Improved Breeding in Dairy Goats and Milking Sheep

(Guidelines for the development of National breeding plans)

A report for the Rural Industries Research and Development Corporation

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Foreword

Representatives of the dairy goat and milking sheep industries met in October 2000 in a RIRDC workshop to establish research priorities for their industries. In both cases they identified genetics and genetic improvement of milking livestock as being at the top of their agenda. As a result, Emeritus Professor David Lindsay was retained by RIRDC to develop plans for national breeding programs for both dairy goats and milking sheep.

The project was developed in three stages with progress reports after each stage. The first reported on the perceptions and requirements of the industries in Australia (October 2001). The second dealt with the way in which breeders in other countries organise their genetic programs (April, 2002). Based to a large extent on these, another report (July 2002) set out a framework for a national breeding scheme. It was not prescriptive, as many of the options required careful deliberation by those members of the industry who would be implementing the program or affected by its decisions.

As a result, in September 2002, RIRDC convened two national workshops, one for each industry, with as many industry members as possible to work through the issues and get breeding plans under way for both industries.

This final report includes the first two reports and presents the Workshops’ options that were available and their strengths and weaknesses. It also outlines the steps agreed to by the industry representatives to set up the infrastructure for breeding plans that would incorporate those features that the industries believe best suit their needs.

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This report, a new addition to RIRDC’s diverse range of over 900 research publications, forms part of our New Animal Products R&D program, which aims to accelerate the development of viable new animal industries.

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Simon Hearn
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Executive Summary

The combination of modern genetic theory and the undoubted enthusiasm and commitment of most producers in the Australian dairy goat and sheep industries, strongly suggest that very successful national breeding plans can be put in place. There is no reason for these plans to be any less successful than some that are operating overseas and making some of the fastest genetic progress of any of the animal industries in the world.

There are some features of the Australian milking goat and sheep industries that constrain the type of plans that can or should be developed and will make them, in some senses, unique. The most obvious of these constraints are the small size, both collectively and individually, and the geographical spread of the industries in Australia.

These can be overcome partly by collaboration and the use of breeding links through artificial insemination. Probably most important, individual producers do not have to forego their independence or their identity to participate in a program that requires their collaboration in nothing other than the breeding aspect of their enterprise.

Six main issues were identified:

- Development of satisfactory breeding objectives and selection criteria.
- Identification and recording of pedigrees.
- A robust and repeatable program of herd recording.
- A service that uses pedigree and production information to provide breeders with breeding values on their own and others’ stock and to build and store data bases.
- A means of identifying and assessing overseas genetic material from countries with a history of genetic progress in milk sheep and dairy goat animals, meeting quarantine requirements and, if applicable, integrating these animals successfully into Australian flocks and herds.
- A coordinator or coordinating body that will ensure that the program of identifying, testing, evaluating, promoting and communicating runs smoothly and to the satisfaction of the breeders who will be the stakeholders.

Development of satisfactory breeding objectives and selection criteria:
Both industries have agree that they wish to take a commercial approach rather than a stud approach to breeding. The sheep industry will be developing a single, Australian milking sheep breed and the goat industry is considering whether it will do the same thing or concentrate on two breeds. The breeding objectives of both industries are identical; “The improvement of profitability through enhancement of quality and quantity of milk from animals that are easy to milk and resistant to common parasites.”
Common selection criteria are milk volume, content and concentration of protein, content and concentration of fat. Other factors that will be considered by industry groups are milk characteristics (total solids and somatic cell count), lactational characteristics (length of lactation, ease of milking and udder shape) and conformational and management characteristics (feet, worm resistance, temperament, size and fertility).

Identification and recording of pedigrees:
Both industries have agreed to adopt full pedigreeing of the breeding flocks and herds to make way for progeny testing and the use of BLUP analysis and the generation of estimated breeding values. These will be used to make accurate selection and speed the rate of genetic progress over that of conventional selection procedures.

A robust and repeatable program of herd recording:
There was agreement that it would be best to use only one laboratory for all samples to minimise possible differences between laboratories.

It was resolved to make the recording of volume and the collection of samples for subsequent analysis of milk components the responsibility of the individual breeder. It could be done by the breeders themselves or by a milk recording service employed by the breeders.
A service to provide breeders with breeding values and store data bases:
The industry needed to decide relatively early on a data handling service. This is clearly an area where
the two industries must liaise and negotiate with potential suppliers and final choice will depend on
the final needs and the price that the industry is able to negotiate. It was informally agreed that there
would probably be benefits in both the sheep and goat breeders using the same supplier.

A means of identifying and assessing overseas genetic material:
It was impossible to make firm recommendations about importing genetic material because of the
uncertainties of whether such importations will be allowed and the expected high cost. However, given
the rapid genetic progress that has been made in some countries such as France, it could be expected
that if these restraints are overcome the chances of well selected material making a significant impact
on the dairy sheep and goat industries in this country will be high.

The industry representatives felt that there would be a need to introduce animals through an evaluation
scheme. Such a system would need to compensate importers for the high costs involved but, at the
same time, ensure that poor performing imported animals are not disseminated widely through the
Australian industry. The industry representatives generally felt that this was a long way down the
track and would be a decision for an industry Board at the appropriate time.

An industry structure including a coordinator:
The participants from both industries agreed on the following general structure:
The breeding program will be supervised by a Board elected from the industry members and
there will be a coordinator to provide advice continuity and ongoing development of the
program. A steering committees for both industries has now been formed to bring this
structure into being. It was also generally agreed that it would be preferable to have a single
coordinator for both industries at least in the short term and that funding should be sought to
provide seed money to allow the appointment.

The workshops had little time to discuss the relatively complex biological, genetic and social issues
that will eventually make up the national plan. The most important of the issues for this discussion are
presented in this report. The first of these addresses the broad organisational structure, and the
industries needs to decide on this structure to set their directions and begin planning the details of their
national programs within that broad structure.

This report describes a national dairy breeding program that has the capacity to develop, in a relatively
short time an Australian dairy breed (or breeds) of sheep or goats that will enhance industry’s capacity
to produce milk, cheese and related products more efficiently. The “Decisions made” sections
illustrate that the establishment and running of the program is, to some extent, complex. However,
when the program is up and flourishing the only thing about it that will be new will be its structure.
The services to make it work are already in place. We believe that the industries, though they are
comparatively small in relation to those in some other countries, have the capacity to harness the
enthusiasm of breeders and the power of modern genetics to make a unique contribution toward
ensuring that they are competitive on the world scene through the proficient production of the
industries’ basic material—milk.
1. Introduction
The combination of modern genetic theory and the undoubted enthusiasm and commitment of most producers in the Australian dairy goat and sheep industries, strongly suggest that very successful national breeding plans can be put in place. There is no reason for these plans to be any less successful than some that are operating overseas and making some of the fastest genetic progress of any of the animal industries in the world.

1.1 Constraints to a national breeding program
There are some features of the Australian milking goat and sheep industries that constrain the type of plans that can or should be developed and will make them, in some senses, unique. The most obvious of these constraints are the size and geographical spread of the industries in Australia.

Size
Compared with many European countries where sheep and goats are milked the total flock size is very small. However, the key issue is the effective size of the breeding flock. So, if enough individual breeders combine to establish a substantial, effective flock (ie where there are more or less common breeding goals and there is some planned and recorded exchange of genetic material), size need not be a major constraint. In fact, depending on the degree of collaboration, the potential rate of improvement could match that of most overseas countries with the exception of France.
However, the relatively small size of the Australian populations of both sheep and goats makes it highly desirable that there be only one program for each species. Fragmenting the effort by having two or more programs would reduce effective progress substantially. A scheme in which each breeder ran a separate program independently would be even less effective.

Geographical distribution.
The industries are widespread and are represented significantly in all states of Australia. This immediately puts restrictions on some of the opportunities for collaboration in a breeding scheme in which members from all states have indicated that they wish to participate. Most of these relate to the difficulty of arranging frequent face-to-face meetings among producers and of personal visits from a possible coordinator. However, almost all other potential problems associated with the wide spread of the industries are relatively easily overcome with modern communication and transport. For example, access to information of all kinds and receipt and delivery of numerical data from flocks and herds is now instantaneous through electronic means, as is access and contribution to national databases. We will be recommending the use of artificial insemination as an integral part of the program. This obviates the need to move male animals physically around Australia and has the added advantage of avoiding the possibility of exposure to important diseases like footrot, OJD and internal parasites. Similarly we will be recommending using a single laboratory for analysis of milk samples as part of milk recording and this, too, is relatively simple as the samples are small, can be preserved and are only a few hours away from a chosen laboratory by air transport.

Strength in cooperation
A brief analysis of breeding programs in the animal industries of the world quickly shows that those that have been the most successful are those that have a large population base. By contrast, those that have functioned on a small scale as individually discreet breeding units have made relatively slow progress. Large populations do not have to be owned by a single individual or company although this is usually the case in the poultry industry. The dairy cattle industry also has a huge effective population base for breeding but achieves progress through very large artificial insemination companies servicing large numbers of independent producers with a total of millions of animals. These producers’ only common link is that their animals are all contributing to the population base on which the breeding program is built. Another model is outlined for French milking sheep in the second report of this series. In this scheme the farmers are less independent than most dairy cattle farmers because almost all of them sell their milk to the same company. The farmers retain ownership and control of their rams and the breeding program by participating in a huge breeding cooperative. The
French milking goat industry is less closely united but maintains a breeding program to which they are all committed in principal so that the population of animals in the program is still very large.

So there are a number of models and it is a major first step for the Australian industries to establish the model that best suits them while endeavouring to work with as big a population as possible in the national breeding scheme.

The size of the scheme is important in many ways. There are economies of scale at all levels of the program from milk recording and analysis to data manipulation. The use of the best animals in the scheme can be maximised. The collective designing and, later, fine tuning of the program gives a greater chance of customising the scheme to suit the greatest number of participants. It is easier to provide support, when and where needed. Probably most important, individual producers do not have to forego their independence or their identity to participate in a program that requires their collaboration in nothing other than the breeding aspect of their enterprise.

The Merino Model

The largest breeding population of domestic ruminants in Australia is the Australian Merino sheep. A whole culture and tradition has been built from the days of Macarthur to this day and, with some recent and successful exceptions, this culture persists and has, arguably been the cause of the Australian wool industry being one of the most genetically stagnant animal industries in the world.

The graph on page 3 contrasts the genetic progress that has been achieved in sheep for wool in Australia and sheep for milk in France. French milking sheep produce, on average, about 2.8 times as much milk as they did in the ‘60s before serious breeding plans were put in place. By contrast, Australian wool sheep have made almost imperceptible progress in the same period.

There are many reasons for the difference and lessons to be learned from these differences. One is the very focussed and uniform breeding objectives of the French breeders compared with the varied and largely poorly defined objectives of their Australian counterparts. Another is the collective decision of French farmers in the 50s and 60s to move to modern genetic principles that became available for the first time in that era. But, arguably, the most critical factor is a conceptual one. French farmers produce each year’s crop of rams in order to improve the capacity of their flocks to produce milk. Rams as animals in their own right are not sold for high prices and are valued at little more than their cost of production. Australian producers of merino rams produce animals sale animals at prices as high as possible with the productivity of the offspring very much a secondary consideration. This has led, over the years to a culture in which preparation of rams and marketing have dominated the industry while objective consideration of the potential productivity of these animals has been largely neglected. Consequently, rams have brought incredible prices relative to the value of commercial animals but progress in productivity has been slow.
This contrast is included here to reinforce the strong recommendation that the Merino model be avoided at all costs in developing breeding plans for the milking goat and sheep industries. Whatever models are finally agreed to, the trading in males needs to be negotiated at a price that rewards breeders for their time, enterprise and expenses but encourages all parties to keep their eye on the main game—the potential to improve the quantity and quality of their female offspring. In fact, as emerging industries, the milking goat and sheep industries have the exciting potential to demonstrate to the wool industry models that they should be following if they wish to lift their game.
2. The issues

In the first report to RIRDC, six main issues were identified that need to be addressed in the development of a national breeding plan. Producers have to weigh these and decide on the options before deciding on the overall plan. The issues raised in the first report were:

- Development of satisfactory selection criteria.
- Identification and recording of pedigrees.
- A robust and repeatable program of herd recording.
- A service that uses pedigree and production information to provide breeders with breeding values on their own and others’ stock and to build and store data bases.
- A means of identifying and assessing overseas genetic material from countries with a history of genetic progress in milk sheep and dairy goat animals, meeting quarantine requirements and integrating these animals successfully into Australian flocks and herds.
- A coordinator or coordinating body that will ensure that the program of identifying, testing, evaluating, promoting and communicating runs smoothly and to the satisfaction of the breeders who will be the stakeholders.

2.1 Development of satisfactory selection criteria.

We have assumed throughout this program that the breeding objective is the improvement of commercial animals and their ability to produce milk of high quality profitably. In the case of sheep almost all milk is transformed into cheese, yoghurt or related products. In the case of goats there is also a demand for whole and dried milk. Fortunately, the characteristics of milk that best suits the production of all of these products are likely to be very similar. However producers and processors need to reaffirm this and be sure that there are not other objectives for which provision should be made in the breeding program.

Selection Criteria

*Volume of milk.* Production of high volumes of milk is the most obvious characteristic for a desirable dairy animal and breeding systems in all dairy animals usually include volume as a criterion. However, it is interesting that the selection index for dairy goats in France does not include volume directly. This is because milk volume is made up of solid material; mainly fat, protein and sugars, and water. A high proportion of the water is discarded in most of processing systems and fat and protein are the ultimate commercial components. By selecting for total fat and total protein, the French index concentrates on these commercial components but, of course, at any given concentration of fat or protein the higher the volume of milk the more of the components are produced. Thus, volume must always be measured to calculate the total weight of fat and protein, even though it may not be included directly in the components of some selection indices. Presently in Australia, most processors are paying on volume alone for simplicity but they have mostly indicated that they will probably change at some stage to payment for solid components.

*Fat.* The proportion of fat can make clearly discernible differences to the quality of transformed products and one of the dilemmas facing the processor and, as a result, the producer, is the most desirable concentration of fat. Continuous selection for increased concentration of fat in the milk may result in concentrations that are higher than is desirable. The French found this to be the case about 10 years ago and reset their breeding objectives accordingly. They now aim to increase the total fat produced per animal while keeping the concentration at the same level. They achieve this by including both criteria in their selection index but weighting their selection index to maintain a constant concentration. Their results over the last 10 years suggest that they have succeeded because total fat per lactation has increased and concentration of fat has remained about the same.
**Protein.** Good cheese making depends on a satisfactory concentration of protein in the milk and protein is considered an important nutritional component in whole milk, so protein is a major component of most selection schemes for milking animals. As with fat, the total production of protein is considered as important as the concentration but there is less need to keep the concentration at a given level because there do not seem to be the same problems with increased concentration of protein.

**Total solids.** Before modern instruments were available, a compromise that was sometimes advocated to avoid separate measurement of, and selection for, fat and protein, was to use total solids as a composite selection criterion. However, modern instruments for milk analysis carry out both tests simultaneously so that there are no economies at the analytical stage. Most processors prefer to see these two components treated separately because they play very different roles in the manufacturing process. As a result, few, if any, comprehensive breeding schemes choose to use total solids rather than its two most important constituents.

**Cell count.** This is a measure of the bacteriological status of the milk which on the face of it, seems to be a tool for management rather than breeding. However, recent research shows that cell count is moderately heritable and it is therefore possible to breed successfully to improve this trait. It is not yet being used systematically in the French breeding system but it being considered and owners of goat herds with habitually high cell counts are encouraged to choose bucks for artificial insemination that have low EBVs for cell count as a long term means of overcoming their problem. This is an option for Australian breeders of both sheep and goats because the analytical instruments for measuring milk fat and protein will deliver information on cell counts at no extra cost. In fact, it will cost more to remove cell counts from the data than to analyse and include them!

**Management criteria.** These criteria are the ones that do not impinge directly on the quantity and quality of milk but impact on the profitability of the flock.

Many producers feel that they need to improve ease of milking and, more specifically, this comes down to an udder shape that is compatible with rapid machine milking. Selection for udder shape has been practiced successfully in French goats and sheep. They have developed standards including measurements and a scoring system to ensure as much uniformity as possible from one herd to the next. They also have trained assessors (usually the milk tester) which standardises the assessment across farms. If the Australian industry takes our recommendation (later) that milk testing be done by producers themselves, using external assessors will not be an option. Udder shape is moderately heritable so genetic progress will be possible. However, if producers decide that they wish to include this as a criterion it will need an expert panel to develop an agreed set of standards and a means of ensuring that these standards are uniformly applied across the breeding program.

Some sheep and goat producers have introduced selection procedures for Faecal Egg Counts (FEC) in an attempt to reduce their dependence on anthelmintics. This may be particularly relevant for milking animals where intensive production encourages the build-up of worms but the safe use of drenches is restricted to non lactating periods. If it is decided that FEC is to be used there will need to be a uniform method of sampling and analysis because worm burdens and worm species differ both from region to region and according to the physiological state of the animals (pregnant, lactating, growth stage).

**Other.** Progress in our understanding of the genome of animals and the capacity to identify genes, groups of genes or loci that are associated with functional activities is such that we can envisage new and more accurate ways of identifying animals for particular characteristics, both desirable and undesirable. An example was given in the second report in April this year where we reported that the French had identified a single major gene for alpha s1 casein which has an effect on protein production. Animals with a single dose of the dominant allele for alpha s1 casein (called C+) produce milk that, on average, has a protein percentage that is 0.25% points higher than those that have no such allele. Those that have a double dose of the allele (called C++) are 0.47% points higher. This makes it
an allele particularly important for the cheese maker. Because it is a major gene, it is simply inherited so that a buck with C+ will pass on the C+ to one out of every two offspring and a buck with C++ will pass on this C+ to all of his offspring.

So far, the French have been using this very promising information cautiously. They take blood samples, as a matter of course, from all bucks destined for AI to verify their pedigree through DNA analysis and they use the same blood to check the casein s1 alpha status. They recommend that producers use semen from bucks designated C+ and C++ over does that have milk that is low in protein. This information is available for all semen sold by the AI centres but producers may use it or not as they wish.

As other information about genes becomes available, decisions of this sort will have to be made. The essential thing is to have a breeding program that is flexible and able to incorporate new selection criteria. The program we propose later in this report will be capable of doing this. However a decision to incorporate new criteria needs to be discussed and agreed by producers so as to maintain a common focus. A mechanism also needs to be such that new genetic information can be assessed by the industry and used appropriately.

2.2 Decisions made about selection criteria.

There is no limit to the number of traits for which selection is possible but there are compelling reasons to keep the program as simple as possible. Breeders considered the following points when deciding on selection criteria:

- The more criteria for which one selects the slower the progress one makes in any one of them.
- However if a breeding objective involves a lot of selection criteria and each of these contributes to the objective, then the most rapid progress to the overall objective will be made using all of the criteria.
- At a practical level the cost of the breeding program increases as the number of traits that have to be measured, recorded and processed increases.
- Not all breeders need select for exactly the same things in a national program. In fact, some variability is desirable but it is best that the major items be common..

**Breeding objective**
It was decided that the publicly stated breeding objectives of the national breeding program be: “The improvement of profitability through enhancement of quality and quantity of milk from animals that are easy to milk and resistant to common parasites”.

Other options such as introducing breed standards and adding meat or other production objectives were ruled out for the present.

**Selection criteria**
*In the milking sheep industry* firm decisions were made that

- Volume of milk
- Total fat content and concentration
- Total protein content and concentration

would be essential selection criteria but the industry would need to consider also

- Somatic cell count
- Length of lactation
- FEC
- Ease of milking, including udder shape, and
- Longevity
In the dairy goat industry participants felt that a national program should definitely include

- Volume of milk
- Total fat content and concentration
- Total protein content and concentration
- Total solids
- Length of lactation
- Somatic cell count.

They also believed that a number of other criteria might be included:

- Ease of milking and udder shape
- Feet
- Worm resistance
- Temperament
- Size
- Fertility

It was agreed that these supplementary traits should be discussed and included or otherwise by an industry group set up to decide details of the breeding plan and its implementation.

The question of breeds.
Participants from the milking sheep industry felt that there would be no attempt in the breeding plan to preserve the integrity and ideals of any particular breed but that they would work towards the development of a new Australian Dairy breed made up of whatever components appeared to offer the opportunity for progress. Members of the Dairy Goat industry were divided on this issue and felt that some more discussion was need before a policy to work with only one or more than one breed.

2.3 Identification and pedigree recording

The key to success of modern animal breeding is the use of relatives to help estimate the worth of each individual animal. This is particularly relevant in the dairy industry where only the female expresses the traits most useful to the industry. The complexity of the calculations and the data storage needed to make these estimations meant that this aspect of breeding has only been possible since the availability of powerful computers. However, nowadays all of this can be done relatively cheaply and efficiently off-farm so that the breeder needs only to know why the calculations are done and not necessarily how. Nevertheless, the essential task at the farm level is the identification of animals and their parents so that detailed pedigrees can be calculated, updated and stored. Some breeders already collect such information, others can but do not, and yet others do not wish to spend the time to collect these records. Unfortunately, participation in any worthwhile scheme depends on a capacity and willingness to identify an animal’s dam and sire at birth and to continue to record the animal’s production of milk and other criteria important to their worth as breeding animals. Collection of pedigrees and of production information would have to be a minimum commitment for any breeder to enter the national program.

One important extension of this recording is that it be uniform across the industry or at least the part of it associated with breeding. We will see later that the efficacy of the overall breeding program is enhanced greatly when we can link herds or flocks and compare individuals in different environments and on different farms. Fortunately, at the recording level, there is already a system in place that allows every animal to have a unique identity in computerised data bases and this can fit without modification into the dairy industry. Each animal has a 16 digit code that is too cumbersome to be useful on-farm, but modifications with a 3 or 4 digit contraction are adequate for individual flocks of herds.
Some of the difficulties in recording arise from:

1. **Identifying the sire of the young animal.** This involves planning the mating either by
   - individual mating, either natural or by artificial insemination
   - single-sire group mating or
   - DNA “fingerprinting” or pedigreeing

Of these, DNA pedigreeding is the most simple but also, by far, the most expensive. A blood sample is taken at any time after the birth of the animal and this is matched with the DNA profile of the parents stored in a data bank. The present costs of services that do this work vary between $13-19 per animal. Most people think this is too expensive but it is almost certain that, as numbers rise and the system becomes increasingly automated, the price will fall.

2. **Ensuring that identification is permanent.** The most common system is the use of plastic ear tags. However, a significant proportion of these become lost or rip out during the lifetime of the animals so, for a breeding program, double tagging, or tagging and tattooing is almost mandatory to be sure of maintaining permanent track of all animals in the population. Ear tags are often not convenient, when milk recording, especially in milking sheds where the operator is behind and below the level of the animal. Hock tags are sometimes used for this reason but most breeders think that these are lost even more frequently than ear tags.

Bar coding has been tried but has difficulties associated with the bars becoming dirty.

Electronic tagging is now possible and the price of tags varies from about $2.60 to $7.00. The cheaper ones are buttons containing a “passive” transponder incorporated into a conventional ear tag so that they can be read visually as well as electronically. The more expensive ones are implanted under the skin. They are almost impossible to lose, but must always be read using a “reader”. The electronic tags have the potential advantage that they may be read automatically during routine operations such as milk recording and weighing. Overseas in the dairy sheep and goat industries, and in Australia in the bovine dairy industry, they are being used with automatic feeders and in other non-breeding applications.

**Decisions made about pedigree recording**
Participants in both industries agreed that pedigree recording was essential to any worthwhile breeding program and that they would all participate to make sure that pedigrees would be kept as accurately as possible.

### 2.4 Herd recording

**A. Milk recording**

One of the major costs in breeding animals objectively is the cost of measuring the animals’ performance of objectively. This is particularly the case for the dairy animal because it must be sampled frequently to get a reasonably accurate estimate of its performance.

Sheep and goats produce less milk that dairy cattle but most of the things that must be recorded are the same and so cost relatively more. This means that these costs must be cut wherever possible to arrive at a competitive price. What are the possibilities?

**Sampling:** In much of the dairy cattle industry, a herd-recorder visits the farm and takes charge of identifying the individual cows, recording the volume of milk, taking representative milk samples and delivering these to an analytical laboratory for determining composition. As part of that service, to facilitate the process, herd-recorders may also bring with them the apparatus for measuring and sampling in-line. In many parts of the dairy cattle industry the costs associated with this method are justifiable particularly when the herds are in close proximity. In addition, the price on a per-animal basis can be rationalised when compared with the much higher monthly income from a dairy cow.
In the dairy sheep and goat industries, neither of these justifications applies, so the industries must look to reducing costs as much as is compatible with getting acceptable and reliable results. There are ways that this can be done.

Producers, themselves, can take responsibility for measuring the volume of milk produced by each animal and taking a sample for later analysis at a laboratory. In fact, this is already happening in the dairy cattle industry in a number of areas of Australia. One of the fears expressed at the outset of this practice was that some producers might “cheat” by recording higher volumes of milk or sampling milk at the latter stage of the milking period to take advantage of the richer milk at that stage. This has proved not to be the case. In the first place, from a management perspective, the individual producer is the principal person who is being cheated and, within a comprehensive breeding program with adequate links, anomalies associated with over-performing animals will come to the surface very quickly.

However, even when measurements are taken by producers, there are still substantial costs associated with recording. The extra labour in identifying, measuring, sampling and checking is significant and the gear for in-line testing is expensive—around $700 per stand. Some producers already have this gear and, since it is normally required only once per month, they and others may wish to participate in a sharing deal. The apparatus is the same for cows, goats and sheep except that the sampling valve must be changed for the smaller animals. This modification is not difficult or expensive. In fact the same apparatus could be shared among cattle, sheep and goat breeders if they were all in the same area. It is possible also, but not necessarily recommended, to sample milk by by-passing all of the flow into a separate container and sampling from it after careful stirring. This technique reduces the capital cost but increases the time and effort.

An option that is not viable is to spread the sampling over several days as this would increase the environmental variability.

A system that is used in the French dairy sheep industry is “modified milk testing” where only a few samples are taken at chosen times in the lactation. This results in only a small reduction in accuracy compared with the full recording regime. Single recordings taken at night or in the morning are adjusted to full-day recordings by using a correction factor based on the total amount of morning or evening milk produced by the whole flock. It is important to note that this technique is used only with females that are not going to be dams of sires to be used in the next generation. Nevertheless, under the French system, this is about three-quarters of the females in the industry. When the aim is to distinguish only three categories of females in the flock—good, satisfactory or cull—the level of accuracy is considered to be adequate. By contrast, dams with high breeding values, likely to have sons that are candidates for selection, undergo the full “official” recording to ensure that the information for this purpose is as accurate as possible.

The same type of scheme is not used in the French goat industry where recording costs substantially more than in the sheep industry and this, in turn, discourages many producers from measuring and recording milk production.

We recommend that that a version of the “modified” scheme be explored in the Australian scheme for both goats and sheep to lessen costs.

**Analysis:** Samples of milk for each animal are placed in fifty-millilitre jars containing a preservative. The identity of the female is recorded on the label and all of the samples are sent to a laboratory for analysis. For three reasons we recommend that the same laboratory be commissioned for all testing. First, the chance of negotiating an attractive price will be greater. Second, the degree of control over the information and the flow of information into the industry’s database is simplified. Third, the comparability between samples will be better. The analytical equipment used for analysis needs to be calibrated regularly. For dairy cattle samples with large throughputs this is done regularly—standards
are easily obtained and there are many opportunities to compare samples across laboratories. The instruments used for cows have to be recalibrated to give accurate readings for samples of either sheep’s or goat’s milk. It is unlikely to be economical for several laboratories to do this each time they process a batch of sheep or goat samples. It is therefore likely that the results from one laboratory will not compare exactly with those from another. On the other hand, if all the batches are tested in one laboratory, they will be comparable even if the calibrations are slightly out.

A rough quote from one laboratory in Victoria, Dairy Technical Services, was, “A little under” 50 cents per sample provided that samples were properly labelled and the results for each batch could be exported in bulk by electronic mail to a nominated data processing provider. For this, the producer would get information on fat, protein and cell count.

**Other sampling:**

*Faecal Egg Counts.* There is a standardised way of collecting faecal samples and, if FECs are to be used in the breeding program, it would probably be done on–farm by the breeder. As far as we are aware there is no compelling biological reason for FECs to be analysed centrally on the grounds of uniformity. They are highly variable and even if procedures are standardised there are no methods for standardising results. However, a single analytical site would simplify transfer of results to the database.

*Conformation.* A more difficult area is in the assessment of the subjective data such as udder shape or breed points. Udder shape is used as a selection criterion in France but assessment is done by milk testers who are trained to provide reasonably standard judgements. If owners do their own milk recording they will also have to have some guidance into the assessment of udder shape or conformation so that the information is regular across the whole population of animals.

**Decisions made about herd or flock recording**

The industry needed to decide whether it wanted to use a single analytical laboratory or allow producers to have their milk analysed at the laboratory most convenient to them. Representatives from a commercial analytical laboratory for bovine milk samples described the possible problems associated with standardisation and calibration where relatively few samples (compared with the bovine dairy industry) were involved.

There was agreement that it would be best to use only one laboratory for all samples to minimise possible differences between laboratories. However it was also agreed that further tests would have to be carried out to ascertain the degree of accuracy that could be expected and the necessity for constant recalibration. Sheep milk which is much higher in fat than either goat’s or cow’s might pose particular problems. The laboratory representatives offered assistance in this area, particularly in obtaining overseas information.

It was resolved to make the recording of volume and the collection of samples for subsequent analysis of milk components the responsibility of the individual breeder. It could be done by the breeders themselves or by a milk recording service employed by the breeders.

No decisions were made at the meeting about standardising recording of faecal egg counts or conformation scores.

**2.5 A genetic information service and database**

Producers will want to keep a database of their current animals both for their own records and for aiding management decisions. This same database is updated to include parents and relatives of the animals. Records of their performance will also be maintained by the service provider that the industry chooses. The service provider will supply software that enables the producer to enter raw data quickly and to retrieve both management data and information about individual animals.
These data will also be in a form that is compatible with the provider’s own programs and can be sent to them electronically. Whenever a male is transferred between producers or, more likely, artificial insemination or embryo transfer is used, the records of the transferred animal and its relatives will also be transferred automatically to the data base provided the flocks or herds are on the same database. The service provider will periodically provide written lists of the animals, preferably every 6 months but at a frequency agreed between the provider and the producers. This list will contain Estimated Breeding Values (EBVs) on all traits for all animals including a combined EBV score that weighs each trait according to its importance. This information will be the essential basis for decisions about selection and breeding. There will also be agreed information such as lactation lengths, ages, progeny records and benchmarking information that can be used in making management decisions.

One potential provider, Lambplan, (or Kidplan for goats) quoted a cost of $2.00-2.20 per animal for its lifetime plus an annual fee of $165 per producer. This is the same cost as is charged to meat or wool producers. They claim that, providing the information on milk were provided to them electronically each month the cost would not be different, despite the fact that, in the other industries, they only have to handle new data once or twice a year. The National Dairy Herd Improvement Association has also indicated that it would like to be involved and would facilitate negotiations with a provider from the dairy cattle industry. Depending on the services required, they have told us that they would likely be able to operate at a competitive price.

Data flow between the main parties in a National breeding program
**Decisions made about a genetic information service**

The industry needed to decide relatively early on a data handling service. It is preferable for ease of handling, uniformity and negotiation to have only a single provider.

The two most likely possibilities were

- Lambplan/Kidplan which has a good record of genetic services of the sort required to the meat and wool industries with a few clients in the dairy industry.
- A member of the National Herd Improvement Association with an equally good reputation in providing performance data and genetic services to the dairy cattle industry.

This is clearly an area where the two industries must liaise and negotiate with potential suppliers and final choice will depend on the final needs and the price that the industry is able to negotiate. It was informally agreed that there would probably be benefits in both the sheep and goat breeders using the same supplier.

**2.6 Importing overseas genetic material**

This issue of the breeding program was dealt with in detail in the second interim report. The main findings are summarised here.

The quality of the breeding programs for small dairy ruminants in France and the demonstrable success in developing the productivity of these animals suggest that the inclusion of animals out of these programs in an incipient Australian program would be highly desirable. There is a clear attraction to the possibility of taking advantage of 20 or 30 years of focussed and successful breeding to “kick start” the local program. Under present regulations, and for the foreseeable future, live animals cannot be imported into Australia and all imports must be in the form of frozen semen or embryos. There are therefore two major barriers to be overcome in the importation of genetic material;

- sourcing high quality animals in the country of origin and their handling for the collection of ova or semen under appropriate conditions and
- meeting the strict conditions of the Australian Quarantine and Inspection Service

**Sheep.** The main French breed that would interest a potential Australian importer of dairy sheep is the Lacaune. It is the most advanced genetically and has the best documented performance of any the world’s sheep breeds. But it is not simply a matter of choosing good animals and buying them. All of the best rams are housed at the two cooperative AI and Test centres neither of which has the sale of rams as part of its business plan. Australians will find this concept difficult to comprehend given the long tradition in this country of the sale of rams, sometimes at very high prices, being an important component of our sheep industry. The few animals that the French have sold in the past have been at ridiculously low prices which has not made them very enthusiastic about this form of trade. The ram breeding and AI cooperatives are entirely under the direction of producers and the 400 or so elite farms where the best females are found are also controlled to some extent by the cooperative.

There are, however, Lacaune sheep in other countries including the USA, Canada and other European countries where they are used for producing milk. As far as we can ascertain these animals were sourced from the lower tiers of the Lacaune system and not from the elite flocks or the ram breeding centres. However these flocks are genetically only about 5-7 years behind the producers in the upper echelon. Realistically, this is the probably the most likely source of genetic material for prospective Australian buyers.

**Goats.** In contrast to the French dairy sheep industry the French goat industry makes purchasing genetic material comparatively simple. They make it clear that they are in the business of selling semen, in fact it is the same semen that they sell to their own breeders with the exception of the half dozen or so special animals reserved for the Genes + contractors. The same organisation that sells
semen, CAPRI-IA also advertises that it sells embryos, although the exact mechanism of selecting does, which would have to be done in conjunction with a private producer, is not spelt out.

The collaborating government controlled laboratory of INRA-SEIA at Rouillé is as well equipped as any in the world to treat does and collect embryos. There is an organisation called SERSIA France that handles the business dealings associated with exporting genetic material from animals. They would have to be involved to obtain the necessary papers for eventual importation but the procedure is relatively straight forward.

Quarantine: Dealing with the Australian Quarantine system is another matter. Some of the major barriers were outlined in the Second Report. In summary, it is virtually impossible to introduce genetic material from French dairy sheep breeds into Australia under the present protocols under which the quarantine system works. However, there is a strong probability that new information will lead to modifications to the protocols and the possibility of entry in the next 12 months. For goats it seems possible, though still difficult, to find genetic material that would meet the present protocols and process it through the existing rules. Quarantine rules are very tight for very good reasons but they are also subject to change as new ways are found to detect and guard against target diseases. For example, the fact that only sperm and embryos are now used rather than live animals has nullified the threat of many otherwise menacing diseases. If a foolproof way of taking account of Scrapie were to be discovered, then problems with most of the other potential diseases could probably be overcome relatively simply. In recent times AQIS has shown a willingness to work with potential importers to find solutions rather than systematically reject proposals for importation.

Whatever the case, importation, if it is possible, will be expensive and this raises two problems. The first and obvious one is finding the money and the second is to find a way of recovering this expenditure while objectively assessing the real worth of the animals under Australian conditions. Historically, importers of new genetic stock into this country have attempted to realise on their investment quickly by marketing their seed stock to other producers at very high prices. Little, if any, objective appraisal of the animals **vìz a vìz** local animals has been tried until sufficient progeny have been generated without selection over several generations and their price has approached normal commercial values. The dairy industries need to find a way of ensuring that this does not happen because it will:

- dilute the real merit of the imported animals by failing to cull poor animals and
- waste breeding time by using untried imported animals to the exclusion of tested local ones

The solution lies in incorporating the imported progeny as soon as possible into the overall breeding program so that cross- and pure- bred animals can be compared with local stock. In this way, the new breeds will be incorporated into the national flock at a pace that matches their genetic superiority over local animals. In other words, if they are better than existing strains, they will have a very wide influence, if they are not, they will have done little or no damage to the national flock. The difficulty is to find a satisfactory way to compensate individual importers or syndicates for their substantial investment, if this approach is taken.

**Decisions made about importing animals**

We were unable to make firm recommendations about importing genetic material because of the uncertainties of whether such importations will be allowed and the expected high cost. However, we expect that if these restraints are overcome the chances of well selected material making a significant impact on the dairy sheep and goat industries in this country will be high.

Is there a satisfactory way of compensating individual importers or syndicates while ensuring that diffusion of the imported genetic material to the industry is based on the real merit of the animals?
The industry representatives felt that there would be a need to introduce animals through an evaluation scheme but generally felt that this was a long way down the track and would be a decision for an industry board at the appropriate time.

2.7 Coordination of the national breeding program(s)

In view of the many issues discussed above it is clear that a national breeding program for dairy animals will need to be a well coordinated. We believe that the operation requires a dedicated person, although not necessarily someone employed on a full time basis. The industry itself would supervise the coordinator and collectively make key decisions about breeding policy. Below is a proposal that the dairy goat and dairy sheep industries should consider separately. It is meant to be indicative and certainly not prescriptive and the key imperative is to keep it as simple as possible.

Steering Committee: The industries will need to begin the process with a steering committee whose task will be to put the permanent structure in place. This committee would meet as frequently as necessary and, according to need, some of these meetings could be by phone. This interim committee should aim to have a more permanent structure in place in 6-8 months. Five members would be appointed immediately by each industry, goat or sheep, and a sixth would come from the appointed committee from the other industry. This is because we believe that there are many advantages in having the two industries working together wherever possible while remaining independent. The task of these committees is to:

- Set the essential components of the national program in place.
- Appoint, instruct and monitor the coordinator.
- Set up a procedure for the election of a Board.
- Act, in the place of the Board, until it is functional, in appointing service providers and negotiating fees on behalf of the industry.

The Board. The national breeding scheme for each of the industries would be under the control of a Board of six members. Five of these would be members of the industry (producers, processors or others if appropriate) elected by the industry (a decision by the steering committee is need on how this would be done), the sixth would be an elected member of the Board of the other industry, goat or sheep. The Board would meet at least twice a year, in person or by phone hook-up and have the following duties:

- Take responsibility for the overall running and management of the national breeding scheme for the industry.
- Administer and monitor the coordinator.
- Formulate and fine-tune breeding policy in consultation with the coordinator and genetic advisers as appropriate.
- Decide on issues of new membership to the program and, where necessary, on questions such as the allocation of semen.

The Coordinator: The coordinator is the person on whom the overall success of the program will depend. We propose that he or she will be responsible for the day-to-day running of both the goat and sheep breeding programs and will divide time equally between the two. Until the exact size and scope of the programs are known we suggest the this be a fractional appointment rather than full-time but with the option of expanding should the programs warrant it. The duties of the coordinator are:

- Assist the Steering Committees and Boards to set up and run the national breeding programs.
- Provide coordination and support, as directed by the Board, to members of the national breeding programs and act as a focus for extension of new ideas and products associated with dairy sheep and goat breeding.
• Liaise with an appropriate analytical laboratory to process producers’ samples.
• Guide producers on procedures for milk sampling and conformation scoring of animals.
• Liaise with the agreed provider of the programs’ database of animals and genetic information.
• Ensure that data flows smoothly to and from the provider and the producers and that the genetic information is in a form that producers can use easily.
• Maintain a back-up of all information on the database and guard the industries’ ownership of the data it contains.
• Encourage research and development in genetics and related aspects of dairy sheep and goats.
• Encourage new members to enter the breeding programs and facilitate the inclusion of their herds and flocks.
• Prepare annual reports on the physical and genetic progress of the program and set up lists of male animals including proven sires and males worthy of progeny testing within in the scheme for the Boards to consider.
• Act as secretary to the Boards and make recommendations to them as appropriate.

**Decisions made about coordination of the national breeding program**

The participants from both industries agreed on the general structure as proposed above and moved to appoint steering committees for both industries. It was also generally agreed:

• that it would be preferable to have a single coordinator for both industries at least in the short term.
• that funding should be sought to provide seed money to allow the appointment of a coordinator. Possible sources for such funds were discussed.
• that Boards for the respective industries should be set up as soon as practicable.

Steering committees were set up in the respective industries and were to begin meeting as soon as possible to get the infrastructure for the breeding programs underway. The members were:

*For the milking sheep industry:*
- Marius Cuming (convenor)
- Sandy Cameron
- Jock McMahon
- Robert Manifold
and the power to co-op other members as necessary

*For the dairy goat industry:*
- Michael Wardell (convenor)
- Steve Russell
- Tony Barker
- Anne Bolt
- Sandy Cameron
- Gaille Abud
+ one representative of Queensland goat breeders
and the power to co-op other members as necessary
2.8 Breeding Organization for Milking Sheep and Goats

In this section of the report we explore how these issues can be translated into a workable breeding program for dairy sheep and goats.

We discuss options on how animals might be selected to contribute to the scheme, who will own the animals and how people are rewarded for the extra effort they put into the testing and proving of animals. We then present three scenarios that differ in the degree of collaboration between breeders and the degree of group versus individual ownership of the animals selected to contribute to the breeding scheme. They also differ in the degree of independence of each individual and how they may contribute and benefit from the cooperative arrangements in the breeding scheme.

As foreshadowed in previous sections, the description of the program concentrates on the males selected and used to breed replacement females in the flock. In milking schemes there is considerable time lag between the conception and birth of young males, their testing and evaluation, and the point at which they are extensively used in the herd or flock. This is because males are accurately evaluated only when their offspring are measured for the traits of interest, which, in this case, is their milk quantity and quality. This program for dairy animals differs from those in meat and fibre production systems where the males’ own measurements play a large part in selection. This time lag between breeding of the male and his evaluation has two effects. It significantly increases the cost of the program and it makes it much more beneficial to have strong collaboration between flocks or herds. For this reason, we recommend that the dairy sheep and goat industries attempt to collaborate to a degree that is greater than in either meat or fibre enterprises. However the three scenarios presented differ greatly in the degree of collaboration involved.

Classification of animals
To simplify the description of the schemes below, dams and sires have been classified into groups. These groups identify animals that play significantly different roles in the breeding program. However, animals from different groups might well require similar records to be taken and the same animal may move between groups at different stages of its life.

Group 1M – males that have passed progeny testing (authenticated males)
Group 1M males will have been bred from the very best females, pre-selected as the parents of the next generation of test males and progeny tested. The sires in this group are selected because their daughters, bred as the group 2F test females, are on average better performing than the daughters of other young males in their group. There will not be a large number of these males each year. In fact, the number of authenticated males selected each year is a trade off between using more males to make sure that there is not too much inbreeding and using fewer males to get the fastest genetic gain. Of course, the final number that we can use depends on the total number of animals participating in the whole program, but it will probably be no less than 5 males selected each year as authenticated males. There is no upper limit but, for the time being, we could not expect more than 10 as a maximum.

Group 2M – young males for progeny testing (test males)
These will be the best males bred from the Group 1F females (below). When they reach breeding age, they will be mated to enough females to produce 25 to 40 Group 2F daughters that will reach first lactation and be milk tested. Then, based on the results of their daughters’ milking, the top 5 to 25% of these young males will be elevated to become group 1M males. The numbers of young males that can be tested is limited by the numbers of females available for “test matings”. There is substantial discussion below about the numbers of females available for these matings, and how this affects the accuracy of evaluation. We would expect that there may be enough females available for 20 young males to be tested in this group each year. In other words, this is about 1000 matings to produce 500 of the daughters to be test milked as group 2F females.
**Group 3M – sires to be available for natural matings (backup males)**

Conceptually, this group differs from the other groups here, as it is a group of sires that are produced to fulfil a requirement for natural mating to cover females failing to conceive to AI. These sires can be produced as required within a pedigreed flock from group 1F females whose EBVs are not good enough for them to make the grade as parents of test sires. Backup males can also be retired authenticated sires that have been replaced by younger, better animals or test sires that fail to make the next step up to authenticated sires. Herds or flocks that are test milking females can plan to produce these group 3M males as and when required for use in the flock in which they are bred because they will be using the BLUP system for producing EBVs. This would help to minimise live animal transfers between properties which is important for bio-security.

**Groups 1F – females to breed males (authenticated females)**

These females are the “top” EBV dams that are identified and authenticated by their own measurements as the females that will have the very best offspring. These special females will be mated to authenticated males that have very high accuracy of evaluation (Group 1M males). They need to be fully and accurately recorded for their milk production but they can be the daughters of females from either Group 1F or 2F. Total numbers of sires required in the scheme each year determine the number of females required for this group. All rams used for live mating and as backup rams to the AI program, are produced from these females. This group of animals is not expected to be more than 10% of the programs’ female population and may well be half of that number if backup rams are used for more than one season. Females will be selected into this group on the basis of their EBVs and even the young females born from 1F females would need to be evaluated for a full lactation before they could be considered for selection in the 1F group. A sample calculation of the numbers of 1F females required in the program is shown at the end of this section. Without requiring live backup bucks or rams, this group could arguably comprise a minimum of 40 dams but many more are actually used to help avoid future inbreeding and provide some freedom for culling on conformation traits. The production of good quality, backup sires for natural matings is a bonus that comes from running more than the minimum number of 1F females.

**Group 2F – females that are the result of a progeny test mating (test females)**

These are females that will be fully milk tested as part of the evaluation of their sires, the young, group 2M males. Ideally, their dams will be females that have full measurements (retired group 1F or previous group 2F females), but they may come out of the best Group 3F females if the evaluation is sufficiently accurate at the commercial level or if not enough pedigreed females are available. The proportion of these “test” matings compared with the “commercial” matings can vary considerably without having a drastic effect on the rate of genetic improvement in the population. More importantly, the number of females required is determined by the number of young 2M males that the program wants to test. In typical dairy cattle schemes these test matings can account for about 20% of the total matings but it doesn’t seem that this proportion is very critical either. Simulations have shown that genetic gain is relatively insensitive to the proportion of the total animals put into test matings. Increasing test mating from 20% to 40% of the population does not have big impact on the rates of genetic gain, so it is not critical (in terms of genetic gain) if a relatively large proportion of the population is required for test matings. The French successfully use about 40% for both their sheep and their goat programs.

For each male to be accurately evaluated it is desirable to have at least 25 female offspring tested. As the numbers of offspring goes up, so does the accuracy of the progeny test (as shown in the graph below). But, the advantage becomes less and less, so that progeny testing more than 50 offspring per tested male gives no extra gain at all. Given the relatively small size of the total Australian flock, it may be desirable to test closer to 20 test females per young male in the initial stages so that more young males can be tested.

There are several factors that affect the accuracy of test evaluations. One of the most important is the heritability of the traits that the industry group chooses as selection criteria. In addition the trade off between accuracy and being able to test more males is a decision to be made by the group, after they
have defined the breeding objective and worked out how many females are available to fit into the 2F category. It is quite straightforward to provide response curves like those on page 21 for most variables that affect genetic gain. However, there are many inter-related decisions to be made about the numbers of animals in all of the above groups. We recommend that the fine tuning of the breeding structure wait until the breeding objective is decided, the approximate size of the population has stabilised and the number of cooperative breeders is better known. Decisions on how many males to test and how many females to mate to them needs to be revisited regularly as it becomes clearer how many flocks are prepared to test milk, and how many milking females there are in those flocks. We also need to know the degree of collaboration between breeders, in order to decide on the maximum numbers of young males that can be tested.

**Group 3F – (commercial females)**
These females will be mated to proven males. They are measured to select which of them should remain in the herd or flock. They will not have offspring that are considered as potential males – all of their male offspring will be culled but their daughters will make up most of the commercial milking animals.
### 2.9 Key questions in the design of the scheme

There are several key questions to be addressed about how the co-operation in the scheme is implemented. These questions refer to ownership and location of the animals in the various categories described above.

**Q1: Who will own (and run) the Males (1M or 2M)?**

In the French Lacaune scheme all males that are identified as potential Group 2M rams are sent at weaning to a central location, at which stage they cease to be the sole property of the farmers who bred them. They belong to the collective program. Under a scenario where artificial insemination is the main reproductive option this has several advantages as the cost of testing the 2M males is spread evenly across the eventual cost of producing Group 1M males. By contrast, if individuals retain ownership of males at the group 1M or 2M stage then those individuals carry considerable risk associated with the outlay required to test several of the group 2M males. For example it is likely that few and, in some cases none, may make the move to 1M status. It is also unlikely that a producer will be able to test many of his own males as well as staying genetically linked to the wider population.

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**THE POTENTIAL RATES OF GAIN GIVEN HYPOTHETICAL SIZE OF STOCK CLASSES**

| Total numbers of females milked | 5000 |
| Test matings | 1000 = 20% |
| Group 2F test females | 500 |
| Group 2M test males = 20 (mated to 50 females each with 100% weaning) |
| Group 1M authenticated males = 5 new animals each year |
| Group 3F matings | 3,800 |
| Group 1F females = 400 matings (the object is generate 20 males for testing, and the remaining males are potential 3M or backup sires) |
| Selected proportions: 1M = 5/20 = 5 rams selected as sires to breed sires (SS) |
| 1F = 400/5000 = 400 ewes selected as Dams to breed sires (DS) |
| NB only 60 females are required from the 400 group 1F animals to produce 20 |
| test sires = 60/5000 |
| 1M/3F = 5/20 = sires to breed dams (SD) |
| 3F replacements = Dams to breed Dams = 70% of females used as replacement dams (DD) |
| Generation interval = the average age of the animal when their progeny produce their first outputs. SS = SD = 6.5 years; DS = DD = 4.5 years |

**Selection intensity:**

- SS = 1.27; DS = 2.60; SD = 1.27; DD = 0.47

**Selection accuracy sires = 87%, dams =50%**

**Annual improvement**

\[
\text{Annual improvement} = \frac{\sum (\text{Intensity} \times \text{Accuracy} \times \text{Genetic Standard Deviation})}{\sum \text{Generation Interval}} \\
= \frac{(1.27 \times 0.87 + 2.60 \times 0.50 + 1.27 \times 0.87 + 0.47 \times 0.50) \times \text{Genetic Standard Deviation}}{6.5 + 4.5 + 6.5 + 4.5} \\
= 0.17 \times \text{Genetic Standard Deviation}
\]

If heritability of the index = 0.25 and there is a 10% variation (phenotypic standard deviation) around the mean

**Annual genetic improvement = 0.85% of the mean**

Based on the above calculations the graph above shows the relationship between the number of test sires and annual genetic improvement.
This discussion presumes that the co-operative has some say in the movement of a male from a 2M classification to a 1M classification. We certainly recommend this as a minimum criterion. There are advantages to running the 2M males in one location in terms of ease of semen collection and distribution. The difficulty is that these (or retired 1F sires) are the ideal backup males to be using for natural mating in commercial flocks within the program.

**Q2: Will the 1F and 2F females be spread around different flocks, or run centrally?**

With modern statistical techniques it is possible for the 1F females to be spread around different milking flocks, as in the Lacaune scheme, and still be linked genetically as if they were all part of the same flock. Producers running these females in their flocks must pedigree the animals and participate in a milk testing scheme. Possibly, people may choose not to run 1F or 2F females because of the extra requirements of pedigree keeping and milk testing. If this is the case, then there must be sufficient flocks in the program doing the full testing of both 1F and 2F animals to keep the scheme viable, and there must be some rewards to those who go to the extra trouble of taking records. Some commercial farmers may wish to record a limited number of females. These farmers would be running predominately 2F rather than 1F females. An extreme scheme (which we do not recommend) is for a single property to be identified as the place for 1F females to be milked and recorded, with a limited number of other properties designated to run 2F females. For this to work there would have to be a requirement to sell any animals designated as 1F to the central property. This idea of a “central” rather than dispersed nucleus has other disadvantages such as risk of disease through movement of animals, and reduced input and relatedness of the commercial producers to the breeding decisions. We are therefore recommending that the program be built around a dispersed nucleus rather than a central nucleus.

**Q3: Who plans the matings at the group 1 level?**

If there is to be a dispersed nucleus, then each individual is relying on other people in the scheme who are running group 1F females to mate these females to the appropriate males. Modern techniques for allocated mating (TGRM – copyrighted by LambPlan for example) are now available, but more importantly there must be adequate linkage between different flocks for the proper evaluation to be carried out. In one of the schemes below it is possible for individuals to plan their own matings but we are not recommending this in a dispersed nucleus scenario. If there is no central ownership of 1M males, and consequently semen from different sires is highly variable in cost, then it is very difficult to ask people to pay for inseminations that are planned centrally. In a group scheme, there is the opportunity to reward people for their contribution to testing and running different animals by providing semen from the top animals at a discount or for free.

**Q4: What is charged for semen, and what is available to external parties?**

The costs of testing animals and measuring milk production needs to be recouped at some stage by those who undertake this extra trouble and expense. Traditionally, this has been done through premiums charged for males or semen. In a group scheme the idea is to spread costs across the different collaborators according to their contribution. In terms of maximising genetic gain, it is an advantage to spread the costs of measurement evenly across all sires. If this is done then semen costs do not influence breeders in determining which sires they will use so the main factors in a selection decision are the breeding value of the animal and the risks of future inbreeding.

In a co-operative scheme it is possible for those who are providing test measurements on an animal to charge the central scheme a standard fee for collection of test information. It would then be the responsibility of the group to recoup these costs through the appropriate charge for semen from authenticated and tests sires. This idea of charging a central body the total of the costs of testing allows much better averaging of the costs of testing across different sires. If done as a cost recovery exercise, then sale of semen to new or external parties who are not participating in the scheme would allow some degree of profit for those who have made the capital outlay to initiate the scheme.
Q5: Who determines if semen can be released?
The definition of what is a 1F or 2F male should be pretty straightforward based on the EBVs and the breeding objective. In schemes such as the meat sheep LambPlan system there are lists of “top sires” published as available for general use in the population. Obviously the best of the best males need to be used over group 1F females, and it seems eminently sensible that these matings are planned centrally and that these matings have priority if there is a question of shortage of semen. If the group has tight control over semen then it is not an issue as to which sires make the authenticated sires listing. However, if individuals retain sire ownership then the organisation as a whole is likely to have difficulty in limiting the number of animals that are assessed as top sires. These decisions would influence considerably the ability of an individual to recoup the costs of measuring and testing males. In addition, appropriate linkage is required to maintain the effectiveness of the statistical evaluations, and rules about use of adequate numbers of test sires must be implemented and monitored by the industry groups as an important prerequisite for sires achieving authenticated status.

Q6: How does the scheme expand?
The decision to allow new players into the scheme must be carefully considered and appropriate ways of recouping past expenditure on genetic improvement put in place. There is a big advantage in expanding the genetic base and encouraging efficient production within the industry by supporting new participants entering the program but this has to be weighed against the set-up and running costs of the program borne by the foundation members.

Q7: How is “breed” accounted for, and what is the role of crossbred animals?
For some people breed is an important consideration in selection of sires. Where the industry decides to maintain separate breeds there would be considerable gains to be made by combining certain aspects of different breed schemes. Certainly each breed would be required to maintain separate group 1F females and 1M males, but a co-operative approach to testing group 2M males would have advantages in terms of reducing the numbers of sires that need to be tested. This is particularly true if commercial producers are prepared to run and test females that are crosses between the different breeds in the scheme. The French goat program has roughly equal numbers of Saanen and Alpine animals and they maintain the “purity” of these two breeds by running separate breed programs within the main genetic scheme. Many of the producers in the scheme run crossbred animals and decide on the breed of sire that they use on the basis of performance alone. On the other hand, the French Lacaune sheep program deals with only one breed which simplifies things, but, 40 years ago the Lacaune breed did not exist in its present form. A number of similar but distinct breeds were incorporated into an integrated breeding program and became the single breed. This may well be worth considering as a model for the Australian dairy sheep.

2.10 Examples of breeding programs

These three brief examples are put forward to allow producers to weigh the advantages and disadvantages of some ways of organising a national breeding plan. The industry may wish to firm up on one of these or to make modifications that best suit them and the Australian scene.

Scenario 1 – the group ownership model

- In this scenario all males for testing and subsequent use would be owned cooperatively and run centrally.
- Sires would be selected at birth, based on parental EBVs, and at weaning would be transferred to a central location for growing out and subsequent semen collection.
- Individuals would retain ownership of all females but the group would decide which sires would be used over females from group 1F.
• For group 2F matings the individual owners would nominate how many test milkings they are prepared to carry out and the group would allocate particular young males to their choice of females.
• There would be no charge for semen for group 1F matings – but semen for group 2F matings would attract a charge at a lesser rate than for semen from authenticated sires.
• Individuals would not be recompensed for their testing outlay – but would receive access to semen at reduced rates.

**Scenario 2 – the hybrid model**

• In this scenario group 2M males would be identified at birth, and the individual with ownership of the male would be required to arrange semen collection to produce a specified number of doses. Enough doses for progeny testing of the young males would be sold to the co-operative at a specified cost. The breeder would be prohibited from selling semen from young males either inside or outside of the scheme.
• If at a later date a test male were elevated to group 1M status, the cooperative would buy at cost a minimum of (say) 5000 doses of semen from that male.
• The cooperator would be required to mate any group 1F females on his property to a male as directed by the group, with semen being supplied free of charge.
• Individuals would nominate how many group 2 females they were prepared to test milk and charge the cooperative for the cost of collecting those milk records. Semen for those test female matings would be charged at a reduced rate. The individual would be required to use the test semen over specified females in his flock.
• The cooperative would calculate the annual total cost of test measurements and set the price of semen from authenticated sires so as to recover measurement and management costs completely. The semen from all authenticated males would be the same price.
• The owner of the male would be able to sell semen to non cooperating flocks at a rate of his choosing but not less than the cost charged within the breeding program.

**Scenario 3 the individual ownership model**

• The breeder would be required to mate group 1F females to males specified by the co-operative with the requirement for semen to be purchased from the owner of the male at a specified cost
• The breeder never loses ownership of animals or semen under his control.
• The breeder of the male would be authorized to sell semen from the authenticated male to other co-operators at a specified rate. For flocks outside the breeding program the breeder could sell semen at a price of his choosing but never less than within the program. The group would advertise the authenticated males amongst its collaborating breeders on an authenticated male list that contained only the top 15 males (so sires would move off the list as better young sires are produced).
• The breeder would have made available to him a list of semen available from test males, and would be able to select which test males he wished to use in his flock, and to which females he wished to mate them.
2.11 Decisions made about the design of the scheme

The workshops had little time to discuss the relatively complex biological, genetic and social issues that will eventually make up the national plan. The most important of these issues are presented here in a number of sections. The first addresses the broad organisational structure, the others looks at matters of more detail within that broad structure. In its further deliberations, the industry needs to decide on the first section to set its directions and begin planning for a national program. Some of the matters raised in the other section are not so crucial in the first instance and can be attended to as the program is being set up.

Section A. A desirable organisational structure

1. Which of the three scenarios is closest to an appropriate breeding plan for our industry?
   
   *Scenario 1*
   *Scenario 2*
   *Scenario 3*

2. What are the major modifications that need to be made to make the selected scenario fit the industry more closely?

Section B. The national population structure

The following two key questions will set the foundation population structure. Most of the other questions such as number of dams in the 1F group of sires in the 1M and 2M groups will be determined automatically using the proportions discussed in this report once the approximate key population numbers have been resolved. Extensive computer systems are now available to optimise such breeding structures.

How many breeders will be involved and how many animals will be available
   
   * At the ram breeding level?
   * At the testing and proving level?
   * At the level of using breeding stock or genetic material from the scheme?

How many tested, authenticated males should enter the program each year?
   
   We recommend at least 5.
   
   * 5
   * A number more than 5

How many separate “pure” breeds should be represented in the national dairy breeding program?
   
   We recommend as few as seems sensible.
   
   * 1
   * 2
   * More than 2 ?

Section C. Terms of trade in genetic material

What charges for semen (based on a calculation of total costs and a reward to the breeder for effort)

A) For authenticated males to participants providing 1F ewes for breeding rams
   
   * Full costs
   * Nominal cost
   * Free
B) For authenticated males for all other uses by participants
   - Full costs
   - Nominal costs
   - Free

C) For authenticated males to breeders outside the program
   - Full costs
   - Full costs plus a standard premium
   - Whatever the market can bear, varying according to the sire
   - No sales at all to outside breeders

D) For untested males (2M) to participants providing dams to produce test females (2F)
   - Full costs
   - Nominal costs
   - Free

E) For untested males (2M) to breeders outside the program
   - Full costs
   - Full costs plus a standard premium
   - Whatever the market can bear, varying according to the sire
   - No sales at all to outside breeders

What charges for males for natural mating (3M), either surplus to needs due to age or failure to enter the 1M or 2M groups, or bred for the purpose?
   - To participants
   - To breeders outside the program.

3. Conclusion

This report describes a national dairy breeding program that has the capacity to develop, in a relatively short time an Australian dairy breed (or breeds) of sheep or goats that will enhance industry’s capacity to produce milk, cheese and related products more efficiently. The “Decisions made” sections illustrate that the establishment and running of the program is, to some extent, complex. However, when the program is up and flourishing the only thing about it that will be new will be its structure. The services to make it work are already in place. We believe that the industries, though they are comparatively small in relation to those in some other countries, have the capacity to harness the enthusiasm of breeders and the power of modern genetics to make a unique contribution toward ensuring that they are competitive on the world scene through the proficient production of the industries’ basic material—milk.
Report 2: - Breeding Schemes for dairy sheep and dairy goats in Europe

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1. Introduction

This the second of three reports as part of the project “Improved breeding in dairy goats and milking sheep” The first part was a report on the needs and aspirations of Australian breeders of dairy goats and milking sheep and particularly their attitudes to the development of a national breeding program in each of the industries.

This second report describes how the goat and sheep dairy industries in Europe, particularly France which has the most advanced and comprehensive programs, organise their programs. I spent almost three weeks on a study tour of the main producing regions, the principal genetics and physiology laboratories, the National Breeding Institute (Institut de l’Élevage) and the breed societies.

There is little likelihood that the programs in place for either species in France can be transposed onto the Australian scene unaltered but the principles and many of the details will undoubtedly help form the base for the systems that Australian breeders will eventually adopt. The extraordinary success in genetic improvement of dairy sheep and goats that is now patently clear in other countries should certainly motivate progressive breeders in this country to set up as comprehensive a breeding program as they can.

It can be seen from this report that the detailed organisation of goat and sheep breeding programs is substantially different in the two species although both have worked well. In thinking about possible programs for Australia, it is worth remembering that there are many options and they are not confined to one species or the other.

I was assisted in France by a number of colleagues who enabled me to see the industries at grass roots level and get opinions and attitudes from farmers, technicians and scientists as well as getting the raw data on the programs. I have attempted to include these where relevant in this report.

I also collected a lot of other information and written material on issues such as out-of-season breeding, synchronising oestrus, and housing that are not directly associated with the national breeding programs but which may interest some Australian breeders. They are not included in this report and most are not in English but I can make them, or a rough translation, available in due course.

The third report, due at the end of June will be the draft of proposed national breeding plans and options for the two species in Australia. It will draw on the first two reports for background but will focus on how we might adapt to our own conditions and overcome our own problems in getting a cost-effective plan off the ground. At that point, the dairy goat and sheep industries will be encouraged to become involved to decide on programs that will ensure that the genetic capacity of the animals keeps pace with progress in other parts of the industries.
2. Breeding schemes for dairy sheep in Europe

Introduction

Southern Europe is considered the home of dairy sheep because of a long tradition of cheese production and consumption in most of the countries that line the Mediterranean. There is also a large population of sheep in North Africa but many flocks are nomadic, statistics are rubbery and there is little development of organised breeding.

Within the Mediterranean basin, Greece has by far the biggest sheep population followed by Italy, Spain and France (Table 1). However, among these, the sheep milk industry in France has by far the most advanced and successful breeding programs. Most of the other countries use historic methods of selection and breeding and very little recording of milk production. Without a systematic and unbiased recording scheme, large scale and effective breeding programs are unlikely to be successful.

(Table 1) Populations of milking sheep in the principal countries of the Mediterranean Basin and incidence of milk recording. (from Barillet, 1995a)

<table>
<thead>
<tr>
<th>Country</th>
<th>Population of ewes ('000)</th>
<th>Major breeds</th>
<th>Percent milk recorded</th>
</tr>
</thead>
<tbody>
<tr>
<td>Greece</td>
<td>10,108</td>
<td>Karagouniki, Lesvos</td>
<td>0.5</td>
</tr>
<tr>
<td>Italy</td>
<td>5,408</td>
<td>Sarda, Comisana</td>
<td>3.9</td>
</tr>
<tr>
<td>Spain</td>
<td>4,000</td>
<td>Churra, Latxa</td>
<td>2.2</td>
</tr>
<tr>
<td>France</td>
<td>1,235</td>
<td>Lacaune, Manech</td>
<td>65.5</td>
</tr>
<tr>
<td>Portugal</td>
<td>500</td>
<td>Serra da Estrella</td>
<td>4.3</td>
</tr>
<tr>
<td>Tunisia</td>
<td>210</td>
<td></td>
<td>1.0</td>
</tr>
<tr>
<td>Hungary</td>
<td>65</td>
<td></td>
<td>1.8</td>
</tr>
<tr>
<td>Germany</td>
<td>60</td>
<td></td>
<td>2.5</td>
</tr>
<tr>
<td>Israel</td>
<td>65</td>
<td>Awassi, Assaf</td>
<td>12.1</td>
</tr>
</tbody>
</table>

Italy is attempting to develop a national breeding scheme but has had problems. The first scheme attempted in the early 1990s to set up a complete breeding station near Sienna to breed rams for the industry. Advanced reproductive technologies such as multiple ovulation and embryo transfer (MOET) were to be used to increase family size and speed up the turnover of generations. However, the plan has been frustrated, first by uncertainty on the part of individual breeders about a largely government-backed scheme and by the presence of two contagious diseases on the island of Sardinia, where two thirds of the milking sheep (3.5M) are found; foot and mouth disease and, in the last 2 years, bluetongue. This has restricted movement of animals and the scheme has been put on hold. Annual genetic gain in Sarda sheep is estimated to have been about 0.9 per cent since 1990. However, as part of a European Community co-operative initiative, a joint French-Italian endeavour at Bonasai in Sardinia is looking at developing a synthetic breed between the French Lacaune and the Italian Sarda. There are over 1000 ewes in this flock which is being closely studied scientifically but has so far had little impact in the national flock.

In Greece, breeding schemes are largely restricted to individual progressive breeders but the average size of flocks and the lack of infrastructure support have impaired progress markedly and there are relatively few sheep milking records. There are two centres, one a cooperative and the other a government station that are attempting to provide a start to systematic, scientific breeding.

For the Karagouniko breed a genetic improvement program has been established in central Greece by the Karditsa Animal Improvement Centre, in which a nucleus population of 20 000 sheep kept in 350 flocks is recorded. The records identify ewes for keeping or culling as breeders. In addition there is a
limited progeny test for rams. After being tested for growth rate, body conformation and semen production, the best 20 young rams each year are used over a total of 6,000 ewes on 100 farms. Four or five of these rams are selected, on their daughters’ performance to be used for planned matings with high performance ewes (Georgoudis et al., 1995).

For the Chios sheep, a nucleus flock of 500 has been kept at Chalkidiki since 1977. Female and male lambs are selected on individual weaning weight and on dam’s performance for milk production and litter size. (Georgoudis et al., 1997)

These two examples seem to represent the extent to date of systematic, modern breeding of dairy sheep in Greece.

Spain, also, has large number of sheep but little recording. The few, relatively small, systematic breeding plans have already shown some progress; an annual genetic gain between 0.8 and 1.2 per cent. in the recorded flocks. The milk production in the country has risen in recent years as a result of an increase in the number of animals. It is reported that they have imported a large number of Awassi and Assaf sheep in the last five years.

Israel has the highest proportion of recorded animals of any country apart from France but it has a relatively small population and breeding schemes are confined to individual kibbutz with little or no linking between them. The Ein Harod kibbutz is reputed to have the most advanced Awassi sheep for milk production and exports them as being “heavy milking, very hardy and well adapted to harsh conditions” although comparative figures are unavailable. However the cross between the Awassi and the Friesian called the Assaf now outnumbers the native Awassi. In Israel, the population base for both breeds is restricted (40,000 for Assaf and 25,000 for Awassi) and, with it, the potential rate of genetic progress.

Schemes for genetic improvement of milking sheep in Europe

The most obvious way of improving poorly producing sheep is to import other animals reputed to be better adapted to milk production and there is some literature on comparisons among breeds in the Southern Europe and Mediterranean region. The outcomes of these comparisons are interesting for us in Australia because we are in the process of making similar decisions about the most effective breeding plans. The most popular breeds in the comparisons have been the East Friesian, Chios and Awassi. Most of the comparisons showed that the imported breeds were better than the local animals but not by as much as predicted and their adaptability was “very disappointing,” according to Barillet (1995b) with high disease and mortality rates.

The two options have been to cross the imported and local breeds to avoid having more than 50 per cent imported blood or to ignore imported breeds altogether and to select among the local breeds in their own environment.

There have been three notable crosses that are now more or less fixed; the FSL in France (Friesian-Sarda-Lacaune), Frisarta in Greece (Friesian with a mixture of local breeds) and Assaf in Israel (Awassi-Friesian). There doesn’t seem to be much objective information yet on how well they compare with conventional breeds of sheep.

On the other hand there is a of information on the progress being made with highly focussed selection programs that rely on the improvement of indigenous animals without outside crosses, especially in France.
It is therefore to France that we must look for examples of breeding success and organisation. The backbone of the industry in France is the five “departments” that make up the Roquefort region (Figure 1). Thirty years ago the famous (and relatively expensive) Roquefort cheese was made and matured in the caves of the Causses (or tableland) region and milk was drawn from the surrounding districts but also from the other two sheep-milk producing regions of France, the Atlantic Pyrenees and Corsica, a Mediterranean island off the south of France. The consumption of Roquefort cheese, which is exported all over Europe and to the US, has not diminished since then but the amount of milk produced has risen so spectacularly that milk is now only drawn from the local region and only about 50 per cent of that is made into Roquefort cheese. The rest is made into yoghurt and other, mainly, soft sheep cheeses. The other two regions shown in figure 1 have numerically fewer sheep and have had to develop new sheep milk products to sustain their industry. Some of the huge increase in milk production is attributable to an increased number of animals but much is due to the improvement in genetic merit of the animals. All three areas have individual breeding schemes but the oldest, biggest and most successful is the one at Roquefort. It is now one of the classical examples of spectacular genetic achievement in any animal industry in the world.

Figure 1: The main dairy sheep areas in France
The organisational structure for sheep selection and genetic improvement in France:

There are literally hundreds of farmer groups and cooperatives in France and it is very difficult to know where they all fit into the overall scheme. However, for any one industry there are a few that are important in the running of that industry. The following brief description refers only to those that are important to the national milk-sheep breeding program. They are shown diagrammatically in Figure 3.

In the 1950s there were a number of closely related breeds of sheep used for the production of milk. With the formation of a cooperative of farmers supplying the Roquefort cheese factory, it was decided that the breeds or sub-breeds should gradually amalgamate to form a single Lacaune breed and that boundaries, imagined or real, between breeds should be ignored. The farmers formed a sort of breed society, UPRA Lacaune, which sets standards and breeding objectives but unlike Australian breed societies its objectives rely largely on measurement rather than subjective appraisal. Lacaune sheep are no longer exhibited competitively at shows but the UPRA runs promotions and demonstrations to popularise the breed and its products. For example, at the Paris Salon d’Agriculture (equivalent to the Royal shows in

Figure 2: UPRA Lacaune demonstrating machine milking of sheep at the Salon d’Agriculture in Paris

Figure 3: Interaction between the main groups associated with the organisation of the Lacaune breeding program
Australia) they milked sheep and ran cheese tastings for the visitors, mostly from the city. The animals were in fact culls because, for health reasons, the breed now has a policy of slaughtering all sheep that are massed collectively with others rather than returning them to farms.

Milk testing began in 1957 and AI was first used in 1963. The effectiveness and extent of AI received a boost about 1973-4 when synchronisation of oestrus using progestagen-impregnated sponges (ironically, a technique first developed in Australia) was introduced.

The expansion of the scheme has been carefully monitored and organised to point where its sheer scale and its demonstrated efficacy are unmatched anywhere in the world.

The organisation of the program is based on two centres, the Confédération Generale de Roquefort and the OVI-TEST Cooperative. They were formed in 1970 and 1972 as farmers’ co-operatives. They are identical in size and function and the reasons for having two rather than one are historical and are no doubt steeped in Gallic perversity rather than logic. Nowadays, the reasons given for their continued failure to amalgamate are that they are each of a size that is efficient, that the element of competition in an otherwise monopolistic system is healthy and that they are tightly controlled. They are run by farmers and are overseen and coordinated by UPRA, the breed society, also a farmer-run organisation, with strong input and collaboration from INRA, the French equivalent of CSIRO.

They direct three key functions in the breeding program. First, they are totally responsible for the flock testing and analysis for milk production and certain ancillary activities such as typing for udder scores and identification procedures. Second, they carry out the artificial insemination program. The production of milk is largely seasonal and so is AI. The same technicians do both tasks, so are employed throughout the year and well known to the producers. The third major role is the management of the AI stations in which are run the elite rams as well as the young rams that are under test or awaiting results from daughters already born. This involves about 2000-2,500 animals on each station.

The two centres are assisted by four advisory panels, chaired by producers and with key research personnel. These panels cover genetics, reproduction, health and nutrition. It is through these panels that the considerable research that supports the Lacaune program is generated and advice is obtained in case of problems. The extension of information at the farm level is usually conducted by the AI and herd-test technicians who are regular visitors to several thousand farms.

In 1980, a third centre, GEBRO, was created to develop the meat characteristics of the breed. This centre was developed by breeders outside the Roquefort region and dealt mainly with reproductive characteristics (prolificacy and fertility) and with the growth rate of young males. The best of these were then progeny tested for growth and carcase qualities of their offspring. In 1989, one of the “Milk Lacaune” centres, OVI-TEST also set up a “Meat Lacaune” subsidiary by developing a individual test station for young males and a progeny test facility. Since 1997, the two Meat Lacaune groups have actively bred and sold about 8,000 young females per year produced from their progeny testing activities. In numerical terms the “Milk Lacaune” flock is far bigger than the “Meat Lacaune” flock, which is seen by many as nothing more than a secondary activity with about 38,000 ewes and 93 breeders compared with 800,000 ewes and 2,500 breeders.

A small subsidiary of the UPRA (Breed Society) called Genelex was created in 1996 to oversee the sale and, occasionally, exportation of Lacaune sheep to other countries. In theory, the animals are selected either at the farms of top breeders for females or at Conféeration Roquefort or OVI-TEST for males and Genelex gives permission for the sale to go ahead and arranges some of the formalities. I was informed from several sources that, in practice, such permission is difficult to get and the rulings by Genelex are apparently very inconsistent. The likely reasons for this will be discussed later in this report.
The Lacaune breed.
The Lacaune has been converted by intensive, selective breeding in the last 40 years from a local, unremarkable milk producing breed to a specialist, outstanding milk-producing breed, probably unmatched in consistency and performance anywhere in the world. The improved Lacaune (Figure 4) is relatively large—adult females weigh ~70kg, males ~90kg—and produces about 1.6 lambs per year. As discussed above, its meat attributes have encouraged a small section of breeders to set up a Meat Lacaune sub-breed in which selection is for both meat and milk qualities but these animals make up only a small proportion of the population.

Many breeders and geneticists say that the amount of wool on the breed has declined since the beginning of intensive selection for milk and they have little more than a thatch of short wool on the back and sides with no wool on the head legs or belly.

They are reputed to breed almost year round but in practice they are bred seasonally and production of milk and cheese is confined to the period December to July (equivalent, in seasonal terms, to May-December in Australia). Certainly, breeding activity is bulked around June and July which is before the natural breeding season (equivalent to November-December in Australia). More ewes are bred by AI than by natural mating, but each farm has a number of “back-up” rams. No frozen semen is used, only fresh-chilled semen collected each day (Figure 5). I was told that, at the height of the breeding season, as many as 10,000 inseminations per day are achieved. The technique is the simple over-the-rail, cervical insemination carried out by technicians from the AI stations. Many of the flocks synchronise matings.

Almost without exception, lambs are left on the ewes for 30 days after which they are weaned. Some are exported to Spain and Italy where they are slaughtered to produce 6-7kg carcasses for those markets but most are either finished on the farm or sold to be finished in specialised feedlots. These animals reach a carcase weight of 17-19kg for rams and 15-17kg for ewes at about 100 days.

The Causses (or tablelands) region around Roquefort is between 700 and 1000 metres above sea level and therefore relatively cold in winter. The soils are poor compared with many other regions of France. Sheep generally lamb indoors and remain in barns until the Spring in March when they begin to get a significant proportion of their feed from pasture.

We normally think of Europe in general and France in particular as having had a stable sheep milking industry for a long time. However

<table>
<thead>
<tr>
<th>Year</th>
<th>Number milking sheep</th>
<th>Number of producers</th>
<th>% farms with milking machines</th>
<th>Average flock size</th>
</tr>
</thead>
<tbody>
<tr>
<td>1960</td>
<td>450,000</td>
<td>8,200</td>
<td>3.2</td>
<td>60</td>
</tr>
<tr>
<td>1980</td>
<td>580,000</td>
<td>3,570</td>
<td>49.1</td>
<td>162</td>
</tr>
<tr>
<td>2000</td>
<td>800,000</td>
<td>2,490</td>
<td>~100</td>
<td>320</td>
</tr>
</tbody>
</table>
Australia is not alone in developing a sheep milk industry. Table 2 illustrates how even in Roquefort, the industry is changing and growing rapidly, even in the last 20 years. There are little more than a quarter of the producers that there were 40 years ago but they have become fully mechanised and each has over six times as many sheep as their counterparts in 1960.

The way sheep are bred

**The overall breeding structure.** Almost all of the 800,000 ewes and the 2,500 producers in the Roquefort region are part of the breeding scheme but they do not all have an equal role. The female population is arranged in a pyramidal structure. The top 20 per cent of breeders (who own about 25 per cent of the ewes) constitute the main nucleus at the top of the pyramid and it is only from this group that the rams in the breeding program are obtained. Farmers outside of the nucleus also use AI extensively and purchase rams from the two ram centres. In this way, they stay at a genetic level that is not far from the producers in the top part of the pyramid. They participate in the breeding scheme by assisting in the progeny testing of young rams by making about 40 per cent or more of their inseminated females available for this purpose.

All of the rams for AI are held at the two AI centres but individual producers keep some rams for back-up because AI is normally carried out for each ewe only once each season. Most of the rams for natural mating are purchased through the breeding centres rather than from other farmers.

In the top echelon there are about 160,000 ewes. The approximately 400 owners of these ewes have to agree to certain conditions to have the right to remain in this group. The advantages of their doing so are that their animals will be genetically 5-7 years ahead of commercial flocks (see later) and they receive a government subsidy to assist in flock testing. I was unable to find out the exact size of this subsidy. There is a relegation and promotion system each year, described to me as being akin to that in the soccer football league. Producers who do not perform adequately as judged by their peers, or who opt out voluntarily, are dropped and a small number of new producers from the “second division” are permitted to come in. In reality, the numbers involved at this margin are quite small and there is no mandatory relegation as in the soccer league. The conditions for participation in the nucleus group include:

1. agreeing to inseminate a large proportion of the flock with semen from the AI centres.
2. agreeing to carry out “official” milk testing on all females in the flock
3. allowing the AI centre to take ram lambs from elite dams that have been especially mated for this purpose
4. maintaining an unspecified level of solidarity with the whole scheme

At the second, or “commercial”, level, there are about 550,000 sheep owned by about 1500 breeders which are milk tested in a scheme which is described as “simplified” and is much cheaper than the “official” scheme used in the nucleus ewes. Breeders in this group have access to AI and, in fact, some 350-400,000 ewes out of the 550,000 in the group are inseminated. A small amount of AI is also carried out on the 80-90,000 ewes in the third level that are not milk tested. The rest are mated naturally with rams from the scheme. In other words, almost no one breeds their own rams and it is claimed that virtually 100 per cent of sheep of the Lacaune breed in the region are influenced by the rate of genetic progress in the nucleus.

Note that in this scheme the top rams are not owned by the farmer on whose farm they were born. The ram cooperative and AI centre is the sole proprietor. It arranges the insemination that conceived the animal and acquires it as soon as it is weaned at about 30 days. The farmer has no say, except as a member of the cooperative, in his future use or disposal. Of course, all of the female lambs from these planned matings are the farmer’s sole property. This is quite different to the case in most western countries and it is claimed that its biggest advantage is that there is no incentive to overplay the worth of individual rams or to stray from objective assessment in order to make sales or achieve higher prices than competitors.
**Milk testing and the use of records:** The centre of the whole scheme is a huge emphasis on milk testing.

Commercial, twice-daily milking begins at 30 days and at this time the daily milk production falls significantly due to the loss of milking stimulus from the lamb(s). It is important to recognise that all figures for milk production for this breed do not include the first 30 days as they often do in other countries and with other breeds.

In recognition that milk testing is relatively expensive, a system has been devised to fit the testing method and complexity with the use to which the records are likely to be put.

In the top nucleus from which rams are ultimately chosen testing is as complete as deemed necessary. This usually means six, monthly, twice-per-day tests for volume, and analysis for milk fat and protein at each test. Until 1985, only the volume of milk was recorded and this only at the first lactation. After this time the quality of the milk was included in the analysis and second and later lactations were also used. A points method for the scoring of mammary glands for ease of machine milking has also been adopted in the last few years and at the request of the Roquefort cheese makers, an automatic method of measuring milk production and scoring for cell numbers has been developed and was put in place in 1999. The genetic parameters for cell counts in sheep milk are still being calculated from the data that is emerging and, when these are sufficiently accurate, they will be included in the selection indexes.

In the “commercial” flocks, on the other hand, the simplified testing is confined to 3 to 4 measures of milk production during the middle of the lactation period. Milk is measured at either the evening or the morning milking, but not both, and the full daily production from individuals is calculated by using the bulk milk production of the flock morning and evening. The ewe’s total daily production is calculated by multiplying her single recording by the ratio of the morning and evening volumes in the tank. This restricted testing is the result of research investigating the penalties in accuracy for measuring in this way. Ideally, according to Francis Barillet who instigated the scheme, enough information to be useful can be obtained from just two milkings, two months apart taken in the middle of lactation. Of course, not all sheep in a flock begin lactation at the same time so the recorder has to be on the farm more often than twice, so, in practice, 3 or 4 tests are usually carried out.

As the purpose of measurement in these commercial flocks is principally for management rather than for genetic gain per se the inaccuracy associated with this simplified recording is considered acceptable. Milk testing is used for classifying the ewes in the flock into three broad categories of about equal size; those that should be used for AI, those that should be confined to producing replacement ewes in the flock through either AI or natural mating and those that should be culled. Some of the inseminated animals are used to progeny test young rams which are invariably also represented in the “officially” tested flocks. Analysis of these performance of these young rams accounts for the less stringent testing in the commercial flocks by giving information from this source a different weighting.

The whole milk testing process has been evolving over time and it will continue to do so, The geneticist most involved with milking sheep in France, M. Francis Barillet, predicts that there will be further modifications in the future to take account of new needs, for example for processing and quality factors, and of new genetic techniques such as the identification of major genes for milk production. There is already in place a campaign for the elimination of Scrapie in this breed (see page 31).

**The use of records for breeding:** Breeders get information about their animals in the form of Estimated Breeding Values rather than absolute amounts of milk, fat or protein. In essence, this means that all of the animal’s relatives, often back several generations and including recorded half sisters,
contribute to the final estimate of the animal’s true genetic worth. The system of doing this is identical with that now being used in Australia and elsewhere for dairy cattle and for meat cattle and sheep. The technical term is BLUP or **Best Linear Unbiased Model**. It not only takes into account the performance of the animal and its relatives but also the differences in the flocks in which the record was made, the age of the animal, the year and the season.

All of this information gives a much more accurate estimation of the *genetic* value of the animal than the animal’s individual performance alone. In addition, it has the advantage of providing accurate estimates of the breeding value of males and for lambs of both sexes, for which there is, of course, no milking performance. The analysis of the records, the calculations of estimated breeding values and the maintenance of the whole database are done by INRA (the French equivalent of CSIRO) at their genetics station at Jouy-en-Josas near Paris.

Apart from the information on individual animals, breeders are given other information that “benchmarks” the performance of their flocks in all of the traits measured with that of their previous year’s performance and with that of the rest of the average of other breeders in the program. The form of the information is similar to that given to goat breeders and shown in Figure 12 on page 19. The breeding scheme is illustrated in Figure 6. Its essential features are:

- The flocks are divided into two groups; the top 20 per cent of flocks and the rest.
- Within the 160,000 ewes in the top group, about 8,000 are singled out on the basis of their estimated breeding values as the very best performers. They are spread among 400 participating farms.
- The AI stations then inform the owners of these ewes that they will be using semen from the top, tested rams to mate the ewes and that, if they have male lambs they will reclaim them at weaning to take back to the AI station. The choice of rams for these elite matings is left entirely to the AI.

Figure 6: The breeding scheme for Lacaune sheep in the Roquefort region of France
stations who use estimated breeding values but, in addition, a computerised statistical technique which in Australia is called TGRM (Total Genetic Resource Management). This is a strategy that plans matings to ensure that family lines are maintained (there are 15 families in the Lacaune breeding system) but avoids inbreeding and other inappropriate outcomes.

- As a result of these elite matings about 2,500 young rams are produced (success rate to AI is about 65 per cent). Around 1,500-1,600 of these rams are selected on visual traits and taken to the breeding centres where they are reared to hogget age.
- About 200 are culled on growth performance and other traits and of the remaining 1,300-1,400 about 900 are sold to breeders at all levels of the system. The remainder, about 450-500 with the highest estimated breeding values, enter the AI centre of the station and are used for progeny testing at about 8 months of age.
- Each of the 450-500 young rams is joined by AI with 200 ewes at random in the flocks to ensure that, eventually there will be at least 40-50 tested ewe progeny.
- In effect, this means that around 40-50 per cent of all AI matings are with semen from young rams under test. The remaining matings use semen from “improver” rams determined in tests in previous years. In general, the higher the ranking of the improver ram the more he is used in the AI program.
- Rams under progeny test are kept for 2 years until the results of the tests are known and at that time the best 100 of them are selected to join the “improver” flock and the rest are sold to breeders for natural mating or sent to the abattoir depending on their performance.
- Breeders have little choice in the rams that are used but are guaranteed a fair distribution of tested and untested rams.
- All insemination is with fresh semen so, without a stock of frozen semen, the AI stations cannot predict the availability of semen from individual rams. There are no plans to move towards using frozen semen because fresh semen does not require the complexity of laparoscopic insemination and can be done by lay technicians.

Outcomes from the breeding program in milk production and composition

1. Milk yield. The ultimate value of a genetic improvement scheme is the rate and consistency of the animals in those traits that have been subject to selection. Figure 7 shows that the genetic trend in the Lacaune for milk production has been been positive at about 6 litres per year or around 2.5 per cent pa. However the upper curve in Figure 7 shows that since 1995 there has been little improvement in milk yield. This is explained by the bottom curve in which the flock x year effects have decreased as a result of a change in the rules for the production of Roquefort cheese in which producers have been compelled to reduce the amount of supplementary feeding. These changes were introduced to preserve the image of the cheese as an ecologically acceptable product and to guard against oversupply. In effect, producers are now achieving the same amount of milk from their animals as in 1995 but much more efficiently.

Figure 7: Genetic improvement milk yield of Lacaune breed 1981-2000 (Barillet, 2001)

Figure 8: Trend for milk yield in nucleus and commercial flocks (Barillet, 2001)
Of equal interest is the relationship between the yields obtained by the 20 per cent of elite producers who breed all of the rams in the overall system and the commercial producers who eventually get the genetic benefits from these rams. As Figure 8 shows, since 1980 the annual increase in milk yield has been identical in the two classes of flocks but there has been a lag of about 40 litres corresponding to 5-7 years of gain. This is a common pattern in nucleus schemes in a number of species. It is interesting to note that the milk yield of the Lacaune has virtually tripled since the 1960s.

2. Protein and Fat: In the early development of the Lacaune breeding scheme, milk yield was the prime objective but in the 1980s the compositional components, protein and fat, were included as objectives at the request of the cheese makers. Since that time there has been a modest increase of from 0.02 to 0.03 percentage points per year. There is a modest negative relationship between milk yield and milk composition so it was thought prudent to push for reasonably small percentage increases in milk fat and protein. Total production of these components will, of course, increase with milk yield so long as their percentage composition does not fall.

3. Other factors. The stated strategy as enunciated by Barillet (2001) has been to monitor certain traits like reproductive performance and feed efficiency that might begin to slip as a result of deliberate breeding for more obvious traits. But there are some traits that are being considered seriously to be included in the “global breeding goals” in the near future. A lot of background research has gone into developing a measure for “milkability” based on udder shape and teat angle which is due to be incorporated next year with the aim of producing sheep that are easier and quicker to milk by machine. There has also been some concern as a result of the monitoring process showing that the somatic cell count and milk yield were mildly correlated. In other words successful selection for milk yield may increase the somatic cell count and incidence of mastitis. Genetic breeding values for somatic cell scores are being given to breeders in the nucleus flocks in 2002 and these may be incorporated in the global plan later on.

In addition, a massive program is being implemented in 2002 for the elimination genetically of Scrapie from the Lacaune breed. This is covered more on pages 31-32 of this report.

Other breeding schemes for milking sheep in France.

The Lacaune breeding system was the first and is the biggest in France. It is the model on which programs in most other countries are based. The breeding programs for the fledgling sheep milk industries in the United States and Canada and for breeds in a number of European countries have all emulated at least some of the favourable aspects of this model. This includes the other two major sheep-milk producing areas in France, the Pyrénées Atlantique and Corsica.

Neither is as big or has been focussed on scientific breeding as long as the Roquefort region but the schemes are now well established and have made great progress. They are of interest because they have some features that are different from the Lacaune model that have required a modified approach. I did not meet people from the Corsican society but I was well briefed by several members of the organisations that run the breeding program for the Pyrénées-Atlantique region.

Pyrénées Atlantique region. This region covers the south west of France including the Pyrénées mountains and the Basque country of northern Spain. It once supplied milk to Roquefort cheese makers but this was discontinued in the 1980s due to oversupply. They now produce a range of regional sheep cheeses and yoghurts in 10 main cheese factories mostly under regional quality control labels.
Their concentrated breeding program began in 1980 with the formation of an organisation called CREOM. So it is effectively 15 or so years younger than the Roquefort program. Their objectives differ from those in Roquefort in that there were originally four visibly different breeds instead of one and two of these traditionally spend summer in the mountains and winter in the plains of the Atlantic coast which made logistics more difficult.

Table 3: Statistics for sheep-milk breeds in the Pyrenees Atlantique region

<table>
<thead>
<tr>
<th>Breed</th>
<th>Basco-Béarnaise</th>
<th>Black-head Manech</th>
<th>Red-head Manech</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total females</td>
<td>70,000</td>
<td>190,000</td>
<td>210,000</td>
</tr>
<tr>
<td>No producers</td>
<td>330</td>
<td>891</td>
<td>1792</td>
</tr>
<tr>
<td>Flock size</td>
<td>212</td>
<td>213</td>
<td>117</td>
</tr>
<tr>
<td>Production (l)</td>
<td>127</td>
<td>114</td>
<td>138</td>
</tr>
</tbody>
</table>

They quickly united two of the breeds; the Basque and the Béarnaise, which physically resembled one another, to form a single breed now known as the Basco-Béarnaise. This left three breeds that persist to-day (see examples in Figure 9). Statistics for each of them are shown in Table 3.

The breeding scheme is similar to that in Roquefort but the numbers are smaller. The main features of the scheme are:

- 450 breeders, or 1 in 6, flock-test for milk production
- About 100,000 ewes are involved
- 75,000 ewes are inseminated artificially
- 250 young rams are tested per year
- 150 rams are kept as “improvers”

The heaviest concentration of animals involved in the flock testing and progeny testing is in the Red-head Manech breed because these do not spend summer in the mountains. Breeds are kept separate in the overall scheme in much the same way as families are kept discrete in the Lacaune. However there is a “leakage” of breed type in which a proportion of breeders are prepared to cross-breed their animals, basing their decision on the performance of rams rather than their breed. This is most apparent in the flocks that go to the mountains in the summer and the farmers buy rams from the breeding centre for natural mating. However, the rules for regional quality control of sheep products often specify the breed of sheep which restricts the proliferation of crossbreeding and the eventual uniting of the breeds into a single entity.

M Luc Boucheron of CREOM described the development of the breeding scheme for the Pyrenees Atlantique over the 22 years of its existence. “Ten years of gaining the confidence of the growers followed by ten years of justifying that confidence—and now, at last, we are making progress”. One could hope that we, in Australia, can speed up at least that part of the process!
References


Barillet 1995b Genetic improvement of dairy sheep in Europe Great Lakes Dairy Sheep Symposium Madison 1-19


Introduction

Three countries, Greece, Spain and France produce, in roughly equal proportions, eighty percent of the goat milk produced in Europe. European goat breeding is strongly oriented towards milk production, with only 3% of the world goat population it produces 20% of the world’s goat milk. Most of it is transformed into cheese and, in the past, most of this was manufactured on-farm. However, in the last 20 years, France and Spain have seen an increasing amount of the cheese being made in specialist dairies to which the milk is delivered (around 70% per cent now in France). Italy, and most of the smaller producing countries still manufacture most of their cheese on farms. As with the sheep milk industry the French lead the way in the development of successful breeding plans for their industry and this report will concentrate on these breeding plans and their strengths and weaknesses as models for an Australian Breeding Plan.

The dairy goat industry in France

General: (Note: The general statistics for the French goat industry have been covered well in the RIRDC report by Gaille Abud and Arthur Stubbs, 2001.) Most of the milking goat industry in France, 1.1 million animals, is in the three regions depicted on the map; Poitou-Charentes, Centre and Loire. The main infrastructure and services are also in these regions. Only two breeds, the French Alpine and the Saanen, predominate and, unlike the sheep breeds used for milk, neither is French in origin. The next most popular breed is the Poitevine with a total of only 1500 registered animals. Almost all milk produced is converted to cheese with little yoghurt and virtually no whole goats milk being marketed.

The consumption of goat cheese is increasing at about 5% per cent per annum and this has been attributed to the image of goat’s cheese being the product of natural farm conditions compared with cow milk’s more industrialised image. Many cheeses have introduced an AOC or guaranteed quality assurance program to capitalise on this. The conditions for complying with the AOC have been set largely by the producers themselves but they have posed problems for some producers. For example, the image of goats frolicking in green fields is largely illusory because, at least until now, most enterprises have been entirely confined indoors. To maintain the right to use the AOC, some have had to purchase land to provide the necessary outdoor space for their animals. Others have had to rethink their worm control programs because totally hand fed animals have little or no trouble with worms while pasture-fed animals usually require drenching which, in turn, has to be done under stringent guidelines to comply with the conditions of the AOC.
**Year-round production:** Milk is produced all year round to provide a constant supply of cheese, most of which is sold and eaten without much storage. The animals are seasonal breeders and all of the farms that I visited were using techniques to ensure that at least half of the herd kidded out-of-season to maintain a consistent supply of milk. Most use adjustment of the daily light available to animals with or without the use of melatonin (Regulin) implants (Figure 10). They often used these techniques with both bucks and does because bucks are also affected by the season and produce less semen of poorer quality in the spring than the autumn. The “male effect” or “buck effect” is also used routinely to induce early mating in does. These techniques have been entirely successful and so most producers now organise to have two kiddings a year—October, which is out-of-season and Feb March which is in-season. As with sheep, hand milking has been replaced entirely with machine milking. Kids are weaned after a few days and the newly kidded does are brought into production within a week of parturition. The kids are artificially reared (Figure 11), either on the farm or in specialist rearing enterprises. There is little or no French equivalent of the Italian Capretto, or 5-7 kg carcase. A lot of goat meat is eaten in the country but it is from 3-4 month old, heavier and more conventional carcasses.

**The organisation of French goat breeding.**

The structure of the organisations that control the milking goat industry in France is much looser than that for the dairy sheep industry. Part of the reason for this is traditional. Until relatively recently, most goats cheese was made on farms and sold independently and this independence has carried through to the structure of the industry. Nonetheless, a large number of regionalised cooperatives were formed and most still exist. Some have taken on the responsibility of developing, registering and supervising the AOC status of the regions.

However, when it came to setting up the national breeding scheme most of these cooperatives united to form or to use major groups that serve all of their needs, which are:

- A “breed society” or UPRA (Unité nationale de selection et de Promotion des RACES)
- A herd recording system
- A data processing facility
- An Artificial Insemination Centre

Each of these, in turn, has representatives from the myriad of other committees and organisations that make up the French scene. In general they are chaired by farmers and made up predominantly of farmers. However, they also include technicians and scientists so that the technical skills and scientific merit of what they administer is of a high order.
1. The Breed society—CAPRIGENE: This is the UPRA but it differs from the normal concept of a breed society in that it unites all of the major breeds, of which Saanen and Alpine constitute over 90 per cent, rather than representing only one of them. Its major focus is the improvement of the economic value of the animals through genetics rather than promoting show competitions based on appearance. Thus, it is clearly unlike the Australian concept of a breed society. Caprigene keeps pedigree data, herd recording performance data and provides these to producers and to the AI centres. It monitors progress and organises and sanctions the planned matings that are such an integral part of the national breeding scheme.

Figure 12: Sample from an information sheet provided to breeders by CAPRIGENE each 6 months

They take the information produced from the herd test data and processed by the genetics section at INRA (CSIRO equivalent) and provide breeders with the information on which to make their breeding decisions. A sample from a typical information sheet for breeders is shown in Figure 12. The information includes actual performance of each animal together with the estimated breeding values for each of the traits; milk, total protein, total fat, per cent protein, and per cent fat (in fact, they calculate the milligrams per litre of protein and fat rather than percentages but this can be converted to per cent by dividing by 10). The more important information from a breeding point of view is the group of estimated breeding values for each of these traits calculated from the animal’s own performance (if it is a female) and the performance of all of its recorded female relatives. In addition, they estimate a combined breeding value taking into account all of the traits and their economic and genetic values. This is called the ICC (Index Combiné Caprine) and, in practice, is the figure that most breeders take notice of. The formula used to calculate the ICC is:

\[ ICC = 1 \times \text{Total Protein} + 0.4 \times \% \text{Protein} + 0.2 \times \text{Total Fat} + 0.1 \times \% \text{Fat} \]

It is most interesting to note that this combined index which is claimed to produce the optimal genetic progress does not contain the amount of milk produced. Obviously, the amount of milk produced influences the total protein and fat produced but it is not used directly in the index.

Breeders also get information on the parents and grandparents of the of the animal including the ICC and, in the case of males, the number of daughters that were tested.
Another interesting innovation in recent times has been the introduction of “typing” for each animal. The technicians of the AI centres “type” the animal during one of their visits and this is heavily weighted towards the shape and attachment of the udder and the placement of teats. Each animal is given a typing score of -1, 1, 2, 3, or 4. Breeders can use this as they wish but for the breeding of potential “improver” bucks only does with a score of 3 or 4 are considered. Only about 1 per cent of does get a score of 4. (Further details of the typing are shown in the section on AI stations, pages 23-24).

Included in the list of information is a column marked “Qualification” or Grade with letters A, B or C. This divides the animals into three groups based on their estimated breeding values and their type. Grade A animals must have a breeding value or ICC rating above about +3, depending on season, and a typing score of 3 or 4. Grade C animals have an ICC value of +1.0 or less or a typing score of 2 or less or both. Grade B animals are intermediate. Under this system an animal with a very high ICC breeding value but with a low value for type, due, for example, to a faulty udder, cannot be given an A grading. By contrast a high type value cannot raise an animal with a mediocre estimated breeding value to an A grading.

CAPRIGENE also provides breeders with a lot of benchmarking information to help in management and breeding decisions. Breeders can see where they are in all of the traits compared with their performance in the previous year. They are also given the average performance in these traits of all of the animals recorded by CAPRIGENE. The object is to alert breeders to potential problems of, say, low fat percentages. If they find that they are below average or their herd is less good than the previous year in this area they may wish to seek management solutions or to mate their animals with bucks that have breeding values that are particularly strong in the trait in question. Information in this category covers 12 areas. The form of this information for two of them is shown in figures 13 and 14:

- Proportion inseminated
- % females each year from selected bucks
- Estimated Breeding value for total protein
- Estimated Breeding value for percent protein
- Estimated Breeding value for total fat
- Estimated Breeding value for percent fat
- Estimated Breeding value for ICC (see figure 113)
- Distribution of bucks by their grade
- Distribution of breeding does by age and conformation
- Distribution of breeding does according to grade.
- Benchmarking on performance (see Figure 14)
The breeders that I visited said that they made extensive use of this information not only for making breeding decisions but for decisions about feeding and management. For example, M Lamoriniere who manufactures his own cheese under the AOC, St Maure de Touraine, believes that his successful concentration on improving the fat percentage of his milk has led to his producing a moister and smoother cheese.

2. The herd recording system. Unlike their sheep breeding counterparts, who handle their own milk recording, the goat breeders have opted to contract out herd recording to an organisation called France Contrôle Latier (FCL). FCL handles most of the herd recording for dairy cattle in France and uses the same infrastructure, analytical laboratories and personnel for goats. This seemed sensible and, from an Australian standpoint, was interesting because it is an attractive option for a breeding program in this country. However, a number of producers raised said that there are problems with this approach. The first of these is the perception that the goat industry is the “poor cousin” and that the FCL was not interested in being flexible about its recording protocols. Breeders felt that they had little say in the way in which recording was carried out. At present, the methodology of goat recording is identical to that of dairy cattle—two records taken on one day each month for 9 months. This means that recording is relatively expensive and very much more expensive per litre of product than with cattle. This may explain why there are only about 160,000 goats recorded each year compared with nearly 800,000 ewes out of total populations that are similar in size.

One producer, M. Blanc of Sancerre who is not part of the major breeding program, nonetheless believes that milk recording is important for his management and spends the equivalent of $A6,000 per annum to have his 250 goats milk tested. This is a big expense and many producers were not prepared to pay it. As milk recording is an integral part of any objective breeding system, this means that they are not part of the national dairy goat breeding plan. Instead, they buy in bucks from other breeders. When they were asked about the criteria that they used to decide which bucks to buy they universally declared that they looked primarily at the ICC index value. Some said that they bought the animals unseen on this criterion alone. They reasoned, very logically, that they could get the benefit of the breeding program without trouble and expense by buying their bucks from people who were in the program. They apparently pay a reasonable sum for these animals and some of the breeders in the program made a significant part of their income from sale of male breeding stock. The danger is that the fewer people in the program the more the program costs and, more importantly, the slower the genetic progress. These factor are worrying the people in CAPRIGENE.

On the other hand, several producers who did not use milk recording felt that they would do so if there were a “simplified” and therefore cheaper test available as there is in the sheep milking industry. It is at this point that the apparent inflexibility of the recording organisation is seen as a possible hindrance to progress.

3. Data Processing. The data for both pedigrees and for milk data are processed by the genetics division of INRA at Jouy-en-Josas which provides the estimated breeding values and other processed data to CAPRIGENE for managing and distribution and also maintain the database. This has the dual
advantage of making use of the huge data handling facilities of the government organisation and ensuring that the INRA geneticists are able to monitor and, where necessary, carry out research to fine tune indexes and other information from time to time. The same organisation processes the data for all dairy sheep and, as far as I know, all dairy cattle.

4. Artificial insemination—CAPRI-IA. There are, in fact two AI centres for goat breeders. The first and by far the largest is CAPRI-IA, a cooperative, administered by breeders, that works closely with the genetics group, CAPRIGENE, (see 2. above). They have common members of their boards and are physically located in the same building in which they share office facilities to economise on administrative costs. The second, INRA-SEIA, located in the same general area, near Poitiers is a government owned station run by INRA (CSIRO equivalent). This station has a mandate to do research into reproductive techniques in goats. It has a small, commercial role in which it carries out inseminations on farms within a radius of about 25 km from the laboratory and justifies this as a means of keeping its research in touch with reality. The two stations are in a form of competition commercially but collaborate closely to ensure uniformity of delivery and purpose. They both have state-of-the-art facilities for semen collection freezing and processing but, of the two, INRA-SEIA has by far the best facilities for embryo transfer.

If it transpires in the future that embryos are collected to send to Australia (see later), this would be the best, and possibly the only centre with the facilities, staff and governmental authority to do it.

However, at present almost no commercial embryo transfer is done in goats in France and the 120 or so transfers per year carried out here are done on an experimental basis and mainly for the training of staff.

Figure 15: Diagram of breeding scheme for Alpine and Saanen milking goats in France
Health and quarantine facilities are of the highest standards at both centres. Neither the bucks or the semen processing laboratories are accessible to visitors without stringent precautions and animals go through a stringent entry process to minimise the introduction of disease entities. The bucks are held indoors at all times and are subject to a photoperiodic regime that ensures that they experience very little fluctuation in breeding activity. Semen is collected throughout the year and frozen for later use.

Between the two centres, about 60,000 inseminations are carried out per year and CAPRI-IA is responsible for about 90 percent of these. All inseminations are with frozen semen which contrasts with the dairy sheep industry where only fresh semen is used. There are three main reasons for this. The first is the anatomy of the genital tract of the two species. Properly frozen sperm are highly fertile in both species but lose most of their mobility in the process of freezing and thawing. To be able to fertilise an egg they must be placed in close proximity to it in the uterus by the inseminator. The cervix of the ewe is impenetrable and, to have any real chance of fertility, frozen semen must by-pass the cervix surgically and this is achieved by using laparoscopy. By contrast, the cervix of the doe, like that of the cow, can be penetrated with a pipette and the semen placed in the uterus where it is close to the ovum. The second reason for preferring frozen semen is that it can be collected and stored throughout the year to avoid short-term shortages during the breeding season. The third is that young bucks being progeny tested do not have to be retained by the centre awaiting the data from offspring. Once sufficient semen has been stored, the animals can be sold and their genetic material utilised or destroyed depending on the milk record of their daughters. The conception rate is between 60 and 65 percent.

The program of genetic improvement, which is presented diagrammatically in Figure 15, is similar in principal to that used in the milking sheep industry but the scale is much smaller. This is because of the very much smaller proportion of the total population of the goat industry that participates in the program. There are about 60,000 inseminations per year compared with ten times that number in sheep and about 150-160,000 goats that are milk-tested compared with about 800,000 sheep. This restricts both the numbers of bucks that can be progeny tested and the number of tested bucks available to the industry. Nonetheless, the numbers and the resultant genetic gain are still very impressive.

To build the nucleus of breeders who will produce the “improver” bucks for the industry, contracts are drawn up among the breeders who are willing to take part. These contracts, called “Genes +” contracts require that:

- the breeders inseminate a minimum of 30 percent of the females in their herd,
- continue to participate in herd recording and deliver male offspring from “planned” matings” to the AI centres for testing,
- have a commitment (unspecified, as far as I could determine) to the national goat improvement plan.

For this they get access to semen from the top bucks in the centres and, if they increase the proportion of the herd that is inseminated they get one free dose of semen in each four new does presented for insemination.

By using the estimated breeding values of does in the nucleus, matings are planned each year by the AI centres and CAPRIGENE to produce new candidate males. The matings are “planned” so that they avoid inbreeding and do not put too heavy a burden on any one breeder. Up to 400 of the best does and 5-7 of the best bucks from each breed are selected each year for such matings. They are expected to produce about 150 males that are taken as kids to the centres where, on the basis of health tests and conformation faults, about 50 are eliminated. The rest are grown on and a further 30 are culled for poor growth rate, low libido or poor quality semen. The remaining 70, roughly equal numbers of Saanen and Alpine, then enter the AI program and their semen is distributed among the participating flocks. About 180 does are inseminated to each male (12,500 does in all) with the expectation that around 70 daughters of each buck will eventually be recorded. In practice semen is continued to be
taken from the young bucks, even after the does have been inseminated, until a stock of from 4,000 to 10,000 frozen straws of semen has been built up. The animals are then sold, so the centre has large vats of semen in liquid nitrogen but is not overstocked with live animals.

After the results of the progeny tests become available, 50 percent of the semen of bucks whose daughters have less than average performance is discarded and the remainder is used as “improver” semen.
Unlike the sheep AI centres, the goat centres allow breeders to choose, if they wish, the bucks that they will use with their females and a detailed catalogue is printed each year to allow them to do this. The use of frozen rather than fresh semen ensures that, within limits, there is sufficient semen from even the most popular bucks. The breeders in the nucleus have exclusive use of the very best 4-5 bucks of each breed not only for the elite does that may sire future bucks but for their whole herds. The bucks with the highest ICC values are, naturally, those most in demand and this causes problems with availability from time to time. Semen from all but the few elite bucks is also available to people outside the breeding program including overseas buyers. This, too, is a major difference from the sheep AI centres.

The AI technicians from the centres also carry out typing of the females in the herds that are inseminated and this information is used for giving the females a conformation score. This score may or may not be used by individual farmers when planning their breeding program. But, because does with a score below 3 (on a scale 0-4) are never used as mothers of bucks destined for AI centres, the typing score is a vital ingredient in ensuring that conformation is an integral part of the national breeding system. The objective basis for the typing score for the mammary gland is shown diagrammatically in figure 16 which is taken from an explanatory booklet for goat breeders. It is interesting to note that all of the scoring, except for “depth of body”, is associated with the shape and attachment of the udder. The accompanying notes in the booklet point out that depth of body and milk production are totally independent. Those traits that can be physically measured such as teat length and diameter are measured and those that can’t are scored from 1 to 9. All tested bucks are given an estimated breeding value for each of these criteria which is the average of at least 30 daughters. This value for each of the 8 criteria is based on 100 being the average, very high being 120 and very low being 80. Then, depending on the criterion, the score above or below 100 indicates the relative value of the buck as a breeder for that trait:

- The length of teats and form of the rear udder should be as near average (ie 100) as possible.
- The front udder attachment, the profile, the floor of the udder, the rear attachment and the orientation of the teats should be as high as possible. Interestingly, a high floor of the udder is related to a lower total milk production but is considered important for ease of milking and the lifetime performance of the doe.
- The depth of body, with no relationship to milk production can be as the breeder wants it.

Recently, it has been discovered that a single major gene for alpha s1 casein has an effect on protein production. A study showed that animals with a single dose of the dominant allele for alpha s1 casein (called C+) produce milk that, on average, has a protein percentage that is 0.25% points higher than those that have no such allele. Those that have a double dose of the allele (called C++) are 0.47% points higher. This makes it an allele particularly important for the cheese maker. Because it is a major gene, it is simply inherited so that a buck with C+ will pass on the C+ to one out of every two offspring and a buck with C++ will pass on this C+ to all of his offspring.

So far, the French have been using this very promising information cautiously. They take blood samples, in any case, from all bucks destined for AI to verify their pedigree through DNA analysis and they use the same blood to check the casein s1 alpha status. They recommend that producers use semen from bucks designated C+ and C++ over does that have milk that is low in protein. This information is available for all semen sold by the AI centres. In general, the incidence of dominant alpha s1 casein alleles is much higher in Alpines than in Saanens. The implications of this for cheese making and the fact that CAPRIGENE is the society covering both breeds may be the reason for the caution. On the other hand, alpha s1 casein is thought to be one of the major factors causing protein reactions to cow’s milk in some infants. Its low level in goat’s milk may make goats milk a useful substitute for feeding allergic children. By breeding for higher levels of this protein, goats’ milk may lose this advantage.

**Other considerations:** The down side to using AI in the French goat industry is that it is very expensive. One breeder quoted me the equivalent of $A50 per doe for a single dose with no free
returns. Another breeder quoted $A30-42 depending on the number of does to be inseminated at the same time. This explains why only about one tenth as many goats as sheep are inseminated each year. Exacerbating the problem is the fact that CAPRI-IA, the main organisation carrying out insemination, is geared up with equipment and personnel capable of carrying out at least 120,000 inseminations per year but only achieve 60,000. Breeders are charged enough to cover costs so CAPRI-IA admit that the cost could be almost halved if twice as many people used the service. The AI centres do not sell males for natural mating as their counterparts in the sheep industry do. Instead, many of the breeders who are part of the national scheme obtain a significant part of their income from the sale of breeding bucks.

I talked with several forward thinking breeders who had made conscious and reasoned decisions not to use AI. They argued that they were financially better off to buy bucks and mate their herds naturally. When questioned about the criteria that they used for choosing bucks, they were adamant that they would only use bucks from “genes +” herds and base their decisions on the ICC values of both the dam and sire. In other words they did not wish to be part of the national breeding scheme for economic reasons but relied heavily on others producing the animals for them and understood the importance of estimated breeding values in selection. This is a rational approach but a real concern for the industry in France because the national breeding scheme is in danger of foundering if costs escalate and more people leave the scheme. As it is, the numbers of breeders and animals directly involved with the scheme are falling while the number of animals in the industry as a whole is continuing to grow.

**Outcomes from the breeding program in milk production and composition.**

The national breeding program for dairy goats has had demonstrable success as Figure 17 shows. In the 17 years, milk yield has risen from a mean of under 600 litres per lactation to around 780 litres or 1.8% per annum which is an impressive figure for the whole industry. Fat concentration has risen about 0.4, and protein about 0.5 percentage points. The concentration of protein has risen more than that of fat and from a lower base which reflects the stronger emphasis placed on this trait in the ICC index. By and large the annual responses are less than those in sheep. For example, the Lacaune has improved 2.5 percent for milk yield annually, but there are fewer animals and the intensity of selection is less in the goat industry. Breeders who also make their own cheese claim that the quality of the milk for cheese making has also improved but there are no objective data supporting this. It can be expected that the impact of molecular genetics and the inclusion of selection for alpha s1 casein in the breeding program will
accelerate progress in at least some criteria in the future.

The AI centres use figure 18 to point out that those herds that use AI have a better performance than those that do not and, among those that use AI, the more the better. This ignores the possibility that those who are likely to be users of AI may also be better farmers but the results still suggest that the bucks used for AI are better than those used for natural mating.

**References**

4. The desirability and feasibility of importing genetic material from France

Introduction

Given the quality of the breeding programs in place for milking small ruminants in France and the demonstrable success in developing the productivity of these animals there is little doubt that the inclusion of animals out of these programs in an incipient Australian program would be highly desirable. The third report in this series which will be making recommendations and options for an Australian breeding program will outline ways to ensure that introduced genetic material from any source is objectively assessed and integrated into a Australian environment. However, a priori, there is a clear attraction in the possibility of taking advantage of 20 or 30 years of focussed and successful breeding to “kick start” the local program. Under present regulations, live animals cannot be imported into Australia, all imports must be in the form of frozen semen or embryos. There are therefore two major barriers to be overcome in the importation of genetic material:

- sourcing high quality animals in the country of origin and their handling for the collection of ova or semen under appropriate conditions and
- meeting the strict conditions of the Australian Quarantine and Inspection Service.

Sourcing of high quality animals and collection of genetic material

1. Sheep. The main French breed that would interest a potential Australian importer of dairy sheep is the Lacaune. It is the most advanced genetically and has the best documented performance of any the world’s sheep breeds. But it is not simply a matter of choosing good animals and buying them. All of the best rams are housed at the two cooperative AI and Test centres neither of which has the sale of rams as part of its business plan. Australians may find this concept difficult to comprehend given the long tradition in this country of the sale of rams, sometimes at very high prices, being an important component of our sheep industry. The manager of one of the cooperative centres explained to me that they breed and test Lacaune rams to improve the production and quality of the milk produced by the females on producers farms. They are not interested in selling rams as a source of revenue and to do so may take their focus away from their main objective. On the other hand, several researchers claim that the genetics of the breed is at a high level and systems that they have in place will probably keep it at the forefront so it is reasonable to sell animals to capitalise on this resource. It is likely that they could expect repeat purchases as the animals continue to improve and the sale of these animals could represent a significant source of additional revenue that could be used to subsidise other parts of the breeding program. The few animals that they have sold in the past have been at a ridiculously low price which has not generated much enthusiasm for this form of trade. But it is the UPRA or breed society that determines the policy, not scientists, and they have almost absolute control over the best animals, both male and female. The ram breeding and AI cooperatives are entirely under their direction and the 400 or so elite farms where the best females are found are also controlled to some extent by them. First, through their sub-organisation, GENELEX, they must approve any animals that are sold for export and to whom. Any breeder of elite animals who sought to bypass this system would risk being demoted from the elite group. When I inquired about the possibility of their selling cull-for-age animals I was informed that they are only sold to abattoirs and are not for general sale even to other Lacaune breeders.

There are, however, Lacaune sheep in other countries including the USA, Canada and European countries where they are used for producing milk. As far as I am aware these animals were sourced from the lower tiers of the Lacaune system and not from the elite flocks or the ram breeding centres. In fact, as discussed earlier in this report, the second tier of producers over which the UPRA has much less authority are genetically only about 5-7 years behind the producers in the upper echelon. Realistically, this is the probably the most likely source of genetic material for a prospective Australian buyer.
Having acquired the animals, it would then be necessary to assemble them and prepare them for health tests and for semen or embryo collection. There is no organisation that I know of that does this so it would be necessary to find an individual to carry out these tasks. Bearing in mind that, in living memory, no sheep or goats have ever been exported from France to Australia there would be an element of trial and error. However there are two people who could be helpful to a prospective Australian importer.

One is an expatriate Welshman, Jim Windsor who has spent the last 10 years on his own farm in France near the town of Agen. He milks sheep, including Lacaunes, markets his own cheese and yoghurt under his own brand name in France and is an active member of the British Milking Sheep Association. He knows the industry well and has acted as a sort of agent for export of a number of breeds of sheep from France at various times.

The other is Jean-Charles Vallet, a Frenchman who was once with INRA but now acts privately as a consultant and teacher in reproduction and reproductive techniques. He knows the complexities of the system in France and once visited Australia for a short time in 1988.

The collection of semen or ova would be best done at the laboratory of INRA-SEIA at Rouillé where the manager, Dr Bernard LeBoeuf, has confirmed that the laboratory and facilities are approved by the French Government which would be a condition for AQIS allowing the material into Australia. Dr Yves Cognié, of INRA, France’s leading reproductive technologist (and an Australiaphile! ) told me that he would be willing and able to carry out the work should it eventuate that some deal were struck by an Australian importer.

Goats. In contrast to the French milking sheep industry the French goat industry makes purchasing genetic material comparatively simple. They make it clear that they are in the business of selling semen, in fact the same semen that they sell to their own breeders with the exception of the half dozen or so special animals reserved for the Genes + contractors. The same organisation that sells semen, CAPRI-IA also advertises that it sells embryos although the exact mechanism of selecting does, which would have to be done in conjunction with a private producer, is not spelt out. The collaborating government controlled laboratory of INRA-SEIA at Rouillé is as well equipped as any in the world to treat does and collect embryos. There is an organisation called SERSIA France that handles the business dealings associated with exporting genetic material from animals. They would have to be involved to obtain the necessary papers for eventual importation but the procedure is relatively straightforward.

Meeting the conditions set by the Australian Quarantine and Inspection Service

The outbreaks of foot and mouth disease, and BSE in Europe, especially the United Kingdom, have made quarantine requirements for the importation of genetic material even more stringent than before. However, the Australian Quarantine and Inspection Service have introduced new protocols for the importation of sheep and goat genetic material in the last 18 months. To this date, no one has brought material in under the new regime. The modified regulations take into account recent improvements in our understanding of some of the diseases but also the fact that sperm or embryos often carry less risks than live animals. The old protocols involved a quarantine period of 7 years to guard against the late appearance of Scrapie but the new ones allow the use of material as soon as it is imported. The trade-off involves an extremely rigid pre-importation control in the country of origin.
The full protocols run to some 30 pages for each species but they are basically similar. Briefly they require that:

- The country be free of the most serious diseases like FMD and BSE.
- It has a rigid notification and eradication scheme in place for the more serious diseases
- Tests are carried out, where such tests exist, for all of the relevant diseases, including some already in Australia and that the test be government approved.
- The animals be at least 5 years old
- The collection of sperm or eggs be done under government control on premises approved by AQIS
- On completion of the collection, the animal be slaughtered and brain and nervous tissue be cultured to test for the presence of Scrapie.
- A DNA sample be taken to verify the identity of the animal when its offspring are born in Australia.

At present importations are possible from many of the European Union countries but not the UK because of its FMD status.

The major disease by far that concerns AQIS (and Australia) is Scrapie. It is endemic in Europe and, so far, we are free from it. It was thought to be caused by a “slow” virus because symptoms do not usually appear until the animal is 3-4 years old. This was the reason behind the former long quarantine period of 7 years and is the reason behind the new protocols requiring animals at least 5 years old. It is now known that the causal organism is a prion, the same class of organism as that which causes Mad Cow Disease or BSE. BSE is now believed to be transmissible to humans and some small doubt still exists about whether or not Scrapie is also transmissible to humans. There is also a lot of work going on in Europe to determine whether sheep and goats can be vectors for the cow prion, BSE. While these doubts remain, it is more important than ever to keep Scrapie out of Australia.

In the last few years, using molecular biology techniques scientists, mainly from France have shown that there is a gene in both sheep and goats, called the PrP gene, that has alleles which give susceptibility or resistance to Scrapie. A large number of breeds, especially in sheep, have been screened for the presence of these alleles on the PrP site and it has been found that some have a much higher proportion of resistant alleles than others. Interestingly enough one of the races with a very low proportion of resistant genes is the Manech milking breed of the Pyrenees. There is also a relatively high incidence of Scrapie in that region.

AQIS has included in its protocol that potential donor animals should be typed for PrP and only those with very low resistance to Scrapie be allowed to provide genetic material for importation to Australia. The reason for this seemingly unusual condition is that animals with low resistance should express the disease while those with high resistance might not show it but still carry the infectious factor.

In France, and in the UK and Holland, massive programs are under way to eliminate Scrapie in sheep by genetic means. This is based on the observation over many ten of thousands of animals that those with a double measure of the resistant allele have never shown symptoms of Scrapie even after experimental attempts to infect them. In addition, those animals with a single measure of the resistant allele are extremely hard to infect but there have been a few breakthroughs. The programs involve typing all animals for the PrP gene and mating them in a way that increases as quickly as possible the frequency of the resistant alleles. The most advanced breed in this program is the French Lacaune because its mating is so heavily controlled. From this year, 2002, all rams used in the breeding centres and distributed by them will be “homozygous resistant” (ie have a double dose of the resistant allele). All progeny born from these rams will have at least one resistant allele. Of the females of this generation, at least half of their progeny will have a double dose. It is planned that all Lacaune animals will be genetically immune by 2006.
Therefore, from the point of view of importing genetic material from the Lacaune breed we are already too late if AQIS retains its present protocol. French geneticists to whom I spoke were critical of the conditions imposed by AQIS on two counts. The first was that, in their opinion, slaughtering and culturing nervous tissue and brain is unnecessary and insensitive. They claim that a culture from a simple biopsy from the tonsils of animals will demonstrate the presence of the disease as early as 2 months of age even though overt symptoms of the disease may not appear until two years later. Second they claim to have evidence that animals typed as “double resistant” not only are resistant to the disease but re unable to act as carriers for it.

In the goat, the story is far less positive. Goats in general, seem to be less susceptible than sheep to Scrapie and there are a number of alleles for the PrP gene in goats. However, so far it has not been demonstrated that that there are alleles that give protection from Scrapie. A paper at the World Goat Conference in Tours 2000 (Goldmann, 2000) suggested that certain genotypes have an effect on the duration of incubation of the disease. To add real confusion, Billinis et al (2002) studied 51 Greek goats, both healthy and infected and found 11 different genotypes present. Each of the eleven were seen in at least one of the sick animals and each seen in at least one of the healthy ones. So, it seems premature to think that there is the possibility of selecting goats for resistance through this gene as is now being done vigorously in the sheep. Equally, there does not seem to be much use trying to use the gene in quarantine protocols for goats: the presence or absence of certain alleles does not, at this stage, give much indication of whether the animal is resistant or susceptible.

Since returning to Australia I have had talks with the AQIS people including Dr Judith Bourne, who is responsible for the protocols in this area about the French views and their latest information. AQIS must remain cautious and conservative. To do otherwise would be irresponsible. However I believe that they are also trying, as far as prudent management will allow, to accommodate Australian livestock breeders who wish to introduce new genetic material. They are now aware of the latest French information about sheep but they do not have the irrevocable proof that it is valid in all cases because the scientific article with the data and, presumably, its justification is not due to appear until August.

In summary, it is virtually impossible to introduce worthwhile genetic material from French dairy sheep breeds into Australia under the present protocols under which the quarantine system works. However, there is a strong probability that new information will lead to modifications to the protocols and the possibility of entry in the next 12 months. For goats it seems possible, though still difficult, to find genetic material that would meet the present protocols and process it through the existing rules.

References


Billinis et al 2002 Journal of General Virology 83 . 713
Appendix 1— List of people consulted

Names and occupations of people consulted in study tour of France
26 February —15-March 2002

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<thead>
<tr>
<th>Name</th>
<th>Location</th>
<th>Occupation</th>
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<td>Name</td>
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<td>Mr Jim Windsor</td>
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Appendix 2 - The Workshop Participants

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Progress report to
Rural Industries Research and Development Corporation
1 October 2001

Project number: DRL-1A

Improved Breeding in Dairy Goats and Milking Sheep

Principal Researcher: David Lindsay
Other Researchers: James Skerritt,
Roberta Bencini
Commencement date: 02/04/01
Completion date: 01/10/02
Project objectives

- Clarify breeding objectives for dairy goat and milking sheep enterprises
- Identify and assess present breeding objectives, performance recording and selection methods
- Propose future program options and recommend a preferred improved breeding option
- Assess the likelihood of adoption of improved breeding and ways to generate this adoption
- Evaluate the need for importation of new genotypes and, if desirable, the type and source
- Identify the opportunity and impediments in importing desirable genotypes
- Recommend how imported genotypes could be incorporated in the proposed breeding program
- Document how to measure the increase in production per head and milk quality by using the improved breeding program
1. Introduction

The first phase of the project, canvassing the main players in the sheep milk and goat dairy industries, is now complete. In this phase most of the above objectives were examined informally with the interviewees. A list of the people who were consulted is appended to this report.

The methodology was to present them with several hypothetical breeding strategies that could be used in a national breeding policy and explore their reaction to these strategies and their potential willingness to participate. In particular, I sought opinions on the perceived merits of a coordinated breeding system relative to the breeding methods that they now have in place.

Present breeding strategies in the Sheep and Goat milk industries.

The level of sophistication and effectiveness of breeding plans in both industries is very low. In general, few breeders have systematic plans in place for choosing breeding animals, particularly males, and those that do recognise that their options are severely limited by the lack of reliable information. Some milk producers test the volume and quality (fat and protein) of the milk produced by their females but use the information more for management than for breeding. Pedigreeing of the animals—the methodical identification of offspring and parents—is not common in commercial units and so the identification of males from top producers is also difficult. Commercial goat milk producers often source their males from small studs many of which have production records but relatively few animals. Unfortunately, most of the producers with whom I talked had little confidence in such records believing them to be heavily inflated due to selective feeding and pampering. The choice of breeding stock in most of these studs is heavily biased towards conformation and “dairy type” rather than production records.

Producers of sheep milk are in an even worse position because there are no sheep dairy studs at all and few production records except for their own. Instead they tend to resort to the concept of “breed”, choosing, for example, East Friesians, Texel-Dorset cross or Awassis because they are reputed to be good milk producers. In reality, even the reputed dairy breeds like the East Friesian and the Awassi have not been selected in Australia for ten or more generations and were originally introduced here principally for their meat rather than their milking attributes.

Attitudes towards the development of a National Breeding Program.

Most of the leaders in the sheep and goat milk industries recognise very clearly the need for a coordinated and scientific approach to the improvement of dairy breeds. They are very well aware of the enormous and continuing success of scientific breeding in the bovine dairy industry and have confidence that, with the right programs in place, their industries can emulate this achievement.

Most of them have had to spend part or all of the last decade endeavouring to get on top of the manufacture and marketing of dairy products and as a consequence animal breeding and other aspects of the production system have received little attention. They claim that they are now better placed to turn their attention to breeding and are keen to get a program under way. Almost all of them recognise that markets are still a problem and have varying degrees of optimism about market prospects in the next decade. Some will be happy to see the present level of activity in the industries being maintained but most are confident enough to be planning expansion of their herds or, in the case of processors, their throughput of milk. For example, one sheep producer was in the preliminary stages of a plan to use 20,000 animals to provide milk to make Haloumi cheese for export and a goat dairyman has plans to set up a 4000 doe dairy in the near future as part of an ambitious expansion program. Clearly, sheep and goats with solid breeding backgrounds based on production and milk quality are an integral part of developments on this scale. Within the dairy goat industry, the positive tone of the report by Kate
Stoney and Julie Francis on marketing goat dairy products in Asia has been a stimulus to much of the enthusiasm.

At the level of importing genetic material from countries with well established breeding programs such as France, Italy and Israel, the response is more equivocal. This seems to be associated with two factors; the perceived complexity of the protocols for importing sheep and goat embryos and semen into Australia, and the viewpoint, at least in the dairy goat industry, that overseas animals may not produce any better than local ones. However, there is some interest in exploring both of these issues more fully and they are being addressed as part of this project.

There is, understandably, a degree of commercial rivalry among producers who also manufacture milk products that compete in the markets. By contrast, the success of a National breeding program will depend largely on the way in which all producers pull together to provide links between herds and flocks, facilities for progeny testing, information for and access to national data bases and support for a central infrastructure to provide them with the resources they need for effective breeding. Most appreciate this and expressed their willingness to become part of a “national flock” for purposes of breeding superior animals some of which might be used by other producers.

It therefore seems likely that, if an acceptable scheme is developed most of the major commercial milk producers will take advantage of it. Acceptability will depend on the satisfactory development of 6 key factors that will link to provide a functional overall program. This program should lead to relatively rapid genetic in the short term and into the foreseeable future because the base herds and flocks are at present largely unselected or selected at low intensity for milk and milk quality.

The six key issues are:

- Development of satisfactory selection criteria.
- Identification and recording of pedigrees.
- A robust and repeatable program of herd recording.
- A service to use pedigree and production information to provide breeders with breeding values of their own and others’ stock and to build and store data bases.
- A means of identifying and assessing overseas genetic material from countries with a history of genetic progress in milk sheep and dairy goat animals, meeting quarantine requirements and integrating these animals successfully into Australian flocks and herds.
- A coordinator or coordinating body that will ensure that the program of identifying, testing, evaluating, promoting and communicating runs smoothly and to the satisfaction of the breeders who will be the stakeholders.

The final report to RIRDC will address how each of these six issues can be optimised within the existing Australian sheep milk and goat dairy industries with recommendations for implementation. The remainder of this interim report summarises progress of the project under each heading to the end of September 2001 and indicates the questions to be addressed in the rest of the project.

1 Development of satisfactory selection criteria.

It is important that the selection criteria for choosing breeding animals be clearly and carefully established at the outset of a breeding program. Changes along the way or unclear criteria restrict genetic progress. In addition wide differences in selection criteria among breeders can dissipate genetic improvement and slow progress within the industry as a whole. There seems to be good consensus among breeders about the properties of milk that should be targeted but there is more diversity of opinion about other factors associated with the animals themselves.
• **Milk and milk quality:** At the present time, most processors of cheese and yogurt who source their milk from producers pay on volume of milk alone. They agree that the constituents of milk can vary widely between farms and within seasons and that this affects the yield of final product. However, when total delivered volumes from any one producer are small and access to test equipment is difficult, processors find it easier to measure and pay on volume alone. Despite this, they all agree that payments in the future must include total solids or its major components, fat and protein as in the dairy cow industry and breeders are more than prepared to select for criteria for which they will be paid. The basis for payments should be similar for cheese, yoghurt or dried milk. Overseas information shows that, in goats, selection for the A allele at the \( \alpha_s \)-casein locus results in very significant gains in yield of protein and fat and is now being incorporated in selection programs for Saanen and Alpine goats in that country. It may be worth incorporating in an Australian program.

• **Factors associated with the animal.** One or two breeders felt that breed type and, in the case of goats, “dairy” type were essential criteria in any program. Others felt that this would be covered adequately if they concentrated on selecting for productivity. There was general agreement that that udder shape was important for rapid and trouble free machine milking although some felt that the use of the “sagi hook” could adequately compensate for poorly shaped udders. Similarly, breeders were divided about the ideal period during which lactation should be measured especially in goats. In the absence of pregnancy dairy goats will produce for 2 years or more in a single lactation. Clearly their total lactation cannot be easily compared with that of animals that kid annually. It is likely and totally justifiable that some breeders will have different selection criteria than others and breeding schemes should cater for this. The essential is that the main criteria, volume of milk and its quality, be part of all schemes to ensure that the industry as a whole progresses at a rate close to maximum while maintaining diversity at the margin.

**Still in progress:**

• Compare selection criteria in countries with successful breeding schemes with those proposed for Australia.

• Find out how the French schemes in particular are planning to incorporate new technologies for testing allele frequencies into their breeding criteria.

2. **Identification and recording of pedigrees.**

An essential feature of modern quantitative techniques is the use of estimated breeding values (EBVs) or estimated progeny values (EPVs) instead of individual performance. These are obtained by BLUP (best linear unbiased prediction) techniques which use information on the relatives of the animal being assessed as well as its own performance. It is a superior approach in all animal breeding but is particularly applicable in the dairy industry where performance of male animals cannot be assessed. It requires not only performance recording but a method of recording the pedigree of the animals—most usually controlled mating and identification of the animal at birth. Recording of this information is simplified by the availability of a number of software programs that often comes with packages supplied by commercial data manipulation companies. But the area that breeders may find difficult is the physical gathering of the information. Commercial breeders with big herds or flocks may have problems in providing the facilities and the time to identify all animals clearly. In the future, DNA fingerprinting of all animals in the herd or flock will almost certainly eliminate most of this problem but, for the present, the cost at about $19 per animal is prohibitive for owners of sheep and goats. This cost will fall in the future as competition develops and the techniques become more refined but, in the short term, large units will be faced with a considerable outlay to meet this need. Many owners of smaller units who were interviewed already recorded matings and births and did not consider that this would pose an impediment to their participation in a coordinated breeding scheme. By contrast, those with bigger groups of animals and those planning big expansion saw the identification of animals as a major hurdle that would involve a change in their management systems to overcome.
Still in progress:

- Consultation with operating and pending DNA-identification companies to assess the likely time frame for decreasing costs to a level that is commercially acceptable for goat and sheep milk producers.
- Discussion with French and Italian farmers with large herds about their methodologies
- Development of scheme within the overall Australian breeding program to accommodate breeders who feel that they can only pedigree a proportion of their herds through the use of nucleus herds and tiered breeding techniques.
- Obtaining information, including costs, on new tagging and identification procedures that may be useful for sheep and goat breeders.

3. A robust and repeatable program of herd recording.

The need for herd recording is undisputed but the methodology must be reliable and standardised. It is not simply a matter of applying the methods and facilities available to producers of bovine milk because of the much smaller scale of the sheep and goat milking industry and their wide geographical dispersion. For example, the unit cost of recording small ruminants is the same as for dairy cattle and this virtually prohibits the use of completely serviced herd recording assistance. Breeders will have to record as much of the information about their own animals as they can and use outside services to carry out specialised analysis such as fat and protein percentage. Some breeders thought that others may cheat in order to make their own animals look better but this is not a major concern. Jim Saunders of the National Herd Improvement Association which is the umbrella organisation for most of the dairy cattle herd improvement providers in Australia says that more and more farmers are carrying out most of their own recording with no record of manipulating the system because there is so little to gain. However where breeding and the provision of male animals to commercial producers is left to a number of small studs this may be a problem. The breeding scheme envisaged for the sheep and goat industries will be designed for the commercial producers who will largely be producing their own breeding animals and for whom, as with dairy cattle breeders, there would be no advantage in fiddling the system.

Essentially, herd recording requires the measurement of milk volume and the testing of its contents at designated, regular intervals. What is measured and the accuracy of the testing needs to standardised for there to be a nationally useable system. Fortunately, the analysis of milk samples from goats and sheep can be done in the same laboratories and with the same equipment as for cows’ milk. Whether preserved samples are done centrally at one laboratory or processed by the nearest herd improvement provider is not important because standards are already in place.

Measurement of milk volume requires relatively expensive equipment (~$700 per meter) which, for most cattle dairies, is supplied on the day of the test as part of the service by the local herd improvement provider. The meters bleed off a small sample of milk during the milking process for later analysis. A valve fitted to dairy cattle meters allows them to be used for sheep or goats and some goat breeders use this service routinely. However, the service is not available in all areas. The geographical distribution of goat and sheep milking herds and the presence of many of them outside the normal dairy cow regions are disadvantages here. Producers in these regions may have to consider purchasing meters, presumably cooperatively, and ensuring that they are moved regularly from place to place as required. This is the system used by some dairy cattle producers in remoter areas like north Queensland. Herd recording is a valuable management tool as well as an essential part of objective breeding and this may influence decisions to purchase meters. In addition milk meters for sheep and goats are identical and it may be feasible, in some circumstances at least, for the two industries to support one another.

The task of recording is quite disruptive to the dairy routine on the day of recording and the traditional frequency is once a month at both the night and morning milking. French workers have looked at ways of reducing the frequency of recording based on the penalties for inaccuracy and the purpose for which the information will be used. For example, less frequent testing is acceptable where the females tested
are not likely to be used to produce prospective sires. Under certain circumstances, analyses for protein and fat are not needed as frequently as measurement of volume. This is a potential area for savings in time and labour.

**Still in progress:**
- Obtain estimates of costs and availability of milk recording equipment for both hire and purchase.
- Get full details on the shortcuts in recording that the French producers have found acceptable and relate them to an Australian breeding program.

4. **A service to use pedigree and production information to provide breeders with breeding values of their own and others’ stock and to build and store data bases:**

Fortunately, Australia is well served in this area and the fact that we are dealing with milking sheep and goats rather than milking cows or meat or fibre producing sheep and goats makes little difference to the choice of service. We have already approached Lambplan and the Dairy Herd Improvement Scheme and both have expressed enthusiasm to expand their activities to provide a complete service to the dairy goat and sheep industries. We have yet to talk to Animal Breeding Services in NSW. There are also overseas providers of good data storage and processing services that could be used. Transferring data back and forth to anywhere in the world is simple so that the industries are not confined to Australia.

In the end the industries themselves will need to choose their service provider and we will be recommending that the contenders for the job address the industry to outline their services and prices. The important factor that the industries will need to consider is that they should choose only one provider for their industry, partly to ensure uniformity of the information that they receive, but principally to ensure that the database that will be generated will be in one place and complete. The database will be an increasingly invaluable resource for research and auditing of breeding progress and the sheep and goat industries will need to retain a measure of control over it.

**Still in progress:**
- Continue to involve providers of genetic data processing to develop options for the sheep and goat industries from which to choose the best possible service.
- Explore the services available in other countries with sheep and goat milking industries and their relationships with the industries they service.
5. A means of identifying and assessing overseas genetic material from countries with a history of genetic progress in milk sheep and dairy goat animals, meeting quarantine requirements and integrating these animals successfully into Australian flocks and herds:

Some overseas countries with extensive sheep and goat milk industries, particularly France, have had extensive objective breeding schemes in place for over 30 years and have improved the dairy production of their animals spectacularly. In French sheep, for example, the measured progress in milk volume over the last 20 years has been around 6 litres per annum and the production has doubled in that time. The progress in goats is reported to be on a similar scale. It is reasonable to assume that there is genetic material that could be used to advantage in the Australian industries if we can import it and if it is used wisely.

AQIS, the Australian Quarantine Authority, has recently brought out new protocols for the importation of sheep and goats from selected countries and I have discussed these at length with them. To date they have had no request to import sheep or goat semen or embryos under the new protocols.

The Foot and Mouth outbreaks in the UK have eliminated that country as a source but their dairy sheep and goats are of marginal interest anyway. Importations are possible from France, USA and Italy under very strict conditions. Essentially, the donor animals have to be at least 5 years old, come from herds that are officially disease free and, after the semen or embryos are collected, must be slaughtered so that their brain and spinal nervous tissue can be cultured to test for the presence of Scrapie. If these tests prove to be negative the semen or embryos can be imported and used immediately in Australia. There is one other factor which needs to be addressed in intended imported animals. There are traceable loci in both sheep and goats for alleles (designated PrP alleles) that give animals resistance to scrapie. The frequency of these has been mapped in a number of breeds and Dr Elsen at Toulouse is the French expert in this area. AQIS looks more favourably on animals of breeds where there is a low frequency of the PrP alleles so that any infection with Scrapie will not be masked. However, they inform me that they are open to negotiation on this issue.

Thus, there are many factors to consider when planning importation and the costs will probably be very high but the rewards for obtaining the fruits of 30 years objective selection for the traits that Australian dairy farmers need may warrant the expense. Selection of the animals to provide semen and embryos in countries with active breeding programs in place and copious documentation should be relatively simple. Meeting the quarantine requirements may be harder.

Still in progress:
- We have the detailed protocols from AQIS and plan to examine the facilities in France and in Italy for their capacity to meet the protocol requirements.
- The European breeds that will be of interest are Lacaune and East Friesian sheep and Saanen and Alpine goats. For the final report we will evaluate the availability of high quality animals, their likely cost and contact agents.
- We will prepare a table of PrP allele frequencies for breeds and strains of interest to the Australian dairy industries.
- Since there is now some selection in certain countries for a high frequency of the PrP alleles there may be an opportunity to negotiate favourable purchases of otherwise high quality individual animals that have been rejected because of low frequency. This will also be explored.
- As part of the overall breeding plan for the Australian industries we will prepare a scheme for the controlled incorporation of imported genetic material into local herds and flocks.

6. A coordinator or coordinating body that will ensure that the program of identifying, testing, evaluating, promoting and communicating runs smoothly and to the satisfaction of the breeders who will be the stakeholders:

Much of the breeding plan that will be recommended will be new to many of the sheep and goat breeders and will need coordinating and promotion. It is unlikely that a worthwhile national scheme can be viable without such coordination for many reasons.
• Breeders are going to need reassurance as they enter new activities and will need help in interpreting the output from the service providers.
• Promotion of the scheme is needed to encourage as many participants as possible to increase its effectiveness and the overall rate of progress.
• It is important that there be smooth interaction between breeders and the service providers for herd testing and for genetic evaluation and the development of on-farm and off farm databases.
• Encouragement to use artificial insemination and to facilitate the exchange of semen and genetic material between participants.

Still in progress:
• The final report will have a suggested job description for a coordinator including the amount of time they might spend and the desirability or otherwise of a joint appointment between the goat and sheep industries or a part time appointment.

General considerations

The project is progressing well and the enthusiasm of the key people in the industry that have been consulted is promising. There are still about 6 industry people that have not yet been interviewed due to absence or prior commitments at the time of the proposed visit. They will be contacted during the next few months as the opportunities become available.

DRL plans to visit the contacts that will be made in Italy, France and Spain in March 2002 where much of the remaining background information on the issues outlined above will be finalised. Then, with the other two colleagues in the project (JWS and RB) the detailed draft breeding plan will be put together and submitted in August 2002 for the meeting of producers in August or September.

A further progress report is scheduled in three months time (01/10/2002). I (DRL) will be on holidays for 6 weeks from early October. During that holiday, I have arranged to make initial contact with a number of the European geneticists, sheep and goat breeders and industry personnel with whom I plan to have longer meetings the following March. Nevertheless, there will be only a limited amount of new information to report on 1 January.

As I see it there are two options. Either report as scheduled with the limited amount of new information on 1 January and present the rest in the draft report due in August, or delay the progress report until say 30 April, 2002, presenting the draft report as scheduled in August. I would appreciate advice on this at your convenience.
Sheep and goat industry personnel consulted so far as part of this project.

### 1. Sheep

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<tr>
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<tr>
<td>Robert Manifold</td>
<td>Mount Emu Creek Dairy</td>
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<td>Camperdown, Vic.</td>
<td>Processor</td>
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<td>Bruce Elizabeth and Mac</td>
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<tr>
<td>Cumming</td>
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<tr>
<td>Herman Raadsma</td>
<td>Univ of Sydney, NSW</td>
<td>Producer,</td>
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<tr>
<td></td>
<td></td>
<td>Researcher</td>
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<tr>
<td>Phillip Ledin</td>
<td>Warragul, Vic.</td>
<td>Breeder</td>
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<tr>
<td>Trevor and Debbie Dennis*</td>
<td>Cloverdene, Karridale WA</td>
<td>Breeders,</td>
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<tr>
<td>Mr Wacoub Homaizi</td>
<td>Owner YYH Holdings</td>
<td>Breeder,</td>
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<tr>
<td></td>
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<td>(Awassi Sheep)</td>
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<tr>
<td>Graham Daws</td>
<td>Manager, YYH Holdings</td>
<td>Breeder</td>
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### 2. Goats

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<tr>
<td>Hanna and Michael Wardell</td>
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<td>Tony Barker</td>
<td>South Riana, Tas</td>
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<td>Joe Hall</td>
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<td>Malcolm Barton</td>
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<td>David Brown</td>
<td>Milewa Cheeses Milewa, Vic</td>
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<td>Gabrielle Kervella</td>
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<td>Raelene Heston</td>
<td>Korot St, Warambool, Vic</td>
<td>Breeder</td>
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<td>Editor, <em>Goat World</em></td>
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<tr>
<td>Sandy and Julie Cameron</td>
<td>Meridith Dairy</td>
<td>Breeders</td>
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<tr>
<td>Gayle Abud</td>
<td>Hurstbridge, Vic</td>
<td>Breeder, Consultant</td>
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<tr>
<td>Arthur Stubbs</td>
<td>247 Drummond St, Carlton, Vic</td>
<td>Consultant</td>
</tr>
<tr>
<td>Michael Rocca</td>
<td>Gunns Plains, Tas</td>
<td>Breeder</td>
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<tr>
<td><strong>Other</strong></td>
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<tr>
<td>Jim Saunders</td>
<td>National Herd Improvement Assn., Vale St, Melbourne Vic</td>
<td>Herd Improvement CEO</td>
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<tr>
<td>Robert Banks</td>
<td>Univ of New England, NSW</td>
<td>Genetics consultant</td>
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<tr>
<td>Michael Hibbert</td>
<td>AFFA, Canberra, ACT</td>
<td>Manager, Live Animal Import and Export</td>
</tr>
<tr>
<td>Judith Bourne</td>
<td>Biosecurity Australia, Canberra, ACT</td>
<td>Veterinary Officer, Animal Biosecurity</td>
</tr>
<tr>
<td>Martin Holmes</td>
<td>AQIS, Canberra, ACT</td>
<td>Manager Animal Programs</td>
</tr>
</tbody>
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