A new international infrastructure for beef cattle breeding

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Implications

- Ireland has established a new information infrastructure for cattle breeding and has performance data on a large percentage of commercial beef and dairy cattle, in addition to performance data on seedstock as found in many countries. This structure facilitates genetic evaluation for animals, of all breeds and crosses, in terms of their ability to generate profits from milk and beef production under Irish commercial conditions.
- Interbeef is being established to facilitate the sharing of beef data internationally between like-minded organizations and to provide more accurate and extensive genetic evaluations in the base and scale of each participating beef population.
- Interbeef has the potential to provide beef farmers served by participating organizations with much better information for selecting animals for importation from other countries. Such collaboration will enable beef producers to better address the range of efficiency and environmental challenges they face.

Introduction

The purpose of this article is to use Ireland as a case study to illustrate how a national effort to establish an effective beef cattle breeding scheme creates the structural elements required for a new international infrastructure for beef cattle breeding. Over the last 13 years Ireland has established a new infrastructure to facilitate the genetic improvement of dairy and beef cattle. Primary responsibility for leading the development rests with the Irish Cattle Breeding Federation Society Ltd. (**ICBF**). These developments in local infrastructure have included the formation of ICBF, creation of the ICBF cattle-breeding database, implementation of the animal-events (**AE**) data collection system, the creation of linkages with other local data collection systems, and the ICBF genetic evaluation system.

Our recent focus, in collaboration with a number of other like-minded organizations and researchers in other countries, has been the development of an international infrastructure to assist Irish beef farmers in accessing the information they need to select cattle worldwide on the basis of their genetic ability to produce profits for Irish farmers. Research has established the practicality of combining ancestry and performance data from several countries in a combined genetic evaluation where the genetic correlations between countries are less than 1, and the fixed effects are also different in each country (INRA, 2004; Phocas and Donoghue, 2004). Attention was then turned to establishing a prototype routine service to meet international demand (Schild et al., 2005). The initial technical issues associated with providing a routine service have now been solved (Forabosco et al., 2010), and our focus is now on establishing such a service for a range of traits, breeds, and beef cattle populations. A large amount of work is still required, but enough is now known to enable the Interbeef data and service infrastructure to be established. This paper describes these developments and identifies how they are expected to affect the efficiency of beef production worldwide.

Defining the Problem

Meat from cattle (beef) is a valuable source of nutrients for humans and represents a significant source of income for farmers in many countries. However, cattle also consume large amounts of feed in the form of roughages and concentrates, and the by-products of digestion of these feedstuffs, especially methane, are the focus of much recent attention on the impact of cattle on the environment. There has also been an increase in the level of concern among consumers about the welfare of farmed animals associated with practices such as castration, dehorning, and weaning.

Cattle demonstrate a great deal of genetic variation in the amount of beef produced relative to the inputs they require and the amount of by-products, including methane, produced. The problem for the cattle farmer is to locate and utilize those animals that have the genetic capability to generate the maximum level of desirable outputs relative to the cost of inputs and the cost of undesirable by-products.

The local environment for the cattle farmer varies greatly depending on climate, terrain, presence of disease, availability of infrastructure, distance and access to markets, societal norms, and government regulations. This variation has a significant influence on the cattle genotype that will deliver the best economic and social returns for the herd owner. Perhaps even more important, this environmental variation makes the estimation of the influence of genetics more difficult to assess for animals located in less favorable environments compared with those located in more favorable environments. How often do we see beef seedstock portrayed as enjoying the most favorable of environments? Does this result in seedstock selection being biased in favor of only those animals located in favorable environments with a consequential loss in potential genetic gains?

The economic concept of profit is used here as the most convenient single measure to account for outputs, inputs, and by-products. It provides a useful tool for facilitating informed decisions where there are multiple considerations associated with a range of production system alternatives. The key element of this approach is to place an economic value on each consideration. The greatest profit is generated where the mix of outputs, inputs, and by-products is optimized by placing a financial value on these factors. Profit is simply the sum of the income items less the sum of the cost items. Our focus is to ensure the contribution of genetics to cattle farm profit is maximized. Our goal is to create an infrastructure that achieves

doi:10.2527/af.2011-0019

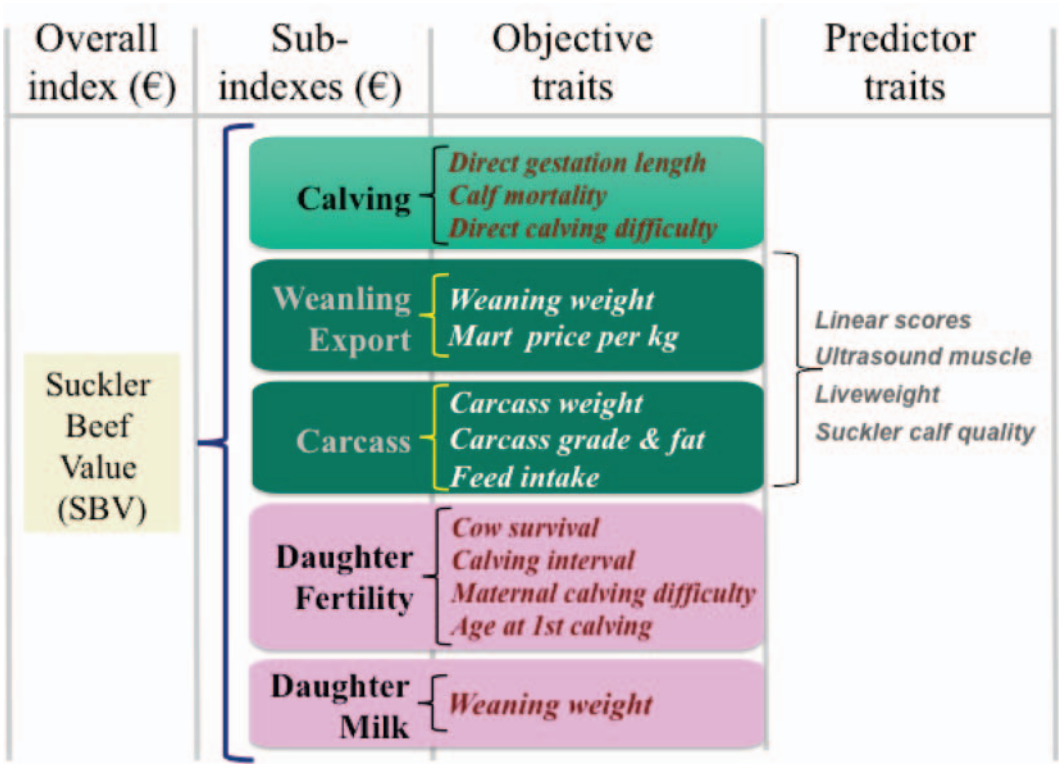

Figure 1. Structure of the suckler beef value index developed as part of the Irish beef cattle breeding infrastructure.

this for Irish cattle farmers. The model we have developed to achieve this involves the linking of local cattle breeding information infrastructures through an international infrastructure for beef cattle, Interbeef.

The Formation of ICBF

The ICBF was established in 1997 and commenced operations in 1998, with its current structure being finalized in 2000 (ICBF, 2006). Its main activities are those associated with developing the cattle breeding infrastructure in Ireland, operating the cattle breeding database, providing genetic evaluation services, overseeing cattle breeding programs, and providing information useful for cattle breeding decisions. The ICBF is owned by the cattle industry, with policy set by a board of 16 with 15 appointed by the shareholders and 1 appointed by the Department of Agriculture Fisheries and Food (**DAFF**).

Since its inception, much of the work of ICBF has been focused on improving the quantity and quality of data available for cattle breeding. New technologies have been utilized and business arrangements established with shareholders and industry stakeholders alike, with the overall goal of ensuring that Irish farmers have access to high-quality information for use in breeding more profitable cattle.

Beef Breeding Objectives and Selection Criteria

A widespread industry consultation supported by extensive research resulted in an agreed breeding objective and selection criteria for beef cattle in Ireland (Amer et al., 2001). The focus of the objective is farm level profitability, accounting for the most significant sources of income and cost. Beef income is also considered in the dairy breeding objective for Ireland. An overall index, the suckler beef value, is expressed in economic terms and computed from economic sub-indexes for calving, weanling export, beef carcass, daughter fertility, and daughter milk (Figure 1). These indexes and the evaluations for some of the key component traits are expressed as €uro-Stars on a 1- to 5-star scale with each star representing an interval covering 20% of the population. Examples are readily available on the ICBF website at http://www.icbf.com.

The ICBF provides the genetic evaluation system for dairy and beef cattle breeding in Ireland. This system operates in close association with the ICBF database. The ICBF is a full participant in the activities of Interbull, the international dairy genetic evaluation organization, and is currently providing leadership for the establishment of Interbeef.

The genetic evaluation system used by ICBF is an across-breed system with a single base for each set of traits. For some traits (e.g., calving and carcass data), the evaluation uses data from dairy and suckler herds, and the results are comparable across dairy and beef breeds.

With the establishment of clear and agreed-upon breeding objectives, the focus of the efforts of ICBF has moved to improving the availability of relevant data on animals in the herds of commercial producers. These animals are less prone to biases associated with selective recording and selective husbandry.

Creation of the ICBF Cattle Breeding Database

At the time ICBF was formed, there was a large number of separate computer systems supporting aspects of cattle breeding in Ireland. Each

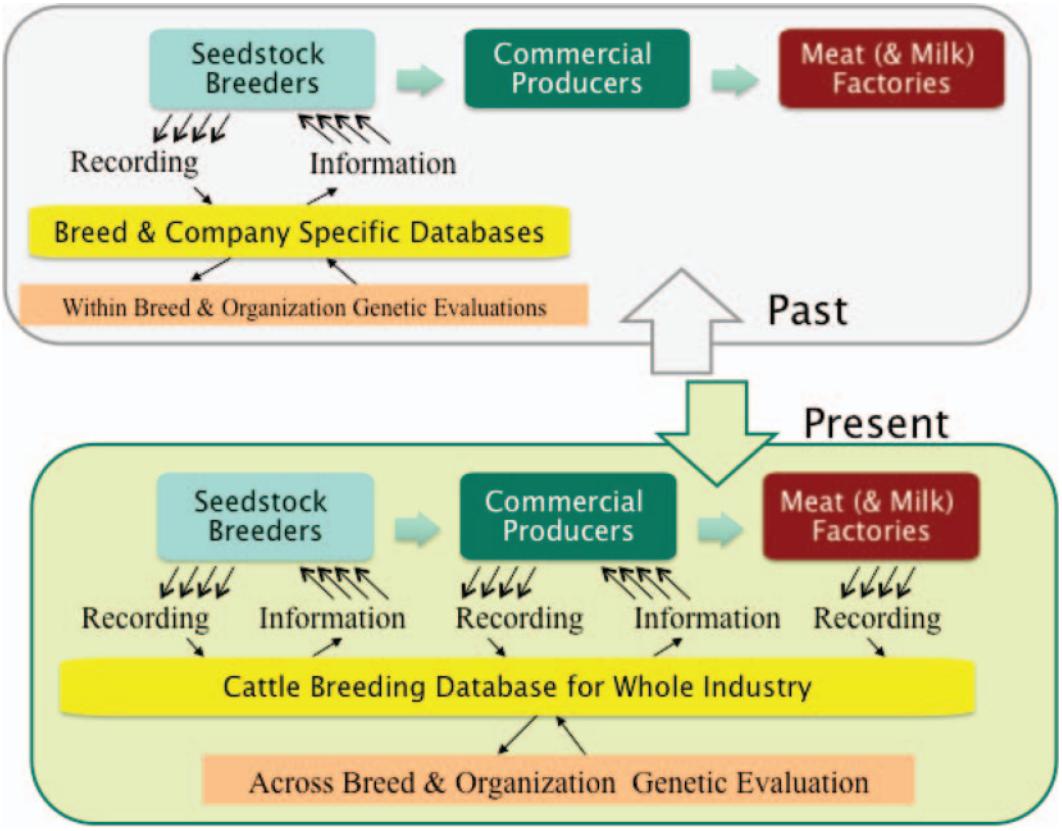

Figure 2. Past versus present information infrastructure of Irish beef cattle breeding.

had its own data collection system and supported the information needs of one or more aspect of the cattle breeding industry. For example, each herd book (there were 18 at that time) had its own system, each milk recording organization (there were 8 in 1998) had its own system, and DAFF operated separate systems for genetic evaluations and the official calf registration and cattle movement monitoring system (**CMMS**). These systems used several different animal identifications and held limited cross-references between databases.

The ICBF established its cattle breeding database using a software system from a Dutch cattle breeding organization. Creating the database involved an enormous effort to negotiate agreements for the sharing of data, to establish shared data collection systems, and to consolidate the existing computer files into a single shared database. Figure 2 illustrates the change in the information infrastructure that has taken place in Ireland. The figure shows the move from a focus on seedstock producers, organized by breed, to a supply-chain structure supported by a single integrated database and associated genetic evaluation system. The key principles underpinning the agreement between organizations to share data are summarized in Table 1.

The ICBF established a team of information technology developers, supported by a number of contractors, to customize the Dutch database to meet the needs of the Irish breeding industry. This customization has now reached the point where the ICBF database requires no support from the Dutch supplier.

The ICBF cattle breeding database supports, through the use of a range of new technologies (Cromie et al., 2008), the information needs of milk recording, herd books, artificial insemination organizations, and cattle farmers. Farmers are able to access their own data in the database through the web-based HerdPlus service. Figure 3 illustrates the data sources, information outputs, and services that are currently supported by this database.

It is important to note that genetic evaluations are a peripheral yet integral element of the ICBF database. All data used in the evaluations are sourced from the database, and all results are returned to the database from which they are published and distributed.

Implementation of the AE Data Collection System

The AE data collection system was developed, as part of the overall database development, to replace the overlapping data collection systems operating in 1998. This system was built to remove duplication in data collection, at farm and organization levels, and to ensure that all the data required for cattle breeding and other official purposes were collected efficiently and accurately.

The AE system collects data on those cattle breeding events (e.g., calving, birth, identification) that are first known to the farmer. Both paper and electronic systems are supported. Data collected in this way are accessible to those participating organizations that provide cattle breeding services to the herd. The AE system has revolutionized cattle breeding data collection in Ireland by providing a single unified data collection system that removed duplication and facilitated widespread participation in performance recording and genetic evaluations.

The ICBF database (Figure 3) has been fully operational for dairy, beef, milk recording, beef performance recording, genetic evaluations,

Table 1. Principles of data and information sharing agreement underpinning the Irish Cattle Breeding Federation (ICBF) database

Principle
Contributors of data to the creation of the database retain ownership and can obtain a copy of their data at any time.
All data originating on farm, and known first to the farmer, are captured through animal-events, a system controlled by ICBF.
The ICBF operates an industry-wide network of systems to facilitate the electronic sharing of relevant data collected for other purposes. Examples include inseminations, slaughter data, and sale data.
All data in the database are available for research subject to a minimal set of conditions.
Genetic evaluations are an integral element of the database.
The herd owner controls service-provider access to herd and animal data.
Service providers have access to data and information systems needed by their particular businesses for those herds that have granted access.
HerdPlus is a service provided by ICBF to the herd owner that facilitates access to all data and information relevant to the herd in the database.
Service fees are set on the basis of *user pays* and *full cost recovery*.

and herd books since 2005. Approximately 77,000 herds, with 1.8 million calvings, representing 90% of the entire Irish cattle herd, were participating in one or more aspects of the database by the end of 2010.

Linkages with Other Data Collection Systems

The ICBF database has access to data collected by a wide range of organizations for other purposes. The data collected and stored in the ICBF database from these other sources include the following:

- Calf registrations through DAFF. All calves born in Ireland are first registered by DAFF, albeit based on data provided by farmers through the AE system, and only then added to the ICBF database. This ensures that the official European Union ear tag identification and associated subsequent movement records are available for all Irish animals entering the ICBF database.
- Cattle movements, exports, and deaths as recorded through CMMS. This eliminates the need for any of the cattle breeding organizations to collect these data. A nightly data feed is pro-

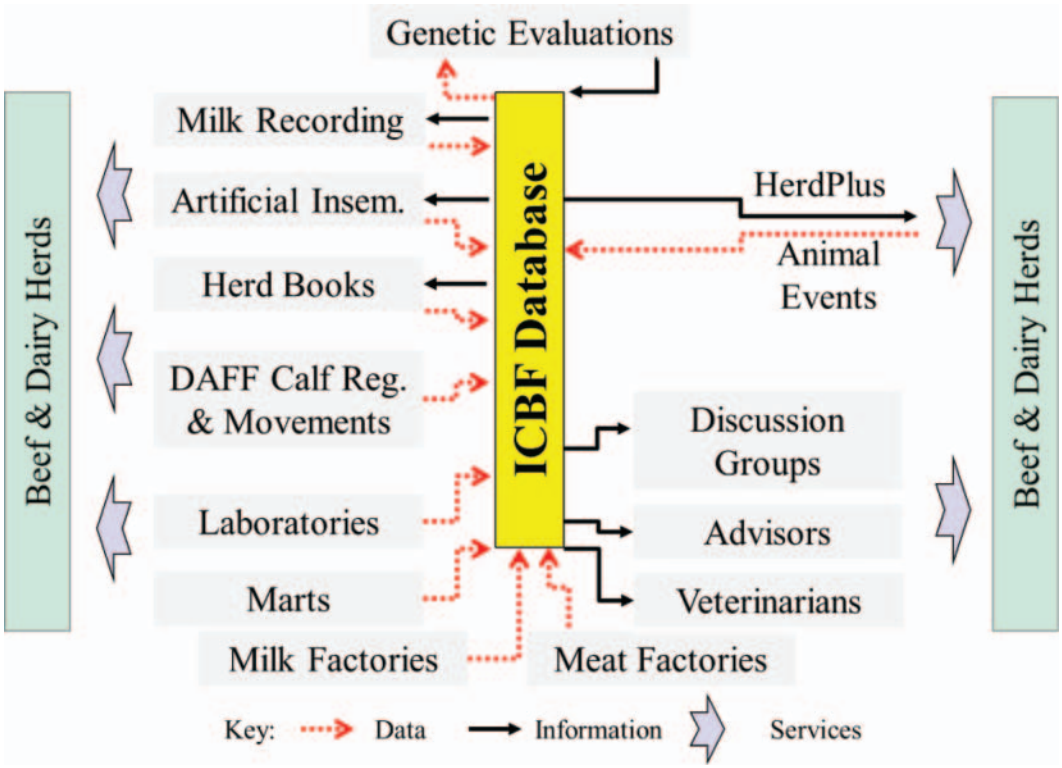

Figure 3. Schematic of local infrastructure for cattle breeding in Ireland. Irish Cattle Breeding Federation database showing data sources, information outputs, and services to farmers.

vided to ICBF for all movements into or out of herds participating in the database.

- Slaughter data from meat processing plants in Ireland. These include slaughter date, carcass weight, carcass grade, and fat score according to the EU standardized grading system. More recently, the two photographic images of individual carcasses that are used in carcass grading are also being collected for animals slaughtered in Ireland (Allen and Finnerty, 2001).
- Sale data from marts (livestock marketing agencies). These include dates, body weights either by individual or lots, and prices per kilogram of body weight.
- Milk records from milk recording organizations. The ICBF database is an integral part of the milk recording and result reporting process that operates in Ireland.
- Artificial insemination records from technicians. The ICBF has developed a handheld computer system that links directly to the ICBF database for insemination recording. This system is used by all the main artificial insemination field service companies operating in Ireland.
- Linear scoring, dairy and beef, and weight recording services. The same handheld technology used for artificial insemination technicians is provided by ICBF for linear scoring and classification services.

These linkages ensure that neither farmers nor organizations are faced with duplicated effort in collecting data that have already been collected for another purpose. The result is a greatly increased availability of data to all participants in the ICBF database.

Animal Welfare, Recording, and Breeding Scheme

The animal welfare, recording, and breeding scheme (**AWRBS**) was launched in January 2008 by DAFF as a 5-year program with the dual objectives of improving animal welfare and improving the scope and quality of data available for beef cattle breeding. Key elements of the scheme included the adoption of best practice animal welfare associated with castration, dehorning, and weaning. It was also a requirement of the scheme that the AE recording system of ICBF be used to record key events including the sire of calves. In return, the farmer received a payment of €80/cow initially and, more recently, €40/cow. Funding is provided by DAFF. This scheme had a dramatic impact on the availability of sire, calving, weaning, and docility data from commercial suckler herds.

Progress

The amount of beef-related data collected has increased dramatically, as illustrated in Table 2. The biggest increase coincides with the introduction of the AWRBS in 2008. The collection of carcass data commenced before 2008, but the advent of the AWRBS has significantly affected the number of animals for which the sire is known. This illustrates the benefit and importance of having a database that links animal details recorded at birth with those recorded at slaughter.

Table 2. Progress in number of records of data collected

Year	Births[1]	Animal events births[1]	Pedigree births[1]	Herds[2]	Carcass–known sire[1]	Carcass–unknown sire[1]	Docility[1]
2003				12	0.010	0.021	0.006
2004	0.73	0.47	0.09	16	0.184	0.307	0.018
2005	0.94	0.54	0.09	22	0.211	0.385	0.021
2006	1.02	0.60	0.09	29	0.286	0.711	0.016
2007	1.11	0.61	0.09	33	0.336	0.924	0.014
2008	1.84	1.25	0.10	74	0.355	0.944	0.581
2009	1.82	1.31	0.10	76	0.422	0.838	0.679
2010	1.79	1.24	0.10	77	0.782	0.679	0.696

[1]Millions.
[2]Thousands.

Interbeef: International Infrastructure

The Irish beef breeding population encompasses a substantial number of beef breeds. For all of the beef breeds in Ireland there are populations in other countries with larger numbers of recorded animals. What is the best strategy for obtaining access to information from these other populations to enable Irish farmers to make well-informed decisions on the importation of genetic material?

Our strategy is to work with other like-minded countries to establish an international network for sharing beef genetic evaluation information. In this respect we have been building on the Interbull model that operates for some 30 countries, 6 breeds, and 6 trait-sets for dairy cattle.

Our initial work conducted in partnership with other European and Oceanic countries involved research comparing 2 main strategies:

- MACE (multiple-trait across-country evaluations), which uses the sire evaluation output of national genetic evaluation systems and is the approach used by Interbull for dairy cattle.
- Phenotypes where the raw performance data are used in a combined multi-trait analysis with each country treated as a different trait (i.e., genetic correlations between countries of less than 1).

Research by INRA (French National Institute for Agricultural Research) and AGBU (Animal Genetics and Breeding Unit, University of New England, Armidale, Australia) demonstrated the practicality and desirability of the latter strategy (i.e., a combined analysis of performance data). Based on these findings, Interbeef is now moving to establish a routine international genetic evaluation service for beef breeds and traits. Key elements of the proposal are summarized in Figure 4 and below.

Structure and Operations

Interbeef is a working group of ICAR (International Committee of Animal Recording; http://www.icar.org) and is pursuing 5 objectives relevant to beef cattle:

a) provide a forum for sharing knowledge on recording and genetic evaluations,

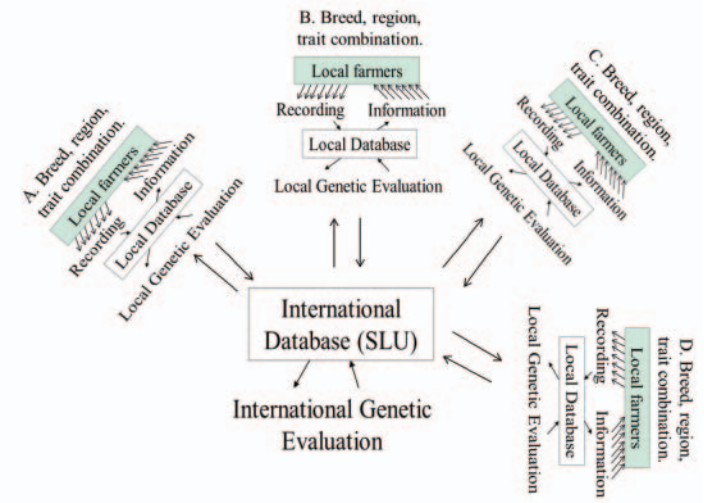

Figure 4. Schematic of international infrastructure model for Interbeef.

b) maintain guidelines and standards for beef cattle performance recording,
c) conduct international surveys relevant to beef cattle performance recording,
d) develop international genetic evaluation services, and
e) facilitate the use of genomic selection.

Interbeef is guided by a steering committee appointed by the board of ICAR and includes a geographical and technical spread of enthusiastic supporters. A scientific advisory committee has also been established to give advice on technical issues. The current annual budget for Interbeef is €100,000, which is funded by a number of beef cattle performance recording and genetic evaluation interests along with a contribution from ICAR.

Participants in Interbeef are service users. Service users are ICAR members who are organizations able to represent country, breed, and trait combinations: beef performance recording database operations, beef performance and ancestry recording service provider(s), and genetic evaluation service providers. Interbeef services are based on an agreement that covers fees, rules for participation, roles and responsibilities, operating procedures, data flows and interfaces, quality control and query support, data protection and methods, and models for international genetic evaluations.

The planned service will include the creation of a database of pedigrees and performance data to be used in research and in the computation of international genetic evaluations for beef breeds and traits. The evaluations are to be provided to the service users for distribution in their respective country-breed-trait-set combination. Interbeef will not be publishing evaluations. That role rests with the service users. Figure 4 provides a schematic of the planned operation of Interbeef genetic evaluation services.

Progress

A prototype database has been established and tested for 2 breeds, 6 countries, and 1 trait set. Methods for resolving animal identification conflicts have been developed and tested. A multi-trait genetic evaluation system has been developed and tested by INRA and transferred to the Interbull Centre where it has been implemented using MIX99 (MTT, 2011) software. The Interbull Centre, which is part of the Swedish University of Agricultural Science in Uppsala, Sweden, has been chosen to be the operational unit of Interbeef because it already provides a very successful and similar service for dairy cattle.

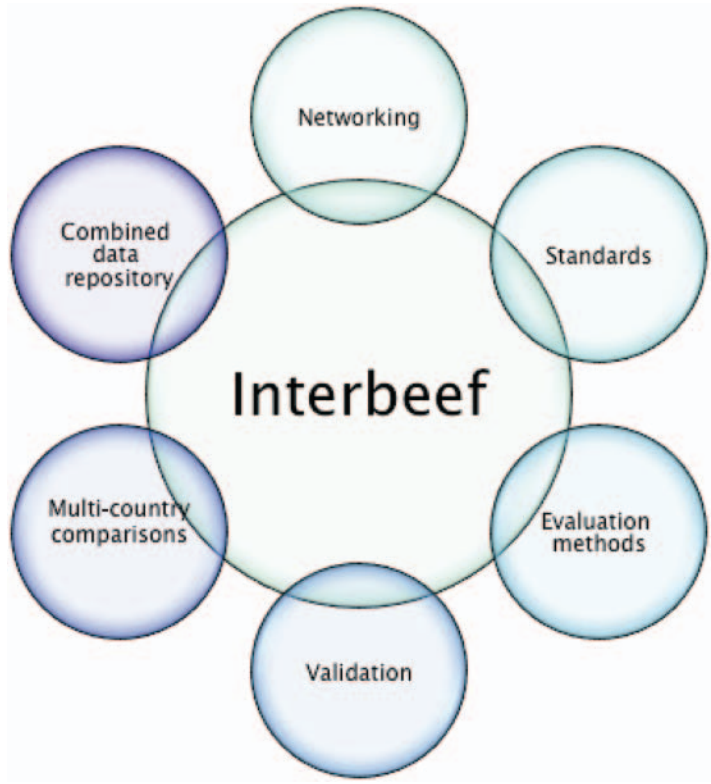

Figure 5. Elements of Interbeef infrastructure for beef cattle.

Rationale for Establishing Interbeef

Experience from Interbull has demonstrated that international collaboration in cattle breeding can be very successful. Interbull has created a forum in which the providers of genetic evaluation services for dairy breeds and traits have been able to come together to not only create valuable international genetic evaluation services but also to share research results, discuss operational experiences, and jointly tackle a wide range of technology challenges. This has led to substantial and rapid improvements in all aspects of dairy cattle genetic evaluations in the participating countries. We believe this model is needed and will be highly effective for beef cattle.

Interbeef services, as illustrated by the Irish case, are needed to help beef producers to make more informed decisions on the importation of seedstock. This is a challenge faced by many countries and beef cattle populations. As with dairy, the other side of this is that exporters of seedstock need information on which to identify the beef cattle genetics that are desired in particular animal populations. Beef cattle seedstock trade is potentially a very important tool for enabling beef cattle farmers to address the problems identified above.

Genomics technology offers the prospect of more rapid genetic improvement, especially in difficult-to-measure and low-heritability traits such as reproduction, fertility, heat tolerance, and disease resistance. It

is clear that large reference populations in which high-quality phenotype data are routinely available are required to develop and validate genomic predictions. A structure for pooling data files across populations is essential for achieving much larger reference populations than are currently available for beef cattle.

For Interbeef to succeed, it is essential that there be a high level of data exchange, including data on pedigrees, phenotypes, and in due course, genotypes. For beef cattle breeding organizations to be willing to enter into data sharing of the type envisaged under the Interbeef model, the systems and procedures need to operate efficiently and protect the interests of the service users. We believe that the track record of the Interbull Centre provides an ideal starting point in this regard.

Interbeef, using the example of Interbull (as summarized by Figure 5), is now at the point where initial services can be established and a forum for beef cattle breeders to regularly interact on an international basis can be provided. Further information is available on the Interbeef website (http://www.interbeef.org). This structure can help beef cattle producers use genetics as a tool to address the many challenges they are facing.

Conclusions

In the last 13 years the Irish cattle breeding industry has undergone a complete redevelopment of its data gathering and genetic evaluation infrastructure. The key developments include

- the establishment of ICBF as a working partnership between the organizations involved in Irish cattle breeding,
- the establishment of a shared cattle breeding database,
- the implementation of a data collection and sharing system that eliminates duplication at the farm and organization level,
- development of a genetic evaluation system that identifies, on a worldwide basis, those cattle that are most profitable under Irish conditions, and
- support and promotion of increased international collaboration in beef breeding and genomics.

Irish farmers, research scientists, herd books, and artificial insemination companies have responded by making good use of the greatly increased amount of information now available. As a result, Irish farmers are now able to better exploit the potential of genetics as a tool for improving the profitability of their enterprises.

Interbeef will facilitate the international genetic evaluation of beef breeds and traits. It has considerable potential to increase the accuracy of the local evaluation for foreign selection candidates.

Ireland is enthusiastically supporting Interbeef because of its potential to improve the profitability of beef production in Ireland through better-informed decisions on selective imports of breeding stock. The main beneficiaries in Ireland are expected to be Irish beef producers. Other beef cattle breeding populations now have the potential to join in this innovation and gain a range of benefits of great value to beef producers.

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