identify useful genetics, a network of plot and on-farm trials, databases, evaluation systems and research has been established. These initiatives are described in this issue.



Demystifying the black box – genetic evaluation

Genetic evaluation of dairy cattle might seem like a black box – data comes in, fancy maths occur and genetic information comes out. In a way, that is true, but there really is much more to the national genetic evaluation system for dairy cattle.



Jeremy Bryant, NZAEL manager

Key findings

- Genetic evaluation of dairy cattle is dependent on precise and widespread animal identification, on-farm measurements and accurate recording.
- Detailed and comprehensive measuring and recording allows better decisions.
- Genetic evaluation indices are not as complicated as they seem and are practically and economically relevant.

Genetic evaluation comprises several key factors that can be broken down into two main parts:

Animal identification, measuring and recording (on-farm)

This starts with recording which sire was mated to which cow, then assigning the calf to the correct dam. When progeny are born, body weights and body condition scores, herd test results, conformation traits, milking speed and temperament observations, recording reason and time of exit from the herd are all determined.

Genetic estimation (off-farm)

Phenotypic data (animal details and performance) is recorded on-farm or in the lab, with separation of genetic effects from environmental effects. These help produce breeding values (BV – the genetic estimates) for individual traits.

These BV are combined with economic values used to produce breeding worth (BW) or production worth (PW). ►

Figure 1. New Zealand dairy cattle genetic evaluation system



Parentage identification



Correct parentage identification is crucial for accurately calculating genetic evaluations.

Correct parentage identification is crucial and, in many herds, often poorly completed. A recent study of 20,000 cows from 97 herds found that 23 percent of cows tested had incorrect sire information¹.

Mismothering can occur naturally when many cows calve in a short space of time. Progeny of genetically superior sires can easily be assigned to inferior sires. Hence, the superior sires do not get credit for their elite progeny. Their genetic evaluations are biased downward, in effect shrinking the scale of BV and BW².

This also impacts on farmers' own cow genetic selection decisions when cows are not assigned their own calf. This inaccurate information feeds back on the dam's genetic merit estimate.

Two approaches can address poor parentage identification on-farm.

- Assign someone dedicated and well-trained in checking and recording births. This includes tagging calves in the paddock and recording every birth and mother's identification as close to birth as possible.
- Verifying parentage using a DNA sample.

New Zealand Animal Evaluation Limited (NZAEL), a subsidiary of DairyNZ, has recognised that poor parentage could be contributing to reproof effects.

Reproof effects are where a bull's estimate of genetic merit from hundreds or thousands of daughters is lower than that based on initial progeny test results with fewer daughters. This may be because the estimates of genetic merit in progeny test herds (historically approximately 5 percent misparentage²) are far more accurate than in commercial herds (23 percent misparentage¹).

NZAEL is attempting to improve estimates of bull genetic merit by determining the heritability within a herd. Heritability is an estimate of the proportion that genetics or genes alone, and not environment, contribute to differences in performance between individuals.

When heritability is lower than average, parentage recording in that herd is generally poorer³. This approach can screen herds so they provide more accurate data to produce estimates of sire genetic merit.

Genetic estimation



The animal's parentage information and ongoing phenotypic data feeds into genetic estimation.

Recording and measuring



A contemporary group, where animals are compared with their contemporaries, is an essential element of genetic evaluation. A contemporary group is a group of cows of the same age in the same herd, that calved in the same year and season (autumn or spring). This ensures an accurate genetic-only estimate for the animal.

Phenotypic measurements and recording can come from many different sources.

Herd testing provides essential 'contemporary group' data on milk yield, protein, fat and somatic cell count.

Weighing cows significantly improves the accuracy of a cow's PW, because weighing allows better identification of more efficient animals. For example, if the whole herd is weighed and 10 cows are culled on PW, three out of those 10 cows would be different if weighing was not undertaken⁴.

Recording of calving and mating events is essential for estimating fertility breeding value.

In New Zealand a TOP (traits other than production) system is used primarily in progeny testing herds but also by breed society members. Participating breed society and AsureQuality inspectors are contracted by breeding companies to inspect sires' progeny for traits such as capacity, body condition score, legs, udder support and udder overall.

They also ask farmers to score cows on a one to nine scale for milking speed, temperament and overall opinion. Some of this data helps predict cow longevity and enable breed companies to cull, or use with care, those bulls with poor BV for TOP traits.

All this data is used to calculate BV, BW, PW and reliability of values. Knowing the relationship between animal performance and their detailed genomic makeup is important.

If the sire or dam is unknown, an animal may be assigned to a genetic group which represents the 'average' sire or dam for all unrecorded animals of the same birth year, breed and country of origin.

When estimating BW and reliability, an animal's ancestry, performance and progeny performance are all considered. As the number of progeny increases, this provides a greater contribution to BW than ancestry or own performance (Figure 2).

The concept of contemporary groups, using within-group comparisons of animals, is an essential element of genetic evaluation.

A contemporary group is cows of the same age in the same herd, that calved in the same season of the same year (autumn or spring), e.g. two-year-olds that calved in spring 2013.

This ensures an accurate genetic-only estimate for the animal. To obtain this, statistical models remove non-genetic effects such as fixed (rearing) and temporary (feeding, climate etc. at the time of the herd test) environmental effects and stage of lactation effects.

The effect of lactation stage should be considered to ensure genetic estimates are not biased for when the cow calved.

The 2006 introduction of the Test Day Model allowed better adjustment for stage of lactation, the environment of each herd test day and differences among cows in terms of maturity and persistency⁵. This resulted in an improved accuracy of evaluation.

BV (genetic merit) and PV (genetic merit, hybrid vigour and permanent environment) are then estimated for individual traits, using primarily New Zealand data⁶, and combined with economic values to estimate BW and PW. All traits contribute to the animal's BW, as illustrated in Figure 3.

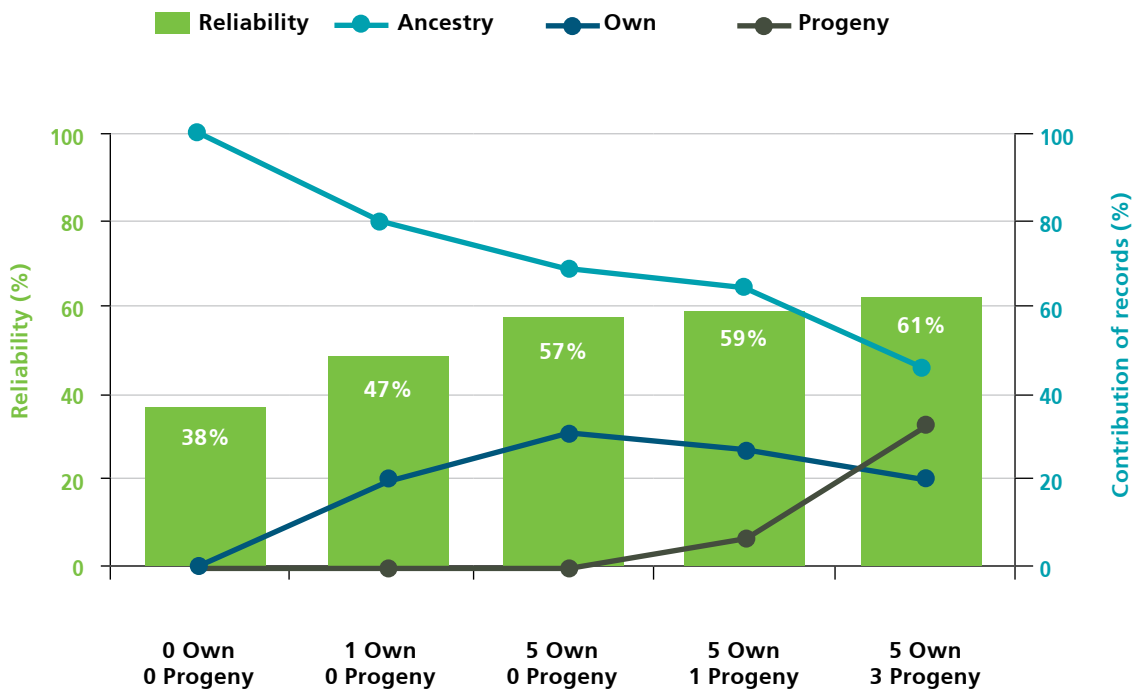
Economic values for all traits are estimated using a breeding objectives model. Economic values for individual traits are calculated based on a one unit change in trait value from industry averages.

For milkfat, the economic value is calculated based on a five-year rolling average (four years historical + one year forecast) farm gate milkfat price adjusted to the consumer price index [CPI]; minus the cost to produce 1 kg of milkfat; minus the reduction in stocking rate to account for that additional kg of milkfat.

The cost to produce 1 kg of milkfat accounts for energy requirements and the opportunity cost of feed.

Footnote: ⁶For overseas sires with or without few New Zealand daughters overseas, data from Interbull is included.

Figure 2. Contribution of ancestry, own and progeny records to reliability



EXAMPLE SIRE

Figure 3. Calculating breeding worth (BV= breeding value, EV = economic value)

Breeding worth (\$/5 t DM)				\$147/35%
	BV		EV	\$ Contrib.
Protein (kg)	28	x	\$9.17	\$257
Milkfat (kg)	22	x	\$2.04	\$45
Milk (litres)	600	x	-\$0.099	-\$59
Liveweight (kg)	70	x	-\$1.66	-\$116
Somatic cell (score)	-0.1	x	-\$38.37	\$4
Fertility (% calved at 42 days)	2	x	\$7.18	\$14
Residual survival (days)	20	x	\$0.135	\$3

Conclusions

Genetic evaluation is a fully integrated system. It encompasses signals from economic markets to determine economic values and traits of importance to the value; identifies, measures and records on-farm; genetic evaluation techniques and information technology to provide genetic estimates.

Accurate and comprehensive phenotypic data recorded on-farm is vital to strengthen the accuracy of genetic evaluation outputs.

The genetic evaluation system and estimates of the traits included are continually being enhanced and expanded, based on research undertaken in New Zealand and overseas.

Fast facts

- A recent study based on 20,000 cows from 97 herds found that 23% of the cows tested had incorrect sire information¹.
- Weighing cows will significantly improve the accuracy of a cow's PW. For example, if the whole herd is weighed and 10 cows are culled on PW, three out of those 10 cows would be different if weighing was not undertaken⁴.

This research was funded by New Zealand dairy farmers through DairyNZ Inc.



Weighing cows will significantly improve the accuracy of a cow's PW.



Value of genetic improvement

The effect of genetic improvement of dairy cattle is an often forgotten component of a farm system. This is perhaps not surprising, as genetic improvement is about incremental, long-term gains. These gains often go unnoticed as years go by. Yet, there are some real tangible on-farm profitability and wider benefits of genetic improvement.

Key findings

- Over 10 years, the accumulated value of genetic improvement alone for an average single dairy herd is in excess of \$250,000.
- Genetic improvement in dairy cattle provides many benefits, including additional milksolids per cow, greater lifetime feed efficiency, higher capital value and improved nitrogen use efficiency.
- Genetic gains can be realised by investing in high breeding worth (BW) bull teams proven in a New Zealand pasture-based environment.



Jeremy Bryant, NZAEL Manager
Peter Amer, Abacus Bio

Our national focus for genetic improvement in dairy cattle is to “identify animals whose progeny will be the most efficient converters of feed into farmer profit”. There are two key words in the national breeding objective (NBO) statement that encapsulate tangible benefits of genetic improvement – efficiency and profit.

To illustrate efficiency and profitability gains arising from genetic improvement, we can consider an average jersey herd today and key differences solely due to genetics in 10 years’ time. Every year, the national herd improves by about \$11 BW units.

This translates into an additional \$11 profit per 5 t DM consumed. These cows produce an additional 2.3 kg MS per lactation and have a greater feed demand to support the additional milksolids (about 16 kg DM).

Liveweight is largely unchanged, so the cows produce more milksolids per kg of liveweight. The cost of energy for maintenance is diluted and cows produce more milksolids per tonne of dry matter.

Over a 10-year period, genetic improvement has contributed to:

- an extra 23 kg of milksolids per cow
- 160 kg DM increase in feed demand per cow
- 5% increase in the amount of milksolids produced as a percentage of liveweight
- 2.5% increase in the amount of milksolids produced per tonne of dry matter
- \$107 increase in profit per 5 tonne of dry matter.

Assuming the average herd size today, the 10 year accumulated value of genetic improvement at current economic values for a single herd alone is \$257,730 (Figure 1).

Positive environmental benefits

A recent study indicated that high genetic merit (high BW and production worth [PW]) cows had significantly higher milk yield, more nitrogen incorporated into milk and less into urine (Table 1)¹.

Another demonstrated benefit of genetic improvement is an increased livestock capital value. Based on data from AgriFax, high BW animals sold in the lower South Island fetch on average \$100-\$300 more than low BW cows². ▶

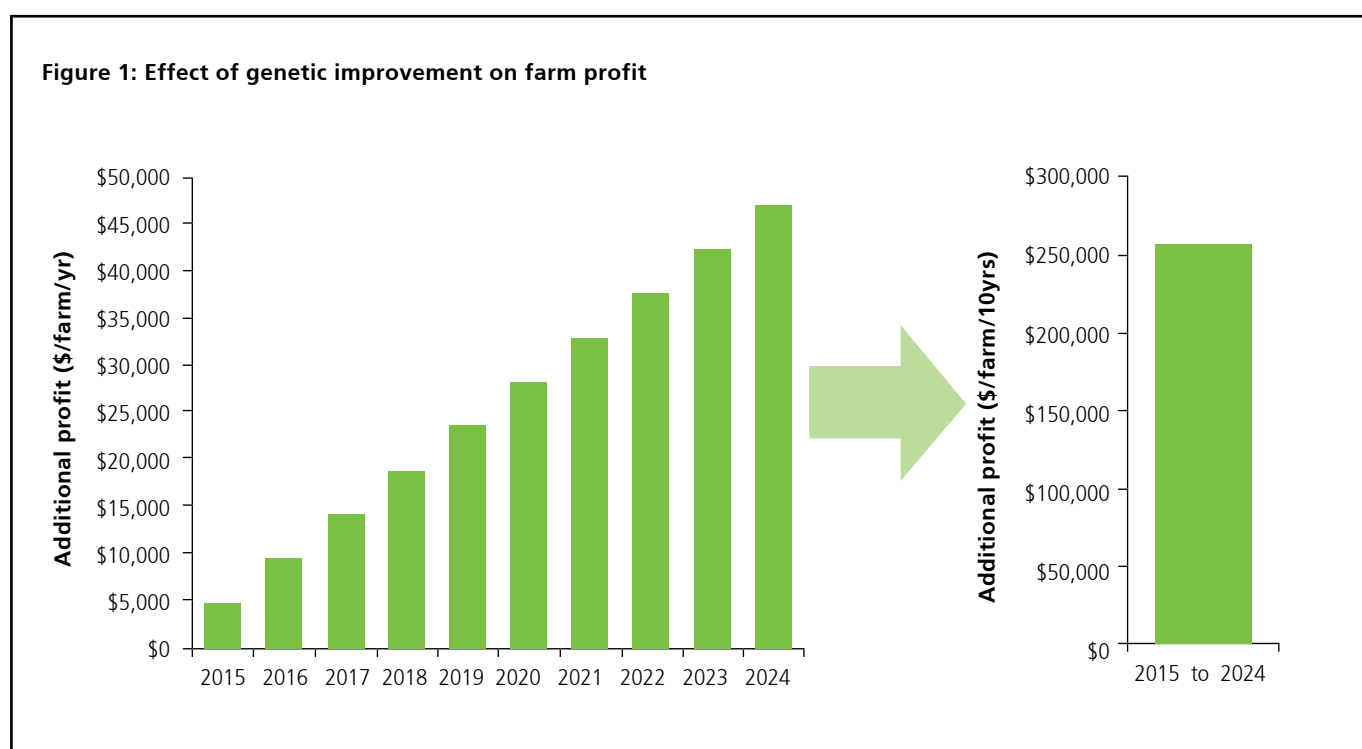
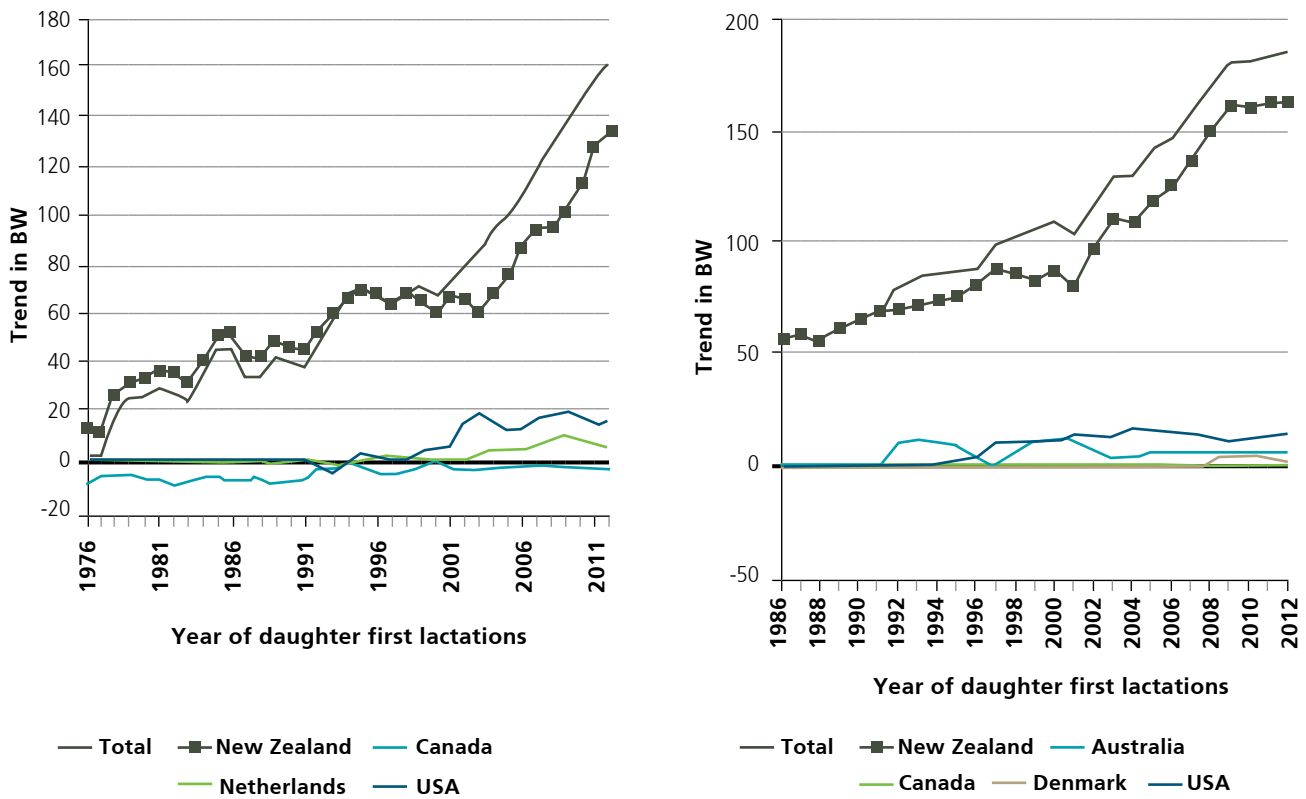


Table 1: Effect of genetic merit on dry matter intake, milk energy output, milk nitrogen and urinary nitrogen efficiency.

	High BW/PW	Low BW/PW
Breeding worth (\$/5t DM)	198	57
Production worth (\$/5t DM)	319	10
Dry matter intake (kg DM/cow/day)	16.0	14.8
Milk energy output (MJ/cow/day)	59.1	48.3
Milk nitrogen/nitrogen intake ratio (g/g)	0.22	0.18
Urinary nitrogen/nitrogen intake ratio (g/g)	0.40	0.46

Figure 3: Contribution of New Zealand and overseas genotypes to sources of genetic gain in BW in friesians (left) and jerseys (right).



Realising genetic improvement

The most powerful way to realise genetic gains is to use elite BW bull teams proven in New Zealand. Recently, a study to explore the sources of genetic gain (New Zealand or overseas) in both jerseys and friesians was undertaken.

The research proved that the strength of New Zealand genetics was due to its strong domestic genetic improvement infrastructure, unlike other countries that relied on the importation of overseas genotypes^{2,3}.

The research showed that the true test of an animal’s genetic merit is if its progeny perform well in a New Zealand system on a mainly pasture-based diet. Relying on an overseas-based proof was not a good indicator of how those sires’ progeny might perform in New Zealand.

That’s not to say that overseas genotypes have not been valuable. They do enhance genetic diversity and contribute positively to genetic gains in individual traits. For instance, holstein-friesian bulls from the USA have contributed significantly to genetic gains in protein.

However, there was a notable negative trend in fertility arising from the importation of overseas bull semen. This contribution to declining fertility made by overseas bulls has now been arrested due to more focus on fertility overseas and due to fertility being strongly emphasised in BW and bull selection by breeding companies.

Conclusions

Over 10 years, the accumulated value of genetic improvement for a single herd alone is in excess of \$250,000. This is achieved via genetic gains in milksolids production and improved lifetime feed efficiency.

Genetic improvement also has environmental benefits leading to less urinary nitrogen per kg of dry matter consumed and per unit of milksolids. High BW cows have a higher market value than their low BW counterparts. These genetic gains can be best realised by investing in high BW bull teams proven in a New Zealand pasture-based environment.

Fast facts

Over a 10-year period, genetic improvement has contributed to:

- an extra 23 kg of milksolids per cow
- 160 kg DM increase in feed demand per cow
- 5% increase in the amount of milksolids produced as a percentage of liveweight
- 2.5% increase in the amount of milksolids produced per tonne of dry matter
- \$107 increase in profit per 5 tonne of dry matter.

Funded by New Zealand dairy farmers through DairyNZ Inc.



Forage Value Index: the PW for pasture

The DairyNZ Forage Value Index (FVI) can be described as the pasture equivalent of the production worth (PW) index for dairy cows, with a few twists.

Key findings

- The DairyNZ Forage Value Index (FVI) is in its build phase.
- The blueprint is well mapped out and there are no obvious substantial technical barriers that would stop it in its tracks.
- However, a lot of data is required for individual cultivars and new research knowledge is needed to ensure the FVI is fit-for-purpose and well-aligned with what farmers can expect to see in their paddocks.
- The most significant limiting factor is time – time required to collect performance value (PV) information for cultivars/ species, regions and traits. The other limitation is resolving the big science questions about persistence between species competition, the relationships between nutritive value and feeding value, and the effects of different scales of evaluation on cultivar rankings.
- The FVI is currently akin to a ‘rising one-year-old’ but it will grow out to be one of the best cows in the herd, once fully mature.



David Chapman, DairyNZ

Jeremy Bryant, Muyi Olayemi, Elizabeth Leonard, Julia Lee, Wendy Griffiths, Cathal Wims, Bruce Thorrold, DairyNZ. Grant Edwards, Lincoln University.

At its core, the FVI is a ranking system, initially focusing on perennial and short-term ryegrass cultivars. Like the PW index, several traits are included and cultivars are ranked according to the cumulative economic benefit of each trait compared with a genetic base of older ryegrass cultivars, such as Nui, for perennial ryegrass.

One of FVI’s twists is that rankings are presented for four different regions within New Zealand, whereas the PW index applies nationally. There are two main reasons for this. The first is that the economic value (EV) of traits like dry matter yield differ according to region. The second reason is that cultivar performance values (PV) follow a different ranking order when compared across regions (at least for seasonal dry matter yield).

Pasture growth is highly influenced by climate and there are ►

significant genotype x region interactions in cultivar performance which are probably related to differences in the intensity of, for example, summer moisture deficits and insect pest pressure.

Another twist is that the FVI applies to a whole cultivar, where the seed that makes up each cultivar is a collection of thousands of different individual genotypes. Hence the FVI cannot be used for breeding purposes like the PW index – it is purely an evaluation tool.

Plant traits

Several plant traits influence profit derived from ryegrass-based pastures. Theoretically, all can be included in a forage value index however, practically, traits can only be included if:

- an EV can be calculated for them
- they can be accurately and routinely measured in field trials
- sufficient data is available from which to calculate PV for individual cultivars.

The key productivity traits in perennial temperate grasses are dry matter yield and nutritive value, with persistence also considered critical in regions subject to periodic climatic and biotic stresses.

The importance of these traits has been established for many years¹ and reinforced by recent reviews^{2,3}. EV can be calculated for each, though published EV are mostly confined to dry matter yield, with relatively few examples available for nutritive value⁴.

In New Zealand, the National Forage Variety Trial (NFVT) system operated by the New Zealand Plant Breeding Research Association (NZPBRA) is the only national, systematic cultivar evaluation scheme in operation.

In the past, the NFVT has measured only dry matter yield; hence this is the only trait for which sufficient data is available to calculate PV for cultivars at present. For this reason, the current DairyNZ FVI (dairynz.co.nz/fvi) is restricted to dry matter yield. However, field trialling has already expanded to include testing for nutritive value and persistence.

An important outcome of the multi-trait approach is that trade-offs among plant traits can be made explicit. For example, selecting plants to maximise above-ground growth may dilute some of the characteristics required for long-term plant survival under intense grazing, in the presence of periodic growth stresses such as insect pest damage or soil water deficits.

The negative relationship between ability to survive under adverse growing conditions and the rate of production of above-ground biomass is very well-established in plant ecology⁵. Pasture plant breeders counter the possible negative effects of unintended co-selection by backcrossing new selections with elite germplasm that is well-adapted to the target environment⁶.

This is a ‘yield versus persistence’ trade-off. A multi-trait FVI provides a way to make such trade-offs explicit, so farmers can directly compare the pros and cons of different options available to them.

Filling in the gaps

The pathway from where we are now to a fully functional FVI that farmers trust and use frequently includes the steps listed in the table (right).

Work is underway in all of them, carried out collaboratively by the partners in this programme (DairyNZ, NZPBRA, AgResearch, Lincoln University and Massey University). There are also close links to researchers at the Teagasc Moorepark Research Centre in Ireland who are developing a similar system for the Irish dairy industry⁴.

Looking further ahead

Most of the steps outlined in the table (right) are focused on ryegrasses since they are the most heavily used forages in the New Zealand grazing industries. However, other species, such as tall fescue, white clover or lucerne, can be included in future, if sufficient PV data is available.

Likewise, while the traits being considered initially are all about production, environmentally-related traits could be included in future. For example, if some forages reduce total nitrogen intake of animals and, therefore, total urinary nitrogen load, they may help reduce nitrate leaching to levels permissible under regional land and water plans.

When permissible leaching limits are known, it should be possible to calculate an EV for this trait and then explore its effects in the multi-trait index.

This work is funded by New Zealand dairy farmers through DairyNZ Inc.



Steps to a fully functioning Forage Value Index (FVI)

What do we need to do?	Why and how?
<p>Complete the FVI lists for seasonal dry matter yield for all cultivars of annual, Italian and perennial ryegrass, including specific cultivar x endophyte combinations for the perennials</p>	<p>The primary source of data for this is the National Forage Variety Trial (NFVT) series, with protocols in place to determine when a cultivar has been tested sufficiently in different regions to be eligible for inclusion in the FVI. This is ongoing, providing the bed-rock testing for all new cultivars as they come onto the market.</p>
<p>Confirm whether or not the cultivar rankings for dry matter yield emerging from NFVT hold when cultivars are subject to normal farm management</p>	<p>There are many differences between the way pastures are managed in NFVT plots and the way they are managed in farmers paddocks. Therefore, the pasture equivalent of the sire proving scheme in animal evaluation is being set up to build confidence in the FVI. The FVI article in the April 2014 <i>Inside Dairy</i> provides more information on the cultivar proving scheme.</p>
<p>Add nutritive value information to the FVI</p>	<p>Nutritive value is routinely included in European cultivar merit testing schemes⁷, but has not previously been assessed in New Zealand. In 2013, a trial comparing 23 perennial ryegrass entries under full irrigation or partial irrigation was established at Lincoln. All the major nutritive value attributes (digestibility, crude protein, fibre etc) are being measured at each harvest. Information from this trial will be used to: 1) calculate PV for the FVI of cultivars included in the trial, and 2) determine how many trials are needed where, and how often they should be repeated, to provide a full picture of cultivar differences.</p>
<p>Determine the best way to measure persistence and set up the required intensity and frequency of trials</p>	<p>Persistence is the most difficult of the three main traits to address. Firstly, there are different ways of defining 'persistence' which need to be standardised². Secondly, the extent to which plant genetics contribute to persistence failure relative to management and/or major environmental stresses like drought and pest attack is not known. Thirdly, by definition, it takes many years to test how well cultivars truly persist. Genetic tools and plant phenotype analysis are now being used to address the first and second points. In 2013 and 2014, NZPBRA initiated a new series of trials dedicated solely to comparing cultivars for persistence which will also help address the second and third points.</p>
<p>Determine how to account for the effects of competition between grass and clover on dry matter yield and nutritive value</p>	<p>All NFVT yield trials are conducted using ryegrass monocultures. However, farmers almost always sow white clover with perennial ryegrass and performance rankings can change when clover is included in the mix⁸. Since 2012, DairyNZ and AgResearch have been conducting experiments in four regions (Waikato, Manawatu, Canterbury and Southland) comparing eight perennial ryegrass cultivars grown with or without white clover, at each of two nitrogen fertiliser levels to address this issue and provide direction regarding how to adjust FVI information if necessary.</p>
<p>Account for, if necessary, differences between cultivars in the efficiency with which animals graze them</p>	<p>Farmers and researchers commonly observe that tetraploids are grazed more readily than diploids, leaving more consistent residuals. The outcomes for the overall amount of pasture grown and eaten, and pasture quality, on farm could be very important. It is necessary to understand if such differences can be explained simply by differences in nutritive value, or if other features need to be taken into account to position cultivars accurately. Initial work conducted in the Waikato last spring/early summer measuring pasture structure of, and animal grazing behaviour on, eight perennial ryegrass cultivars will be expanded in 2015, to the point where differences in milk production can be assessed and related to pasture characteristics⁹.</p>
<p>Confirm that the economic differences between cultivars predicted in the FVI eventuate when the expected differences in dry matter yield and nutritive value are captured in extra grass grown, milk production and profit</p>	<p>The FVI relies on computer models to calculate economic values and small-plot trials to derive performance values. Several assumptions must be made to translate these to the farm and these assumptions need to be tested in a self-contained grazing system experiment.</p>



Breeding robust dairy cows

The dairy industry national breeding objective is to ‘identify animals whose progeny will be the most efficient converters of feed into farmer profit’. To achieve this objective, seven traits are used in the calculation of breeding worth: milkfat, milk protein, milk volume, liveweight, residual survival, somatic cell count and fertility.

Key findings

- Accurate records are important. Animals with incorrect parentage can reduce the rate of genetic gain.
- Despite low heritability, genetic progress towards cows that are less susceptible to lameness may be possible.
- Selection for facial eczema tolerance is possible and a pool of sires contributing to greater tolerance is available.
- Better fertility genetics may be possible by using new trait definitions.



Susanne Meier, DairyNZ scientist

Selection on a broader range of traits may ultimately result in greater sustainability and profitability of dairy farming.

This project is currently evaluating on-farm recording of animal parentage, if a greater rate of genetic gain for fertility is possible, heritability of susceptibility of lameness and tolerance to facial eczema.

Heritability estimates the proportion that genetics or genes alone, and not environment, contributes to differences in performance between individuals.

Accurate recording increases genetic gain

Led by *AbacusBio*

Internationally, the average parentage errors (assigning the wrong sire to an animal) are between 4-23%¹. A recent study evaluating parentage errors in more than 20,000 cows from 97 herds, indicated that 23% of New Zealand cows tested had incorrect sire information². However, in 12 of those herds, the parentage error exceeded 40%.

Correctly identifying replacement heifers allows retention of the most genetically superior animals (see *Inside Dairy* June 2012, pg 20). Hence, assigning the wrong sire can reduce genetic gain, with lower heritability traits, such as fertility, the most affected³.

Is lameness inherited?

Led by *Lincoln University*

Lameness is costly and prevalence can vary significantly with 4-50% of cows within a herd affected each year^{4,5}. Previous research using clinical lameness records has identified a genetic component of this trait⁶. A more specific study of pasture-based lameness was needed. Lameness records from 65 South Island herds (>100,000 cow records) over three seasons were used⁴. The heritability of lameness was calculated to be 5%, similar to that determined for cows overseas ($h^2 = 7\%$)⁶. Despite the low heritability of lameness, the genetic variation in lameness susceptibility between sires is high, with the potential to reduce the prevalence of lameness in daughters by up to 15%.

Tolerating facial eczema

Led by *CRV-Ambreed*

Facial eczema (FE) is of significant concern for animal welfare and productivity. FE is caused by exposure to toxins (sporidesmin) from a fungus present only under certain environmental

conditions. Identifying tolerant animals through natural exposure takes considerable time. For dairy sire selection, this means sires are 'old' before an accurate proof of FE tolerance is available.

A similar approach to that used by the sheep industry is being trialled to accelerate the identification of tolerant sires. Using a standardised challenge with sporidesmin, several young bulls have been identified as 'FE tolerant' and semen from bulls more tolerant to FE is available. Increasing protection against FE through breeding 'tolerant' animals is a slow process, so continued proactive management for FE will be required for some time yet.

Gains in fertility

Led by *AbacusBio*

The possibility of increasing genetic gain for fertility was evaluated using data from the National Herd Fertility Study². Novel approaches to calculate fertility traits, including some new traits, were tested to improve the accuracy of the fertility breeding value (BV).

This approach included penalising cows that had reproductive interventions (such as treating cows for anoestrus or inductions); calculating calving rate to artificial insemination as calving days from planned start of mating (including heifer calving dates); and the first recorded date of oestrus for all cows. These traits increased the accuracy of the fertility BV by 12%. The next step of validating the potential improvement in breeding for better fertility is now underway.

This is part of the Transforming the Dairy Value Chain Primary Growth Partnership programme, funded by DairyNZ and the Ministry for Primary Industries.



The next step of validating the potential improvement in breeding for better fertility is now underway.



New research to improve cow fertility and lifetime productivity

DairyNZ has a new research programme to improve both cow fertility and lifetime productivity on dairy farms. This is part of a partnership programme with the Ministry of Business, Innovation and Employment (MBIE) and additional funding from AgResearch.

Key findings

- DairyNZ is leading new research to develop novel approaches to accelerate genetic gain in fertility and enhance farmers' ability to manage for improved fertility.
- The intended outcomes for farmers are 1) cows that are inherently more fertile, and 2) improved resources for taking managerial advantage of these better genetics.
- Linked research will investigate premature death, involuntary culling and health-related production losses in dairy cattle with the aim of developing farm management strategies that profitably extend cow longevity and increase lifetime productivity.
- DairyNZ, MBIE, AgResearch, universities, veterinary and independent researchers are contributing to the overall programme, along with LIC, CRV Ambreed, Fonterra, and commercial herd owners.



Claire Phyn, Chris Burke and John Roche,
DairyNZ

This programme's primary focus is to improve herd reproductive performance in New Zealand dairy systems and lift lifetime productivity by reducing chronic under-performance and poor survival of animals due to many known and unknown reasons.

Together, these inefficiencies are estimated to cost the dairy industry \$1 billion annually. By reducing these costs substantially, the research is aiming to improve farm profitability and animal welfare.

Over the next seven years, DairyNZ and MBIE will contribute equal funding to the research programme. Additional funding and resources are being provided by AgResearch, Fonterra and LIC.

DairyNZ principal scientist Dr John Roche is leading the overall programme, which involves a large team of New Zealand and international scientists.

Achieving industry targets for reproduction

The profitability of dairy farming could be increased by \$500 million per year if industry targets for reproductive performance are achieved.

The New Zealand targets are that “the average dairy herd will achieve a 78% six-week in-calf rate and a 6% empty rate after a 12-week mating period, without the need for hormonal interventions”.

These goals will not be achieved using current knowledge and technologies alone. A biological breakthrough is required.

The fertility aspect of the research is led by DairyNZ’s Dr Chris Burke, with scientists from AgResearch, University of Victoria-Wellington, University of Queensland, Cognosco, AbacusBio and New Zealand Animal Evaluation Ltd (NZAE).

The aim is to develop ways to accelerate genetic gain in fertility and manipulate the biology that underpins cow fertility.

The first challenge is reducing the 30% of conceptions in the first 35 days after insemination that are not sustained as a pregnancy. The magnitude, timing and reasons for pregnancy failure in commercial herds will be measured for the first time in a study led by AgResearch, supported by DairyNZ and Fonterra.

Another key research platform, however, will be an animal model with extreme diversity in genetic fertility. This herd will be used to unravel the underlying biology that differentiates

genetically fertile from infertile cows.

A ‘low’ vs ‘high’ fertility herd will be built from heifers born to about 2800 carefully-selected contract matings in spring 2014. The final herd will be 200 cows of each fertility group.

The animals will be monitored from just after birth through growth, puberty, first pregnancy and to at least first calving to understand phenotypes associated with fertility. These studies will identify new and better ways to measure fertility phenotypes and create the basis for improved genetic selection.

Reducing premature mortality

The ‘lifetime productivity’ project will first determine the timing, incidence and reasons for premature death, non-fertility involuntary culling and health-related productivity losses in dairy cows.

Little is currently known about animal wastage and under-performance in New Zealand dairy systems. Evidence from international studies indicates that the incidence of accidental and premature deaths, and involuntary culling (due to health, welfare or fertility problems) is unacceptably high across a range of dairying systems and is increasing.

If the international trend is followed in New Zealand, it is likely many more than 200,000 cows are lost each year for poorly understood reasons. Cow longevity and lifetime productivity may decline further as dairy systems intensify, particularly with more housing and non-pasture feeds, and as individual cow production increases and herd size grows. ►



If industry targets for reproductive performance are achieved, the profitability of dairy farming could increase by \$500 million a year.

A team of scientists and veterinarians from DairyNZ, Massey University, AbacusBio and Cognosco will conduct a large-scale study using herd records from commercial farming operations across the country. These will also help determine the economics of cow survival and potential improvements in the national genetic evaluation system.

In parallel, VetSouth clinicians will evaluate a computer-based tool for post-mortem diagnosis of cause of death. Canadian technology will be tested to determine its value as a future aid in animal husbandry and herd health programmes, to increase the longevity of dairy cows.

During the second half of the programme, potential solutions to mitigate early animal attrition and productivity losses (as identified from the above approaches) will be investigated in animal experiments and field trials.

The final outcomes will be industry recommendations on animal husbandry, nutrition and farm management practices that reduce premature mortality, increase cow lifetime productivity, and improve animal health and welfare.

Fast facts

- Dairy farming profitability could be \$500 million greater each year if industry targets for reproductive performance were achieved.
- 30% of conceptions in the first 35 days after insemination are not sustained as a pregnancy. The magnitude, timing and possible reasons for pregnancy failure in commercially-operated herds will be measured for the first time in a study led by AgResearch, supported by DairyNZ and Fonterra.
- If the international trend is followed in New Zealand, it is likely many more than 200,000 cows are lost each year for poorly understood reasons.

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Effects of farming without N

(*Glasse et al.¹*)

- A 'No-N' farmlet (no nitrogen [N] fertiliser applied, stocking rate [SR] of 2.56 cows/ha) was compared with a 'Control' farmlet (~181 kg N/ha/year, SR of 3.06 cows/ha).
- The Control farmlet produced 2.9 t DM/ha pasture and 193 kg MS/ha more than the No-N farmlet, both averaged over the 10 years.
- Profitability was very similar for both farmlets in six of the years, with N increasing profit in the other four years.
- When the ratio between milk price and fertiliser cost is more favourable, N fertiliser will increase milk production and profitability.

Sensor data diverge between lame and non-lame cows

(*Kamphuis et al.³*)

- Farmers from five commercial properties recorded all lameness events for 1.5 seasons and sensor data (liveweight, milk yield, milking order, milking duration and activity) was compared for lame versus non-lame cows.
- For cows that developed lameness, changes in sensor data became apparent in the 14 days before farmer detection. Trends were, on average, for decreased liveweight, activity, milk yield and milking duration, and increased milking order. In comparison, on average, non-lame cows had no change in data trends.
- Sensors already available on-farm may have potential to detect lame cows automatically.

Do pastures of mixed plant species make for better dairy farming?

(*Woodward et al.²*)

- A three-year trial compared a 'Mixed' pasture (containing grasses, clover, herbs and lucerne) with a 'Standard' perennial ryegrass and white clover pasture.
- Milk yields and total dry matter (DM) production were similar, although the mixed pasture produced more DM in summer than the standard pasture, while the reverse was true in winter.
- With the mixed pastures, more nitrogen (N) was partitioned into milk, with less into urine.
- In future, more diverse species pastures could form part of mitigation strategies to reduce N leaching.



Amino acids in early pregnancy

(*Meier et al.⁴*)

Amino acid concentrations in uterine fluid during early pregnancy differ between fertile and sub-fertile dairy cows.

- The amino acid (AA) content of uterine fluid from New Zealand and North American strains of holstein-friesian cows (fertile versus sub-fertile cows) at day 17 of pregnancy was measured.
- The North American cows had different AA concentrations in the uterine horn, containing the embryo.
- Combined with differences in gene expression in cells lining the uterus of these same cows, these divergences could explain poor embryo growth, and decreased embryo survival.