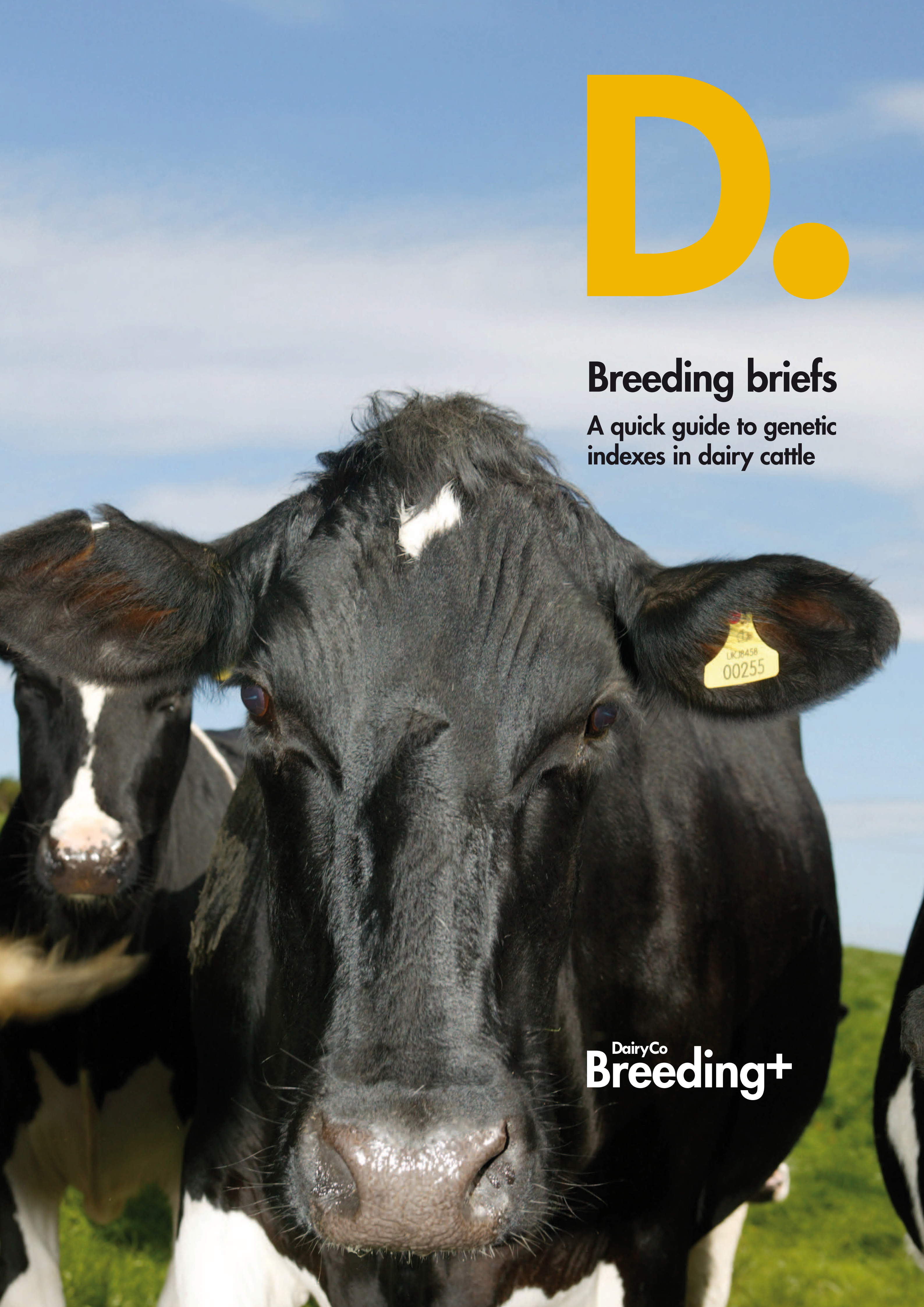


Breeding briefs

A quick guide to genetic indexes in dairy cattle

DairyCo Breeding+

Contents.

Introduction.

High quality cattle are at the heart of profitable dairy farming. This requires good quality genetics and without this – however good your management – there is a ceiling to your herd's performance and profitability.

This isn't just about genetics for milk production. It's also about health, welfare, management and type traits, each one of which can make an important contribution to profitability and each of which can be improved through breeding.

At a time of tight margins, a series of poor breeding decisions can mean the difference between profit and loss; even between a business's survival and failure. Yet the time, cost and effort needed for a good breeding decision to be made is much the same as those needed for a bad one.

Even more important is the fact that breeding decisions are cumulative. Their effects build up over the generations such that a problem can be introduced or cured over just a few years through the breeding choices made.

This booklet aims to identify some of the tools of genetic improvement so that better breeding decisions can be made. It concentrates on the theory and adds comments on using breeding tools in practice and for those confronted with an overload of information, it helps identify the figures to seek out and prioritise.

Genetic indexes: the theory.

What are they and why do we need them?

A genetic index provides a measure of an animal's ability to pass its genes on to the next generation. These could be genes for production, for health, for lifespan, for conformation or for any trait that is inherited and can be measured. Although we are most familiar with genetic indexes for milk, fat and protein, it's a common misconception that indexes only relate to production. Genetic indexes are far more than this and their application for non-production traits is becoming increasingly important.

In measuring an animal's genetic merit and assigning it a genetic index, every effort is made to disregard the effects of its environment and to strip all of its performance down to the bare genetics. This means that a 12,000 litre cow from a high input system can be compared with one in an extensive herd averaging 6,000 litres. Equally, bulls whose daughters are milking in different production systems can also be fairly compared.

Before we had genetic indexes we had no way of fairly making such comparisons, but today genetic indexes play a particularly important part in helping us decide which bull to use. Each herd will have weaknesses it would like to correct and choosing the best bull to correct the weakness is an important part of the process. We can only make this decision if we have a measure of his genetic ability and know the type of daughters he is expected to breed.

How are they calculated?

In the calculation of a genetic index (often colloquially known as a proof), information is drawn from a variety of sources to produce the best possible estimate of an animal's genetic worth. This includes information on the animal's own performance where appropriate and information on the performance of other family members. Since an animal's performance is a combination of genetics and environment we need to make certain allowances for these environmental effects. In doing so, considerations such as age, lactation number, stage of lactation, herd performance and season are all taken into account.

For a bull, the most important component of his proof is his daughters' performance. For a cow the most important component is her own performance. When either a bull or cow is too young to have any daughter or performance information of its own, its genetic index will be calculated entirely from family information. This type of estimated genetic index for young animals is called a Pedigree Index, since information is based on the animal's family or pedigree. However, as the animal accumulates more information of its own, so its family information becomes progressively less important.

Information included in genetic indexes originates with both milk records organisations (eg, production and cell count information) and breed societies (eg type and locomotion information) or a combination of the two (eg fertility and longevity). It is then used in the calculation of genetic indexes by DairyCo Breeding+.

In the calculation of genetic indexes for production or production-related traits, information from five lactations is generally used. In the calculation of genetic indexes for type or type-related traits, information on heifer classifications is generally used.

It is important for the industry that all sources of information used to calculate genetic indexes are independent and free from commercial bias, which is why these indexes are produced by DairyCo Breeding+, and in the case of black and white type by Holstein UK, rather than by the breeding companies themselves.

The Test Day Model

A new method used in the calculation of genetic indexes for production was introduced in 2005, which has significantly improved their accuracy. This is called the Test Day Model (TDM). In the calculation of genetic index, TDM uses production information from every milk recording test day, up to and including the fifth lactation. It takes better account of management and environmental conditions affecting performance than before; it provides earlier genetic information for bulls and cows and allows a smoother transition to be made from Pedigree Index to the animal's actual proof.

How are genetic indexes expressed and what do they mean?

In the UK most genetic indexes are expressed as Predicted Transmitting Abilities (PTA). PTAs predict to what extent a given trait will be passed on to an animal's offspring. They do not predict the offspring's actual performance - which will clearly vary widely depending on management - but instead they predict the amount of a trait the offspring will, on average, receive from its parents, compared with 'average' parents whose PTA is zero (see also genetic bases). This principle applies to both male and female PTAs.

Production traits.

Genetic indexes for production were the first to be introduced and have played an essential part in the increases in milk production witnessed in recent decades (see 'What genetic progress has been made?').

Milk, fat and protein

The production traits for which all male and female dairy cattle are assigned a genetic index are as follows:

Milk kg, fat kg, fat %, protein kg, protein %.

Daughters of a bull with a PTA of 650 kg milk are on average predicted to produce 650 kg more milk in a lactation than the daughters of an average bull whose PTA is zero. The range of values for a PTA will vary from trait to trait such that a milk PTA may exceed 1000 kg whereas a fat kg PTA is unlikely to be more than 40 kg.

Persistency

The persistency of cows' milk production also now has a genetic index, thanks to the introduction of the Test Day Model. Bulls' persistency PTAs provide an indication of their daughters' ability to maintain production through the lactation.

They are derived from yield at 280 days as a percentage of yield at 60 days. PTAs for Holstein bulls range from around 57% (low persistency) to 67% (high persistency), with a higher figure generally reflecting flatter lactation curves. It is generally believed that flatter lactation curves will result in fewer metabolic problems and may therefore result in better health and fertility. However, research is yet to be carried out in the UK to confirm the genetic link between lactation shape and health traits. We therefore recommend that persistency PTAs are only used as a secondary screening of bulls.

Table 1: Breed averages, minimums and maximums for persistency PTAs (%)

Breed	Min	Avg	Max
Ayrshire	51	57	63
Brown Swiss	55	61	67
Friesian	60	64	68
Guernsey	55	60	65
Holstein	57	64	71
Jersey	56	61	66
Montbeliarde	54	60	66
Shorthorn	52	57	62

Health, welfare and fitness traits.

A growing significance is being attached to health, welfare and fitness traits, not simply because these traits are needed to sustain milk production over several lactations in modern farming systems, but also because of the growing demand from consumers for high health and welfare produce.

Although management practices are key in determining both health and welfare, it is very possible to breed robust cows which inherently have a better chance of experiencing high health and welfare standards.

Health or welfare traits for which dairy cattle are assigned a genetic index are as follows:

Somatic cell count

Somatic cell count PTAs are expressed as a percentage and generally fall within the range +30 to -30. For every 1% in a bull's SCC PTA, a change of 1% in his daughters' SCC is predicted. For example, daughters of a bull with a -10% SCC are expected to have cell counts 10% lower than daughters of a bull with a SCC PTA of zero. So, negative figures for SCC PTAs are desirable as these indicate a reduction in cell counts. Because of the strong link between SCC and mastitis, SCC can also be used as a selection tool to reduce mastitis incidence.

Negative PTAs for somatic cell count are desirable.

Fertility

The PTA for fertility (Fertility Index, FI) provides a prediction of female fertility. It is expressed as a financial figure (£) and is based largely on a combination of calving interval and non-return rates. On average, for every £ increase in a bull's FI, an improvement in his daughters' calving interval of just under half a day is predicted as well as just under half a percent improvement in non-return rate at 56 days.

Fertility Indexes generally fall within the range of -15 to +15, such that a +15 bull's daughters are expected to have about a seven day shorter calving interval than daughters of an average bull whose FI is zero.

Information included in the calculation of FI is as follows:

1. calving interval
2. non-return rate at 56 days
3. body condition score
4. milk yield at around the time of insemination (110 days)
5. days from calving to first insemination
6. number of inseminations needed to get a cow in calf

The first two of these components are by far the most important, although early in a bull's life it is necessary to use more of the others as predictors of fertility, as well as parent information.

An average herd can reduce calving interval by around seven days in one generation by using the best Fertility index bulls. These benefits accumulate over the generations.

Lifespan

PTAs for Lifespan (LS) are expressed in terms of lactations and generally fall within the range of -0.5 to +0.5. They are calculated from actual daughter survival when that information is available. When it is not – as in the case of young bulls

– information on type (feet, legs and udder), cell count and family is used to make the best possible predictions of lifespan. The choice of traits used in this prediction is based on extensive research using many years of cow records which have indicated which traits are most strongly related to survival.

Lifespan PTAs predict reduced or increased survival, such that daughters of a +0.5 bull are predicted to survive, on average, 0.5 lactations longer than daughters of a bull with a lifespan PTA of zero. In other words, they will milk for around 150 more days.

An important feature of Lifespan PTAs is that they predict involuntary rather than voluntary culling. Because there is such a strong relationship between milk production and survival (because low producers are generally culled earlier from the herd), Lifespan PTAs are corrected for milk production. This correction ensures the PTA is more a measure of daughters' ability to survive than of their failure to produce milk (which of course would be apparent from their PTA for production).

Locomotion

When locomotion proofs were introduced by Holstein UK in 1995, the UK was the first country in the world to measure this trait. Since then, many countries have followed suit, while in this country, locomotion has become widely considered to be the most important of all the type-related traits. The genetic index for locomotion is expressed on a scale of around -3 to +3, with zero representing the average. The best locomotion scores of +3 or higher predict the transmission of an excellent gait – or a perfectly parallel movement of the legs in which the back feet are placed in the spot the front feet leave.

Table 2: Range of values for genetic indexes currently available for health and welfare traits

Trait	Bad	Good
Somatic Cell Count (%)	+30	-30
Fertility (£)	-15	+15
Lifespan (lactations)	-0.5	+0.5
Locomotion	-3	+3

Other traits could arguably be added to this health, welfare and fitness category, in particular, some of the conformation traits. However, for simplicity, these have been categorised under 'type traits'.

Management traits.

As farms concentrate cows on to larger units, face growing economic pressures and have dwindling numbers of staff, so management traits allowing a streamlined and undisrupted milking routine become ever more important.

The following fit broadly into this category.

Temperament

Although rearing and handling are key to shaping a cow's temperament, the clear genetic component to this trait has led to the calculation of genetic indexes for temperament in the parlour. Expressed on a standardised scale of about -3 to +3, the highest indexes indicate the predicted transmission of a placid temperament.

Ease of milking

Genetic indexes for ease of milking are also expressed on a -3 to +3 scale, with low minus figures representing very hard milkers to high plus figures predicting very fast milking and daughters potentially running milk.

Calving Ease

Calving Ease indexes are expressed as 'percent Easy Calvings', on a scale of about -3 to +3 and are centred around a breed average of zero, with positive figures indicating that calvings are predicted to be easier than average and negative figures predicting more difficult calvings.

The two genetic indexes together give a complete picture of a bull's 'calving performance'.

- Direct Calving Ease (dCE %) gives a prediction of the ease with which a calf by that sire will be born.
- Maternal Calving Ease (mCE %) predicts the ease with which a daughter of that sire will give birth

Direct Calving Ease is likely to be of most interest in the first instance, and is naturally going to be important when breeding maiden heifers, where the use of negative dCE% should be avoided as these are predicted to give a higher proportion of difficult calvings.

Attention should also be paid to Maternal Calving Ease, as long-term selection for dCE% without any regard to mCE% could set up problems for the future.

Type traits.

Type traits can play an important role in determining a cow's suitability for sustained milk production and many of the 17 traits assessed have an impact on cow durability. The data is collected on first lactation cows by the breed societies each of which determines its own breed standards.

Linear type traits

The traits referred to as linear are measured by increments on a linear scale and essentially describe the way a cow looks. The scale used to measure the trait on each cow should not be confused with the scale for the expression of the genetic index for type for a bull. A bull's type proof is expressed on a scale of -3 to +3, but it is most important to be aware that because linear assessment measures the degree and not the desirability of each trait, the highest score is not necessarily the most desirable.

Table 3: Descriptions of the two extremes for genetic indexes for linear type traits

	Trait	-3	+3
1	Stature	Small	Tall
2	Chest width	Narrow	Wide
3	Body depth	Shallow	Deep
4	Angularity	Coarse	Sharp
5	Rump angle	High pins	Low pins
6	Rump width	Narrow	Wide
7	Rear leg side view	Straight	Sickled
8	Foot angle	Low	Steep
9	Fore udder attachment	Loose	Tight
10	Rear udder height	Very low	Very high
11	Udder support	Broken	Strong
12	Udder depth	Below hock	Above hock
13	Front teat placement rear view	Outside of quarter	Inside of quarter
14	Teat placement side view	Close	Apart
15	Teat length	Short	Long
16	Rear teat placement	Apart	Close
17	Condition score	Low	High

These traits are commonly expressed on a bar chart which provides a useful at-a-glance assessment of a bull's predicted breeding pattern. However, whilst it is generally considered desirable for bars to be on the right hand side of the chart, this need not necessarily mean the extreme far right, depending on breeding priorities. For example extreme stature improvement is no longer desirable for most producers. Two very obvious exceptions are rear legs viewed from the side and teat length, each with approximately mid-score optimums. Once again, the intermediate score of zero represents the breed average for all linear traits.

Composite type traits

The two composite traits of 'legs and feet' and 'mammary' also appear on a bull's bar chart but unlike the 17 linear traits above, these are described in terms of desirability rather than degree. Based on the type evaluator's observations, they are also expressed on a -3 to +3 scale, with the highest scores indicating the best overall quality in these three areas.

Type merit

Type merit is a prediction of a bull's ability to transmit overall type and is based on a combination of his daughters' scores for mammary, legs and feet and body confirmation, in order of importance. Again it is expressed on a scale of around -3 to +3.

For a fuller explanation of genetic indexes for type, readers are referred to the breed societies or the DairyCo Breeding+ manual.

Genetic indexes for selection.

Although genetic indexes for the many individual traits now measured can reveal a great deal about an animal's breeding expectations, their detailed study can be time-consuming and is often impractical on many farms. This is where selection indexes such as PIN (Profit Index) and PLI (Profitable Lifetime Index) can come into play. Such indexes bring together a variety of traits into one figure which can be used as a simple screening tool.

£PIN (Profit Index)

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. Like other indexes, it is compared to an average PIN of zero. It is based purely on production traits (milk, fat and protein). These traits and their relative importance in PIN are shown in the pie chart below.

PIN provides a reasonably useful means of taking a broad brush approach and a useful ranking tool. Its limitations include its lack of any non-production information which can relate to profitability and its suitability specifically for payment based on components. However, such problems always exist with the 'one index fits all' approach and geared as it is towards a UK average requirement, it is a widely useful single figure.

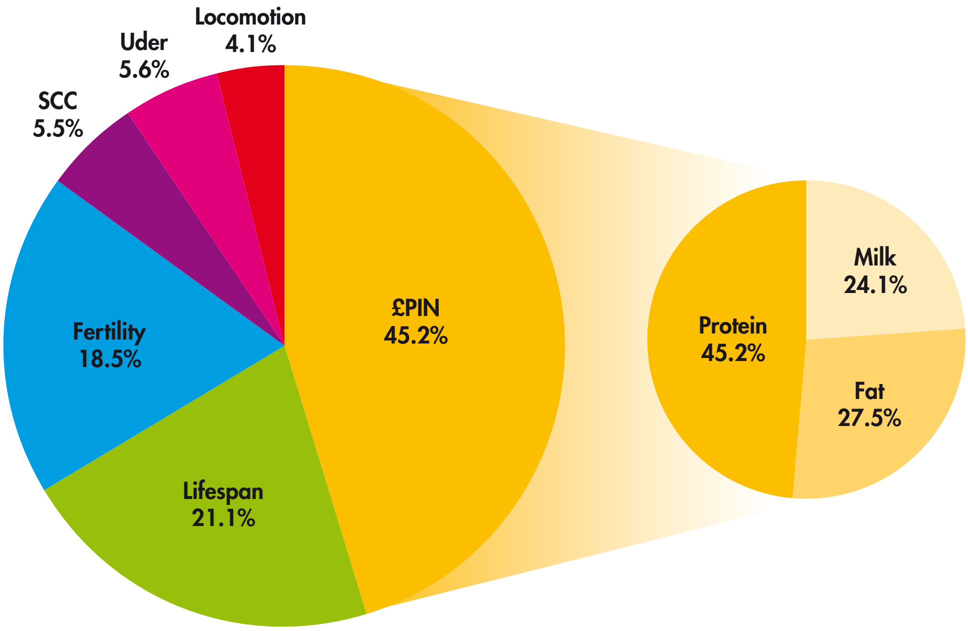
£PLI (Profitable Lifetime Index)

PLI improves on PIN by adding specific health, welfare, fitness and lifespan components to the same production formula. Each trait is weighted by its relative economic value and the resulting single figure continues to represent the financial improvement an animal is, on average, predicted to pass on to its offspring. However, since 2007, this improvement has been expressed on a lifetime basis, rather than a single lactation basis.

The PLI's revised formula for 2007 increased its emphasis on the 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 formula for PIN and PLI appear in the glossary and the relative emphasis given to each trait is approximated in the pie chart below.

Graph 1: Relative emphasis of traits included in PLI and (inset) PIN



Other countries' selection indexes

Most other dairying countries publish selection indexes similar to our own PIN and PLI. Since they are based on different economic conditions and breeding priorities, and are designed for use in different cattle populations, they have limited relevance in the UK and should not be used to select bulls for UK farming conditions.

Base changes.

All discussion about PTAs so far has focused on the figures providing a comparison with an average animal. This average animal has a PTA of zero for every trait. But as the national herd makes genetic progress, naturally that average also goes up. It's for this reason that we have base changes – in effect an occasional re-calculation of the average. If we didn't – because of genetic progress - almost every animal would eventually be better than the 'average' determined many years before!

So, every five years, the national average for every trait is recalculated and reset to zero. For example, in 2010 the genetic base was re-calculated for all breeds other than Friesians. That's why you'll occasionally see PTA referred to as PTA2010. However, for simplicity's sake the suffix is generally dropped despite the fact that every PTA calculated in the ensuing five years will technically be a PTA2010.

Whenever there is a base change, there will be a noticeable reduction in PTA values across the board, although the base change itself causes no change in ranking.

The important point to remember from all of this is to compare like with like. A PTA2010 should never be compared with an earlier or later PTA and equally, only PTAs from the same proof run should be compared. Be particularly cautious of published bull catalogues which are generally out of date within four months of publication.

How reliable are genetic indexes?

The reliability of genetic indexes varies widely depending on the amount and source of information used in their calculation. On production traits for example, a Pedigree Index based on a parent average typically has a reliability of around 30-40%. But a widespread proof for a bull based on the performance of daughters in several hundred herds could have a reliability of up to 99%. The lower the reliability of the proof, the more likely it is to change as more daughters are added, so it is important to use such bulls with caution.

When bull proofs are published, the number of daughters contributing to the figures and the number of herds in which they are found is generally also specified. Where there is a high proportion in just one or two herds, there are again greater chances of instability.

There are two further principles that are worth bearing in mind:

Firstly, when the proofs of foreign bulls are converted to UK-equivalent figures (see 'Genetic indexes from other countries') their reliability figure is reduced as part of the conversion process. Thus, a 99% reliable foreign bull will never reach 99% reliability in his UK-equivalent proof.

Secondly, when a trait has a lower heritability (see 'To what extent are traits passed down the generations?') more information is needed to reach the same reliability as more highly heritable traits. For example, the reliability of Fertility Index is likely to be far lower than that for a production PTA

Table 4: Typical production PTA reliabilities for bulls

Reliability	Comment	Information contributing to PTA
10-29%	Extremely low	Some Pedigree Indexes involving estimates from relatives
30-40%	Very low	Most pedigree Indexes involving estimates from parents with reasonable reliabilities
41-55%	Low	Some Pedigree Indexes. Usually the sire is well proven and the dam has very high reliability
56-65%	Low to moderate	Bulls with officially published PTAs (minimum 50%)
66-75%	Moderate	Bulls with early progeny test data and typically foreign bulls
76-90%	Moderate to high	Proven bulls with a first crop proof
91-98%	High	Proven bulls with a large number of daughters from a wide cross section of herds
99%	Very high	Widely proven and used AI bulls

What genetic progress has been made?

Average milk production in the Holstein breed has increased from around 5,000 kg in the 1980s to over 8,000 kg today. Although much of this increase is attributable to improved management, better genetics have played an important part. It's impossible to be absolutely precise about the relative contributions, but it has been estimated that genetics are responsible for more than half of this increased production.

To what extent are traits passed down the generations?

Genetic improvement depends on traits being inherited down the generations. The degree to which a trait is observed to be passed down the generations is described as its heritability. Some traits are far more heritable than others. As rule of thumb, the more heritable a trait, the easier it is to improve the trait through breeding. Examples of highly heritable traits include fat or protein percentage of milk.

Although the quickest progress can be made through breeding for highly heritable traits, traits of low heritability can still be improved through breeding. Many such traits (eg fertility or cell counts) have a tendency to get worse as milk production goes up. This gives selection for these health and fitness traits added importance.

As our understanding of environmental interactions improves, it is possible to improve the heritability of traits. Thus, although they will still continue to be passed down the generations to exactly the same extent, our observation of this process can improve.

Table 5: Current UK dairy trait heritability estimates

Trait	Heritability
Production	
Milk Yield	55% (0.5)
Fat Yield	47% (0.47)
Protein Yield	51% (0.51)
Fat Percentage	68% (0.68)
Protein Percentage	68% (0.68)
Linear Type	
Stature (ST)	41% (0.41)
Chest Width (CW)	25% (0.25)
Body Depth (BD)	33% (0.33)
Angularity (ANG)	34% (0.34)
Rump Angle (RA)	30% (0.30)
Rump Width (RW)	26% (0.26)
Rear Leg Side (RLS)	20% (0.20)
Foot Angle (FA)	10% (0.10)
Fore Udder Attachment (FUA)	22% (0.22)
Rear Udder Height (RUH)	23% (0.23)
Udder Support (US)	19% (0.19)
Udder Depth (UD)	35% (0.35)
Teat Placement Rear (TPR)	29% (0.29)
Teat Placement Rear (TPS)	29% (0.29)
Teat Length (TL)	29% (0.29)
Composite Type	
Legs and Feet	16% (0.16)
Mammary	27% (0.27)
Type Merit/Type Score	32% (0.32)
Management	
Somatic Cell Count	11% (0.11)
Locomotion	10% (0.10)
Lifespan	6% (0.06)
Fertility	3% (0.03)
Temperament	11% (0.11)
Ease of Milking	21% (0.21)
Body Condition Score	27% (0.27)
Direct Calving Ease	7% (0.07)
Maternal Calving Ease	4% (0.04)

Genetic indexes from other countries.

Most dairying countries in the world produce their own genetic evaluations but they are each calculated within a different population of animals and they are each expressed in a manner unique to that country. For these reasons, it is never possible to directly compare UK and foreign figures.

However, over the years methods have been developed to provide foreign-proven bulls with UK-equivalent figures. Originally this was done with the use of simple conversion formulae applied to each component of the proof. Today however, the process is more complex and uses a technique called MACE (Multiple-trait Across Country Evaluation).

The process is undertaken by an organisation called Interbull. They compare the performance of bulls in all the countries in which the bull has a proof. Where the information is limited – it may compare the performance of other family members such as his sire in each participating country. This process has improved the accuracy and stability of proofs and allows bulls with little or no UK information to be used with more confidence.

The UK and Interbull co-ordinate their work so that all the genetic indexes, from the UK and from Interbull, are published simultaneously three times a year.

Almost all traits (production, type, health and welfare and management PTAs) are now evaluated by Interbull.

Genetic defects.

A number of genetic defects are known to cause problems in dairy breeding. Most prominent among these are:

Bovine Leukocyte Adhesion Deficiency (BLAD) - causing a fatal deficiency of the immune system. Complex Vertebral Malformation (CVM) – causing stillbirths or more commonly abortion or foetal re-absorption before 260 days of gestation. Mule Foot (MF) – causing the two claws of the hoof to become fused.

Because these conditions are caused by recessive genes, they will only be expressed when two carriers of the defective gene are mated together, and only then in about one in four of the offspring.

However, all AI sires are tested and any carrying the defective gene will be identified by suffixes *BL, *CV and *MF, respectively. Matings should be avoided between carrier parents, to prevent any risk of expressing a genetic defect.

Only a tested-free coding (*TL, *TV and *TM for BLAD, CVM and Mule Foot respectively) indicates the animal is definitely not a carrier. No coding simply means no notification of a test result has been received so the animal may or may not be carrying the defect.

Table 6: International coding for main breed genetic defects

Defect	Carrier code (WHFF)	Tested-free code (WHFF)
BLAD	*BL (BLC)	*TL (BLF)
CVM	*CV (CVC)	*TV (CVF)
Mule Foot	*MF (MFC)	*TM (MFF)

Genomics.

Through the study of genomics, significant advances in our knowledge of gene structure and expression have been made. Marker Assisted Selection is commercially available to any livestock farmer and may offer the potential to accelerate genetic improvement faster than through conventional means although the currently available markers are of limited use to the average dairy farmer today.

More recent advances in the technology are now offering the opportunity to conduct genome wide association studies - commonly referred to as "Genomic evaluations".

A genomic evaluation is produced from an animal's own DNA as well as the more conventional source of parent average and performance information. Its reliability is currently assessed to be greater than the parent average alone (which is generally around 35 per cent reliable) but less than an evaluation based on progeny performance (which can be up to 99 per cent). Reliabilities achieved for genomic evaluations on young bulls are currently around 65 per cent. As an animal accumulates progeny information, so the genomic (and parent average) component contributing to its index, gradually diminishes.

Since 2009 several countries are now publishing these genomically enhanced PTAs, and in the UK we hope to provide genomically enhanced evaluations in 2011 for all traits we currently measure and evaluate.

Detailed reference to this subject area falls outside the scope of this booklet on genetic indexes. For further information, refer to the DairyCo website.

Genetic indexes in practice.

Breeding priorities.

The breeding priorities of commercial dairy farmers have to be driven by profitability. At the root of this is milk, fat and protein production. This is the case whatever the farming system – whether a high input system on a year-round total mixed ration or an extensive system on grazed grass all year. Any herd's most profitable cows will be its most efficient production cows, although the ideal proportions of milk, fat and protein will vary according to milk contract. However, it is generally considered that pursuit of total milk solids is the best long term breeding policy for most UK herds.

But there are other drivers of profitability, most notably lifespan and fertility. Without these, production cannot be sustained over many lactations and at low cost. This is why lifespan and fertility are the next most important components of our national breeding index, PLI, after total milk solids. PLI has been designed to identify the animals who are predicted to transmit the greatest financial improvement in their lifetime, so using it as a primary selection tool is recommended for most UK herds.

There will inevitably be further specific areas in need of correction, and feet, legs and udders – essential to sustain trouble-free production in modern management systems – should have high priority. Similarly, high cell count herds are advised to avoid high cell count bulls. All of these traits are also included to a degree in PLI.

Equally, some farming systems will demand a specific type of cow such as medium sized, less angular animals for extensive farming systems. Others will derive high income from livestock sales and will find specific type traits are in keen demand.

In reality, most herds' breeding programmes should involve improving a combination of traits to produce animals which are both more productive and functionally sound, and have the potential to enjoy high standards of health and welfare. There are many bulls within the top 100 PLI list that should achieve this balance and it is not necessary to only focus on the fashionable top 10. However, it is also not advisable to use bulls that are low on the PLI rankings for the reasons given above. For any herd, using a reasonable spread of such bulls is the safest policy, rather than using one bull across the herd.

Prioritising PLI will maximise lifetime profitability

- Look for the type traits your herd most needs to improve
- Don't choose low heritability traits as your primary selection choices
- Focus on no more than three of four traits at a time

- Use a spread of at least three or four proven sires to reduce risk
- Refer to the DairyCo Breeding+ manual or your breed society for more on corrective breeding for type.

Computerised mating programs.

There are many computerised or web-based mating programs available from both commercial companies involved in selling bull semen and independent organisations offering the service as an extension to type evaluation. Such services will usually take account of your own breeding priorities and make recommendations based on the principles of complementary breeding. They can also prevent the continuation or introduction of known genetic defects and avoid excessive inbreeding. While such packages can play a useful part in making breeding decisions, it is important to establish whether the program bases its recommendations on both type and production data and to ensure they are based on the established scientific principles of genetic improvement. Finally, all bulls should ideally be included in the recommendations, rather than those from just one company.

Using young sires.

Young bulls have a place in most herds and their use is essential to the continued availability of improved UK-proven genetics. The rewards can be great if a young sire proves successful and AI companies operating structured progeny test schemes can offer worthwhile inducements to take part.

However, this must be balanced against the bulls' low reliability and unknown calving ease. Participants are therefore advised to:

- Use a team of young bulls and never use one young bull extensively
- Only use those with a high Pedigree Index
- Limit their use to about half the herd used to breed replacements
- Avoid use on maiden heifers
- Refer to the DairyCo Breeding+ manual for more on using young bulls.

Inbreeding, outcrossing and hybrid vigour.

Inbreeding occurs when animals related to each other are mated, resulting in the concentration of genes. Although a certain level of concentration has historically been considered desirable and can be used to 'fix' a trait so it is consistently expressed down the generations, too much inbreeding is not recommended. It can lead to significant losses in production, fertility, longevity and general vigour.

The closer the relationship between the animals, the greater the level of inbreeding, such that a father bred to his daughter or a brother bred to his full sister would lead to 25%

inbreeding. This is considered excessive and commercial producers are advised to avoid matings that lead to an inbreeding level of greater than 6.25%. To monitor your own herd inbreeding levels, DairyCo now routinely publishes inbreeding percentages for all cows included in your Herd Genetic Report (See section on Herd Genetic Report, and please see the DairyCo Breeding+ manual for details of inbreeding levels and an inbreeding calculator).

Too much inbreeding can be addressed by outcrossing to an unrelated animal. Improvements in production, fertility, longevity and general vigour are likely to result, although the improvement is attributed to hybrid vigour (or heterosis) rather than actual genetic gain and this benefit therefore doesn't transmit on to progeny. Good hybrid vigour gives the outcrossed animal better performance than the average of its parents (but rarely better than the best parent), which is exploited in the extreme by crossing two entirely different breeds.

However, cross-breeding can lead to a loss of uniformity; improvements attributed to hybrid vigour are not passed down the generations; it raises breeding questions for breeding subsequent generations and it should be taken as an option with thought to defined breeding goals and subsequent generations.

Frequently asked questions.

Q Can male and female PTAs be compared with each other?

A Yes. In the UK we publish male and female PTAs on the same scale.

Q Can I compare a Friesian with Holstein proof or a Jersey with a Guernsey?

A Each breed is expressed against its own genetic base or average and with its own breed variation. Since these are not the same they can not be compared.

Q Why can't I compare an April index with one from August if they're compared to the same average?

A Although averages are only recalculated every five years, every bull proof is updated in every proof run (3x yr). So, comparing across runs means you are comparing old against new data. This should be avoided.

Q Why should I worry as bulls are all pre-screened?

A It's true that AI companies only market their best bulls and no bull that was poor in every area would be brought to the market. However, all bulls have strengths and weaknesses, just like all herds, and it's important to find those that are suited to your particular needs. With over 700 available to choose from with many different qualities, an ability to understand their proofs allows more informed breeding decisions to be made.

Q Will a computerised breeding package make suitable choices for me?

A Different packages do different things. The best will include both production and type, and take account of genetic defects and inbreeding. Make sure that all bulls are included and not just those from a particular company. If these criteria can be met, then these programs can be a good management tool.

Q I don't have time to study the figures; what short cuts can I take?

A If you have time for nothing else, select bulls on PLI and consider complementary breeding through the use of a computer mating program.

Q Will cross-breeding speed up my herd's genetic progress?

A The beneficial effects of cross-breeding are not brought about through genetic improvement but arise as a result of hybrid vigour. This isn't passed down the generations and therefore does not result in long term genetic progress.

Q Can I compare proofs from another country with UK proofs?

A No. Always use UK proofs. Each country's proofs are published on a different scale so make sure you only use those published on the UK scale.

Q My cows already have enough production. Shouldn't I just focus on type?

A Production efficiency is still important and should remain an essential part of your breeding decisions. But use the opportunity to select other traits you want to improve such as lifespan, fertility, somatic cell count or specific type traits.

Glossary.

Estimated Breeding Value (EBV) – A genetic index equivalent to 2 x PTA.

Genetic base – The average genetic merit of animals born in a given period, which is used as a reference point for the expression of PTAs. The current UK genetic base is the average genetic merit of cows born in 2005. Because it was reset in 2010, we sometimes use the expression PTA2010.

Genetic index – Colloquial generic term for a PTA.

Genetic merit – Colloquial generic term for a PTA.

Gene – The basic unit of heredity within animals' cells which codes for a particular trait to take a particular form. Genetics – The study of the mechanisms of hereditary transmission and the variation of inherited characteristics. Also used to describe the complete genetic make-up of an animal that determines its characteristics and performance.

Genome – The entire complement of the animal's genetic material.

Genomic selection – The selection of animals through PTAs derived from DNA-profiles based on many thousands of genetic markers (see also MAS).

Genomics – The study of gene structure, arrangement, regulation and expression.

Genotype – The genetic makeup, as distinguished from the physical appearance/performance (phenotype) of an animal.

Heritability – An estimate of the degree to which a trait is passed down the generations. Expressed on a scale 0 to 1 (or 0% to 100%).

Heterosis – Increased performance arising from the crossbreeding of genetically different animals, as measured by the extra improvement over the average performance of the parents.

Hybrid vigour – See Heterosis.

Inbreeding – Inbreeding arises when individuals which are related bred together. The closer the relationship, the higher the level of inbreeding.

Interbull – International Bull Evaluation Service, responsible for the international comparison of dairy genetics. Linear traits – Traits measured on a scale from one biological extreme to the other. The resulting numerical description indicates the degree and not the desirability of the trait. (Examples are stature, foot angle and teat length.)

MACE – Multiple-trait Across Country Evaluation is the method used to calculate international genetic evaluations by Interbull (see also Interbull).

Marker Assisted Selection (MAS) – Selection for a specific gene with desirable characteristics by identifying a nearby marker gene.

Pedigree Index – Genetic index calculated from half the sire and half the dam index.

Phenotype – The observable physical traits of an animal (such as stature or milk yield) as determined by both its genetic makeup and environmental influences.

Predicted Transmitting Ability (PTA) – A measure used to express the genetic potential of an animal as a parent. The value indicates the superiority (or inferiority) of an animal compared to an average genetic base (see also genetic base).

Profit Index (£PIN) – Financial index designed to maximize profitability from milk production by giving optimum weights to kilograms milk, fat and protein under 'average' UK conditions. This index is expressed as profit per lactation (see also genetic index). £PIN = Milk (kg) PTA x -0.027 +

Fat (kg) PTA x 0.8 +

Protein (kg) PTA x 1.71

Profitable Lifetime Index (£PLI) - Financial index designed to maximize farm profitability from a combination of £PIN and 'fitness' traits. This index is expressed as profit per lifetime (see also Profit Index (£PIN) and Selection Index). £PLI = £PIN +

Lifespan PTA x 25.4 + SCC PTA x -0.19 + Locomotion x 1.13
+ Udder composite x 1.81 + Fertility index

Progeny testing – The primary way of establishing the genetic value of bulls through structured comparison of the performance and appearance of their daughters in a range of herds.

Proof – Colloquial term for a PTA.

PTA – See Predicted Transmitting Ability.

Recessive gene – A gene whose expression is masked by the presence of a dominant partner. Only when two copies of the recessive gene are present will the trait be expressed.

Reliability – An indication of the likelihood of a PTA being a true estimate of an animal's genetic value. Values fall between 10 and 99%.

Selection Index – An overall score of genetic merit combining information from several measured traits. Often used as a ranking index.

Test Day Model – The method used to calculate production PTAs from individual milk test day records.

Where to find the information.

Bull proofs.

Bull proofs are published three times a year in April, August and December. They are always available on the DairyCo Breeding+ website or are printed widely in the national press.

Bulls can be ranked on many different criteria on the DairyCo Breeding+ website. Get to the bull lists through www.dairyco.org.uk; choose breeding information and Breeding+; then select your breed and the type of report. Click on the downward arrow on the column of interest to rank in descending order, with improvers at the top of the list.

Your herd.

You can obtain a genetic report for your own herd if you milk record. These reports give PTAs for all animals in the herd after each proof run and a herd summary giving average PTAs by lactation number gives a snapshot of genetic progress. Also included are inbreeding coefficients for each animal in the herd.

Herd Genetic reports can be requested from the Breeding+ website at: www.dairycobreeding.org.uk/hg_reports.asp or by contacting the DairyCo office

National averages.

You can compare your own herd's performance with national figures through the DairyCo Breeding+ website. Choose breeding information and Breeding+, then select your breed and choose any of the reports in the statistics section.

Table 7: GB industry contact details

Organisation	Website	Telephone
DairyCo	www.dairyco.org.uk	02476 692051
DairyCo Breeding+	www.dairycobreeding.org.uk	
The Centre for Dairy Information	www.thecdi.co.uk	01923 695298
Breed societies		
Ayrshire Cattle Society	www.ayrshirecs.org	01292 267123
British Friesian Breeders Club	www.britishfriesian.co.uk	01530 223446
Brown Swiss Cattle Society	www.brownswiss.org	01335 324009
English Guernsey Cattle Society	www.guernseycattle.com	01923 695204
Holstein UK	www.holstein-uk.org	01923 695200
Jersey Cattle Society of the United Kingdom	www.jerseycattle.org	01923 695203
Montbeliarde UK	www.montbeliardeuk.co.uk	01768 361946
Shorthorn Society of United Kingdom and Ireland	www.shorthorn.co.uk	02476 696549
AI companies		
Alta Genetics Inc	www.altagenetics.com	01763 260832
Avoncroft Genetics Ltd	www.avoncroft.com	0800 7831880
Bullsemen.com	www.bullsemen.com	0808 2023230
Cogent	www.cogentuk.com	0800 7837258
Dairy Daughters	www.dairydaughters.co.uk	0800 614904
Farmer To Farmer	www.farmertofarmer.co.uk	01253 837999
Genus Breeding Ltd	www.genusbreeding.co.uk	0870 1622000
LIC	www.licnz.com	01725 553008
Semex UK	www.semex.com	0800 868890
Sterling Sires	www.sterlingsires.co.uk	01531 890810
World Wide Sires UK	www.worldwidesires.com	0800 1613371
Milk Records Organisations		
CIS (The Cattle Information Service)	www.thecis.co.uk	01923 695319
NMR (National Milk Records)	www.nmr.co.uk	08701 622547
UDF (United Dairy Farmers)	www.utdni.co.uk	02890 372237

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