THE GUERNSEY GLOBAL BREEDING PROGRAMME
PRINCIPLES & PROGRESS

The Pilot Guernsey Global Breeding Programme (GGBP) commenced in 2002 although the basic principles of a Young Sire Programme had been established and implemented earlier.

The potential disadvantage of the breed's numerically small size has been turned into a real advantage - by persuading herd owners in the Island and UK to take charge of their breed improvement within a cooperative structure.

THE PRINCIPLES OF GGBP

- Guernseys have a small world population, less than 100,000 cows
- There are 22,000 cows on Milk Recording schemes that qualify for local and international genetic evaluation
- Use of Conventional Progeny Testing is no longer appropriate to this small global population
- Widespread use of any one bull across all populations has inbreeding implications

SOLUTION

The solution to this situation is not new. Numerous geneticists have proposed similar actions over many years from the beginning of the AI service in Guernsey. Dr. Ken Deeble recommended this solution when the decision was made to import semen. It was repeated by Dr. Ted Burnside at the World Conference held in Guernsey in 1992 and subsequently by Prof. John Woolliams of Edinburgh University, the acknowledged world authority on the management of small population breeds.

- Use a large number of Young Sires sparingly within each population
- Ensure Connection between Populations by exposing a few Young Sires from Foreign Populations within each population

THE PROGRAMME

Every breeding programme needs to have four elements

1. **DESIRED OBJECTIVES**
2. **APPLICATION**
3. **STRATEGY**
4. **EVALUATION**

DESIRED OBJECTIVES

The objectives of GGBP were decided by a questionnaire sent to all Guernsey Breed Societies. The results indicated that Guernsey breeders desired to:

- **IMPROVE YIELDS**
- **RESTORE COMPONENT LEVELS**
- **IMPROVE UDDER CONFORMATION**
- **IMPROVE FEET/LEGS AND LOCOMOTION**
- **REDUCE SOMATIC CELL COUNT**
- **Add New Traits (Fertility)when available**

APPLICATION
The results of the Questionnaire were sent to Dr. John Woolliams of Roslin Institute, Edinburgh University.

Dr. Woolliams used a computer model to predict the result of applying index weights to the various selected traits in order to achieve the DESIRED OBJECTIVES over time.

The result: THE GUERNSEY MERIT INDEX (GMI)

The Guernsey Merit Index is based on PTAs (Predicted Transmitting Abilities) for the Desired Traits and expresses the overall breeding value of an animal summed over all the improvement goals.

N.B.
Predicted Transmitting Ability is a measure of the genetic merit of an animal after all management and environmental factors have been removed. It is an estimation of the future performance of an individual animal's offspring in relation to the offspring of all animals.

The trait emphases in the Guernsey Merit Index are:

PTA Milk + PTA Fat + PTA Protein	**60%**
+ PTA Feet/Legs Composite	**12%**
+ PTA Mammary	**23%**
+ PTA SCC	**5%**

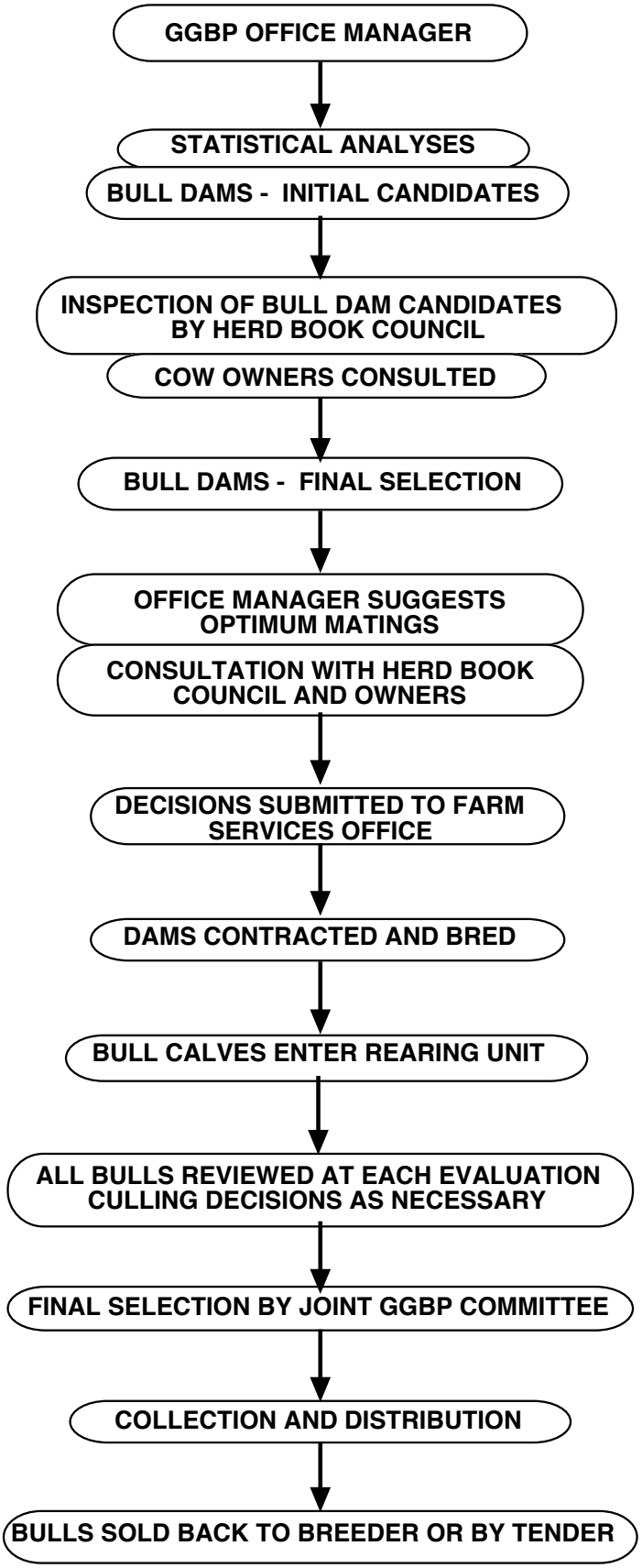
GMI is designed to
- **improve Production and Component levels**
- **Hold Foot and Leg Scores (already considered to be the best of any breed)**
- **Improve Mammary Scores**
- **Reduce SCC**

STRATEGY

- **Teams of bulls are released each year**
- **Bulls are selected on Parent Average Transmitting Ability (PA)**
- **Parent Average Transmitting Ability is half the sum of the Predicted Transmitting Ability of both parents.**
- **Parent average PTAs have a lower reliability than those of proven bulls**
- **BUT what GGBP loses in reliability it gains in rate of turnover**
- **Bulls should be used at random to avoid bias in their evaluation**
- **Some bulls will be better than others**
- **But it is THE TEAM RATHER THAN THE INDIVIDUAL BULL that moves the population forward**

OPERATION
The Programme operates a strict decision making routine as demonstrated in the diagram below. The Joint GGBP Committee consists of the RGA&HS Herd Book Council and the English Guernsey Cattle Society Future of The Breed Committee, each of which generally sends four delegates to meetings that are held twice each year under the Chairmanship of our Consultant Geneticist, Dr. Maurice Bichard OBE. The Committee selects new candidate young sires from data sheets and performance pedigrees and discusses refinements to GGBP operation such as adding new traits to the GGBP Index.

GGBP - ISLAND MANAGEMENT



EVALUATION – ISLAND OF GUERNSEY

In 2008 62% of calves registered with RGA&HS were by GGBP bulls. We now have sufficient data to give an indication of how GGBP is affecting the genetic merit of our Island Population.

The following table compares the average performance of 22 GGBP bulls used in the Island that have a proof with All Proven Bulls and All Bulls with a UK proof that were born in the same years (1999-2003). These figures refer to GGBP bulls used 2002- early 2005.

Bulls DOB 1999-2003	Daughters	Milk	Fat	Prot	%Fat	%Prot	GMI
GGBP BULLS	79	189	15.0	8.4	0.11	0.03	236
All WORLD PROVEN	Not Given	168	9.1	6.5	0.02	0.01	153
ALL UK PROVEN	30	73	5.4	3.6	0.00	0.02	99

The following graphs show that progress is indeed being made in the desired traits.

Fig A: PROGRESS OF GMI IN THE ISLAND POPULATION 2001-2008

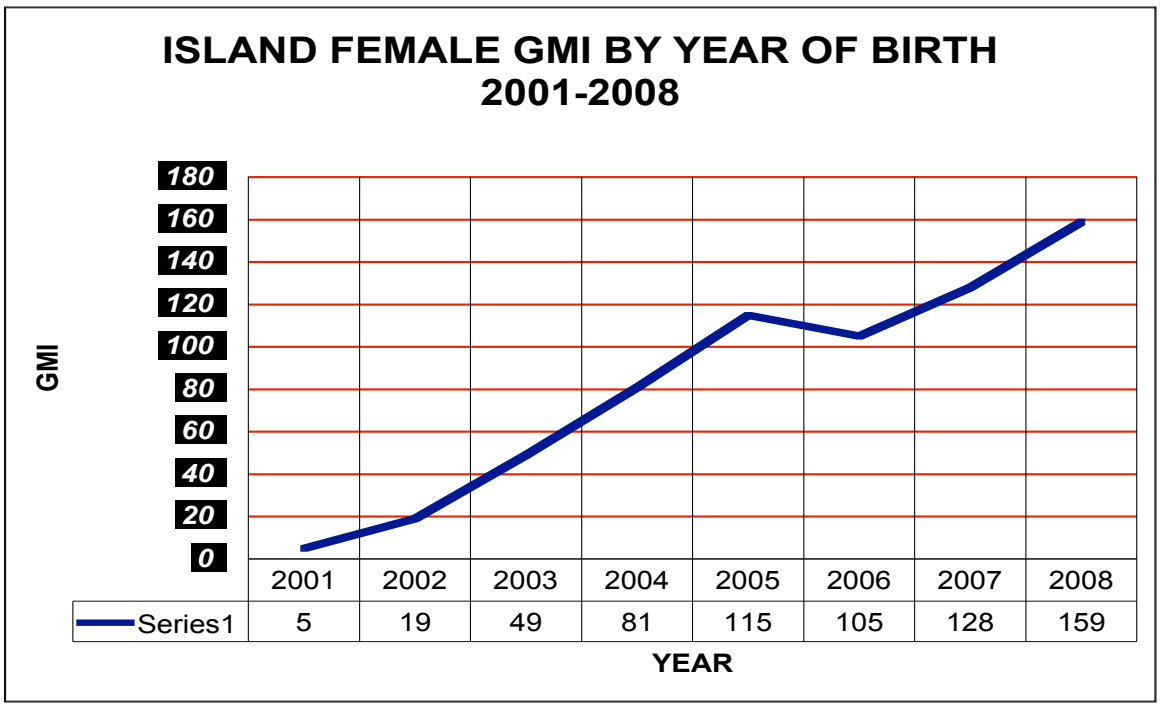
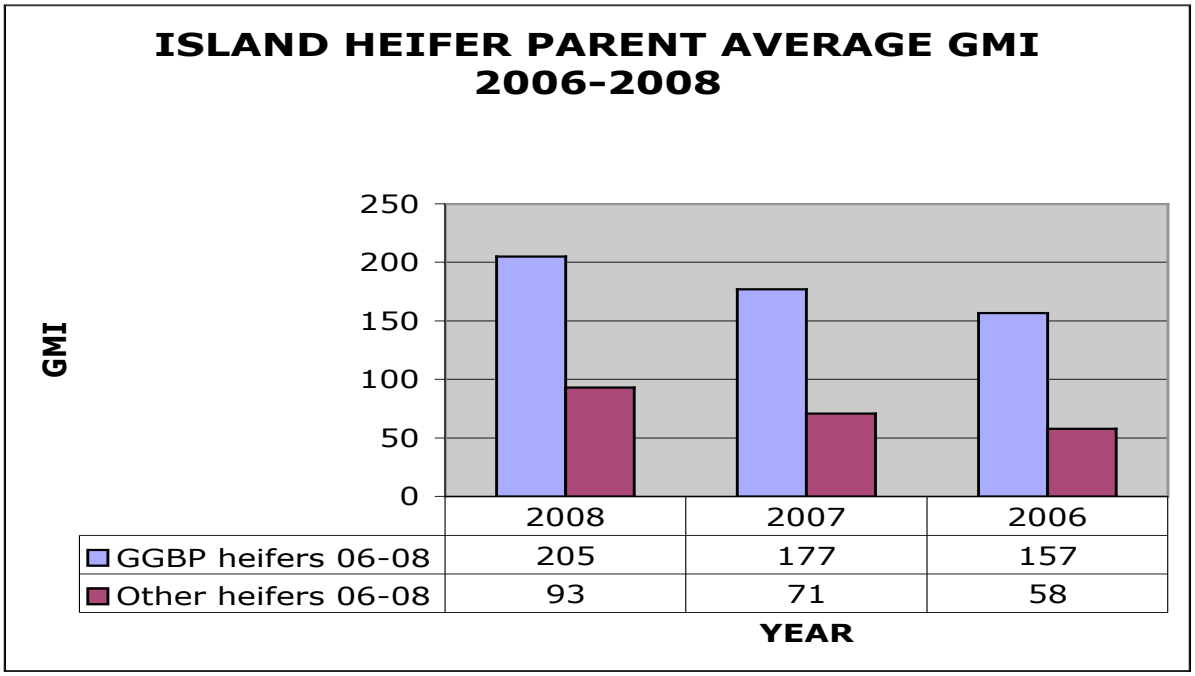


Fig B: Parent Average GMI of Island Heifers sired by GGBP bulls compared with GMI of Heifers sired by other Proven and Farm bulls 2006-2008



EVALUATION UK AND ISLAND COMBINED

DairyCo Breeding+ has produced the following graphs showing progress in the joint population (Island plus + UK) for the traits included in the Guernsey Merit Index.

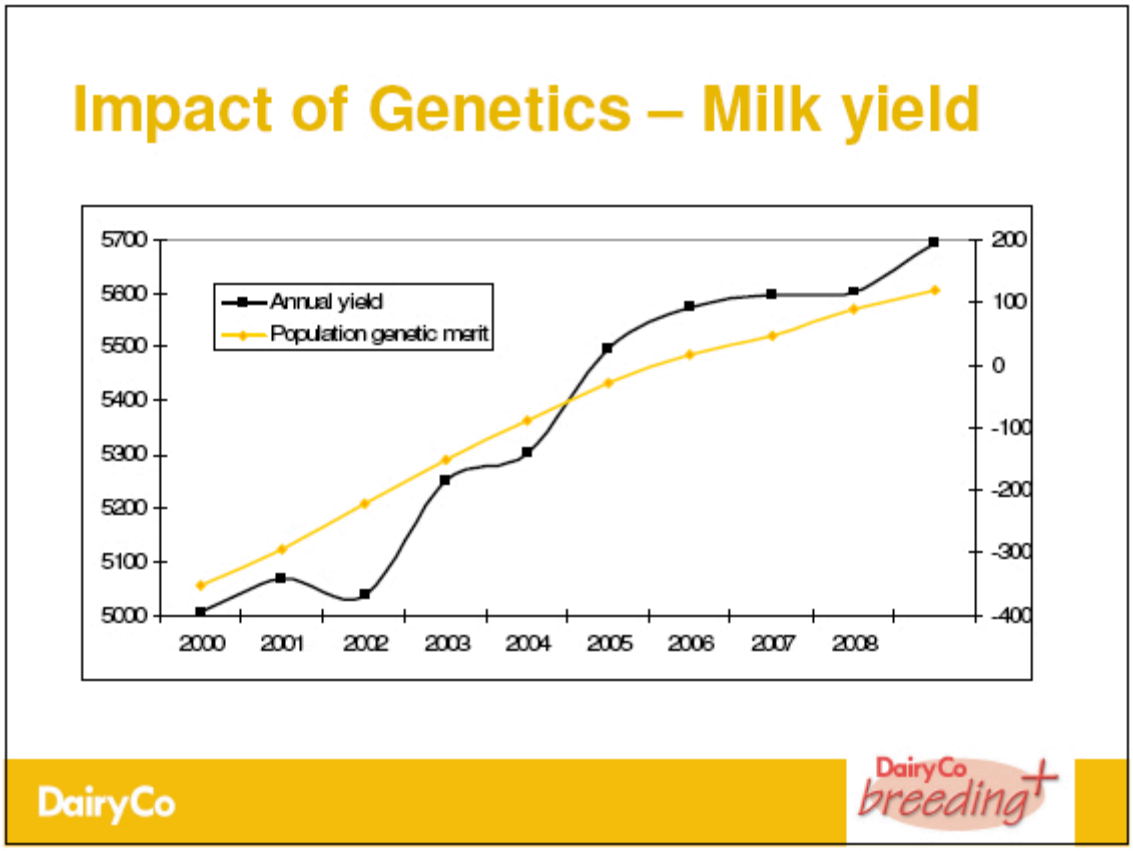


Figure 1: Genetic Progress in Milk Yield

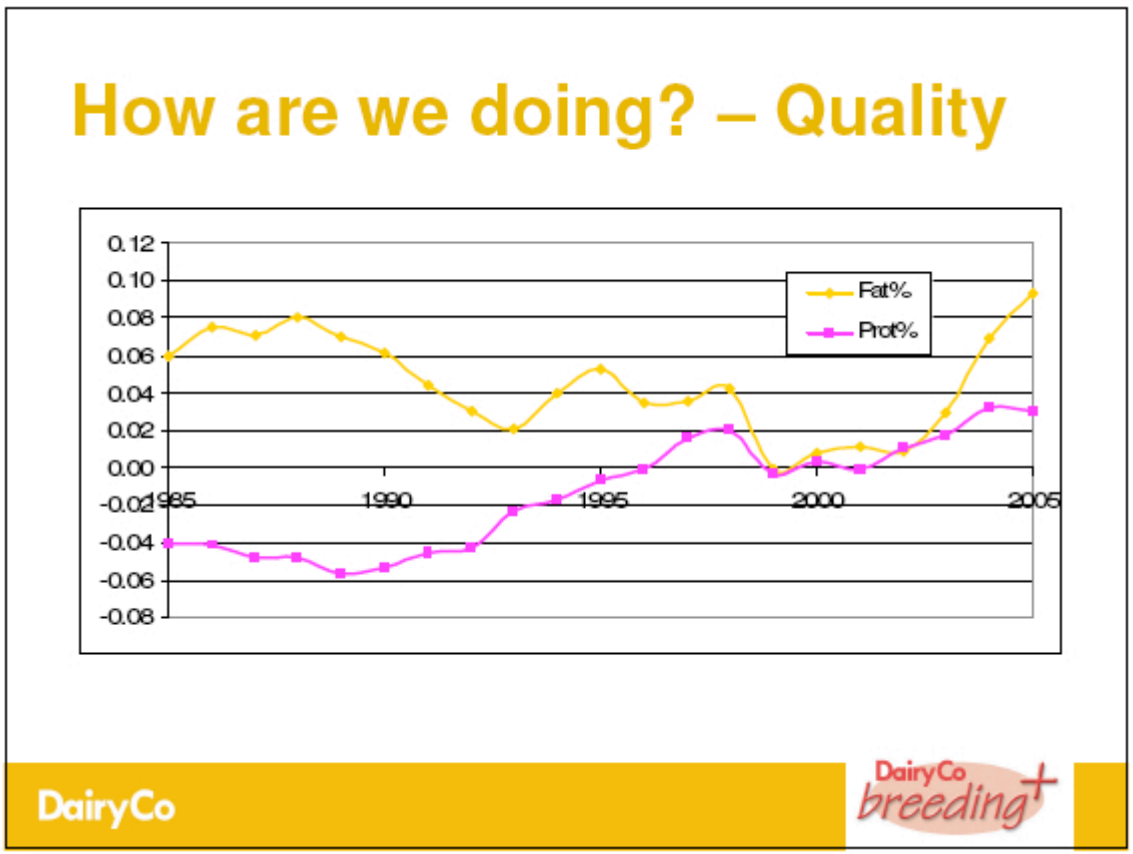


Figure 2: Progress in Fat and Protein

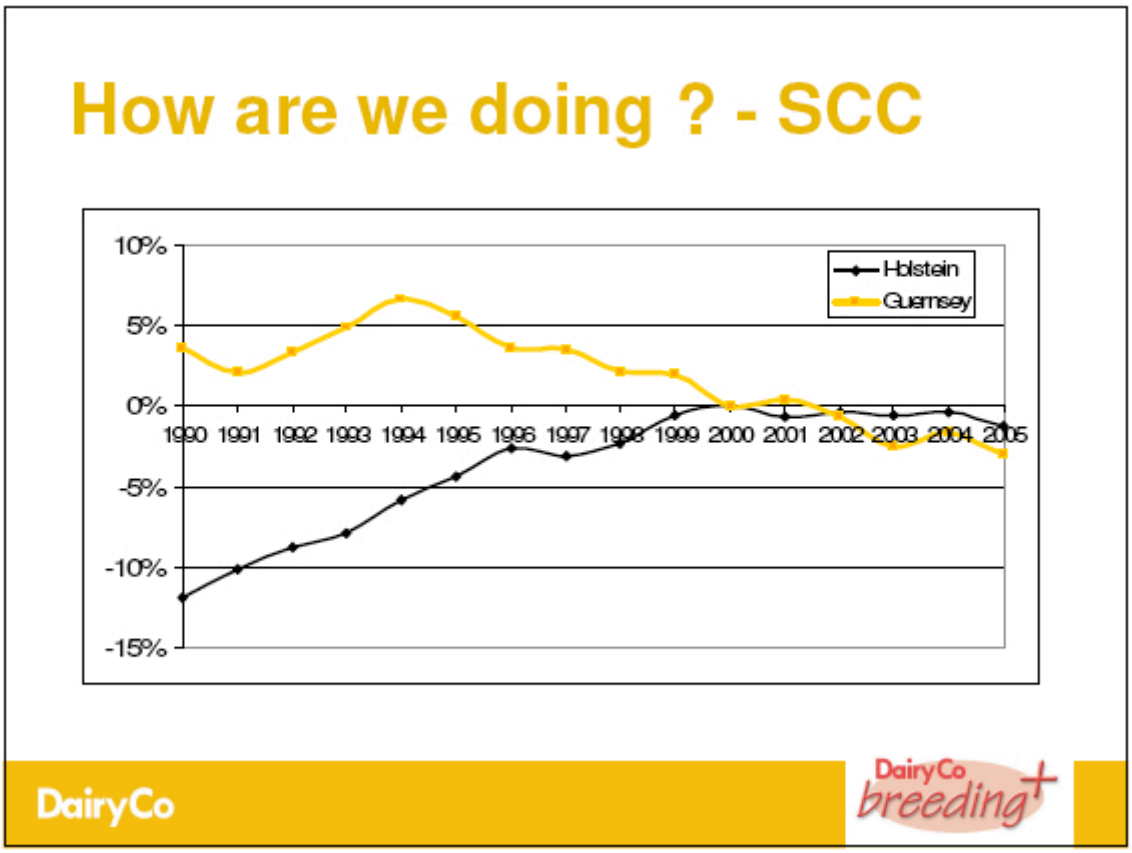


Figure 3: SCC in the Guernsey Breed is steadily declining (improving)

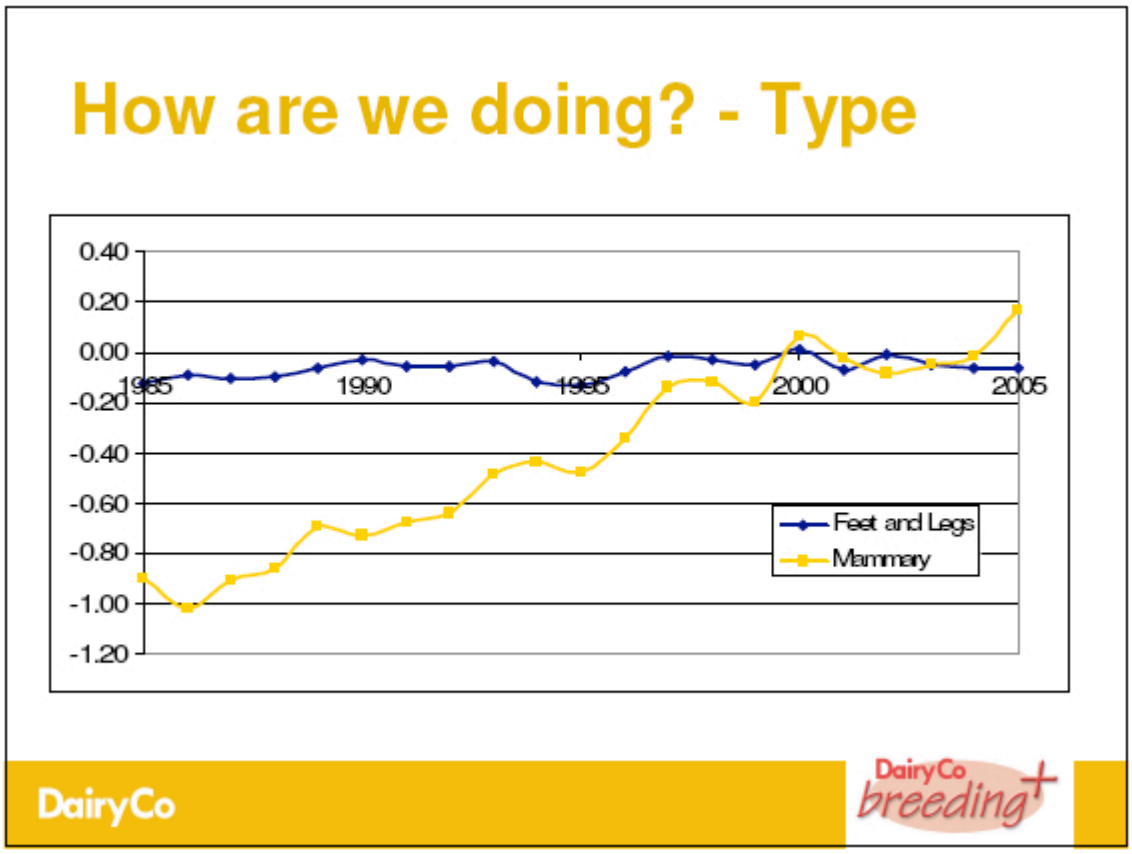


Figure 4: Genetic improvement in Mammary Systems and maintenance of Foot and Leg merit

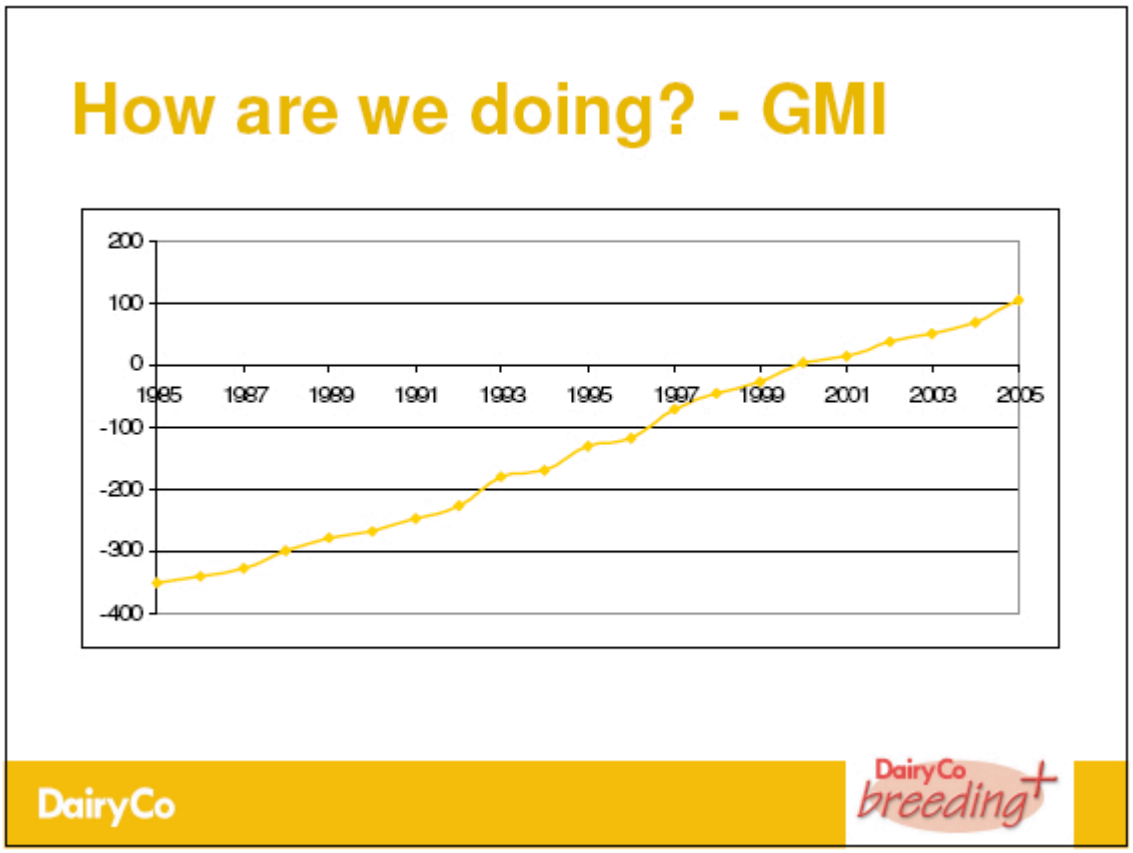
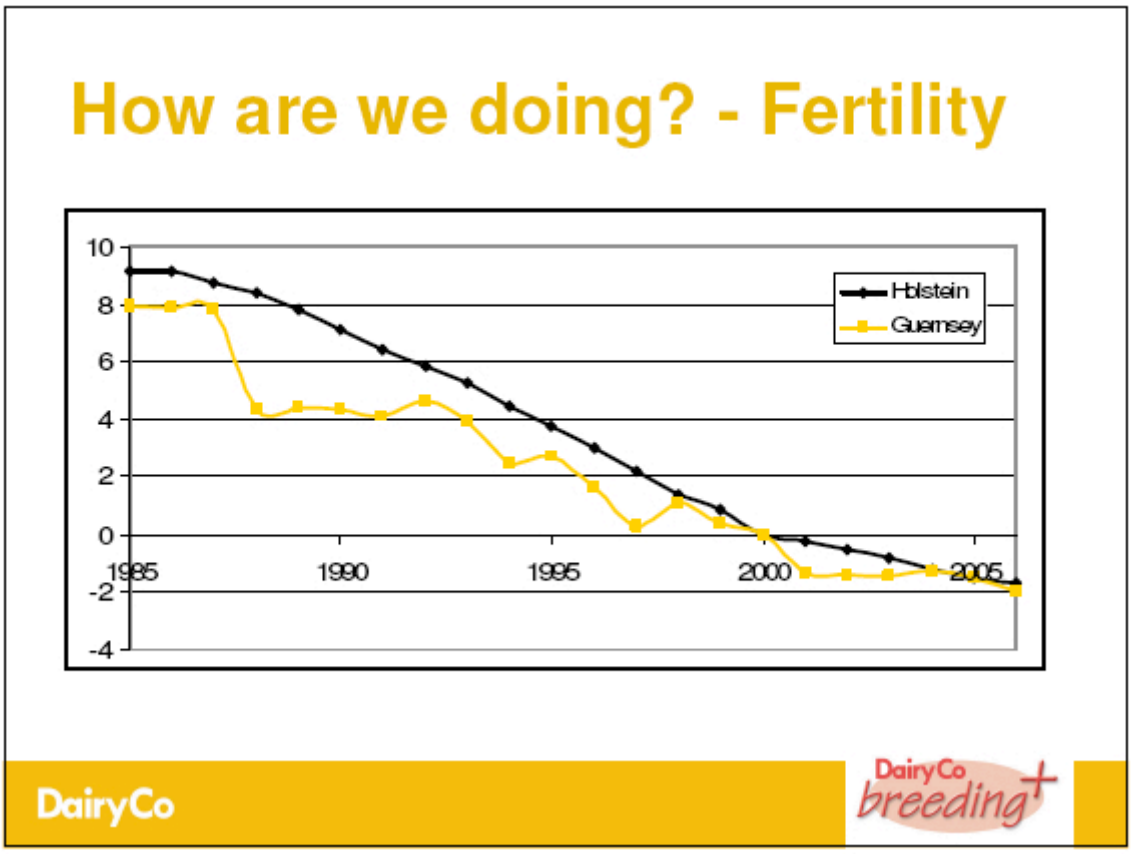


Figure 5: Genetic improvement as measured by the Guernsey Merit Index

Female Fertility

GGBP has achieved the desired results in production and conformation BUT as the productivity of our cows has increased, there has been a noticeable decline in Female Fertility as indicated by increased Calving Interval and non return to service.



Nutrition plays a part in Improving Fertility but as in other traits, so does genetics. Other breeds, particularly in Scandinavia, have shown that by including Fertility as a trait in a breeding index, it is possible to arrest a decline and even improve Female Fertility. The GGBP Management Committee is actively engaged in addressing this issue.

Genetic Progress compared with other breeds at the 2010 Base Change
The Genetic Merit for all recorded traits and breeds in UK and the Channel Islands is calculated three times every year by EGENES at Edinburgh University. Results are then sent to the Interbull Laboratory in Uppsala, Sweden, where international evaluations are computed so that every country can express and compare the genetic merit of all animals on each individual country's scale.

Every five years, the national average for every trait is recalculated and reset to zero to account for the genetic progress made.

With the January 2010 proof run the genetic base was re-calculated for all breeds and was reset to the average genetic merit of cows born in 2005.

The table below gives a summary of the base changes for the production and fitness traits, which represent the genetic progress made in the five-year period (with signs reversed):

Breed / Trait	Milk	Fat	Protein	Fat%	Prot%	PIN	SCC	Lifespan	Fertility Index	PLI
Holstein	-141	-6.6	-4.2	-0.02	0.00	-9	2	-0.1	1.5	-35
Ayrshire	-132	-4.6	-4.4	0.00	0.00	-8	0	-0.1	1.7	-33
Friesian	-192	-5.8	-5.9	0.03	0.01	-10	1	-0.1	0.4	-46
Guernsey	-112	-6.7	-4.8	-0.03	-0.02	-11	2	-0.1	1.0	-39
Jersey	-85	-4.0	-2.7	0.03	0.02	-6	0	-0.1	0.0	-27
Shorthorn	-62	-2.7	-2.6	-0.01	-0.01	-5	1	0.0	N/A	-18

From this table it can be seen that the Guernsey breed made very good progress indeed when compared with other breeds and, despite its small population size, was the leader in improvement in Profit Index (PIN), and second overall in progress in the Profitable Lifetime Index (PLI).

Profit Index predicts the additional margin over food and quota costs per lactation a bull or cow is expected to pass on to its progeny, on the basis of future milk market requirements.

PLI is based on production traits (milk, fat and protein) to which are added health, welfare, fitness and lifespan components. Each trait is weighted by its relative economic value and the resulting single figure represents the financial improvement an animal is, on average, predicted to pass on to its offspring. The PLI formula emphasises health, welfare and fitness traits, reflecting both the farming industry and wider consumer demand to strive for higher animal welfare standards, as well as the impact of these traits on profitability. The current formula has reduced the emphasis on production traits to 45%.

The base change for Foot & Leg and Mammary systems was:
Mammary System Overall: 0.3, Feet & Legs: 0.1

Guernsey Merit Index revealed an improvement of 110 points GMI.

These changes almost exactly reflect the progress predicted by Dr. John Woolliams in his original report on the implementation of GMI.

The Future
The GGBP Committee is actively addressing the matter of improvement in Female Fertility. To this end we have employed a geneticist and statistician, Dr. Janet Roden. Dr. Roden has completed her first contract, which was to investigate and make proposals for the inclusion of fertility as an additional trait in the Guernsey Merit Index. Dr. Roden has also documented procedures for computing the genetic merit of GGBP candidate bulls and the selection of bull mothers with particular reference to maintaining genetic diversity.

A Sustainable Breeding Programme
The maintenance of genetic diversity within the breed is of vital importance. Improvement can only come from genetic variation. If we narrow down our genetics by always returning to the same families for our bulls we will pay an inevitable and damaging price. *Fikse & Philipsson (see below)* remind us that 'In small populations progeny testing is of limited value for selection of bulls for wide-spread use, as such use is not possible from an inbreeding point of view. However, progeny information, as well as records of all relatives, can be used for evaluation and selection of parents of young bulls, each one of which should be limited in use'.

The Guernsey is a minor, small population breed. If we want to survive in a competitive world, we need to be smart. Being smart means having a globally sustainable breeding programme.

A sustainable dairy cattle breeding program should be characterized by:

- ◊ A continuous genetic improvement of productivity to keep the population commercially competitive in relevant areas for production.
- ◊ The generation of products which have such value that they are marketable at a profitable farm-gate price.
- ◊ A broad definition of breeding objectives to take into account selection for all major economically important traits with a special restriction that fundamental characteristics of fertility, health and survival do not decline.
- ◊ Management of inbreeding at such a level that no depression of important traits resulting from increased inbreeding occurs. The effective population size should be monitored and selection practiced to keep it above levels at which the breed is considered to be at risk of endangerment. (*Fikse & Philipsson)*

In their paper, 'Development of International Genetic Evaluations of Dairy Cattle for Sustainable Breeding Programs', (Food and Agriculture Oganisation of the United Nations bulletin 41 2007 'Animal Genetic Resources Information' Issued in conjunction with the Interlaken International Conference http://www.fao.org/docrep/010/a1206t/a1206t00.htm) W.F. Fikse & J. Philipsson state:

'In scrutinizing the criteria for sustainability of breeding programs for dairy cattle, and the review of what has happened in the most globally prominent breeds used for dairy production, it is obvious that certain facts indicate that some breeds, especially Holstein, are faced with severe problems that question the sustainability of the breed. The unfavorable correlations between e.g. production and fertility, or the rising stillbirth trend, have not been met globally by adequate means for genetic evaluation and selection until very recently. Still, for these breeds used globally there is no body that takes the overall responsibility for directing their development into more harmonized breeding programs in line with the criteria for sustainability rather than focusing on traditional breeding for conformation, and especially for such traits that are unfavorably correlated with fitness of the animals.

However, there are notable exceptions…….Another example and problem is

demonstrated by the Guernsey breed, which has been declining in numbers for some time. In most countries the breeding program is characterized by traditional selection for just production and conformation, the latter leading to bigger and less fertile cows. However, the World Guernsey Cattle Federation has taken the initiative to launch a global breeding program based on sound scientific principles, whereby the genetic diversity is considered in combination with selection for a continuously broader breeding objective (Luff, 2006). It takes time, however, to harmonize ideas and breeding objectives and principles of selection across continents used to different breeding traditions, but such global efforts are very well worth supporting. This is also emphasized by the fact that the breed seems to offer certain characteristics in its milk that differ from other major breeds.'

Guernsey Milk

The traditional qualities of Guernsey milk and milk products are perhaps the best-kept secret of the breed. We all know that Guernsey milk is different. It has its own special taste, colour and mouth-feel and it has unique compositional qualities.

Among these unique qualities is the presence of the protein Beta-Casein A2 in the milk of approximately 96% of Guernseys as opposed to most other European breeds which carry a predominance of Beta-Casein A1. A1 beta-casein and its derivative beta-casomorphin7 (BCM7) have been implicated in numerous health issues including Type 1 diabetes, heart disease and autism. There are currently over 100 peer-reviewed papers on this subject. There is an ongoing debate about how compelling the present evidence is, but anecdotal evidence suggests that some people who thought that they were lactose intolerant may be intolerant to A1 milk through the release of BCM7. There is further anecdotal evidence that some autistic people benefit from A2 milk.

Genomics

On 24th April 2009 Science, the world leading publication of The American Association for the Advancement of Science, published two of the most important papers in the field of animal breeding and evolutionary biology since Darwin's renowned 1868 work, *The Variation of Animals and Plants under Domestication*. *The Genome Sequence of Taurine Cattle: A Window on Ruminant Biology and Evolution* from the Bovine Genome Sequencing and Analysis Consortium and *Genome-Wide Survey of SNP Variation Uncovers the Genetic Structure of Cattle Breeds* from the Bovine HapMap Consortium make fascinating reading and can be found at www.sciencemag.org or by using direct links at www.worldguernseys.org.

The World Guernsey Cattle Federation is rightly proud of its involvement in the Bovine HapMap Consortium.

In the first phase of the HapMap Project we learned about the differences between breeds and in particular that the Guernsey's relationship to other European breeds is rather distant. Since then the shift has been towards looking at traits of economic importance.

All animals inherit one half of their genes from each parent, BUT which half? Up to now this has not been known, as is clearly demonstrated by the very different genetic evaluations/performance of full brothers/sisters. Soon we hope to be able to predict which of two full brothers will be the best BEFORE he is used. This in turn will eventually help to reduce the costs of GGBP and increase the confidence that can be placed in GGBP Young Sires

Genomic evaluation will be very important for those traits that are expensive or difficult to assess. Health traits, such as mastitis and other disease resistance, as well as fertility and longevity feature in this category. HOWEVER, accuracy will depend on farmers having kept very good on farm records.

The World Guernsey Cattle Federation has committed $USA 25,000.00 towards eventual genomic assisted evaluations for Guernseys. We are already identifying high reliability bulls both from museum stocks of semen and from more recently used bulls.

We will be working closely with Dr. Curt Van Tassell of the USDA Bovine Functional Genomics Laboratory and the American Guernsey Association. WGCF is also hoping to participate in the EU\USA Quantomics Project through its relationship with Roslin Institute.

Guernseys are a numerically small breed and it will be impossible to match the number of bulls that were sampled for the first evaluations of the Holstein. However a paper published by Vincent Ducrocq et al. gives hope for the smaller breeds. Ducrocq, of the French National Institute for Agricultural Research, believes that smaller breeds will need to collaborate and develop joint genomic selection programmes. He suggests that Interbull would be the obvious place where such work could be coordinated. Based on recent research, it appears that we need DNA profiles on 800 bulls (from their semen) with existing progeny and family data sufficient to give breeding values with a reliability of 50% or more. If we can get these, then we might hope to derive genomic predictions on a newborn calf with an accuracy of about 60%.

WGCF has received an invitation to collaborate with Interbull in developing a genomic evaluation system for the breed. Interbull is currently investigating the Guernsey breed population structure with a view to helping with future strategy.

Acknowledgements
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WGCF also recognises the invaluable assistance received from Dr. Maurice Bichard, Professor Jan Philipsson (Secretary of Interbull), Professor John Woolliams (Edinburgh University), Dr. Mike Coffey (EGENES), Dr. Eileen Wall and Dr. David Morrice (Roslin Institute), Dr. Janet Roden (Aberystwyth University), Dr. Ted Burnside (former head of CGIL University of Guelph), Dr. Curtis Van Tassell (Bovine Functional Genomics Laboratory and the Animal Improvement Programs Laboratory, U.S. Department of Agriculture) and many other scientists who have given their time to help in the development of an unique breeding programme that brings the application of science directly to the enhancement and sustainability of the world's farm animal genetic resources. WL 2010