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# SOME ASPECTS OF PROGENY TESTING IN SHEEP

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## Introduction:

**S**ELECTION has as its objective the identification and propagation of those superior animals which are believed to be capable of reproducing their good qualities in their offspring. The major emphasis must be placed on the word "identification," for it is in this word that are embodied the essential differences in the methods of application of selection to livestock breeding. Various methods can be used for the identification of the superior animals of which the main ones are: by considering the individual merit of the animal, by the evaluation of its pedigree and by the evaluation of its offspring. While the history of animal breeding shows that all three methods of identification of superior stock have been used, the emphasis placed upon them at different times has varied. However, 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 or individual merit is sufficient only to maintain the existing standard of quality. It has shown further that the most accurate method of selection is based on the evaluation of an unselected sample of the offspring of the individual animal.

While the principles underlying progeny testing are simple, its integration into the practice of sheep breeding presents more serious problems. Problems involved in progeny testing of sheep are, in part, problems of the wider field of sheep breeding and their interrelation necessitates a simultaneous discussion of both, for it is within the framework of the breeding industry itself that progeny testing must be applied. Its claimed ability to produce improvement in other forms of livestock must be reviewed in the light of the inherent limitations to progress in the betterment of sheep stock.

The data here presented have been derived from a special experimental flock of 450 ewes which has been set aside for the study of progeny testing at Massey Agricultural College.

## Subjective Gradings:

It has long been recognised that variations between different animals give scope for improvement in livestock. It is, therefore, manifestly necessary that adequate means be available for the detection of these variations. Moreover increase in objectivity and precision of methods of recording these differences will, as Nichols (1945) has stressed, considerably simplify the task of improvement. Though many contributions have been made to the science of objective measurement of wool characters, the only features which can be measured by methods which have the prerequisite of being generally applicable to stud practice are greasy fleece weight, staple length and hairiness as measured by the medullometer. Hence in the evaluation of fleece quality, it is necessary to resort to subjective evaluation by eye and hand.

To the difficulties in fleece analysis is added the complication of studying the productivity of the animal from the point of view of meat production. Apart from records of weight and growth rate, the conformation of the animal must again be described subjectively unless some system of slaughtering a proportion of the offspring for carcase evaluation is adopted.

Estimates of the accuracy of the more important of these subjective evaluations derived from repeat trials are quoted.

Character	Error of Judgement (plus or minus)	Consistency
Count	.62 (Count intervals)	.80
Fleece Quality (14 grades)	.64 grade	.64
Body grading (14 grades)	.74 grade	.81

The Error of Judgement is a standard deviation derived from the analysis and can be interpreted as the limit of the deviation from the correct estimate which the judges would not exceed more than once in three times. Only once in twenty times would the judges exceed the limit of deviation set by twice this figure. It can be seen that in all these gradings, the estimate is seldom in error by more than half a grade and they are thus remarkably consistent. These results indicate that in the absence of more objective measures, the subjective methods of evaluation can be usefully employed in sheep recording and experimentation. As carcase quality can only be truly judged on the hooks, it is of interest to note that a correlation of .70 was found between the body grading on the hoof and the Export Carcase grade as judged on the same animal after immediate slaughter.

#### Heritability Estimates:

The polygenic nature of the inheritance of productive characters in sheep makes impossible an analysis of the number and kind of genetic factors at work. The analysis of the observed variation into its genetic and environmental components is the necessary compromise. Using dam-offspring correlations, paternal half sib correlations and intrasire regressions of offspring on dam, the following results have been obtained:—

#### INTENSITY OF INHERITANCE OF FLEECE CHARACTERS

Fleece weight	.10	— .15
Staple length		.21
Hairiness	.50	— .70
Count		.41
Fleece quality		.14
Handle		.44
Lustre		.27
Colour		—
Character: Forequarter		.20
Character: Hindquarter		.38
Character: Side		.27
Back wool		—

#### INTENSITY OF INHERITANCE OF BODY CHARACTERS

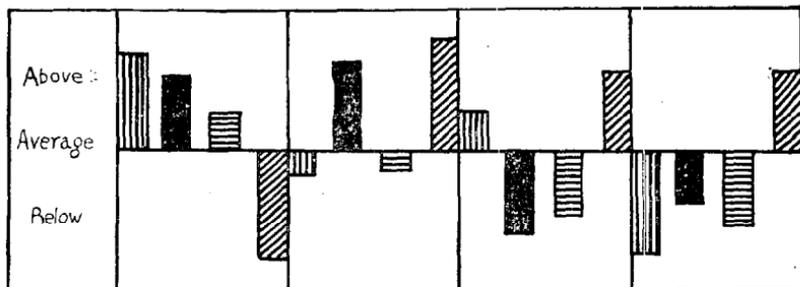
Body as a whole	.12
Head	.40
Breed type	.41
Length of leg	.80
Bone quality	.58
Shoulders	.20
Back	.17
Loin	.11
Hindquarters	—

These results are substantially in agreement with those of McMahon (1943) but are at variance with his figures in placing higher heritability values on hairiness and Breed Type Grading.

Within the limits of similar environmental conditions, these figures give a basis for advocating the type of breeding programme that will best bring about improvement. They allow of a division of the features into two groups on the basis of their intensity of inheritance. Thus Head Type, Length of Leg, Breed Type, Bone Quality, Count, Handle, Hairiness, etc., may be classed as strongly inherited while Fleece Weight, Fleece Quality and Body Grading are weakly inherited. It has been emphasised by many writers that selection on phenotype will bring about improvement most rapidly in strongly inherited characters while the progeny test is necessary for improvement of weakly inherited characters. These estimates of heritability are consequently of considerable importance in elucidating the problem of deciding what features of production need be considered in progeny testing. On this basis, then, it may be said that the essential characters to consider in a progeny test are Fleece Weight, Fleece Quality and Carcase Quality. Nevertheless, it must be stressed that the heritability estimates represent only one aspect of the problem of deciding what to progeny test for. The first step is to define the objectives which are to be aimed at in breed improvement—a factor on which we have only broad generalisations and few exact facts. There is little information, for instance, on the relative economic importance of fleece and carcase characters in sheep, nor have adequate studies been made of the interrelationships of fleece and carcase characters, all of which are necessary facts, for defining realistically the objectives of sheep improvement.

#### Sire Differences:

The analysis of variance technique has been used for determining the significance of sire differences for a large number of fleece and conformation gradings and carcase measurements. The means of sire groups graphed in relation to the mean of all progeny are shown in Figure I for the characters, Fleece Weight, Fleece Quality, Body Grading, and Breed Type.



This figure illustrates an important but well known feature in breeding work. It emphasises that the best ram for a certain character is not necessarily the best for other characters. The necessity of considering a number of features in a breeding programme to ensure maximum economic gain, limits the rate of improvement for any one feature. This points to the necessity for investigation of the relative economic importance of the fleece and carcase characters in sheep to determine those characters which are of most importance and should be given the greatest consideration. It also brings into prominence the need for construction of selection indices to utilise the information obtained by progeny testing in the most efficient way. Hazel (1943) and Panse (1946) have indicated the theoretical requirements for and the mode of construction of selection indices, but in the absence of information on the importance and interrelationships of characters, equal weighting for each character appears best.

The above argument is based on the desirability of using a sire that is an "improver" in every character. This naturally may not be required by the breeder. He may be concentrating on improvement of one particular character, and then the best sire for his purpose will be the one which is outstanding in improving that one particular character with the added proviso that it maintains the standard in other characters. This provides a strong reason against the use of a sire index based on the totality of the characters of the offspring and indicates the graphical method of showing the sire's value for each character considered as being the better method.

### **The Application of Progeny Testing:**

While most of the experimental work on which the foregoing data has been based involves a system of progeny test which is complicated both in its technique and the intricacy of the statistical procedures, this experimental approach leads to the possibility of framing a practical method which can be applied in commercial stud practice.

It should be noted, too, that because most sheep studs are relatively large in numbers it is possible to test a number of rams in any one year and to raise their offspring under similar environmental conditions. This tends to eliminate any environmentally induced correlation such as that which may occur in dairy cattle breeding where there is a tendency for the progeny of one bull to be raised under one set of conditions while those of another bull are raised under somewhat different conditions. However, the practical use of progeny testing raises some important problems.

The number of offspring required to test a sire is a necessary piece of information in progeny testing. If too many offspring are required to prove a sire, the rate of progress may be reduced by limiting the number of sires which can be tested (Lush, 1943). Hence, in order to test the maximum number of sires, it is necessary to know the minimum number of offspring required without sacrificing the accuracy of the progeny test. Considerable differences of opinion are found among writers on this aspect of progeny testing but in general, the answer is supplied by a knowledge of the variability among the offspring which leads to its accurate formulation as given by McMahon (1943). Results from the present data confirm those given by McMahon (1943) in showing that little information is added for each extra offspring beyond 14-15 and it appears that this number is sufficient to give a progeny test of adequate accuracy in breeding of Romney Marsh sheep.

A second problem that merits attention is that of the assessment of the progeny groups. In breeding practice, the first careful analysis of fleece and carcass characters is usually made at the hogget stage. This practice suffers from some disadvantages from the point of view of progeny testing and improvement. Firstly, no records are taken on animals which are culled at weaning or which die prior to description as hoggets, and as a result, no cognisance can be taken of them in any progeny testing programme. Secondly, and more important, the evaluation of the progeny of a ram is delayed for a further eight to ten months after the lamb stage. As Dickerson and Hazel (1944) have stressed, the annual genetic progress expected from progeny testing is considerably influenced by the age of the ram when the progeny test information can be obtained, so that leaving the appraisal of the progeny till hogget age has a definite effect on increasing the generation interval and decreasing expected yearly gain. Moreover, evaluation on the basis of the lamb characteristics enables the sire to be tested prior to the next tupping season and thus eliminates the necessity of either using the sire lightly during the subsequent year because its merit is unknown, or having to use him widely merely on the basis of speculation as to his probable value.

At the same time, the effectiveness of selection based on evaluation at the lamb stage over that based on the hogget is dependent largely on the relationship existing between the characteristics of the animal at the two ages. For this reason, a correlation analysis was done to determine the relationship between lamb and hogget characteristics. With fleece characters it was found that all the correlation coefficients were significant but were not high enough to be reliable for prediction purposes. A similar situation was shown with the carcass characters though in this case Head Grading and Length of Leg seemed sufficiently highly correlated to be useful for purposes of prediction. The general conclusion drawn from this study was that the reliability of early appraisal on lamb characters is not high especially when a few top animals have to be selected from a large number of possible candidates. Hence it seems necessary to still regard the hogget age as the earliest reliable time for carcass and fleece analysis.

A further obvious fact in progeny testing is that not all rams can be tested. As Goot (1946b) has shown, the testing of 20% of rams as suggested by McMahon (1940) is impracticable if more than about 7 progeny are required, because of the number of ewes which need to be mated. From his results it is suggested that about 4.6% of the yearly crop of lambs could be progeny tested if an average of 15 progeny is required. Hence some selection must be made of those animals which are to be used as candidates for the progeny testing scheme. It is further obvious that this selection must be based on individual merit with perhaps some attention to pedigree. The method suggested in recent years has been to select these rams for progeny testing on the basis of their quality for highly heritable characters, for it is in these characters that the phenotype most accurately reflects the genotype of the animal. These rams can then be progeny tested on the basis of their weakly heritable characters.

Bearing these facts in mind, it can then be suggested that the essential features of any scheme of progeny testing are:—

1. The individual identification of the ewe flock and of lambs at birth.
2. Accurate knowledge of the sire of each offspring.
3. Accurate collection of data and records.

In general, these do not introduce any new factor into stud practice. The practical difficulties in the second requirement have been reviewed by Wheeler (1945) and suggestions submitted for overcoming them.

#### **The Effect of Using a Progeny Test on the Generation Interval.**

In a theoretical examination of the effectiveness of selection, Dickerson and Hazel (1944) have brought into prominence the fact that the use of progeny testing results in an increase in the interval between generations, an aspect which must be taken into account in comparing the relative merits of selection on individual merit and progeny testing. It is proposed in this section to review their results and the effect of progeny testing on the generation interval in so far as the limited information concerning stud flocks in New Zealand will allow.

There are two factors which determine annual improvement from selection in any closed population. They are:—

1. The average genetic superiority of those animals which are selected to be parents over the group from which they were chosen and

2. The average age of the parents when their offspring are born or the generation interval. The average yearly improvement is thus the ratio of the first factor to the second. While not disputing the accuracy of the progeny test, Dickerson and Hazel (1944) point out that the average annual progress expected by its use is greatly influenced by the length of time which is taken in order to obtain the progeny test information i.e. it increases the average age of the sire when its offspring are born. The longer interval between generations which results may more than offset the advantage of the more accurate selection obtained by its use and thus decrease annual genetic improvement.

As examples of the application of this method to sheep they consider the yearly genetic progress for weanling traits (those which can be evaluated at weaning) and yearling traits (those which can only be evaluated satisfactorily at the hogget stage) in a flock of 100 ewes using different progeny testing plans as compared with progress achieved by using the two best two-tooth rams selected on individual merit.

The plans used are:—

- (a) Using the best tested ram from the previous year on 60-70% of the ewes. Rams first used as two-tooths.
- (b) Using an auxiliary flock of 100 ewes to test 7 two-tooth rams and using the two best ones on the basis of this progeny test in the main flock as four-tooths or older.
- (c) Testing the best 4 ram lambs on 40 ewes and the remaining 60 mated to the best two-tooth ram from the previous year.
- (d) Using an auxiliary flock of 100 ewes to test 7 ram lambs and using the best two of these the following year as two-tooths in the main flock.

The results are shown in the table as the percentage increase in annual genetic progress over that attained by selecting the two best two-tooth rams each year.

Plan	Heritability	Weanling Traits	Yearling Traits.
A	.30	4%	Reduces imp.
	.10	11%	3%
B	.30	6%	Reduces imp.
	.10	20%	5%
C	.30	20%	—
	.10	28%	—
D	.30	22%	—
	.10	37%	—

The differences shown between weanling and yearling traits occurs simply because selection on progeny test can be made a year earlier for weanling than for yearling traits. In the case of selection on individual merit in plans A and B, the generation interval is kept constant at two years while, the use of progeny testing increases the average age of the sires saved in the second culling when their subsequent offspring are born, to 3 years in the case of weanling characters and 4 years with yearling traits.

As it can be seen that under plans A and B the maximum increased progress due to progeny testing is not great, it is thus of interest to see to what extent the generation interval affects selection in the typical sheep stud of this country. To this end some data quoted by Goot (1946a) have been used for the purpose of comparing the generation intervals in Romney Marsh studs. Table IV of the above paper gives the average percentage age composition of rams used for breeding in two studs A and X and in all Romney Marsh stud flocks which were static in numbers for three years prior to the investigation. These are reproduced below.

Age of Rams. (at birth of lambs).	Stud A.	Stud X	Studs Static in Numbers
1 year	2.0	20.8	2.0
2 year	37.0	48.1	27.8
3 year	24.0	17.9	24.5
4 year	14.0	10.4	19.6
5 year	10.0	2.8	12.5
6 year	9.0	—	8.5
7 year	4.0	—	3.0
8 year and over	—	—	2.1
Generation Interval.	3.41 years	2.50 years	3.65 years.

Because in the above cases figures for the number of offspring docked or weaned per ram are not available, it is necessary to make an approximation to this by using the number of ewes put to each sire of each age as given also by Goot (1946a). This involves the assumption of a 100% of lambs weaned for each age group. On this basis approximate intervals between generations for the rams were calculated and were given in the last line of the table.

It seems to me that the following tentative conclusions may be drawn from the above results.

1. The figures for Romney studs static in numbers are based on approximately one-fifth to one-seventh of total Romney stud ewes and rams and may reasonably be taken as an outline of the actual operation of selection in the typical Romney Marsh stud. If this be the case, the trend of age composition of rams indicates, as Goot (1946a) has stressed, that once a ram is chosen as a stud sire it is apt to be used, barring death, sterility etc. till it is culled for age or fear of in-breeding. After a ram has entered the flock, little or no culling is done on the basis of productive characters. Hence the practice of selection on individual merit as it apparently does take place in Romney Marsh studs is very much less efficient than that visualised by Dickerson and Hazel (1944) because the generation interval is markedly increased (by 82.5%) while the selection differential (and hence genetic improvement per generation) is only slightly increased by having to select fewer rams (about 12%).

2. Studs A and X are notable in that, in both, the breeding policy has been based on progeny testing though comparison of the figures for age composition of the rams show that different methods have been adopted. In Stud X a high proportion are put to the test as hoggets while in stud A, the initial use of the ram is delayed, till it is a two-tooth. Further, in Stud X only 3% of rams are used as full mouth allowing a higher proportion of young rams to be used and tested and thus reducing the generation interval very markedly. Hence, in comparison with the operation of selection on individual merit as shown in (1) above, this method not only reduces the generation interval considerably though decreasing the selection differential slightly, but also increases the accuracy of selection by the use of progeny testing.

3. It must be stressed that these conclusions in no way conflict with those of Dickerson and Hazel (1944). Rather, it has been shown that progeny testing can be more efficient in producing improvement than the method of selection on individual merit as it is apparently operated in stud breeding. It is not implied that it is necessarily more efficient than the method of early selection in which the best 4% of young rams are used as two-tooths and thereafter discarded, thus achieving a rapid rotation of the generations.

## Summary and Conclusions.

No pretence has been made in this paper toward adequately covering all the problems involved in progeny testing in sheep. No attention has been given to the knotty problem of the repeatability of progeny tests of the same ram in different seasons or the oft quoted difficulty that outstanding improvers seem to be few and far between. It may well be that the answer to these problems lies in the adoption of a system whereby the proportion of the flock mated to the tested sire is varied according to its superiority as shown by progeny test.

Moreover, undue emphasis may have been placed on the part played by the generation interval in breeding though this time factor has largely been neglected in discussions of progeny testing. At least, the discussion of this aspect has put the progeny test in a reasonably favourable light as compared with selection as practised in stud breeding. At the same time it is probable that attention to the development of correction factors for known environmental effects and fuller use of pedigree in an attempt to increase the accuracy of early selection, may be the most profitable approach.

Finally, the conclusion cannot be escaped that progeny testing is not the panacea of all the ills besetting the sheep breeder. The undue optimism as to the startling improvements which it would produce that characterised the earlier thinking about progeny testing must certainly now give place to a more sober and considered attitude.

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# Discussion on Mr. McLean's and Mr. Rae's Papers

Dr. McMEEKAN: I would like to congratulate both speakers on their very fine papers, and in particular to thank them for the very great comfort they have brought to me. I had been under the impression that, alone amongst the research institutes, we at Ruakura had failed to produce any positive results from progeny testing and it is nice to know that Massey and Lincoln are finding comparable difficulties. Insofar as Mr. McLean's work is concerned the position is really very disturbing when it is considered with the work of Miss Walker at Ruakura where she has shown fairly conclusively that a similar situation exists in fat lamb production insofar as ewe selection is concerned. If a very high degree of selection for good or bad conformation ewes as mothers of fat lambs is employed, practically no commercial differences are produced in the progeny. The farmers present can at least go back to their farms, I suggest, and buy the cheapest ewe on the market and the cheapest Southdown ram on the market with every confidence, knowing they will produce just as fat lambs as a man who pays a lot for his sire.

Mr. MITCHELL: As a fat lamb breeder I was very interested in Mr. McLean's paper. Could he tell me whether there was any difference in the grading of the progeny of the high and low grade sires?

Mr. McLEAN: No, there was no difference. Actually there were only 15 lambs out of about 800 in the past two years that were graded lower than "Prime Canterbury" and these were not necessarily from the low grade sires.

Mr. MORICE: Is it true that a reasonably good type of Southdown ram will definitely give the same result as a fat lamb sire as a ram of considerably greater price? Can Mr. McLean give his assurance that we definitely are wasting money paying higher prices for Southdown rams for fat lamb breeding purposes?

Mr. McLEAN: I think that is quite true. As an illustration I can mention the demonstration that we had towards the end of the second year's work. At one of the College field days we drafted the lambs up merely for our own purpose, to see if there were any differences. We divided up all the progeny into their sire groups and we had the sires there also. By that time of the year the rams which were virtually culls had improved in appearance and the good ones had gone back in appearance so the difference was not so apparent as when we first bought them. However, we commenced the trial with those differences. One particular Southdown breeder picked out the progeny of one of the cull rams as being the best pen of lambs. It would appear that the great difference seen in the quality of rams as presented at a fair is very largely due to the amount of condition they are carrying and the skill with which they are prepared for sale. I think the explanation is that, provided a ram is a Southdown it does not greatly matter what it looks like.

Mr. LOGAN: I would like to ask Mr. Rae whether he has any figures showing the relation between hogget and later fleeces.

Mr. RAE: I have not analysed anything beyond the hogget stage. The relationship between the lamb and hogget characteristics is generally fairly low, as one would expect, because the correlation between production in two successive seasons is a rough method of determining the heritability and therefore where the heritability is low it is to be expected that the repeatability also will be fairly low. It is quite probable that the correlation between the hogget and later fleeces will not be high.

Mr. SHORT: I would like to ask Mr. Rae whether he has considered the difficulties in handling data derived from only 15 progeny from one ram. Animals vary in type of birth and sex—there are singles, twins, males and females. Dividing 15 into those four classes gives very small groups and I would suggest before stating definitely that 15 is sufficient it would be wiser to concentrate on fewer rams and obtain larger numbers of progeny and so build up a basic body of information on type and sex differences which we must have before we can work on smaller numbers with any degree of certainty.

Mr. RAE: I quite agree that with only 15 progeny the difficulties of type or birth and sex do become very important. The answer to that problem lies in the development of correction factors for sex and type of birth. I would like to point out, however, that most of the experimental work on progeny testing is based on a much larger number than 15 and as data accumulates, the building up a sufficient body of data to determine those correction factors, is possible.

Dr. DRY: What would happen if one were to buy up the worst Southdown rams and the worst Southdown ewes and mate them? Would you have just as good a flock as anyone else? Has he any information of the heritability within the Southdown flocks? What differences are there between the good and the bad?

Mr. McLEAN: We have no information at all with regard to the heritability of the various features within a Southdown stud. The trial is based on the premise that if those differences do exist between studs or within studs and if we use as a measure of the economic importance of those characters, the ability of such rams to leave such characters in cross-bred progeny then those differences would be apparent. There are small differences but they cannot be seen, by looking at the progeny and I am sure that most farmers would expect to be able to see some differences. They are very difficult to measure but if we want to improve the fat lamb quality of Southdowns it is these small differences that we must seek out and use for improvement. Whether by using rams which show superiority in cross-bred progeny by mating them to Southdowns, one would get an improvement in the purebred Southdown's progeny is perhaps another matter—that is the next step after having found heritable differences.

Mr. HANCOCK: I think the last point made is a very important one. Listening to Mr. McLean one might think that one cannot get improvement by progeny testing or by phenotypic selection and that would be a very sorry situation and not one that you can logically entertain because there have been improvements made in various breeds especially Southdowns. In the breeding of Southdowns I think they provide a very special problem and I do not think on theoretical grounds that the breed can be improved by trying to pick rams for the next generation from the cross-bred offspring because the high milking ability of the dam used will cover up all the differences that may exist. I think the fat lamb breeding quality of Southdowns might be a very difficult one because the fattening quality and milking ability are two characteristics that may be incompatible in an animal. To measure the quality of the Southdowns one must use straight breeding. One should not pick the best ones—those that grow fastest—because they may come from the mothers with the best milking ability and they may be the worst from the point of view of fat lamb quality. The same applies to pigs. Farmers found it very difficult to select both for pre-weaning growth and fattening ability after weaning. Those two things seem to be opposite and that is why, in pig breeding, very much better results are obtained by cross-breeding than by pure breeding. I think the main idea was to see whether phenotypically selected animals would show any difference.

Mr. McLEAN: That was one of the ideas only. If you wish to criticise the validity of the results on the basis of possible heterotic effects as a consequence of cross-breeding I am quite prepared to admit that possibility but not the covering up effect of the dam's milking ability which by the design of the trial is presumed to be random but one cannot get away from the point that if the Southdown is bred for one purpose—to produce fat lambs by cross-breeding—its value as a breeding animal should be assessed on whether or not it is good or bad for that purpose. It is perfectly obvious—that improvement has occurred in the Southdown breed by phenotypic selection. For purposes of fat lamb production, all Southdowns are very good and it becomes therefore increasingly difficult to find differences which can be used for further improvement, and this seems to be the way to identify these differences.

Miss McFARLANE: Have the lambing losses with the poor and good classes been considered at all?

Mr. McLEAN: There were no differences with regard to the fertility levels of the high and the low grade sires or in the mortality rates of their progeny in early life.

Mr. OMUNDSEN: What do you mean by "cull"? Do you mean as regards condition or a cull as regards true Southdown type?

Mr. McLEAN: By "cull" I mean the kind of rams that you would throw out from your flock as unsuitable for presentation at a fair because they did not conform to what is generally accepted as representative of the breed.

Mr. OMUNDSEN: Well then it was not just on condition?

Mr. McLEAN: Not necessarily, but it might have been. In actual fact, the appearance of a Southdown depends so much on whether it is in high or low condition.

Mr. OMUNDSEN: Were they leggy?

Mr. McLEAN: Yes. They look leggy when they are thin.

Mr. ROACH: Mr. McLean mentioned that the rams after they have been held for a year were almost exactly the same in appearance and that suggests that the difference between them is dietetic. Would he not tend to exaggerate any differences there are if he held his rams on the place a year before using them at all so that any differences which were there genetically and not merely dietetically became apparent before the experiment started?

Mr. McLEAN: That is true—the poor rams looked a little better and the good ones a little worse than when purchased, showing clearly that the initial differences in appearance were largely environmental; but it is on such differences that price variation depends and the price is a general measure of the farmers assessment of quality. One of the purposes of the trial was to test, by progeny testing, the efficiency of this method of selection based on appearance.

Mr. PHILLIPS: I would like to ask Mr. McLean a question concerning the selection of the rams. If we assume that rams are likely to breed to the average of the flock from which they come, were the rams used in this work typical of the flocks from which they came or were the flocks as a whole, judged by general Southdown standards, much the same and from one flock you had the best that they were offering and from the other the worst?

Mr. McLEAN: The aim in selection of the sires was to obtain a small sample from each breeder which would be representative of the average quality of the stock he presented for sale in that year.

Mr. MITCHELL: I would like to ask Mr. McLean if there were any difference in the lamb-getting ability, particularly in the first year between the poor quality rams and the higher grades?

Mr. McLEAN: No—except that in the second year one low grade ram proved totally sterile.

Mr. PATON: What does the finding leave the stud breeder to aim for?

Mr. McLEAN: We are trying to find more accurate and more certain ways of selection for the stud breeder. I do not think we have found them yet so we have little to offer at the present time, but when all the data are analysed, I think there will be something constructive to offer.

PROFESSOR CAMPBELL: The first speaker's paper seems to me to indicate that the main difficulty is, for the ordinary commercial man at the moment, that the means at his disposal for picking rams, do not provide him with an opportunity to grade the rams in such a manner that he will get any significant difference in the quality of their offspring. Can either of the speakers give any hope to the commercial man of the means of selection being improved so that he can pick out rams that will give him significantly better results?

Mr. McLEAN: As far as the selection of Southdowns for fat lamb production is concerned I cannot see any way in which he can do it. If one considers the breeding system used by many Southdown breeders in our district one finds that there are transfers at the stud fair of sires from one stud to another, depending a little on the popularity of the particular breeder at the time so that we have what is, in effect, a common inter-breeding population of Southdowns in the district and it would be therefore unreasonable to expect to find major differences between flocks. No flock, or very few flocks, have been "closed" for sufficiently long to have developed a type which is characteristic of the breeder. Within flocks, probably greater differences exist.

Mr. WARD: There is a great deal of confusion of thought to my mind, as to the value of studying selection on phenotype in one generation, as both speakers have done, and the question of the total inheritance value of the character studied. Referring to Mr. Rae's paper where he has studied the intensity of inheritance of fleece characters, and he suggests that that can be measured by means of regressions of daughter on dam. I want to suggest that that does not measure intensity of inheritance. It measures the advantage of selection over one generation only and I illustrate my point by indicating that the F.I. generation resulting from the mating between red Hereford cattle and black polled Angus would leave offspring all black in coat colour. On breeding from the F.I. generation one gets one quarter of the offspring with red coat colour. Here a single generation study of the intensity of inheritance would give spurious results. Mr. McLean mentioned the question of the closing of the flock over a number of generations in order to bring out breeding differences. I think there is a fundamental issue at stake, in this particular point, in that we are concentrating attention on one generation differences whereas a breeder must attempt to measure the value of breeding over many more generations than one. Hancock with his identical twins is tackling total inheritance problems on the dairy side but I doubt whether total intensity of inheritance can be measured by the daughter-dam single generation regression or inter-sire regression method.

Mr. RAE: In the first place I would point out that the use of the words "intensity of inheritance" is rather loose and tends to have come into common usage as a synonym of the word "heritability." This latter represents, in the main, the additive genetic variance or the part of the variance which is acted upon by selection. The effect of selection is to gradually narrow down the extent of the genetic variance. This process, however, is relatively slow, so that under a breeding system of straight selection with a character of low heritability, the genetic variance or the heritability value falls off only gradually from generation to generation.