Sheep Breeding:

Complex Decision Making and Brand Loyalty

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Executive summary

Market research was conducted to investigate sheep breeding decisions from a consumer behaviour perspective. Interviews with woolgrowers, extension professionals, brokers and consultants were used to identify the key criteria that influence the sheep breeding decisions of woolgrowers. The interviews were used to design a mail survey that was distributed to woolgrowers throughout Victoria.

The key findings of the study are:

Woolgrowers can be classified into six breeding strategies based on their beliefs about the key risk factors involved in breeding principles. These beliefs, which are firmly grounded in their experiences, relate to:

- The impact of the environment on the ranking of bloodlines in terms of fibre diameter and fleece weight.
- Genetic interactions between rams and ewes,
- Differences in livestock management between the stud and the commercial woolgrower, and
- The likelihood that fleece characteristics such as crimp definition and frequency and staple structure are more reliable indicators of skin traits such as wool follicle size and density than are objective measurements of fibre diameter and fleece weight.

The three major selection methods (visual assessment, objective measurement, fleece characteristics that reflect skin traits, selection indexes) play an important role in the decisions of most growers. Differences in breeding strategies lead to differences in the relative importance growers place on different selection methods.

Despite the scientific evidence, approximately 80 per cent of woolgrowers in the sample believe that changing environment can generate changes in the ranking of bloodlines in terms of fibre diameter and fleece weight. Severe financial pressure over recent years has prompted deep-seated dissatisfaction among many woolgrowers with their breeding performance. This has motivated many growers to change their views on sheep breeding. Nearly 50 per cent of woolgrowers in the sample now follow a breeding strategy that emphasises subjective fleece characteristics that they believe are more reliably related to important skin traits such as follicle size and density than measures of fleece weight and fibre diameter.

Studs tend to follow focus differentiation strategies. Different studs specialise in servicing the needs of woolgrowers in different segments. A minority of woolgrowers, approximately 14 per cent, reported they seek advice from staff of the Department when changing studs or selecting rams.

The findings from the study suggest there are three strategic options for influencing the breeding decisions of woolgrowers. These are:

- Alter woolgrowers' belief that the environment can generate ranking effects in terms of fibre diameter and fleece weight. This will be difficult to achieve but is critical for increasing the rate of genetic gain in the industry by:
  - Expanding the range of bloodlines and sires considered by woolgrowers,
  - Increasing the rate of adoption of associated practices such as performance recording, bloodline comparisons and centralised sire evaluation.

- Alter woolgrowers' beliefs about the strength and validity of the relationships between subjectively assessed and objectively measured fleece characteristics and important skin traits such as follicle size and density. There is considerable evidence that many woolgrowers are changing their beliefs about these relationships. Further research may be required to ensure the validity or otherwise of these beliefs.

- Assist woolgrowers in each segment to improve their breeding decisions within the context of their existing breeding strategy by promoting the outcomes of research and extension activities in ways that are tailored to the views and needs of growers in each segment.

The major recommendations arising from the study are:

The Department assign priorities for research and extension in terms of:

- Changing woolgrowers' beliefs that changing environments can generate ranking effects in terms of fibre diameter and fleece weight.
- Changing woolgrowers' beliefs about the strength and validity of the relationship between subjectively assessed and objectively measured fleece characteristics and important skin traits such as follicle size and density.
- Assisting woolgrowers in each segment to improve their breeding decisions within the context of their existing breeding strategy.

The Department validate priorities for research and extension through consultation with woolgrowers in target segments.

The Department canvass with industry the possibility of conducting a national study using the methods employed in this study. Such a study could provide useful insights into the impact that different research and extension activities can have on woolgrowers' beliefs about breeding principles.

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Introduction

Breeding decisions are crucial management decisions in wool enterprises. Being important and complex decisions there are a variety of ways in which woolgrowers might make these decisions. In this paper we discuss sheep breeding decisions from a consumer behaviour perspective. We then use this perspective to identify the key criteria that influence the way in which breeding decisions are made.

In the next section we briefly describe the findings of previous studies into sheep breeders and woolgrowers' beliefs about sheep breeding. We then draw on theories of consumer behaviour to characterise decisions about sheep breeding as examples of complex decision making. On the basis of interviews conducted with woolgrowers and extension professionals we form a tentative classification of woolgrowers according to their beliefs about sheep breeding. We then report the results from a mail survey of woolgrowers. Finally, we summarise the major findings of the study and discuss the implications for research and extension in sheep breeding.

Previous studies into beliefs about sheep breeding

In one of the earliest surveys of woolgrowers, Love, Clarke et al. (1987) found that Victorian woolgrowers favoured visual criteria such as handle and crimp over measured criteria such as fleece weight when selecting rams. They also found that a high proportion of growers purchased rams with assistance from stock agents, stud owners and professional sheep classers.

In the most comprehensive survey of stud Merino breeders undertaken in recent years Butler, Corkerey et al. (1995) found that most breeders rated factors such as wool handle, character and colour as more important than fleece weight or fibre diameter when selecting rams. Opinion varied as to the importance of index rank and pedigree. They found that sheep classers, wool classers and ram buyers were regarded as the most credible sources of information about breeding programs.

Butler, Corkerey et al. (1995) also found that most breeders regarded 'similar breeding objective', 'similar climate', 'measured performance', and 'performance of sheep elsewhere' as factors influencing the decision to purchase rams from other breeders. They found opinion varied as to the importance of 'success in wether trials and only a small proportion of breeders regarded 'involvement in sire reference schemes' as important.

Importantly, Butler, Corkerey et al. (1995) found that most breeders believe that performance recording is not as valid as traditional methods of assessing sheep. Yet most breeders believed that their clients understood wool measurements and only 30 per cent believed fleece tests were inaccurate.

More recently, Pope, Atkins et al. (1996) found that most commercial woolgrowers in New South Wales use a combination of visual and measured criteria to select rams with visual tending to be more important. However, growers differed greatly in the relative importance they attached to each criterion. Nearly half of growers surveyed sought advice on breeding from sheep classers, wool classers or stud breeders. Only a small proportion sought advice from a consultant or from staff of NSW Agriculture. They also found that the most frequently cited reason for changing studs was poor performance or genetics. Pope, Atkins et al. (1996) did not report the nature of the visual criteria used by growers or investigate the factors underlying stud choice.

In an investigation of selection practices among stud breeders in New South Wales Casey and Hygate (1992) investigated the importance of visual and measured criteria to breeders when assessing traits such as fleece weight, fibre diameter, body weight, and wool quality. They found that breeders used both visual and measured criteria for assessing fleece weight, fibre diameter and body weight. Stud breeders relied almost entirely on visual criteria for judging wool quality. They found again found that individual stud breeders differed in the relative importance they placed on visual and measured criteria.

In short, previous studies have consistently found differing beliefs and opinions about sheep breeding among both stud breeders and woolgrowers. We do not believe these differences are random or idiosyncratic. Decisions about sheep breeding determine future flock performance and farm profitability. These decisions are too important to be left to chance or whim. We believe breeding decisions are the product of careful and considered deliberation. We think differing beliefs and opinions about sheep breeding can be explained by understanding systematic differences among breeders and growers in their perceptions of the risks involved in sheep breeding.

In the following section we draw on theories of consumer behaviour to characterise decisions about sheep breeding as examples of complex, systematic decision making.

Involvement and purchase decisions

Consumers make purchase decisions in a variety of ways depending on circumstances. The way in which a purchase decision is made is determined by two key factors: the level of consumer involvement in the product and whether different brands of the product are perceived to be significantly different.

Low involvement purchases are purchases that are unimportant to the consumer (Assael 1998). These purchases are commonly inexpensive products that are routinely purchased and involve little risk. Where this is the case the consumer is unlikely to devote much, if any, time and effort to consideration of alternatives before making a

purchase. Typical low involvement purchases are groceries, toiletries, and laundry products.

High involvement purchases are purchases that are important to the consumer (Assael 1998). These purchases are often closely tied to self-image and ego, and usually involve some risk - financial, social or psychological. Where this is the case the consumer is more likely to devote time and effort to careful consideration of alternatives before making a purchase. Typical high involvement purchases are homes, motor vehicles, white goods, clothing and perfumes.

Breeding decisions are a form of high involvement purchase. The selection of rams determines the current and future financial potential of the farm enterprise. The decisions are complex because a range of factors needs to be considered, and the outcomes can be difficult to predict. This means breeding decisions are financially risky. They also entail social risks and psychological risks in that the outcomes of breeding decisions affect the wellbeing of family members and influence woolgrowers' feelings of achievement and self-fulfilment.

When the consumer believes there are significant differences between brands of a high involvement product, the brand selected for purchase may be chosen using one of two approaches depending on the consumer's previous experience with the product. One approach is described by complex decision-making, the other by brand loyalty.

Complex decision making and brand loyalty

The first steps in a complex decision making process involve learning about the attributes of each brand and developing a set of criteria for choosing a suitable brand (often termed purchase or benefit criteria). These criteria are, in essence, the key benefits sought by the decision-maker. In the case of consumers these benefits are generally a function of the consumer's past experiences, their lifestyle and their personality.

In the case of farming these benefits are more likely to be a function of the farm context into which a new practice must be integrated (Kaine and Lees 1994). Broadly speaking, the farm context is the mix of practices and techniques used on the farm, and the resources available to the farm business, that influence the benefits and costs of adopting an innovation.

Having settled on a set of criteria for deciding between brands, the next step is to evaluate all the brands against these criteria, and finally to make a brand choice. Following purchase the consumer will evaluate the brands performance. Satisfactory performance will reinforce the consumer's judgement and promote the chances of repurchase. Dissatisfaction with product performance will lead to reassessment and decrease the likelihood of repurchase. Dissatisfaction will also promote the likelihood of purchasing an alternative brand.

The complex purchase process can be influenced in two ways (Assael 1998). Basically these cause consumers to change the purchase criteria they use to evaluate brands, or cause them to change their beliefs about the criteria different of brands exhibit. These changes produce changes in consumers' evaluations of brands. These, in turn, may cause changes in brand choices.

The more strongly woolgrowers believe that different breeding choices lead to different breeding outcomes, the more their approach to breeding decisions will resemble complex decision making. For example, the commercial woolgrower can be characterised as having to choose between three different approaches to sheep breeding. These are the 'traditional' approach, the 'selection index' approach, and the 'elite wool' approach to sheep breeding. Conceptually, each of these approaches represents a different 'brand' of sheep breeding in terms of the characteristics and traits that are employed as criteria for selecting sheep. They also differ in the nature of the selection rules that are applied to these criteria.

The traditional approach, developed before the advent of objective measurement of wool traits and the application of advanced quantitative genetics in sheep breeding, involves visual assessment of fleece characteristics and conformation traits. The decision rules governing mate allocation in this approach take the form of non-compensatory decision rules such as the satisficing heuristic (see appendix A).[1] This means sheep must meet certain standards on relevant characteristics and traits to be considered suitable for breeding. The range over which higher scores on some traits can be traded-off against lower scores on other traits is limited.

The 'selection index' approach involves the use of objective measurement of fleece and carcase traits, and the application of theories of quantitative genetics. The decision rules governing mate allocation in this approach take the form of a weighted additive decision rule. This is a type of compensatory decision rule. Minimum standards for each characteristic or trait need not be set using this type of rule. Consequently, the range over which higher scores on some traits can be traded-off against lower scores on other traits is greater.

The 'elite wool' approach involves the evaluation of conformation traits and the visual assessment of fleece characteristics which are indicative of desirable skin traits. These visual assessments may be supplemented by objective measurement of fleece characteristics. The decision rules governing mate allocation in this approach also tend to take the form of satisficing decision rules. This means sheep must meet certain standards on relevant characteristics and traits to be considered suitable for breeding and the range over which higher scores on some traits can be traded-off against lower scores on other traits is limited.

While these alternatives are not entirely mutually exclusive they are quite dissimilar in many respects. They do represent fundamentally different approaches to sheep

[1] In appendix A we describe some of the rules or processes people use to make choices, and the factors that affect the use of these rules. We also briefly discuss the ways in which these rules may be used by woolgrowers to choose studs and select rams.

breeding and can lead to quite different breeding outcomes (see Francis 1999). This suggests that when choosing a breeding approach woolgrowers may tend to follow a complex decision making process. In other words, growers will formulate a set of criteria for judging the merits of a breeding approach, form a set a beliefs about each approach rates against those criteria, and choose the approach which is most consistent with their criteria.

Woolgrowers will be attracted to those stud breeders that exhibit an approach to breeding that is consistent with their own. Hence, studs can attract clients by signalling their breeding approach to growers using their promotional literature. This suggests that woolgrowers can be classified into market segments on the basis of the criteria they employ to judge the merits of different breeding approaches. If a number of these segments are present in the market, individual studs can create a competitive advantage by pursuing a focus differentiation strategy and specialising in meeting the needs of growers in a particular segment (Porter 1985).

When repeated purchasing of a chosen brand consistently generates a high degree of satisfaction then complex decision making may be replaced by brand loyalty. Brand loyalty is the second approach to purchasing high involvement products. Brand loyalty is more than just habitual purchasing of a brand. It represents a personal commitment to repeatedly purchase a brand on the basis of favourable attitudes towards the brand. In situations where the purchase of a product entails a high level of risk, then brand loyalty may be an effective strategy for reducing risk. Brand loyalty does not equate with habit (Assael 1998).

Brand loyal consumers may switch brands for a number of reasons. These include a change in the consumer's needs, dissatisfaction with the favoured product due to continually poor performance over a period of time, and learning of an alternative brand which is demonstrably superior, possibly from reference groups such as other farmers, or family.

Woolgrowers who believe changing ram sources entails uncertainty will exhibit behaviour similar to brand loyalty in circumstances where they have repeatedly purchased satisfactory rams from a source. This source may be a stud or an adviser such as a sheep classer, a stock and station agent or a breeding consultant.

Breeding strategy and purchase criteria

To identify the factors that influence woolgrowers' breeding decisions we interviewed fifty woolgrowers throughout Victoria as well as extension staff, researchers, sheep classers and stock and station agents. From these interviews it emerged that the key issue for woolgrowers is to reduce the difficulty of predicting the outcome of introducing a stud ram into a commercial ewe flock. Woolgrowers believe a number of factors contribute to their difficulties.

First, woolgrowers believe when a stud ram is introduced to a commercial ewe flock the characteristics of the progeny will depend partly on environmental differences

between the stud and the wool growing property. Many woolgrowers believe the influence of the environment is so strong that a superior bloodline in one environment can be decidedly inferior in another environment.

Second, woolgrowers believe when a stud ram is introduced to a commercial ewe flock the characteristics of the progeny will also depend partly on genetic interactions between the stud ram and the ewe flock. Many woolgrowers believe these interactions can be strong enough to ruin the performance of an apparently superior sire.

Third, woolgrowers believe when a stud ram is introduced to a commercial ewe flock the characteristics of the progeny also depend on differences in livestock management between the stud and the commercial woolgrower. Many woolgrowers believe the influence of management is so strong that a superior bloodline under one management regime can be decidedly inferior under another management regime.

Generally speaking, it is not possible to determine the relative contribution of these three factors to breeding outcomes under commercial conditions. Consequently, woolgrowers vary in their perceptions of how influential these factors are depending on their individual backgrounds and experiences. Most growers believe, for example, that environmental conditions can have a major impact on traits such as susceptibility to fleece rot or resistance to internal parasites. However, while some growers believe that environmental conditions can have a major impact on the relative fibre diameter and fleece weight of different bloodlines, others discount this possibility.

The reliability of the relationships between skin traits and objectively measured and subjectively assessed fleece characteristics were identified as a fourth risk factor by some woolgrowers. Growers have different opinions about the strength of the relationship between skin traits such as follicle size and density, and objectively measured fleece characteristics such fleece weight and fibre diameter. Growers also have different opinions about the strength of the relationship between traits such as follicle size and density, and fleece characteristics such as crimp frequency and definition, and staple structure. Differences in growers' opinions about these relationships leads to differences in growers' beliefs about the correct criteria for choosing studs and selecting rams.

The most fundamental breeding decision a woolgrower must make is to choose a strategy to counteract the risks and uncertainties involved in comparing rams from different bloodlines under different environments and choosing a ram that will suit the conditions on their property. The differences among growers in their views on the influence on ram performance of the four factors we have described means that growers have different views on the risks entailed in comparing the performance of bloodlines and choosing rams. As a consequence, they adopt different strategies to manage these risks.

In the terms used to describe complex decision making by consumers, woolgrowers' opinions on factors such as genetic interactions with the environment and the relationship between skin traits and fleece characteristics are the sheep-breeding equivalent of purchase criteria. Wool growers' opinions on these factors constitute

their criteria for evaluating and choosing between alternative strategies to counteract the perceived risks involved in comparing the performance of rams from different bloodlines and choosing a ram that will suit the conditions on their property. This means the key to understanding the adoption of new breeding practices by woolgrowers lies in understanding woolgrowers' perceptions of the risks involved in sheep breeding. The strategies that growers choose to combat these risks determine the set of studs they will consider as potential ram suppliers. The strategies also determine the value and relevance to the woolgrower of the various breeding practices and techniques that are available.

Each of these risk factors and the strategies for counteracting them is described below.

Environmental differences

The effects on sheep of changing their environment are categorised into two types – scale effects and ranking effects (see Woolaston 1987). A scale effect occurs when a change in the environment produces an absolute change in a trait but the relative performance of sheep from different bloodlines remains unchanged. For example, sheep from one bloodline might cut heavier fleeces than sheep from another bloodline in one district. Both bloodlines might cut lighter fleeces in a second district however the heavier cutting bloodline still produces a relatively heavier fleece than the lighter cutting bloodline. Hence, even though the absolute fleece weights are changed by shift in environment, the relative ranking of the two bloodlines in terms of fleece weight is unchanged.

A ranking effect occurs when a change in environment produces different changes in a trait sheep such that the relative ranking of different bloodlines is reversed. For example, sheep from one bloodline might cut heavier fleeces than sheep from another bloodline in one district. A ranking effect occurs when the heavier cutting bloodline in that district produces a lighter fleece than the lighter bloodline in a second district. In other words, the change in environment has a much greater impact on the heavier cutting bloodline than the lighter cutting bloodline. The ranking of the bloodlines in terms of fleece weight is reversed by the change in environment.

There is both empirical and anecdotal evidence for the presence of scale effects. While there seems to be widespread acceptance among woolgrowers of the presence of ranking effects among bloodlines, this is not entirely supported by the scientific literature. This literature suggests that while ranking effects are present for certain characteristics, such as susceptibility to fleece rot and resistance to parasites, ranking effects do not appear to be significant among bloodlines with respect to fibre diameter and fleece weight. However, there is some doubt as to whether the scientific evidence is conclusive (Woolaston 1987). Note that both ranking and scale effects can lead to errors when a selection index is used to make bloodline choices (Woolaston 1987).

In our view, the disparity between the scientific literature on the presence of ranking effects and woolgrowers' beliefs is primarily a product of the differences between observations made under commercial and experimental conditions. When a

woolgrower introduces a stud ram from another district to their flock, scale and ranking effects cannot be distinguished. Furthermore, these environmental effects are confounded by the differences in management practices and by genetic interactions between the ram and the ewe flock. There is every chance that ranking effects may be observed on some characteristics (such as susceptibility to fleece rot) in conjunction with scale effects on other characteristics (such as fleece weight). Consequently, it is not surprising that, on the basis of experience, many woolgrowers strongly believe in ranking effects.

Growers who believe in ranking effects believe that sheep from different bloodlines respond differentially to a change in environment. These growers will only regard comparisons of sheep as meaningful when comparisons are made under similar environmental conditions. For these growers, this means the performance of rams under stud conditions can only be used as a reasonable predictor of performance on their property if the stud and their property operate in similar environments. Even when environmental conditions are similar, allowances may still need to be made for management differences in terms of pasture and grazing systems, animal husbandry and so on. Consequently, these growers will look for a breeding strategy that reduces the risks of unpredictable environmental effects.

There are a number of different breeding strategies woolgrowers might adopt depending on whether or not they believe ranking effects occur with respect to fibre diameter and fleece weight.

The bloodline comparison strategy

Woolgrowers that do not believe that environmental conditions can change the ranking of bloodlines, at least in terms of fibre diameter and fleece weight, are likely to believe that the performance of bloodlines in one environment can be generalised from one set of environmental conditions to another. The outcome of this belief is that, in principle, rams can be safely purchased from studs operating in different environments outside the grower's district. Consequently, these growers will be interested in a breeding strategy that utilises comparisons of bloodlines across different environments. However, measurements of fibre diameter and fleece weight cannot be directly compared across environments because of the presence of scale effects. Consequently, legitimate comparisons across environments require testing all candidate bloodlines in one environment or testing subsets of bloodlines in different environments and using link teams or sires as benchmarks.

These woolgrowers are likely to regard across environment bloodline comparisons of merinos using wether trials (Atkins, Semple et al. 1992; Atkins, Coelli et al. 1995; Casey 1998) and central sire evaluation (Coelli 1998; Swan, Coelli et al. 1998) as useful because sheep at a particular site are being compared under identical management conditions. Growers who believe ranking effects are unimportant are likely to accept the rationale underlying the use of link teams or link sires to make across-site comparisons. Although environmental and management conditions at different sites may differ substantially from conditions on the grower's property, these

differences are irrelevant in terms of fibre diameter and fleece weight because the focus is on relative performance for these two traits. These growers may still need to make allowances, of course, for differences the impact that environmental and management conditions may have on other traits such as susceptibility to fleece rot.

The purchase of rams using a strategy based on bloodline comparisons across different districts means rams can only be purchased from bloodlines that are entered in appropriately designed wether trials, or are participating in central sire evaluation and from studs that have adopted performance recording.

The following strategies are used by woolgrowers that believe environmental conditions can change bloodline ranking in terms of fleece weight and fibre diameter. Since relatively few Victorian studs are involved in bloodline comparisons or sire evaluations across different districts growers that believe environmental conditions cannot significantly change bloodline rankings may be forced to consider using these strategies.

The stable characteristics strategy

There are a number of strategies that woolgrowers that believe ranking effects are an important risk in sheep breeding may adopt. One of these strategies is to select sheep that the grower believes are relatively insensitive to changing environments. There are two approaches to implementing this strategy.

One approach is to purchase from studs whose rams are reputed to perform satisfactorily across a number of districts. Good performance across a number of environments might signal a degree of stability in the performance of the bloodline in different environments. This stability could be interpreted by the woolgrower as providing a measure of confidence in the performance of the bloodline in the grower's environment. These woolgrowers may rely on a number of information sources to evaluate bloodlines including wether trials, observation at field days, and the opinions of sheep classers, wool broker representatives and other growers.

These woolgrowers are likely to regard across environment bloodline comparisons of merinos using wether trials (Atkins, Semple et al. 1992; Atkins, Coelli et al. 1995; Casey 1998) and central sire evaluation (Coelli 1998; Swan, Coelli et al. 1998) as useful because sheep at a particular site are being compared under identical management conditions. However, these growers may not accept the rationale underlying the use of link teams or link sires to make across-site comparisons. Instead these growers will try to identify bloodlines or sires that rank highly in trials across a number of sites. In other words, they will tend to select on the performance of bloodlines or sires that appear in a number of trials. Hence, these growers will tend to focus on comparisons of the performance of link teams or sires. These growers will need to make allowances for differences that the ewe base and environmental and management conditions may have on wool and other traits.

A second approach draws on growers' beliefs about traits such as the size and density of skin follicles. This approach is described in the following section on skin traits and fleece characteristics.

The same environment strategy

Another strategy to deal with the influence of environment is to purchase rams only from studs located in the grower's district. A variant of this strategy would be to purchase rams from studs outside the district that have sold rams to other growers in the district that have performed well. A more uncertain possibility is simply to purchase rams from studs in any region with a similar environment.

The growers who follow these types of strategies are likely to be uncomfortable with practices that involve comparing sheep across environments. Such growers may discount for example, the results of bloodline comparisons based on wether trials (Atkins, Semple et al. 1992; Atkins, Coelli et al. 1995; Casey 1998) or centralised sire evaluation (Coelli 1998; Swan, Coelli et al. 1998). These growers will be sceptical of such comparisons because the rationale underlying the use of link teams and link sires to make comparisons across environments contradicts their experience and beliefs. On the other hand, these woolgrowers may regard bloodline comparisons such as wether trials conducted in their district as useful. This is because such trials are conducted under local conditions and management even though they may be regarded as limited from a scientific perspective.

These growers will need to make allowances for differences in their ewe base and management conditions compared to the studs.

The stud reputation strategy

Some growers that believe the environment has an important influence on the ranking of bloodlines may follow a strategy of selecting a bloodline simply on the basis of reputation. These growers are relying on indicators of the commercial success of a stud over an extended period of time as a signal that the bloodline that generally performs well. Such indicators would include a distinguished bloodline history, success at shows, and continued high prices for rams. High demand for the progeny of a stud over a sustained period of time suggests that many woolgrowers have a high regard for the performance of the bloodline. These woolgrowers may rely on a number of information sources to evaluate bloodlines including wether trials, observation at field days, and the opinions of sheep classers, wool broker representatives and other growers. This strategy might be especially effective for those growers that wish to devote a limited amount of time and effort to choosing a bloodline.

The growers who follow these types of strategies are likely to be uncomfortable with practices that involve directly comparing sheep across environments. They may

regard bloodline comparisons such as wether trials conducted in their district as useful.

The progeny testing strategy

In principle, woolgrowers could compare the merits of different bloodlines by undertaking on-farm progeny testing (Roberts 1997). This involves testing the performance of rams that have been purchased from a stud by evaluating the characteristics of their progeny. Sires that produce progeny with unsatisfactory characteristics are culled. Sires producing progeny with satisfactory characteristics are retained and used as flock rams.

Since rams from different bloodlines are performing under identical conditions they can be compared free of any scale and ranking effects due to differences between the farm and stud environments. As the comparisons of rams is based on evaluations of their progeny these comparisons also incorporate the effects of genetic interactions between ewes and rams. Progeny testing on-farm is a method for comparing rams from different bloodlines or studs, however, it does not provide a strategy for choosing which studs to compare.

Although, in principle, on-farm progeny testing can be undertaken by commercial woolgrowers many growers do not have a flock of suitable size, the appropriate farm layout or sufficient time and labour to conduct such tests. In addition, progeny should be evaluated as hoggets (Roberts 1997). This means stud rams will be three years old, and running on the farm for nearly two years, before the decision to keep or cull them is reached. Consequently, the commercial life of stud rams on the property may be limited to only three or four years. Note also that progeny testing on-farm does not allow a strict comparison of bloodlines under typical commercial conditions. This is because few commercial woolgrowers purchase sufficient numbers of rams within a season for reliable comparisons to be made. These constraints suggest that relatively few commercial woolgrowers would undertake progeny testing.

Progeny testing may also be undertaken by stud breeders or woolgrowers with especially large flocks for the purpose of selecting sheep for breeding stock. Woolgrowers with especially large flocks often run the majority of their ewes in a ‘commercial’ flock, with a small proportion of specially selected ewes run as a ‘stud’ flock. Some of these growers purchase a number of stud rams to join to their ‘stud’ ewes. Male progeny with satisfactory characteristics are retained and used as flock rams with the commercial ewes. Unacceptable progeny are culled.

The purchased expertise strategy

Another approach to counteracting the risks associated with introducing a stud ram to a ewe flock is to purchase outside expertise. This expertise may be obtained from a number of specialists, the most popular being sheep classers, stud representatives,

breeding consultants and wool broking representatives. Each of these specialists has different strengths and weaknesses.

The type of specialist a woolgrower buys will depend mainly on their perceptions of the most suitable strategy for dealing with the risks involved in sheep breeding. A woolgrower is unlikely to accept recommendations about breeding strategy from a specialist if those recommendations are at odds with the perceptions of the grower. For example, a woolgrower that believes that ranking effects are important is unlikely to adopt a recommendation that either explicitly or implicitly treats ranking effects as relatively unimportant.

The need for correspondence between the perceptions of the woolgrower and their expert adviser means that in many instances the relationship between the woolgrower and the adviser will be a personal relationship. This relationship will be based, to some degree, on developing a shared understanding of the risks involved in purchasing stud rams.

Sheep classers offer personalised expertise in sheep breeding to studs and commercial woolgrowers alike. Classers have varying opinions and beliefs about sheep breeding and wool marketing strategies. While nominally independent, classers are likely to have allegiances to particular studs. In addition to offering expertise in sheep selection to stud owners and managers, sheep classers recruit commercial clients for studs. From the perspective of the commercial woolgrower the fact that specialist breeders rely on classers to assist them in sheep selection is testimony to the expertise and skill of classers. In addition to advising commercial growers on sheep selection and stud choice, classers can offer the grower with a personal introduction to a stud owner. Many growers believe this introduction gives them the opportunity to purchase better quality rams.

Many woolgrowers rely on stud owners, managers or their representatives to assist them in their breeding decisions. Generally speaking, growers who rely on a stud breeder to advise them have an established, long-term relationship with the breeder and are not actively searching for an alternative source of stud rams.

We have reserved the term ‘breeding consultants’ for advisers who have training in quantitative genetics. These consultants may be employed by state government departments or agencies, or by private consulting firms. Given their training, these advisers are likely to follow strategies that take as much advantage as possible of objective measures of performance, both within and across flocks. Hence, the types of breeding strategies recommended by these specialists tend to appeal most to growers that regard ranking effects due to the environment as relatively unimportant, at least in terms of fibre diameter and fleece weight.

Many commercial woolgrowers rely on their wool broking representative for breeding advice. Broker representatives have varying opinions and beliefs about sheep breeding and wool marketing strategies. Also, their familiarity with growers throughout the district is thought to provide them with unique insights into the local factors affecting the performance of different bloodlines across the district. In addition, brokers can offer finance to growers for the purchase of rams.

Genetic interactions between rams and ewes

The genetic interactions between rams and ewes are unpredictable. There are three principal strategies for counteracting the risks associated with genetic interactions. These are the 'single bloodline' strategy, the 'same bloodline' strategy and the 'purchased expertise' strategy.

The single bloodline strategy

One is to purchase rams from a stud that has limited the introduction of new bloodlines into its flock for many years. Such studs are often termed 'closed' studs. This strategy is based on the idea that consistent selection pressure applied over many years has reduced the genetic variation in a flock. Consequently, rams from such a stud will perform similarly with a given ewe flock because they have similar genetic histories.

The same bloodline strategy

This strategy is a variant of the strategy we have just described. The aim here is to purchase rams from studs of the same bloodline as the ewe flock. In this way woolgrowers can approximate the genetic base of the target bloodline. Consequently, rams purchased from the target bloodline will perform similarly with the grower's ewe flock because they have similar genetic histories. Growers wishing to change bloodlines purchase cast-for-age ewes from the same bloodline as the rams they wish to purchase.

The purchased expertise strategy

Another strategy to manage the risks associated with the unpredictable genetic interactions is to rely on outside expertise. The observations made earlier with regard to using expert advice to manage the risks associated with introducing a stud ram to a commercial ewe flock also apply here.

Management differences

Woolgrowers know that livestock management can dramatically affect the characteristics of rams and ewes. Whether growers distinguish these effects into scale effects and ranking effects is not clear. Growers recognise that by appropriate management they can influence, in some degree, characteristics such as fibre diameter and fleece weight. They also recognise that the reliability of measurements of fibre

diameter depends on factors such as the age of the sheep at the time the measurements are taken. Consequently, woolgrowers treat measures of fibre diameter and fleece weight with caution. They realise comparisons between studs cannot be made because differences in management can disguise bloodline differences. Even comparisons of rams within the one stud must be made with care because misleading differences in characteristics between generations can arise from changes in management over time.

There is little growers can do to offset the effects of differences in management. One tactic is to seek studs that have a reputation for running rams under commercial conditions. A second is to assess the performance of the studs' commercial flock. Another is to seek studs that have comparable pasture systems and cropping systems.

Farm context

Different woolgrowers might follow similar strategy but differences in implementation may arise due to differences in farm context. For example, as observed earlier, progeny testing is a more attractive practice for sheep breeders. Other aspects of the farm context also affect breeding practices.

The value of using index selection in a ewe flock depends largely on the quality of the flock, and on culling percentages which are determined by the lambing rates. Typically, the culling rates in commercial wool growing enterprises are fairly low (Casey 1997). Consequently, most culls may be easily identified using visual appraisal. The majority of culls are identified on the basis of poor feet, conformation, growth or presence of black or hairy fibres in the fleece. The limited capacity to cull ewes means that visual assessment of gross characteristics is the only practical approach to ewe selection. In such circumstances, genetic improvement of the flock depends largely on the characteristics of the rams purchased by the grower.

Where culling rates are higher the value of index selection will depend on the diversity of the characteristics of ewes in the flock. The greater the variety in the flock, the more likely culls can be reliably identified using visual assessment and the less likely expenditure on objective measurement can be justified (Casey 1997). The more uniform the flock the more likely that culls cannot be determined solely by visual assessment. Selection on the basis of objective measurements of fleece weight and fibre diameter may be justified. However, the more uniform the flock the smaller the gain from culling, consequently a cast for age culling policy may be warranted. Where the flock is reasonably uniform the greatest potential for genetic improvement of the flock lies with the characteristics of the rams purchased by the grower.

The importance of the wool enterprise in the farm operation will also influence the time and effort devoted to sheep breeding. If, for example, the wool enterprise is run as a complement to cropping the major factor influencing breeding decisions may be the robustness of sheep under variable management conditions. A greater emphasis may also be placed on meat as well as wool production.

Skin traits and wool characteristics

The reliability of the relationships between skin traits and objectively measured and subjectively assessed fleece characteristics was identified as a major risk factor in predicting the outcome of introducing a stud ram into a commercial ewe flock. Growers have different opinions about the strength of the relationship between skin traits such as follicle size and density, and objectively measured fleece characteristics such fleece weight and fibre diameter. Growers also have different opinions about the strength of the relationship between skin traits and other fleece characteristics such as crimp frequency and definition, and staple structure.

The production of wool fibre is a function of the size and density of wool follicles in the skin of sheep. The scientific literature suggests that sheep with higher proportions of secondary to primary skin follicles will produce finer wool than sheep with lower proportions of secondary to primary follicles (Hynd 1995; Clarke, Roberts et al. 1997). The literature also suggests the proportion of secondary to primary follicles is moderately heritable, although nutrition during and immediately after lambing is critical to achieving genetic potential (Gifford, Ponzoni et al. 1995; Hynd 1995; McCloghry 1996). There is also evidence to suggest that sheep with a higher ratio of secondary to primary skin follicles and a high density of relatively straight skin follicles produce finer fleeces with relatively long staples and low grease content (Williams 1982; Clarke, Roberts et al. 1997). This translates into a heavier, higher yielding fleece that is finer than a 'true-to-type' fleece. In other words, the fleece has a lower fibre diameter than the traditional Bradford quality count would indicate.

There is disagreement within the industry concerning the best method for selecting sheep with a high follicle density and a high ratio of secondary to primary skin follicles. Many woolgrowers believe that sheep with these characteristics cannot be selected simply by using objective measurements of fleece weight and fibre diameter. This belief has its foundations in the relationship between follicle density, follicle size and the total follicle area in sheep.

Although follicle density increases as follicle size decreases, the total area of follicles in the skin decreases as follicle size decreases (Hynd 1995). This means that total fibre production falls with declining follicle size. Hence, fleece weight declines with decreasing fibre diameter. Consequently, as selection for lower fibre diameter entails selection for smaller follicle size, selection for lower fibre diameter generally results in a decline in fleece weight (Hynd 1995). Conversely, selection for increased fleece weight entails selection for greater total follicle area per unit of skin. This means selecting for lower follicle density but greater follicle size. Hence, selection for greater fleece weight generally results in an increase in fibre diameter (Hynd 1995).

These findings lead to the conclusion that to maximise fleece weight while minimising fibre diameter requires identifying a bloodline that is has a high follicle density, small average follicle size, and a high ratio of secondary to primary follicles (Ferguson 1999; Watts 1999; Watts undated). Ideally, the primary and secondary follicles should also be of similar size. Sheep with these characteristics are thought to have skins with closely packed, evenly seated, and precisely aligned follicles (Watts

undated). These sheep produce relatively fine, long stapled wool with bold, deep crimp. This wool is uniform in fibre diameter, soft handling and has a high lustre (Francis 1995; Watts 1995; Ferguson 1999; Watts undated).

The relationship between fibre diameter and total follicle area has some important implications. These are:

- First, given environmental conditions can have a scale and possibly, ranking effects on fibre diameter and fleece weight, there is no guarantee that a heavy cutting bloodline necessarily has a higher follicle density than a lighter cutting bloodline with a similar average follicle size in the same district. Differences in fibre diameter may be attributable to differences in the ratio of secondary to primary follicles, differences in the size of primary and secondary follicles, or both. Both of these factors also create differences in fleece weight. However, differences in fleece weight can also arise from differences in follicle group density, and the growth rates of primary and secondary follicles, or all of these. This means the causes, in terms of follicle characteristics, of differences in fleece weight and fibre diameter cannot be identified from the measurements alone. Hence, objective measures of fibre diameter and fleece weight are not reliable guides to follicle characteristics of bloodlines from different districts. Therefore, woolgrowers may prefer to judge the follicle characteristics of sheep using other indicators.

- Second, efforts to improve wool characteristics by selecting sheep on a single skin trait, such as follicle size or density, are unlikely to succeed. Improvements in one trait will be offset by compensatory changes in other traits (Hynd 1995; Ferguson 1999). Hence, efforts to breed sheep with highly developed skin traits depend on assessing a mix of traits and selecting sheep accordingly.

- Third, efforts to improve fibre diameter and fleece weight using a selection index may be self-defeating in the long term. A selection index is a composite of measured traits such as fleece weight and fibre diameter. In an index a relatively high score on one trait can offset a relatively low score on another trait. Hence, sheep with a high fleece weight and high fibre diameter can receive a similar index score as sheep with a low fleece weight but a low fibre diameter. As mentioned above, objective measures of fibre diameter and fleece weight are not a reliable guide to follicle characteristics.[2] Consequently, efforts to increase fleece weight and/or decrease fibre diameter using index scores alone may result in the selection of sheep with undesirable follicle characteristics, especially if the weights used in the index change over time in response to changes in micron premiums. Woolgrowers who accept this argument believe that index selection must be used in conjunction with other, more reliable indicators of follicle characteristics.

To break the nexus between follicle density and follicle size requires identifying sheep that have a high follicle density, a high ratio of secondary to primary follicles and

[2] At a minimum, an index would need to include fleece weight, fibre diameter and the coefficient of variation for fibre diameter to approximate the influence of follicle size, follicle density and ratio of secondary to primary follicles.

primary and secondary follicles that are similar in size (Watts 1995). Many growers believe fleece characteristics such as soft handling, low crimp frequency, high crimp definition, long staples and 'thin' locks (termed 'fibre bundling') may be used to visually identify sheep with relatively high follicle densities for given follicle size (Watts 1995; Clarke, Roberts et al. 1997).

These implications raise a number of possibilities for those woolgrowers that accept them. First, there is the possibility that growers can use fleece characteristics such as crimp definition and frequency, staples length and 'fibre bundling' to identify sheep that will produce finer, heavier and more uniform fleeces than sheep without these characteristics. That is, growers can use these fleece characteristics to identify what are commonly termed 'productive' or 'elite' sheep. This strategy could be used in conjunction with any of the strategies outlined earlier.

The second possibility is that a strategy of purchasing sheep that have relatively high skin follicle density and a relatively high ratio of secondary to primary skin follicles could be used to reduce the scale and ranking effects of changing environments. The reasoning is as follows. Sheep with primary and secondary follicles of similar size, a high ratio of secondary to primary follicles and a high follicle density will produce finer, heavier and more uniform fleeces than sheep without these characteristics. Sheep with these characteristics will tend to respond to a change in environment mainly through changes in staple length. The fibre diameter of sheep with these characteristics should be relatively resistant to environmental conditions. In addition, sheep with these follicle characteristics are also believed to have other desirable attributes such as greater resistance to dust penetration. This strategy represents another approach to the 'stable characteristics' strategy outlined earlier.

Note that some woolgrowers may purchase rams from studs that select sheep on the basis of skin development simply because they believe that wool processors favour the type of wool these sheep produce – wool that is bold, deep crimping and long stapled. They believe that processing margins on these wools should be lower because they produce a more even, stronger yarn with fewer breakages (Watts undated). They also believe these wools produce softer, more comfortable fabrics (Watts undated).

Some woolgrowers believe that, to reach their full potential, sheep with highly developed skin characteristics need a high level of nutrition. Consequently, some of these growers may believe it is not worthwhile adopting this approach to breeding because they are unable to offer appropriate levels of nutrition to sheep of this type.

Finally, woolgrowers may use this approach without having a complete understanding of the biological mechanisms that underpin it. Growers need only be able to identify sheep with the appropriate characteristics and believe that such sheep are likely to produce a finer, heavier fleece under their conditions than sheep without those characteristics.

In conclusion, woolgrowers develop strategies for choosing studs and selecting sheep based on their beliefs about the various risk factors that influence the breeding outcomes. Having chosen a stud that supplies satisfactory rams, most growers are unlikely to change studs unless forced to by circumstances.

Stud loyalty

Brand loyal behaviour is likely once a grower has settled on a stud and that stud has supplied rams that have repeatedly met expectations over some period of time. As described earlier, brand loyalty represents a personal commitment to repeatedly purchase a brand on the basis of favourable attitudes towards the brand. In situations where the purchase of a product entails a high level of risk, then brand loyalty may be an effective strategy for reducing risk.

In terms of stud choice, brand loyalty is a logical response to the risks involved in trying alternative studs. Brand loyalty may appear to be traditional or conservative behaviour but this is to mistakenly equate the absence of change with habit or inertia. A brand loyal purchaser continues to monitor other brands, but only to the extent of detecting significant changes in the characteristics of those brands. If a significant change is detected then this may trigger a re-evaluation of behaviour, including the purchase of the current brand.

A brand loyal purchaser will only change behaviour when:

- An alternative brand is demonstrated to be superior to the current brand
- The purchaser becomes highly dissatisfied with the current brand, or
- The product is no longer satisfactory as the needs of the purchaser have changed.

Woolgrowers who have a long established relationship with a stud may have only weakly held opinions about breeding approaches and they may rely virtually entirely on the stud owner to select rams on their behalf. The breeding objectives of some of these growers may be quite vague. This apparent low interest in developing and following a breeding strategy is simply a reflection of the woolgrower's satisfaction with the performance of their current ram supplier and recognition of the uncertainty and risk entailed in changing suppliers. These woolgrowers would begin to exhibit high involvement, complex decision making behaviour should circumstances force them to consider changing their stud.

Woolgrowers that are loyal to a stud are only likely to seriously contemplate changing studs under the following circumstances. These are:

- Poor ram performance for a sustained period
- Quarantine of stud due to discovery of disease (eg Johnnes disease)
- Substantial shift in characteristics of stud rams due to change in stud breeding objectives
- Substantial shift in characteristics of stud rams required due to unsatisfactory financial performance of the wool enterprise
- On the advice of their sheep breeding adviser.

In the case where a change in stud is forced by unsatisfactory ram performance, detection of disease or a change in the breeding objectives of the stud, the woolgrower

can change studs without changing their breeding strategy. For example, a woolgrower that is forced to change stud and that favours a 'same environment' strategy would attempt to identify a stud in the district supplying rams similar to those purchased in the past.

In the case where a stud changes its breeding objectives, woolgrowers may continue to purchase from the stud provided they continue to be satisfied by the performance of the stud's rams. Consequently, some growers may experience significant changes in the characteristics of their wool and their flock over a period of time without changing studs.

In the case where a change in studs is forced by unsatisfactory financial performance of the wool enterprise the chances are the woolgrower will change breeding strategies. If the grower is satisfied that their current stud is providing satisfactory rams per se, then a boost in performance can only be obtained by identifying a stud that supplies a clearly superior product. In other words, the woolgrower is seeking a substantial and rapid improvement in genetic performance. In the past this meant shifting from a 'same environment' strategy to either a 'stable characteristics' strategy or a 'bloodline comparison' strategy. Recently, growers may have continued to follow the same strategy but are changing their views on the relationship between skin traits and fleece characteristics and augmenting their standard strategy by adopting a 'productive' or 'elite' sheep strategy (Stephen 1999). Usually this is achieved with the assistance of specialist advice from a classer or a consultant.

Survey of woolgrowers

A survey questionnaire was developed to quantitatively verify the various breeding strategies identified from our interviews with woolgrowers and to classify woolgrowers into breeding strategy segments. Preliminary versions of the questionnaire were trialed with 25 woolgrowers. Comments and advice on the questionnaire was also obtained from staff of the Department. The revised questionnaire was piloted with a further 21 woolgrowers before being distributed to a sample of woolgrowers throughout Victoria.

The survey was divided into three sections. In the first section information was sought on basic property and wool enterprise characteristics such as property area and district, rainfall, numbers of rams, wether and ewes, lambing and weaning percentages, wool cut per head, and so on. The second section was designed to elicit information on issues such as respondents' beliefs about the presence of ranking effects with respect to fibre diameter and fleece weight and the criteria respondents used when choosing studs. Respondents' answers to the questions in this section were to be used to classify them into breeding strategy segments. The third section was designed to elicit information on issues such as respondents' beliefs about the relative merits of visual characteristics, objective measurements, indexes and district wether trials as aids in selecting sheep. Respondents' answers to the questions in this section were used to validate the results of the classification analysis.

The survey questionnaire was mailed to woolgrowers in the form of a 16-page booklet. The booklet was accompanied by a cover letter describing the purpose of the survey and providing contact details.

Some 3,900 surveys were distributed by mail to woolgrowers throughout Victoria during July 2000 using a mailing list supplied by a market research company. A reminder was posted four weeks later. The mailing list included specialist lamb producers as well as wool producers. A total of 1,117 surveys were returned some ten weeks after the initial mailing. Over 680 surveys were returned because the recipients were not woolgrowers. A further 436 surveys were returned completed. If all non-respondents were wool producers then the response rate among wool producers was only 14 per cent. However, if the proportion of woolgrowers among non-respondents was similar to the distribution for respondents, then the response rate among woolgrowers was 29 per cent. We believe the latter figure is indicative of the actual response rate among wool producers.

General characteristics of the sample

Some general characteristics of the sample are reported in table 1. Merino wool production was the major enterprise on most farms in the sample and approximately 20 per cent of farms in the sample were sheep studs. The majority of respondents, over 60 per cent, were woolgrowers from the Western Districts. Another 20 per cent

of respondents were woolgrowers from central and northern Victoria with the remaining respondents being woolgrowers from Gippsland and the Wimmera.

The wool produced by the woolgrowers in the sample ranged in diameter from 15 microns to 28 microns, averaging 20 microns. The wool cut per head reported by the woolgrowers in the sample ranged from 2 to 9 kilograms per head, averaging 5.2 kilograms per head. This is consistent with an average fleece weight of 4.0 kilograms per head reported for the Victorian flock in 1998/99 (ABARE 1999).

Altogether, the sample represents about 2.8 per cent of wool (including lamb) producers in Victoria. It covers approximately 4.3 per cent of the State flock producing over 5.7 per cent of the State's wool (derived from ABARE 1999).

Breeding strategy segments

Interviews with woolgrowers indicated that their choice of breeding strategy was governed by their beliefs about the risks involved introducing a stud ram into a commercial ewe flock. The most important risk factors identified by growers were:

- The impact of environment on the ranking of bloodlines in terms of fibre diameter and fleece weight.
- Genetic interactions between rams and ewes,
- Differences in livestock management between the stud and the commercial woolgrower, and
- The likelihood that fleece characteristics such as crimp definition and frequency and aligned fibres are more reliable indicators of traits such as wool follicle size and density than are objective measurements of fibre diameter and fleece weight.

Woolgrowers were questioned about these risk factors and the strategies they employed to counteract them in the survey. With regard to the beliefs about the ranking effects of the environment woolgrowers were provided with a scenario in which testing had shown that sheep from one bloodline produced significantly finer wool than sheep from another bloodline. A series of four statements were also provided which were designed to elicit information on the conditions under which growers' believed it would be valid to infer that the relative performance of the two bloodlines would remain the same (see appendix B). A similar scenario concerning ranking effects on fleece weight was also included in the survey.

In figure 1 the proportion of respondents that agreed with the four statements in the scenarios are presented. The majority woolgrowers disagreed with the first statement in both of the scenarios, and agreed with the second and third statements. This indicates that most growers believe the environment does have a ranking effect on wool fibre diameter and fleece weight. Consequently, most growers agreed that it is very difficult to predict the relative performance of two bloodlines (in terms of fibre diameter and fleece weight) in different environments. Most growers also agreed that it is impossible to predict which bloodline is better for your farm simply on the basis of measurements of fibre diameter and fleece weight.

Growers' beliefs about other risk factors and their breeding strategies were elicited by asking growers to rate the importance of a list of reasons for choosing a stud (see appendix B). These reasons reflect the various strategies that were identified by growers for counteracting the risk factors in sheep breeding. Hence, they provide an implicit insight into growers' perceptions of these factors. The results are summarised in figure 2. In the figure the proportion of growers that rated the various alternatives as a 'very important' reason for choosing a stud is presented. The results indicate there is a wide range of opinions among growers about what reasons are very important in choosing a stud. This is consistent with past studies such as Butler, Corkerey et al. (1995).

The reasons that were nominated most frequently as being very important when choosing a stud were a longstanding reputation for producing quality rams (53 per cent) and an emphasis on skin traits and a reputation for breeding productive sheep (51 per cent). A relatively high proportion of growers also nominated an emphasis on skin traits and a reputation for breeding sheep that will do well under most conditions as being very important (41 per cent). The least common reasons cited as being very important in choosing a stud are location in grower's own district (11 per cent) and selling rams to other growers in the district (17%).

The only reason that the majority of growers rated as being unimportant was location in grower's own district (55%). A substantial proportion of growers (almost 40 per cent) indicated they believed selling rams to other growers in the district and selling to growers across a number of districts were unimportant in choosing a stud. Over one third of growers indicated they believed that participation in a central sire evaluation scheme or bloodline performance analysis was unimportant while one quarter of growers indicated they believed the use of a selection index by a stud was unimportant.

There was a general consensus among growers that similarity of climate, reputation for quality, an emphasis on skin traits, the use of selection indexes and participation in bloodline performance analysis and sire evaluation schemes are important influences on stud choice (see appendix C). This reflects the fact that the differences among most growers in their perceptions of the risk factors in sheep breeding are differences over relative, not absolute, importance. This leads different growers to emphasise different aspects of a strategy, or to combine strategies. It also leads different growers to rate most breeding practices as important. Some practices are just relatively more important than others.

We classified woolgrowers into six strategy segments based on their beliefs about the risk factors as revealed by their responses to the scenarios and the reasons for choosing a stud.

Table 1 Selected enterprise characteristics

Sheep flock:	
Merino rams used each year (head)	25 (0 – 230)
Merino wethers (head)	1,429 (0 – 10,000)
Merino ewes (head)	2,013 (0 – 14,414)
Breeding:	
Number of ewes to be joined (head)	1,574 (0 – 13,500)
Weaning percentage (%)	80.1 (25.0 – 105.0)
Culling rate for maiden ewes (%)	19.5 (0.0 – 80.0)
Wool production:	
Average fibre diameter of flock (micron)	19.9 (15.5 – 28.0)
Average wool cut per head (kg)	5.2 (2.0 – 9.0)

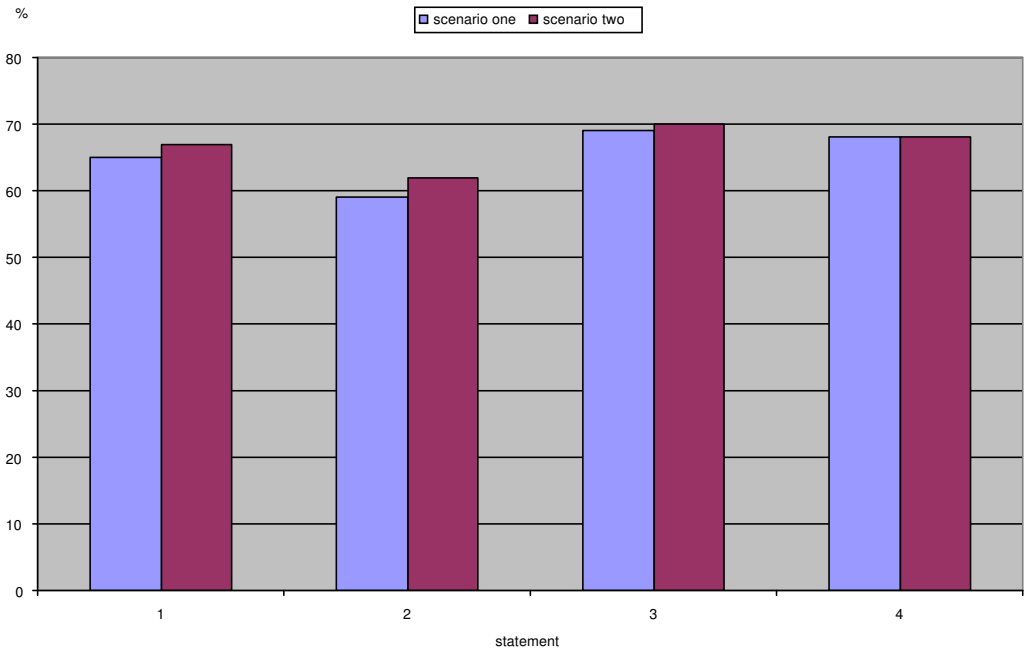

Figure 1 Responses to scenarios about ranking effects

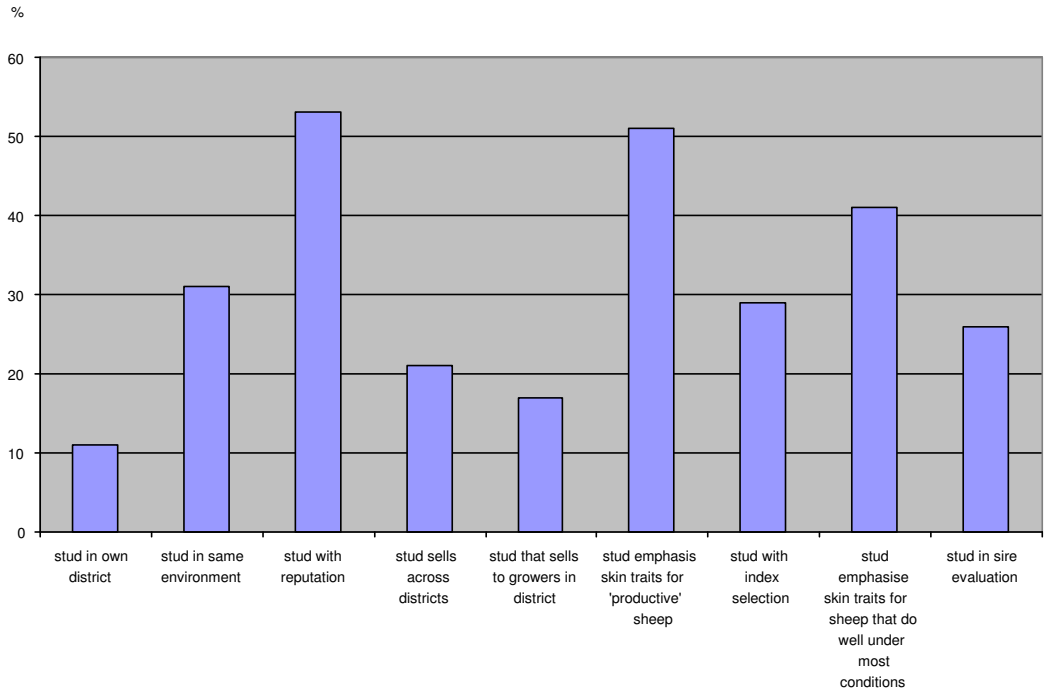

Figure 2 Breeding beliefs about stud choice

Segments one and two

The woolgrowers in these two segments represented 22 per cent of growers in the sample. They believe that changing environments does not change the ranking of bloodlines in terms of fibre diameter and fleece weight, though there may be scale effects. Consequently they see no need to pursue a strategy based on breeding sheep for stability in their performance across differing environments in terms of fibre diameter and fleece weight. These growers are likely to rely heavily on objective measurement and index selection, and will value bloodline comparisons involving cross environment progeny testing using link sires. These growers will tend to be relatively responsive to variations in the performance of studs and are unlikely to be especially loyal to a particular stud.

The growers in segment one (approximately 8 per cent of the sample) also believe that fleece characteristics such as crimp frequency and aligned fibres are more reliable indicators of important skin traits (such as wool follicle size and density) than objective measurements of fibre diameter and fleece weight alone. Consequently, these growers rated an emphasis on skin traits for breeding productive sheep and for breeding sheep that will do well under most conditions as very important criteria for choosing a stud. The growers in segment one will incorporate subjective assessment of fleece characteristics such as crimp definition and frequency, and staple structure into their selection process. The growers in segment one may well employ bloodline comparisons using link sires but will only purchase rams from studs that breed sheep with the appropriate fleece characteristics.

The type one strategist will produce 'elite' type wool. Ted is an example of a segment one grower.

> *Ted does not believe that changing environments leads to changes in the ranking of sheep for fibre diameter and fleece weight. He is confident that measurements of micron and clean fleece weight are essential for every breeding program. However, Ted thinks using these measurements alone can be dangerous and therefore uses a combination of tools for selecting rams. He believes that that additional measurement can be very beneficial, and combines some of these characteristics in an index for ram selection.*
>
> *Ted also believes that the skin theory of Soft Rolling Skins works well if is applied properly, and believes that selecting for fleece characteristics that reflect skin traits is essential as these traits enable you to breed highly productive sheep that will do well under a range of conditions.*
>
> *Ted believes that by using a combination of different methods such as the SRS theory, objective measurement and a selection index, one can*

achieve the best results. Therefore people who have skills in all of the selection methods should make the best genetic gains in their flocks.

The growers in segment two also believe that changing environments does not change the ranking of bloodlines in terms of fibre diameter and fleece weight. Consequently they tend to accept the rationale underlying bloodline comparisons involving cross environment progeny testing using link sires. However, unlike segment one growers, the growers in segment two do not believe that fleece characteristics such as crimp frequency and aligned fibres are reliable indicators of important skin traits. Hence, these growers believe that selection using objective measurements of characteristics such as fleece weight and fibre diameter is the key to breeding better sheep. Hence, they are likely to attach a relatively high importance to objective measurement and index selection.

Chris is a good example of a grower from segment two. The growers in segment two represent approximately 14 per cent of the sample.

Chris needed to produce finer wool in order to remain profitable. Consequently he decided to change studs. The first stud that he tried had some good sheep that were performing well but Chris was dissatisfied because the stud was not supplying enough in the way of measurement results or any details about the breeding history of its rams. Chris also found some of their rams were unpredictable.

Chris now buys rams from two studs that supply Estimated Breeding Values for their rams and both use sires proven through Central Test Sire Evaluation Schemes. These studs have selected rams that have done well in the Sire Evaluation schemes and used the semen from these rams to breed their own rams. This means that the rams that Chris buys are sons of the best rams across Australia.

Chris is confident that he is using top quality rams and from now on will only buy from studs that offer Estimated Breeding Values and use proven genetics.

In figure 3 the beliefs of growers in segments one and two about ranking and the predictability of the performance of sheep with respect to fibre diameter are presented.[3] The results show that these growers, who do not believe in ranking effects, believe that it is not difficult to predict the relative performance of bloodlines under different conditions, especially when they remain in similar environments. Note that the growers in segment one are significantly more likely than growers in segment two to believe that it is impossible to predict bloodline which bloodline will perform better on your farm simply on the basis of fleece weight and fibre diameter measurements.[4] This is consistent with the belief of growers in segment one that the relationship between skin traits and fleece weight and fibre diameter measurements is unreliable.

[3] They have similar beliefs with respect to fleece weight.

[4] χ^2=6.55, p=0.01.

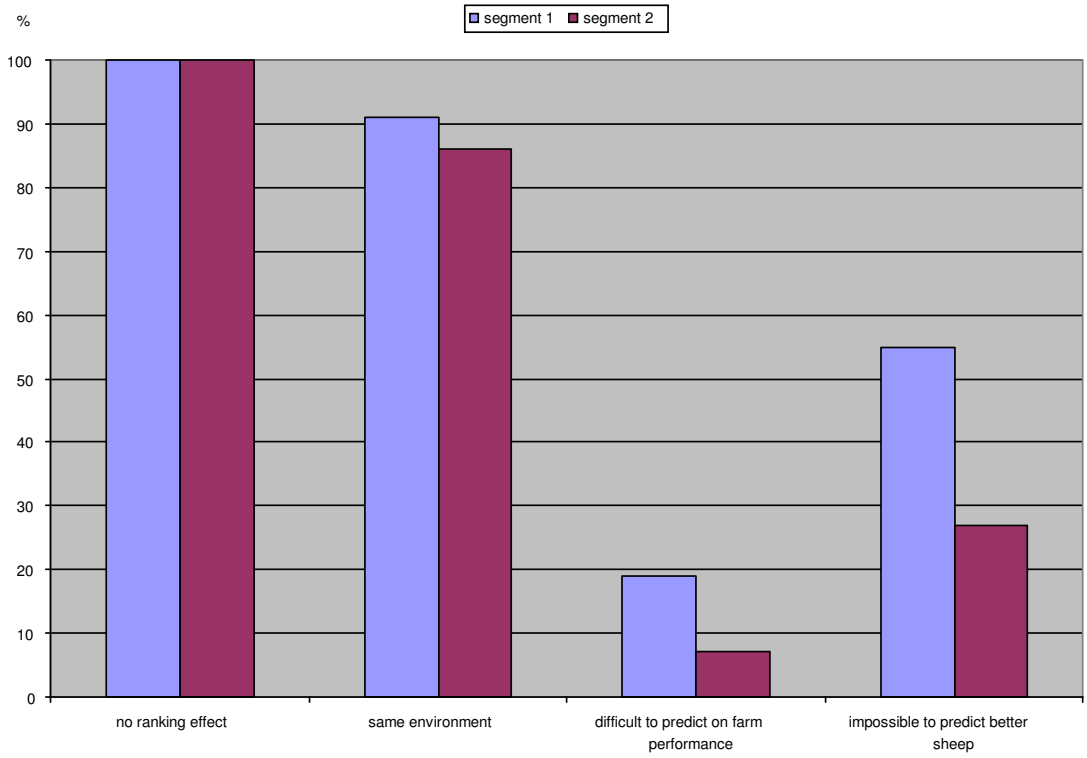

Figure 3 Ranking and predictability, segments one and two

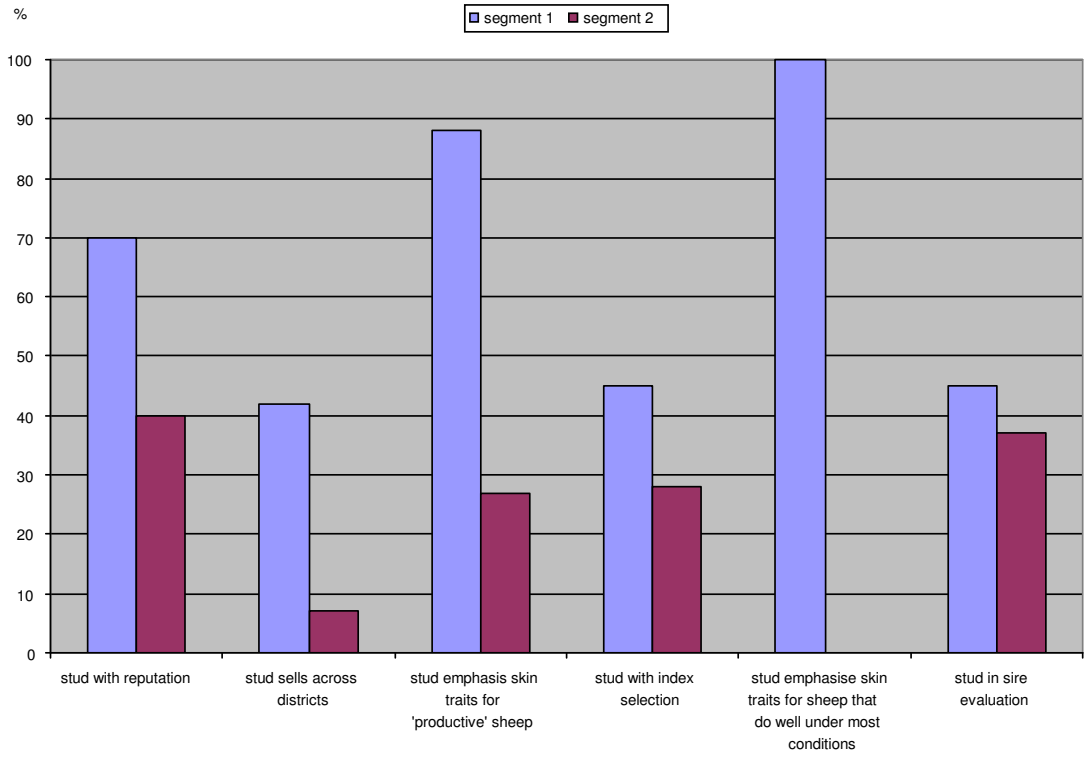

Figure 4 Breeding beliefs about stud choice, segments one and two

In figure 4 the beliefs of growers in segments one and two about stud choice are presented. Note that growers in segment one are more likely to rate buying from a stud that emphasises fleece characteristics that are related to skin traits as very important compared to growers from segment two. Growers in segment one are significantly more concerned about purchasing rams from a stud with a longstanding reputation for producing quality rams.[5] They are also significantly more concerned about purchasing rams from a stud that sell rams to growers across a number of districts.[6]

On the whole, these results seem to be consistent with the fact that growers in segment one accept the implications of believing skin traits can only be reliably assessed by visual assessment of fleece characteristics. These growers will only purchase rams from studs that use 'productive' or 'elite' breeding principles. Having screened for studs on this basis, they will then use objective measurement and index selection procedures to finalise their choice of stud.

A relatively high proportion of growers from both segments purchase rams from studs that participate in sire evaluation schemes. Again, growers in segment one will screen prospective studs for those that use 'productive' or 'elite' breeding principles.

Segments three and four

The growers in these segments represent approximately 39 per cent of respondents. The growers in segments three and four believe that changing environments causes both ranking effects and scale effects in terms of fibre diameter, fleece weight and other traits. These growers believe that they can counter these effects to some extent by breeding sheep with characteristics that are relatively stable across environments.

The type three strategist will produce 'elite' type wool. For instance,

> *Mervyn is a commercial woolgrower who had been using the same traditional fine wool stud for many years. Though he was very happy with the fibre diameter of his flock he was discontented with the wool cut per head and the profits from his wool enterprise. Mervyn decided he needed a new approach to breeding as he was not making sufficient money with the type of sheep he was breeding.*
>
> *Mervyn decided that he needed to improve in two major areas to become more profitable – wool cut per head and wool quality. Mervyn has employed a professional breeding consultant to oversee his breeding program. Mervyn has full confidence in the consultant and is happy to let him make all the breeding decisions including the selection of studs.*
>
> *Mervyn has been using semen from his current stud for about five years and is very happy with the progress they are making. He sees no*

[5] χ^2=7.61, p=0.02.
[6] χ^2=20.09, p=0.00.

immediate need to change studs but would be happy to do so if the breeding consultant recommends it. He is not concerned with buying from studs with similar climates to his as long as the sheep from the stud exhibit the right skin characteristics, which are reflected by elite wool. Mervyn looks for soft handling, deep crimping wool with clearly defined fibre bundles and good nourishment.

While Mervyn believes that some sheep only do well in certain climates there are sheep that will produce well in any area. Therefore as long as you buy the right sort of sheep it does not matter where you buy them or where you take them – they will always do well. These sheep have good skin characteristics, which enable them to produce well in different climates and produce fleeces that have a natural resistance to rain and dust penetration.

The growers in segment three (22 per cent of respondents) achieve this by selecting for sheep that have relatively high skin follicle density and a relatively high ratio of secondary to primary skin follicles. The growers in segment three rely on subjective assessment of characteristics such as crimp frequency and definition, and staple structure as well as objective measurement for characteristics such as fibre diameter and fleece weight to assist the in making selection decisions. These growers may well employ bloodline comparisons based on cross environment progeny testing using link sires to identify bloodlines that perform consistently well under a range of conditions. However, these growers will only select a bloodline or sire from amongst those bloodlines or sires that are present in a number of trials at different sites. This is because the data will be available to directly evaluate the level of, and variation in, the performance of these bloodlines or sires under a range of conditions. Ultimately, however, they will only purchase rams from studs breeding sheep with the correct fleece characteristics.

The growers in segment four (17 per cent of woolgrowers in our sample) attempt to identify sheep with characteristics that are stable across environments by purchasing from studs whose rams are reputed to perform well across a range of environments. The growers in this segment may use objective measurement for characteristics such as fibre diameter and fleece weight to assist selection decisions. These growers are likely to purchase from studs that perform well in wether trials across a number of districts. They may also employ the data from central sire evaluation schemes to identify sires that perform consistently well across a number of environments. However, they will be sceptical of bloodline comparisons made across different environments using data from link sires alone. Like the growers in segment three, the growers in segment four will tend to select a bloodline or sire from amongst those bloodlines or sires that are present in a number of trials at different sites. This is because the data will be available to directly evaluate the level of, and variation in, the performance of these bloodlines or sires under a range of conditions.

Brian is a typical example of a grower from segment four,

Brian has recently started farming independently of his family and is now free to select the stud of his choice. Brian decided to change to a new bloodline because he felt that the performance of his parents' flock had not improved over the last twenty years. Brian decided that he would only buy from studs that were proven to have performed well over a number of wether trials. Because there are very few Victorian studs included in the NSW Combined Wether Trial results Brian chose to buy rams from a stud in New South Wales. This was a stud that he identified as a consistent winner across many regions.

Brian is happy to travel the long distance to buy rams though he would be keen to investigate some Victorian studs if there were any with proven performance across a number of trials. However, there are not many Victorian studs with enough wether trial data and so Brian is not be confident that any of them would perform well on his farm.

Growers in segments three and four may be relatively unresponsive to variations in the performance of studs and will be loyal to a stud that consistently supplies satisfactory rams.

In figure 5 the beliefs of growers in segments three and four about ranking and the predictability of the performance of sheep with respect to fibre diameter are presented.[7] The results show that these growers, who believe the environment has an important influence on ranking of bloodlines in terms of fibre diameter, believe it is very difficult to predict the relative performance of bloodlines under different conditions, especially when they change environments.

In figure 6 the beliefs of growers in segments three and four about stud choice are presented. Note that a high proportion of growers in segment four rate buying from a stud that emphasises fleece characteristics that are related to skin traits as very important. This suggests that many growers in this segment are combining both variants of the 'stable characteristics' strategy for identifying bloodlines that will perform well under most conditions. Growers in segment three are significantly less concerned about the reputation of a stud than growers in segment four.[8] We had expected that reputation would be a very important factor for a high proportion of growers in both segments.

A relatively high proportion of growers from both segments rated the use of a selection index as very important. The proportions are similar to those for segments one and two. However, a smaller proportion of growers from segments three and four rated participation in sire evaluation schemes or in bloodline performance analyses as very important compared to segments one and two.

[7] They have similar beliefs with respect to fleece weight.
[8] χ^2=26.8, p=0.00.

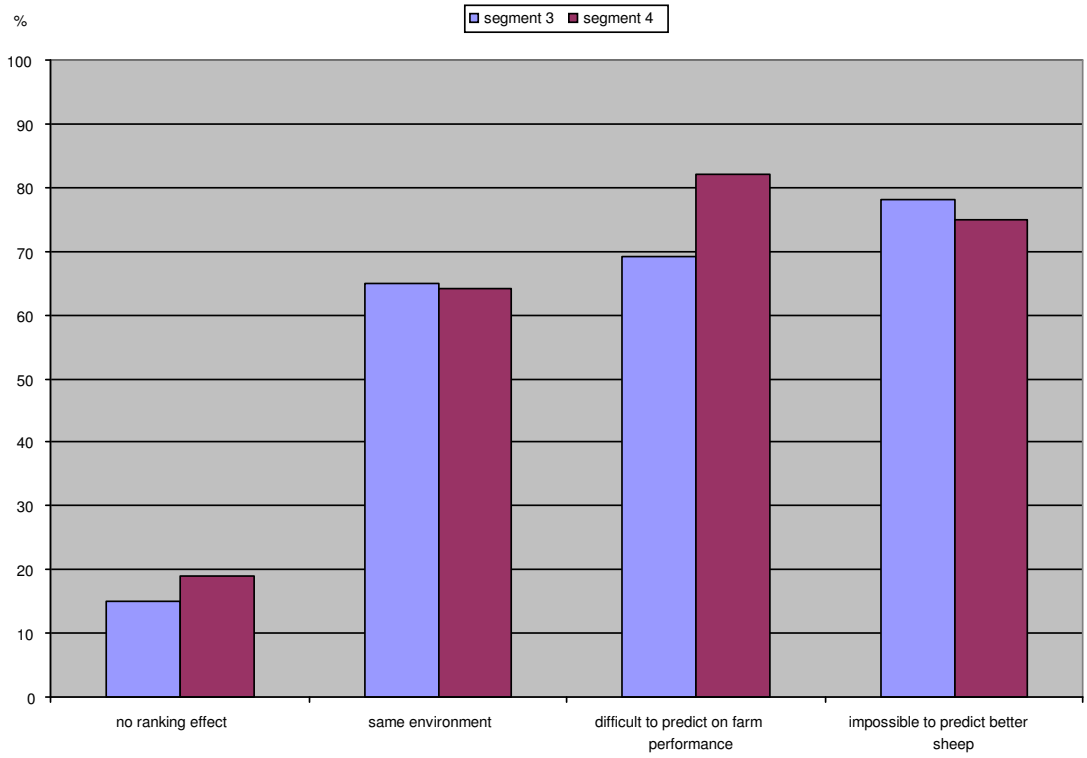

Figure 5 Ranking and predictability, segments three and four

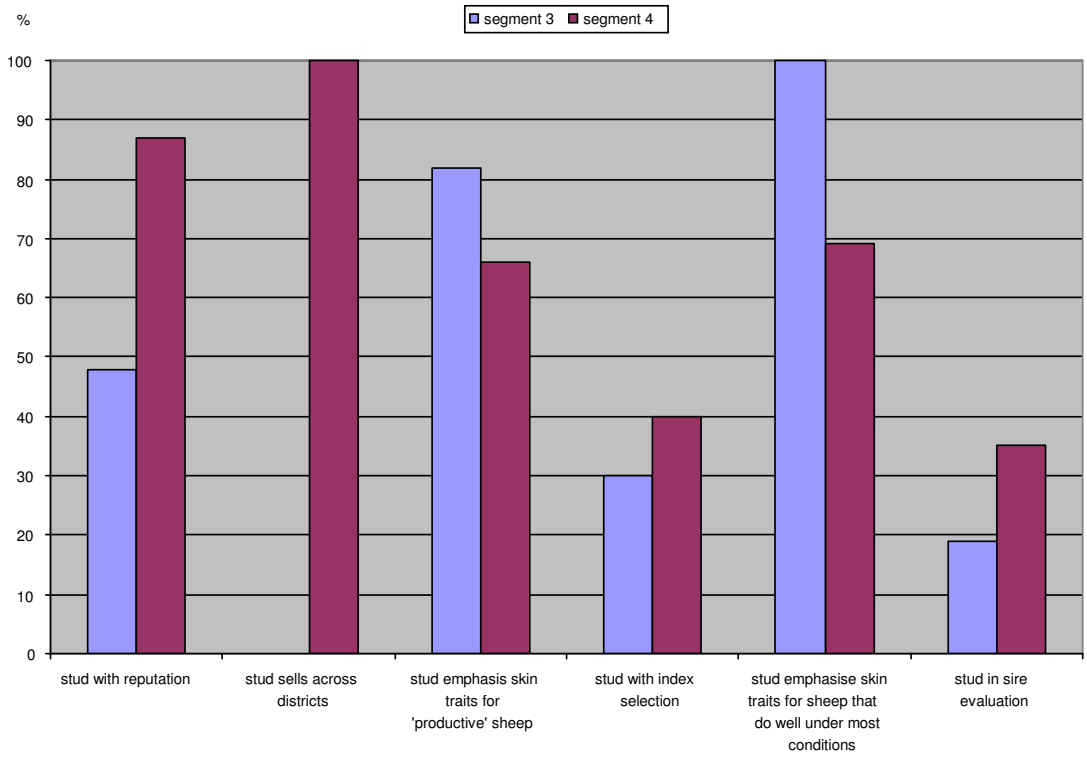

Figure 6 Breeding beliefs about stud choice, segments three and four

Segments five and six

These growers represent approximately 39 per cent of respondents. They believe that changing environment causes important ranking effects and scale effects in terms of fibre diameter, fleece weight and other traits. They are not convinced these effects can be overcome by breeding for sheep with stable characteristics across environments. Instead, they believe that the most reliable strategy is to purchase rams that are reputed to perform well. These rams may be obtained from a stud in the district or from a stud outside the district that supplies rams that are reputed to perform well in the grower's district. Or they may simply purchase rams from a long established, highly reputable stud.

Woolgrowers in segment five (11 per cent of woolgrowers) also believe that sheep that have relatively high skin follicle density and a relatively high ratio of secondary to primary skin follicles are likely to produce relatively heavier and finer fleeces compared to sheep that do not have these characteristics. They may also believe that these sheep are less sensitive to variations in nutrition. Consequently, these growers will only purchase from studs supplying rams that produce wool that is soft handling and lustrous with a bold, deep crimp and long staple. These growers may use objective measurement to help select for characteristics such as fibre diameter and fleece weight.

The type five strategist will produce 'elite' type wool. For example,

> *Trevor runs 4000 merino ewes with an average fibre diameter of 20 microns and wool cut of about 4 kilograms per head. He is keen to increase the fleece weight of the flock and reduce the fibre diameter at the same time. His sheep classer advised him to change studs as the rams he was being supplied with were performing badly and he was losing money. He decided with the advice of his classer that he needed to change to a different type of sheep that would be more productive.*
>
> *It was a big decision to change studs and Trevor was very nervous about bringing in new bloodlines and risking what he had already had. As he became more convinced about the benefits of good skin characteristics, he became more confident about selecting a stud that would improve the performance of his flock. However, to minimise risks Trevor was keen to select a stud from within his district or from an area with a very similar climate to his farm.*
>
> *With the help of his sheep classer Trevor identified a stud in a similar environment that sold rams to a number of farmers in his area. The stud classer had an excellent reputation and his rams were reputed to do well around Trevor's district. The rams had the right wool type and skin characteristics and Trevor became convinced that they would improve the performance of his flock. Using both visual assessment and some figures supplied by the stud Trevor and his classer picked out rams with good*

frames, a suitable fibre diameter and good style with an even, deep crimping wool.

Although it is too early to tell if his flock is improving, Trevor is now confident that his fears about changing bloodlines were unnecessary. He is convinced that the new rams will do well and he will increase his wool production and the quality of his wool without affecting his fibre diameter. He is also hoping that one day the wool industry will catch on the benefits of this type of wool and that the benefits will be seen not just with on farm production but in the sale of the wool as well.

The growers in segment six represent 28 per cent of respondents. The growers in this segment, unlike those in segment five, do not necessarily believe that sheep that have relatively high skin follicle density and a relatively high ratio of secondary to primary skin follicles are likely to produce relatively heavier and finer fleeces compared to other sheep. Some growers in segment six may believe that wool that is bold; deep crimping and long stapled will attract a processing premium and will aim to breed sheep producing wool with these characteristics. Other growers in this segment may believe that fibre diameter, staple length and fleece weight are the key determinants of revenue and use objective measurement to select for these traits.

Some growers in segment six may believe that traditional wool traits such as high crimp frequency and style are the key determinants of revenue. Consequently, these growers may rely heavily on subjective assessment to judge fleece characteristics. They may use objective measurement to help select for characteristics such as fibre diameter and fleece weight. Some growers in this segment, who have always relied on their stud supplier to meet their breeding needs, may not have strong convictions about sheep breeding.

Colin and Joseph are examples of woolgrowers in the segment six.

Colin buys rams from a neighbouring stud but does not see the rams before he gets them. He has land that runs right opposite the stud and many people local connect his sheep with the stud so he feels it is in the studs best interests to give him good rams. Colin trusts them to supply good quality rams and the stud classer comes over each year to class the ewes and pick out suitable rams. Colin has about five thousand sheep and buys about fifteen rams a year so he feels he is a valued customer.

Colin does not monitor or measure his wool production but leaves the genetics to the stud and concentrates on environment and improving pasture productivity. He has never been dissatisfied with the rams they have supplied and it would need to be proven beyond a doubt that the rams are poor and that he is losing money before he would consider changing studs.

Colin is happy with his sheep and sees no reason to change. He has heard about the Worlds Finest Ram project but has taken little notice of the results. The results would not change the way he feels about his stud

so even if they perform badly it will not effect him because the rams do well at his place and he is happy.

Joseph is a different example of a segment six grower.

Joseph buys rams from a neighbour who breeds his own rams plus a few extras for a couple of locals. The rams are cheap and are run in the paddock under local conditions so you know how they are going to do on your place. Joseph believes that the rams sold at shows and proper studs are often shedded and aren't tested under real farm conditions so you don't know what will happen when you get them home. They can be a disappointment as they can really deteriorate when they have to cope out in the paddock – there is no point in paying a lot of money for a ram that will fall apart when you get home.

The neighbour does pretty well with his sheep and he doesn't have any problems with them. Joseph says 'The figures change a lot and don't really mean much because they depend on what the season was like but we are pretty happy that our sheep do okay. We don't get the newspapers so we don't hear about a lot of trials and other sort of stuff'.

The growers in these segments are likely to be strongly loyal to a particular stud and some may be strongly interested in the results of local wether trials.

In figure 7 the beliefs of growers in segments five and six about ranking and the predictability of the performance of sheep with respect to fibre diameter are presented. The results show that most of these growers believe that it is very difficult to predict the relative performance of bloodlines even when they remain in similar environments.

In figure 8 the beliefs of growers in segments five and six about stud choice are presented. The growers in segment five combine buying rams from studs with a breeding emphasis on breeding 'productive' sheep with one of a number of other strategies. These are either purchasing from studs that have a reputation for breeding quality rams (53 per cent), or purchasing from studs with a similar climate (43 per cent). Approximately 24 per cent of the growers in this segment nominated buying rams from studs with a breeding emphasis on breeding 'productive' sheep as the only very important reason for choosing a stud.

Nearly half of the growers in segment six did not rate any reason as very important in choosing a stud. Those that did nominate a reason as very important selected either having a reputation for breeding quality rams (36 per cent), a similar climate (24 per cent), use of a selection index (22 per cent) or participation in a sire evaluation or bloodline analysis (19 per cent). Note that these growers, like those in other segments, rated most other reasons as important factors in choosing a stud.

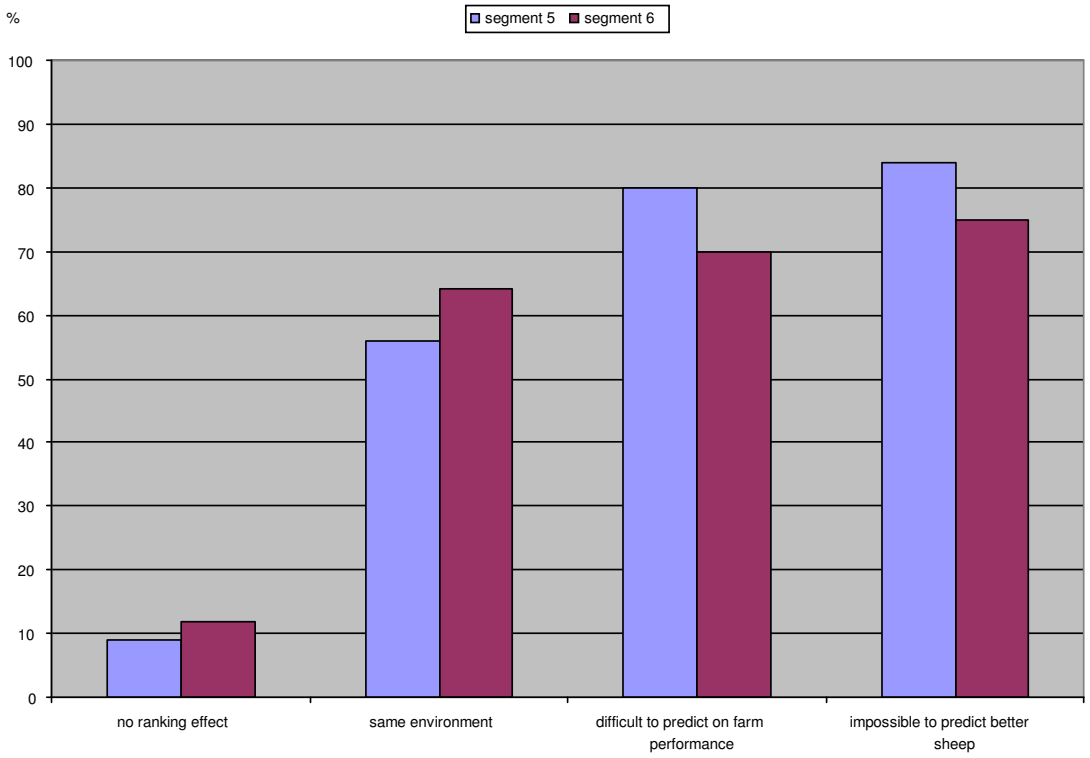

Figure 7 Ranking and predictability, segments five and six

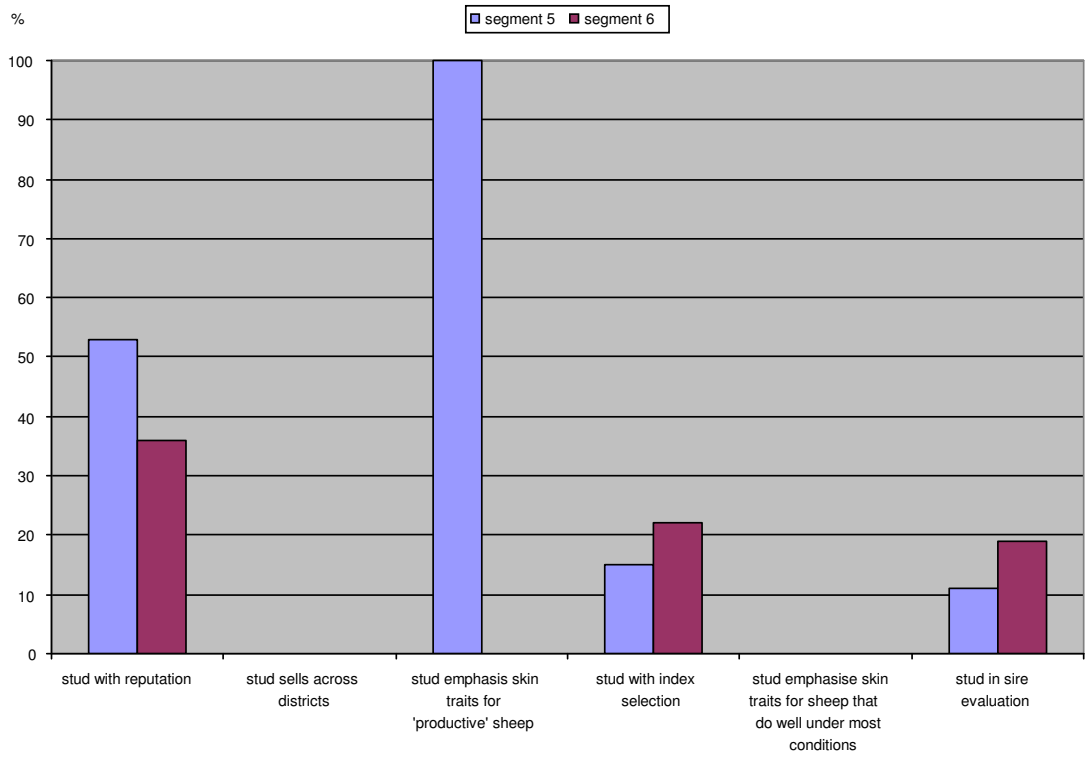

Figure 8 Breeding beliefs about stud choice, segments five and six

Segment membership and enterprise characteristics

We found there was no relationship between segment membership and the biophysical characteristics of sheep enterprises such as location and rainfall. Segment membership was also unrelated to enterprise characteristics such as the size of ewe and wether flocks, or the number of rams used. The proportion of woolgrowers that manage a cattle enterprise was the same across the segments (44 per cent on average), as was the proportion of woolgrowers that manage a cropping enterprise (54 per cent on average).

In terms of flock management we found that woolgrowers in the first segment reported significantly higher culling rates on maiden ewes (26 per cent) than woolgrowers in other segments (around 20 per cent in other segments).[9] A smaller proportion of woolgrowers in segment six class their mature ewes compared to other segments (54 per cent and approximately 70 per cent respectively).[10]

Approximately 21 per cent of the enterprises in the sample were sheep studs. This proportion did not vary significantly across the segments. This finding is consistent with the possibility that many studs tend to specialise in servicing the needs of woolgrowers in a particular market segment or niche. In other words, this finding is consistent with the possibility that many studs follow a focus differentiation strategy (Porter 1985). A focus differentiation strategy is successful in circumstances where different purchasers of a product are interested in substantively different attributes in a product. In other words, different key criteria govern the purchasing decision of different buyers. In the case of sheep breeding, different studs specialise in selling rams to growers in each breeding strategy segment.

Segment membership and wool production

We found the average fibre diameter of the flock reported by growers was similar across the segments at approximately 20 microns.[11] However, woolgrowers in segment one reported a significantly higher average wool cut per head compared to growers in segment two (see figure 9).[12] The woolgrowers in segment one also reported a significantly higher average wool cut per head compared to growers in segments three and five.[13] In fact, the woolgrowers in segment one reported a significantly higher average wool cut per head than growers in all other segments except for growers in segment four.

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[9] $F_{4, 408}=2.69$, $p=0.03$

[10] $\chi^2=11.02$, $p=0.05$.

[11] $F_{5, 408}=3.52$, $p=0.11$

[12] $F_{1, 80}=6.24$, $p=0.01$

[13] $F_{5, 100}=5.05$, $p=0.03$

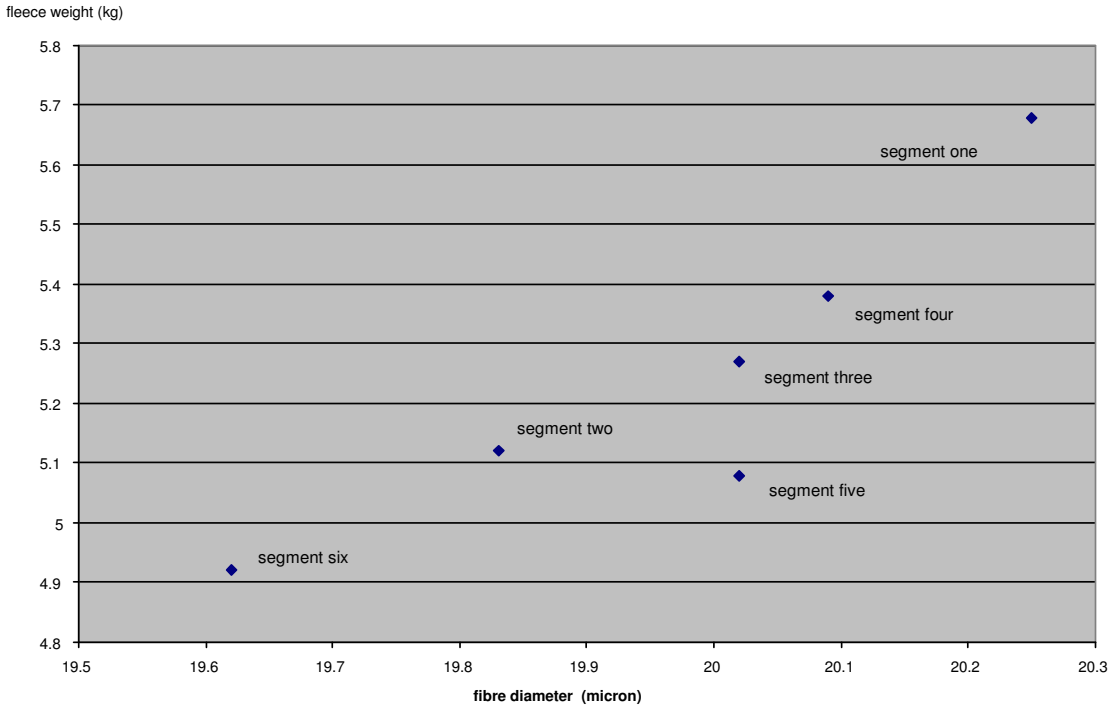

Figure 9 Fibre diameter and fleece weight by segment

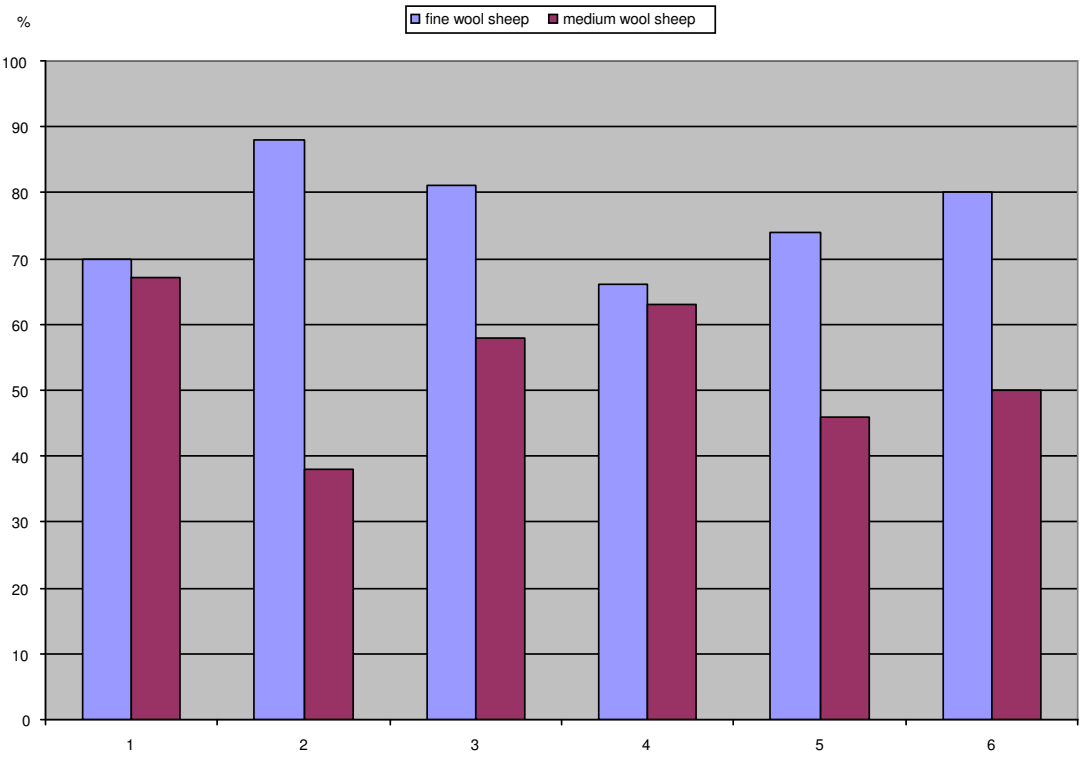

Figure 10 Farm conditions and type of sheep

There were significant differences in growers' beliefs about the suitability of their farms for different types of sheep.[14] Growers in segment two were more likely than other growers to believe conditions on their farm suited fine wool sheep and were less likely than other growers to believe conditions on their farm were suitable for medium wool sheep. Growers in segments one and four were marginally less likely than other growers to believe conditions on their farm suited fine wool sheep and were more likely than others to believe conditions on their farm suited to medium wool sheep (see figure 10). This result seems to be in accord with the relatively high fleece weights reported by the growers in these two segments.

Segment membership and breeding objectives

Growers were asked to indicate their main breeding objectives. No differences were found across the segments in the breeding objectives of growers except with respect to 'improving wool quality'. The majority of growers were trying to reduce their fibre diameter and increase their fleece weight (see figure 11). While growers in all segments were trying to improve wool quality, a higher proportion of growers in segments one and three were trying to increase wool quality compared to growers in other segments (see figure 12).[15] This result is consistent with the focus on 'elite' wool production in these segments.

Segment membership and bloodline beliefs

Woolgrowers were asked to indicate if they believed it was practical for them to change to a finer bloodline. Approximately 65 per cent of growers believed it was practical for them to change. There were no differences across the segments in this proportion.[16] The minority of growers who did think it was impractical for them to change to a finer bloodline thought their wool cut per head would be lower (62 per cent) or they would end up with sheep that were too small (58 per cent).

Woolgrowers were also asked to indicate if they believed it was practical for them to change to a heavier cutting bloodline. Approximately 57 per cent of growers believed it was practical for them to change. A higher proportion of woolgrowers in segments two and three think it would be practical to change to a heavier cutting bloodline than in other segments (see figure 13). The growers in these segments produce relatively lighter fleece weights compared to growers in segments one and four. A higher proportion of woolgrowers in segments four believe it would be impractical to change to a heavier cutting bloodline than in other segments.[17]

[14] For fine wool sheep χ^2=12.00, p=0.04, for medium wool sheep χ^2=12.52, p=0.03.

[15] χ^2=14.03, p=0.01.

[16] χ^2=5.12, p=0.40.

[17] χ^2=20.92, p=0.00.

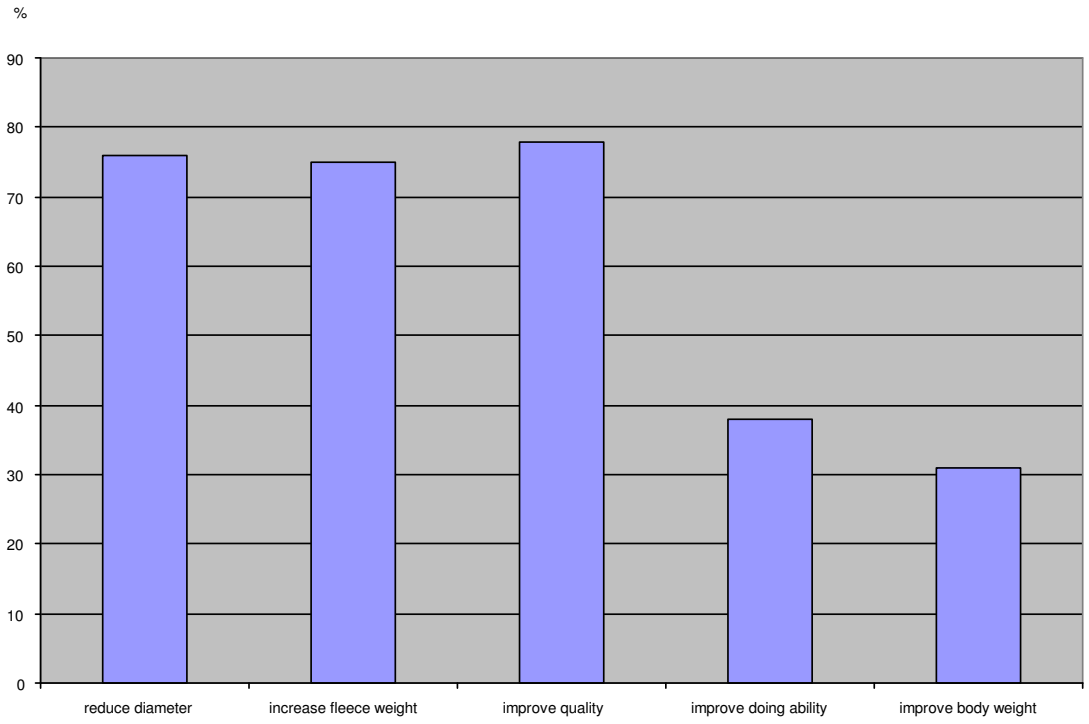

Figure 11 Breeding objectives

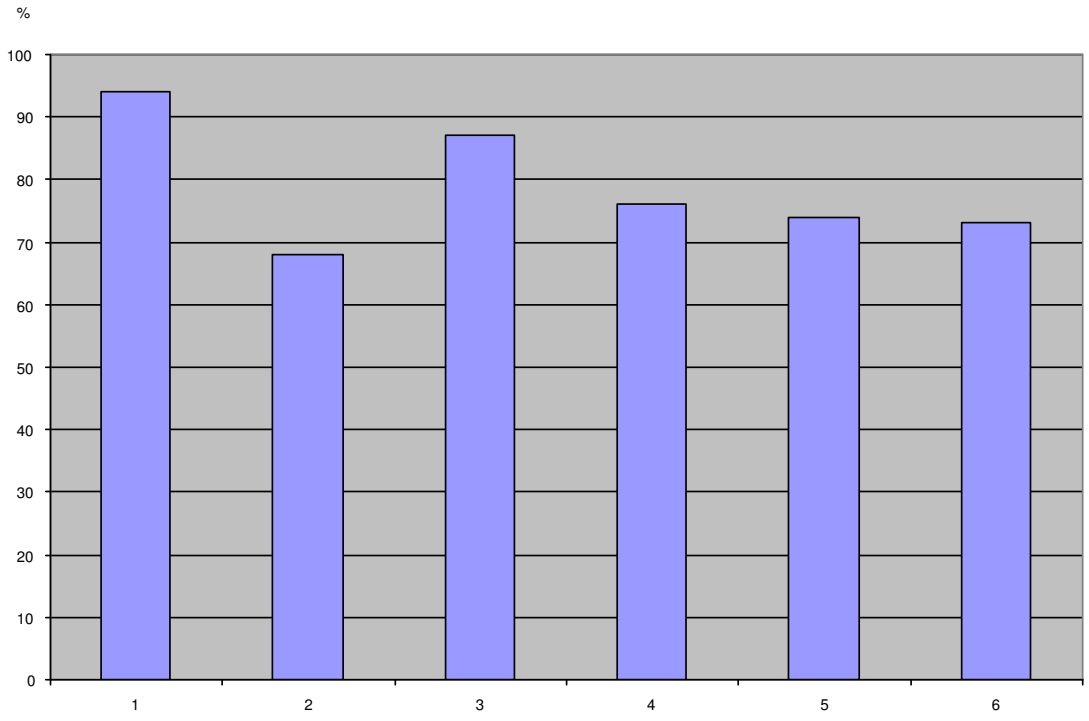

Figure 12 Improving wool quality by segment

This may reflect the fact that these growers believe their conditions suit fine to medium wool sheep and they are already achieving relatively high fleece weights.

Those growers who thought it was impractical to change thought a heavier cutting bloodline would not stand up to conditions in their district (54 per cent), their fibre diameter would blow out (64 per cent) or they would get too much fleece rot (51 per cent). Woolgrowers in segments one, four and six were more likely than other growers to believe changing was impractical because a heavier cutting bloodline would not stand up to conditions in their district (see figure 14).[18]

Segment membership and ram selection techniques

We found significant differences across the segments in the relative importance growers placed on different techniques for selecting rams. Most woolgrowers agreed that visual assessment is essential and useful when selecting rams but these assessments must be backed up by objective measurements of characteristics such as fibre diameter (see figure 15). A relatively low proportion of growers in segments two and six regard visual assessment of wool quality as essential when selecting rams.[19] This is consistent with a high proportion of growers in each of the other segments believing that the attenuated relationship between skin traits and measurable fleece characteristics is an important risk factor in sheep breeding. A small but relatively high proportion of woolgrowers in segments one and six agreed that visual assessment can be unreliable and misleading compared to other segments.[20]

Most woolgrowers agreed with the statement that objective measurement of wool characteristics is useful when selecting rams but these measurements must be backed up by visual assessment of wool characteristics (see figure 16). However, the proportion of woolgrowers in segment one that agreed with this statement was significantly lower than in other segments.[21] This is consistent with a high proportion of growers in this segment believing that ranking effects and the attenuated relationship between skin traits and measurable fleece characteristics are not important risk factors in sheep breeding.

Woolgrowers varied in their views on the importance of fleece characteristics that reflect underlying skin traits such as follicle type and density (see figure 17). Woolgrowers in segments one, three and five were more likely to regard fleece characteristics that reflect underlying skin traits as essential and critical to improving flock productivity than growers in other segments.[22]

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[18] χ^2=13.32, p=0.02.

[19] χ^2=17.49, p=0.00.

[20] χ^2=12.60, p=0.03.

[21] χ^2=10.55, p=0.06.

[22] χ^2=28.14, p=0.00.

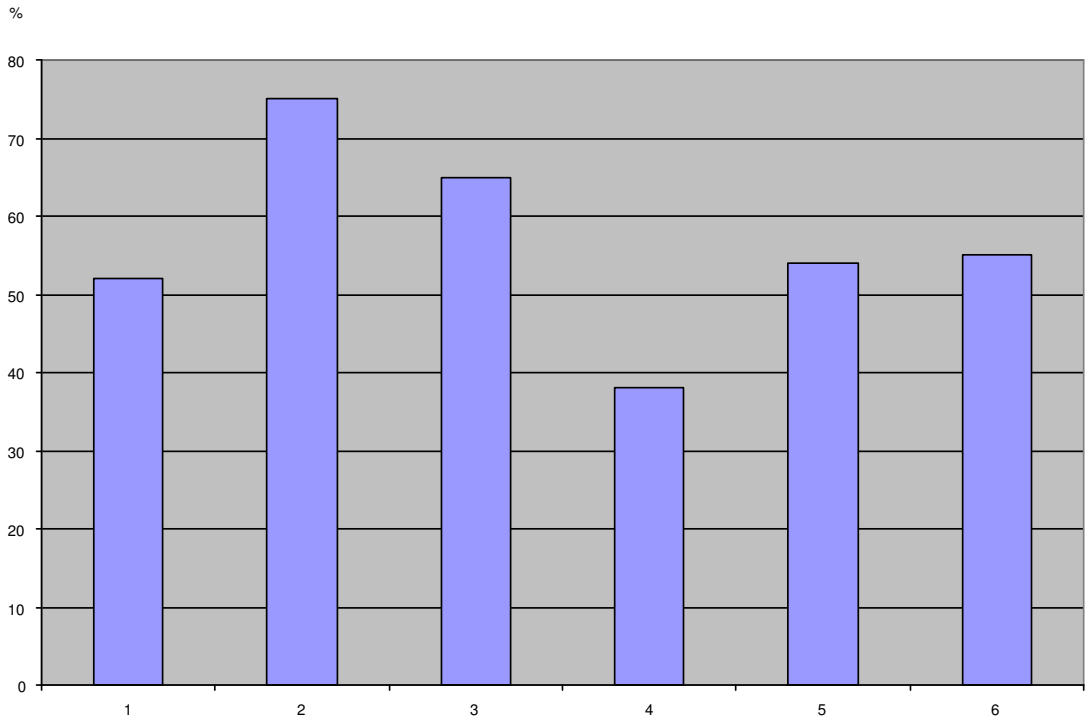

Figure 13 Practical to change to a heavier cutting bloodline (by segment).

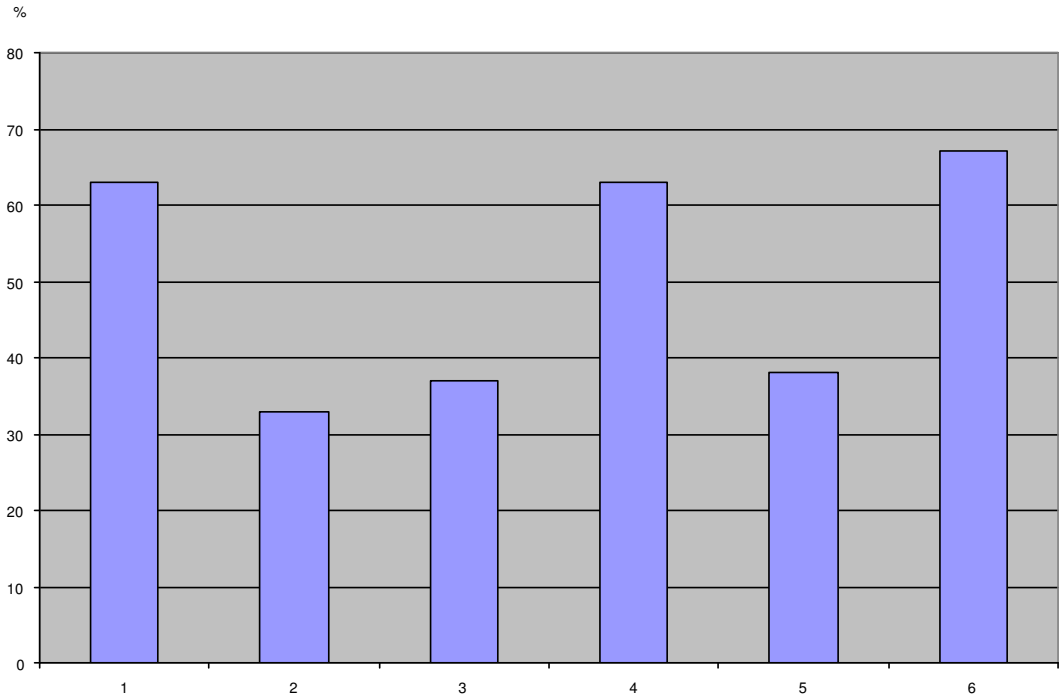

Figure 14 A heavier cutting bloodline would ‘not suit conditions’ (by segment).

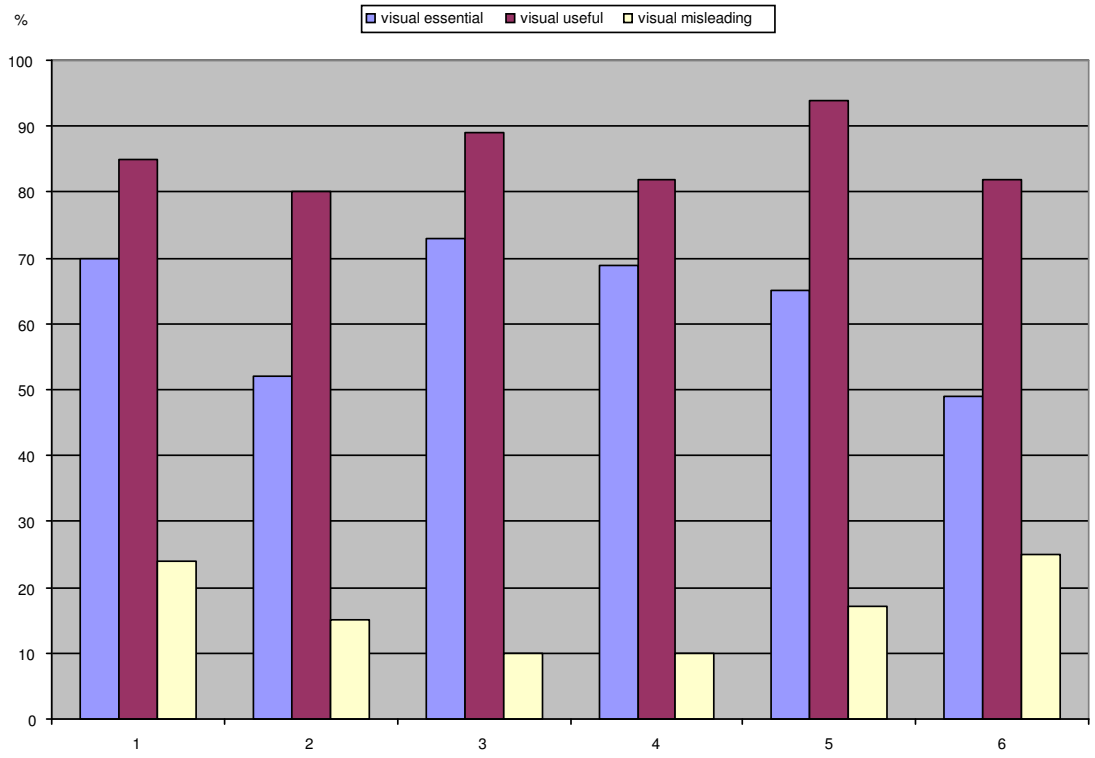

Figure 15 Visual assessment by segment

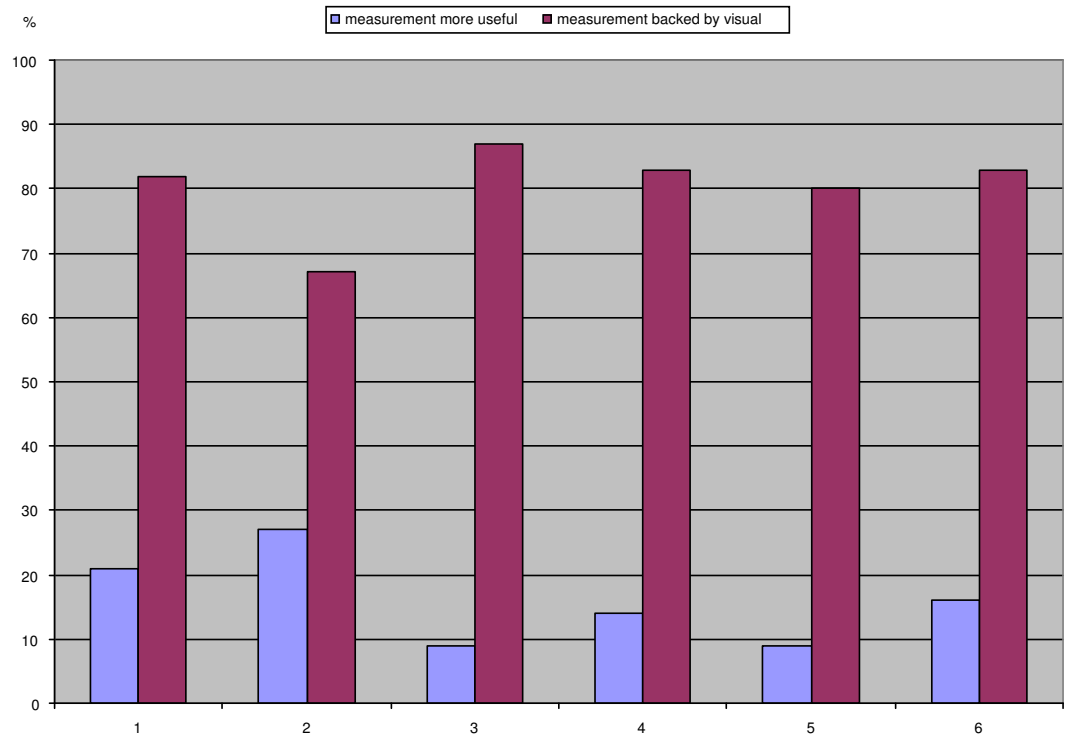

Figure 16 Objective measurement by segment

This is consistent with the views of growers in each segment on the relationship between skin traits and objective measurements of fibre diameter and fleece weight. Approximately half of the growers in each segment believe that selecting using fleece characteristics that reflect underlying skin traits is useful but must be backed up by objective measurements. In short, woolgrowers in segments one, three and five attach greater importance to using fleece characteristics that reflect underlying skin traits when selecting rams than woolgrowers in other segments.

Most woolgrowers, nearly 70 per cent, agreed with the statement that a selection index would be helpful when used in conjunction with visual assessment of wool characteristics. However, a higher proportion of woolgrowers in segments one and two regarded the use of a selection index as the most efficient and effective way of selecting the best sheep than did growers in other segments (see figure 18).[23] Also, a higher proportion of woolgrowers in segments one and two reported they used a selection index when selecting rams or would use an index if more studs made them available (see figure 18).[24] These results seem to be reasonably consistent with the growers in segments one and two regarding ranking effects as being an unimportant risk factor in sheep breeding.

Woolgrowers' opinions on district wether trials varied considerably. Almost 50 per cent of the growers in the sample believe that wether trials demonstrate how different bloodlines will perform in a district and help in making realistic comparisons of studs (see figure 19). Overall, more than 50 per cent of growers do not regard district wether trials as useful. About one third of the growers in each segment believe wether trials are not useful either because they are biased by the selection skills of entrants, do not represent pure bloodlines, or are run under management conditions different to their farm. Woolgrowers in segments five and six were less likely than other growers to regard wether trials as demonstrating how different bloodlines will perform in their district.[25]

Overall the pattern of responses across the segments concerning the relative importance of different methods for selecting rams seems consistent with their perceptions of the risk factors in sheep breeding and their breeding strategies.

[23] χ^2=15.17, p=0.01.

[24] χ^2=19.39, p=0.04.

[25] χ^2=14.85, p=0.01.

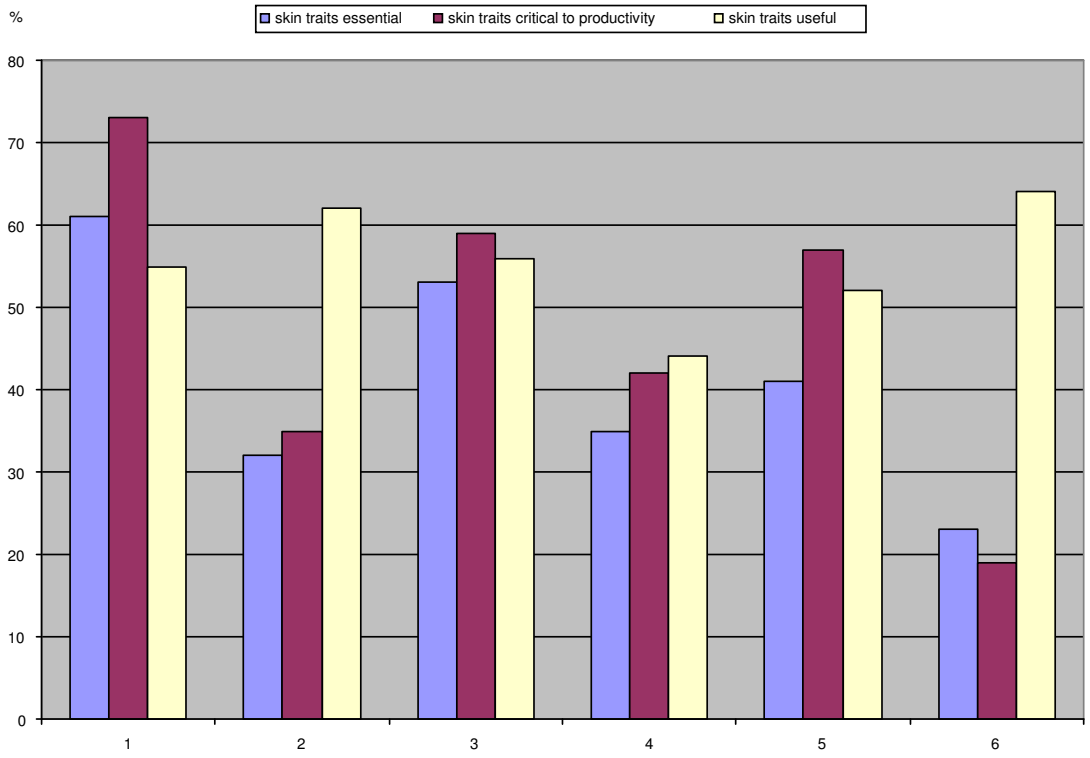

Figure 17 Fleece characteristics and skin traits by segment

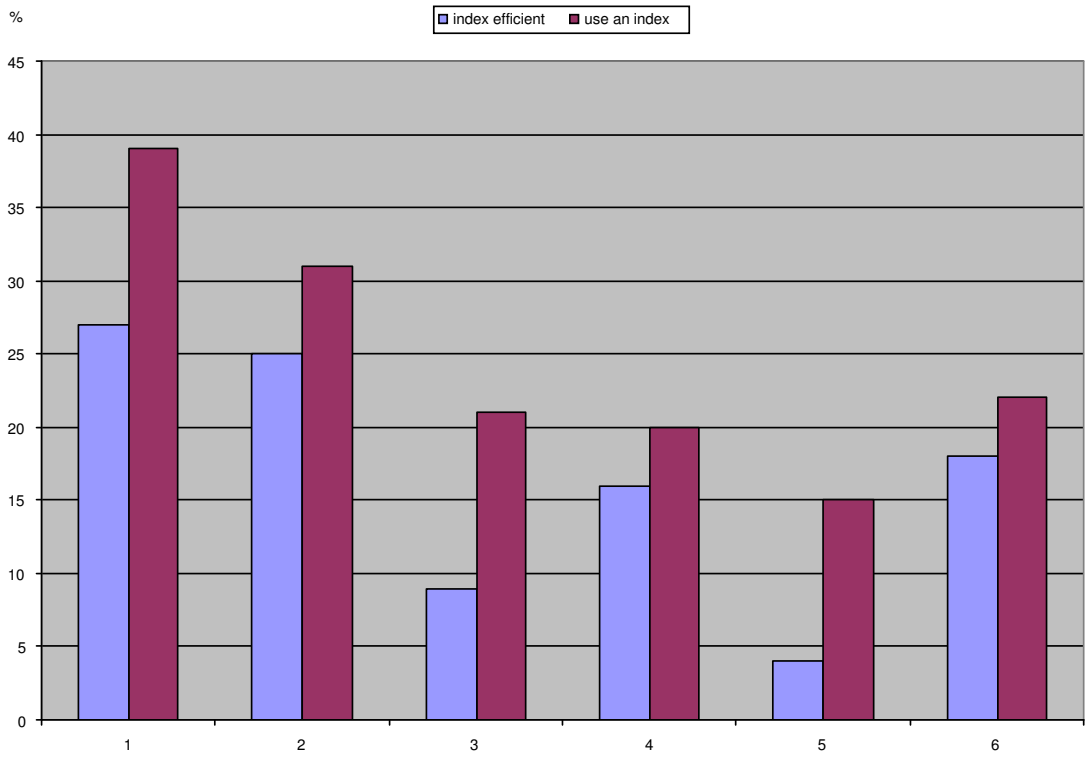

Figure 18 Index selection by segment

Segment membership and stud loyalty

Most woolgrowers obtain their rams from a nearby stud, or a Victorian stud or interstate stud in a district with a similar climate (see figure 20). However, there are some differences across the segments in their dependence on these sources. We expected that growers in segments five and six would be less likely than the growers in other segments to purchase from an interstate stud. This is the case (see figure 21).[26] We expected that growers in segments one and two would be more likely than the growers in other segments to purchase from an interstate stud. This is the case for segment one but not for segments two. Woolgrowers in segments three and five are more likely than woolgrowers in other segments to purchase their rams from a nearby stud.[27]

Woolgrowers in segments four and six were much less likely to have changed studs in the last five years (see figure 22).[28] Woolgrowers in these two segments were also much less likely than growers in other segments to have tried alternative studs in the last five years (see figure 23).[29] Conversely, the woolgrowers in segment one were more likely to have changed studs and tried alternative studs in the last five years than growers in other segments. These results are consistent with expected low levels of loyalty for woolgrowers in segments one and two. They are also consistent with possibility that a relatively high proportion of growers in segments one, three and five are new members of these segments.

Woolgrowers changed studs for a number of reasons. The most common reasons were because the producer wanted a ram with different characteristics (54 per cent), the stud was not improving fast enough (19 per cent), or because their sheep classer or breeder advised them to change (21 per cent). There was some evidence to suggest that woolgrowers in segments three and five were more likely than other woolgrowers to change studs because they wanted a ram with different characteristics (see figure 24).[30] This is consistent with new entrants into these segments. Finally, there was some evidence suggesting woolgrowers in segment two were more likely than other woolgrowers to change studs because their stud was not improving fast enough.[31]

Woolgrowers sought advice about changing studs from many sources. The most popular were independent sheep classers, wool representatives from a broking firm or another farmer (see figure 25). Only 14 per cent of woolgrowers indicated they sought advice about changing studs from staff of the Department.

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[26] χ^2=12.89, p=0.02.

[27] χ^2=10.94, p=0.05.

[28] χ^2=15.80, p=0.01.

[29] χ^2=13.84, p=0.02.

[30] χ^2=9.09, p=0.10.

[31] χ^2=9.12, p=0.10.

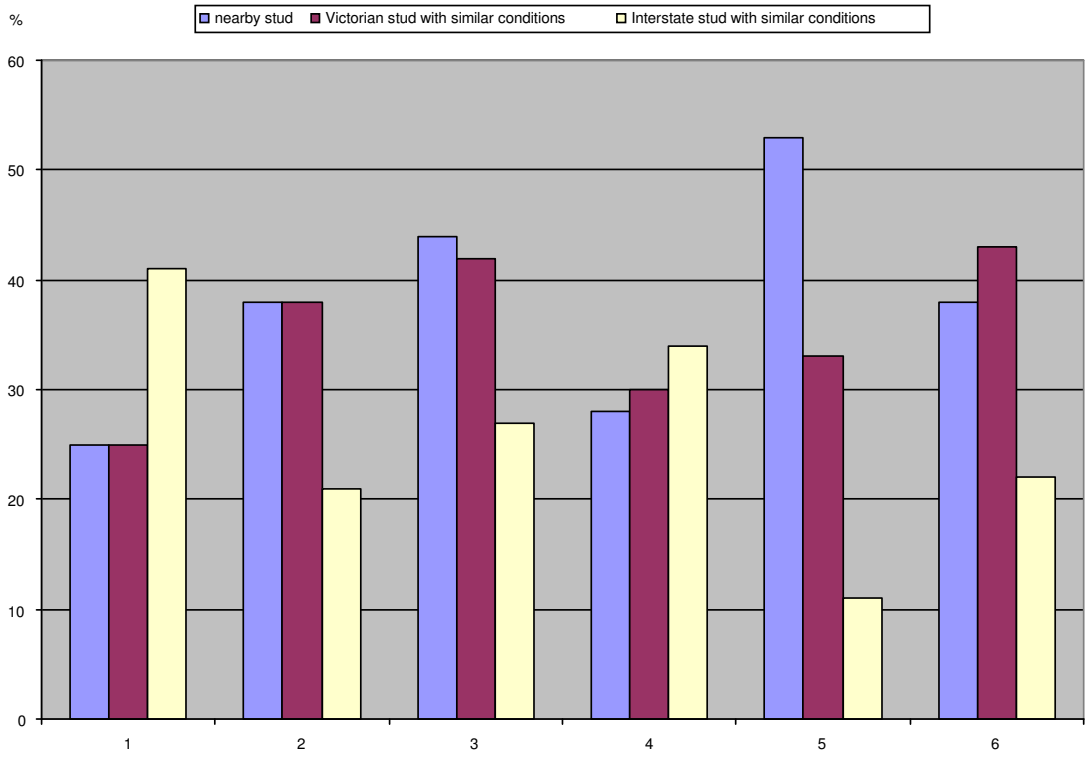

Figure 19 District wether trials by segment

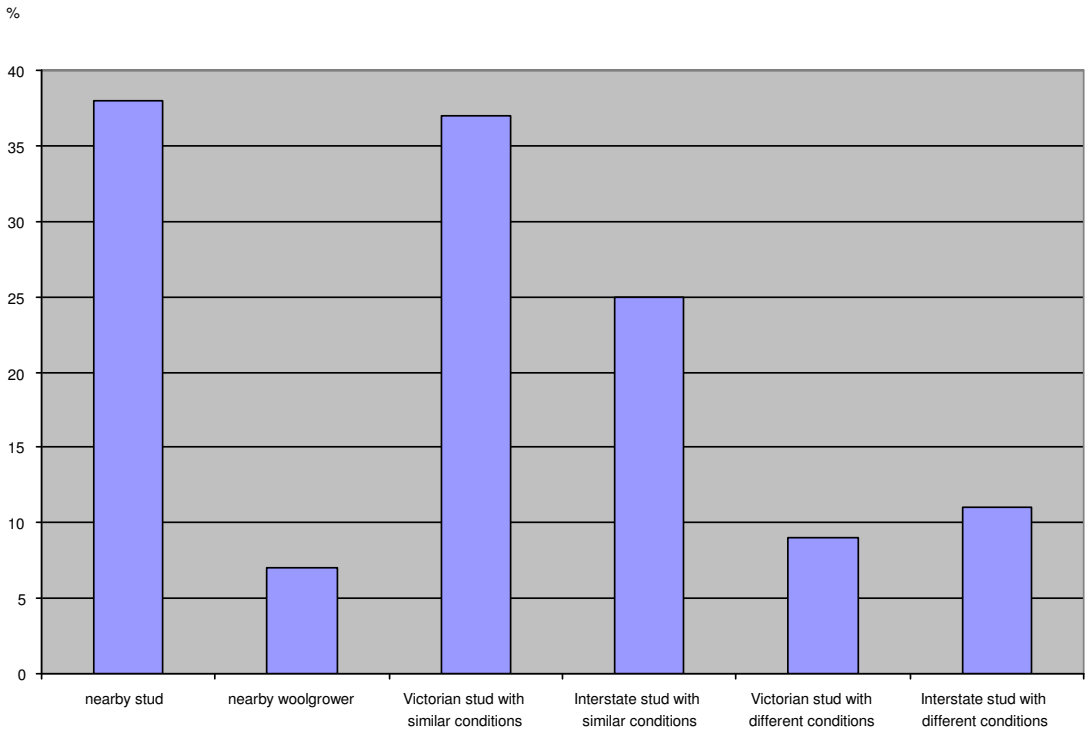

Figure 20 Ram source

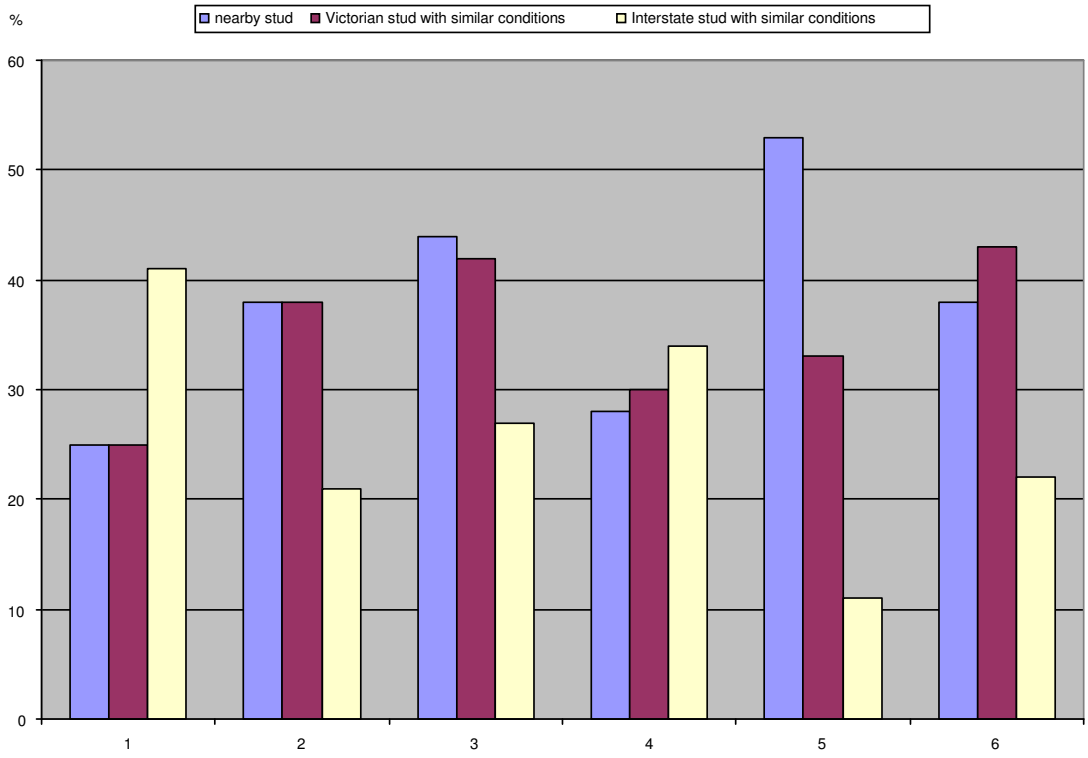

Figure 21 Ram source by segment

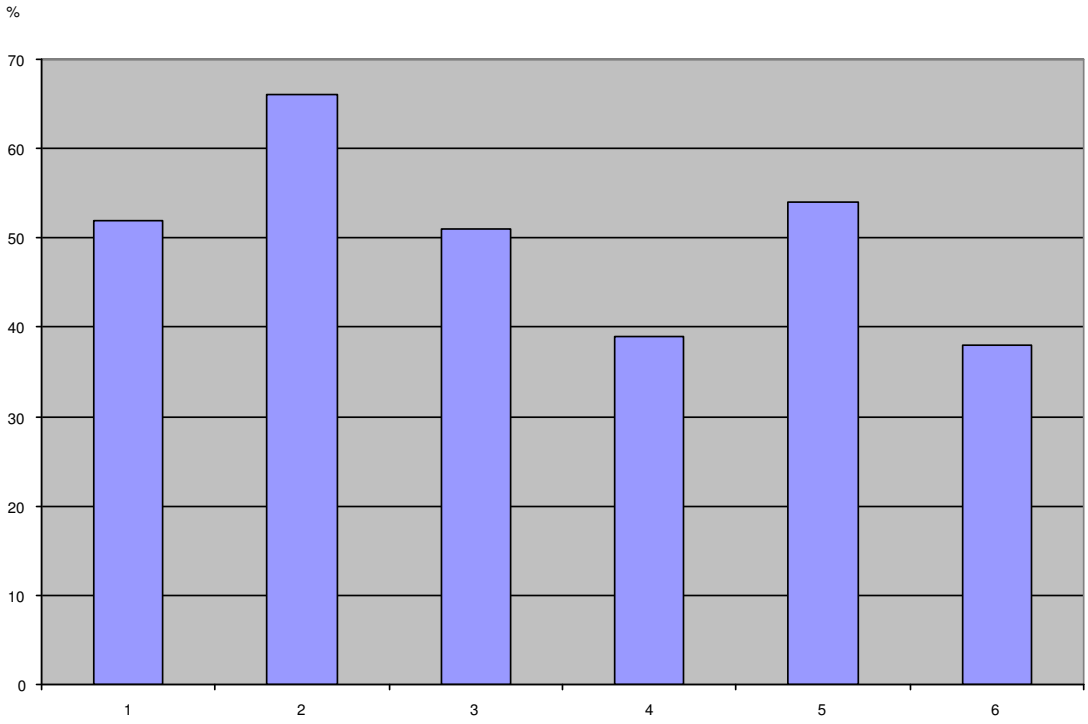

Figure 22 Growers changing stud in last five years by segment

Woolgrowers in segments one and three were more likely than other woolgrowers to seek advice about changing studs from a stud classer (see figure 26).[32]

Comparison with other studies

Our findings with respect to the general variation among growers in the factors that influence stud choice and the relative importance of different selection techniques are similar to the findings of past studies.

The presence of breeding strategy segments among stud breeders and woolgrowers implies that individual woolgrowers will differ from each other in a number of ways. First, breeders and growers will differ in their perceptions of the relative merits of visual and measured criteria for selecting rams. Differences among stud breeders and woolgrowers in the relative importance of visual and measured criteria for selecting sheep have been found in a number of studies (Love, Clarke et al. 1987; Casey and Hygate 1992; Butler, Corkerey et al. 1995; Pope, Atkins et al. 1996).

Second, individual breeders and woolgrowers will also differ in the criteria they use for selecting studs. Butler, Corkerey et al. (1995) found differences in the criteria used by breeders to evaluate studs. The importance to most breeders of 'similar climate' and 'performance elsewhere' as criteria for judging studs is consistent with a concern to account for the ranking effects of the environment when making breeding decisions.

Individual breeders and growers will differ in the sources they depend on for advice about sheep breeding. Butler, Corkerey et al. (1995) and Pope, Atkins et al. (1996) found breeders and growers rely on a range of sources for advice about sheep breeding.

Finally, individual breeders and growers will differ in their opinions of the merits of practices such as performance measurement and sire reference schemes. Butler, Corkerey et al. (1995) found that most breeders believe that performance recording is not as valid as traditional methods of assessing sheep and that opinion varied as to the importance of 'success in wether trials and 'involvement in sire reference schemes' in judging studs. They also found opinion varied as to the importance of index rank and pedigree in judging rams. These findings are also consistent with a concern on the part of many breeders to account for the effects of the environment when making breeding decisions

Generally speaking, the variety in beliefs and opinions about sheep breeding among stud breeders and woolgrowers found in previous studies appears consistent with the presence of strategy segments such as we have described in this study.

[32] χ^2=11.84, p=0.04.

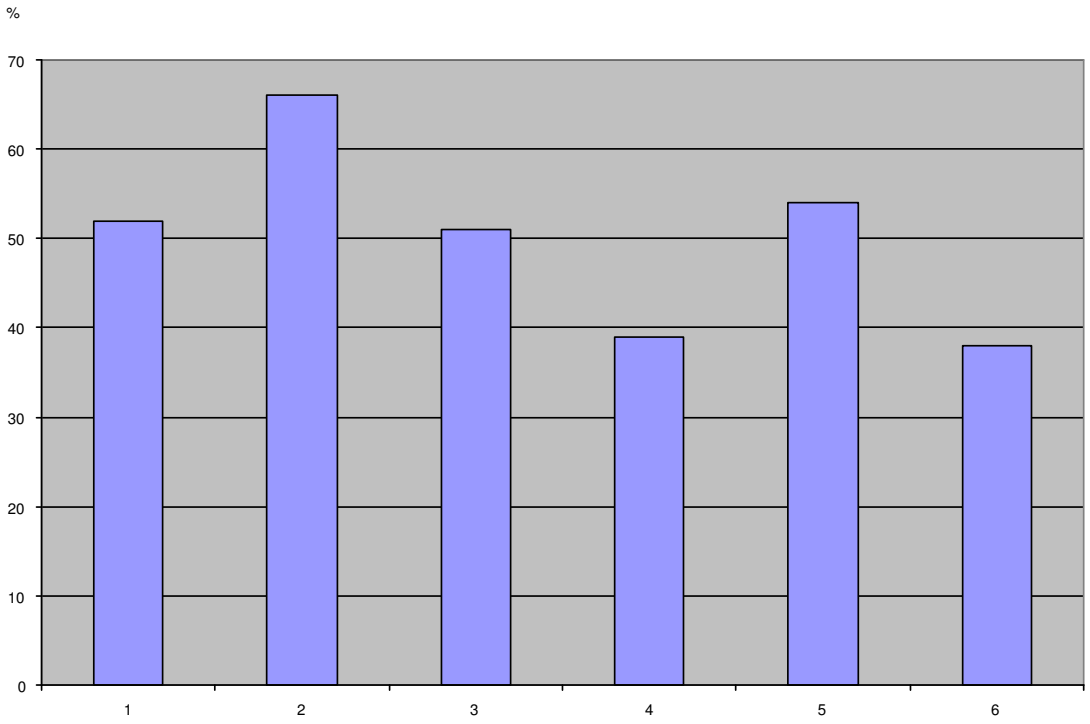

Figure 23 Growers trying alternative studs in last five years by segment

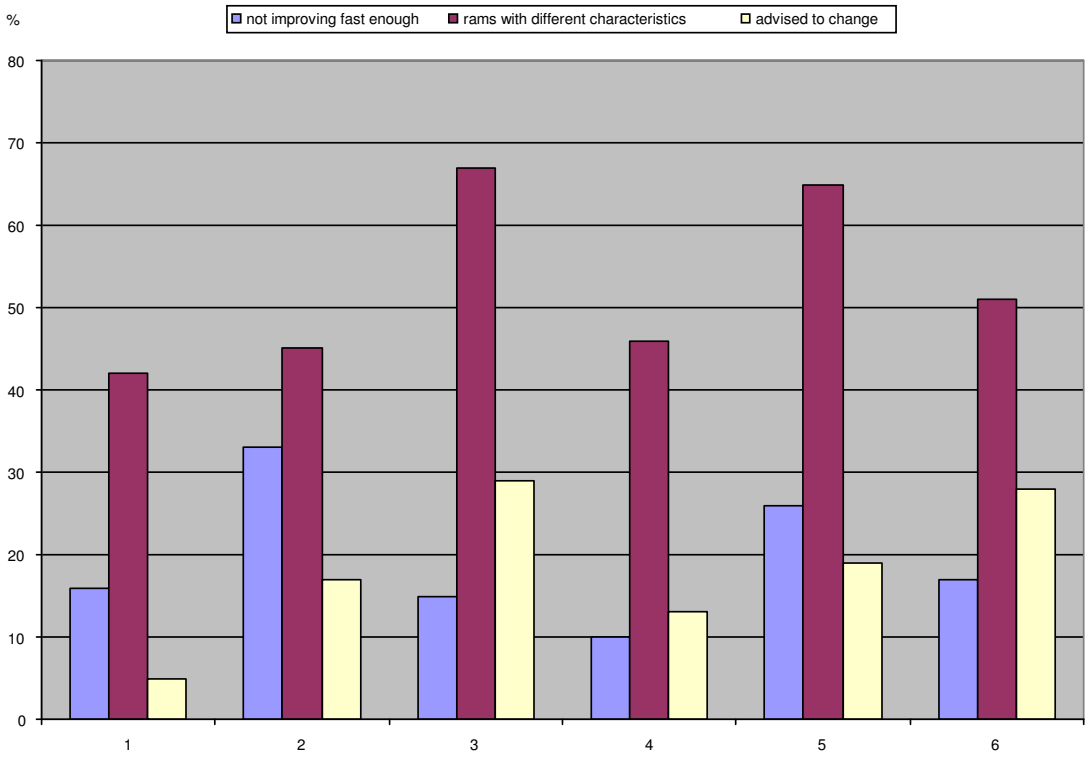

Figure 24 Reasons for changing stud by segment

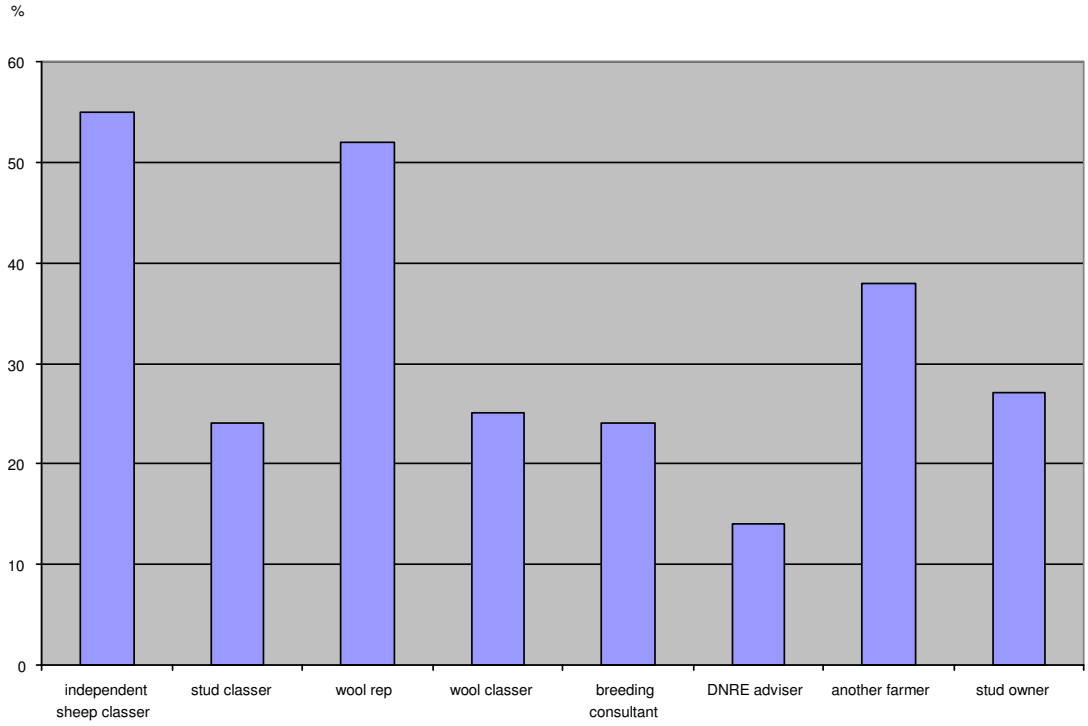

Figure 25 Sources of advice on sheep breeding

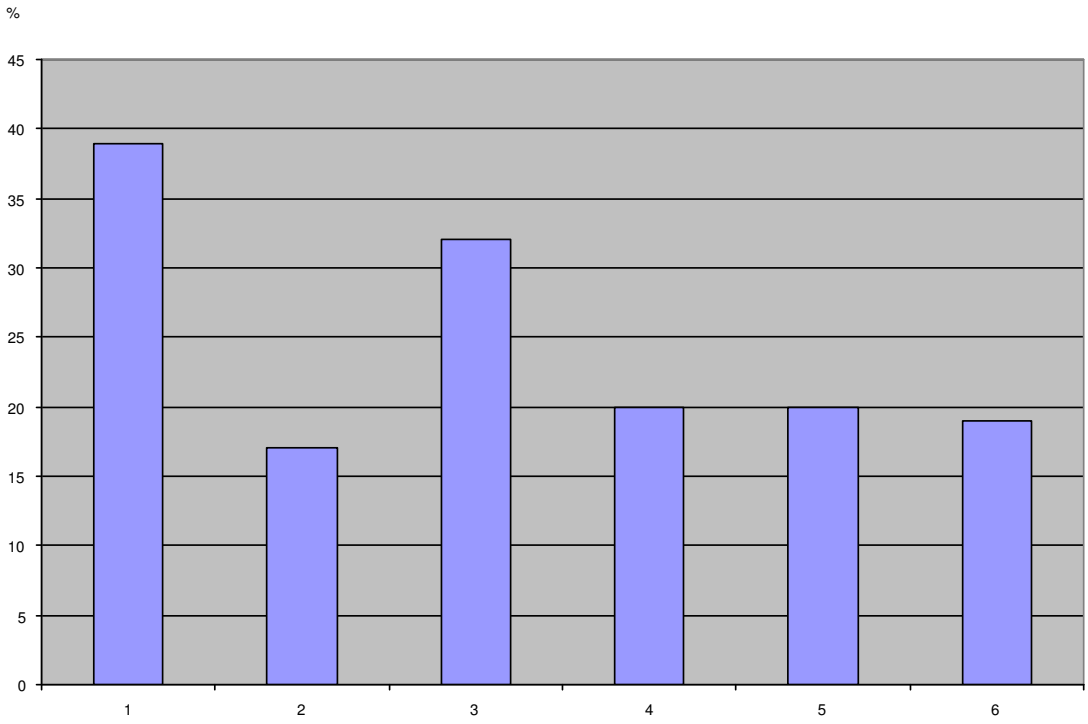

Figure 26 Use of stud classer for breeding advice by segment

Conclusion

Overall the results of the study support our initial findings from interviews with woolgrowers and extension staff. Our findings with respect to the general variation among growers in the factors that influence stud choice and the relative importance of different selection techniques are similar to the findings of past studies.

The differences that were found across the segments in terms of the relative importance of selection methods, sourcing of rams, and stud loyalty are consistent with the risk perceptions and breeding strategies of growers in each segment. These differences were also largely consistent with our expectations about the attitudes and behaviours of growers in each segment based on our interviews. This suggests that the variation others have observed the factors that influence stud choice and the relative importance of different selection techniques can be explained by differences among growers in their perceptions of the key risks involved in sheep breeding.

Discussion and implications

The findings from the study raise important implications for research and extension in the wool industry. The findings indicate there are three strategic options for influencing the breeding decisions of woolgrowers:

The first strategic option is to changing woolgrowers' beliefs that the environment has an important impact on the ranking of bloodlines in terms of fibre diameter and fleece weight. In principle, the rate of genetic gain in the industry is maximised when growers select from among the widest possible range of bloodlines. However, most growers select from a restricted range of bloodlines. This is the result of their strategic responses to their perceptions of the risks involved in sheep breeding. This implies that changing the breeding strategies of growers may accelerate the rate of genetic gain in the industry. In particular by changing woolgrowers' beliefs that the environment can change the ranking of bloodlines in terms of fibre diameter and fleece weight. Such a change should increase the rate of adoption of practices such as performance recording, bloodline comparisons and centralised sire evaluation.

Changing woolgrowers' beliefs about the ranking effects of the environment will be difficult to achieve. Woolgrowers' views about the ranking effects of the environment are fundamental to their conception of the world of sheep breeding and are based on their direct experiences of breeding outcomes. The body of evidence that is required to challenge and to reverse these beliefs would be substantial.

Changing woolgrowers' beliefs about the ranking effects of the environment would involve activities such as conducting demonstration trials using the same bloodlines over a wide range of environmental conditions to demonstrate the absence of ranking

effects. Such trials may need to account for genetic interactions between rams and ewes in their design.

The second strategic option involves altering woolgrowers' beliefs about the strength and validity of the relationship between subjectively assessed and objectively measured fleece characteristics and important skin traits such as follicle size and density. There is considerable evidence that many woolgrowers have changed, or are changing, their beliefs about this relationship. There is debate within the industry as to the scientific merit of the relationship between subjectively assessed fleece characteristics such as crimp frequency and aligned fibres and skin traits. The presence of the debate signals a need for further research to establish the validity or otherwise of these beliefs.

Note that, in principle, woolgrowers can change their beliefs about the reliability of the relationships between subjectively assessed and objectively measured fleece characteristics and important skin traits such as follicle size and density without changing their beliefs about the ranking effects of environmental conditions. Growers can also change their beliefs about these relationships without changing their beliefs about the potential to breed sheep that are less sensitive to environmental change than others by identifying sheep that suit a wide range of conditions. Hence, the shift to breeding 'productive' or 'elite' sheep does not require growers to reverse their fundamental conceptions about sheep breeding.

Growers are motivated to change their beliefs about the reliability of the relationships between objectively measured fleece characteristics and important skin traits because of deep dissatisfaction with breeding performance. Usually the shift is prompted by severe financial pressure creating a need to achieve rapid advances in flock productivity. Hence the shift to breeding 'productive' or 'elite' sheep tends to build on, rather than contradict, the experiences of growers. All this suggests that these shifts would be extremely difficult to counter or reverse.

The third strategy is to assist woolgrowers in each segment to improve their breeding decisions within the context of their existing breeding strategy by promoting the outcomes of research and extension activities in ways that are tailored to the needs and views of individual segments. The presence of strategy segments among stud breeders and woolgrowers means that any 'advanced' breeding practice is unlikely to be universally attractive to woolgrowers. Growers will only adopt practices that are consistent with their beliefs about the risks involved in sheep breeding. For example, most woolgrowers believe that changing environments can have important ranking effects on wool and fleece traits. This means most growers will be sceptical of the value of advances such as centralised sire evaluations and combined wether trial analyses. Widespread acceptance of advances such as these will not occur until growers' beliefs change.

The implication for extension programs in sheep breeding is that they must incorporate activities that are tailored to the different needs and views of each segment. For example, workshops on the use of Estimated Breeding Values would be targeted at segments one and two. Workshops on using subjectively assessed fleece characteristics reflecting skin traits in conjunction with objective measurements might

be targeted at segments three and five. Efforts to conduct activities, such as breeding workshops, that attempt to cater for all segments are likely to be counter-productive. Such workshops, by definition, will contain material that is irrelevant much of the time for many participants.

Note that participation by members of a target segment in a particular activity can be achieved by ensuring that promotional information describes the activity in ways that are relevant to the context of the target segment. If the promotional material reflects the opinions and concerns of the target segment then the members of that segment will be the most likely to self-select and participate in the activity.

This strategy also involves promoting the outcomes of research and extension activities in ways that are tailored to the needs of individual segments. Consider, for example, the NSW wether trials reported in the Merino Bloodline Performance series. This series, which is presented as a set of linked wether trials, is primarily of interest to woolgrowers in segments one and two. The series could be useful to woolgrowers in segments three and four if presented as data from a set of separate, consistently run wether trials. The series may also be useful to a proportion of woolgrowers in all segments if presented simply as wether trials in their district. This strategy could also include activities such as incorporating information on fleece characteristics that are associated with skin traits into wether trials or other projects to assist woolgrowers from segments one, three and five.

Finally, this strategy might include activities such as standardising procedures for objectively measuring characteristics such as fibre diameter and fleece weight. Such activities would assist all growers by removing some biases from objective measurements. However, they are unlikely to change growers' reliance on these measurements to any great extent.

Key findings

The key findings of the study are:

- Woolgrowers can be classified into six breeding strategies based on their beliefs about the key risk factors involved in breeding principles. These beliefs, which are firmly grounded in their experiences, are:
  - The impact of environment on the ranking of bloodlines in terms of fibre diameter and fleece weight.
  - Genetic interactions between rams and ewes,
  - Differences in livestock management between the stud and the commercial woolgrower, and
  - The likelihood that fleece characteristics such as crimp definition and frequency and aligned fibres are more reliable indicators of skin traits such as wool follicle size and density than are objective measurements of fibre diameter and fleece weight.

- The three major selection methods (visual assessment, objective measurement, fleece characteristics that reflect skin traits, selection indexes) play an important role in the decisions of most growers. Differences in breeding strategies lead to differences in the relative importance growers place on different selection methods.
- Despite the scientific evidence, approximately 80 per cent of woolgrowers in the sample believe that changing environment can generate changes in the ranking of bloodlines in terms of fibre diameter and fleece weight.
- Approximately 50 per cent of woolgrowers in the sample follow a breeding strategy that emphasises subjective fleece characteristics that they believe are more reliably related to important skin traits such as follicle size and density than measures of fleece weight and fibre diameter. The change in the views of many growers on this issue has been provoked by severe financial pressure over recent years. This has prompted deep-seated dissatisfaction among these growers with the rate of progress achieved using objective measurements.
- Studs tend to follow focus differentiation strategies. Different studs specialise in servicing the needs of woolgrowers in different segments.
- Only a minority of woolgrowers, approximately 14 per cent, seek advice from staff of the Department when changing studs or selecting rams.

Key implications for research and extension

The findings from the study raise important implications for research and extension in the wool industry. There are three strategic options for influencing the breeding decisions of woolgrowers:

- Alter woolgrowers' belief that the environment can generate ranking effects in terms of fibre diameter and fleece weight. This will be difficult to achieve but is critical for increasing the rate of genetic gain in the industry by:
  - Expanding the range of bloodlines and sires considered by woolgrowers,
  - Increasing the rate of adoption of associated practices such as performance recording, bloodline comparisons and centralised sire evaluation.

- Alter woolgrowers' beliefs about the strength and validity of the relationships between subjectively assessed and objectively measured fleece characteristics and important skin traits such as follicle size and density. There is considerable evidence that many woolgrowers are changing their beliefs about these relationships. Further research may be required to ensure the validity or otherwise of these beliefs.

- Assist woolgrowers in each segment to improve their breeding decisions within the context of their existing breeding strategy by promoting the outcomes of research and extension activities in ways that are tailored to the views and needs of growers in each segment.

Recommendations

The major recommendations arising from the study are:

- The Department assign priorities for research and extension in terms of:
  - Changing woolgrowers' beliefs that changing environments can generate ranking effects in terms of fibre diameter and fleece weight.
  - Changing woolgrowers' beliefs about the strength and validity of the relationship between subjectively assessed and objectively measured fleece characteristics and important skin traits such as follicle size and density.
  - Assisting woolgrowers in each segment to improve their breeding decisions within the context of their existing breeding strategy.

- The Department validate priorities for research and extension through consultation with woolgrowers in target segments.

- The Department canvass with industry the possibility of conducting a national study using the methods employed in this study. Such a study could provide useful insights into the impact that different research and extension activities can have on woolgrowers' beliefs about breeding principles.

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Appendix A

Decision rules and heuristics

People employ a variety of decision rules to make choices (Payne, Bettman & Johnson 1993). The rule used in any particular situation depends on the characteristics of the decision task (such as complexity) and the characteristics of the person (such as experience). Decision rules can be classified into two broad types, compensatory and non-compensatory.

Compensatory decision rules

Compensatory decision rules allow trade-offs between attributes across alternatives. A higher score on one attribute can compensate for a lower score on another. A breeding index is an example of a compensatory decision rule. Rams are assessed on a number of measured traits such as fleece weight and fibre diameter. These measurements are combined to form a weighted aggregate score. The importance of different attributes in the index is reflected in their weighting, and the weights can be varied according to the objectives of the ram buyer. The rams that return the highest weighted scores can then be identified and selected for a breeding program. Some compensatory decision rules are:

- The weighted additive rule. Attributes are weighted according to importance. An alternative is evaluated on the basis of the weighted sum of scores on all attributes. The alternative returning the highest score is selected. This approach is complex and time consuming. Attributes must be commensurable.
- The equal weight heuristic. Attributes are treated equally. An alternative is evaluated on the basis of the sum of scores on all attributes. The alternative returning the highest score is selected. This approach is also complex and time consuming. Attributes must be commensurable and measurable using a common scale.
- The frequency of good and bad features heuristic. Threshold scores are determined for each attribute. Attribute scores above the relevant threshold are counted as good features, scores below the threshold are counted as bad features. Alternatives are selected on the basis of the most number of good features, the least number of bad features, or some combination. This approach is more complicated and time consuming.

An example of the use of the frequency of good and bad heuristic may be the selection of rams from a stud. The grower may decide on thresholds for a number of traits. Rams are assessed and receive either a tick or a cross according to whether their score for each attribute is above or below the threshold. Rams that have the highest number of ticks are selected and purchased.

Non-compensatory decision rules

Non compensatory rules are used when attributes are not commensurable. For example, most woolgrowers do not usually regard lower fibre diameter or higher fleece weight as offsetting poor conformation. Some non-compensatory heuristics are:

- The satisficing heuristic. Alternatives are considered sequentially as they present. A minimum threshold score is determined for each attribute. Alternatives are discarded if they fail to pass the threshold on any attribute. The first alternative returning scores for each alternative greater than the respective threshold is selected. This approach is simple and quick. This is a non-compensatory decision rule. Note that alternatives are not compared directly. Attributes are not required to be commensurable, however, they must be measurable.

The use of the satisficing heuristic is appropriate when alternatives under consideration are deemed suitable as long as they meet certain minimum criteria. This saves time and effort and can be efficient when dealing with a large number of alternatives such as when classing ewes. Ewes are retained except when they fail to meet the minimum requirements on any of the attributes considered. For example a good size ewe with excellent wool quality would still be culled if she does not meet the minimum standard for foot conformation.

- The lexicographic heuristic. This heuristic is used when there is one dominant attribute of importance. The alternative returning the highest score for that attribute is selected. If two alternatives tie, the alternative with the highest score on the next most important attribute is chosen. This approach is also simple and quick but only useful when one attribute far outweighs the others in importance.

This heuristic might be used when selecting a ram from among a particular group of stud rams. If the grower places particular importance on frame then he may select a ram from within the group solely because it is the ram with the biggest frame.

- The elimination-by-aspects heuristic. This heuristic is also used when a particular attribute is considered most important attribute. A minimum threshold score is determined for that attribute. Alternatives returning scores on that attribute below the threshold are rejected. If two or more alternatives remain, the process is repeated for the next most important attribute. This approach is also simple and quick.

This heuristic may be used when culling ewes. A grower may decide that all ewes below a certain weight should be culled. If there are too many ewes remaining, the grower may then cull all ewes that have not lambed.

- The affect referral heuristic. The person elicits a previously formed evaluation for each alternative from memory and selects the most highly evaluated alternative. This heuristic can only be applied to repeated choices.

- The habitual heuristic. The person selects the alternative chosen last time. This heuristic can only be applied to repeated choices.

The heuristic adopted by a decision-maker depends on the nature of the decision problem they face and the characteristics of the decision-maker themselves. The nature of the decision problem can be analysed in terms of task effects and context effects.

Task effects describe the general complexity of the decision problem, the way in which the problem is presented and the way in which information is displayed. The complexity of a decision problem depends on the number of alternatives available, the number of attributes which describe alternatives, and the period of time within which a decision must be reached. The more complex a problem, and the greater the time pressure, the more likely a non-compensatory heuristic will be used.

The way a problem is presented, the response mode, also influences the heuristic used by a decision-maker. The way in which a problem is presented determines the type of judgement task the decision-maker must perform. For example, one heuristic may be used to solve a problem presented as a choice task. A different heuristic may be used to solve essentially the same problem when it is presented as a matching task (Payne, Bettman & Johnson 1993).

The heuristic used by a decision-maker may also be influenced by the way in which information about alternatives is displayed, and constraints on the order in which alternatives must be evaluated, known as agenda effects.

Finally, context effects relate to the differences between alternatives with respect to attribute values. For example, how similar are alternatives. The greater the similarity between alternatives, the more likely compensatory a heuristic may be used. Other context effects influencing heuristic selection include the way scores on attributes are correlated, whether alternatives are comparable, whether alternatives represent losses or gains, and reference point effects (see Payne, Bettman & Johnson 1993).

Decision rules and sheep breeding

The fact is, for a variety of reasons, people use different rules to solve different problems. Different people may use compensatory or non-compensatory rules, or even a combination of both to solve the same problem. This has important implications for the perceived relevance of decision aids.

Consider, for example, the application of index selection to the selection of a ram. The index selection approach involves evaluating candidate rams on the linear sum of weighted attributes such as fibre diameter and fleece weight. Index selection is an example of the application of the weighted additive rule. The use of this rule requires the attributes on which rams are evaluated to be commensurate. In other words, one attribute must be able to be expressed in terms of the other.

The propensity to use index selection will depend, in part, on the extent to which key traits are thought to be commensurable. If some key traits are not commensurable this will limit the use of index selection. Fibre diameter, staple length, staple strength and variation in fibre diameter are generally agreed to be commensurable – a higher score on one of these traits can compensate for a lower score on another. However, these traits are not generally regarded as being commensurable with other traits such as susceptibility to fleece rot and conformation. If these other traits are thought to be important then a composite decision rule is required.

The order in which rules are used will depend on whether commensurable or incommensurable traits are thought more important. For example, a satisficing rule may be used to cull sheep that are unsatisfactory with respect to incommensurable traits. The sheep remaining may then be classed on commensurable traits using some form of weighted additive rule such as index selection. Alternatively, sheep may first be culled on commensurable traits using index selection. An elimination-by-aspects rule might be then be used to cull any sheep that are unsatisfactory with respect to incommensurable traits.

Similar reasoning suggests that composite rules apply to the selection of 'elite' wool sheep. Assume the biological characteristics of the sheepskin are incommensurable with fleece traits such as fibre diameter and fleece weight, and desirable fleece traits are contingent on the biological characteristics of the skin. This means that selection might proceed first on conformation characteristics using an elimination-by-aspects rule. The second step is to select sheep on the basis of desirable skin characteristics. If these characteristics are commensurable then a compensatory rule may be applied. Given these characteristics are evaluated by visual assessment simplified compensatory rules such as the frequency of good and bad features heuristic might be applied. The use of an index (measurements of fibre diameter and fleece weight) could be applied as a final step in the selection process.

When it comes to classing large number of sheep within a short period of time, a combination of the affect referral heuristic and the habitual heuristic may be used. For instance, classers might use a variant of the affect referral heuristic to establish 'standard' evaluations for particular classes of sheep. These 'standard' evaluations are based on past evaluations of similar sheep, calibrated by classing a sample of the flock. Having established these 'standard' evaluations the classer may then use the habitual heuristic to rapidly evaluate large numbers of sheep.

In this discussion we have described how differences in woolgrowers' beliefs about the comparability of sheep and fleece traits can influence the combination of decision rules they use to make breeding decisions, and the sequence in which traits are treated. Importantly, these beliefs may be key reasons for the limited reliance on objective measurement of fleece traits in sheep selection.

Appendix B

Selected survey questions

Ranking scenarios for fibre diameter and fleece weight

1. Suppose a friend of yours has used rams from two different bloodlines. The progeny of one bloodline, Pharaoh Park, test significantly finer than the progeny of the other, Caesar Station. You have not seen sheep from either bloodline and you have no other information about them.

   Do you agree or disagree with the following statements?

(Please tick the box that comes closest to how you feel about each statement)

	Agree	Disagree
If you used these bloodlines on your property the Pharaoh Park progeny will <u>always be finer</u> than the Caesar Station progeny.	ρ	ρ
It would be very <u>difficult to predict</u> which bloodline's progeny would be finer on your farm.	ρ	ρ
Provided they stay in a <u>similar environment</u> the Pharaoh Park progeny will continue to be finer than the Caesar Station progeny.	ρ	ρ
Even though the Pharaoh Park progeny <u>may be finer and cut a similar fleece weight</u> to the Caesar Station progeny, it is impossible to predict which are the better sheep for your farm.	ρ	ρ

2. Suppose a friend of yours has used rams from two different bloodlines. The progeny of one bloodline, Princes Park, are cutting significantly heavier fleeces than the progeny of the other, Viscount Station. You have not seen sheep from either bloodline and you have no other information about them.

Do you agree or disagree with the following statements?

(Please tick the box that comes closest to how you feel about each statement)

	Agree	Disagree
If you used these bloodlines on your property the Princes Park progeny will <u>always cut heavier</u> than the Viscount Station progeny.	ρ	ρ
It would be very <u>difficult to predict</u> which bloodline's progeny would cut heavier on your farm.	ρ	ρ
Provided they stay in a <u>similar environment</u> the Princes Park progeny will continue to cut heavier than the Viscount Station progeny.	ρ	ρ
Even though the Princes Park progeny <u>may cut a heavier fleece weight of similar micron</u> to the Viscount Station progeny, it is impossible to predict which are the better sheep for your farm.	ρ	ρ

Stud selection criteria

1. Woolgrowers we have spoken to have given many reasons for choosing a stud. For some woolgrowers it is important to take conditions in the district into account when choosing a stud. In the table below we have listed some of the reasons they gave for choosing their stud. Could you indicate how important each reason is to you?

   (Please tick the box that comes closest to how you feel about each statement)

	Very Important	Important	Not Important
I like to buy from a stud in my own district	ρ	ρ	ρ
I like to buy from a stud in a district with a climate similar to my own.	ρ	ρ	ρ
I like to buy from a stud with a longstanding reputation for producing quality rams.	ρ	ρ	ρ
I like to buy from a stud that sells rams to woolgrowers <u>across a number of districts</u> because I can be pretty sure their rams will do well under most conditions.	ρ	ρ	ρ
I like to buy from a stud that sells rams to <u>woolgrowers in my district</u> so I can be confident their rams are suited to my area.	ρ	ρ	ρ

2. Some woolgrowers were concerned about the way their stud went about breeding sheep. In the table below we have listed some of the reasons these woolgrowers gave for choosing their stud. Could you indicate how important each reason is to you?

(Please tick the box that comes closest to how you feel about each statement)

	Very Important	Important	Not Important
I like to buy from a stud that places an emphasis on skin traits and has a reputation for breeding productive sheep.	ρ	ρ	ρ
I like to buy from a stud that uses a selection index to combine a number of fleece and fibre measurements into a single value to select their rams.	ρ	ρ	ρ
I like to buy from a stud that places an emphasis on skin traits and has a reputation for breeding sheep that will do well under most conditions.	ρ	ρ	ρ
I like to buy from a stud that has entered rams in a Central Sire Evaluation Scheme or has performed well in Merino bloodline performance analysis.	ρ	ρ	ρ

Appendix C

Grower ratings of criteria for choosing studs

Criteria	Very important	Important	Not important
I like to buy from a stud in my own district	11	34	55
I like to buy from a stud in a district with a climate similar to my own.	31	51	18
I like to buy from a stud with a longstanding reputation for producing quality rams.	53	35	12
I like to buy from a stud that sells rams to woolgrowers across a number of districts because I can be pretty sure their rams will do well under most conditions.	21	41	38
I like to buy from a stud that sells rams to woolgrowers in my district so I can be confident their rams are suited to my area.	16	44	40
I like to buy from a stud that places an emphasis on skin traits and has a reputation for breeding productive sheep.	51	40	9
I like to buy from a stud that uses a selection index to combine a number of fleece and fibre measurements into a single value to select their rams.	29	45	26
I like to buy from a stud that places an emphasis on skin traits and has a reputation for breeding sheep that will do well under most conditions.	41	46	13
I like to buy from a stud that has entered rams in a Central Sire Evaluation Scheme or has performed well in Merino bloodline performance analysis.	26	39	35

Notes: values are percentage of growers giving rating.

Appendix D

Key features of segments

Segment one

- 8 per cent of woolgrowers.
- Do not believe the environment can change the ranking of bloodlines in terms of fleece weight and fibre diameter.
- Do believe that fleece characteristics such as handle, crimping and staple structure are better indicators of desirable skin traits (follicle size and density) than measurable fleece characteristics such as fleece weight and fibre and fibre diameter.
- Attach a relatively greater importance to subjective assessments of fleece characteristics (crimping, staple structure) that are thought to be related to skin traits.
- Tend to produce 'elite' type wool.
- More likely to prefer studs that place an emphasis on skin traits and with a reputation for breeding 'productive' sheep that do well under most conditions.
- More likely to use index selection.
- More likely to prefer studs that use performance recording.
- More likely to use bloodline comparisons based on using link teams or sires across environments.

Segment two

- 14 per cent of woolgrowers.
- Do not believe the environment can change the ranking of bloodlines in terms of fleece weight and fibre diameter.
- Do not believe that fleece characteristics such as handle, crimping and staple structure are better indicators of desirable skin traits (follicle size and density) than measurable fleece characteristics such as fleece weight and fibre and fibre diameter.
- More likely to attach a greater importance to objective measurements of fleece characteristics such as fleece weight and fibre diameter.
- More likely to prefer studs that use performance recording, index selection and/or participate in sire evaluation schemes or merino bloodline performance trials.
- More likely to use index selection.
- More likely to use bloodline comparisons based on using link teams or sires across environments.

Segment three

- 22 per cent of woolgrowers.
- Do believe the environment can change the ranking of bloodlines in terms of fleece weight and fibre diameter.
- Do believe it is possible to breed bloodlines that are less sensitive than other bloodlines to different environments.
- Do believe that fleece characteristics such as handle, crimping and staple structure are better indicators of desirable skin traits (follicle size and density) than measurable fleece characteristics such as fleece weight and fibre and fibre diameter.
- Attach a relatively greater importance to subjective assessments of fleece characteristics (crimping, staple structure) that are thought to be related to skin traits.
- Tend to produce 'elite' type wool.
- More likely to prefer studs that place an emphasis on skin traits and with a reputation for breeding 'productive' sheep that do well under most conditions.
- Less likely to prefer studs that use performance recording.
- Use bloodline comparisons based on using sires across environments to identify bloodlines or sires that perform well in a range of environments.

Segment four

- 17 per cent of woolgrowers.
- Do believe the environment can change the ranking of bloodlines in terms of fleece weight and fibre diameter.
- Do believe it is possible to breed bloodlines that are less sensitive than other bloodlines to different environments.
- May believe that fleece characteristics such as handle, crimping and staple structure are better indicators of desirable skin traits (follicle size and density) than measurable fleece characteristics such as fleece weight and fibre and fibre diameter.
- Attach equal importance to subjective assessments and objective measurements of fleece characteristics.
- More likely to prefer studs that have a longstanding reputation for producing quality rams and selling to woolgrowers across a number of districts.
- Use bloodline comparisons based on using sires across environments to identify bloodlines or sires that perform well in a range of environments.

Segment five

- 11 per cent of woolgrowers.
- Do believe the environment can change the ranking of bloodlines in terms of fleece weight and fibre diameter.
- Do not believe it is possible to breed bloodlines that are less sensitive than other bloodlines to different environments.

- Do believe that fleece characteristics such as handle, crimping and staple structure are better indicators of desirable skin traits (follicle size and density) than measurable fleece characteristics such as fleece weight and fibre and fibre diameter.
- More likely to attach a relatively greater importance to subjective assessments of fleece characteristics (crimping, staple structure) that are thought to be related to skin traits.
- Tend to produce 'elite' type wool.
- More likely to prefer studs that place an emphasis on skin traits and with a reputation for breeding 'productive' sheep.
- Unlikely to use index selection.
- Unlikely to use bloodline comparisons based on using link teams or sires across environments.

Segment six

- 28 per cent of woolgrowers.
- Do believe the environment can change the ranking of bloodlines in terms of fleece weight and fibre diameter.
- Do not believe it is possible to breed bloodlines that are less sensitive than other bloodlines to different environments.
- Do not believe that fleece characteristics such as handle, crimping and staple structure are better indicators of desirable skin traits (follicle size and density) than measurable fleece characteristics such as fleece weight and fibre and fibre diameter.
- More likely to prefer studs from a similar climate that have a longstanding reputation for producing quality rams.
- Vary in their beliefs about the relative importance of subjective assessments and objective measurements of fleece characteristics.
- Unlikely to use index selection.
- Unlikely to use bloodline comparisons based on using link teams or sires across environments or studs that use performance recording.

Figure D.1 Segment schema