

SHEEP BREEDING RESEARCH AT TRANGIE

INTRODUCTION

B.J. MCGUIRK*

Research into the genetic improvement of the Australian Merino was initiated in the 1940's. Almost simultaneously, independent research programmes were started at Trangie and by the CSIRO at both Badgery's Creek and Cunnamulla. These studies were among the first to estimate genetic variation for production characters in sheep, and again among the first in checking the reliability of selection theory in predicting responses in domestic livestock.

Since its inception the Trangie sheep breeding programme has examined a wide range of topics related to the improvement of the Australian Merino. This **review** will not attempt a comprehensive assessment of that programme but will concentrate on three areas which were considered important at the outset and are still of interest today. These are selection for increased wool production, selection for increased reproductive performance, and the importance of skin **fold** as a breeding objective in the Australian Merino. In reviewing these research findings, reference will be made to similar studies conducted at other research centres, especially those undertaken by the CSIRO. In addition, we will attempt to indicate the extent to which recommendations arising from these research programmes have been adopted by the Merino Industry.

BEGINNINGS AT TRANGIE

F.H.W. MORLEY**

In the late 1940's livestock improvement was poised to exploit the new understanding of breed improvement which was based largely on the theory of quantitative genetics as developed by Fisher, Wright and **Haldane**. Lush, Dickerson and Hazel had extended this **theory** to examine the merits of different approaches to livestock improvement, including progeny testing, mass selection and between and within-family selection. The development of selection index theory had also helped to identify breeding objectives and selection criteria in commercial breeding programmes.

The remarkable development of the Australian Merino had been achieved without the aid of quantitative genetic theory, and fleece weights had doubled in the previous 80 years. Nevertheless many breeders were concerned about the lack of obvious improvement in fleece weights since the **1920's**, and were searching for better methods. The zero or slow rate of improvement in fleece weight was interpreted in some quarters as indicating a low heritability, perhaps due to inaccurate assessment. Other explanations offered included antagonism between characters and the operation of genotype-environment interactions, as the "stud" environments were markedly superior to those found in most commercial flocks. Selection for show points also came under fire.

The publication of Hagedoorn's (1939) book, and the subsequent visit of

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the Dutch poultry geneticist also served to question traditional selection and breeding methods. He was a strong supporter of progeny testing as the key to livestock improvement, though his nucleus scheme had been developed for sire selection for egg production in poultry, where the expression of the most important trait is obviously sex-limited. While his emphasis on progeny testing received some support from breeders, the development of soundly-based breeding programmes for the Australian Merino clearly called for a major sheep breeding research programme.

TRANGIE PLANS

Research on breeding for resistance to blowfly strike was initiated at Trangie by Dr. H.G. Belschner in the 1930's. Since other production attributes had to be maintained, the objectives were broadened and the programme directed towards:

1. Determining which characters should be investigated, characters such as fleece weight, fertility and resistance to flystrike;
2. Providing the necessary facilities, including land, animals and laboratories;
3. Developing measurement techniques and management procedures for the breeding flocks;
4. Collecting data from animals born as the result of controlled matings;
5. Estimating genotypic and phenotypic parameters;
6. Formulating breeding plans and promoting these to the industry and breeders.

Of the characters available for study, clean fleece weight called for early attention, as it and fibre fineness largely determined the income a grazier might expect. The adaptation of the sheep to the environment, as expressed in its reproductive performance, was also obviously important. While susceptibility to breech strike could be largely overcome by the Mules operation, body strike was a problem which required attention. There also seemed some justification for reducing the degree of skin folding as a means of reducing shearing injuries. Beyond these broad objectives there was considerable uncertainty, especially as to the importance of many wool characters in breeding programmes.

In all there were approximately 5000 medium wool **Peppin** sheep on the Station. This included a stud flock of 400 ewes (Registered Flock No. 78), which were not used for research purposes, and a flock of approximately 2000 second stud ewes which could be. There was plenty of land to run the experimental **sheep**, but facilities for numerous controlled matings had to be developed. Techniques of artificial insemination were modified to suit the circumstances and were the basis of many of the controlled matings which were made. **Reliable** fences had to be built to ensure the accuracy of pedigrees from paddock matings. There was no laboratory or facilities for analysis of wool samples and even basic resources such as a supply of electricity were not available. A laboratory with facilities for scouring samples and for estimating yield and fibre diameter was started in 1948 and completed in 1950.

Experimental matings had been made during the 1930's and early 1940's between sheep of varying degrees of skin folding on the breech. This programme was modified and expanded into a "Progeny Testing" flock in 1943. Initially four rams were tested, two of which were donated by the Bundemar stud. The progeny of one of these rams cut some ten percent more wool than the progeny of the others. The Index flock as it came to be known consisted of 700 to

800 ewes which were drawn initially from the "Second Stud". Of these, 30 to 40 percent were mated to two or three proven sires and the remainder to about 15 young rams for progeny testing. This flock gave both encouraging results and large amounts of data suitable for analysis. By 1951 the ewe hoggets in the "Index Flock" were producing clean fleeces as heavy as those of the stud and were appreciably plainer.

DEVELOPING THE PROGRAMME

As data accumulated the need for training in genetic analysis became painfully evident. In 1948 I was fortunate in receiving a CSIRO studentship to study with Lush, Hazel, and Kempthorne at Iowa. Data from Trangie, including those posted to me from Trangie in 1949, formed the basis of the first genetic analysis of a Merino flock. The first estimates of genetic parameters were based on too few animals to be regarded as definitive. Nevertheless they were internally consistent in suggesting that the heritabilities of fleece weight, crimp frequency, hoggetliveweight, and skin folds were high (Morley 1951) indicating that selecting on an animal's own performance for such characters should lead to satisfactory rates of genetic progress (Morley 1952). The negative genetic correlation between fleece weight and crimp frequency could be expected to restrict progress in fleece weight if crimp frequency was also to be held constant (Morley 1955).

These analyses were extended on my return to Trangie, to include both additional information on production characters and data on such subjectively scored characters as wool colour, character and handle, and both birth coat and face cover (Morley 1955b). The analyses of the production data confirmed the Iowa findings (Morley 1955a), and inbreeding was shown to have a serious depressing effect on production (Morley 1954).

At the same time a number of experimental flocks were established to check the reliability of these statistical analyses in predicting response to selection. An additional aim was to develop genetically diverse groups which could provide material for fundamental research on the physiology of wool production and perhaps in other fields related to sheep production. Four sets of plus and minus selection flocks were started, each of 100 ewes and these were joined to five rams which were replaced each year. The sole criteria of selection, apart from excluding animals with deformities and black wool, were weaning weight, skin folds, fineness (crimps per inch), and clean fleece weight. An additional flock of 200 ewes and ten rams with selection at random constituted a control. The first results from these selection experiments generally supported predictions based on estimates of genotypic parameters.

A thorough assessment was also made of breeding plans for the Merino industry, including a study of the optimum number of age groups of rams for genetic improvement and the relative merits of selection based on individual performance ("mass selection") or progeny test results (Morley 1955c). This indicated that near-maximum rates of improvement in fleece weight could be obtained from mass selection without resorting to progeny testing or complex systems of pedigree evaluation. Accordingly the progeny-testing programme initiated in 1943 was modified so that selection of replacement breeding stock was based solely on their own performance. The Index flock, which came in time to be called the Selection Demonstration flock, was intended to highlight problems which might be encountered in the application of the best available information on sheep improvement.

In conjunction with these genetic investigations, a considerable amount of field research was also undertaken, and produced many valuable benefits. These included modifications to the Mules operation, techniques for the application of insecticides, especially for blowfly control, and determining seasonal variation in reproductive activity. The genetical studies thus became part of a broad programme of research on the biology and economics of sheep production.

INDUSTRY APPLICATION

By 1954 the research at Trangie and that from CSIRO flocks showed that fairly rapid genetic progress was possible, provided characters were measured accurately from animals run together, and provided that these measurements formed the main basis of selection. If the studs implemented such programmes, genetic benefits should pass to the whole industry as genotype x nutritional interactions appeared to be relatively unimportant (Morley 1956,).

At a conference at Sydney in May 1954 of sheep and wool extension officers from all States the major concepts were accepted with some healthy scepticism, but also with enthusiasm. There was general agreement that selection of Merino sheep could be improved if it were based on objective measurements. This necessarily downgraded the finer points hitherto (and now) so widely considered in sale and show judging. Plans were made for the training of extension workers, and for dissemination of the new approaches to breed improvement.

The main objectives of the genetic programme had thus been realised. Obviously more research was needed to improve measurement procedures, particularly for fibre diameter. The long-term consequences of intense selection for production characters needed to be monitored, while the possibilities for improving reproductive performance by selection warranted attention. But the major aim was to apply improved methods of selecting for increased wool production, by modifying selection and breeding practices in the studs. This development offered great opportunities to enterprising breeders. The ball was now in the court of the industry and its advisors.

THE EFFECTS OF SELECTION FOR INCREASED FLEECE WEIGHT

B.J. McGUIRK

Single character selection flocks were established at Trangie both to check predicted responses to selection, and to provide genetically diverse material for physiological investigation. In addition, commercially-oriented flocks were established to provide information on the long-term effects of adopting recommended breeding programmes, where the emphasis was on improving wool production.

In the **Fleece Plus** flock selection has been solely for increased clean fleece weight at hogget shearing (Pattie and Barlow 1974). The effects of selection in this flock have also been estimated over a number of years using a Fleece Plus Relaxed flock, which was split off from the Fleece Plus flock in 1968 and maintained without selection until 1973. Reference will also be made to the Fleece Minus flock, in which selection has been solely for reduced clean fleece weight, and to the Crimps Plus and Minus flocks (Robards and Pattie 1967). Responses in all of these flocks have been estimated as deviations from an unselected control flock, referred to as the Random flock.

The Selection Demonstration flock was developed from a progeny testing

programme and subsequently operated as an "open-nucleus" flock, with a ram breeding Nucleus of 200-300 ewes, and a commercial Flock of 400-500 ewes. Selection of replacement breeding stock was primarily for increased clean weight, after a preliminary culling of animals with excessive face cover or skin fold, or with low crimp frequency. While it was originally a closed flock, a small number of rams were later introduced either for experimental purposes (to introduce the poll gene) or where animals with outstandingly high performance were available from studs. The Selection Demonstration flock was disbanded in 1972.

RESPONSES TO SELECTION

Selection increased clean fleece weight in the Fleece Plus flock and in both the Nucleus and Flock portions of the Selection Demonstration flock (Figure 1). Averaged over five drops of hoggets, the Fleece Plus Relaxed flock produced seven per cent more greasy wool and 16 percent more clean wool than the Random control flock. These gains were achieved by 16 years or six generations of selection.

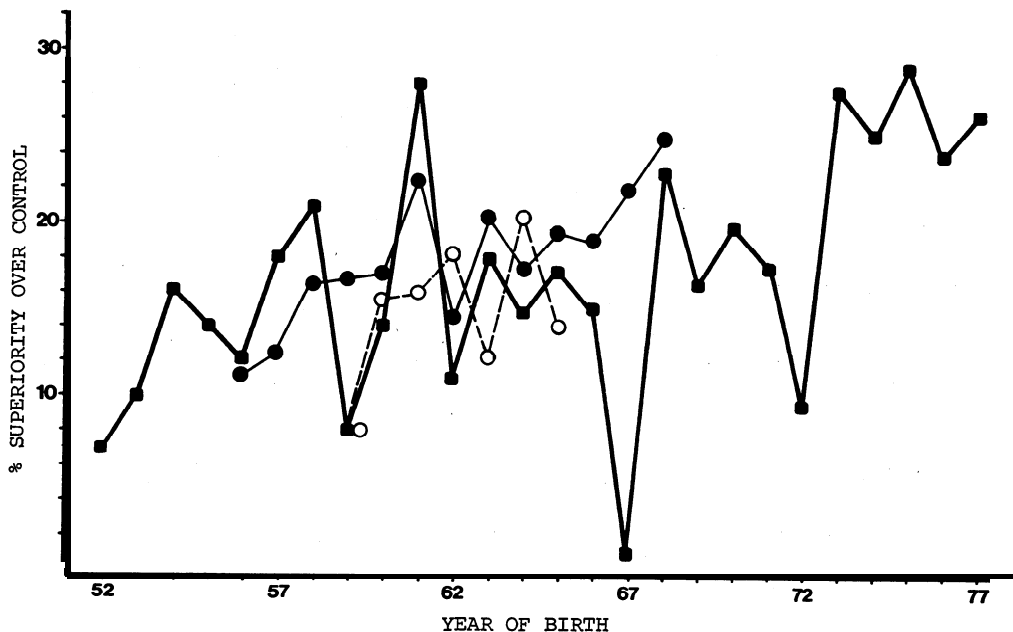


Fig. 1 Responses in clean fleece weight

- Fleece Plus, rams and ewes, 1952-77
- Selection Demonstration Nucleus, ewes only, 1956-68
- Selection Demonstration Flock, ewes only, 1959-65

Pattie and Barlow (1974) examined fleece weight responses in the Fleece Plus flock over the period 1952-1965 and concluded that response had plateaued. One of the difficulties in assessing such a claim is the variation in annual wool production in the Random flock. A further complication is that the apparent superiority of the Fleece Plus flock in a particular year appears to be directly related to the level of performance of the Random flock (B.J. McGuirk unpublished data).. In order to minimise the annual fluctuations, percentage difference between the flocks have been averaged for 5 four-yearly intervals

(1952-55 drops, 56-59, etc.) , and two final three-year-period (1972-74, 1975-77) drops. Then we find the Fleece Plus flock's superiority as follows: 11.8, 17.3, 17.7, 16.2, 19.1, 19.8 and 26.5%. While this break-up of the data is arbitrary, it suggests that response to selection is still being achieved, and that gains over the period 1952 to 1977 are approximately one per cent per year.

The analysis of selection responses in the Selection Demonstration is only preliminary at this stage but average gains in clean fleece weight are approximately one per cent per year over the period 1956 to 1968. Nucleus and Flock hogget ewes were not run together in all years but in most years in which they could be compared, the Nucleus hoggets produced more clean wool.

TABLE 1 Differences between Fleece Plus Relaxed and Random hoggets (5 drops)

| | Fleece Plus Relaxed | Random |
|-----------------------------------|---------------------|--------|
| Greasy fleece weight (kg) | 4.56 | 4.27 |
| Yield (%) | 68.4 | 62.9 |
| Clean fleece weight (kg) | 3.11 | 2.67 |
| Body weight (kg) | 35.0 | 35.5 |
| Staple length (cm) | 9.5 | 9.1 |
| Crimp frequency (crimps per inch) | 8.5 | 10.7 |
| Fibre diameter (microns) | 22.1 | 20.6 |

Correlated responses in the Fleece Plus flock were described in detail by Barlow (1974). Differences between the Fleece Plus Relaxed and Random hoggets show that selection for increased fleece weight produced wool with a higher yield, longer staples, fewer crimps per inch and a higher average fibre diameter, all of which were expected. As in the CSIRO flocks selected for increased fleece weight (Turner *et al.* 1970), gains in fleece weight in the Fleece Plus flock were achieved **primarily** through an increase in the components of wool production per unit area of the skin (Williams 1970), rather than through increases in those affecting the wool growing surface area (body size and skin wrinkle).

The voluntary feed intake of Fleece Plus and Minus sheep is similar and the increased wool production of the Fleece Plus flock due to an increased efficiency in converting feed into wool (Williams 1980). Differences between the Fleece Plus and Random flocks in wool production per unit area of skin and in net efficiency appear to be increasing with time (Robards *et al.* 1972). As intake is increased so too does the fleece weight superiority of the Fleece Plus and Selection Demonstration flocks (Saville and Robards 1972). The differences observed in feed efficiency appear to reflect differences in cystine utilisation (Williams 1980). **Correspondingly** wool production in the Fleece Plus flock is particularly responsive to infusions of cystine and methionine (Williams *et al.* 1972).

Selection for increased fleece weight also lowers the sulphur concentration of the wool (Williams 1980). The effect is not simply one of dilution in a higher level of wool production, as the total sulphur output is generally greater from the Fleece Plus animals, **especially** when the availability of sulphur-containing amino acids is high. Similar differences in sulphur content have been found between Crimps Plus and Minus wools and these have been associated with a variety of other chemical changes, including a lower yield of high-sulphur.

wool proteins, changes in both **proportions** and sulphur content of some of the high-sulphur subfractions and changes in amino acid composition (see McGuirk 1980).

A number of manufacturing characteristics are likely to be affected by such differences in sulphur content. These include the ability of wool to take and retain set and resistance to compression. Differences in setting characteristics between Crimp Plus and Minus wools have been confirmed (Campbell, et al. 1972), while resistance to compression is negatively correlated genetically with fleece weight (Watson et al. 1976). However both of these undesirable changes can be remedied during processing. Provided there is no increase in average fibre diameter, selection for increased fleece weight should improve most aspects of worsted manufacturing performance (Lipson and Walls 1962), probably because the incidence of short fibres is reduced.

SELECTION FOR SKIN FOLDS AND FERTILITY'

K.D. ATKINS*

SKIN FOLDS AS A BREEDING OBJECTIVE

The optimum level of skin folds **for** a Merino flock has long been a matter of debate. While it is well recognised that heavily developed sheep are more susceptible to breech strike and pose additional management problems, producers have been reluctant to breed a plain-bodied Merino on the grounds that **wool** production would decline. The denser, lower yielding fleece commonly found on developed sheep was also thought to offer improved protection against water and dust penetration

Flocks selected for high and low levels of skin fold, the Folds Plus and Folds Minus flocks, were established at Trangie in 1951 and maintained until 1972. Selection was effective in both directions and the realised heritability for the divergent selection programme of $0.36 \pm .04$ over the period 1951 to 1969 (McGuirk 1973) agreed well with the heritability estimate of 0.4 for the base population (Morley 1955a).

Selection for increased skin fold led to a moderate increase in greasy fleece weight, but as wool yield was lower, there was only a small increase in clean fleece weight. The average realised genetic correlations were **+0.31**, **-0.11** and **+0.18** respectively for greasy fleece weight, yield and clean fleece weight (B.J. McGuirk unpublished data). The increase in surface area resulting from increased folds was largely offset by a decline in wool production per unit area, principally from reduced staple length (Robards et al. 1976). Similar results were reported by Turner et al. (1970) for the **CSIRO wrinkle** selection flocks, where the high wrinkle **flock cut** no more wool than the control. As the Trangie Folds Plus sheep had higher feed requirements for maintenance than control flock animals (Robards et al. 1976), selecting for increased skin folds is clearly a very inefficient method of selecting for increased fleece weight.

The higher yolk content (or lower yield) or wool from the Trangie Folds Plus animals did not increase resistance to fleece rot. Over the period 1963 to 1972, the average incidences of fleece rot among **hoggets** in the Folds Plus, Random control and Folds Minus flocks were 43 percent, 41 percent and 40 percent respectively (K.D. Atkins and B.J. McGuirk unpublished data).

The most dramatic correlated response to selection for skin fold **occur-**

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red in fitness characters. This is best summarised by comparing the Folds Plus and Minus flocks on net reproductive rate, measured as the number of ewe hogget replacements produced by a ewe in her lifetime. Dun (1964) estimated a net reproductive rate for Folds Plus ewes of 1.248, compared with 2.270 for Folds Minus ewes. Wastage from the breeding flock due to deaths or necessary culling was higher among the Folds Plus ewes, and the reproductive performance of the Folds Plus flock was poorer due largely to a higher proportion of dry ewes, and higher lamb losses between birth and weaning. The difference observed by Dun in the percentages of wet ewes underestimates the true difference between the Folds Plus and Minus flocks as higher proportion of Folds Plus rams were rejected for poor semen quality prior to joining (McGuirk 1969). The superiority of the Folds Minus flock in wet ewes and litter size was greater in years of adversity (Dun 1964).

The relative contribution of ram and ewe effects to the differences in reproductive performance between the Folds Plus and Minus flocks is not clear, but both probably contribute. Dun and Hamilton (1965) attributed the total difference in flock fertility between the Folds Plus and Folds Minus groups to differences in ram fertility. On the other hand, McGuirk (1973) estimated a negative genetic correlation between reproductive performance of ewes and their fold score in the Trangie population.

The results from the Folds Plus flock clearly point to the undesirable effects on reproductive performance and overall fitness which could arise from selection for increased skin folds. At the same time, selection for reduced skin folds lead to lower clean fleece weights so that selection for reduced skin fold was more effective in reducing fleece weights than selection for increased skin folds was in increasing wool production.

THE FERTILITY FLOCK

The Fertility flock was established in 1959 with the aim of increasing reproductive performance by improving twinning and lamb survival and by reducing the number of dry ewes (Atkins and Robards 1976). There was also some selection for increased fleece and weaning weights and for reduced levels of skin fold and face cover. Body size, skin folds and face cover were included as selection criteria both to improve easy care characteristics and because they were thought to be correlated with improved reproductive performance. The selection programme was discontinued in 1974.

The reproductive performance in the Fertility flock has been compared with that in an unselected Random control flock for the final three years of selection (1971-1973) (Table 2). The Fertility flock is superior in all measures of performance, but not all of this difference is necessarily genetic. Some portion probably represents current generation improvement, as all ewes that were dry in any year or which lambed but failed to rear a lamb to weaning were culled. Part of the difference may also represent a mating management effect as the Fertility ewes were joined to a syndicate of rams while the Random ewes were paddock-joined to individual rams.

In an attempt to apportion the total response into genetic and non-genetic responses, the difference in reproduction rate between Fertility and Random flock was estimated separately for each year between 1959 and 1973, and for each age group of ewes. The annual rate of divergence of the flocks was then taken as the estimate of genetic progress, with the intercept of the regression line indicating the combined effects of mating management and current generation gains.

TABLE 2 Reproduction rate of Fertility and Random control
flocks between 1971 and 1973

| Component | Fertility flock | Random flock |
|--|--------------------|-----------------|
| Ewes lambing/ewe joined | 0.92 | 0.78 |
| Multiple births/ewe lambing | 0.52 | 0.32 |
| Lambs born/ewe joined | 1.47 | 1.10 |
| Single lambs surviving to weaning/ single lamb born | 0.93 | 0.86 |
| Multiple lambs surviving to weaning/ multiple lamb born | 0.85 | 0.78 |
| Lambs weaned/ewe joined | 1.24 | 0.91 |

When pooled **across** ages, the estimated rate of genetic improvement in ewes lambing per ewe joined and lambs born per ewe joined were respectively 0.03% and 1.8% per year. Since the means in Table 2 correspond to approximately 10 years of selection, the predicted genetic difference between the flocks would be 0.3 percent and 18 percent for ewes lambing and lambs born respectively. Thus about half the observed difference in lambs born per ewe joined would appear to be genetic.

Genetic gains were also achieved in clean fleece weight and weaning weight. The estimated rates of improvement were .036 kg or 1.3% per year for hogget clean fleece weight and 0.3 kg or 0.8% per year for weaning weight. Face cover and skin fold scores have both been consistently lower in the Fertility flock (Table 2).

INDUSTRY ACCEPTANCE OF TRANGIE SHEEP BREEDING RESEARCH

RECOMMENDATIONS

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The major aim of the Trangie sheep breeding programme has been to provide the Merino industry with soundly based breeding programmes. In New South Wales the Merino studs provide the great majority of rams used in commercial flocks, so that genetic progress in the industry is largely determined by the selection and breeding practices in the studs (McGuirk 1976). In promoting recommended breeding programmes, the extension campaign has attempted to improve these practices, generally by incorporating objective information on production characters.

There are some well established principles of extension theory which are important to bear in mind when attempting to change industry attitudes. The target audience must see the suggested changes as being relevant to their needs and goals, as **offering** real rewards, preferably in the form of financial incentives, and as being achievable with the resources available and not too complex. The chance of success is increased if the suggested changes have already been shown to work under commercial conditions. The extension methods chosen for the campaign should be appropriate both for the target audience and for the subject of the campaign. And the credibility and communication skills of the extension worker will also influence the chance of success.

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FLEECE MEASUREMENT AND SELECTION FOR FLEECE WEIGHT

The procedure recommended to incorporate fleece measurement information into fleece weight selection programmes was the 'half-classing' method proposed by Morley (1955c). This allowed for a preliminary culling on wool and body faults but selection was directed mainly to increasing fleece weight. However, despite the considerable efforts of both research and extension workers, only a minority of studs modified their traditional classing procedures. Most studs continued to select sire replacement by visual assessment and the few studs which obtained fleece measurement information generally did so only for their reserve rams (Sav-age and McGuirk 1976).

Probably the overriding reason for the slow adoption of fleece measurement by the stud industry was that breeders did not see its application as relevant - they did not see the need for change (Animal Production Committee 1974). To the breeder, fleece weight was only one of the many characteristics to be considered when selecting stud sires. Sheep **classers** claimed they were accurate enough in identifying the heavy cutters, especially as they were also attempting to improve wool quality and conformation traits. Studs did not see any obvious financial benefits in adopting the recommended breeding programmes, and many felt that their position within the well established hierarchy of the stud industry would be jeopardised. And it was difficult to see how the recommended **programme** could be implemented without major modifications to a stud management programme.

During the 1970s industry attitudes to fleece measurement began to change. The biggest single influence was undoubtedly the introduction of objective measurement to wool auction sales. **Sheepmen** began to talk about yields and microns and it seemed logical to some at least that if wool was to be sold by measurement and classed along objective standards, then surely the process should flow through to sheep breeding. A further important development was the adoption by a number of studs of breeding programmes that placed considerable emphasis on fleece measurement, demonstrating that objective information on fleece characters could be incorporated into commercial breeding programmes. These studs also developed flock ram grading schemes based on measurement, and showed that flock owners were prepared to buy flock rams in short wool.

In 1977 a new extension programme was initiated by the New South Wales Department of Agriculture to capitalise on these developments. Central to this **programme** was the establishment of a free fleece measurement service operated from Trangie Research Station.

The service encouraged studs to test whole drops of rams and this enabled flock ram buyers to select rams with the aid of information on greasy wool production and fibre diameter (McGuirk 1978). But the service had the broader aim of educating stud and flock breeders to the value of objective measurement as an aid in breeding programmes. It was hoped that an improved understanding, would lead to greater use by stud breeders in the selection of their own sires.

Since the introduction of the Trangie service an increasing number of studs are having all their rams measured. During 1979 the service measured 3500 rams from 130 studs which represented 40 percent of all Merino rams sold in New South Wales. A number of factors have contributed to the early success of the service. The opinions of stud breeders and **classers** were sought before it was started, and they have been regularly informed of all relevant developments. Extension officers have strongly identified themselves with their 'own' service, and **actively** promoted it. This has led to much closer contact between the **ex-**

tension worker and stud breeder, both in the collection and interpretation of the results, and in planning management changes which were needed to meet the physical requirements of the service. For example, rams had to be shorn twice - once as lambs and again some months later. This meant an extra shearing for many studs. Extension officers had to recognise the structure and requirements of individual studs plus the need to economically justify policy and management changes.

Commercial producers have shown that they are prepared to pay more for higher producing rams. Since 1977 eight Merino studs in New South Wales have conducted annual flock ram auctions. At these auctions the production information provided by the Trangie Service was made available prior to sale. On each occasion the prices paid were positively correlated with the rams' greasy wool production. The extension effort is now directed towards encouraging studs to develop ram grading schemes which reflect differences in production, either by grading on production, or by identifying the heavy cutters within the normal visual grades. We believe that the more widespread use of fleece measurement as an aid both to stud and commercial selection decisions will depend heavily on the influence and buying power of commercial producers. With this in mind, the New South Wales Department of Agriculture, in conjunction with the New South Wales Stud Merino Breeders' Association, has launched a statewide extension campaign aimed at flock breeders, to further explain the benefits fleece measurement offers them.

SKIN FOLDS

The Merino industry believes that a certain amount of skin fold is necessary to achieve reasonable fleece weights. On the other hand, it is generally believed and recognised that heavily developed sheep have a poorer contribution than plain-bodied sheep, take longer to shear and are more prone to flystrike. The Folds selection flocks at Trangie supported these views on wool production and survival, and also identified the association between high skin fold and low fertility.

The Folds selection programme at Trangie has not had a major impact on industry attitudes to skin wrinkle. Producers are generally unaware of the relationship found between **folds and** fertility. Many stud breeders concluded that the Department was promoting totally plain-bodied sheep, the Folds Minus type, which they found unacceptable because of their poor wool production. They could also point to many commercial flocks which expressed a greater degree of fold than the Trangie Folds Plus sheep, yet produced acceptable and often higher lambing percentages.

Drinan and Dun (1965) examined differences in production between **plain-bodied** and developed ewes in commercial flocks in a total of 14 field trials. While the developed ewes cut an average 0.45 kg. more greasy wool, the **plain-bodied** ewes marked an average of 17 percent more lambs. However, this difference in fertility was not consistent in all flocks. More recent field trials (Donnelly 1978; Baillie 1978) have indicated similar average differences in production, with the plainer ewes showing to greater advantage in fertility in poor years.

The field trial evidence indicates the difficulties in blanket recommendations regarding the optimum level of skin fold for a particular flock. Where production differences are known for individual flocks, selection policies can be determined to maximise total economic returns. Currently, there is a trend towards plainer bodied sheep in the industry, usually for ease of management.

But changes in skin fold in commercial flocks will be determined by selection policies in the studs. Again it is up to flock breeders to change these policies, by expressing a preference for plainer bodied rams.

FERTILITY

Most Merino breeders would prefer higher reproduction rates, in order to rebuild depleted flocks, increase income from the sale of surplus stock and enable more intense selection of replacement breeding stock. However, many would choose to achieve this with a minimum of twins and they do not see increased twinning as an important breeding objective. They claim that twins have lower survival rates than singles, particularly in dry seasons, and grow more slowly, and that pregnant ewes carrying twins are more prone to pregnancy toxæmia. What many producers do not realise is that twins are necessary to achieve a high lambing percentage. Experience from many sheep fertility field trials shows that for average Merino sheep flocks to approach a lamb marking of 100 percent, 20 to 30 percent of ewes must rear twins.

There are practical problems in selecting for increased twinning under commercial conditions, even though research by CSIRO (Turner 1978) and at Trangie has demonstrated that successful programmes are possible. Under extensive grazing conditions it is often impracticable to identify twins and twin bearing ewes, especially when labour is limited. And progress is unlikely to be rapid, as the heritability of reproductive traits in the Merino is low.

One solution open to producers who wish to improve the reproductive performance of their flocks is to purchase rams from research flocks of known high fertility. The availability of Booroola rams (Turner 1978) to industry has created keen interest among the small number of breeders interested in producing highly fertile sheep. To exploit the potential superiority of highly fertile ewes, it will be necessary to improve the nutritional management of the breeding flock, and also to increase supervision of lambing. If suitable management procedures can be developed and the highly fertile cross can be shown to be both more productive and more profitable under commercial conditions, then producers generally may be prepared to reassess their attitude to twins.

SUMMARY AND CONCLUSIONS

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Selection was effective in all of the single character and commercial selection flocks considered in this review. In the single character flocks which were discussed (the Fleece Plus, Folds Plus and Minus), direct and correlated responses were generally in the direction expected and the realised genetic correlations in quite good agreement with estimates obtained for the Trangie population prior to selection. Based on the Trangie and CSIRO findings, estimates of genetic parameters do seem to provide a reasonable basis for predicting responses to selection. The agreement between the Trangie and CSIRO fleece weight selection results is also reassuring (Turner 1977). This agreement also applies to changes in such characters as the sulphur content of wool and changes in the efficiency of conversion of feed to wool (see Williams 1980), characters for which no estimates of genetic correlations with fleece weight were available when the selection experiments began.

One of the major advantages of selection flocks is that they facilitate the systematic and comprehensive study of correlated responses to selection, including an examination of the physiological basis for differences in production.

These physiological studies are of special interest as they may identify alternate selection criteria for characters of economic importance. More generally the flocks can be used to predict the long-term effects of implementing recommended breeding programmes in the industry. It is in this context that some of the changes in the high fleece weight selection flocks are of particular importance. Based on the available evidence (Williams 1980; McGuirk 1980), the full benefits of fleece weight selection programmes will not be realised unless the availability of sulphur-containing amino acids can be increased. For this reason, the possibility of supplementing grazing sheep with cystine or methionine under commercial conditions calls for further examination (De Wet 1975).

Currently recommended programmes for increasing fleece weight can be seen as a refinement of current industry practices, as the traditionally minded stud breeder is usually attempting to increase wool production per head. Further research could contribute to the adoption of fleece measurement as a selection aid. For example, more extensive information is required to convince breeders that **hogget** wool production, **based** on perhaps as little as six month's wool growth, is a reliable 'indicator of an animal's breeding value for lifetime production. In N.S.W. there is also a growing body of opinion that selection should be on greasy and not clean fleece weight. Selection of greasy weight should not lead to an increase in wool yield, which many breeders **believe** will increase susceptibility to water and dust penetration.

The situation with twinning and skin folds is somewhat different, in that their importance as breeding objectives under commercial conditions needs to be more clearly identified and demonstrated to the industry. Industry acceptance of the findings is likely to be greater if the necessary field trials are conducted under commercial conditions, covering a range of environments, strains and bloodlines. The Booroola and Trangie Fertility flocks could contribute **significantly** to studies on the importance of twinning to Merino productivity and profitability, provided that the field trials are supplemented with more detailed studies to identify the nutritional and management requirement of highly fertile ewes.

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