Uruguayan Dairy Genetics

Technical Assessment

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Executive Summary

Genetic improvement is an important tool for deriving long-term, permanent, and cumulative productivity benefits across the dairy sector. Optimisation of rates of genetic gains requires considerable ongoing investment in genetic evaluation infrastructure, phenotype (and genotype) collection systems, and extension efforts to create flow of information to be made available to the different stakeholders, especially farmers.

Mejoramiento y Controle Lechero Uruguayo (MU) is the central organization which consolidates the national system to record performance and delivers information produced by the Instituto Nacional de Investigación Agropecuaria de Uruguay (INIA) along with several other dairy sector organizations (i.e. Evaluaciones Genéticas Lecheras, EGL), on genetic evaluations of bulls and cows in Uruguay.

MU and INIA have sought assistance from AbacusBio to undertake an "Assessment report based on local documents and interviews of key advisors, producers, genetic providers, industry and government representatives".

This report comprises an assessment of primary areas of the Uruguayan dairy genetic evaluation and delivery systems, including:

1) a comprehensive analysis of the technical and commercial requirements to increase adoption of genetic improvement initiatives for the dairy industry in Uruguay,
2) potential opportunities to improve delivery of genetics tools (services, products, and information), from a commercial, technical, and scientific perspective, and
3) a critical analysis of the operational integration between MU, INIA, EGL, and their partners throughout the dairy industry.

Overview

The dairy sector in Uruguay is aiming to establish the required structure that will provide support for farmers to achieve higher profitability through increased efficiency.

There is a specific strategy to create a connection between genetic improvement, its tools and principles, and their direct impact on-farm in both the short and the long-term. The existing strategy for the sector addresses several initiatives to reach this target, particularly focusing on extension services and increased rate of genetic gains through additional adoption of genetics tools, services, and resources.

The milk price and quality incentives based on milk composition have driven most of the decisions on-farm and influenced farmers' investments and behaviour on adopting new technology.

Throughout the assessment, farmers and stakeholders made clear statements that genetics is not a priority within their day-to-day routine on-farm. For many farmers, the "casas de semen" have the responsibility of selling the most appropriate genetics for each farm. For these farmers, information about genetics is provided by the semen seller, and there is a gap in priority compared to managing feeding (focusing on better grazing management and pasture quality) and health (particularly mastitis and overall milk quality) of the herd, because in their view, these are more tangible short-term priorities for the dairy farm.

In general, there is a perception that for most farmers herd health and functionality are increasing in importance compared to the role of production (milk yield). There are signals, however, of an association between genetics and its use as a lever to reduce health and fertility issues on-farm in the long-term. The importance farmers attribute to conformation traits has shifted into a strict focus on functionality, particularly regarding udder health (and conformation of the udder and teat set to the milking equipment), fertility, and longevity.

The aim of increasing productivity and profitability of Uruguayan dairy farms is underpinned by the Índice Económico Productivo (IEP) which represents the national breeding objective for dairy cattle. The recent gains achieved on-farm are perceived to be related to the IEP and its reference to the local milk payment system. This has elevated awareness about the potential role of genetics in contributing to the overall profitability of the dairy operation.

Challenges

The biggest challenge for the dairy sector in Uruguay is to provide the required support for farmers to achieve higher profitability through increased productivity and efficiency.

There are many initiatives on-farm addressing production and management practices, particularly on feeding, grazing and pasture management, and cow health. These areas are important and could benefit from data and information captured on-farm on a large number of dairy operations. Because genetics is mostly driven by availability of records at an individual animal level, it is critical to utilise such data to support decision making on-farm and to inform the dairy sector's extension and research efforts, policy making, and market intelligence.

Therefore, the critical solutions to the challenges identified for the Uruguayan dairy sector throughout the assessment were:

1) **Implementing a data and information infrastructure to integrate the multiple data sources existing in the dairy sector and utilised by farmers**. Currently, multiple systems exist without any level of integration, creating loss of opportunities to support farmers. Some examples include MU's herd testing recording services, Asociación Rural Del Uruguay (ARU) pedigree control, Conaprole and FUCREA's databases and the Sistema Nacional de Información Ganadera (SNIG[1]) information system.
2) **Provide genetics, management, and technical solutions to all farmers.** This includes transforming the current EGL genetics framework into a service available to all dairy farmers in Uruguay. Currently, only purebred animals (pedigree registered, grades, and general non-registered) have access to genetic evaluations (and therefore the ability to rank their animals on IEP). This limits options to increase adoption of genetics services to dairy farmers. The infrastructure for integrated data and information would be largely leveraged from this broader access to genetics solutions strategy.
3) **Demonstrate the value of performance recording and data integration to the sector through extension efforts and a communication strategy**. This includes strengthening performance recording, reporting, benchmarking, and decision support tools, all of which largely promoted and utilized by extension services, and technical assistance to

[1] https://www.snig.gub.uy/principal

dairy farmers. Extension efforts and communication with farmers would benefit from the data and information infrastructure, and support scaling up adoption of genetics services and tools, considering the 'genetics to all farmers' strategy' would underpin these efforts, impacting on-farm productivity and profitability.

4) **Use of genetics to drive progress within the sector, support decision-making within and outside the farmgate, and setup the sector to face future challenges**. This includes utilising data, information, and genetics tools to deal with issues such as Greenhouse Gas (GHG) emissions, environmental inventory, and social development. It also includes using these resources to define strategies to manage farmers' priorities on cows and bulls suited to their specific production systems.

5) **Create a connection between genetic improvement, its tools and principles, and their direct impact on-farm in both the short and long-term.** The pasture-based dairy production system in Uruguay has been largely influenced by bulls from USA which are not necessarily selected in the same conditions. Genetic improvement has become more important in this scenario, as there is a strategic importance to demonstrate the value of bulls (proof of merit) selected for Uruguay under tools developed specifically for the Uruguayan dairy sector. This focuses particularly on extension services and increased rate of genetic gains in economically important traits for pastoral dairy systems, such as fertility, survival or longevity and cow weight.

Increasing adoption of genetics tools

This is the main target of several initiatives led by MU, INIA, EGL, and the technical group supporting the Uruguayan dairy sector.

Important aspects of the profitability challenge involve enabling all dairy farmers to record data and access useful information, such as EBVs (EPDs), cow rankings, and inbreeding, supporting benchmarking and informing the decision-making process. These benefits result from adopting genetic improvement and breeding tools within the herd, as well as from the proper technical/extension support (extension services' capability).

In Uruguay only approximately 25% of the cows and 11% of the dairy herds participate in the national dairy breeding scheme. As reference, in countries that also adopt pastoral-based dairy systems such as Australia, Ireland, and New Zealand, the level of herd testing and adoption of genetics tools (EBVs, index rankings) is around 50%, 61%, and 75%, respectively.

The challenges presented above are inter-connected. An integrated strategy around data and information with proper extension, semen supply, and support services to farmers would lead to increased level of adoption of genetics tools. However, it is critical that these tools are made available to all dairy farmers.

Recommendations

Based on the above, a series of recommendations have been proposed as part of the assessment of the Uruguayan dairy genetics structure. These recommendations address the challenges of the sector and better position farmers, stakeholders, and sector leaders for the future.

In general, the recommendations in the following tables assume that the Uruguayan dairy sector is mature enough to benefit from this strategy and the resources that underpin it.

Table 1. Strategy focused on data & information.

Recommendation	Description
Recommendation 1 Establish the data sharing infrastructure to integrate data sources of useful information to the sector	Establish a highly effective ***sector leaders*** steering committee led by MU and Conaprole. Develop an Application Programming Interface (API) structure to allow communication among different databases, strengthen data recording, extension, and research efforts. An initial focus on a specific integration project will demonstrate the approach, e.g. connecting with Conaprole's database.
Recommendation 2 Establish a coordinated extension effort to deliver benefits of data, information, and genetics tools to farmers and stakeholders	Develop a series of benchmarking tools then connect them with existing extension services and programs. Implement a training/upskilling program to technical advisers on dairy farming. The training/upskilling program should be focused on the economics of selection, breeding objectives, and application of breeding tools to support farmers. Development of a bull ranking app available to all farmers, supporting bull selection efforts, and integrating with semen companies' tools.
Recommendation 3 Implement a communication strategy to demonstrate the value of data, information, and genetics tools to farmers	Develop a range of reports with useful information for farmers to use routinely on-farm. Including useful content, e.g. lists of animals available for culling and selection, expected calvings, and parentage information. Deliver the strategy through channels to reach all types of farmers, such as online, by mail, magazines and dairy newsletter across multiple organizations and institutions, including semen companies. The communication strategy will help to consolidate genetics as an integrator within the industry.

Table 2. Strategy focused on increased adoption of genetics tools.

Recommendation	Description
Recommendation 4 Widen access of genetics tools to all dairy farmers and stakeholders in the sector	Design the EGL evaluation structure to be available to all Uruguayan dairy farmers (commercial farmers and registered breeders, all breeds and crossbreds), including multi-breed evaluation.
Recommendation 5 Mobilize the EGL technical group to include new traits and adjust the infrastructure	Incorporate new traits into the genetic evaluation pipeline, such as longevity, cow live weight, mastitis, udder, and feed efficiency. These traits should be added to the IEP, to widen its scope and attract more users.

aiming at increased rates of genetic progress	Change the unit of expression of the IEP to "$ per cow per lactation", as opposed to a standardized unit. This would improve communication of genetics tools by applying an "economics language" that is more relevant to farmers. Adjust the Economic Value (EV) of Fat & Protein, and Fertility on the IEP. The current milk component values seem misaligned to current international dairy market signals, and the fertility value does not have enough weight to impact the genetic trend of fertility. Strengthen genomics efforts across multiple traits (including new traits, e.g. feed efficiency, GHG emissions). This would aim to reduce generation interval, increase prediction accuracy, and consequently the increase rate of genetic progress. This should also address challenges with younger bulls for both AI and NM (domestic bulls).

Table 3. Supporting projects underpinning challenges and recommendations.

Project	Description
Project 1 New data & information structure business case (led by MU & INALE)	Establishment of the steering committee group with sector leaders. Undertake a business case assessment focusing on the value proposition (costs and benefits) for the sector and for each partner organization (Conaprole, MU, ARU, Breed Societies, dairy support companies, government through SNIG, other), including the required investment and net benefit for implementing such strategy within the sector. Decide specifications for the integration the Application Programming Interface (API) structure, including interfaces and integrated reports.
Project 2 Data integration API (led by MU)	Development and implementation of the API to coordinate the exchange of data and information across different sources. Implement the program to one initial pilot project (e.g. Conaprole).
Project 3 Dairy Farm Reports and tools (led by MU, Conaprole & FUCREA)	Engage on a national online survey to gather input from dairy farmers and extension service providers on the most valuable information for different types of farmers. Develop a range of simple and useful reports to be used to support management and selection decisions on-farm. Assess the possibility of developing an integrated GHG inventory calculator to be used on-farm and off-farm.

Project 4 All herds genetic evaluations (led by INIA)	Initiate the required efforts to implement an across breed genetic evaluations (multi-breed). This should be associated with an eventual Genomics Strategy, where the structure required to develop and establish reference populations would consider herds of multiple breeds used to parameterize genetic evaluation models.
Project 5 Genomics Strategy (led by INIA)	Initiate the required structure to develop and establish reference populations of multiple breeds and the necessary phenotyping protocols. Introduce the concept of genotyping bull calves for use as natural mating bulls. This project would have a direct impact on dairy farmers using herd bulls to mate their cows. Feed Efficiency Initiative: develop the required research initiatives to establish the infrastructure to measure feed intake (feed intake, feed efficiency, residual feed intake) and genotype herds involved in the project. Conditioned to the Feed Efficiency Initiative, investigate the required infrastructure to expand the project to include environmental traits (GHG, N_2)
Project 6 Fertility & survival improvement models (led by INIA)	There is need to adjust the models and trait definitions for the genetic evaluations of Fertility (and potentially connect this to survival/longevity) by adjusting calving interval in partly seasonal herds, including variance components, culling reasons, etc. This includes the adjustment and implementation of EVs to the IEP.
Project 7 Cow liveweight model (led by INIA & Univ. de la República)	Accounting for phenotypes from different sources on-farm (weights, stature score) and off-farm (carcass weights). This includes the adjustment and implementation of EVs to the IEP.
Project 8 IEP additional traits & economic values (led by Univ. de la República)	Mastitis & Udder composite, longevity, cow live weight, BCS, and re-assess EVs for Fat ($0.46), Protein ($2.17), and Fertility ($1.31). This includes the adjustment and implementation of EVs to the IEP.
Project 9 Bull ranking & selection app	Establish a bull ranking app available to all farmers, supporting bull selection efforts, and integrating with semen companies' tools. This tool should reach data and information from multiple sources.

Background

Genetic improvement is an important tool for deriving long-term, permanent, and cumulative productivity benefits across a sector.

Optimisation of rates of genetic gains requires considerable ongoing investment in genetic evaluation infrastructure, phenotype (and genotype) collection systems, and extension efforts to create flow of information to be made available to farmers and to different stakeholders throughout the sector.

In Uruguay, the coordination of the dairy genetics structure is a responsibility of Mejoramiento y Control Lechero Uruguayo (MU), the organization which coordinates the national system to record performance and deliver information on genetic evaluations of bulls and cows. This system incorporates the genetic evaluation infrastructure, service delivery, as well as research and development (R&D) supporting dairy genetics. This structure has historically received varying levels of government support (R&D and sector funds) and stakeholder investment (i.e. INALE funds and dairy farmers paying for usage of the infrastructure).

Evaluación Genética de Ganado Lechero Uruguay (EGL) holds the core of the genetic improvement infrastructure to the sector and provides genetic improvement services (i.e. breed-specific genetic evaluations for purebred animals) for the dairy sector. MU and the Instituto Nacional de Investigación Agropecuaria de Uruguay (INIA), along with the Instituto National de la Leche (INALE) and other organizations, established and presently coordinate EGL's operation.

The biggest challenge for the dairy sector in Uruguay is to provide the required support for farmers to achieve higher profitability through increased efficiency. The existing strategy for the sector addresses several initiatives to reach this target, particularly focusing on extension services and increased rate of genetic gains.

This report presents a general assessment of the dairy genetics structure in Uruguay. The AbacusBio team have applied their global knowledge in commercial models and experience in innovation across a wide range of dairy genetics projects to support MU and INIA to consider a strategic plan to increase adoption of a commercially oriented national breeding program by dairy farmers. Identification of challenges and proposition of strategies for an integrated approach between dairy genetics and use of data and information to drive increase of productivity and profitability has been the focus of this assessment.

Report structure

The layout of this report reflects the scope of the work and the approach through which the assessment has been conducted. The core set of observations and recommendations are described in the Executive Summary.

During the process, there were several important points discussed during the meetings and presentations. These points are presented in the format of Appendices described in the following sections of the report. All notes from the meetings with farmers and industry stakeholders are also presented as Appendixes.

Finally, a summary of the stakeholder presentation that introduced the outcomes of the assessment to those involved in the process is attached to this report.

Appendix 1. Dairy sector overview

The Uruguayan dairy sector is underpinned by a modern genetic improvement framework and well-structured with functional organizations, engaged farmers (approximately 3,400 dairy farmers, 760,000 dairy animals) and stakeholders.

The sector is under permanent demand for increased productivity and profitability, which is driven by both, the sector's exporting nature and the requirement to improve productivity on an ever-transforming dairy enterprise. Dairy farms in Uruguay are transitioning to more intensive, bigger operations, with larger herds, but still mostly operate under a pastoral-based production system.

Despite the recent growth in dairy productivity, i.e. reducing number of dairy farms with higher production thus maintaining the overall milk production with higher milk quality (more solids, less somatic cell count), the successful implementation of the genetic improvement infrastructure needs permanent upgrading and investment. This is important because there is a range of dairy systems in Uruguay, from smaller family operations (25% of dairy farms), through to small/medium commercial scale (68%), and corporate, large-scale operations (7%).

There is a specific strategy to create a connection between genetic improvement, its tools and principles, and their direct impact on-farm in both the short- and the long-term. The existing strategy focuses primarily on extension services and increased rate of genetic gains through additional adoption of genetics tools, services, and resources. The increase in productivity and profitability is the main target of Uruguayan dairy farming.

Market

The current market for Uruguayan dairy products is largely focused on the strong export market and to a smaller extent, the domestic market[2]. Approximately 85% of the milk produced in Uruguay, from about 75% of farmers, is supplied to processing plants. Milk is then processed into the main products, milk powder (98% exported), cheeses (46%), butter (71%), and UHT milk (15%), which are largely destined for export. The remainder of the milk produced commercially is processed on-farm and mostly commercialized in the form of cheese.

The focus on exports (70% of all dairy produced) is the main driver of a clear payment system which includes premiums for protein and milk fat, and penalties for milk volume and somatic cell count. There are minimum quality standards for milk composition, somatic cell count, conductivity, and overall milk contamination, all of which are part of the milk payout to farmers at the farmgate. The average price per litre of milk to the producer ranged in 2021[3] from USD $0.32 to $0.36 or between USD $4.15 to $4.57 per kg of milk solids.

The government determines the price of fluid milk sold to consumers. From September 2021, the price per litre has been established at $36 (Uruguayan Pesos, or USD ~$0.83)[4].

[2] Estadísticas del Sector Lácteo Anuario DIEA 2020 - https://www.inale.org/estadisticas/estadisticas-del-sector-lacteo-anuario-diea-2020/

[3] https://www.inale.org/estadisticas/precio-al-productor-y-composicion-de-la-leche/

[4] https://www.inale.org/wp-content/uploads/2021/09/Resolucion-DO-152-021-setiembre2021.pdf

The milk price and quality incentives based on milk composition have driven most of the decisions on-farm and influenced farmers' investments and behaviour when adopting new technology.

On-farm

There is a national system where all cattle in the country is identified and most farmers are associated to a dairy cooperative to which they supply milk to.

The average commercial dairy farm has approximately 126 lactating cows grazing on 222 hectares (75% of dairy farms are smaller than 200 ha), with an average 5,047 litres per cow per lactation[5].

The average profitability of the dairy system ranges from USD $100 to $ 150 per hectare (between 5.5 – 7.5% return on assets per year) as consequence of an average profitability of USD $0.05 per litre of milk or $0.71 per kg of milk solids[6].

Facts & figures

There has been a trend of decrease in the total number of farms (Figure 1) and an increase on the average size of dairy operation with slightly bigger herds and higher average production (

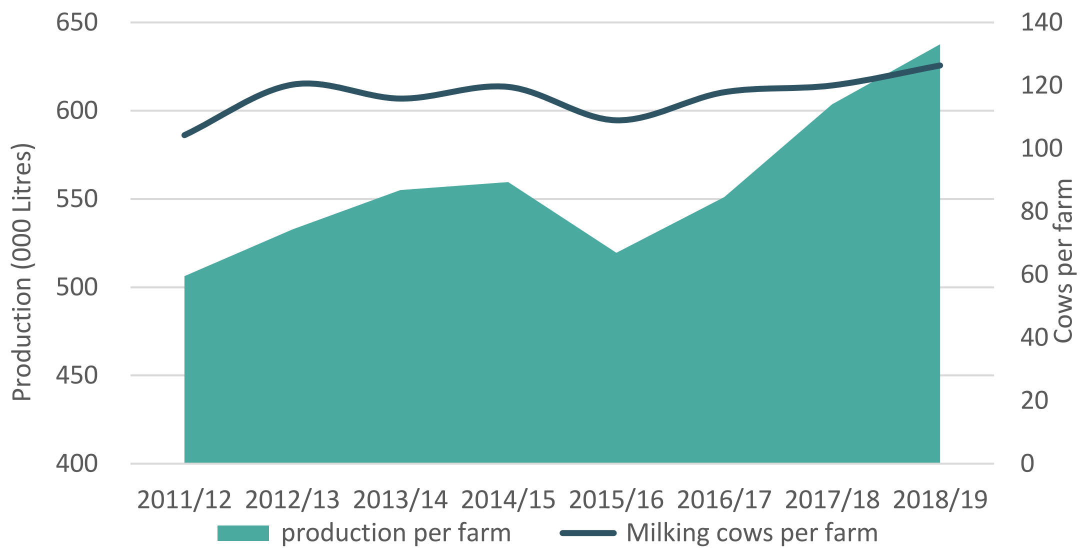


Figure 2). This is an important trend considering most dairy farms in Uruguay are considered small to medium scale with herds around 80 – 100 cows on average and over 70% of all operations established in farms with less than 200 hectares.

The reduction in number of dairy farms has not impacted the overall dairy production because most farms aim to become more efficient and seek increases in productivity and profitability. Dairy farmers have also made significant effort to improve the quality of the milk produced, both for milk composition and overall somatic cell count.

5 https://www.inale.org/estadisticas/estadisticas-del-sector-lacteo-anuario-diea-2020/

6 https://www.inale.org/wp-content/uploads/2019/06/Beca-Evolucion-de-los-sistemas-de-produccion-lecheros.pdf

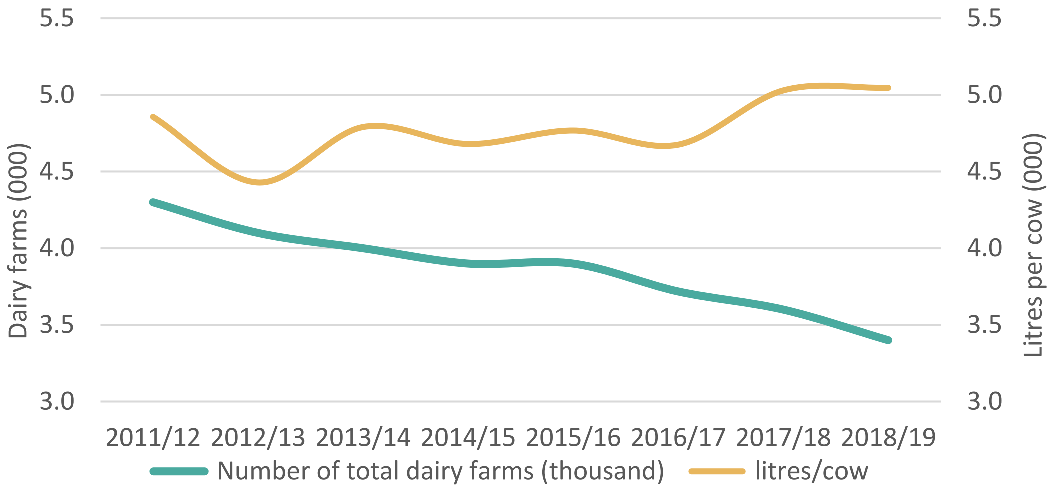


Figure 1. Number of dairy farms and average milk production per cow over the lactation period.

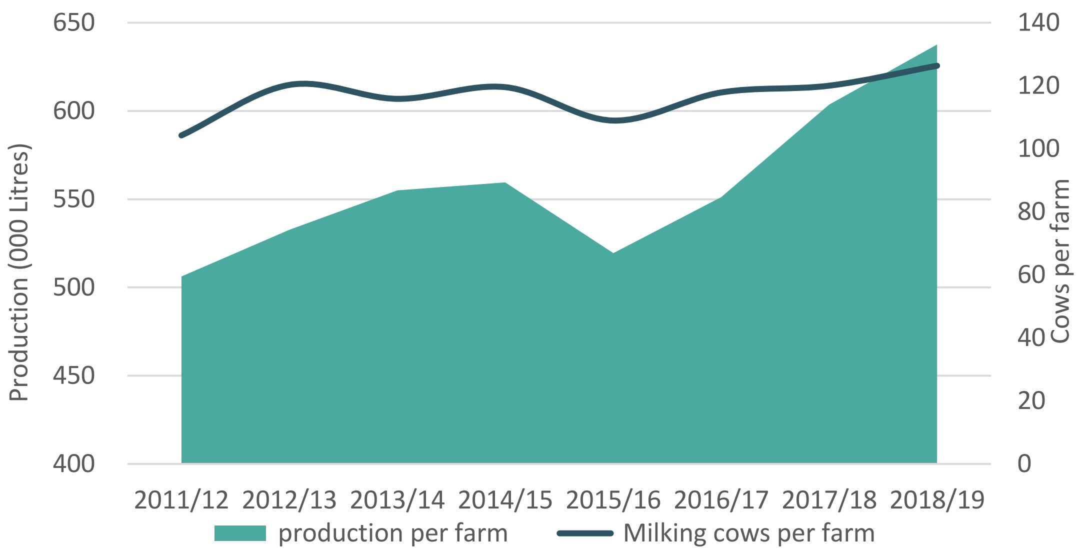


Figure 2. Increase in average production per farm and herd size over the last years in Uruguay.

The increase in average production per farm is still following the typical seasonality of milk production (Figure 3). This seasonality results from a combination of climate, forage production, and the planned calving pattern which avoids the hotter and drier summer months of the year from November to January (Figure 4).

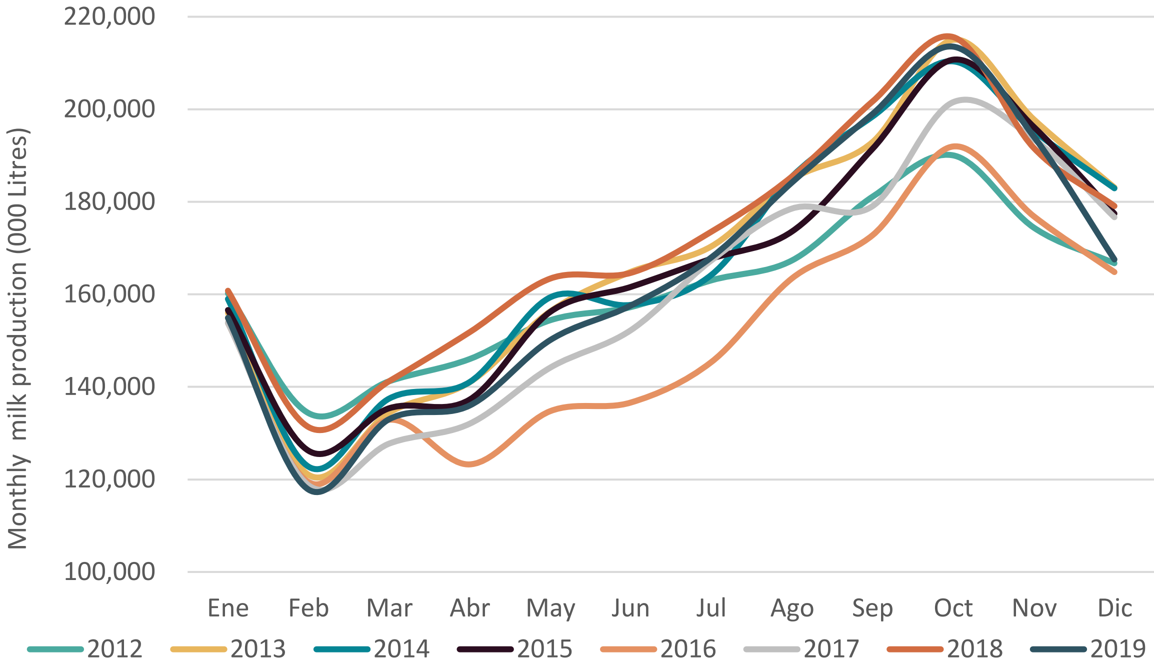


Figure 3. Historical monthly average milk production in recent years in Uruguay.

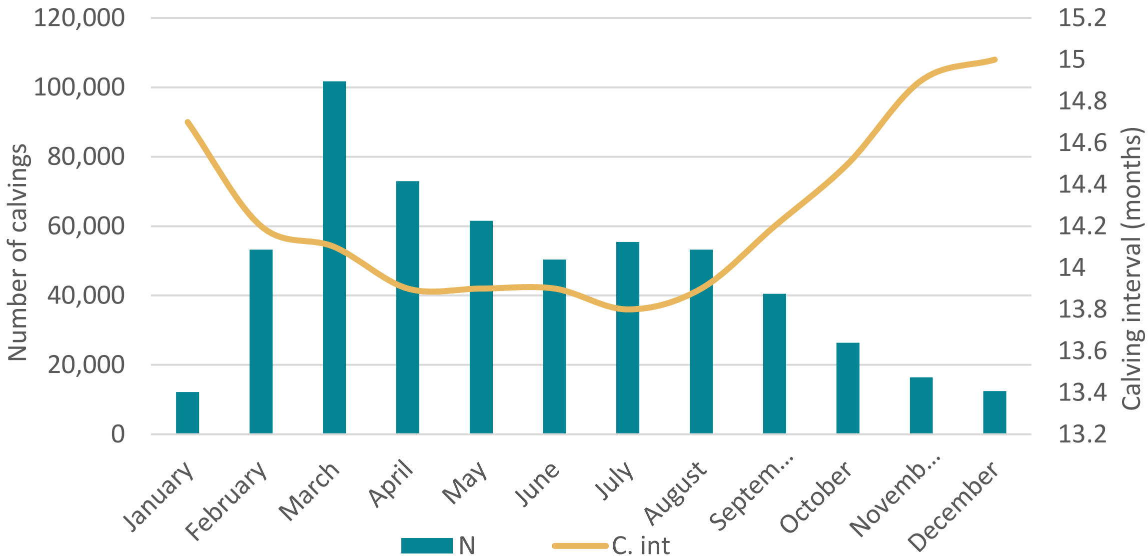


Figure 4. Annual average calving pattern of dairy cattle in Uruguay.

The bulk of dairy production is concentrated in the southwestern parts of Uruguay, particularly in Florida, San José, and Colonia (Figure 5). Approximately 70% of the milk production comes from these regions.

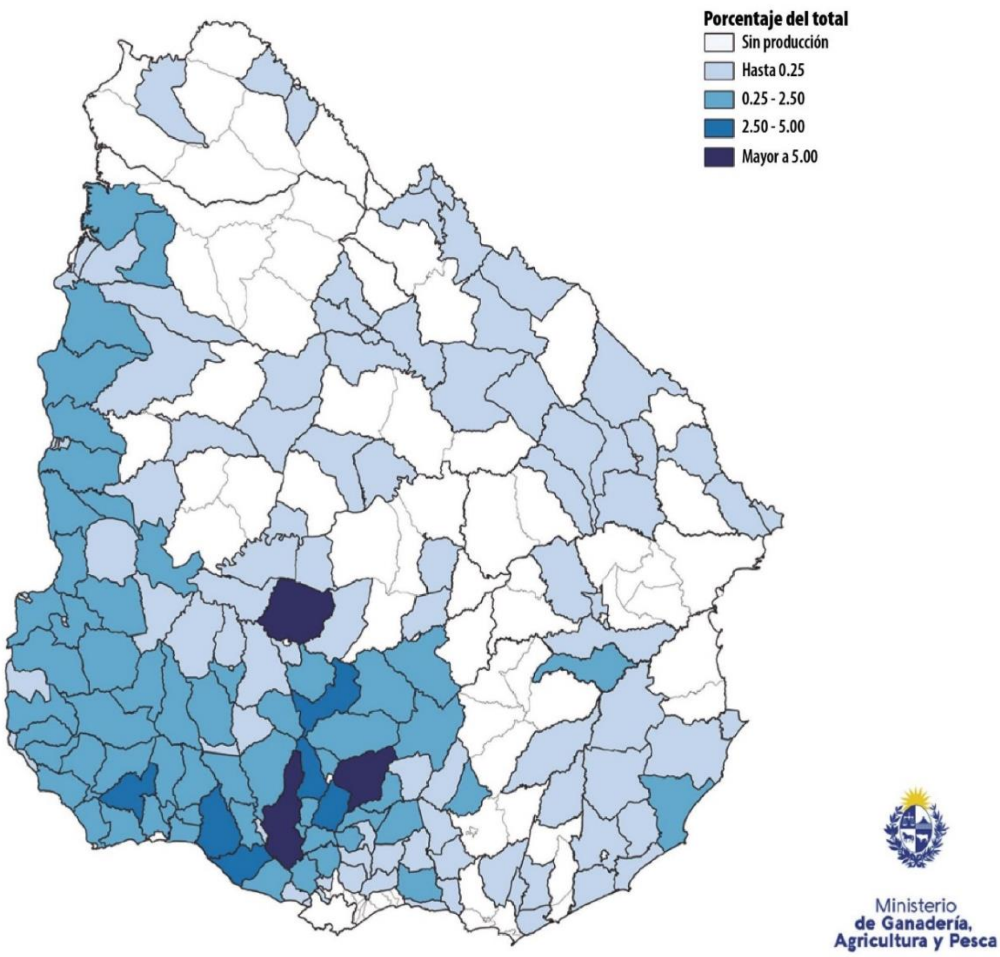


Figure 5. Regional distribution (%) of milk production in Uruguay.

Appendix 2. Observations on the current sector structure

Well-established and organized sector

A clear sign of the maturity of the Uruguayan dairy sector is the existence of an organization dedicated to coordinating genetic improvement initiatives. Those involved in this well-established structure combine public and private partners to deliver services and useful information to farmers (Figure 6).

Mejoramiento y Control Lechero Uruguayo (MU) is the consolidation of a national system of recording performance and delivering information on genetic evaluations of bulls and cows through a centralized organization in Uruguay. MU provides a single database service that improves the value of the information to dairy producers.

MU and the Instituto Nacional de Investigación Agropecuaria de Uruguay (INIA), along with several other dairy sector organizations (including the Facultad de Agronomía de la Universidad de la República, Asociación Rural Del Uruguay (ARU), Sociedad de Criadores de Holando, other), established the Evaluación Genética de Ganado Lechero Uruguay (EGL, Uruguayan Dairy Cattle Genetic Evaluation) which provides the core of the genetic improvement infrastructure to the sector.

The EGL operates closely to other sector entities such as the Instituto Nacional de la Leche (INALE) and Conaprole, the main dairy cooperative in Uruguay, to support farmers to improve their operations and the overall utilisation of dairy genetic resources.

The existing structure (Figure 6) has historically received varying levels of government (R&D and sector support funds) and stakeholder investment (i.e. funds from INALE and dairy farmers paying for usage of the infrastructure). In summary, there is a clear influence by several engaged farmers and stakeholders on the dairy sector.

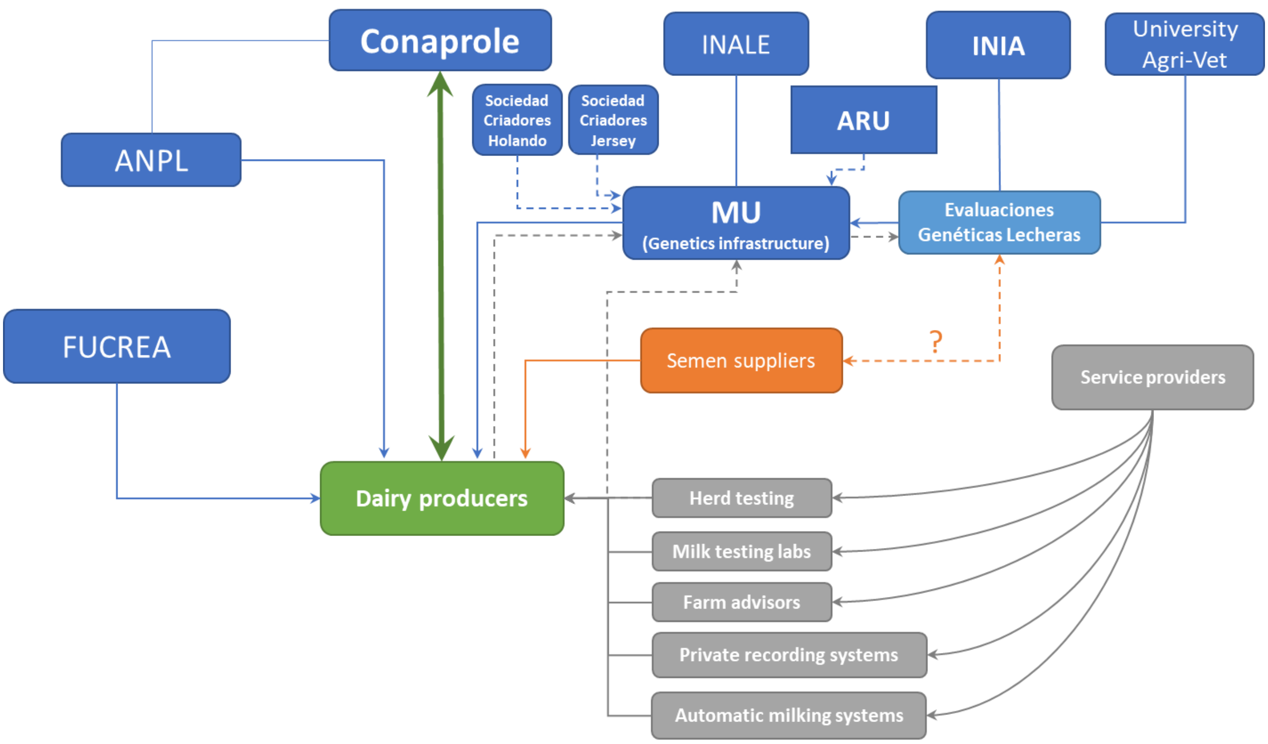


Figure 6. Diagram of the Uruguayan dairy genetics structure.

Appendix 3. Observations on the market for Uruguayan dairy products

Functioning structure focused on international markets

Organizations such as INALE and Conaprole provide direction and leadership to the dairy sector by structuring the commercial supply of milk and distribution of dairy products to both the domestic and the export markets. These organizations respond to approximately 30% and 70% of the income to the sector, respectively. The Conaprole cooperative specifically leads in its ability to capture the bulk of milk produced in the country. Other cooperatives and smaller milk processing businesses, including several on-farm processing facilities, also have an important role in the dairy market, particularly domestically.

Dairy product focuses and market value

The exports market is largely focused on dairy products as opposed to fluid milk. This places a great importance on both the composition (milk fat and milk protein) and the quality of the milk produced (somatic cell count (SCC), conductivity). Furthermore, this is reflected in the practised payment system for dairy farmers in Uruguay, similar to other countries where pastoral-based dairy production is the predominant system. In these cases, milk payment ($MP_{\$}$) is referenced on a traditional formula:

$$MP_{\$} = F_{kg} + P_{kg} - V_L$$

where, F_{kg} is milk fat, P_{kg} is milk protein and V_L is volume.

The quantity of milk fat, milk protein, and volume of water in the milk are determined by its composition. Therefore, processing facilities will adopt quality standards that determine the final milk payout to farmers. This payout can be expressed either:

- per kilogram of milk solids (kg MS), or
- per litre of milk (L) supplied.

Farmers will normally receive a premium for high quality milk with high milk composition and low SCC or will be penalized for milk that does not meet the standards.

In 2021[7], the average milk price per litre of milk to the producer ranged from USD $0.32 to $0.36 or between USD $4.15 to $4.57 per kg of milk solids for an average milk composition of 3.96% fat and 3.47% protein. As determined by the government from September 2021, the price of fluid milk (price per litre) sold to consumers has been established at $36 (Uruguayan Pesos, or about USD $0.83)[8].

The influence of commercial structure on commercial strategy

The commercial structure of the Uruguayan dairy sector has influenced the commercial strategy of the dairy operation. The milk price and quality incentives based on milk composition have driven most on-farm decisions and influenced farmers' investments and behaviour when adopting new technology. The outcome of these influences is reflected in

[7] https://www.inale.org/estadisticas/precio-al-productor-y-composicion-de-la-leche/
[8] https://www.inale.org/wp-content/uploads/2021/09/Resolucion-DO-152-021-setiembre2021.pdf

the evolution of average composition of the milk (Figure 7) as well as milk production and breakdown of dairy products (in milk litres equivalent) over the last years (Figure 8)[9].

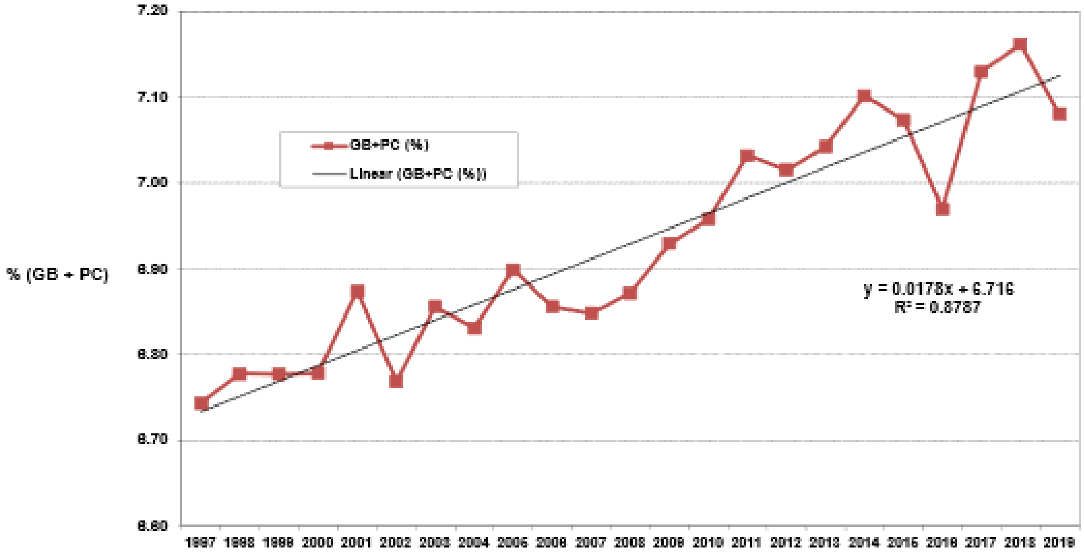


Figure 7. Evolution of the fat and protein milk composition supplied to Uruguayan milk processors in recent years.

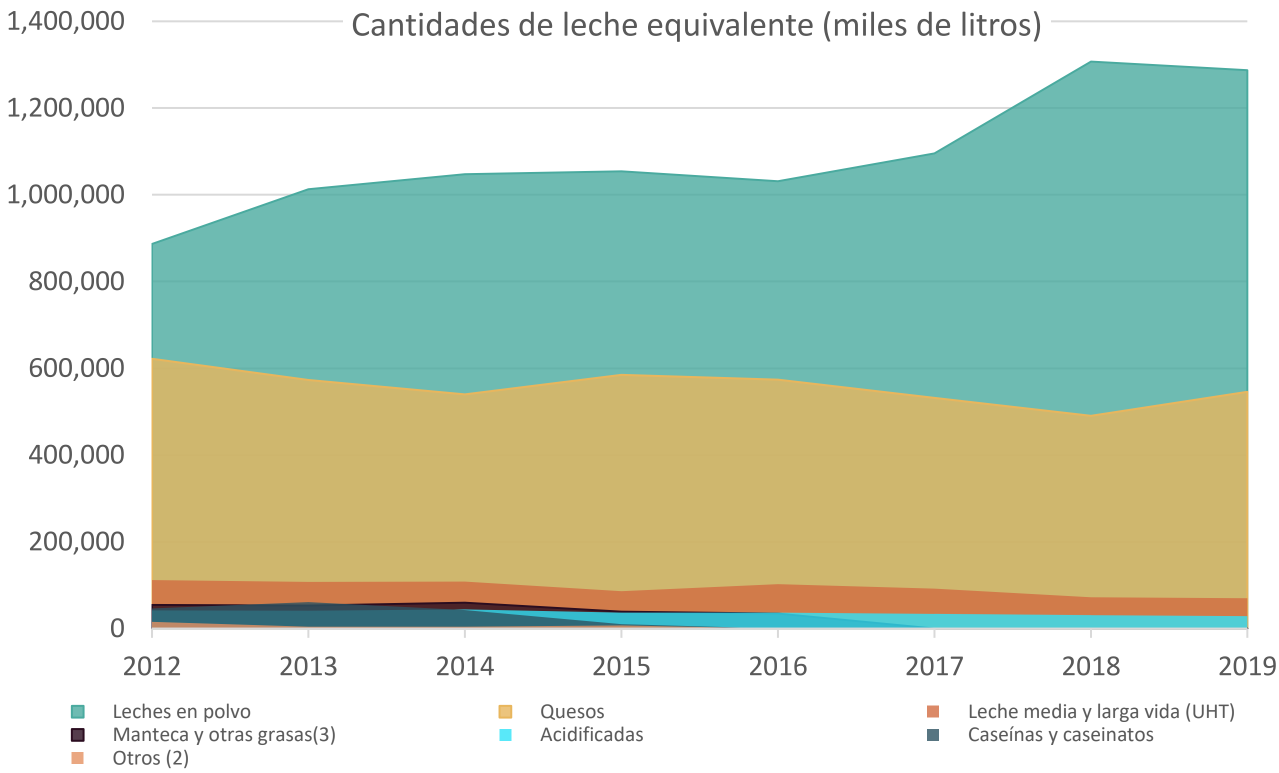


Figure 8. Breakdown of milk supply in Uruguay by dairy product from 2012 to 2019.

[9] Milk equivalent (000 litres), milk powder (Leches en polvo), fluid UHT milk (leche merdia y larga vida), acidified dairy e.g. yogurt (acidificadas), cheese (quesos), butter (manteca y otras grasas), casein (caseínas y caseínatos).

Appendix 4. Perceptions from behind the farmgate

The role of genetics considering dairy production on-farm

There is a range of production systems used by Uruguayan dairy farmers. In general, most producers adopt pastoral-based systems with a varied level of feed supplementation. Milk production is therefore based on the intensive use of pastures with strategic supplementation of concentrates and use of silage. Approximately 50% of the area dedicated to dairy has improved pastures, allowing to obtain relatively low average production costs per litre of milk or per kg MS.

The average commercial dairy farm in Uruguay has approximately 94 lactating cows grazing on 222 hectares (75% of dairy farms are smaller than 200 ha) (Table 4[10]), with an average 5,047 litres per cow per lactation. This is confirmed by the profile of milk supplier members of Conaprole which receives more than 70% of its milk supply from dairy farmers producing less than 2,000 litres of milk per day (**Error! Reference source not found.**).

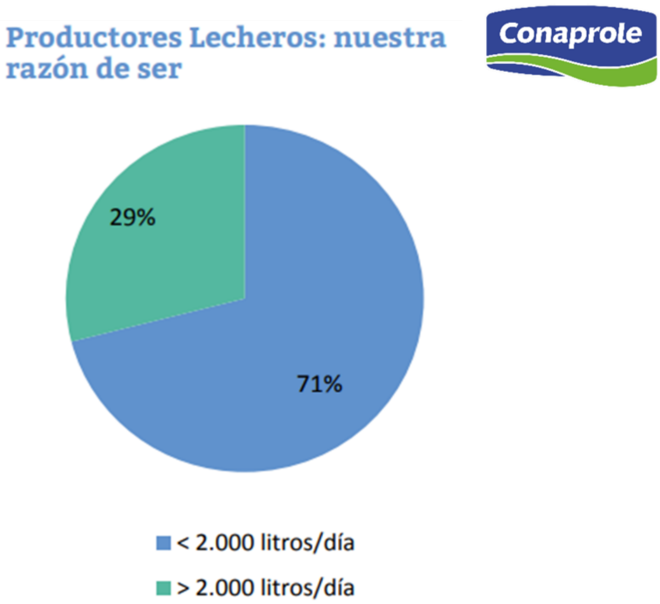


Figure 9. Conaprole's milk producers' distribution by volume of supply.

The role of genetics therefore is critical to support both pastoral farming and intensive supplement using dairy systems. Genetics is also important to support small-, medium-, and large-scale dairy operations with different structures and requirements.

The range of production systems and dairy operation scale are directly influential to the strategy that supports development of the sector. Research initiatives, extension services, and milk production to the market can all be impacted by a genetic improvement strategy. The strategy can also be informative for the future direction of Conaprole's product development. This is because the overall milk composition is directly affected by the genetic merit of the herd. Thus, the market access strategy can also be influenced by genetics.

[10] https://www.inale.org/estadisticas/estadisticas-del-sector-lacteo-anuario-diea-2020/

Table 4. Evolution of the number of commercial dairy operations per year according to area ranges.

Farm size range	Year							
	2011/12	2012/13	2013/14	2014/15	2015/16	2016/17	2017/18	2018/19
Up to 50 ha	1,360	1,265	1,226	1,162	1,074	966	966	852
50 to 199 ha	1,981	1,923	1,885	1,835	1,871	1,795	1,789	1,634
200 to 499 ha	628	618	607	601	630	608	620	596
500 ha or more	336	330	335	321	298	349	313	341
Total Dairy farms	**4,305**	**4,136**	**4,053**	**3,919**	**3,873**	**3,718**	**3,688**	**3,423**

On-farm, what is the most appropriate Genetics for Uruguay?

Throughout the assessment, farmers, and stakeholders (including advisers) made clear statements that genetics is not a priority within their day-to-day routine on-farm although increasing productivity and profitability are their primary goals. Producers and sector leaders might lack clarity on the important role of genetics and how much value it adds to the sector. A distinct perception was that the value of pasture, grazing management, and farm/herd management are more tangible short-term priorities on-farm.

The understanding of genetics seems to be limited to breed, origin, and for many farmers, the additional information provided by the "casas de semen", which defines what is necessary to identify the most appropriate genetics for each farm. Comparatively, there is a gap between the level of commitment to manage dairy herd genetics (including the level of information provided by the semen seller), and the willingness to manage feeding (focusing on better grazing management, pasture quality, and supplements) and health (particularly mastitis and overall milk quality) of the herd.

There are signals of an association between genetics and its use as a lever to reduce health and fertility issues on-farm in the long-term. The importance farmers attribute to conformation traits has shifted into a strict focus on functionality, particularly regarding udder health (including conformation of the udder and teat set to the milking equipment), fertility, and longevity. The working group from MU, INIA, and Facultad de Agronomía believes that Uruguay is moving towards the global goal of more healthy and functional cows as a major driver of increased productivity and profitability for dairy farming.

Origin of genetics used in Uruguayan dairy farms

The Uruguayan dairy sector is largely dependent on genetics imported from overseas (Figure 10). Most of the bulls' semen used in breeder herds and commercial operations originates from the USA. It is important to highlight that dairy production systems in the USA are largely distinct from Uruguay. This is because in the USA dairy production is based on intensive feedlot systems with high levels of concentrate supplementation, preserved forage provided as part of the total mixed ration (TMR), and no grazing.

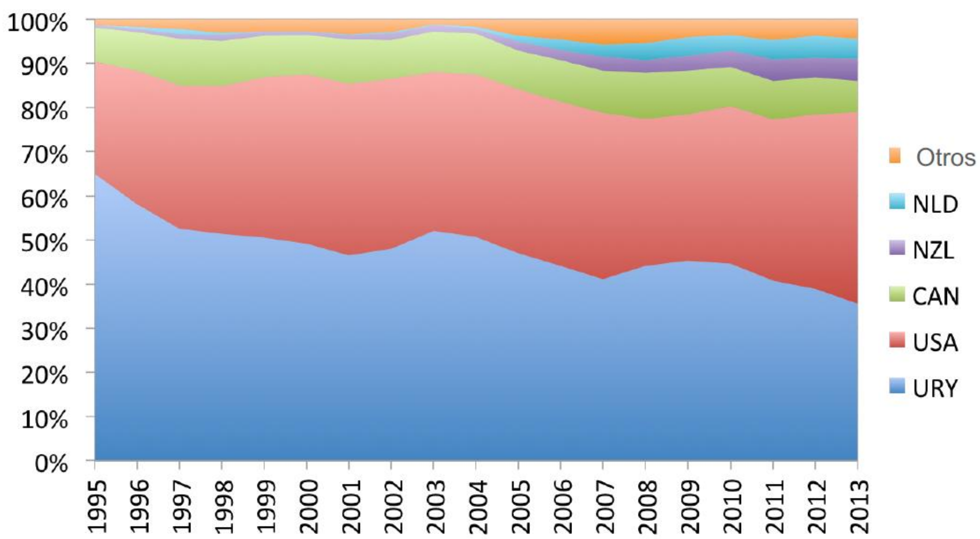


Figure 10. Origin of bulls used in Uruguay historically.

The use of semen and herd bulls in dairy farms

Most Uruguayan dairy farmers do not follow an informed selection procedure when purchasing bulls' semen. Producers normally require a range of bulls, and every farmer has their own opinion and preferences. Many farmers follow the advice from semen salesmen and frequently the momentaneous milk price and heifer market drives the use of bulls. In this case, when milk price is high and or demand for heifers is increased, farmers might opt for semen from more expensive bulls, with higher potential of production. Alternatively, farmers may opt not to buy semen and simply buy bulls available in the market when milk prices are not attractive. This can be seen in the group of farmers (10 to 15% of commercial producers) who sell their own dairy products (cheese in particular) directly to consumers.

However, the factor that drives farmers the most is the need for cows to conceive. Cows must be pregnant reasonably soon after calving if the following calving does not occur in summer. Thus, if the market for heifers (e.g. China exports) is promising then farmers use dairy bulls to mate cows following up on AI. Otherwise, another round of AI with imported bulls may be the preferred option.

In this context, there might be a missing link between genetics, sustainable production, costs, and cow functionality - all of which impact the overall profitability of farms. This is evident in the different requirements and distinct breeding objectives need for small-family farms, commercial farmers, large-scale operators, and dairy breeders. These differences in needs and objectives is where the role of IEP plays is critical for Uruguayan dairy production.

The Índice Económico Productivo (IEP)

The aim of increasing productivity and profitability of Uruguayan dairy farms is underpinned by the Índice Económico Productivo (IEP) which represents the national breeding objective for dairy cattle. The IEP resonates extremely well with farmers because it reflects the local payment system. In general, the IEP has created awareness about the potential role of genetics in contributing to the overall profitability of the dairy operation, and therefore has become an essential tool to direct the national dairy herd.

The IEP (and some company indexes) have more recently started to influence bull selection to a greater extent. For most farmers however, the use of indexes is not accessible information due to a lack of understanding and clear explanation of these tools. Thus, there is need to establish significant extension efforts to revert this trend.

The national breeding objective (NBO) for dairy in Uruguay is expressed in USD$ per cow per lactation. The equation that represents this NBO is presented below:

$$NBO_{USD\$} = -0.0353 \cdot \text{Volume}_{EPD} + 0.4663 \cdot \text{Fat}_{EPD} + 2.1788 \cdot \text{Protein}_{EPD} - 0.4998 \cdot \text{Calving Interval}_{EPD} - 46.6567 \cdot \text{Somatic Cell Score}_{EPD}$$

where $EPD = 0.5 \cdot EBV_i$ represents the expected progeny difference for the different i traits.

Differently from the NBO, the IEP index is presented on a base scale of 100 (i.e. currently the best bulls are approximately 140 – 150 IEP units). Note, there is an average IEP of 100 = $25 additional profit per cow per lactation. The relative trait emphasis or importance ($\%EPD_i = |EV_i| \cdot \sigma_{gi}$) of the IEP index is presented in Figure 11 below.

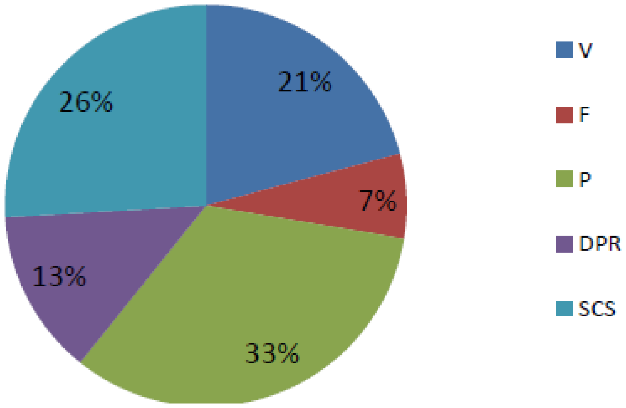


Figure 11. Relative trait emphasis in the IEP index.

An important point of discussion is whether the 100-point scale is best unit option to deploy the index to the dairy farming community. This strategy was established when the IEP was first released and aimed at facilitating communication and understanding of the principles of the IEP by farmers, thus conducing to early adoption. As the sector moves forward, the components of the index should reflect the goals of the sector.

Delivery of value to farmers

Delivery of value to farmers comes with supporting them to benefit from higher productivity, improving the profitability of their operations, and/or improving their quality of life.

The main driver of the adoption of genetics tools and services in any dairy industry is the perception of value (or benefit) of using these tools and services or using the available information to make decisions that result in one or more types of benefits mentioned above.

In Uruguay, only approximately 25% of the cows and 11% of the dairy herds participate in the national dairy breeding scheme. This level of adoption is low considering other reference countries which also adopt pastoral-based dairy systems. As an example, Australia, Ireland, and New Zealand, the level of herd testing and adoption of genetics tools (EBVs, index rankings, other) is approximately 50%, 61%, and 75%, respectively.

Strengthening the value of these tools to farmers will be crux of adoption. The question stands: how can the value of genetics be demonstrated to most dairy farmers in Uruguay?

MU's offer

To assist farmers in achieving increased productivity and profitability, enabling access to useful information, such as EBVs, cow rankings, and inbreeding, is vital to supporting benchmarking and informing the decision-making process.

The previously described challenges of adoption of genetics tools are inter-connected and to be overcome, require an accessible integration strategy around data and information with proper extension, semen supply, and support services to farmers.

MU supplies the national dairy cattle database of performance recording, offering reports and feedback to farmers with a complete set of genetic information (examples in Figure 12). Some of the outputs of MU's services to dairy farmers are listed below:

- Herd genetic evaluations which predict the genetic merit of animals and herds

    - EPDs and Repeatability for cows, heifers, calves, and bulls for several traits, including those included in the IEP.
    - Inbreeding coefficients
- Informe de Primavera – summary analysis of the herd's productivity over the last 5 years at both a herd level and individual cow level
    - Production KPIs, herd composition, total milk production, milk production curves, lactation length reports per cow and herd means, other
    - Reproduction KPIs, calving distribution pattern, calving interval, calving to conception, other
    - Milk quality KPIs, milk fat and protein composition, somatic cell score/count means, other
- Reports describing both individual cows and herd averages per lactation and across lifetime
- Technical support from the MU team on
    - Software and systems' operation, including integration with milking measuring devices
    - Registration services for certification on pedigree and breed requirements
    - Development of sales catalogues and certificates
    - Herd testing services (outsourced service) and discount on milk sample testing

Despite the range of services, the benefits are only achieved by farmers as consequence of adopting genetic improvement and breeding tools within the herd, as well as from the proper technical/extension support (extension services' capability). In this context, it is essential to point out that not all MU's services are available to all farmers.

It is important to make the information broadly available, which means not only making it accessible but also translating the complexity of the system into terms and information that are relevant and appropriate to farmers of at all levels, systems, breeds, and crossings.

REPORTE DE EVALUACION GENETICA

ESTABLECIMIENTO GEA

Mejoramiento y Control Lechero Uruguayo

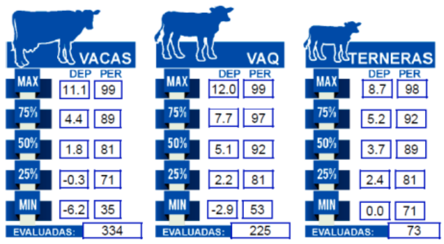
INTITUTO NACIONAL PARA EL MEJORAMIENTO LECHERO | NUEVA YORK 1673 - 2924 8512 - MONTEVIDEO - URUGUAY | WWW.MU.ORG.UY

ALIAS	HBU	Nombre	IND100	REPIND	PERIND	DEPL	REPL	PERL	DEPGR	DEPGRI	REPGR	DEPPR	DEPPRI	REPPR	PERGR	PERPR	DEPTP	REPTP	PERTP	DEPRC	REPRC	PERRC	PADRE
138	S001816	VAN HEUVENS VA REMEDY S1F	128	0.97	99	-288	0.98	45	13.90	0.39	0.98	3.80	0.22	0.97	98	85	1.42	0.92	96	0.094	0.96	35	VALDEN HI
108	S000838	VALDEN HI APPLAUSE-ET S2F	126	0.92	98	-33	0.92	45	18.90	0.31	0.92	9.10	0.16	0.91	99	96	0.31	0.82	80	0.11479	0.9	31	SRB HANSENS
126	199514	BRKEL MAGIC BOJANGLES S3F	124	0.92	98	-88	0.93	45	6.50	0.15	0.93	4.10	0.11	0.92	87	85	1.16	0.86	93	-0.145	0.91	82	SRC LAKESIDE DG
118	S000921	LAKESIDE S D MEADOWS	123	0.93	98	79	0.94	64	5.60	0.04	0.94	6.70	0.06	0.93	87	93	0.20	0.88	77	-0.242	0.92	92	ELITE MOUNTAIN
107	S001044	BAGWORTH KALUMBURU	122	0.87	98	-41	0.88	45	12.30	0.21	0.88	10.30	0.18	0.86	97	97	0.11	0.66	75	0.24791	0.85	9	WHINLEA MAGLEY
128	S001462	DELTA FIDELITY	122	0.95	98	4	0.95	46	9.90	0.15	0.95	10.00	0.15	0.95	95	97	-0.43	0.87	58	0.116	0.94	29	KIAN
134	201776	BAGWORTH PF GRANDEUR S1F	122	0.96	98	-35	0.96	45	7.90	0.14	0.96	5.90	0.11	0.95	91	92	1.35	0.85	95	-0.032	0.94	63	PUKETIRO
140	200067	RI-VAL-RE RAGER-RED-ET	121	0.64	97	-47	0.67	45	8.90	0.16	0.66	2.60	0.06	0.62	93	79	0.26	0.32	79	-0.24138	0.57	92	PINE-TREE RELIEF
109	S001070	CARSONS RADICAL S2F	120	0.95	97	287	0.96	95	5.50	-0.07	0.96	13.20	0.05	0.95	87	99	0.00	0.87	72	-0.082	0.94	73	WHINLEA MAGLEY
106	S000841	REILLYS MIGHT S1F	120	0.84	97	-35	0.86	45	7.20	0.13	0.85	5.10	0.10	0.83	88	88	1.43	0.63	96	-0.04986	0.8	67	GLENMEAD
115	S001169	FAIRMONT MINT-EDITION	120	0.95	97	-128	0.96	45	7.40	0.19	0.96	5.20	0.15	0.95	88	88	0.70	0.91	88	0.074	0.95	40	TOP DECK KO
117	S001069	HIGGINS FORMAT	119	0.97	97	66	0.97	61	-0.80	-0.05	0.97	6.70	0.07	0.97	54	93	0.42	0.92	82	-0.195	0.96	88	WHINLEA MAGLEY
GOLDSTAR	SK2924	KERNDT MAXIE GOLDSTAR ET	118	0.79	96	117	0.82	73	-1.00	-0.08	0.78	4.20	0.00	0.78	54	85	0.76	0.65	88	-0.389	0.74	98	KERNDTWAY
64	SK2924	KERNDT MAXIE GOLDSTAR ET	118	0.79	96	117	0.82	73	-1.00	-0.08	0.78	4.20	0.00	0.78	54	85	0.76	0.65	88	-0.389	0.74	98	KERNDTWAY
133	198303	MOLENKAMP GRIFFITH P	118	0.66	96	-204	0.69	45	6.70	0.22	0.69	3.10	0.16	0.65	88	79	0.16	0.62	76	0.07792	0.62	38	FASNA ASTERIX
137	201770	SAVANNAHS HF HAMMER S1F	118	0.95	96	18	0.94	50	5.50	0.07	0.95	5.20	0.07	0.94	87	88	0.48	0.65	84	-0.104	0.92	76	HIGGINS FORMAT
136	201773	BAGWORTH PF LAUNCHPAD	118	0.91	96	91	0.91	68	6.90	0.05	0.92	10.00	0.10	0.90	88	97	-0.58	0.63	52	0.059	0.89	42	PUKETIRO
104	S000654	MIDPELER MISTY	117	0.94	96	-65	0.94	45	13.90	0.25	0.93	5.50	0.12	0.93	98	92	-0.38	0.82	60	0.087	0.92	35	SUBLIEM TULIP
135	S001615	EDWARDS BANQ OVATION S3F	116	0.95	95	-59	0.95	45	-5.20	-0.05	0.95	8.70	0.17	0.94	30	96	0.04	0.79	73	0.166	0.94	20	SRD

Año de Nacimiento

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
DEP Proteina	0.10	-0.80	0.10	1.30	1.00	2.70	3.20	1.60	4.30	6.70	3.80
DEP Proteina MU	-2.20	-1.40	-1.10	-0.60	-0.10	0.40	1.10	0.90	2.20	3.80	4.80
Animales GEA	127	164	136	139	171	118	133	132	99	115	81
Animales MU	21200	22642	22829	22763	24523	27523	25809	25017	22633	19634	16167

2.2 - DEPOMETRO: Valores de su Rodeo según DEP PROTEINA



ESTABLECIMIENTO GEA

2 - DESCRIPCION GENETICA DEL RODEO Y SU EVOLUCION

2.1 - Evolución de la DEP PROTEINA 305 en Hembras según Año de Nacimiento

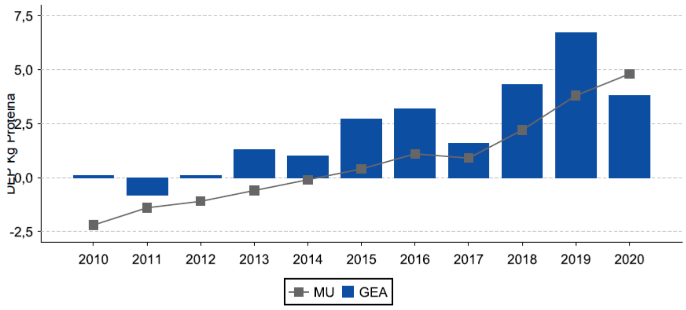


Figure 12. Example of MU EPDs and genetic trends reports.

Observations on MU reports

There are several relevant pieces of information and a level of management data which could be shared and integrated with other data sources and farmer communication channels (e.g. Conaprole’s FosApp and FUCREA’s database). Following a large amount of information made available to users of MU’s system, a strategy to be considered might include:

1) Prioritise IEP index to all levels of reporting and across most KPIs wherever possible, e.g. front trait in the genetic merit description tables and in lists of bulls present in the herd report.
2) Summarizing key pieces of useful information in one upfront figure that becomes the standard reference for all farmers. This would consolidate the quantity of information and highlight key pieces that are essential to the strategy.
3) Constructing a Key of all abbreviations to provide clarity and united understanding.
4) An electronic interactive version of the “Informe de Primavera” could be welcomed by farmers as there is useful information in the report, particularly regarding culling and selection decisions at the individual animal level.
5) Inbreeding diagnostics with a clearer description of the inbreeding coefficient, i.e. presenting the units (%) and adding a target line that informs where the average level would be expected to be.
6) Presenting interesting information like the “Bull presence in herd” table which clearly describes the influence of different bulls.

Potential additional value through data and information sharing

The multiple parts of the genetic improvement structure have specific targets. However, there is a general perception of the social contribution of participating in the genetic improvement effort through MU because it creates connections and opportunities to share data and information with other organizations. Thus, additional benefits to be considered could be:

1) MU being a catalyst to share and aggregate data across a wide range of dairy producers
2) Particularly with institutions such as
   - CONAPROLE – most important dairy cooperative in the country. An important source of data and information (not openly shared) including over 2,000 dairy farmers.
   - FUCREA – important for the sector and congregates many farmers. Interchange between dairy farmers looking at integrating production, productivity, and profitability. Provides data and information for the IEP development, and important database for the sector (at herd level, not individual cow level).

These organizations congregate different types of producers, such as small-scale family farms, small-medium commercial dairy farms (majority), and large-scale economic groups.

For MU, in terms of adding value to dairy farmers and increasing adoption of genetic tools and services, there might be strong value in pursuing further support of:

- Economic groups that manage many large-scale herds, not currently included in the system because they cannot be serviced in full (many farms crossbred cattle) and therefore do not see value.
- Commercial farmers of medium to large scale with mainly crossbred herds, not attached to breed societies and or pedigree registration through ARU.
- Smallholder farmers who might not be seen/perceive themselves as large enough to justify participating in the national dairy improvement scheme.

There are concentrated efforts within the different organizations and different initiatives and groups will have different interests and different focus which creates a difficult path for synchronizing performance recording efforts. For instance, FUCREA is largely focused on pasture management, farm management, and farming business initiatives, whereas CONAPROLE is focused on reproduction and milk quality.

These additional aspects of the dairy production system contribute to difficulties faced by producers. For instance, within a herd there might be:

- Animals that are pedigree, SH, or crosses. Some of which need inspection from a certified inspector, adding costs and effort to maintain the system on-farm.
- Farmer records on across multiple platforms - MU system, breed society, FUCREA and Conaprole.
- Other managerial concerns like: milk and animal sales, milk production costs, herd improvement costs, overheads, salaries, etc.

In this context, key questions to be considered and eventually addressed are:

1) Is it possible to propose simplified systems that associate technology and sharing of data and information?
2) Can MU propose and lead the implementation of a system that reduces complexity largely and helps dairy farmers with their day-to-day operations, in partnership with other organizations?

Appendix 5. Countries of reference on pastoral dairy production

Key observations from other countries which lead international production and exports of dairy products.

1) Australia, Ireland, and New Zealand, all have strong well-organized dairy sector structures with organizations responsible for strategic leadership, including responsibility for genetics initiatives, data, and information.
2) These three countries strongly emphasize the importance of genetics throughout the sector by investing, offering string infrastructure (people and technology), and leadership. The organizations coordinating these actions are:
    a. Australia – DataGene[11] (subsidiary of Dairy Australia)
    b. Ireland – Irish Cattle Breeding Federation (ICBF)
    c. New Zealand – NZ Animal Evaluation Ltd (NZAEL) (subsidiary of Dairy New Zealand)
3) Information on available genetics, particularly bulls in the market, is open and fully accessible. In all three countries selection of bulls and cows is based on estimates of genetic merit, i.e. EBVs (or DEPs) and economic selection indexes.
    a. Australia – Balanced Performance Index (BPI) and Health Weighted Index (HWI)
    b. Ireland – Economic Breeding Index (EBI)
    c. New Zealand – Breeding Worth (BW)

Australia case

In Australia the feedback to dairy farmers is provided through a series of tools, on-line informative resources and the Genetic Progress Report (Figure 13). This Report is an effective tool that helps farmers and their advisors to monitor genetic change at herd level and measure the effectiveness of their breeding choices.

The Report is a within-breed analysis of a herd over a ten-year period and shows genetic gains for the economic selection indexes, protein kilograms, fat kilograms, overall type, survival, daughter fertility and cell count. In Australia, there are approximately 5,055 dairy herds with 2,055 (40%) herd recording. The national herd is comprised of approximately 1,410,000 dairy cows with an average annual milk production per cow of 6,170 litres.

DataGene is an independent and industry-owned organization responsible for developing modern tools and resources to drive genetic gain and herd improvement in the Australian dairy industry. This is achieved through research, development, and extension activities. DataGene operates in a highly collaborative role involving industry organizations, private sector agribusinesses, research agencies, and, most importantly, dairy farmers.

[11] https://datagene.com.au/

GENETIC PROGRESS REPORT

DataGene
Solutions for Herd Development
V 1.3

Print date: 27/03/17

National herd ID:

Cows currently in herd: 706

Breed code for this report is:
Holstein and Holstein X

Your Herd's Genetic Snapshot

Rank **2XX** out of 1759 Holstein milk recording herds for BPI

BPI **40** herd average Balanced Performance Index

The bulls you selected over the last 10 years produced Holstein cows with genetic trends that have:

↑ Profit
↑ Production
↑ Overall Type
↑ Longevity
↑ Fertility
↑ Mastitis Resistance

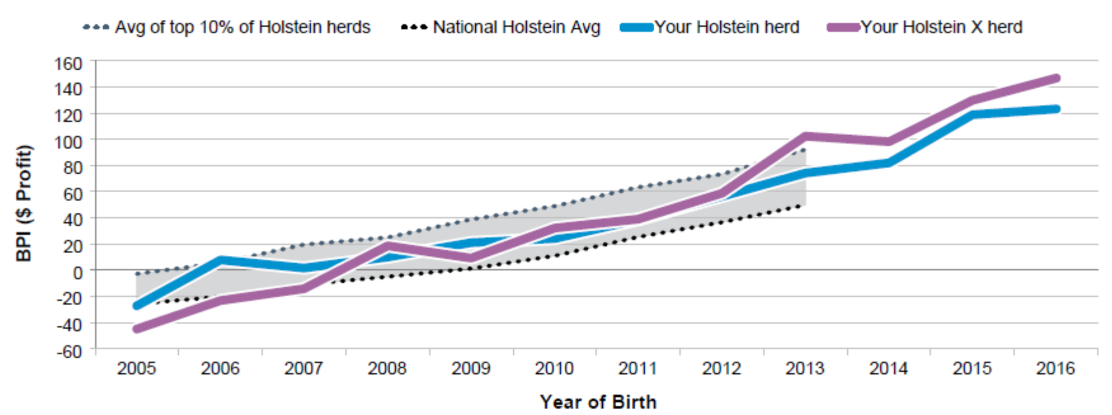
Genetic Trend: ↑ Increased ↓ Decreased ∅ No clear trend

THE Good Bulls GUIDE

Do you want to improve your herd's genetic performance for one or more of these traits?
Use the Good Bulls Guide to choose bulls that perform well in your highest breeding priority areas.

GBG **100%** of the cows born in 2014 were bred from the Good Bulls Guide or by Progeny Test.

Genetic Progress for Balanced Performance Index



The Balanced Performance Index (BPI) reflects the economic drivers of net profitability for the range of dairy farming systems in Australia. Traits include production, survival, type, mammary, milking speed, temperament, cell count, fertility and feed efficiency.

Number of Cows (current and sold/culled)

Year of Birth	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	Total
Holstein	89	184	81	63	128	88	107	138	133	112	123	101	**1347**
Holstein X	64	40	36	29	68	55	58	86	71	76	74	66	**723**

Calves and heifers can be included in this report if they are recorded at your herd test centre.

DataGene is an independent and industry-owned organisation that is responsible for driving genetic gain and herd improvement in the Australian dairy industry, through research, development and extension activities.

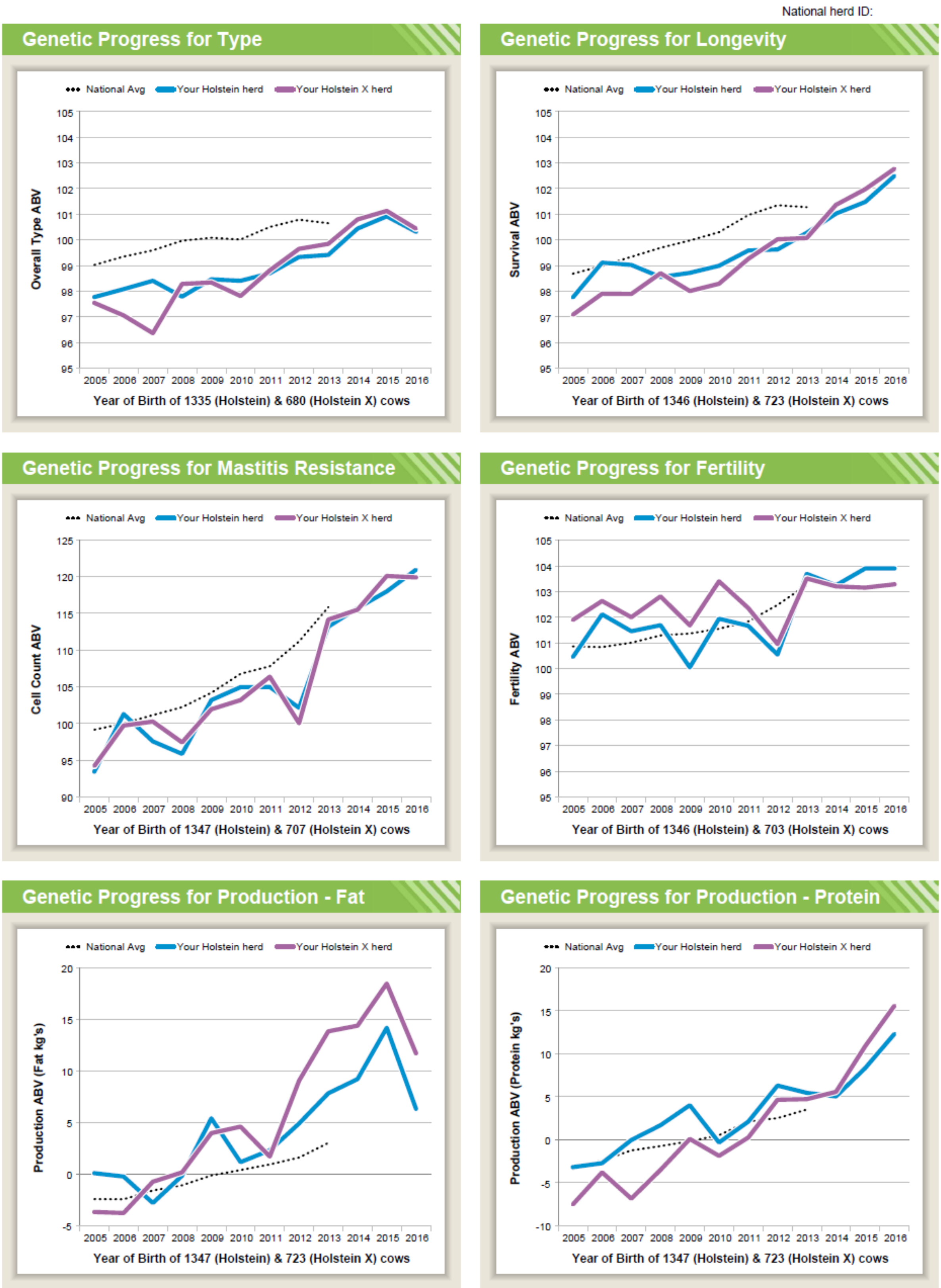


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Figure 13. Example of DataGene's Genetic Progress Report.

The response to selection on the economic selection indexes[12] (BPI and HWI) used in Australia is presented in Figure 14. The emphasis of the BPI index for Holsteins is presented in Figure 15 as an example of the direction that the dairy industry in Australia is pursuing currently.

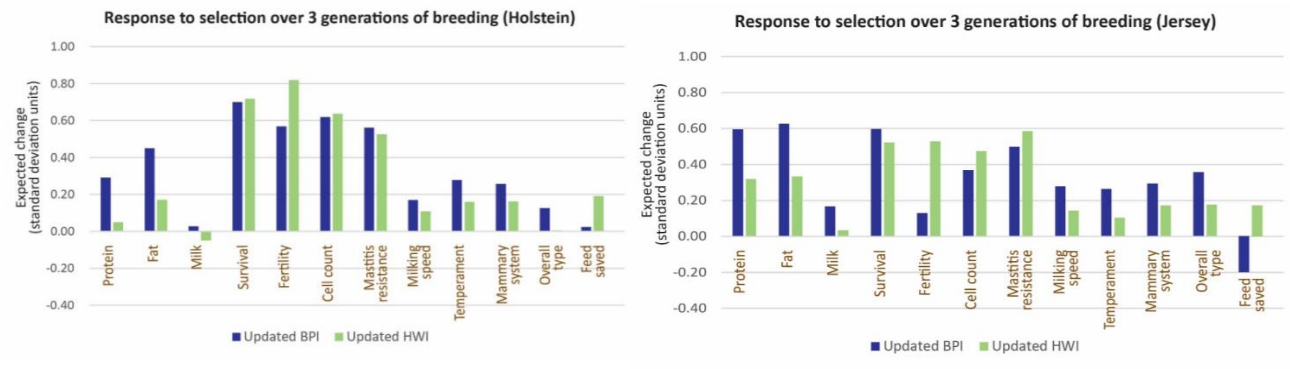


Figure 14. Response to selection under the BPI and HWI for Holsteins and Jersey breeds.

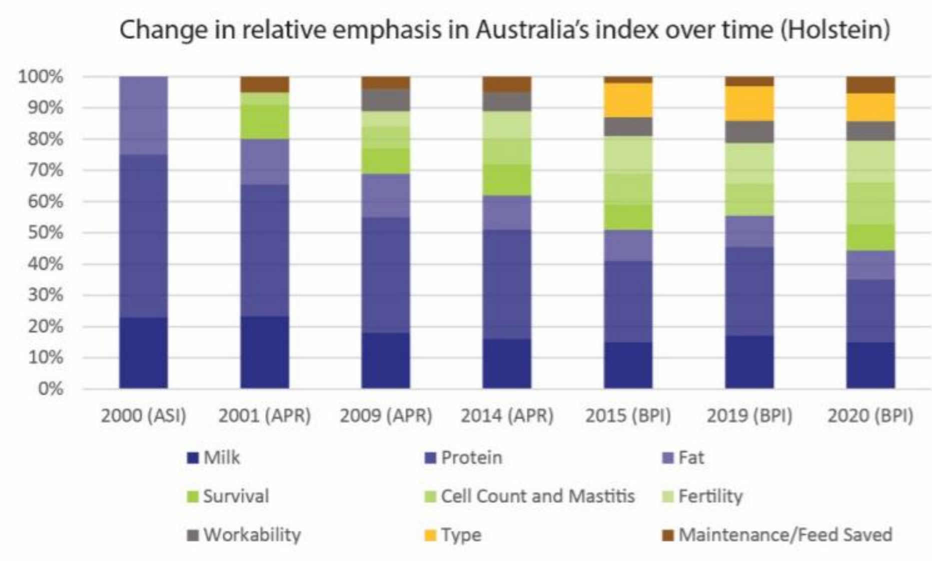


Figure 15. Evolution of the main Australian selection index since 2000.

Ireland case

In Ireland, ICBF coordinates all activities for cattle breeding. The entire cattle population in Ireland is identified and all information is centralized through ICBF, including performance recording, calving events, milk production and slaughter data.

ICBF's mission is to simultaneously benefit farmers, the agri-food industry, and communities through genetic gain. The organization delivers high value, low-cost services from the cattle breeding database, developing, and applying science and technology.

12 https://datagene.com.au/sites/default/files/Upload%20Files/Technote%2026%20BPI%20HWI%20update%20Dec%202020%20%282%29.pdf

The main outcomes are realized through permanent growth in productivity and evolution of genetic trends that confirms genetic improvement continue to be an important lever for the sector, delivering real value for money to farmers and the industry.

HerdPlus[13] is the ICBF genetics platform through which dairy farmers access all the information about their cows, herds, and benchmarking with the sector. HerdPlus uses data from multiple different sources including animal events data, AI data, carcass data, genomic data, milk recording data, weight data, and others. HerdPlus then combines and compiles this data into various profiles, reports, and applications. Some examples of HerdPlus reports are presented in Figure 16. There are many reports and profiles available for farmers, including customised "Genomic Evaluation Reports[14]"

Milk recording Animal Report

MUNSTER A.I. & FARM SERVICES GROUP
BALLYVORISHEEN
MALLOW
CO. CORK
Tel: 022/43228

Herd owner: SAMPLE
Herd No: IE1234567 **Scheme** A6
Print date: 18/11/16
Test date: 11/11/16 **Page 1(10)**

Cow ID	I&R-Tag	Calv. Date	Lact.	Last test day / Yield to date / 305 day yield (predicted)								SCC	EBI
Cow name		Age	Days	M Kg	M Gall	F%	P%	L%	F Kg	P Kg	F+P Kg	Tests>200	(Euros)
Sire ID	Cow Classification	Group	Test									No. Treats	
100		**21/03/16**	**7**	**19.4**	**4.1**	**5.38**	**4.08**	**4.64**	**1.0**	**0.8**	**1.8**	**91**	**108**
		9y 9m	**235**	6275	1340	4.26	3.45	4.83	268	216	484	**0**	
RUU		**Spring**	**6**	***7319***	***1564***	***4.44***	***3.56***	***4.83***	***325***	***260***	**585**	**0**	
101		**30/01/16**	**7**	**Cow dry - 05/08/16**									**126**
		9y 9m	**188**	5781	1235	4.63	3.42	4.62	268	198	466	**2**	
MBH		**Spring**	**3**	***7985***	***1706***	***4.69***	***3.60***	***4.62***	***374***	***287***	**661**	**0**	
102		**14/03/16**	**8**	**19.6**	**4.2**	**4.59**	**4.12**	**4.67**	**0.9**	**0.8**	**1.7**	**1616**	**155**
		9y 7m	**242**	7804	1667	4.24	3.51	4.84	331	274	605	**6**	
LLO		**Spring**	**6**	***8806***	***1881***	***4.33***	***3.60***	***4.84***	***382***	***317***	**699**	**0**	
103		**15/02/16**	**8**	**17.1**	**3.7**	**3.91**	**4.07**	**4.70**	**0.7**	**0.7**	**1.4**	**305**	**143**
		9y 7m	**270**	7570	1617	4.10	3.85	4.98	311	291	602	**6**	
LLO		**Spring**	**7**	***8104***	***1731***	***4.10***	***3.87***	***4.98***	***332***	***314***	**646**	**0**	
104		**18/02/16**	**7**	**19.2**	**4.1**	**4.47**	**3.79**	**4.36**	**0.9**	**0.7**	**1.6**	**81**	**108**
		9y 2m	**267**	8684	1855	3.96	3.51	4.80	344	305	649	**0**	
RUU		**Spring**	**6**	***9312***	***1989***	***4.00***	***3.54***	***4.80***	***372***	***330***	**702**	**0**	
105		**30/03/16**	**7**	**21.9**	**4.7**	**4.02**	**3.63**	**4.72**	**0.9**	**0.8**	**1.7**	**201**	**25**
		9y 2m	**226**	7060	1508	3.20	3.29	4.85	226	232	458	**2**	

[13] https://www.icbf.com/wp-content/uploads/2018/10/Dairy-User-Guide-Published-version-compressed.pdf
[14] https://www.icbf.com/wp-content/uploads/2013/06/Sample-Genomic-Report.pdf

End of Season Fertility Report
Spring 2010

Call 023 8820452

Herd Owner: SAMPLE
Herd Number: IE1234567
Report Date: 09/08/2010

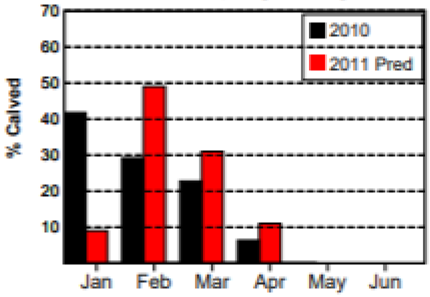
Mating Start Date (MSD):	21/04/2010	14/04/2010	Finish/Last Serve Date:	12/07/2010
	Cows	Heifers	Length of Breeding Season:	12 weeks + 5 days

(a). Calving Summary Data - Report is based on dairy cows that calved from 19/01/2010

	Spring Dairy Calving Dates			
	Start Calving	Median Calving[1]		Last Calving
Cows	19/01/2010	08/02/2010	(20 days)	20/04/2010
Heifers	03/01/2010	31/01/2010	(28 days)	23/04/2010
Herd	03/01/2010	04/02/2010	(32 days)	23/04/2010

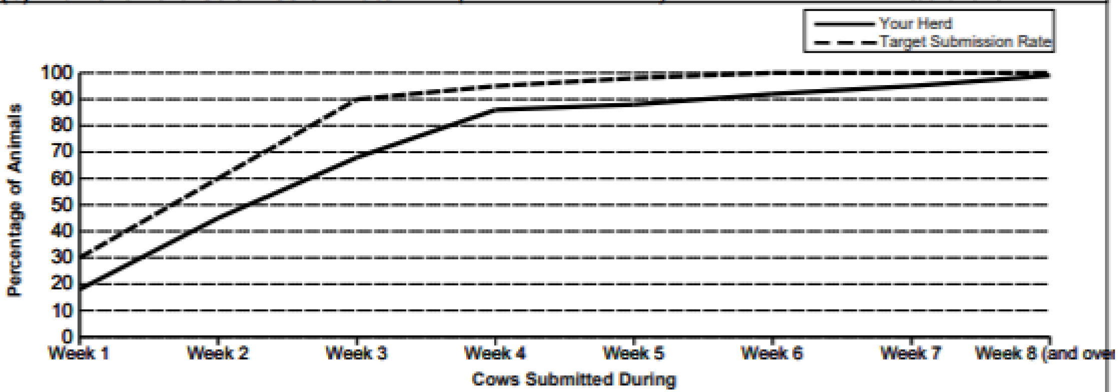
Total Dairy Calvings: 79 Cows Calved & Served: 72
Total Dairy Calves Born: 81 Total number of serves: 190

Current & Predicted Spring Calving Pattern



Explanatory Notes
1 Median Calving: Date on which 50% of cows/heifers have calved as a percentage of cows/heifers calved on report date.

(b). Current Herd Submission Rate - Report is based on dairy cows that calved from 19/01/2010



(c). Key Performance Indicators (KPI's)

Days since Mating Start Date: 111 (Cows) / 118 (Heifers)	Cows: Your Herd	Cows: Top 15%	Maiden Heifers: Your Herd	Maiden Heifers: Top 15%
1. 21-day Submission rate Cows/heifers submitted for mating within 21 days of MSD (50 cows/ 29 heifers) as a percentage calved up to 21 days after MSD (73) /dairy heifers > 11mths (50)	68%	69%	58%	90%
2. 42-day Submission rate Cows/heifers submitted for mating within 42 days of MSD (67 cows/ 43 heifers) as a percentage calved up to 42 days after MSD (73) /dairy heifers > 11mths (50)	92%	85%	86%	95%
3. 1st Service Conception rate Cows/heifers confirmed in-calf to 1st service (33 cows/ 30 heifers) as a proportion of cows/heifers submitted (72 cows/ 43 heifers)	46%	65%	70%	70%
4. 6 Week Pregnancy rate Cows/heifers confirmed in-calf within 6 weeks of MSD (44 cows/ 32 heifers) as a proportion of cows/heifers submitted (72 cows/ 43 heifers)	61%	71%	74%	85%
5. Overall Pregnancy rate * Cows/heifers confirmed in-calf (72 cows/ 43 heifers) as a proportion of cows/heifers submitted (72 cows/ 43 heifers)	100%	91%	100%	96%

* Cows/heifers are assumed in-calf unless marked as empty in the pregnancy check event

3/5

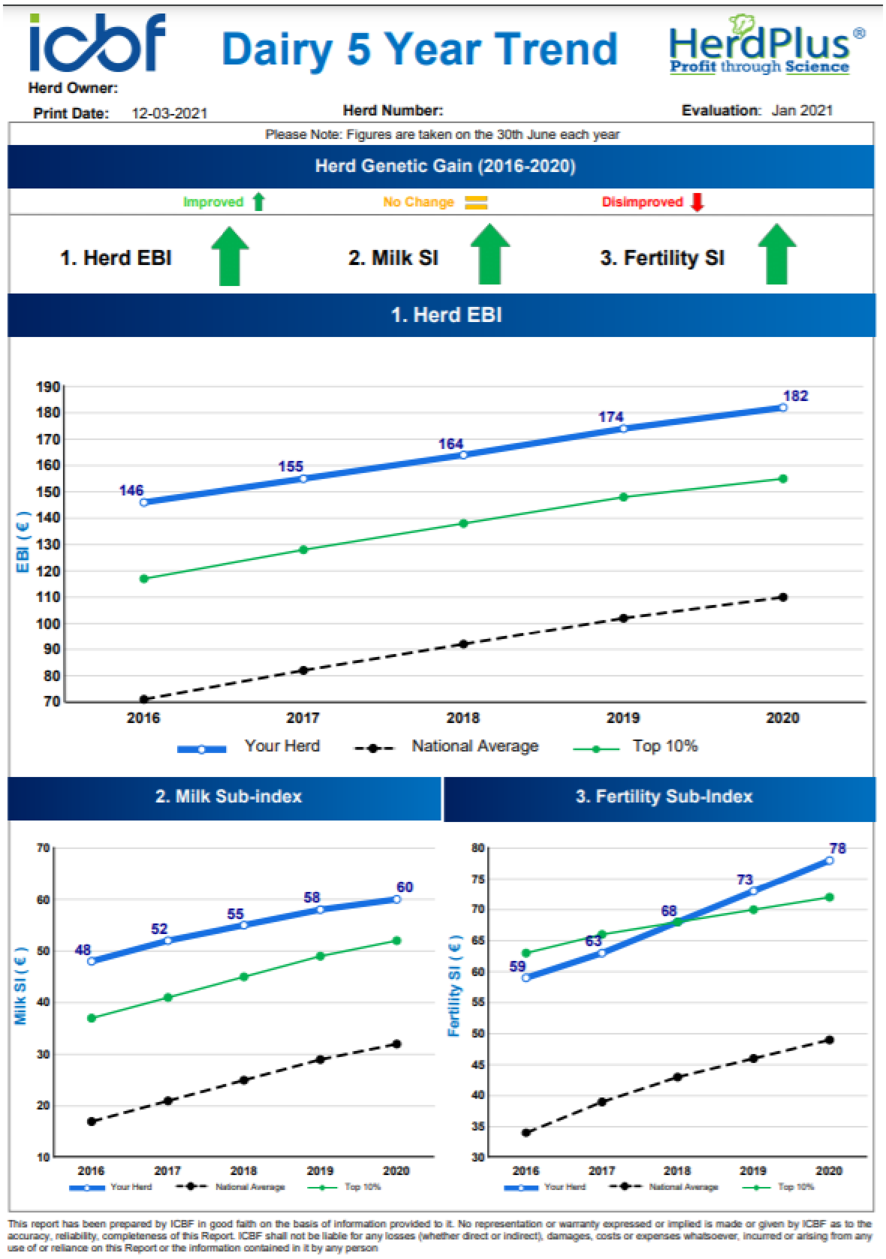


Figure 16. Examples of HerdPlus reports and profiles.

In Ireland, there are over 960,000 cows herd tested across almost 8,000 herds (over 1 million AIs). The national herd is comprised of approximately 1,570,180 dairy cows with an average herd of 101 cows, average daily milk production of 16.7L with 4.63% fat and 3.97% protein (or 1.43 kg F+P per cow per day). The genetic evaluation Base Cow Performance has 5,743L per lactation, 224 kg of fat, 195 kg of protein, 3.90% fat, 3.39% protein, average calving interval of 400 days and average survival between lactations of 82.5%.

The EBI is a profit index that help farmers identify the most profitable bulls and cows, and breed dairy herd replacements from them. The EBI comprises seven sub-indexes related to profitable milk production. These include milk production, fertility, calving performance, beef carcass, cow maintenance, cow management and health. A summary of the sub-indexes, including traits and their relative weightings in the EBI are presented in Figure 17[15].

[15] https://www.icbf.com/wp-content/uploads/2020/02/Understanding-EBI-PTA-BV-Spring-2020.pdf

2018 Economic values and % emphasis for traits in the EBI				
Sub-Index	**Trait**	**Economic Weight**	**Trait Emphasis**	**Overall Emphasis**
Production	Milk	-€0.09	8.9	**34%**
	Fat	€2.08	7	
	Protein	€5.58	17.9	
Fertility	Calving Interval	-€12.59	23.1	**34%**
	Survival	€12.43	10.7	
Calving	Direct Calving Difficulty	-€4.19	3.3	**10%**
	Maternal Calving Difficulty	-€2.31	1.8	
	Gestation Length	-€7.93	4.3	
	Calf Mortality	-€2.58	1	
Beef	Cull Cow Weight	€0.15	0.7	**8%**
	Carcass Weight	€1.38	4.8	
	Carcass Confirmation	€10.32	1.7	
	Carcass Fat	-€11.71	1.1	
Maintenance	Cow Liveweight	-€1.65	6.3	**6%**
Management	Milking Speed	-€0.31	2.5	**5%**
	Milking Temperament	€35.86	2	
Health	Lameness	-€72.47	0.7	**3%**
	SCC	-€43.49	1.8	
	Mastitis	-€82.65	0.8	

Figure 17. Economic values and % trait emphasis in the EBI.

In Ireland, the genetic evaluations carried out by ICBF are informed routinely to dairy farmers who have full access to the genetic merit of their herds thus using this information to achieve faster improvement in traits of importance on-farm. ICBF continually reiterates the message that the observed performance of an individual cow depends on her genetic merit and the environment in which the cow is performing.

Another concept that is often communicated is that it is not possible to directly alter the genetic merit of an individual cow, however improvements can be made for specific traits in her offspring. It is important to recognise the genetic merit of both the cow and the bull in order to make genetic improvements in traits of economic importance.

This strategy has resulted in a strong level of commitment from dairy farmers which are in general smaller size scale compared to countries like New Zealand or Uruguay, but which average genetic merit of their herds can be briefly described in Figure 18. All dairy and dual purpose herds with 30 or more dairy cows are included in the calculation of the national ranking.

	Top 1%	Top 5%	Top 10%	Top 25%	Ave.
2021 Heifers	€274	€245	€232	€211	€184
2020 Heifers	€251	€224	€212	€192	€167
Cows EBI	€235	€206	€191	€166	€130
Herd EBI	€193	€173	€166	€149	€127
Herd Milk	€67	€60	€56	€49	€39
Herd Fertility	€95	€82	€76	€69	€60

Figure 18. National Ranking of Herds and Cows on EBI.

Strong outcomes in terms of genetic progress have also underpinned this strategy. The genetic trends of the EBI index and the Milk and Fertility sub-indexes are presented in Figure 19. The rate of genetic gain in EBI has achieved €12.6 per year over the last 10 years, which is equivalent to 0.20 genetic standard deviation units in EBI. These outcomes are in line with world's best results across all countries and production systems, and have been important in balancing genetic progress evenly across milk and fertility[16].

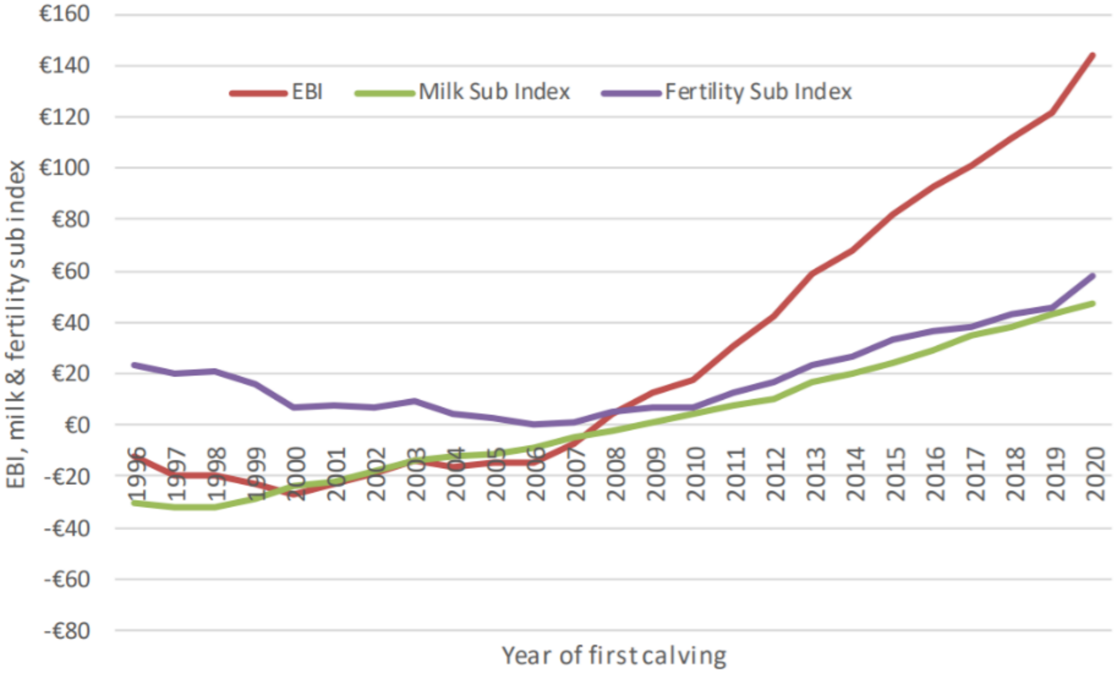


Figure 19. Genetic Trends for dairy females, by year of first calving.

This strategy is also delivering for all breeds, especially Holstein (Figure 20) which is the largest breed in number of animals recorded, data and genotypes within the program.

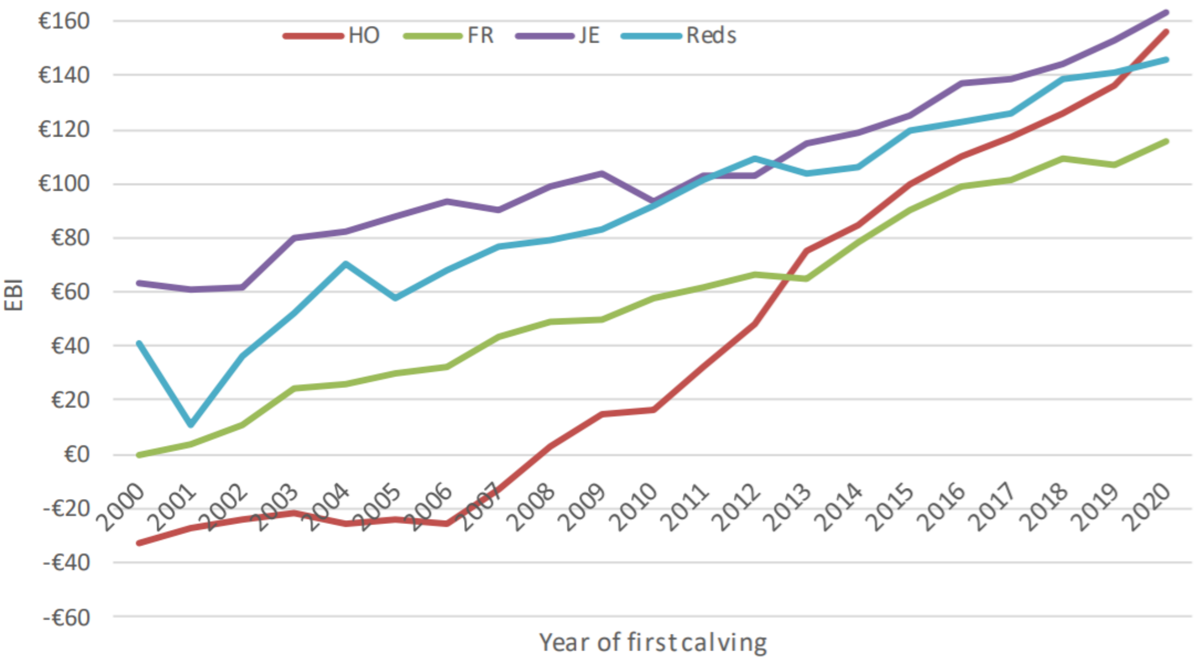


Figure 20. Genetic trends for dairy females, by year of first calving and by main breed of sire.

[16] https://www.icbf.com/wp-content/uploads/2020/03/Dairy_Proofs_Mar2020.pdf

New Zealand case

NZAEL manages the National Breeding Objective (NBO) for New Zealand dairy cattle and now also coordinates the Dairy Industry Good Animal Database (DIGAD) which runs genetic evaluations for bulls in New Zealand. Its aim is to provide dairy farmers with the tools needed to best inform breeding decisions.

This includes developing, promoting, and delivering technologies that optimise genetic improvement in the national dairy herd. The organization defines the required structure to relevant on-farm data that is captured and ensures quality data is analysed accurately using world leading analytical methods. The main outcomes are realized through permanent growth in productivity. The evolution of genetic trends confirms genetic improvement and continues to be an important lever for the sector.

In New Zealand, there are over 4.9 million dairy cows in about 11,180 dairy herds, an average of 440 cows per herd[17]. A total of 3.6 million cows were herd tested in 2019/20 (75% of national total).

The NBO aims to help dairy farmers breed cows that are efficient to convert feed into profit. The Breeding Worth (BW) index represents this objective and ranks cows and bulls accordingly. The "Base Cow" in this case is used to rank the genetic merit of herd cows in terms of genetic merit represented by both the BW and the various traits' estimated breeding values (EBVs).

The genetic base used for calculating BW and EBVs became the average of a group of well recorded cows born in the year 2005. The average performance of this group is presented in Figure 21.

Breeding Worth Traits		
Trait	**Phenotype**	**Previous BV***
Protein	174kg	5.12
Fat	218kg	6.08
Volume	4595L	68.21
Liveweight	467kg**	-3.22
Fertility	TBC	0.49
Somatic Cell Score	208	0.04
Residual Survival	TBC	15.12
Body Condition Score	4.11	0.00

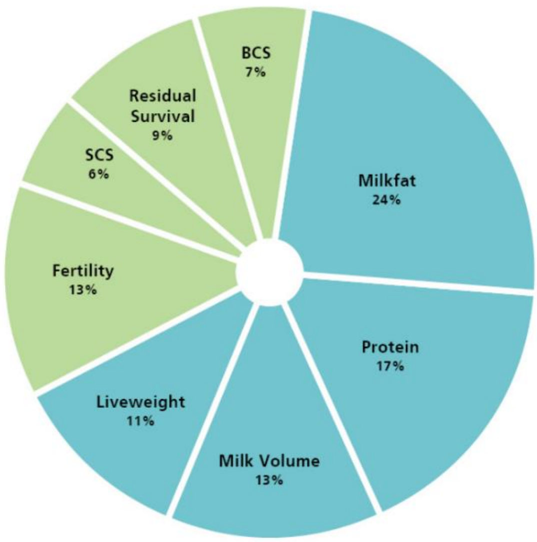
Figure 21. Average performance of the genetic base consisting of 21,585 cows of various breeds and crosses which represent the "Base Cow".

[17] https://www.dairynz.co.nz/media/5794073/nz-dairy-statistics-2019-20-dnz.pdf

The resulting economic values for the various traits included in the NBO are presented in Figure 22, the relative emphasis of these traits presented in Figure 23**Error! Reference source not found.**, and genetic trends for BW and fertility are presented in Figure 24 and Figure 25, respectively.

Trait (units)	BW 2020	BW 2019	% change
		Economic value ($/unit change)	
Milkfat ($/kg)	4.25	3.49	+22%
Milk protein ($/kg)	4.26	4.38	-3%
Milk volume ($/L)	-0.094	-0.092	+2%
Live weight ($/kg)	-1.38	-1.30	+6%
Residual survival ($/day)	0.105	0.112	-6%
Somatic cell score ($/SCS)	-37.11	-37.30	-1%
Fertility ($/CR42)	5.92	5.88	+1%
Body Condition Score ($/unit)	101.96	96.30	+6%

Figure 22. BW economic values calculated assuming industry averages for animal production, feed requirements, and farm systems.



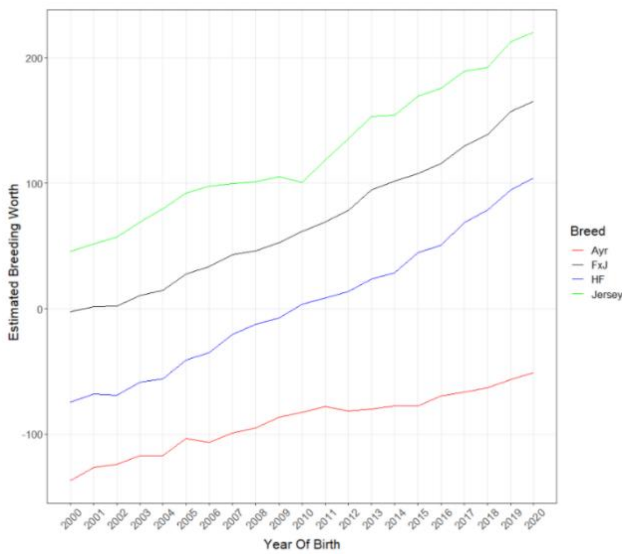


Figure 23. Effective emphasis on the individual traits within Breeding Worth (left).
Figure 24. Genetic Trend Estimated Breeding Worth (BW) (right).

In Figure 26, an example of the tool made available for dairy farmers to support bull selection decisions is presented[18].

[18] https://www.dairynz.co.nz/animal/animal-evaluation/breeding-worth-tool/

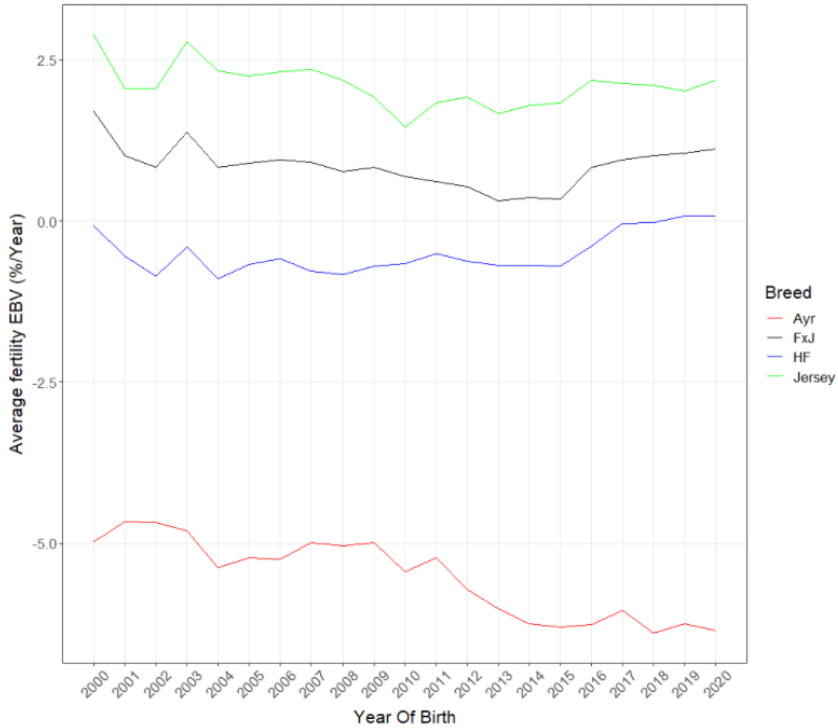


Figure 25. Genetic Trend Average Fertility Estimated Breeding Value (EBV).

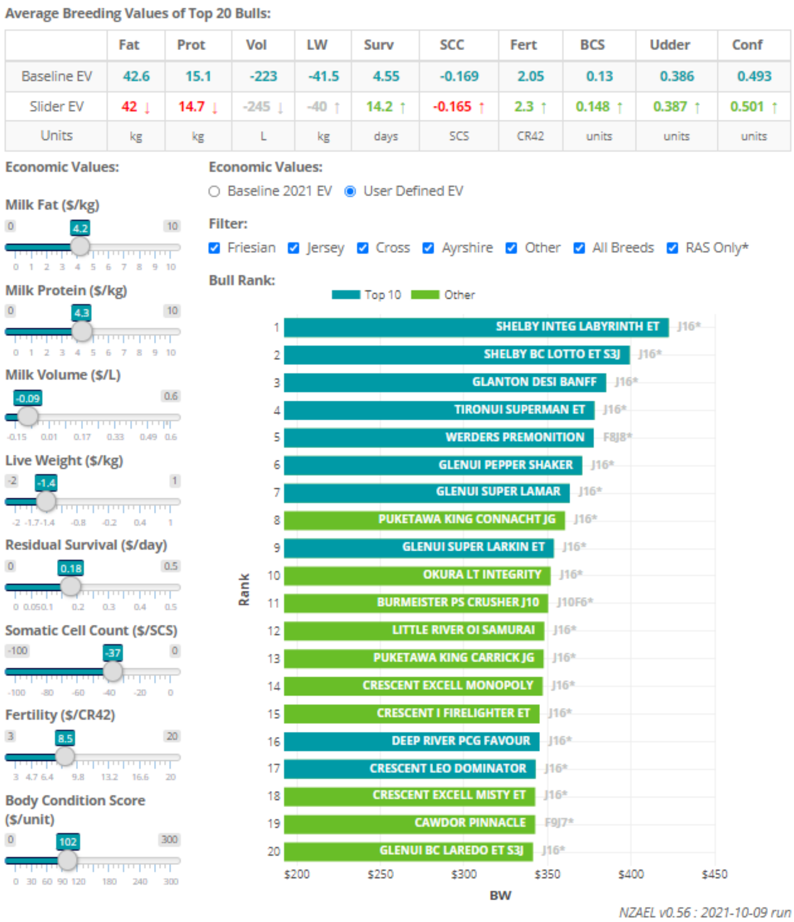


Figure 26. Example of Breeding Worth Tool offered to dairy farmers by NZAEL.

Appendix 6. Impressions on genetic improvement and genetics infrastructure in Uruguay

Uruguay has implemented a sound genetic improvement program for its dairy sector. The basic elements are functional and efficient, particularly the animal identification system, the structure for data collection and herd testing, the genetic evaluations (including economic selection index (IEP) and a genomic selection pipeline), participation in Interbull, and the publication of ranks of commercial domestic and imported bulls under a unified system.

The genetic evaluations (GE) run by EGL consists mainly of a within breed evaluation of a core set of models for key traits (milk, fertility, and type) has been implemented for more than 20 years. GEs are processed three times a year (following the Interbull calendar).

The multi-trait evaluation for milk traits (milk fat, protein, and volume) is based on test-day records. It uses Legendre Polynomials as random effects, with year-herd as fixed effects, and only for the 1st, 2nd, and 3rd lactation.

The fertility model is another important part of the evaluation. It uses a repeatability model for days open, converting outcomes into calving interval at the 2nd lactation. This is a single trait evaluation. Similarly, somatic cell score is a single-trait evaluation and a very important trait for the breeding program. The GE also includes a series of conformation traits on type (udder, teat, feet, legs and dairy capacity or form).

The information from Interbull is used to access international sires' data and genotypes. The DEPs published in Uruguay are a blend between Interbull and domestic evaluations. When the IEP was released, Interbull allowed access to information from bulls that do not have daughters in Uruguay, widening the opportunity to use these bulls.

The most important characteristic of the GE is that it runs a within breed model. Currently, the model removes approximately 15% of the animals in the database for the GE runs because it does not allow crossbred animals to participate in the genetic evaluation. Animals which the pedigree does not confirms 7/8 (87.5%) of a particular breed are automatically excluded from by the model. Animals that are herd tested and recorded in MU, but do not receive genetic evaluations, are included as part of MU's Informe de Primavera.

Farmers are aware of this aspect of the GE and there is questioning about its impact in the overall analysis. For instance, many Jerseys herds cannot be fully serviced by the GE because there is not enough data to support a more complete GE considering the level of crossbreeding in Jersey herds. Therefore, a GE that could cope with crossbred individuals would favour Jersey sire evaluations and provide a wider range of options to farmers.

An important limitation to the system is that there are no local evaluations (or genomic proofs, or progeny test proofs) for bulls or cows that are not pedigree registered. This means, these animals have no EPDs or EBVs available, even though they may have a known pedigree, might have been genotyped, and might have recorded performance and herd testing records. Whilst this is a standard from the point of view of the bull, this neglects important information of the cows. In this case, it is a major limitation in the system.

Opportunities & risk factors to achieve increased adoption

The structure that offers GE for dairy cattle in Uruguay is well prompted for a broader, more inclusive approach. This should be a priority if the objective is to increase adoption.

A critical direction is required on informing farmers about the value to be gained from genetics, when the system might not be suited for part of the producers, e.g. crossbred herds. This could affect many types of dairy operations, such as bigger commercial farms with multiple herds (not interested in breed registrations, but interested in EPDs and index ranks), crossbred herds, and smaller herds that may not perceive themselves participating on a breeding program because they are too small-scale.

This strategy however has risks. It needs significant extension effort, training of technical advisers, and working closely with farmers (and breed societies) to explain what the adoption of genetics tools and services could mean for their operations. Moreover, significant communication across the sector is required.

Key indicators of genetic progress

The indicators of genetic progress achieved thus far in Uruguay demonstrate that significant amount improvement has been achieved in milk production traits (Figure 27) and somatic cell score.

These improvements result from the direction, or trait emphases, from the IEP and because of the bulls made available by the semen companies, which are largely high merit for focused on milk. These reasons have been driven by the payment system which incentivises dairy farmers to follow a strategy focused on milk production.

Genetic progress in fertility (Figure 28) has been slower than expected and the trend on the IEP (Figure 29) is mostly due to the amount of progress in milk production traits. The level of inbreeding across the herd has also increased significantly over the last years (Figure 29).

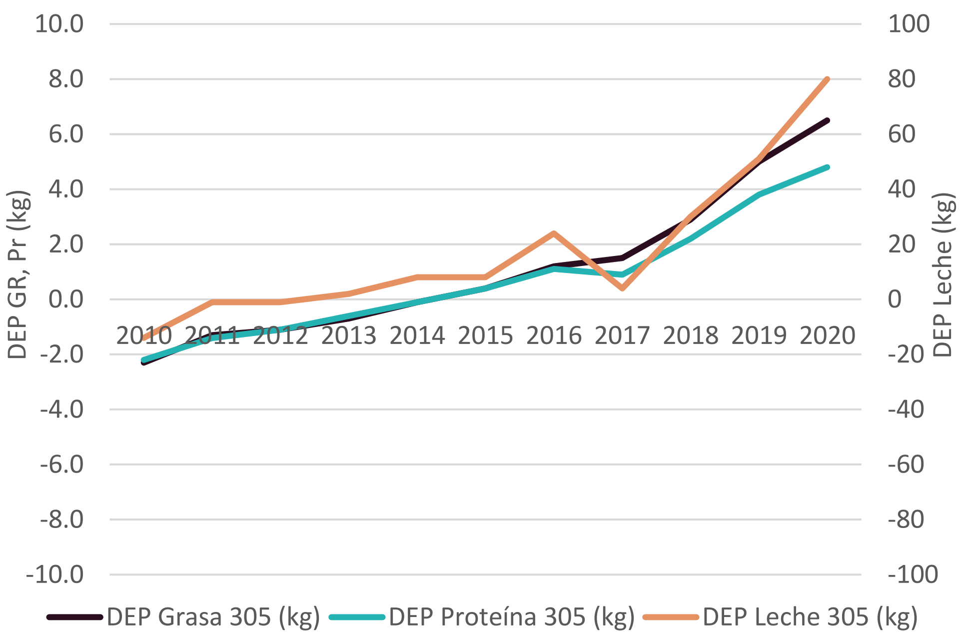


Figure 27. Genetic trends milk production traits.

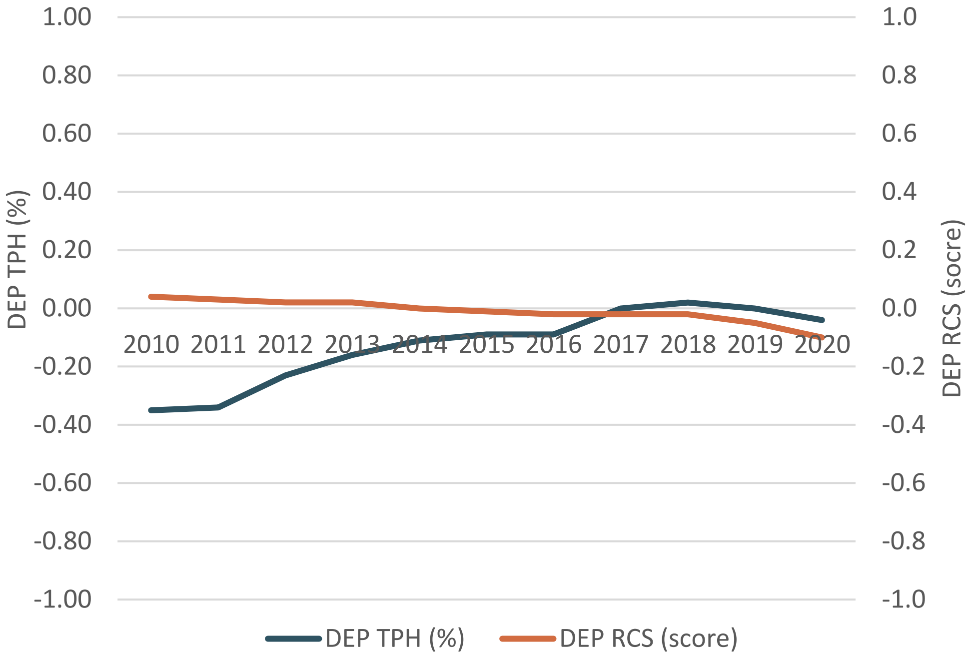


Figure 28. Genetic trends fertility and somatic cell score.

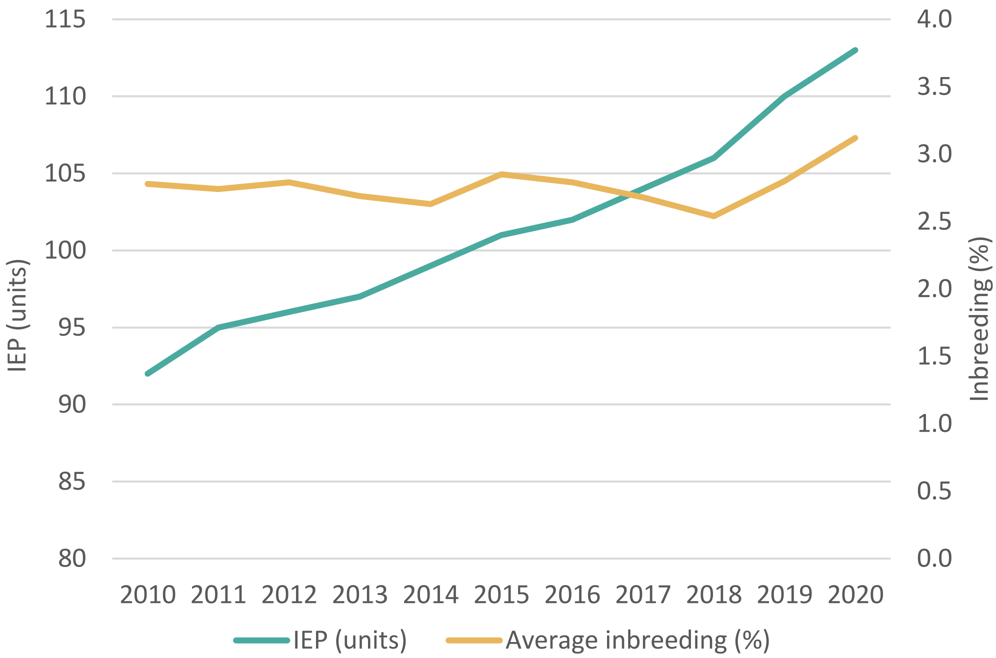


Figure 29. Genetic trends IEP and inbreeding levels.

Economic values of key traits

Milk components

Even though the economic value (EV) of fat, protein, and milk yield have driven most of the genetic progress in the IEP, the economic value of milk fat is very low compared to that of protein. This observation is based on the international dairy prices and considers the scenario for the last five years since the market price of milk fat and its products have increased in value and balanced out or surpassed the price of protein.

The EV of milk and its components is based on the farmgate payout to farmers. In Uruguay it seems like milk processors do not disclose the price paid for fat, even though exports are 70% whole milk powder and cheese, products to which production is largely influenced by the amount of fat as a constituent of milk.

The discussion around milk price, payment system, and the EV of dairy components is important because it impacts the way genetic improvement influences the makeup of the herd. Fat, for example, is more favourably correlated with health and functionality traits (e.g. fertility, resistance to mastitis, etc.), compared to protein and milk volume.

Essentially, the decision on whether to breed cows for a sustainable (and profitable) dairy operation, or breed cows based on what dairy farmers are paid for is complex and needs to be addressed with support to farmers. The discussion would need to focus on deeper engagement with stakeholders, such that an informed decision is made to the sector.

Fertility

The EV of fertility (defined as calving interval, expressed as daughter pregnancy rate) also seems to be lower than expected for a pastoral system. This is because of the importance of fertility on increasing functionality of dairy cows in systems in which seasonality is present, even to a smaller extent.

Fertility trends in the direction that is less desirable because of the lower emphasis on the IEP compared to the importance attributed to milk production traits. Therefore, the use of bulls with higher merit for milk production and lower merit for fertility becomes a practice for most farmers. The suggestion is that the EV of fertility should be considerably higher than the current level, maybe two or three times the current EV.

Another reason for the level of progress in fertility is the nature and definition of the trait itself. Fertility is naturally a low heritability ($h^2 = 0.05$) trait which frequently results slow progress unless a specific strategy is established. This includes increased levels of recording to achieve higher accuracy of prediction and eventually identifying alternative traits in which higher variation can be achieved and selected for.

In Uruguay, there is historic limitation on the use of pregnancy records, information from mating or insemination records. This is because records are not consistently captured and there is limited access. Nevertheless, farmers are currently using pregnancy diagnosis more frequently in their operations and those records are being captured.

A deeper analysis of the calving pattern of dairy cows in Uruguay (Figure 4) demonstrates that there are a proportion of seasonal calving herds (small proportion of herds, although calving pattern indicates some consistent seasonality). It is likely that the entire genetic evaluation might be affected by the definition of fertility to some extent. This is because calving interval (CI) needs to be adjusted for seasonal calving herds, as early calving cows are misjudged in CI fertility evaluations. Therefore, there are alternative predictors of fertility traits that could be captured and adjusted fairly across the different types of herds to inform a deeper analysis and technical models to improve the genetic evaluation for fertility traits.

Genomic selection

The genomics program for dairy cattle in Uruguay was established in 2018. The base reference population was formed by Holstein cows and bulls. It now includes milk production and composition traits, fertility, and somatic cell score.

The genomic selection program for dairy cattle in Uruguay is focused on expanding its reference population. This population is mostly based on cow genotypes, with access to important bulls' genotypes via Interbull, although INIA genotypes important bulls in the market (from semen samples).

The bulk of genotypes are mostly done at the Teagasc genotyping laboratory in Ireland. Approximately 3,000 to 4,000 cows are tested per year. This introduces information into Interbull GMACE and enables accessing data to run the Uruguayan single-step for approximately 1,500 bulls.

The real value of genomics is the ability to increase prediction accuracy on traits with limited information given the low level of recording. For instance, fertility (first to be deployed) and survival (longevity) are traits that largely benefit from genomics. However, there other important benefits to be captured by the dairy sector in Uruguay:

1) Farmers' access to more accurate EPDs on bulls. Ability to determine parentage and make more informed decisions when choosing young bulls.
2) Information from multi-trait GE for milk production, given not all farmers record fat and protein composition in milk. Currently, farmers that do not record fat and protein do not receive EPDs for their cows on these traits.
3) Because Holstein or Jersey bulls without sires and/or dams in the Uruguayan GE cannot be included in the evaluations, genomics is a way to alleviate these limitations.
4) Provide the Uruguayan GE a unified source of information which includes progeny of bulls born in different countries (and used in Uruguay), increasing the accuracy of prediction.
5) Reduced time required to proof bulls under the Uruguayan dairy production systems.

The critical advantage of genomics for Uruguay centres around domestic bulls, as they have less daughters and proofs compared to imported bulls. Semen companies (casa de semen) see a strategic importance around demonstrating the value of a bull (proof of merit), and using genomics to prove a bull is more likely to be successful from a commercial perspective.

Availability of data and information

The unique identification system implemented in Uruguay is an important step for a structured data-driven dairy sector. Currently, the ability to uniquely identify an animal is mainly used at mating and calving events and to fill in governmental requirements of traceability compliance underpinning exports.

Within MU's database, nearly 50% of all cows registered are not involved with pedigree or breed society registrations. These farmers provide parentage and performance data directly through the MU software database system. However, a number of these animals have no access to EPDs. One of the limitations being the access to data.

There is significant limitation in the availability of data from dairy herds in Uruguay. For instance, within the MU system which is the most complete in terms of performance recording, from the 7 million herd testing records only 44% have milk composition data. Fertility data is available historically for only 246,000 cows (540,000 calvings in total), and type and conformation records, are available only for about 52,000 animals.

Information on culling reasons, or records on mastitis and lameness are currently not recorded in Uruguay. This type of information could enable functional culling which would be easily adopted into current practices. This information is however captured by farmers with management systems implemented in their operations. These data should be part of an information system and potentially shared among the different players, e.g. MU, CONAPROLE, FUCREA, other.

The absence of data on cow live weight is another example of key limitation. An effort is being made to evaluate the possibility of using carcass data as an option. There is no use of type and conformation traits (stature and BCS) to predict cow live weight. This could be used to predict some of bulls, complementary to carcass weight. Thus, enabling a EPD for mature weight.

Somatic cell score is a very important trait which directly impacts the income of the dairy operation, as milk processors pay more for better quality milk (i.e., low SCS, high milk fat and protein composition), and economic losses from mastitis are very high. Nevertheless, there is limited data or even a consolidated way to record clinical mastitis.

There is need for an integrated effort to consolidate and connect data sources and data flows, creating local structures that involve herd testing providers, pedigree and parentage controls, and data collected on-farm with support of herd management systems.

The associated genetic information produced by EGL would then be used by the wider sector and reach more stakeholders. These include not only farmer and milk processing organizations, but also organizations involved in the leadership and strategy, R&D, and market access.

In this context, an integrated data collection might still be a limitation if double-entry is maintained in the improved data infrastructure. This should be one of the aims of any sort of integrated solution, such that information fed in one of the data-entry points is utilized throughout several independent databases without need for double-entry.

Appendix 7. The value of genetics to the sector

The modelling of the value of genetics to the Uruguayan dairy sector assumed a total of Uruguayan dairy industry consists of 3,400 farms, each producing on average 640,000 litres of milk per year (or approximately 5,047 litres from 126 milking cows). To measure genetic improvement, the sector currently utilizes the IEP index – the economic index representing profit per cow.

This section describes the following:

1) The current annual rate of genetic gain on the IEP index
2) The value delivered (to farmers and to the sector) by current rates of genetic gain
3) The potential benefits of increasing the rate of genetic gain

This is a high-level analysis – a more detailed analysis should be carried out to determine the specific impact of investments on critical areas, designed to increase rate of genetic gain in the Uruguayan dairy sector.

The current rate of genetic gain on the EPI index

To estimate the herd's level of genetic merit, we have taken the average IEP index value of bulls according to their year of birth, lagged to account for average age of bulls at mating (Figure 30).

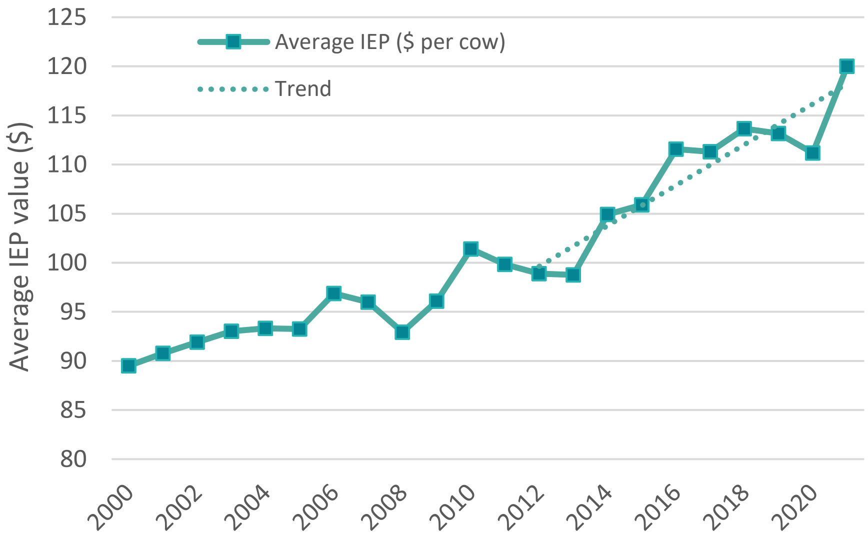


Figure 30: Average IEP value based on bull ranks by year used.

The base level of the IEP index (IEP = 100) indicates an expected cow profit of USD $25 therefore a 1 unit increase in the index suggests that profit per cow will increase by $0.25. We assumed the trend in bulls translates equally to the trend in milking cows, thus for the last 10 years a 2.07 index units trend translates to annual improvement in profit of $0.52 per cow.

The value of the current rates of genetic gain, to farmers and to the sector (i.e. status quo), can then be estimated considering genetic improvement is permanent and cumulative. This means that improved performance for any given trait in one year carries over to the next year. It also means that when measuring 1 years' genetic improvement we need to account for the continued expression of benefits years after the gain has occurred.

To estimate the value of current rates of gain we apply a common method[19] to evaluate benefits, where we assumed 10 years of sustained genetic improvement (at the current rate), then 10 further years where the benefits are "locked-in". We first calculate the present value benefits expressed over the next 20 years, then a fixed annual payment which gives the same present value. This is known as the "annualised equivalent" and is how we report the annual value of genetic improvement.

This concept is illustrated in Figure 31, where the area under the curve represents the present value of projected genetic improvement (expressed per cow). This means the value of 10 years improvement, expressed over 20 years, is $35.83 per cow. This is equivalent to receiving an $2.87 every year for the next 20 years (applying a 5% p.a. discount rate).

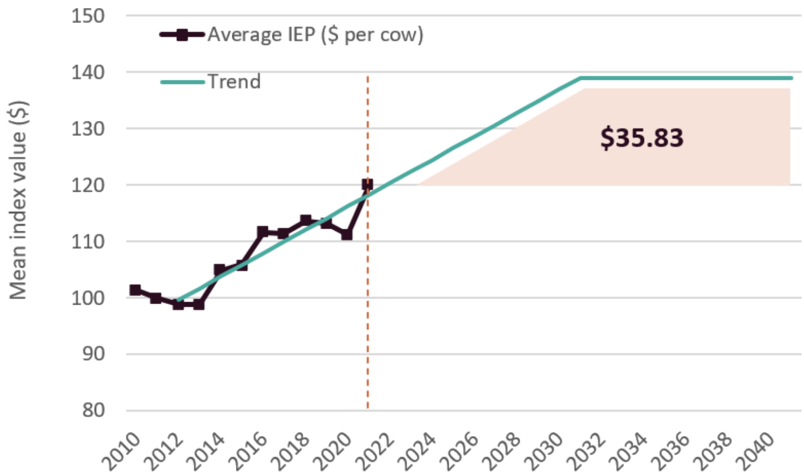


Figure 31: Projected genetic improvement in IEP index (10 years at current rate and 10 years "locked-in").

The average farm in Uruguay contains 126 milking cows. If we scale up the benefits described above this equates to annualised benefits of $363 per farm. Across the industry, this is worth $1.24m per year to the 3,400 dairy farms in Uruguay (the present value of 10 years gain followed by 10 years where benefits are "locked-in" is over $15m).

The potential benefits of increasing the rate of genetic gain

Investments in genetic improvement infrastructure can increase the annual rate of gain, increasing the benefits accruing to farmers each year. The marginal benefits of increasing the rate of gain by various magnitudes are summarised in *Table 6*

The key element to capture the benefit of genetic improvement is by increasing adoption of genetics tools and services and using the available data to inform the sector. This includes using information to remunerate farmers. The use of the IEP is then critical to support such strategy.

The IEP index must be adopted by farmers, and this should be a priority for the sector. However, there is lack of understanding and education around the IEP and the role of genetics in general. This seems to be one of the biggest challenges for the sector (and for MU).

Semen companies are progressing with their work to promote their own indexes and eventually associate these with the IEP; however, this does not seem to be a priority for these

[19] P.R. Amer, G.J. Nieuwhof, G.E. Pollott, T. Roughsedge, J. Conington, G. Simm, Industry benefits from recent genetic progress in sheep and beef populations, Animal, Volume 1, Issue 10, 2007, Pages 1414-1426

companies. Semen companies will be closely following market trends and interpreting market signals. For instance, when the IEP was initially released there was reluctancy from both, farmers, and semen companies, because SCS was not included in the IEP.

A wider index enables more genetic diversity (bulls with different characteristics) and attracts more attention from semen providers to understand their bull rankings. This highlights the importance of the index, and Uruguayan dairy farmers are now looking for the IEP when choosing bulls.

The impact of the IEP

As mentioned above (Appendix 4), the current impact of the IEP is largely driven by its emphasis on milk traits. The EV of fat ($0.46) and protein ($2.17) are lower than expected, considering the international dairy markets and the current value of milk fat. Figure 32 presents the trait emphasis of the current IEP for all bulls and for younger bulls.

An important aspect to consider is that trait correlations between milk production and functionality traits tend to be unfavourable or neutral. Table 5 presents the correlations between traits based on MU bull catalogue.

The combination of these pieces of information allows to estimate the amount of progress to be achieved considering the bulls available and the economic weights from the IEP.

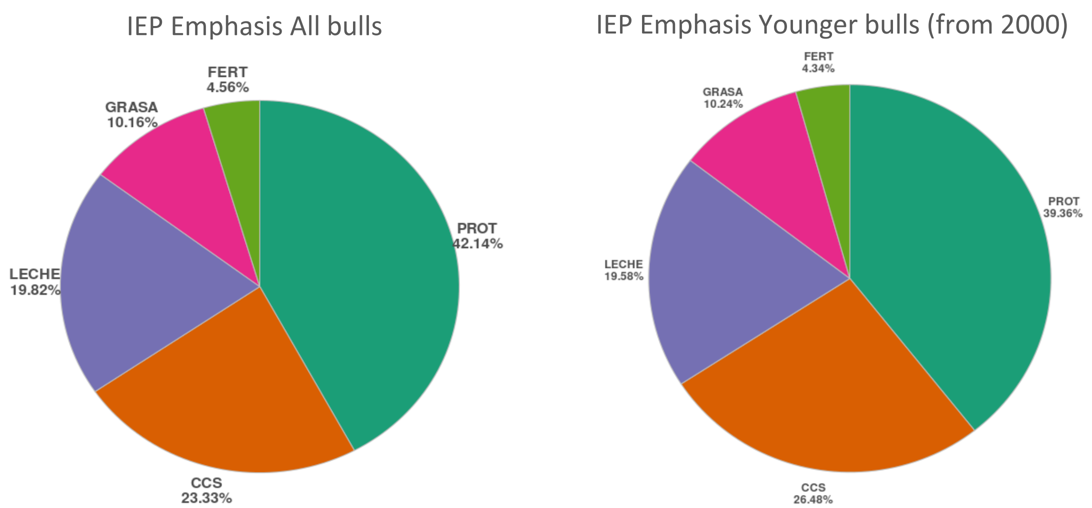


Figure 32. Trait emphasis (%) on the IEP considering different populations of bulls.

Table 5. EPD correlations for bulls included in the Uruguayan semen catalogue.

	IEP	LECHE	GRASA	GRASA_PER	PROT	PROT_PER	FERT	CCS	FINAL_SCORE	RUMP	UDDER	LEGS	DAIRY_SHAPE
IEP	1	0.09	0.59	0.49	0.59	0.68	0.30	-0.61	0.02	0.04	0.02	0.00	-0.02
LECHE	0.09	1	0.43	-0.48	0.75	-0.43	-0.26	-0.04	0.10	0.09	0.08	0.12	0.08
GRASA	0.59	0.43	1	0.59	0.67	0.29	-0.10	-0.18	0.08	0.06	0.09	0.08	0.04
GRASA_PER	0.49	-0.48	0.59	1	-0.02	0.67	0.14	-0.14	-0.01	-0.02	0.02	-0.03	-0.03
PROT	0.59	0.75	0.67	-0.02	1	0.28	-0.10	-0.11	0.08	0.09	0.05	0.11	0.05
PROT_PER	0.68	-0.43	0.29	0.67	0.28	1	0.25	-0.08	-0.04	0.00	-0.04	-0.03	-0.04
FERT	0.30	-0.26	-0.10	0.14	-0.10	0.25	1	-0.27	-0.14	-0.06	-0.12	-0.13	-0.16
CCS	-0.61	-0.04	-0.18	-0.14	-0.11	-0.08	-0.27	1	-0.03	-0.02	-0.05	0.04	0.02
FINAL_SCORE	0.02	0.10	0.08	-0.01	0.08	-0.04	-0.14	-0.03	1	0.53	0.85	0.68	0.79
RUMP	0.04	0.09	0.06	-0.02	0.09	0.00	-0.06	-0.02	0.53	1	0.22	0.48	0.39
UDDER	0.02	0.08	0.09	0.02	0.05	-0.04	-0.12	-0.05	0.85	0.22	1	0.39	0.59
LEGS	0.00	0.12	0.08	-0.03	0.11	-0.03	-0.13	0.04	0.68	0.48	0.39	1	0.43
DAIRY_SHAPE	-0.02	0.08	0.04	-0.03	0.05	-0.04	-0.16	0.02	0.79	0.39	0.59	0.43	1

The expected response to selection under the current IEP is presented in Figure 33 and Figure 34. There is a clear message on the main traits achieving higher rates of genetic progress, protein, somatic cell score, fat, and milk volume. There is a difference in the level of response among traits depending on the bull population used as reference, i.e. all bulls or younger bulls. Figure 33, presents the outcome for all bulls with an overall economic response across all traits of $2.36 per year. Figure 34 presents the response for younger bulls with an overall response of $2.28 per year. These responses to selection are driven mostly by milk and milk quality, and small response in fertility. There is an expectation that milk traits are underestimate at the current EVs. At higher milk component EVs (i.e. $2.50 per kg of fat and $3.50 per kg of protein), the value of genetic progress would be almost doubled, i.e. $5.54 for all bulls and $5.36 for younger bulls.

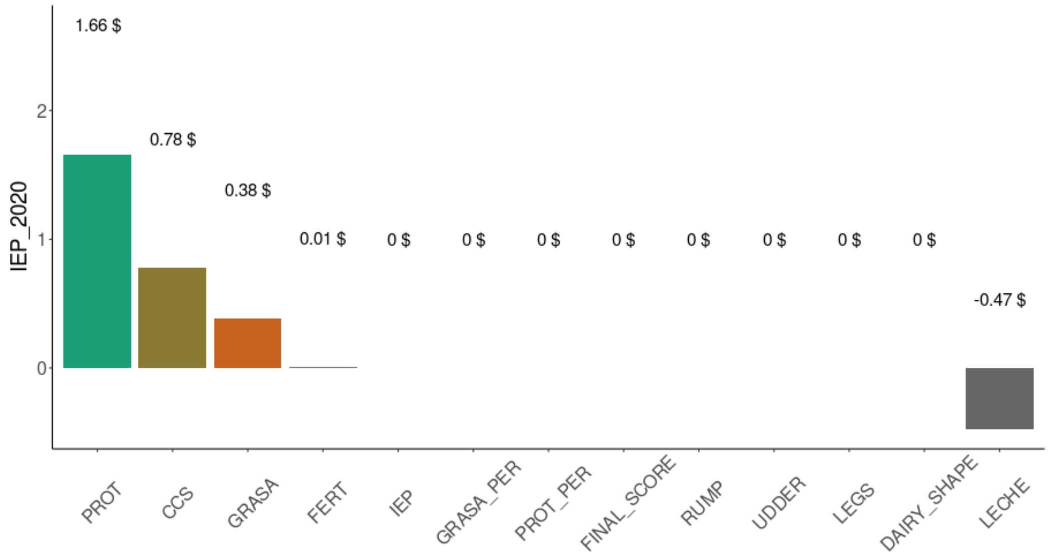


Figure 33. IEP response to selection when using all bulls.

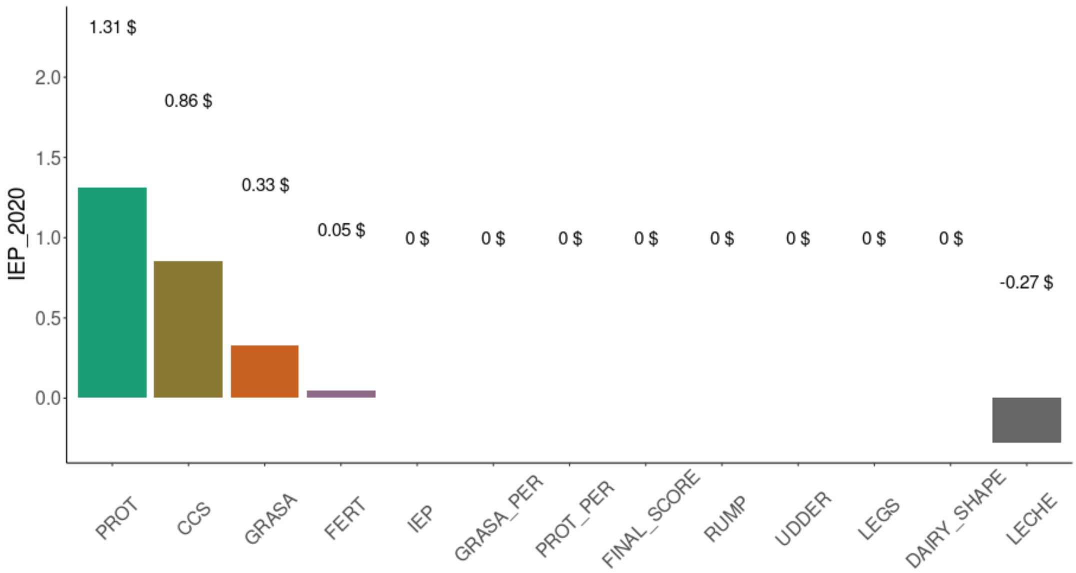


Figure 34. IEP response to selection based on younger bulls (from 2000).

These benefits per cow can be scaled up to estimate sector-wide value of genetic improvement. This represents the status quo and a scenario which assumes increased EVs for milk traits. The concept is presented in Figure *35*, and the potential outcomes in both cases are presented in Table 6

Table 6. Annual benefits at current rate of genetic improvement and from increasing rate of genetic gain.

Indicator	Status quo	Benefit from increasing rate of gain*			
		+25%	+50%	+100%	+200%
Annual IEP trend (index units/year)	2.07	2.58	3.10	4.14	6.20
Annual value per farm ($)	363-726	90.81–181.62	181.62–363.24	363.24–726.47	726.47–1,452.94
Annual value for industry ($m)	**1.56–3.12**	**0.39–0.78**	**0.78–1.56**	**1.56–3.12**	**3.12–6.25**
Present value for industry ($m)	**19.46–38.93**	**4.87–9.73**	**9.73–19.46**	**19.46–38.93**	**38.93–77.86**

*Assuming an average farm with 127 animals and dairy sector with 3,400 farms.

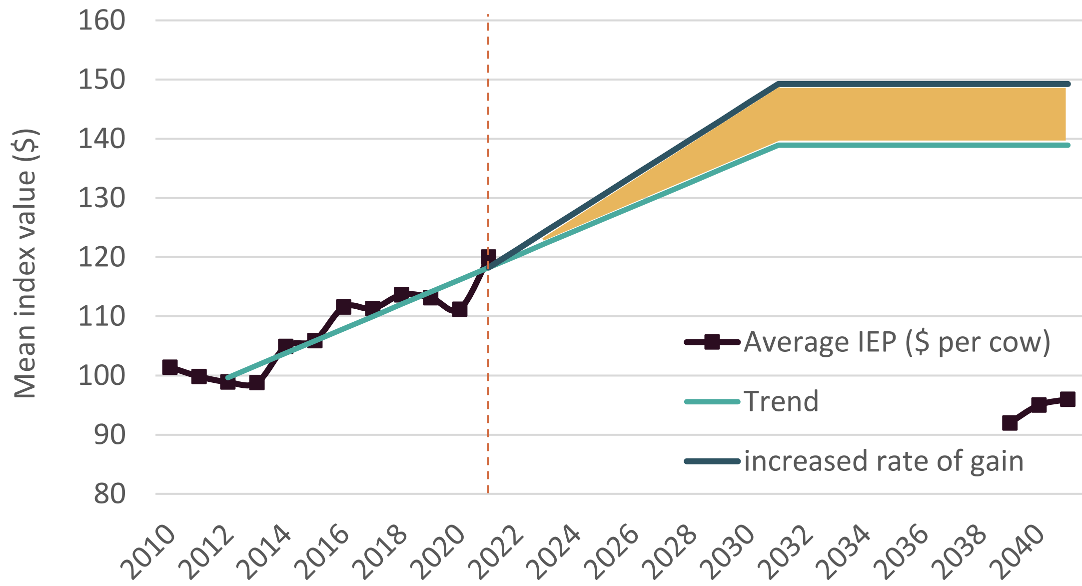


Figure 35. Benefits based on marginal increase in rate of genetic gain.

Appendix 8. Key Recommendations

Based on the above, a series of recommendations have been proposed as part of the assessment of the Uruguayan dairy genetics structure. These recommendations address the challenges of the sector and better position farmers, stakeholders, and sector leaders for the future considering the various challenges impacting dairy sectors globally.

In general, the recommendations assume that the Uruguayan dairy sector is mature enough to benefit from this strategy which addresses the challenge to use data, information, and genetics tools as everyday resources to all Uruguayan dairy farmers. These resources underpin integration, communication, and extension efforts to support dairy farmers to achieve higher productivity and profitability in their operations.

Table 7. Strategy focused on data & information.

Recommendation	Description
Recommendation 1 Establish the data sharing infrastructure to integrate data sources of useful information to the sector	Establish a highly effective ***sector leaders*** steering committee led by MU and Conaprole. Develop an Application Programming Interface (API) structure to allow communication among different databases, strengthen data recording, extension, and research efforts. An initial focus on a specific integration project will demonstrate the approach, e.g. connecting with Conaprole's database.
Recommendation 2 Establish a coordinated extension effort to deliver benefits of data, information, and genetics tools to farmers and stakeholders	Develop a series of benchmarking tools then connect them with existing extension services and programs. Implement a training/upskilling program to technical advisers on dairy farming. The training/upskilling program should be focused on the economics of selection, breeding objectives, and application of breeding tools to support farmers. Development of a bull ranking app available to all farmers, supporting bull selection efforts, and integrating with semen companies' tools.
Recommendation 3 Implement a communication strategy to demonstrate the value of data, information, and genetics tools to farmers	Develop a range of reports with useful information for farmers to use routinely on-farm. Including useful content, e.g. lists of animals available for culling and selection, expected calvings, and parentage information. Deliver the strategy through channels to reach all types of farmers, such as online, by mail, magazines and dairy newsletter across multiple organizations and institutions, including semen companies. The communication strategy will help to consolidate genetics as an integrator within the industry.

Table 8. Strategy focused on increased adoption of genetics tools.

Recommendation	Description
Recommendation 4 Widen access of genetics tools to all dairy farmers and stakeholders in the sector	Design the EGL evaluation structure to be available to all Uruguayan dairy farmers (commercial farmers and registered breeders, all breeds and crossbreds), including multi-breed evaluation.
Recommendation 5 Mobilize the EGL technical group to include new traits and adjust the infrastructure aiming at increased rates of genetic progress	Incorporate new traits into the genetic evaluation pipeline, such as longevity, cow live weight, mastitis, udder, and feed efficiency. These traits should be added to the IEP, to widen its scope and attract more users. Change the unit of expression of the IEP to "$ per cow per lactation", as opposed to a standardized unit. This would improve communication of genetics tools by applying an "economics language" that is more relevant to farmers. Adjust the Economic Value (EV) of Fat & Protein, and Fertility on the IEP. The current milk component values seem misaligned to current international dairy market signals, and the fertility value does not have enough weight to impact the genetic trend of fertility. Strengthen genomics efforts across multiple traits (including new traits, e.g. feed efficiency, GHG emissions). This would aim to reduce generation interval, increase prediction accuracy, and consequently the increase rate of genetic progress. This should also address challenges with younger bulls for both AI and NM (domestic bulls).

Table 9. Supporting projects underpinning challenges and recommendations.

Project	Description
Project 1 New data & information structure business case (led by MU & INALE)	Establishment of the steering committee group with sector leaders. Undertake a business case assessment focusing on the value proposition (costs and benefits) for the sector and for each partner organization (Conaprole, MU, ARU, Breed Societies, dairy support companies, government through SNIG, other), including the required investment and net benefit for implementing such strategy within the sector. Decide specifications for the integration the Application Programming Interface (API) structure, including interfaces and integrated reports.
Project 2 Data integration API (led by MU)	Development and implementation of the API to coordinate the exchange of data and information across different sources. Implement the program to one initial pilot project (e.g. Conaprole).

Project 3 Dairy Farm Reports and tools (led by MU, Conaprole & FUCREA)	Engage on a national online survey to gather input from dairy farmers and extension service providers on the most valuable information for different types of farmers. Develop a range of simple and useful reports to be used to support management and selection decisions on-farm. Assess the possibility of developing an integrated GHG inventory calculator to be used on-farm and off-farm.
Project 4 All herds genetic evaluations (led by INIA)	Initiate the required efforts to implement an across breed genetic evaluations (multi-breed). This should be associated with an eventual Genomics Strategy, where the structure required to develop and establish reference populations would consider herds of multiple breeds used to parameterize genetic evaluation models.
Project 5 Genomics Strategy (led by INIA)	Initiate the required structure to develop and establish reference populations of multiple breeds and the necessary phenotyping protocols. Introduce the concept of genotyping bull calves for use as natural mating bulls. This project would have a direct impact on dairy farmers using herd bulls to mate their cows. Feed Efficiency Initiative: develop the required research initiatives to establish the infrastructure to measure feed intake (feed intake, feed efficiency, residual feed intake) and genotype herds involved in the project. Conditioned to the Feed Efficiency Initiative, investigate the required infrastructure to expand the project to include environmental traits (GHG, N_2)
Project 6 Fertility & survival improvement models (led by INIA)	There is need to adjust the models and trait definitions for the genetic evaluations of Fertility (and potentially connect this to survival/longevity) by adjusting calving interval in partly seasonal herds, including variance components, culling reasons, etc. This includes the adjustment and implementation of EVs to the IEP.
Project 7 Cow liveweight model (led by INIA & Univ. de la República)	Accounting for phenotypes from different sources on-farm (weights, stature score) and off-farm (carcass weights). This includes the adjustment and implementation of EVs to the IEP.
Project 8 IEP additional traits & economic values (led by Univ. de la República)	Mastitis & Udder composite, longevity, cow live weight, BCS, and re-assess EVs for Fat ($0.46), Protein ($2.17), and Fertility ($1.31). This includes the adjustment and implementation of EVs to the IEP.
Project 9 Bull ranking & selection app	Establish a bull ranking app available to all farmers, supporting bull selection efforts, and integrating with semen companies' tools. This tool should reach data and information from multiple sources.

Appendix 9. Overview of the proposed integrated genetics structure of the Uruguayan dairy sector

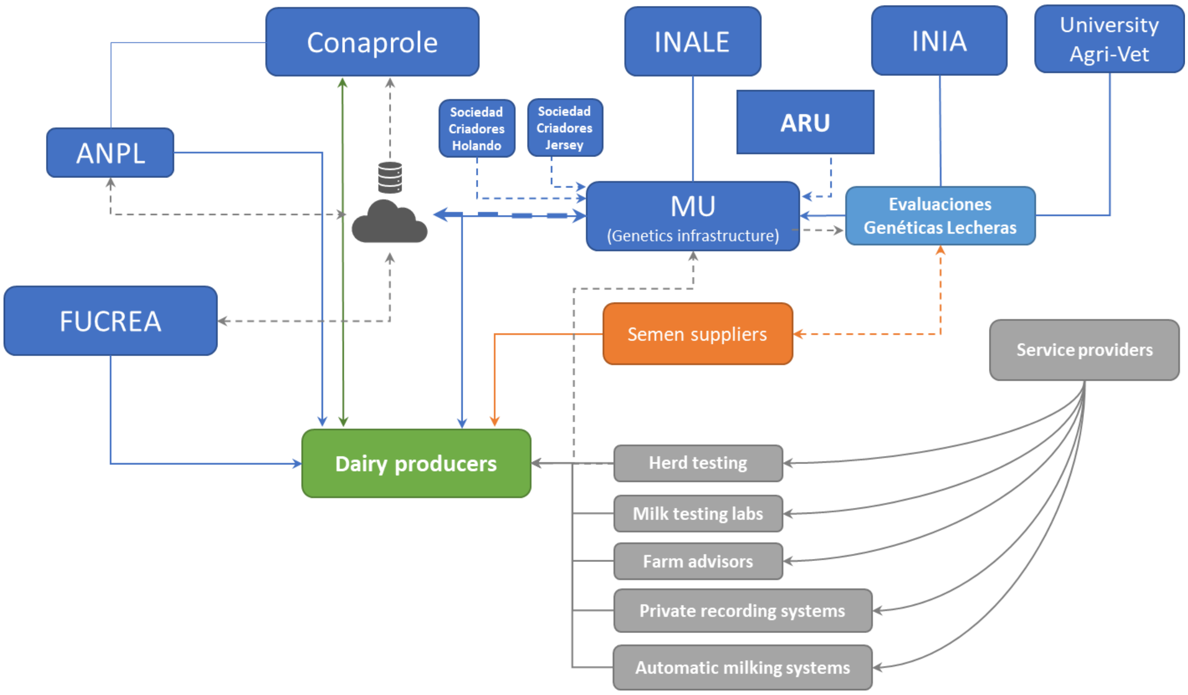


Figure 36. Integrated data and sharing of information structure.

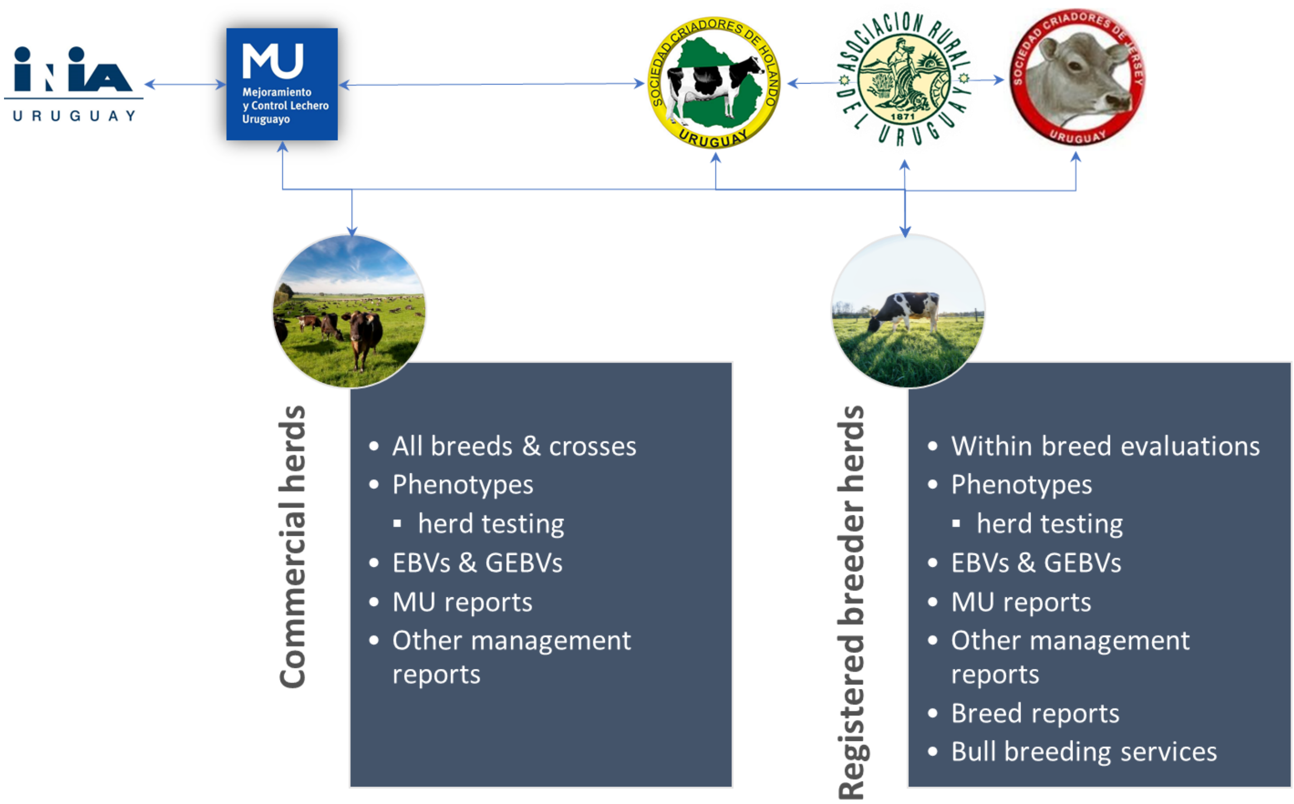


Figure 37. Useful information for the sector.

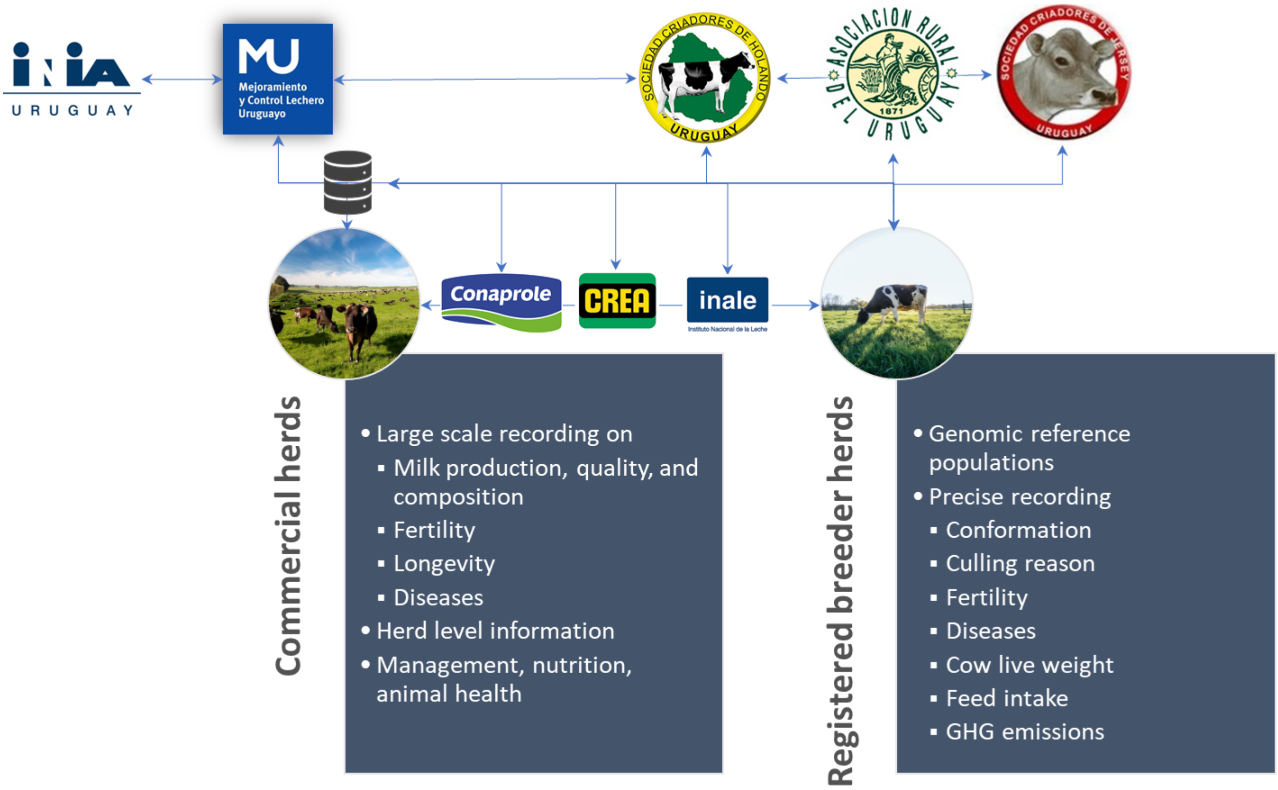


Figure 38. Role of different herd types.