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SOME   ASPECTS  
OF   THE  
PROGENY   TESTING  
OF  
NEW   ZEALAND   ROMNEY   MARSH   RAMS.

Being a Thesis presented by "393" for the Animal Husbandry Section of the  
M. Agr. Sc. Degree.

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M. Agr. Sci thesis

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## INTRODUCTION.

Present animal breeding methods were devised empirically, many of them having their beginnings far into pre-historic and pre-scientific times. Men found by actual experience that certain procedures generally gave more desirable results than other procedures although the basic reasons for this were unknown. Selection, or the choosing for breeding purposes of those animals deemed to be superior, has been the most important of these methods and indeed, fundamental to the application of any breeding system. The quality of all types of livestock as we know them to-day is largely the result of its consistent application as a breeding method.

Selection has as its objective the identification and propagation of those superior individuals which are believed to be capable of reproducing their good qualities in their offspring. The major emphasis must be placed on the word "identification". It is in this word that are embodied the essential differences in the methods of application of selection to livestock breeding. Three methods can be used for the identification of superior animals; by the individual merit of the animal, by the evaluation of its pedigree and finally by the evaluation of its offspring.

While the history of animal breeding shows that all three methods of identification of superior animals have been used, the emphasis placed upon them at different times has varied. The word "prepotent", used by breeders long before the advent of the science of genetics is an indication of the recognition given to the progeny as a guide to the breeding value of the individual. But, prior to the discovery of the laws of inheritance, emphasis was largely placed on selection on individual merit and on pedigree rather than on the use of progeny testing.

Research of recent years into the fundamental basis of selection has emphasised with increasing force that for many characters of economic importance in livestock, selection on individual merit is sufficient only to maintain the existing standard of quality. It has further shown that the most accurate method of selection is based upon the evaluation of an unselected sample of the offspring of the individual animal and that this application of progeny testing in some form is an essential part of any breeding program designed for the improvement of livestock.

The principles involved in the progeny testing of sires have been widely discussed by many writers (Lush, 1943, Hagedoorn 1944). It is based on the fact that each offspring receives a sample of its parents genotype. When the evaluation takes into account a number of offspring of the same animal, opportunity is given for the deceiving effects of environment and non additive gene effects to be cancelled out. Consequently the fundamental genetic effect of progeny testing is that it makes selection more accurate and more effective. It does not change any genetic process.

While the principles underlying progeny testing are simple, its integration into sheep breeding practice presents more serious problems. Essentially, the application of progeny testing has been limited by the difficulties inherent in sheep breeding itself. Any attempt, therefore, to associate the principles of progeny testing with the practice of sheep breeding is hampered by the inadequacy of factual information on the problems of sheep breeding.

These problems may be briefly summarised as

- (1) The lack of or inapplicability of objective measures for many characters of economic significance.
- (2) Largely in consequence of this lack of objective systems of measurement, there is a paucity of knowledge on the inheritance of these characters.
- (3) The necessity for taking into consideration meat production as well as wool production.
- (4) The difficulty in defining "improvement" in quality of wool in particular, because of its wide range of types and uses and the marked, unpredictable changes in demand for these different types.
- (5) The wide range of environmental conditions under which stock of the same breed are expected to produce. This emphasises the necessity for considering breeding in relation to adaptability to various environmental conditions.
- (6) The lack of adequate study of the environmental factors affecting fleece and meat productivity.

It is against this formidable background of largely unsolved problems that the application of progeny testing in sheep must be considered.

REVIEW OF LITERATURE.

In recent years, an extensive literature has accumulated on the subject of progeny testing as a selection method, its application, accuracy and repeatability. Generally, however, it is found that most attention has been paid to it in connection with dairy cattle and poultry breeding while only limited study has been given to sheep and other domestic livestock. In this section, it is intended to summarise only those papers in which the approach to progeny testing is general in outlook and those which deal specifically with progeny testing in sheep.

That the general idea is not a new one is attested by comments made by Varro some 2,000 years ago on the advisability of determining a ram's quality by his get (as quoted by Lush 1943) while in 1826, Andre recommended progeny testing as a main reason for the keeping of stud books for sheep. Robert Bakewell (1726-95) whose renown as an animal breeder was recognised in his own time and still lives to-day, initiated sire testing by leasing his sires to other breeders and then bringing back into his own flock those which proved most satisfactory. Austen (1943) cites Randall writing in 1862 in his book "Fine Wool Husbandry" as stating that no one can proclaim confidently that he has a first class sire until it has been actually tested. "Unless found to produce highly excellent and highly uniform offspring, then the showiest and costliest ram should be promptly abandoned." Austen further quotes from an additional source "The Jondaryan Woolgrower" who wrote in 1868 that "One method of finding out as near as possible the inherited tendencies is to put ram lambs, selected for stud purposes, when six months old, to a few ewes (20 to each ram) similar to those with which they are intended".

Despite these exhortations, the paramount importance of progeny testing did not appear to be properly realised and breeding on the basis of external appearance and pedigree remained in favour. A renewal in the interest taken in progeny testing resulted largely from its successful application with dairy cattle in Denmark at the end of the last century. Its efficacy in producing improvement led to wide investigation and advocacy of the method in many countries and gave rise to the formulation of its theory to the proving of dairy bulls. Numerous indices to indicate the breeding value of the dairy sire have been proposed (Hansson, 1913, Goodale 1927, Edwards 1932, Yapp, 1925, Wright 1932 and later Rice 1944). The usefulness and



accuracy of these have been discussed by Lush (1944). Schemes based on the use of progeny testing have been developed on a national scale in most dairying countries.

The advances briefly mentioned above in the use of progeny testing in dairy cattle have not been paralleled by any similar advance in sheep breeding. From the literature, it appears that the first approach to progeny testing was made on the continent.

Zorn, Kruger and Hauer (1933) working with Hampshire sheep in Germany deprecate the high rate of culling required because the offspring were inferior to their parents. Because mutton production is most important, they considered live weight at four weeks of age and after correction used this as a measure for comparing sires on the basis of a comparison between dams and offspring. By this method they considered the best sires could be selected with greater accuracy.

Arapov (1934) discusses the results of using seven proven sires for artificial insemination in Russia. The lambs born of proven sires were of much higher quality than the average lambs of the same farm for the same year; and improvement over the previous year was of the order of 8 to 11%.

Lavydov (1934) shows the comparison of progeny of different sires in regard to live weight to be difficult. He suggests that the best method is to determine the value of  $k$ , or the intensity of weight development, from the formula  $y = A (1 - e^{-kt})$  (where  $t$  is the age and  $e$  the exponential factor.) for each lamb and to average these values. In this way he shows significant differences between three sires and shows one to be an outstanding improver.

Holomeizer (1935) in progeny testing for fleece characters found differences in most fleece qualities except that of fibre diameter and was able to classify the sires according to the amount of improvement which they brought about in the daughters in comparison with the dams. Kardymovic (1937) discusses a similar type of project on collective farms in the Levokum district in Russia. He considers that an index of overall quality is unsatisfactory because the breeder does not require a "universal" improver but rather a sire that will bring about improvement for specific characters. Three rams were detected on each farm that were superior and they were widely used by artificial insemination. Sannikov and

Sarygina (1939) in the same area also report on the progeny testing of Rambouillet rams for fleece quality and show wide differences between sires.

In Russia, a great deal of attention has been paid to birth weight and live weight in the evaluation of sire differences. Kardymovic and Viebe (1937) quote results of a study of the effect of multiple births and sex on birth weight and give corrections for these factors. They use them for correcting for these effects in progeny evaluation. Moiseev (1937) working with the Précoce breed found correlations of 0.6 - 0.8 between live weight at weaning and at one year. He thus advocates this early evaluation of sires and shows that the results at the two ages correspond. He further studies the effect of the use of rams at six months of age and found that they could be successfully used even for artificial insemination with no deleterious effect on subsequent growth. He thus demonstrates the possibility of the early proving of rams.

Glenbockii (1939) also discusses the effect of sex and twinning on birth weight and concludes that there is no need to correct for twinning provided the ewes are kept under the same conditions and the number of lambs is about 100. He gives correction factors for smaller numbers. Sannikov (1939) is also occupied with the relation between weanling and yearling characters and finds the relationships sufficiently high to be useful in evaluating the progeny of a sire at weaning age.

Attention has also been given to the progeny testing of Karakul sires. Langlet (1935) has devised a form for recording data of the entire progeny of a sire, the various items being evaluated on a scale of ten points. These values are related to those of the dam in order to show whether the sire is producing improvement. Panfilova (1939) gives results of progeny testing and states that the best ewes gave the best offspring. Later he makes the unqualified statement that the progeny testing of rams gives more reliable results if tested on groups of ewes of different quality. Pomanskii (1939) criticises the method of basing the progeny test solely on pelt quality at birth and shows the lamb pelt to be greatly affected by external conditions. He found



a good relationship between pelt quality of the lamb and constitution of the adult and hence stresses the importance of constitution.

Work on progeny testing with sheep in America has also advanced at a relatively slow rate. The survey of "superior germplasm" conducted by the United States Department of Agriculture and published in the 1936 Year Book of Agriculture contains the significant statement that only three of the twenty-four circularised experimental stations are reported as using progeny testing as part of their program. This survey lays stress on the necessity for more knowledge of the inheritance in sheep, adequate methods of measurement of productive characters and the use of systematic breeding methods to produce improvement.

Subsequent to this survey, however, considerable stress has been laid upon the investigation of progeny test methods and the problems involved therein. Phillips et al. (1940) summarise the difficulties in progeny testing sheep as being mainly due to lack of objective measures for production and the necessity for considering more than one form of production. Using body weight, fleece weight and fleece length as objective measures of production, they analyse sire and seasonal differences for Corriedales and Rambouillets. Their results indicate that differences are shown even though the sires were to some extent proved rams prior to use in the flock and they conclude that the chances of finding differences among untried rams should be very good. They finally give details of a simple method of application to usual stud breeding conditions.

Ensminger et al. (1943) discuss the application of progeny testing in small flocks - a problem of major import in the United States. Data on birth weight, weaning weight, slaughter grade and type score were analysed, and they outline a procedure for testing rams when flock numbers are small. They emphasise that the system does not guarantee a rapid rate of improvement, because the number of rams that can be tested at one time is obviously low.

In New Zealand, the advisability of progeny testing has been strongly advocated for the improvement of sheep productivity. McMahon (1940) discusses culling and shows that for those characters that are weakly inherited, it is virtually ineffective as a means of producing improvement in the next generation. He compares the rate of improvement attainable by this method

with that by the use of progeny testing and concludes that selection of rams on the basis of their progeny test would enable improvement corresponding to one pound in fleece weight to be obtained almost in one generation.

In the same year, the same writer (McMahon 1940 b) discusses problems of breeding for wool in relation to measurement of fleece characters. Emphasis is laid upon the use of the nucleus system of breeding (Hagedoorn 1939) whereby the best rams on progeny test and their near relatives form a nucleus or top flock. The remainder of the flock is then used as a testing flock for trying out sires for use in the nucleus.

McMahon (1943) reports analyses of sire differences in conjunction with a study of heritability of fleece and body characters. Highly significant differences are demonstrated between sire means, and calculations are made of the expected superiority of top sires and the number of offspring required for an adequate test. His results draw attention to an important problem - that of repeatability of progeny tests on the same sire. The correlations are not high and indicate individual progeny tests to be less reliable. The same writer (McMahon 1946) gives results of attempts to locate high producing strains of sheep. The fact that there was a close similarity in fleece productivity between strains is disappointing and emphasises again the necessity for progeny testing.

Wheeler (1945) has given a statement of the application of progeny testing in a commercial stud flock. He outlines methods of mating so that the sire of each lamb is known and in particular emphasises the standards used in evaluating the sire's worth. The offspring must show improvement on the standard of the dams, freedom from any bad fault and evenness throughout. It is necessary to consider all the progeny sired by the particular ram.

Kelley (1946) in discussing the progeny testing of fine wool sheep in Australia deplores the lack of knowledge on the inheritance in sheep. He considers that further knowledge is required on the following points:

- (1) Definition of component characters of the fleece and their associations.
- (2) The methods of inheritance controlling these characters.
- (3) Techniques for measuring characters of economic worth.

- (4) The degree of variability occurring among offspring by the same sire in order to fix the number of offspring required for an adequate progeny test.

He considers, however, that much can be done at the present time by appraisal and scoring of progeny of the rams used. He says, "If any sheep breeder carries the process suggested for progeny testing as far as having identifiable progeny groups, he will find much to interest him and many ways of comparing the groups."

Nichols (1945) quotes carcass grading for export as conducted in New Zealand and Australia as a bulk form of measurement suitable for progeny evaluation in lamb and mutton sires. Birth factors such as weight at birth, sex, birth rank, season of birth as discussed by Phillips et al. (1940) are also considered as important, for ordinarily there will not be sufficient lambs from each sire to include equal numbers for each of these factors. He further points out the necessity for estimates of early production, as indicators of later production.

Wide divergence of opinion is found among different writers with regard to the number of offspring required for testing a ram. Frölich (1933) claims that 150 lambs are required for evaluation of the genotype in the Karakul breed. Lush (1935) discusses the relative accuracy of the progeny test and the parents' own performance as measures of breeding value. His conclusion is that only under rare conditions will a progeny test on as few as four offspring be as accurate as a dam's own record (in dairy cattle.) McMahon (1940) considered that 7 lambs would be a sufficient test but later (McMahon 1943) he states that 15 progeny are sufficient to establish the superiority of a ram leaving fleeces 0.8 lbs. above the average, with odds of 19 to 1. Wheeler (1945) is of the opinion that 10 to 15 lambs is sufficient, while Ensminger et al. (1943) indicate that considerable information is gained for each additional offspring up to 8 or 10, while little extra is gained by going above 15. In general, the answer to this problem is supplied by a knowledge of the variability among offspring by the same sire which leads to its accurate formulation as given by McMahon (1943).

A most important aspect of progeny testing has recently been dealt with by Dickerson and Hazel (1944). They approach the subject from

the viewpoint of the average genetic improvement expected yearly from early selection alone as compared with that expected when use is made of the progeny test. They illustrate the important factor of the time required to obtain progeny tests by comparing selection for weanling and yearling traits in sheep. When heritability is low (.10) use of the best progeny tested ram is expected to increase progress about 11% for weanling traits and 3% for yearling traits. These values are increased to 22% and 37% respectively by testing as ram lambs and using an auxiliary testing flock. Their conclusions are that a regular plan of progeny testing is unlikely to increase and may reduce progress unless

- (1) the progeny test information becomes available early in the tested animal's lifetime.

- (2) the reproductive rate is low.

- (3) the basis for early selection is relatively inaccurate.

These conclusions do not conflict with the fact that unbiased progeny test information always increases the accuracy of selection for poorly inherited characters. Rather they mean that, in the time required to carry out the progeny test, the genetic progress from individual selection may be more than that obtained from selection on progeny test. The above conclusions virtually define the frame-work within which progeny testing is likely to be successful.



SECTION II.OBJECTS OF THE INVESTIGATION.

The review of work which has been reported on the application of progeny testing to sheep breeding in New Zealand indicates the necessity for controlled investigation into the various aspects of the problem. Broadly, therefore, the purpose of the project may be defined as an examination of problems associated with the development of a practical method of progeny testing in Romney Marsh sheep. In particular, the aspects which have received attention in this thesis are -

1. methods of measuring productive characters of sheep with particular reference to their accuracy, rapidity and their incorporation into breeding practice.
2. The amount of variation in productive characters which can be attributed to heredity.
3. The value of the lamb fleece and carcass characters in predicting those of the hogget.
4. Measurement of the degree of variation among offspring by the same ram in order to estimate the number of offspring required for a test of known accuracy.

In addition, other aspects have been included among the objects of the experiment, but detailed data will not be available till the next phase of the experiment is completed when it will be possible to consider the repeatability of progeny tests of the same ram on the same ewes in different seasons and other aspects of repeatability. Also, a considerable bulk of data will have accumulated which should allow of a study of correction factors for various environmental and non-genetic conditions.

Finally, close attention is being paid to the data and technique for indications of further problems which may be involved in the use of progeny testing.