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# EVALUATION OF INDUSTRY BREEDING PROGRAMS FOR SHEEP AND GOATS INTRODUCTION AND OVERVIEW

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## INTRODUCTION AND OVERVIEW

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### INTRODUCTION

In his introduction to the Plenary Session of the First World Congress on Genetics Applied to Livestock Production for Sheep, Rae (1974) pointed to the wide diversity of sheep production systems throughout the world. Goats add further to this range in production environments, husbandry systems and to the variety of products for which these two domestic species are farmed. Such variety makes any consolidated review of Genetic Improvement Programs for sheep and Goats very difficult, especially if all important operational features of the production and marketing circumstances for each end product are to be considered in evaluating the success of programs currently being applied around the world. For this reason a decision was made in planning this Session not to attempt the difficult task of reviewing in-depth all those applications of genetic improvement for which published information is available. Rather, it was decided to attempt to draw out the different ways in which breeding programs may be evaluated, giving emphasis to the sort of approaches that have been taken. Because this format would need to refer to specific examples it was considered that these could be chosen to illustrate particular operational features and genetic principles upon which different programs are based. It was also considered that this format would prevent some repetition of descriptive detail already published and that it would provide greater operational insight by highlighting actual applications appropriate to different species, breeds and traits as well as to the production circumstances under which animals were managed.

Throughout this review, genetic improvement is confined to the application of selection, there being a separate Plenary Session of the Congress devoted to Evaluation and Utilisation of Breed Resources through crossbreeding. Other mating plans are also ignored, such as from an inbreeding point of view (Rae 1981), but not from the point of view of applying selection in sire-breeding flocks and especially in the nucleus flocks using elite matings for sire production. These aspects are an important feature of the second review paper by NICOLL et al., which considers inter-flock relationships for application of genetic improvement in a population as a whole rather than only in terms of genetic progress for an individual flock. The latter details are the subject of the first review paper by ATKINS et al..

#### Goat Programs

By necessity, information comes mainly from sheep. Taneja (1982) has considered the large neglect in application of genetic principles for improvement of meat production in the goat, a situation in marked contrast to that which applies to milk production for both goats and sheep (Rae 1982, Steine 1982) and despite the high contribution of meat to total income from goats in developing countries. He points to the low level of investment in research and development, absence of trained personnel and of industry organisation for goat production. Under these circumstances, careful resolution and understanding of successful breeding developments and their operational basis in sheep industries should provide useful guidelines for a more discerning evaluation of goat breeding ventures.

The evolution of breeding programs for sheep and goats often have interesting parallels. Campbell (1984) has recently described the development of a meat-producing Boer goat through selection of indigenous goats for conformation and meat production by farmers in South Africa. From 1970, breeders of Boer goats have participated in a National Mutton Sheep and Goat Performance Testing Scheme which sets an organisational and operational basis to improved production through selection on maternal, growth, feed conversion efficiency and carcass evaluation of sire-progeny groups. However, even with such a background of principles of genetic improvement well-established for sheep and beef cattle, it appears that, to date, breeders of Boer goats have selected mainly for conformation breed traits and cull faults in attempts to develop a well-adapted animal to both browsing and grazing conditions.

For Angora goats in South Africa, Delport and Heydenrych (1984) have recently examined some aspects of their stud industry structure. They noted a higher kid weaning percentage in the parental Angora stud, but no good evidence for significant genetic trends over a 10-year period from 1970. The recommendation of these reviewers to place positive selection pressure on reproductive efficiency would seem in the absence of direct experimental evidence for goats, to be based on successful genetic parallels in sheep. Their recommendation also discounted the current industry practice of selecting against abortions because of its small overall but variable year-to-year contribution to the high incidence of reproductive failure in Angora goats under adverse climatic conditions.

Thus, for specialised fibre production in goats as well as in sheep, reproductive rate is a character of high economic value, as reviewed for sheep by ATKINS et al. in the first paper of this session. The implementation of performance recording schemes for goats also have close parallels with sheep (Delport and Erasmus 1984, Nicoll 1985).

Delport, Erasmus and Heydenrych (1984) have further analysed the industry structure of South African Angora goats, showing its 'classical' reliance by smaller studs on the purchase of superior males from larger breeding units. It was considered that flock size was a major limiting factor to the effective application of within-flock selection, cooperative breeding ventures involving larger nucleus flocks being advocated. These are the sorts of features reviewed, with particular reference to sheep operations, in the second paper of this session by NICOLL et al. .

## Breeding in Difficult Environments

### Adaptation.

Rae (1982) summarised breeding plans for goat production, highlighting the importance of adaptation to environmental conditions as a major objective, especially in tropical regions. Accordingly, recording systems must gather information under the difficult production conditions in which animals are expected to produce. Establishment of sire-breeding nuclei supplying males to producers either directly or through multiplying flocks located in a number of centres seems to be the key organisation feature under these difficult circumstances as discussed by Rae (1974) and NICOLL et al. .

It is inevitable that most of the information on breeding programs for sheep comes from the developed countries (NICOLL et al.). Yet 43% of the world's sheep are found in the developing countries, where they are increasing more rapidly, are of greatest benefit to the even faster increases in human population growth and where they can exploit a renewable grazing resource which is well-suited to utilisation by such small ruminants which are not highly competitive with land for cropping or with the resulting human foodstuffs themselves (Terrill 1984). Under these circumstances, this author advocates selection for number of lambs weaned per ewe for improvement of meat production efficiency. Such an approach is believed to complement rather than be antagonistic to the large amount of natural selection to which established native breeds have been exposed. To achieve this objective Terrill (1984) proposes long-term selection for ability to breed as ewe lambs, retaining for breeding young ewes themselves and their twin- or triplet-born ram progeny. He considers such an approach is more likely to ensure the necessary associated husbandry adaptations as genetic responses are achieved.

Levels of recording.

Rae (1974) proposed a role for indirect selection for reproductive rate under husbandry conditions which may not allow the collection of detailed data such as a ewe's lifetime reproductive performance. Taneja (1974) further promotes this concept for the development of unimproved breeds for apparel wool production by selecting for greasy fleece weight and against the percentage of medullated fibres, although the latter trait has importance in its own right in addition to its indirect value in reducing fibre diameter. In the main however, he is advocating a selection scheme based on simple production records. Taneja (1982) makes similar recommendations for improvement of meat production of goats.

Simplification of recording systems for difficult production systems was also counselled by Rae (1974) with encouragement for greater innovation in this area. Both papers in this Plenary Session consider variation in the amount of pedigree identification possible for different flock circumstances under which sheep and goats are managed. The majority of recent and more sophisticated methods of assessing genetic change require pedigree information as a fundamental basis. There would however, seem to be considerable scope for collecting partial pedigree information - e.g. on sires through recording of just mating group allocations of dams followed by identification of progeny by sire only at or near their time of birth following lambing of the ewes in these same mating groups. Such data might allow use of reduced BLUP models on a sire-of-lamb and/or sire-of-dam basis and would seem to offer much to across-flock ranking procedures, perhaps even for sires used widely through AI. Collection of full pedigree information for sheep and goats requires in addition to mating records, full mothering-up information for the ewe and her offspring at or soon after birth, the very same operations that are required to assess a ewe's reproductive rate. The second paper of this Plenary Session (NICOLL *et al.*) indicates however, that it is not so much the gathering of this information that is difficult, but rather, the permanent identification of high-producing animals and the recording of this information together with other data. Developments in electronic methods of collecting and recording data are of relevance to future development of breeding schemes because of the opportunities they offer in these two areas, as well as in the transmission of the data following their collection (Callow *et al.* 1986).

Breeding Objectives

As illustrated above, several workers have advocated selection for reproductive rate for improvement of sheep and goat production under a variety of industry circumstances. Despite the specialisation of different breeds in the more developed sheep industries, the first paper by ATKINS *et al.* has further highlighted the high relative importance of reproductive rate for most breeds in terms of the contribution it makes to economic returns compared with wool and carcass production. Of further operational generality is the information presented by ATKINS *et al.* and in the reviews by Rae (1984) and Wickham and

McPherson (1985) that predicted selection index gains in aggregate economic value are often insensitive to quite wide variation in the relative economic values given to different traits appropriate to a particular production system, at least within the range of usual variation in product prices.

Genetic Parameters

The authors of the first paper have concentrated on the application of different techniques requiring full pedigree information for prediction of breeding values in the genetic sense. Many schemes use less formal methods of ranking animals prior to selection as ATKINS et al. describe and as described previously by, amongst others, James (1982) and Rae and Anderson (1984). It is axiomatic that more formal approaches are necessary if highly-developed schemes are to be accountable for the time, effort and money expended on them. That most traits experimentally investigated have demonstrated a genetic basis to their expression, at least to some degree, should not be taken to mean that a particular genetic recipe will always be the 'salvation of all ills' even within a common production system or for the same trait under different production circumstances. There may tend to be an increasing commercial tendency in this direction with the greater number of effective commercial and experimental demonstrations being undertaken on the value of selection as a permanent, cumulative and, often, cost-effective way of diversifying animal production.

In the first paper, ATKINS et al. clearly present arguments counselling against an uninformed application of selection where knowledge of genetic parameters is non-existent or limited and especially in selection schemes placing sole reliance on poorly estimated genetic correlations with objectives which are difficult or expensive to measure directly. Rae (1974) and the contributors to his Plenary Session on Genetics Applied to Sheep Breeding Programmes reviewed evidence on the genetic control of reproductive rate and its components, including genetic relationships among these components for sheep, and have discussed suggestions for the use of indirect selection criteria for improvement of reproductive rate. These possibilities were discussed further at the last Congress by Hanrahan (1982). Based on this review and that of Land et al. (1983), no good examples of the successful application of indirect selection for reproductive rate in sheep or goats using biological marker traits are yet available, although research results for sheep point to ovulation rate as a prime candidate (Hanrahan, 1984).

Implementation and Costs

Both reviews in this Session have emphasised that multi-trait objectives are the rule rather than the exception for sheep and goat production. This favours multi-stage selections. Discussion of multi-stage index selection methods by ATKINS et al. illustrates how industry circumstances will influence the optimal design of a breeding program for particular selection objectives. These operational features further strengthen their advocacy for a full economic analysis of the cost benefits of alternative industry programs. NICOLL et al. conclude however that this will seldom be possible because of the lack of information to define a breeding system completely in economic terms, especially for those involving a long and indirect chain of dissemination of genetic improvement through the breeding, production, processing and marketing industries to the ultimate consumer. NICOLL et al. promoted greater inter-disciplinary collaboration in future attempts to improve our understanding of this area. For these reasons also, both reviewers by necessity were forced to concentrate upon the more technical approaches to assessment of industry breeding programs in terms of their individual genetic and operational features rather than as a whole.

As both reviewers indicate, analysis of phenotypic selection differentials have been undertaken in a small number of commercial sheep breeding ventures to predict the likely outcome of a breeding program. These studies, illustrate the social evolution of breeders' attitudes to recording and the extension value of knowing the extent to which performance information has actually been used in their selection decisions (Callow and Binnie 1982, Rae 1984b). This information can also make important contributions to the successful marketing of sires by breeders, thereby assisting the realisation of an economic return on their investment (McGuirk 1982).

Rae (1984b) has further reviewed the many organisational aspects that are involved in implementing breeding programs and their associated central performance recording services, drawing attention to the features they have in common with any business venture involving product development and marketing. He makes a clear separation between the establishment and maintenance phases of industry-wide programs. For both, his review emphasises the importance of good communication to establish effective team-relations among the many individual people and organisations that usually need to be involved. The importance of promotion and servicing personnel was also stressed by Rae (1984b) and NICOLL et al., the role of the extension specialist often changing as the breeding scheme evolves (Callow and Binnie 1982).

Both reviewers have covered methods of estimating genetic change, ATKINS et al. giving greatest attention to details of their within-flock application while NICOLL et al. have discussed them more from an industry-wide point of view. ATKINS et al. make the important distinction between prediction of genetic trends based either on calculation of selection differentials or relative breeding values over time, and the estimation of genetic progress in retrospect using methods which are not dependent on prior knowledge of genetic parameters. They also emphasise that there are costs associated with specially-designed repeat matings which arise from the necessary changes they impose upon the structure of the breeding population, such as through the re-use of semen from less productive sires. In reviewing some of the first estimates of genetic progress (and their standard errors) for commercial sheep breeding ventures, ATKINS et al. indicate that costs may put the methods beyond economic possibility for many within-flock breeding programs. Different considerations apply to cooperative or national improvement ventures (King and Smith 1982) although cost considerations will probably mean that reliance on genetic prediction through routine analysis of phenotypic selection differentials will have greatest operational utility (Clarke 1985).

New Processing Technologies

Up to the present time, application of BLUP to sheep and goat breeding has been hampered by the additional computational costs, especially for multiple-trait evaluations (Rae and Anderson 1982). It is fortunate that application of computing shortcuts (Quass and Pollack 1980) and developments in computer technology are changing this situaiton rapidly.

BLUP favours the application of parent selection at the same time as the new candidates become available for inclusion as replacements in the breeding flock. It also allows the incorporation of some of the effects of previous selection, of special significance to multi-stage selection programs. However, as has been noted, this has the operational requirement that the information on which prior selection was based be known, recorded and included in the BLUP model. This imposes special data recording and storage requirements on the breeding scheme in addition to the extra computing time. Fortunately, however, modern electronic database recording systems favour a clear operational separation of the data-recording, data-housekeeping and data-processing components of centralised recording schemes, with developments in electronic data transmission providing for further operation flexibility by allowing a physical separation of these processes as well (Callow et al. 1986).

Methods for further decreasing the additional computing cost of BLUP or other models to predict genetic trends under multi-trait selection will be of special significance to sheep and goat improvement programs. The BLUP method offers special promise if its trend predictions can become available as low-cost 'by-products' of routine annual predictions of breeding value for flock replacements and their parents.

At the present time the major benefits of BLUP technology are most likely to be in breeding schemes involving some sort of cooperation across flocks to provide for a greater sharing of processing costs, to exploit the lower processing costs of reduced models exploiting specially-designed flock linkages (Grasser and Hammond 1985) and because of the requirement for a more precise ranking among males being used more intensively under AI, especially AI using frozen semen (Rae and Anderson 1982; Lewer 1984). The genetic relationships among sires which are important to the prediction errors in this case are different from those which are most useful for prediction of genetic trends within the overlapping generations of a single breeding flock which has been structured to optimise its genetic response to within-flock selection. Pedigree relationships among the dams in the flock are of special value in this case (ATKINS et al.).

As described by Danell (1982), attention in Sweden is being directed to development of a BLUP procedure for prediction of breeding values of rams based on comparisons of rams with progeny in the same flock using reference sire connections established in several ways - through AI, ram circles and the transfer of ewes across flocks for mating - and using in addition, pedigree relationships among the rams themselves. Some of the operational problems of ensuring sufficient connectedness of genetic relationships across flocks, of assortative mating, of environmental bias through late lambings and special treatment, are discussed by this author who considers the BLUP method to be especially appropriate to sheep industries based on small flocks widely scattered geographically. In Sweden it has apparently encouraged more widespread flock participation in recording, increasing the number of rams being evaluated each year as well as the accuracy of prediction of their breeding values.

For further discussion of these and other new technologies to sheep and goat breeding, readers are referred to the specialist Roundtable Sessions of this Congress.

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