BREEDING OBJECTIVES FOR MERINO SHEEP

J.R.W. Walkley

Department of Agriculture
ADELAIDE SA 5000

INTRODUCTION

At the inaugural conference of the Australian Association of Animal Breeding and Genetics (AAABG) in 1979 the theme covered definition, measurement and recording in livestock improvement. The organisers of our first meeting noted that "The development of a breeding program for genetic improvement depends on a clear recognition of just what should be improved. In a broad sense, this might be expressed in economic terms - as profit or percent return on investment".

Breeding objectives were described as "those characteristics or traits which a breeder wishes to improve, presumably because they have an important effect on herd or flock net income" and the question "What is the relative importance of different characters considered in the Breeding Objective" posed. In addition, the relative importance of the Selection Criteria was raised.

A method of multiple trait selection for animals developed by Hazel (1943) provides a theoretical basis for answering these questions. Selection index theory was used by Ponzoni (1979) in defining Objectives and Selection Criteria for Australian Merino Sheep. In his paper Ponzoni developed an approach for defining the Breeding Objective for a particular commercial Merino flock composition proposed methodology for calculating economic values of the individuals traits in the breeding objective, evaluated the efficiency of various ram and ewe selection indexes and tested the sensitivity of the overall gain in economic units to changes in prices of the products involved.

Subsequent developments have included suggested refinements of procedures for calculating economic values (Ponzoni, 1982 and 1986, James, 1986), an examination of differences in commercial flock composition on the economic value of trait in the objective (Ponzoni, 1982) and an evaluation of the particular traits (e.g. reproduction rate in the objective for a range of flock compositions and economic values (Ponzoni and Walkley, 1984).

In this paper I have attempted to identify the main developments which have occurred in the definition of practical breeding objectives for Merino sheep in the last eight years. Consideration is also given to the optional breeding objectives available in WOOLPLAN (Lewer et al, 1986) and future developments which are necessary to refine our definition of breeding objectives for Merino sheep.

SPECIFICATION OF THE PRODUCTION AND MARKETING SYSTEM

The long term genetic improvement of commercial Merino flock is also solely dependent on selection policies adopted by ram breeding flocks (McGuirk, 1976).

Ram breeders may have clients with Merino sheep enterprises in each of the broad production zones - pastoral, wheat/sheep and high rainfall. Both within and between zones the composition of commercial Merino flocks varies as does the age at which surplus sheep are sold. These variations in the production systems led Ponzoni (1979) to suggest that there will not be a unique selection objective applicable or relevant to all commercial Merino flocks.

The ram breeder, however, could well ask if such variations mean that within his ram breeding flock, separate definitions of breeding objectives were required to meet the needs of commercial clients.

That there is a real need to specify the commercial sheep production system for which genetic improvement is intended has been illustrated by Ponzoni (1981) for different flock compositions and by Ponzoni (1984) for fleece rot and body strike in hoggets. Ponzoni and Walkley (1984) examined the economic importance of genetic improvements of reproductive rate in Australian Merino sheep in a range of flock compositions and for several sets of economic values.

Ponzoni (1981) calculated correlations between breeding objectives developed for four different flock compositions, namely:

(i) a breeding ewe flock in which all surplus offspring are sold as lambs after weaning (FC_1)

(ii) a breeding ewe flock in which surplus offspring are sold at approximately 1.5 years offshears (FC_2)

(iii) a flock of 50% breeding ewes and 50% wethers (FC_3) and

(iv) an all wether flock (FC_4)

The range of flock compositions considered meant that both the individual traits in the objective and the economic value assigned to each trait varied considerably.

The results indicated that the same breeding objective could be safely used in studs providing rams for commercial flocks composed of breeding ewes and in which all surplus offspring were sold, regardless of age at sale (FC_1 and FC_2) or in a flock of 50% breeding ewes and 50% wethers (FC_4).

A study of the economic value of resistance to fleece rot and body strike in hoggets (Ponzoni, 1984) highlighted the necessity for precisely defining the production system for which improvement is intended. If the production system was such that no treatment could be applied to struck sheep, and they subsequently died, as may occur in some pastoral areas, body strike had a very high economic value. In situations in which individual or flock preventative treatment was possible however, the relative economic value of body strike was low or negligible.

Ponzoni and Walkley (1984) showed for reproduction rate that the economic importance of its genetic improvement depended on the production system. Thus the economic importance of reproduction rate, as assessed by percentage contribution to total gain in economic units, was high when surplus offspring were sold as weaners and improved reproduction rate was not associated with increases in production costs. However its value was small if wethers were retained to mature ages or improved reproduction rate was associated with markedly increased production costs.

It is well known that strains and studs within strains of Merino differ in many important productive characteristics such as fleece weight, fibre diameter, reproduction rate and live-weights (Turner and Young, 1969, Mortimer et al. 1985). This variation should also, I believe, be taken into consideration when defining breeding objectives for Merino sheep. If a strain or stud had an appropriate average fibre diameter or liveweight, it seems reasonable to perhaps hold this trait constant, although it must be remembered that imposing such restrictions comes at a cost to overall gain in economic units (Lewer et al. 1986).

The marketing system for sheep and wool imposes constraints on the definition of traits in practical breeding objectives for Merinos. For instance in future, more of the Australian wool clip may be sold with additional measurements of tensile strength and staple length. The value in dollars of a newton/kilotex change in strength has not yet, however, been clearly established by the marketing system.

SOURCE OF INCOME AND EXPENDITURE IN COMMERCIAL FLOCKS

Key developments in recent studies of definition of breeding objectives in Merino flocks has been the recognition that the objectives of ram-breeding flocks should include those traits that influence profitability in commercial flocks and the need to consider all traits influencing costs and returns. Initially, attention was focused on traits which were economically important because they influenced returns to producers (Ponzoni, 1979) even though it was recognised, in theory at least, that all traits of economic importance should be in the objective.

As James (1982) notes, animal breeders had not given a great deal of systematic attention to definition of breeding objectives. The advances made can be seen in, for example, Ponzoni (1979, 1982). In the latter case, costs associated with feed, wool and sheep marketing, veterinary treatments and labour as well as the returns from wool and sheep are clearly documented.

The sources of income and expenditure defined for commercial flocks by Ponzoni (1982) were: Income - wool, surplus offspring and cull-for-age sheep and Expenditure - feed, wool marketing, marketing of surplus offspring and adult sheep, veterinary treatments and labour. The traits identified as influencing returns from wool were clean fleece weight and average fibre diameter. The approach has been refined further (Ponzoni, 1986) by identifying the class of sheep contributing to income from wool. Thus income from wool from lambs, hoggets and breeding ewes is separated and for each class of sheep the major traits influencing income are defined. The approach described by Ponzoni (1986) could be readily adapted to different Merino flock compositions.

We have progressed from using only sources of income, to using income and expenditure and now to including classes of sheep as well in defining breeding objectives.

The procedure of identifying sources of costs and returns in commercial Merino flocks has significantly contributed to the definition of practical breeding objectives because the procedures accurately reflect the real world. In particular it has enabled a clear distinction to be made between "what we would like to improve, not what we can improve" (James, 1986). A frame-work is provided within which the ram-breeder and the ram-buyer can systematically identify the major sources of costs and returns in their particular enterprises. Such an approach also serves to identify areas in which information is lacking; for example feed is a major cost but only recently (Ponzoni, 1986) has an attempt been made to examine the economic value of feed consumption as a trait in the breeding objective.

DETERMINATION OF BIOLOGICAL TRAITS INFLUENCING INCOME AND EXPENSE

In the past, a description of breeding objectives has often meant little more than a list of characters influencing returns and perhaps costs of production, but with "little" indication of their relative importance (McGuirk, 1982). Theoretically, at least, the specification of individual traits and their economic weight is unnecessary (Hill, 1981); the objective could be defined solely as profit.

There do, however, appear to be important advantages in splitting the objective into component traits influencing income and expenses. The major advantage is that a distinction between traits in the objective and characters to be considered as selection criteria is made (James, 1986).

Furthermore, specifying the biological traits allows account to be taken of different compositions, age structures and the number of times a trait is expressed (McGuirk, 1982). The approach described by Ponzoni (1982) has also highlighted limitations in our current knowledge of genetic and phenotypic parameters. For instance hogget clean fleece weight is being used as a selection criterion for clean fleece weight at hogget and later ages on the assumption that the traits are genetically the same at each age. Evidence of Lewer et al (1983) suggests this assumption is inappropriate for New Zealand Perendales at least. James (1982) has presented a convincing case for including feed consumption as a trait in the objective. The logic for this becomes readily apparent when feed is identified as a cost in sheep production systems.

DERIVATION OF ECONOMIC VALUES FOR EACH TRAIT

The economic value of a trait may be defined as the change in profit associated with a one-unit change of that trait assuming all other traits are constant.

Developments in the calculation of the economic value of each trait were reviewed by Ponzoni (1982). Refinements in the calculations of economic values had occurred in four areas - differential expression of traits per lifetime, discounting, allowing for increased costs resulting from genetic change and estimating economic values for different flock compositions.

Several of these developments have been incorporated into profit equations developed for sheep flocks by Jones (1982) and Ponzoni (1982, 1986). The profit equation described by Ponzoni (1986) is comprehensive in that account is taken of all major sources of income and expense for the flock. Biological traits affecting sources of income and expenditure are identified with a separation of traits expressed in breeding and non-breeding sheep. Variable costs associated with the production, harvesting and marketing of wool and surplus sheep were also considered.

As part of his study, Ponzoni (1986) evaluated procedures to account for the differential expression of traits in the breeding objective (discounting or not discounting). The method of calculation of economic values for each trait had only a minor influence on their magnitude and near negligible effects on the genetic gain achieved in each trait.

The genetic gain in individual traits in the breeding objective for Merino sheep has been shown to be quite insensitive to marked changes in the relative prices of the products involved (Ponzoni 1982, Jones, 1982). This finding has important implications for practical breeders using a performance recording service such as WOOLPLAN (Lewer et al, 1986) which offers an option of use-specified economic values.

BREEDING OBJECTIVES

James (1986) suggests the definition of a breeding objective should begin with a specification of all items of income and expenditure and if desired each item may then be analysed as a function of the relevant traits.

Sources of income and expenditure in commercial Merino flocks proposed by Ponzoni (1984) were:

Income	Expenditure
Wool	Feed
Surplus offspring	Wool harvesting and marketing
Cull for age sheep	Marketing of wool
	Veterinary treatments
	Labour

Ponzoni (1986) has proposed a list of traits (see Table 1) which should be considered for inclusion in breeding objectives because of their effect on income and expenditure at a commercial flock level.

Table 1

Biological traits included in the breeding objectives because of their effect on income and expenses derived from the sheep flock.

Effect on profit	Productivity or activity	Class of sheep	Traits
Income	Wool	Lambs	Lamb clean fleece weight (lCFW) number of lambs weaned (NLW)
		Hoggets	Hogget clean fleece weight (hCFW) hogget fibre diameter (hD), NLW
		Ewes	Ewe clean fleece weight (eCFW) Ewe fibre diameter (eFD)
	Surplus offspring	Hoggets	NLW, hogget live weight (hLW)
	Cull for age animals	Ewes	Ewe live weight (eLW)
Expense	Feeding	Offspring (birth to hogget age)	Offspring feed intake (oFI), NLW
		Ewes	Ewe feed intake (eFI)
	Husbandry	Offspring (birth to Hogget age)	NLW
	Wool Harvesting and marketing	Lambs	lCFW, NLW
		Hoggets	hCFW, NLW
		Ewes	eCFW
	Marketing of surplus sheep	Hoggets	NLW, hLW
		Ewes	eLW

Despite its comprehensive nature in which income from wool is partitioned into traits of lambs, hoggets and adult ewes and recognition made of feed intake by young animals and adults, many traits were not included. Ponzoni (1986) cites staple strength and wool colour, fat content of the carcase, disease resistance, easy care and longevity as examples of potentially important traits. In most cases both genetic and economic information is lacking about these traits. Given the relative insensivity of gain in individual traits to changes in prices the lack of accurate economic information is perhaps less important than reliable genetic parameters.

In selection index theory it is assumed that the phenotypic and genetic variances-covariances are known whereas in practice estimates are used. One potential danger of including more and more traits in practical breeding objectives is that the probability of errors in the variance-covariance matrices increases (Hill, 1981).

BREEDING OBJECTIVES - IN PRACTICE

Merino ram breeders in Australia are now offered a range of breeding objectives in the sheep performance recording service WOOLPLAN (Lewer et al, 1986) provided by fleece measurement laboratories.

The traits in the WOOLPLAN selection objective are clean fleece weight, fibre diameter, reproduction rate, sale weight of surplus offspring and weight of cull-for-age sheep. Flexibility in objectives is available through choosing to restrict either average fibre diameter and/or reproduction rate. An option is also provided whereby breeder specified economic weights can be used. The option of using breeder-specified economic values for traits in the breeding objective will no doubt continue to be offered in the future thus enabling "personalised" objectives to be developed by ram breeders. Given this flexibility will be available we need to consider the degree to which further specification of traits affecting sources of income and expenditure at the commercial level needs to be pursued. The approach in practice could be to consider the percentage contribution to overall gain in economic unit of potential new traits and base decisions to include or exclude such traits on this basis. In this context it is worth noting that the trait mature live weight only contributes between 2 and 4 percent of the overall gain in economic units in the alternative WOOLPLAN objectives. Correlations between indices developed for different breeding objectives (e.g. WOOLPLAN and Ponzoni (1986)) could also be used to evaluate the consequences of including additional traits in the objective.

Cunningham (1969) reviewed the principal assumptions used in constructing and using selection indexes and drew the general conclusion (p224) that the greatest source of error is likely to be poor estimates of phenotypic and genetic covariances and the other assumptions were probably not too restrictive. Thus the real need in recording schemes such as WOOLPLAN, which will be used for different Merino strains and even other wool breed sheep, is to use appropriate sets of parameter estimates. Wool is now being sold with measurements of tensile strength and staple length so both economic values and phenotypic and genetic parameters are required to assess whether these traits should be included in practical objectives.

Phenotypic and genetic parameter estimates for fleece rot and fly strike for different Merino strains are now available (James et al, 1986; McGuirk and Atkins, 1984) and an evaluation of indicator characters such as greasy wool colour in WOOLPLAN type objectives is warranted. Such evaluations will need to include a range of economic values for the trait flystrike because the treatment program which is possible to use in practice markedly affects its economic value (Ponzoni, 1984).

CONCLUSIONS

Over the last eight years significant developments in the definition of breeding objectives for Merino sheep have occurred, culminating in the options currently available in WOOLPLAN.

At our inaugural conference, Cunningham (1979) stated "The construction of a breeding scheme requires answers to a logical series of questions". Attempts by animal breeders to apply selection index theory to help ram breeders achieve their goals have partially clarified some of the logical series of questions although in some instances the solutions are not immediately obvious or available.

It is clear that the commercial Merino production system can result in different traits being included in the objective and that the contribution of individual traits such as body strike or reproduction rate to overall gain can vary substantially between production systems.

Consideration has been given to sources of both income and expenditure in the commercial Merino flock and thus provided a frame-work which can be used to readily identify areas of future research and development. Or equal importance, in my opinion, is that the same approach can be used to assist ram breeders clarify their objectives by posing the question "What makes your commercial Merino clients' money?".

The derivation of economic values for traits in the breeding objective has been refined by the use of profit equations which will be used when the economic values used in WOOLPLAN are re-assessed.

Ram breeders specifying their own economic values in WOOLPLAN will be re-assured however by studies which show that gains in individual traits are quite insensitive to large changes in product prices.

While it may now appear insignificant, a crucial factor in the development of WOOLPLAN was that the computer program (SELIND) used to derive indices required traits and variates to be nominated. Furthermore the traits and variates need not necessarily be the same. Thus for the WOOLPLAN objective in which all traits are un-restricted there are six different combinations of variates from which to choose and others will no doubt be offered. Breeders using a particular objective can now readily evaluate the genetic consequences of using additional sources of information in an index as well as assess whether the increase in accuracy provided is worth the extra cost of obtaining the extra information.

I believe WOOLPLAN will achieve acceptance by Australian Merino breeders because it is essentially a formal development of an intuitive approach they use in taking into account the advantages and disadvantages of individuals when choosing rams.

The accuracy of estimated breeding values provided by schemes such as WOOLPLAN depends on the sources of information and the parameter estimates used. The development of WOOLPLAN has clearly identified deficiencies in our existing knowledge of phenotypic and genetic covariances for many Merino sheep characteristics.

While these deficiencies need to be remedied to improve WOOLPLAN it should be noted that if we have poor covariance estimates, we have also undermined the basis for any other selection procedure, so that the best course of action will normally be to construct the best index possible with the estimates available. (Cunningham, 1969).

REFERENCES

Cunningham, E.P. (1969). In: Animal Breeding theory, Agric. Inst., Dublin.
Cunningham, E.P. (1979). Proc. Inaug. Conf. Aust. Assoc. Anim. Breed. Genet. pp. 73-80.
Hazel, L.N. (1943). Genetics 28: 476-490.
Hill, W.G. (1981). Proc. Aust. Assoc. Anim. Breed. Genet. 2: 227-236.
James, J.W. (1982). In: Fut. Devel. Genet. Imp. Anim. Eds. Barker, J.S.F., Hammond, K. and McClintock, A.E. Academic Press.
James, J.W. (1986). Proc. 3rd Wld. Cong. Genet. Appld. Livest. Prod. IX: 470-478.
James, P.J., Ponzoni, R.W., Walkley, J.R.W., Whiteley, K.J. and Stafford, J.E. (1987). In: Rev. Genet. Improve. Sheep. Leura, N.S.W. (submitted).
Jones, L.P. (1982). In: Fut. Devel. Genet. Imp. Anim. Eds. Barker, J.S.F., Hammond, K. and McClintock, A.E. Academic Press.
Lewer, R.P., Rae, A.L., and Wickham, G.A. (1983). N.Z. J. Agric. Res. 26: 315-319.
Lewer, R.P., Ponzoni, R.W, Morgan, P.D. and Vanrenen, D.S. (1986). Proc. 3rd Wld. Cong. Genet. Appld. Livest. Prod. IX: 645-649.
McGuirk, B.J. (1976). Proc. Aust. Soc. Anim. Prod. XI: 13-16.
McGuirk, B.J. (1982). Proc. 2nd Wld. Cong. Genet. Appld. Livest. Prod. VIII: 609-618.
McGuirk, B.J. and Atkins, K.D. (1984). Aust. J. Agric. Res. 35: 423-434.
Mortimer, S.I., Atkins, K.D. and Rogan, I.M. Proc. Aust. Assoc. Anim. Breed. Genet. 5: 218-219.
Ponzoni, R.W. (1979). Proc. Inaug. Conf. Aust. Assoc. Anim. Breed. Genet. pp: 320-336.
Ponzoni, R.W. (1981). Tech. Inf. Circ. No. 56, Dept. Agric., South Aust.
Ponzoni, R.W. (1982). Proc. 2nd Wld. Congr. Genet. Appl. Livest. Prod. V: 619-634.

Ponzoni, R.W. (1984). Wool tech. Sheep Breed. XXXII: pp. 33-40.
Ponzoni, R.W. (1986). J. Anim. Breedg. Genet. (in press).
Ponzoni, R.W. and Walkley, J.R.W. (1984). pp. 378-381. In: Reproduction in Sheep. Eds. Lindsay, D.R. and Pearce, D.T., Aust. Acad. Sci. Canberra.
Turner, H.N. and Young, S.S.Y. (1969). Quantitative Genetics in Sheep Breeding. Cornell Univ. Press. Ithaca, New York.