Secretary's Report to Conference March 2007

MEMBERSHIP

The World Guernsey Cattle Federation links the following societies and associations with the aim of developing and promoting the Guernsey Breed on an international basis: -

American Guernsey Association
Associação Brasileira de Criadores de Gado Guernsey.
Canadian Guernsey Association
English Guernsey Cattle Society
Guernsey Cattle Society of Australia
Guernsey New Zealand
Kenya Guernsey Cattle Society
Royal Guernsey Agricultural and Horticultural Society
South African Guernsey Cattle Breeders
Zimbabwe Guernsey Society

The Federation also has contacts with Guernsey cattle breeders in Japan, Zambia and Italy

Contact has also been made with potential breeders in France, Germany, and Russia

The Current officers of the Federation are: -

PRESIDENT: Mr. Ray Fiebiger, GCSA.

VICE-PRESIDENT: Lt. Col H C Watson, EGCS.

CHAIRMAN OF THE EXECUTIVE BOARD: Dr. John Mozier GA.

EXECUTIVE BOARD: Lt. Col. H. C. Watson (EGCS), Mr. Ray Fiebiger (GCSA), Mr. Jim Lichtwark (GCBANZ), Dr. John Mozier (AGA), The Federation Secretary.

FEDERATION SECRETARY: Bill Luff, WGCF Federation Secretariat, Guernsey

ASSOCIATE MEMBERS: -
World - Wide Sires, USA
States of Guernsey Commerce and Employment Department, Primary Industries Unit, Guernsey (Honorary Associate Member)

FUNDING

Funding is by grant from the States of Guernsey and by contribution from Member Societies. Member Societies undertake internal mailing/ distribution of the Federation newsmagazine, GUERNSEY WORLD. They also contribute financially or in kind to Federation projects and communicate regularly with the Federation Office.

The Secretary carries out most of his work from his home.

Since the 11th World Conference the Secretary visited Canada in 2004 where he attended the National Show and Board of Directors meeting, he also visited World Dairy Expo and met with breeders in Wisconsin. In 2005 the Secretary visited the INTERBULL Laboratory in Uppsala, Sweden where he held discussions at staff level and participated in the Annual Meeting of the European Association for Animal Production and the Interbull Annual Meeting. The Secretary visited the USA in 2005/6 where he addressed the Annual General Meetings of the American Guernsey Association and met with breeders in Oregon, Washington and Wisconsin. The Secretary also visited South Africa in 2006 and will return at the invitation of SA Society later this year.

The Secretary has been closely involved in the progression of the Guernsey Global Breeding Programme Pilot in UK and Guernsey Island. *(For a detailed report on this programme see page ...)*.

FINANCE

Copies of the Federation Income and Expenditure accounts for 2005/6 have been supplied to all member associations and will be available for inspection at their respective offices. Funds held by the Federation at the 1st. of March 2004 totalled £4380.31.

GUERNSEY WORLD.

The official newsmagazine of the Federation, Guernsey World, has continued to carry articles of scientific importance to Guernsey breeders and international breed news to every Guernsey breeder around the world. I must say that I am rather disappointed at the lack of original material sent to WGCF Office by Member Organisations. I do not see the point in reprinting articles that have already appeared in other Guernsey publications unless it is the wish of Members that this should happen. Many of our members produce excellent magazines that cover their show ring successes and interesting local stories in a very commendable manner. Guernsey World has always tried to cover the more technical side of animal breeding and world farming and food issues that are not usually addressed in Members' journals. The magazine is expensive to produce and circulate and I feel that in fairness to our members this can only be justified when there is sufficient original material to make up a quality publication.

WORLD CLASS RECORDS

Three new cows have entered the Guernsey register of World Class Records since the 11th World Conference.

Langhaven Option Nadia Owned by Don & Kathy Langrehr, West Salem, WI is the new World Class leader for 305 day Butterfat, while OCS Dairy Brits Beannie owned by OCS Dairy, Jefferson, MD is the new holder of the World Class Record for 305 day Protein.

Another cow from the same herd, OCS Dairy Heathers Goldfoot is the new holder of the 365 day Butterfat and Protein records.

The current World Class records for Guernseys are:

305D MILK **Breezy Point P Racer**
6-06 39,200M 1,782F 1 ,174P lbs
17,781M 808F 533P kgs

365D MILK **Breezy Point P Racer**

6-06 46,154M 2,175F 1,408P lbs
20,935M 987F 639P kgs

305D FAT Langhaven Option Nadia
3-04 33520M 1,989F 1,084P lbs
15,204M 902.F 492P kgs

365D FAT OCS Dairy Heathers Goldfoot
4.04 43,630M 2,814F 1,471P lbs
19,790M 1,276F 667P kgs

305D PROTEIN OCS Dairy Brits Beannie
3-05 35,730M 1,803F 1,232P lbs
16,207M 818F 559P kgs

365D PROTEIN OCS Dairy Heathers Goldfoot
4.04 43,630M 2,814F 1,471P lbs
19,790M 1,276F 667P kgs

STATE OF THE BREED

The 6th. World Guernsey Census, which covers the period 2003 - 2006, shows a decline in pedigree registrations from 8098 to 7333. However when grade registrations are taken into consideration the decline in all registrations is from 9016 to 8511 over the same period. In the same manner there has been a decline in officially milk recorded Guernseys from 25772 to 21487 over the same period.

PROJECTS IN PROGRESS

INTERBULL

WGCF continues to work closely with Interbull for the benefit of the Guernsey breed. Our annual grant of £5,000.00 (USD 9,800.00) to the Interbull Laboratory has helped to ensure improvements to international Guernsey evaluations. International evaluations are vitally important to the Guernsey with its small populations scattered across the world. Guernsey breeders need accurate predictions of the genetic merit of cows and bulls in other countries expressed in their home country format and using indices that they understand. The Interbull laboratory receives data sent by individual countries and after processing returns MACE evaluations to each participating country's bull and cow evaluation unit. Each country applies its own rules to data publication.

Since the 11th World Guernsey Conference in UK (March 2004) a number of important developments in the routine international genetic evaluations have taken place.

February 2005 was the first routine evaluation for longevity for Guernseys. At that time Australia, Canada and USAparticipated with data, but since then New Zealand and UK have joined as well.

Australia is now participating in conformation evaluations.

New Zealand is now participating in udder health evaluation.

Pilot studies were done for calving traits (calving ease and stillbirth) but too few countries submitted data on Guernsey bulls.

Pilot studies have been done for Guernsey female fertility traits. The results were presented by Jan Philipsson *(see p).*

Solutions to obtain conversion equations for cases (country pairs) that currently are missing will be tested in the March test-run and presumably implemented in the May routine evaluation .

The schedule for international evaluations will change after August. There will only by three routine runs per year with releases in January, April and August.

WGCF greatly values its relationship with Interbull and looks forward to future collaboration.

GUERNSEY GLOBAL BREEDING PROGRAMME

At the 10th. World Guernsey Conference, the Scientific Panel consisting of Dr. E. B. Burnside, Dr. J. Philipsson, Dr. Freddy Fikse and Dr. J. Woolliams was unanimous in its view that the Guernsey Breed had a severe risk of losing its commercial relevance but also that it had opportunities provided that the following were addressed as matters of the very highest priority and urgency:

1. An increasing number of young bulls used for breeding to a MINIMUM OF 75% of all females in all countries.
2. Increasing the number of recorded cows in all countries.

A particularly important and desired outcome of these two actions would be to have MORE COWS SIRED BYYOUNG BULLS included in genetic evaluations

A further important action would be to ensure an active involvement of grade cows in the Guernsey breed development programmes.

You will be hearing this afternoon of the real success of the Pilot GGBP. The two most important factors in the pilot programme are the desire of Guernsey breeders to work in cooperation for the achievement of agreed goals and the scientific management of the programme.

An interesting development has been the custom collection of young sires in a third country (USA) for exclusive release in the pilot programme. This innovation empowers the Selection Panel in consultation with their advisors to obtain young sires that match its breeding goals more closely than has previously been the case.

FURTHER RESEARCH

As reported in 2004, the WGCF has made important alliances and friendships with the international animal science community. Its membership of the International Committee for Animal Recording and Interbull and its close relationship with scientists at Roslin Institute has helped to build a credibility for the Federation that has undoubtedly helped in securing funding for major research projects.

WGCF's membership of the Genesis Faraday Partnership has enabled the Federation to receive grants totalling £15,000.00 (USD 29,000.00) for three research projects since 2004.

DGAT1

The first project identified that the gene DGAT 1 was affecting milk fat in the Guernsey breed. It has been a matter of concern to many Guernsey breeders that some of our populations have suffered a marked decline in butterfat production and percentages over recent years. High components are a traditional part of Guernsey breed characteristics and are crucial to the milk market and therefore producers' income in some countries.

WGCF devised a project in collaboration with ARK-Genomics to investigate the DGAT 1 genotypes in Guernsey cattle, and the application was successful. Genesis Faraday Partnership awarded a £5000 grant to the research group. Merial plc holds the licence for routine testing, and agreed to waive licence fees for this short research project.

David Morrice (ARK-Genomics) and Prof. John Woolliams (Roslin Institute) reported that part of the genetic variation in fat and fat % observed within the Guernsey is due to segregation at the DGAT1 locus. The profile of the 'A' allele on other milk traits remains unclear, however the increase in fat and fat % appears to be well established by this study, and is in agreement with previously published work.

They recommended that, given the high priority placed on maintaining the fat % of Guernsey milk, screening for DGAT1 should be introduced as part of the routine for assessing candidate young sires for selection. This will give an opportunity to select young bulls with much greater confidence over their effect on fat and fat % and reduce the risks attached to achieving their breeding goal. It should not become the sole breeding and selection criterion, and the 'A' allele will likely move to fixation as the breeding programme progresses.

The UK and Island Selection Panel is awaiting commercial availability of a suitable test and will apply this selection tool in the near future.

FEASIBILITY STUDY FOR THE DEVELOPMENT OF A FERTILITY INDEX FOR GUERNSEY DAIRY CATTLE

The second project was a feasibility study for the development of a fertility index for Guernsey dairy cattle.

The report was prepared on behalf of the WGCF by Dr. Eileen Wall of Dairy Cattle Breeding, Sustainable Livestock Systems Group of the Scottish Agricultural College.

The project examined the feasibility of using UK and Guernsey Island nationally recorded data for producing fertility genetic evaluations for the Guernsey. Dr.Wall reported that in co-operation with EGENES and MDC Breeding + the study was able to show that it is possible to carry out a multivariate genetic analysis for a number of fertility traits with production in Guernsey dairy cows. In contrast to the Holstein-Friesian breed there appears to have been no major genetic billdecline in fertility in UK/Island Guernseys over the past 20 years. The results show that there is a wide genetic variation, and therefore scope for selection, in many of the traits in this analysis.

This initial genetic evaluation for fertility In Guernsey was done on a test basis and results need to be further scrutinised. Although proofs have been calculated and show scope for selection the further issues need to be examined.

The results will now be sent to MDC Breeding +, the body responsible for genetic evaluations for dairy cattle in the UK, for their consideration on how to take the work forward into routine evaluations for fertility for Guernsey dairy cows. This process will be greatly aided by the further £5,000.00 SPARK award examining other breeds which will be completed this month (March 2007) and involves MDC Breeding + as a partner.

THE BOVINE HAPMAPPROJECT

WGCF successfully raised funding of £15,000 (US$29,000) to secure Guernsey involvement in the World Bovine Genome Sequencing Project to identify and characterise genetic markers in dairy cattle breeds. The total cost of this programme, which has important implications for long-term breed development, is $52,000,000 and costs for the Guernsey were $250,000. A large proportion of this was secured through international government and commercial sponsorship together with breed organisation commitment. Other funding bodies included The Guernsey Foundation and ABS Global. Guernsey participation in the project has kept our breed at the sharp end of new breeding technology.

SINGLE NUCLEOTIDE POLYMORPHISMS

SNPs are the markers that will be most used in the future because they can be assayed very cheaply, using automatic machinery, so throughput is very high. They provide a much better, more cost effective route for QTL and more importantly gene discovery. They will also provide the basis of a technique called genome wide evaluation by which accuracy of genetic selection can be increased without the expense of unnecessarily losing diversity; Therefore the technique has a great deal to offer to small breeds.

Phase one of the project produced a panel of markers that is relevant to the Guernsey. The initial analysis showed that the Guernsey is quite genetically distinct from other breeds, even from the Jersey. That means that any 'Guernsey Guaranteed' scheme is quite feasible. On the other hand, it makes the selection footprint plan a little more difficult.

Phase one is a step towards carrying out genomic evaluation and a step towards identifying genes of interest to Guernsey.

In the short term we will continue our use of DNA data to focus on markers (or actual genes) which have been shown to account for important proportions of the genetic variation in commercially valuable traits. We have made a start with ß-casein and DGAT genes, but SNPs technology offers an exciting future.

As we look forward, work is in progress for the design of a 60,000 SNP assay platform. It is expected that data from this new assay will build on the original data set to develop an even deeper understanding of the structure and function of the cattle genome. In turn it is expected that the impact of these assays will have a profound effect through enhanced prediction of genetic merit. The world of genetic improvement is poised to take a dramatic step forward!

As genes for economic and health traits are investigated, it will become necessary to adopt procedures to give these genes appropriate weight in our selection process. This has so far been based on PTAs for production and type traits. The major breeding organisations have already developed software to use specific gene information to supplement PTAs.

Genesis Faraday will soon be considering these developments at a teaching day specifically aimed at breed societies. WGCF will be sending representatives to this conference.

NICHE MARKETING AND ß-CASEIN A2

Our breed has a number of unique traits that need to be carefully protected in order to enhance specialist markets for our milk and processed products.

The natural deep yellow pigmentation of Guernsey milk and cream indicating the high levels of Beta Carotene and the unique flavour of our milk and products are important traits that are well known to consumers and processors alike.

The unique Beta Casein A2 status of the Guernsey breed has caused considerable interest from people who believe that Guernsey milk might be better for their health. There is a growing raft of anecdotal evidence available that may confirm this, at least for some sub groups of people who are susceptible to certain medical conditions. The English Guernsey Cattle Society proposes carrying out a research project at a school for autistic children to determine if A2 milk and products from Pedigree Guernsey Cows might be beneficial for individuals with autistic spectrum disorders as part of their daily diet. It is hoped that this trial will be successful. Although in itself this trial is unlikely to be regarded by the medical scientific authorities as conclusive, it may encourage more research in this field.

I believe that even now we can use the anecdotal evidence that we have as a marketing tool in addition to Guernsey milk's other proven attributes.

There has been high profile media exposure of the superb and unique quality of Guernsey beef and there may well be other areas such as the very fine quality of Guernsey hides for specialist leather that could be exploited.

The beautiful cow can be a superb marketing image herself. She is gentle in nature and looks good in her natural grazing environment. Developing an agreed farming policy of care for the environment and good animal welfare could also be part of a brand image for the Guernsey.

Modern production systems need to demonstrate that they are sustainable enterprises that provide wholesome attractive products, give an adequate living to those involved, help preserve the countryside, have no secrets from the urban majority and do not offend their growing concern for product safety, animal welfare and the environment.

You will hear from two Guernsey farmers who are successfully marketing their produce using some of the attributes of the Guernsey cow mentioned above. *(page)*

In combination with GGBP, adding value to our high quality and unique Guernsey milk and milk products is an essential and integral part of what I see as a package that can make a real difference to the financial future of Guernsey breeders everywhere.

DEMAND FOR GUERNSEY CATTLE

It seems that there is a strong demand everywhere for Guernsey cattle, often first time buyers, but it also seems that this is a demand that many of us are finding it very hard to meet. If we believe, as I hope we do, that we have a good product to sell, it follows that we can only advertise this if we are able to produce the goods. No shop advertises goods that it does not stock.

How can we increase the numbers of Guernsey cattle around the world? I recognise that transporting livestock over very long distances can be expensive. We face increasing demands of health and welfare regulations, which, I hasten to add, are generally to be applauded, and in addition to this we will all undoubtedly be facing increased costs associated with fuel and environmental issues. I suggest that embryo transfer and semen sales are a real option for implanting new Guernsey populations in remote areas. We must also accept that one of the fastest ways of increasing Guernsey populations is by giving farmers the possibility to grade up from other breeds through supplementary registers. Many successful breeds have done this in the past and we should really look hard at making it easier for this to happen. The constraints of GGBPmean that we should not encourage second release of bulls in the country of first release, but it does not mean that we cannot set semen aside for export to other populations.

WGCF BELONGS TO ALL OF US

WGCF is a portal for communication between its members and is there to be used. A good example of this has been helping with the re-establishment of the Guernsey population in Brazil.

I must stress that WGCF cannot interfere in any Member Association's internal affairs, neither will it allow its services to be used as a vehicle for criticism of individual Guernsey breed societies or their members. As a not for profit organisation WGCF cannot become involved in trading transactions.

This report has highlighted some of the research and development projects that have been undertaken by WGCF during the past three years. These are generally projects that can be of benefit to all Guernsey breeders: the technologies that have been and are being developed can be taken up by every population. I encourage you all to make use of the services that WGCF can provide. The Federation has shown that it has the international credibility and influence to assist in obtaining the services of world leading scientists and research organisations and has been successful in obtaining funding for realistic projects. If you have practical research projects that you wish to progress, please let WGCF know about them. Provided that you can show that you can implement the results of any research or development project to the benefit of your members, WGCF is there to help.

Bill Luff

New Technologies in Cattle Breeding

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Key Messages

This paper outlines the principles of a number of new technologies that are likely to influence animal breeding in the coming decades, and in particular, examines how they may be used in breeding Guernsey cattle around the world.

The paper will outline the core challenges in breeding, how they are currently tackled in dairy breeding, and how each might be affected by these new technologies.

The Core Challenges of Animal Breeding

There are 3 challenges in all animal breeding:

- knowing or choosing what to breed for (often termed the breeding objective, or selection goal),
- identifying the animals with the best genes for that goal (genetic evaluation), then selecting them for use,
- using the selected animals in a cost-effective breeding program (breeding program design).

Defining the **breeding objective** is a matter of estimating or assigning the importance of each trait. Usually this is achieved through a mixture of economic analysis and informed judgment:

- economic analysis: how much does an extra kg of milk protein contribute to farmer profit, what is the value of an 1% extra calving rate, and so on;
- informed judgement: this is more likely to be applied for traits that do not have clear economic value, or for which economic value is hard to define – examples might include many of the conformation traits, and behavioural traits. Farmers may have strong views about the impact of these, and it is quite appropriate to take this into account when deciding which traits to change by selection, and how much selection pressure to place on them.

Genetic evaluation involves using one or more sources of information about animals' merit to work out which animals have the best genes for the traits of interest.

Traditionally this was originally done by a combination of visual appraisal coupled with some knowledge of animals' production. For most animal breeding in the world for over 50 years now, it has involved careful recording of animals' performance and use of statistical approaches to making the best use of the performance information.

The standard approach in all species today is to use BLUP technology for the statistics – this approach simply uses all information from all relatives, taking account of the closeness of animals' relationships in weighting the different sources of information about each animal.

In dairy cattle breeding, the standard way to collect this information is via a **progeny test**, which involves a number of simple steps:

- some number of elite bulls are mated (usually via AI) to elite dams, to produce sons (and daughters),
- some or all of those sons are mated widely to commercial, herd-recorded cows ,
- the daughters of those matings are themselves herd-recorded,
- this herd recording data is used (via BLUP evaluations) to identify the best of the sons, and indeed to compare them with their sire generation
- the very best of the progeny-tested sons themselves become sires of a new generation of sons.

As long as this approach is carried out carefully, herd recording is sound, and a sufficient-sized population is available, this approach virtually guarantees steady, sustainable progress. Typically, progress is made at about 1% per year. The main problems with this system are:

- **time** – it typically takes 7 years to prove a bull in this system, so that genes are not being turned over very quickly (the generation length is quite long);
- **cost** – this system requires large numbers of cows to support the matings needed (ideally each young bull gets 75-100 daughters milking in 75 or more herds), and also, the bulls have to be kept alive for many years before they start being used.

Nevertheless, this system is the basis of dairy cattle breeding world-wide, and in large, well-organised populations has certainly achieved a great deal of progress.

A sound alternative is to use bulls that are not necessarily sons of proven (ie after 7 years of progeny test) bulls – in other words simply use young bulls whose pedigree indicates that they are likely to be genetically superior.

This alternative is the "**young bull scheme**", of the type now being used by the Guernsey breed. This is based on two very simple but important facts:

- the young bulls bred in the normal progeny-testing scheme are, as far as possible, of **high genetic merit** – they are the sons of elite bulls out of elite dams. So, on average, the young bulls will be the average of their parents' genetic merit;
- the **genes of these young bulls don't get any better** as the bulls themselves get older. All that is achieved by the lengthy process of progeny testing is to identify which of the young bulls are the very best (and how well this is achieved depends on things like the number of daughters, the number of herds they're in, whether there is selective treatment, and so on).

A young bull scheme recognises these facts, and rather than waiting through the long (and expensive) process of progeny testing to identify the very best bulls, uses a team of high average merit bulls (based on their known sires and dams) quickly, widely and usually only once, then repeats the process.

The reason this alternative is so attractive for smaller breeds is that there no cost of holding progeny test sires until their proofs come in (ie for 3-4 years).

Note that the process of herd recording stills goes on, so all cows and bulls still get evaluated, some/many cows are still mated to elite bulls: the key difference between this and standard progeny testing is that under young bull schemes it is very unlikely for any bull to end up with hundreds or thousands of daughters (as is the case with highly fashionable bulls in breeds such as Holstein-Friesians).

There is no significant difference in the rate of genetic progress that these two schemes – standard progeny testing and young bull schemes – can generate when run well. The reason for this is that while standard progeny testing generates very high accuracy of proven bulls, it takes a long time to do so. Young bull schemes rely on somewhat lower accuracy of selection of the bulls that breed new bulls, but much shorter time to selection.

These differences are outlined in the following table:

Key Differences between Standard Progeny Testing and Young Sire Schemes:

Parameter	Standard Progeny Testing	Young Sire Schemes
Cows herd recorded	Yes	Yes
Young bulls enter progeny test	Yes	Yes
Typical number of daughters per progeny-test	75-100	25-50 (This is what tends to happen in the case of the smaller breeds, but larger numbers are better)
Typical number of daughters per older sire	100s to 1000s	50-100
Accuracy of initial selection amongst progeny test candidate bulls	83%	70%
Average age of sires when daughters born	7 years for "proven" sires, 3 years for progeny test sires: approx. 5-6 years for whole population	3 years for the young sires which comprise almost all matings: therefore approx. 3-4 years for the whole population
Sires needing to be "held" until proven	Majority of the progeny test team	None

Essentially, a young sire scheme trades off the chance to find (and market) elite very high accuracy proven sires, for the perhaps simpler process of just using new teams of good young bulls each year. The development of the standard progeny test scheme was probably driven by a combination of the desire to make money out of proven bulls coupled with the lack of statistical tools (BLUP) that allow all animals to be compared with each other, and hence the ability to identify good young bulls at a young age with known (and lower) accuracy.

I have taken some time to outline the standard progeny test scheme and the young sire scheme because the use of the new technologies is really about tackling the same problems – how to identify and mate the best animals in the population.

Readers will note that the preceding section talks about both identifying the best animals (genetic evaluation) and how they are mated (breeding program design). Increasingly in animal breeding the solutions to these 2 core challenges are completely inter-related.

Finally before addressing the new technologies, note that all the major dairy breeding programs are seeking to achieve the cost and speed benefits offered by young sire schemes, but in most cases, breeding companies seek to maximise income, which is usually via sales of semen from proven bulls. For example, the extremely effective Dutch black-and-white breeding program uses reproductive technologies to generate large teams of elite young bulls, which are then very effectively progeny-tested, yielding highly accurate proven bulls. The Dutch use excellent organisation to achieve very reliable progeny tests which also incorporate the information from half- and full-sib sisters of the young bulls, which helps generate information about the progeny-test bulls earlier than their own progeny test. (This is the Delta program, which is a half-way house between standard progeny testing and young sire schemes. For further information, see the Holland Genetics website www.hg.nl).

What to breed for – breeding objectives and the old and new methods

The new technologies I will talk about in the next section do not really affect how breeders make decisions on what to breed for. The challenge remains that of deciding what is important:

- traits of the cow that contribute to income or cost, such as yield of solids, calving rate, and mastitis;
- traits of the cow that affect her ability to deliver income, such as structural soundness, longevity, and temperament.

The main comment here is that increasingly most dairy breeding programs world-wide are using approaches like the Guernsey Selection Index (GSI) which combines these different sorts of traits, and importantly, which address aspects such as size, mastitis and fertility as well as the straight production traits like milk volume, fat and solids.

The New Technologies – what are they?

The technologies I will talk about are of two types:

- methods of detecting individual genes, or sets of genes (DNA technologies)
- methods of increasing reproductive rate (reproductive technologies)

The focus here will be on the DNAtechnologies, but I will show how the two types can be used together even more effectively.

The starting point for discussing DNA technologies is that

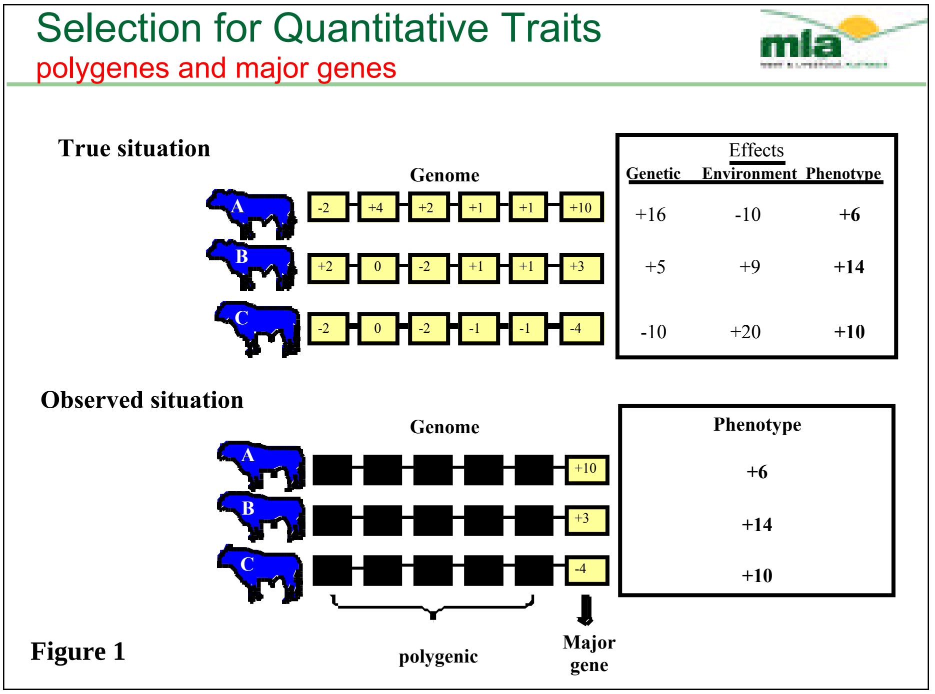


Figure 1

we now have methods that allow us to identify individual bits of DNA – in some cases actual genes.

Broadly, this allows us to do 3 things:

- identify parentage
- determine whether animals have a particular form of known genes
- estimate overall merit from the whole genome using genotype testing information.

Parentage testing is simple – using DNA tests to determine whether a particular animal can be the sire (or dam) of another, with essentially perfect accuracy provided enough genes are included in the test. Parentage testing is not directly relevant to genetic improvement programs as I am discussing here, but information is readily available on it via the web.

The focus of this section is on use of DNAtechnology to determine an animal's genetic make-up for particular known genes. It is worth looking what we mean by an animal's genetic merit. Figure 1 shows in very simple form what we have to deal with in animal breeding. It shows the true and the observed situation:

True: the bulls A, B and C each have a genome made up of a number of genes, each with effect on the trait we are interested in. These translate into total genetic merit for the trait (check it – just add them up for each bull, the totals are in the box at the right under the heading "Genetic Effect"). In addition, each bull has experienced an environment (feed, disease etc) which has an effect on the trait. The combination (sum) of the genetic and environmental effects is the phenotype – what we observe.

Observed: here we cannot see the effects of any of the genes, but do have the observed phenotype. This is the information we use in the BLUP evaluation (along with the phenotypes of all the other recorded animals).

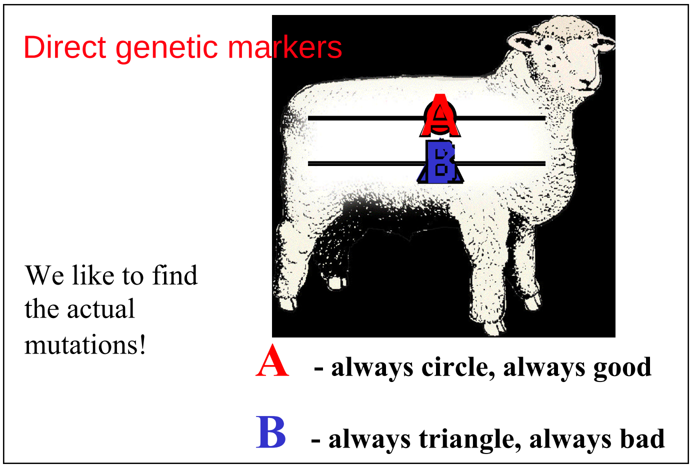
When we have either a test for a gene, or a marker, things are a little different.

We can now use simple laboratory techniques to "read" the DNA: to identify the form of each gene. We can't yet do this for every single gene and know what every single piece of DNAis actually for, but we have made a start.

This means that we are beginning to locate bits of DNA – genes – that are associated with particular traits. In simple terms, these are either:

- the gene itself, or a piece of DNAwithin the actual gene, or
- a piece of DNAnear a gene associated with a trait of interest.

These two possibilities provide us with markers for the particular trait – either a **direct marker**, where we know the location of the gene itself or of some DNA within the gene; or an **indirect marker**, where the piece of DNA is near the actual gene.



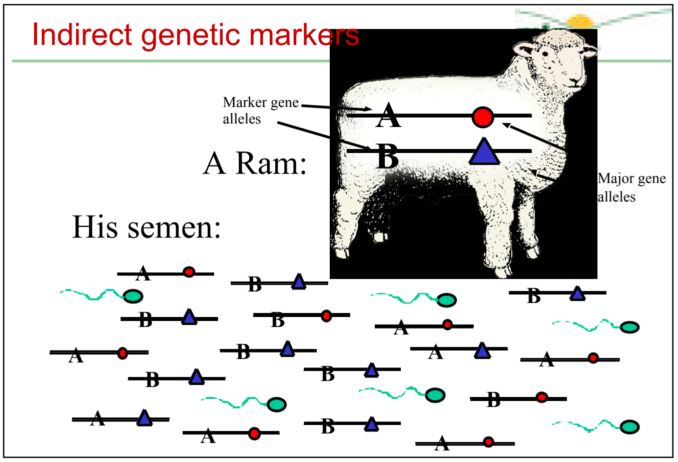
Direct Markers:
Here we can test for DNA that is either the gene itself, or is within the gene.
This allows us to detect which form the gene each animal has – in this case either the favourable form or a less favourable form.

These two situations can be illustrated in pictures:

Note here that this gene exists in two forms (shown as red circle A and blue triangle B), and that one of them is better than the other for our purposes. This is an important point – genes can exist in different forms, and we are trying to find the animals with the good forms of each of the genes affecting the traits we are interested in.

With indirect markers, the situation is a bit more complicated:

Here, the DNA we can test for is some distance from the gene we are interested in – but the closer the better. This is because when sperm and eggs are made, the chromosomes can break and be rejoined – this is called recombination – and the



Indirect Markers:

Here the test is for a piece of DNA that is some distance away from the gene we are really interested in. The closer the marker to the gene of interest, the better.

further apart are the marker and the gene of interest, the more likely this is to happen. When this happens, the link between the marker and the gene of interest can change.

Instead of being 100% confident that the “red circle” marker DNA is associated with the A form of the gene, and that the “blue triangle” marker DNA is associated with the B form of the gene, we have to calculate the strength of this relationship – which might for example be only 75%, and take this fact into account when using our marker test. (Note that the use of markers in this way is likely to be made simpler as we start to use large numbers of gene markers (in the form of snp’s) as is the case with whole genome selection – see later in this paper).

This is a very simple outline of the marker story. Markers can be thought of as flags on a map – they tell us either the precise location of something we are interested in (a direct marker), or that we are somewhere close to the place we are actually interested in (an indirect marker).

The direct markers are more useful to us, but harder to find (at least today). Returning to Figure 1 showing the genes of bulls A, B and C, we can see that with marker tests we now have more information about the genetic make-up of the 3 bulls:

Now, we know the phenotypes of the bulls plus the form of the marked gene (this might be either a direct marker or an indirect marker – the only difference is in our confidence in that assessment).

So what – how does marker information help us?

Figure 1 summarises very simply the situation we are in when we have marker tests – we now know something about the genes making up the animals’ overall genetic merit. But how does that help us?

There are two main benefits:

- **Increased Confidence (usually referred to as reliability of EBVs)**: the marker test gives us more confidence in our estimate of the genetic value of the animal. How much more confidence depends on whether the marker is direct or indirect, how much of the total genetic variation for the trait is explained by the marked gene, and how close the marker is to the gene of interest in the case of an indirect marker.
- **Earlier assessment**: having a marker test allows us to evaluate the animals for that marker at any age, including immediately at birth. This means that we can assess candidate animals for their marker genes, and hence get some information about the trait(s) of interest much earlier than for example waiting for a progeny test. Again, how much benefit this brings depends of how much of the total variation of a trait is explained by the gene we have a marker for, and how close the marker is to the gene itself.

The ideal situation from an animal breeding perspective is to have a direct test for a gene that is 100% responsible for a trait of interest. In this situation, we could simply run a blood test on new animals at birth and immediately know their total genetic merit for the trait we are interested in.

Unfortunately, this is rare. Even in well-known examples such as DGAT – a gene affecting milk fat, and the myostatin gene affecting double-muscling, these genes (which we can test for), they do not explain all the variation in the trait of interest although in both cases they are genes of significant effect).

We can still obtain the benefit of earlier assessment when we have indirect markers, and this can be very useful in reducing the number of animals taken on for more measurement. It is becoming clear that this is perhaps the main way in which markers are impacting dairy breeding programs at present – teams of candidate young bulls are screened for known markers before being put into progeny test, and those bulls least likely to “graduate” (ie turn out to have very high genetic merit) can be culled before progeny testing – thus reducing the cost of the progeny test.

This is essentially how DGAT is used – by screening potential progeny test bulls for example, we can exclude those with the unfavourable form of DGAT, thus saving the expense of progeny testing those animals, which are less likely to be outstanding for overall genetic merit (because they lack the good form of DGAT). Note that the use of DGAT needs care – because its overall effect on the various traits contributing to profit is effectively zero.

The use of markers in breeding programs has been intensively investigated, and some general conclusions are now well-established. These are summarised in the table below, with a comment about their impact on dairy breeding.

One further question should be considered in regard to use of markers in breeding programs – when are they most likely to be useful?

The answer to this question is clear:

- Where heritability is low (traits such as fertility),
- Where the trait is sex limited (traits such as milk production, number of offspring)
- Where the trait cannot be measured before first selection

Aspect or benefit	Comment
Use of markers can allow faster genetic progress	How much faster depends on how good the markers are – how much of the total genetic variation can be detected by the marker(s) – the more the better.
Markers may be breed specific	To use markers with confidence, we need to know the association between the marker and the trait of interest for each breed.
Over-use of markers can restrict longer-term progress	Simply focussing on a marker test in selecting animals may lead to slower progress in the long-term, if the selected animals are only average (or worse) in the rest of their genes.
Markers don't mean you can stop performance recording	Markers only explain a small to moderate amount of the genetic variation (and this is likely to always be the case) – so to find the animals with the **best overall genetic merit**, we must still record performance and use our routine genetic evaluations.

(traits such as milk production, longevity),

- Where the trait is difficult to measure (traits such as disease resistance, some genetic recessive conditions, and carcass traits).

Based on the summary table above, and the conditions listed where markers should be useful, we can conclude that markers should be useful in selecting dairy cattle. As noted earlier, this is already the case for example with DGAT (to a limited extent). However, this conclusion does not mean that we can stop performance recording and selecting using EBVs.

Markers can be useful as an additional tool in selection and breeding programs, but the need to performance record remains, firstly because individual markers or even sets of markers usually only explain a modest proportion of the total genetic variation, and secondly because as selection continues, markers decline in their usefulness. This is because selection actually "fixes" (makes all animals homozygous for) the useful form of the marker, and so it can no longer help us find the animals with the best genes.

This means that we have to continue performance recording both to re-calibrate the markers we already know about, and try to find new markers.

This is a very important point about markers – simply by using them in helping select and make genetic progress, they become steadily less useful. We have to keep performance recording both to update our knowledge of how useful the known markers are, and also to try to find new markers. While this is going on, we can use the known markers to accelerate genetic progress by selecting bulls at younger ages, but we need to keep doing all the things we routinely do anyway – measure performance, calculate EBVs and Indexes, select parents, and in the case of dairy cattle, run progeny testing either in the traditional way or via young sire schemes.

Before concluding with some overall observations about the way forward for the Guernsey breed, it is worth touching briefly on 3 "advanced" applications of the newer technologies.

3 Advanced applications of the new technologies

a) Markers coupled with advanced reproductive technologies:

Theoretical studies have shown that most benefit can be obtained from use of markers when not only do they explain a reasonable proportion of the total genetic variation and they help us assess traits otherwise hard to deal with (as outlined earlier), but also where they can be utilized along with techniques such as embryo transfer (ET).

Where is used systematically to produce families of elite half- and/or full-sibs, markers can help distinguish or screen amongst the family members, which otherwise cannot be distinguished genetically because they all have either the same sire (half-sib families) or same sire and dam (full-sib families).

Here markers can be used to screen out the family members which do not have the favourable form of the marker(s), thus reducing the number of family members needing to be taken on to either progeny testing or lactation and recording. Again, a saving of costs. This principle is now being used in the Delta program of Holland Genetics where adult and juvenile MOET (multiple ovulation and embryo transfer) and oocyte pick-up (harvesting lots of eggs from very young heifers) are used.

How relevant is this to Guernsey cattle? My impression is that effective use of the technologies in this way demands a large-scale, relatively centralized program which can generate substantial amounts of funds to support both the use of the reproductive technologies and the testing facilities for the cows. This is not the case with Guernsey cattle anywhere in the world, so unfortunately I think it unlikely that coupling marker and reproductive technologies will be a fruitful avenue for consideration or investment for this breed.

b) Whole Genome Selection:

This is a very recent development in DNA markers. Here, rather than trying to locate and identify a relatively small number of markers of actual genes affecting traits we are interested in, the approach is to simply test the animals'genetic makeup at a very large number of (essentially) randomly chosen locations across the entire genome (ie across all the chromosomes). At present, this number is in the range 10 or 20,000 locations (the jargon term for the locations is "snp's", pronounced "snips").

The animals' makeup at each of these thousands of locations is then compared with their known genetic merit – using high accuracy EBVs, and this provides a "key" or prediction equation that can be used for other animals in the population that have been assessed for the same thousands of locations.

This allows us to predict those animals EBVs with what appears to be quite high accuracy – **before they have any records!** Again, the accuracy depends on things like how many snp's have been tested, the accuracy of the animals' EBVs that were used for the calibration of the prediction equation, and how fast the population is making genetic progress.

This is effectively the same principle as has already been discussed for markers – the only difference is that here we have thousands of markers, not just a few, and many will effectively be direct markers.

This approach has just started to be used in dairy cattle breeding, with examples in the Dutch (again!) program and also in Australia. Once again, the benefit that is being obtained is to significantly reduce the number of young bulls entering progeny test, and thus reduce costs.

Again we can ask – how useful is this likely to be for Guernsey cattle? Again, unfortunately, I suspect that the answer is "not much". Firstly, using whole genome selection is expensive – at present it costs about $500 Aus per animal for the DNA testing. Secondly, and more importantly, one needs large numbers of highly accurate EBV bulls (or cows) to calibrate the prediction equations. In the Australian example, approximately 1,500 proven bulls (with accuracies all around 90% or above) were used. Without these numbers, at present there is no obvious way to develop the prediction equations that allow us to turn the DNA test for thousands of snp's into high accuracy EBVs.

c) Balancing genetic gain and genetic diversity

Selection means choosing the best animals to breed from. Particularly if done very intensively, this increases the chances that the parents of the next generation will be related. This in turn means that the population will become more inbred over time.

This can cause inbreeding depression, where various faults become more apparent, but also limits the scope for further selection and genetic improvement, because the population becomes more and more similar.

One of the real concerns about using advanced reproductive and selection technologies is that more and more care needs to be taken to manage the relationship amongst the selected animals.

Various approaches are available to help here:

- simple rules, such as do not mate bulls to their half-sib sisters, or some other defined relatives

- rules for generating progeny test teams, such as only use 1 (or some other number) of sons per paternal- or maternal grand-sire

- use of decision tools, such as Total Genetic Resources Management (TGRM).

These tools allow the breeder to decide in advance exactly what balance of genetic gain and co-ancestry (the degree of relationship amongst animals in the population) is desirable.

(More information on these tools can be obtained either at http://xprime.com.au/products/tgrm/, which is the web-site for X'Prime, who commercialise TGRM, or from Professor Brian Kinghorn at http://www-personal.une.edu.au/~bkinghor/.)

The Guernsey young sire program provides a very simple but effective approach to managing the balance of genetic gain and genetic diversity – by ensuring that the young sires chosen each year are sons of a wide range of bulls – in fact the widest number of sire x maternal-grand-sire combinations is desirable.

Conclusions:

This paper has covered two areas:

- traditional progeny test schemes and young sire programs
- DNA markers and their use in dairy cattle breeding programs.

The key messages are:

- Young sire programs are an excellent breeding approach for a breed such as the Guernsey, where numbers and funds are limited, but where breeders are willing to work together and keep good performance records in the different countries involved.
- DNA markers offer some significant benefits to animal breeders, including earlier selection and the opportunity to tackle traits that are otherwise hard to change
- However, benefiting from markers requires knowledge of the value, or effect, of markers in your population – this can only be achieved with good records (ie milk recording but also traits like calving success, mastitis incidence and so on), and funds to invest in "calibrating" the value of the markers.
- More advanced technologies like systematic use of embryo transfer and whole genome selection, for the moment at least, seem likely to be limited in application to larger breeding programs with substantial investment funds.
- We do not yet know how useful a whole genome scan developed in one breed will be for another – it is likely that they will be more transferable than individual markers. The Guernsey breed should keep itself informed about developments in this area.

In short, the Guernsey breed has taken an excellent and very sensible initiative with the establishment of the young sire scheme. Growing this to include more herds in more countries, selecting young bulls from as wide a range of sire lines as possible, using marker tools such as DGAT that are already available, and keeping a watching brief on the newer technologies, is a simple, sound and cost-effective recipe for success.

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