A STUDY OF SOME ASPECTS OF THE GENETIC VARIATION AND COVARIATION OF FERTILITY IN A FLOCK OF NEW ZEALAND ROMNEY EWES

by

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I. INTRODUCTION

"Fertility" is a term generally used to denote the expression of reproductive performance. Any precise definition of "Fertility", however, must depend ultimately on the purpose for which it is intended and the criterion by which it is measured. For the present purpose "Fertility" may be regarded as the rate of reproduction which is measured by some form of a lambing percentage.

The economic importance of fertility in sheep production has not been, until recently, fully appreciated, but still less has its significance in the genetic improvement of sheep been realised.

Many breeds, in particular, the New Zealand Romney* are regarded as dual purpose sheep. They are expected to produce meat and wool. In a flock of sheep, gross financial returns depend on the total amount of meat and wool available for sale. This is a simple function of the production per sheep and the number of sheep. In a self-contained flock, the number of surplus sheep in a given financial year is determined almost solely by the lambing per cent of that year. Thus, it can not be denied that lambing per cent or fertility contributes substantially to the returns from sheep. At

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* The term "New Zealand Romney" is used here to indicate that they are grade sheep, the offspring of many generations of Romney Marsh rams.

same time other economic characters, such as fleece weight, and fleece style in sheep production, must not be neglected.

In order to apportion the importance of each character in terms of its contribution to the gross financial return of a flock, it is necessary to measure its relative economic value. The relative economic value of a character may be defined as the increase in gross financial return per unit change in the expression of the character. Rae (1954) reported the following relative economic values for the New Zealand Romney.

Table I. The Relative economic values of Fleece and Carcass Characters

Fleece weight	1 lb. more increases returns by	47d
Quality number	1 quality finer " " "	12½d
Style	1 grade better " " "	48d
Fertility	1 lamb more " " "	518d
Carcass weight	1 lb. more " " "	17d
Body weight	1 lb. more " " "	8d
Carcass grade	1 grade better " " "	21d
Body conformation	1 grade better " " "	7d

The outstanding feature of the above table is clearly the high relative economic value of fertility. In addition,

Rae (1954) presented the following table which shows the increased return per sheep as a result of one generation of selection, if all the selection potential were used on each of the characters singly.

Table II. Increased return per sheep as a result of one generation of Selection

Fleece weight	10d
Quality number	7d
Style	10d
Fertility	20d
Body weight	7d
Body Conformation	3d

Thus, from these two tables, the objectives of breeding for increased productivity in the New Zealand Romney have been outlined. Most important for present purposes is that increasing fertility leads to by far the greatest improvement in the financial returns of the Romney breed.

Most animal breeders consider selection or the existence of a differential rate of reproduction as the main, if not the only, force at their command for changing the genetic composition of their individual flocks or of a whole breed. Selection for one or several characters, however, depends on both the genetic variability of the population from which

selections are made and the proportion of available animals that are required for breeding purposes. Satisfactory reproductive performance or fertility, therefore, results in larger populations from which a given number of animals may be selected and leads to more rapid genetic improvement.

It is thus evident that high fertility *per se* is an important economic character in sheep but still more, owing to its genetic ramifications through selection, it provides a foundation on which the greater genetic improvement of other economic traits is made possible.

In view of these features of fertility, its place in a sheep breeding programme is undeniable. There are many selection methods which may either be used alone or in combination in a breeding programme. The choice of a particular selection method, however, depends largely on the heritability of the character concerned. In reality, often more than one character is under selection. Some knowledge of correlated responses, but in particular, possible genetic antagonisms between characters of economic importancce is necessary before the most effective breeding programme can be devised. This investigation is, therefore, mainly concerned with the statistical estimation of the genetic variation and covariation of fertility in a flock of New Zealand Romney ewes.

The following aspects will be considered in detail:

1. The effects of age and year on the incidence of barrenness, single births, and multiple births.

2. The estimation of repeatability of the number of lambs born.

3. The estimation of heritability of the number of lambs born.

4. The estimation of the phenotypic covariation between the number of lambs born and weaned and the greasy fleece weight of the ewe.

5. The estimation of the genetic covariation between the number of lambs born and weaned and greasy fleece weight.

6. Applications of the present findings will be discussed.

II. DEFINITION AND DISCUSSION OF TERMS TO BE USED

A. Fertility of the ewe

In popular usage fertility depicts the ability of an animal to produce large numbers of living young. The inability to produce any offspring at all is termed sterility. There are many criteria by which fertility is measured. Various measurements of fertility, however, may not be strictly comparable. Goot (1950) found that a difference of 30 per cent in lambing per cent could be due, simply to the different methods of measurement. It is obvious that the term "fertility" should not be used without adequate definition.

In general, fertility of the ewe may be measured at several different phases of the reproductive cycle. These measurements are usually made at stages where numerical expressions are possible, e.g. the number of Graafian follicles, the number of ova shed, fertilised and implanted, the number of foetuses surviving at different times during pregnancy, the number of lambs born at birth, at docking, weaning and finally reaching breeding age. Ideally, for studies of inheritance, measurements at breeding age are most useful. It is obvious that if all the young died before reaching breeding age, studies of inheritance, in particular the inheritance of fertility, are not possible. On most sheep

farms in New Zealand and the present flock is no exception, disposal of some or all wether lambs and surplus ewe lambs takes place either before or shortly after weaning. As a result, collection of data at first breeding age of the young is usually not feasible. Thus, data collected at weaning appear to be a necessary compromise between the ideal and current management practices.

On the other hand, in the present state of physiological knowledge, the number of lambs born* is the earliest visible and measurable expression of fertility in ewes. In addition, given that identical twins are infrequent in sheep (Johansson 1933, Johansson and Hansson 1943 and Barton 1949) the number of lambs born is, in effect, an estimate of the minimum number of ova shed by the ewe at her last ovulation. Since ovulation rates can not be measured without slaughtering the animal, the number of lambs born at birth is a useful substitute. Measurements taken subsequent to the one at birth are likely to be confounded by effects of weather, shepherding and other managemental practices, and thus are less suitable as a measure of fertility in the ewe.

While the number of lambs born and weaned are useful indices of fertility for individual ewes, on a flock basis, lambing per cent is the usually accepted measure. In the

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*Number of lambs born dead or alive but apparently carried to the full term of gestation.

present study, lambing per cent will be calculated as:

(a) the lambing per cent at birth

$$\frac{\text{The total number of lambs born} \times 100}{\text{The total number of ewes put to the ram}}$$

and (b) the lambing per cent at weaning

$$\frac{\text{The total number of lambs weaned} \times 100}{\text{The total number of ewes put to the ram}}$$

B. Fertility of the ram

In this study, effects due to the fertility of the ram will be assumed to be distributed at random. This assumption appears to be reasonable in the present data. As will be described later, a total of 27 rams has been used and they were mated to ewes chosen at random. Unless otherwise specified, fertility of the ram will be treated simply as a component of the environment to which the ewes are exposed.

C. Terms used in relation to the age of sheep

For the sake of clarity, the correspondence between age of sheep and the measurements of fertility and fleece weight will be described separately.

Lambing in this flock generally commences in August. Lambs are usually weaned in January when they are four to five months old. A two-tooth lambing record corresponds to the age of two years and the four-tooth, six-tooth and eight-tooth records are made respectively at three years, four years and

five years of age.

Hoggets are normally shorn in October when they are about 14 to 15 months old. Ewes are generally shorn in December, approximately a month before weaning. A two-tooth fleece weight represents approximately 14 to 15 months' wool growth. Thereafter, four-tooth, six-tooth and eight-tooth fleece weights are collected at yearly intervals.