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THE PRACTICAL APPLICATION OF SCIENTIFIC PRINCIPLES IN MERINO SHEEP BREEDING

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OPSOMMING: DIE PRAKTIESE TOEPASSING VAN WETENSKAPLIKE BEGINSELS IN MERINOSKAAPTELING

Die implikasies van die tradisionele telingsopset by Merinoskape word geskets. Dit word aangetoon dat dit nie aanvaar kan word dat materiaal uit stoetkuddes 'n hoër genetiese meriete het as diere uit graadkuddes nie. 'n Beskrywing van die wetenskaplike seleksie aktiwiteite van die Telersgenootskap vir Prestasiegetoetste Merinos (T.P.M.) word gegee asook aanvanklike resultate wat verkry is. 'n Uiteensetting van 'n kontrole nageslagstoets, soos ontwerp vir die T.P.M., vir die praktiese bepaling van teeltvordering asook vir die bepaling van genetiese verskille tussen kuddes, word gegee. Hierdie tegniek maak dit moontlik om diere uit verskillende kuddes direk te vergelyk ten opsigte van teelwaardes.

SUMMARY:

The implications of the tranditional breeding structure of Merino sheep is discussed. It is indicated that it is unacceptable that material from stud flocks have a greater genetic merit than animals from commercial flocks. A description of the scientific selection activities of the Breed Society for Performance Tested Merinos (B P M) and also the initial results obtained are given. A controlled progeny test, as designed for B P M for the practical determination of breeding progress as well as for the determination of genetic differences between flocks, is outlined. This technique makes it possible to compare animals from different flocks directly with regard to their breeding value.

A common object in the agricultural industry is to increase the efficiency of production, with the primary aim of increasing the nett income of the producer. The practical implementation of proven scientific principles and techniques are of basic importance in this respect. Genetics as breeding science, can play an important role in increasing the production of wool and mutton from woolled sheep (Pattie, 1964, Turner & Young 1969, Heydenrych, 1975).

As far as Merino breeding in South Africa is concerned, it is generally accepted that the breeding industry forms an approximate hierarchical structure with different breeding strata. In this structure the parent studs form the top stratum with the commercial flocks in the lowest stratum. In a set-up of this nature there is mainly a one way migration of breeding material from the top-stratum (parent studs) to the bottom strata (commercial flocks). As a result, the breeding progress of the whole industry is basically dependent on the genetic progress obtained in the parent studs (Robertson & Asker, 1951; Barker & Davey, 1960). If no breeding progress should be made in the parent studs the continental migration of breeding material will logically result in the equalization of breeding values throughout the different strata of the hierarchy. In this respect an investigation of dairy cattle in Great Britain brought to light that daughters of A.I. bulls, which were carefully selected according to pedigrees from the elite stud herds with regard to milk production, had an average advantage of only one gallon per lactation over the daughters of grade bulls which were normally used for natural mating in commercial herds. These comparisons were made within herds where A.I. calves were reared together with grade progeny. The conclusion was that the elite stud herds were actually not a reservoir of high quality genes. Consequently, the use of bulls from elite stud herds had an average neutral effect on this breed with regard to the increase of milk production (Robertson & Rendel, 1954; Robertson 1954).

The tempo of breeding progress which is made in the parent studs basically depends on the efficiency of the selection method used. In South Africa the Merinos in the studs are mainly evaluated subjectively for selection. The efficiency of the traditional subjective selection method of Merinos in South Africa was investigated by Roux (1961). The author gave 18 experts the opportunity to place only 20 sheep in order of merit for wool production. Thereafter they had to repeat the same procedure at intervals. The sheep were then shorn and the fleece mass determined. The two placings of each individual were correlated and the result showed that the experts were on the average only 55% consistent. Only 9 of the 18 correlations were statistically significant.

The subjective placings were also correlated to the actual order of merit as determined by the weighing of the fleeces. This average correlation was 0,37.

Against this background it can be expected that the efficiency of selection of woolled sheep can be increased appreciably by adopting objective measurements and selecting on measured performance.

Together with within flock selections, an exchange of breeding material between flocks can possibly make a contribution to the genetic progress in the industry as a whole. The exchange of breeding material between flocks will only be of value if there are genetic differences between flocks and the exchange is done on a planned basis. That genetic differences between Merino flocks exist is evident (Jackson & James, 1970). Such differences were also found in dairy cattle (Robertson & Rendel, 1954; Pirchner & Lush, 1959).

In practice, the efficient exploitation of genetic variation between flocks, by the planned exchange of breeding material, is impossible because of the hidden influence environmental variation has on the average performance of the flock. Consequently any current exchange taking place can only be done on a random basis and generally should have a neutral effect on the genetic composition of the Merino breeding industry.

Against this background, the Breed Society for Performance Tested Merinos (BPM) was founded on 2nd September 1972. The primary aims of members of this Society are to evaluate breeding animals scientifically by the application of performance measurements together with the subjective evaluation of immeasurable characteristics and to use these results in a logical and clearly defined selection system.

The procedure for collecting data is explained fully in the General Handbook of the Breed Society for Performance Tested Merinos (BPM) which is briefly as follows:

(i) The breeder makes a subjective evaluation of immeasureable characteristics and animals with cull faults are eliminated.

(ii) Wool samples are taken for analysis by the Fleece Testing Centre, Department Agricultural Technical Services, Middelburg, Cape Province.

(iii) Fleece and body masses are determined and a point score is made for skin fold development.

For the final selection, clean fleece mass, fibre diameter, body mass and skin fold score are combined into a selection index. The calculation of the weighting factors used for the computation of a selection index is explained by Poggenpoel & van der Merwe (1975). The weighting factors with the current market prices are approximately as follows: Clean fleece weight in kg (9), fibre diameter in micron (–1), body mass in kg (1) and total skinfold count (–1).

Discussion of results obtained

Results obtained by members of the Breed Society for Performance Tested Merinos are as follows:

A. *Test for efficiency of selection based on subjective evaluation*

The choice of stud rams was made subjectively by an individual active in the "breeding art". After this the whole group of unselected rams were evaluated objectively. The average values and the specific selection-differentials for the two methods of evaluation are given in Table 1.

Table 1

The average values with regard to clean fleece mass, body mass, fibre diameter and selection index for rams evaluated subjectively and objectively.

Group	n	Clean fleece mass (kg)	S.D. Clean fleece mass (kg)	Efficient clean fleece mass (kg)	Body weight (kg)	S.D. Body mass (kg)	Efficient body mass (%)	Fibre diameter (micron)	I
1	3	6,12	0,13	12,1	38,7	1,00	–12,6	22,00	71,78
2	5	6,04	0,05	4,6	40,1	0,4	0,05	23,65	70,81
3	5	7,06	1,07	–	47,6	7,9	–	24,20	86,94
4	65	5,99	–	–	39,7	–	–	23,19	70,42

1 = selected subjectively for stud breeding
2 = selected subjectively for flock breeding
3 = recommended on grounds of performance measurement
4 = unselected group
n = number per group
S.D. = Selection-differential of characteristics

Efficient = Efficiency of subjective selection in Group 1 and 2 – calculated as selection-differential of Group 1 and 2 as percentage of possible selection-differential obtainable with performance measurement in Group 3.

I = Selection index = 9 (clean fleece mass, kg) + 1 (body mass, kg) – (fibre diameter, µ)

B. *Merit tests*

Table 2

The average values for different characteristics of two-tooth progeny of stud-bred rams and own-bred rams in four flocks

Flock	Progeny group	n	Greasy fleece mass (kg)	Clean yield percentage (%)	Clean fleece mass (kg)	Fibre diameter (μ)	Body mass (kg)	Skin fold score	I
1	KO	98	3,56	68,3*	2,43	21,8	33,93*	7,9	26,1*
	SO	96	3,65	67,1	2,43	21,6	35,19	7,7	27,7
	KR	80	4,28	66,0	2,84	21,4	47,84	8,5	43,5
	SR	92	4,28	64,8	2,79	21,4	48,92	8,3	44,3
2	KO	78	3,19*	67,3	2,15	21,4	28,62	6,4	20,2
	SO	110	3,33	66,6	2,22	21,2	29,61	6,4	22,0
	KR	68	3,46	66,9	2,31	20,5	33,62*	6,1	27,8
	SR	81	3,46	65,6	2,27	20,7	35,33	5,9	29,2
3	KO	25	6,47	57,0	3,69	21,9	39,06	6,0	44,4
	SO	32	6,09	58,3	3,55	21,5	40,05	5,6	44,9
4	KO	148	5,58	–	–	–	33,43	5,3	56,1
	SO	61	5,76	–	–	–	–	5,3	56,2

n = Number per group
KO = ewe progeny of purchased stud-bred rams
SO = ewe progeny of own-bred rams
KR = Ram progeny of purchased stud-bred rams
SR = Ram progeny of own-bred rams
* = average of the two groups differ significantly at the 5% level
** = averages of the two groups differ significantly at the 1% level

In four flocks ewes were divided into two random groups of comparable age. The one group was mated to own-bred flock rams while the other group was mated to rams purchased from a stud flock. After mating all the ewes received identical treatment. At lambing the lambs of each of the two groups were identified and reared together. All progeny were evaluated objectively. The average values for the characteristics of the different groups are given in Table 2.

Noticeable in Table 2 is that in all the tests the progeny of the own-bred rams (although not significant in most cases) attained a higher average index value (or general excellence).

In none of these four flocks could the stud-bred rams improve the flock more than was the case with own-bred rams.

In these specific cases the respective studs are no longer a reservoir of high quality genes and these commercial flocks are, therefore, past the upgrading stage.

C. *Variations in flock averages*

Inter-flock variation in production characteristics is caused by genetic as well as environmental factors. It is, however, unknown what proportion of this vari-

Table 3

A number of flock averages for different production characteristics of rams measured in 1975

Flock	Clean fleece mass	Fibre diameter	Body mass
1	5,05	21,06	58,5
2	4,41	20,95	39,89
3	2,80	18,32	31,99
4	7,74	22,46	62,90
5	7,01	20,48	55,78
6	4,89	21,95	46,53
7	4,35	21,46	51,99
8	4,91	20,37	46,63
9	5,26	21,85	62,13
10	4,56	22,05	55,95
11	3,95	22,68	39,20
12	5,54	21,93	45,10
13	6,38	22,81	53,82
14	3,24	18,77	33,81
15	3,93	20,40	37,56
16	5,47	24,01	56,00
17	3,14	20,62	32,64
18	4,69	20,96	56,59

ation is heritable. As an indication of the variation found between flocks, Table 3 provides flock averages for clean fleece weight, body weight and fibre diameter. These performances were obtained for rams from a number of flocks performance tested in 1975, and running on natural veld grazing. The flocks are located in regions like the Transvaal, different areas in the Karoo, Bushmanland and the South Western Districts.

D. *Selection activity of the Breed Society for Performance Tested Merinos*

The number of two-tooth rams and ewes which were subjected to measurement by the Breed Society for Performance Tested Merinos, as well as the numbers and percentages selected are given in Table 4.

The average values for clean fleece mass, body mass and fibre diameter obtained for two-tooth rams from those flocks which were performance tested in each of the years 1973, 1974 & 1975 are given in Table 5.

In a number of cases, a degree of preliminary subjective selection was done on immeasurable characteristics. It is however, not expected that the relative average values were influenced by this to any degree.

E. *Genetic control flock and the control progeny test of the Breed Society for Performance Tested Merinos*

(a) *Genetic Change*

One of the most useful methods of determining genetic change in breeding flocks is the use of a genetic control flock. There is at present a genetic control flock of Merinos at Tygerhoek – an experimental farm of the Department of Agricultural Technical Services, in the South Western districts. The mating system in this flock is designed to keep the flock genetically stable and to avoid any possible inbreeding as far as possible. Heydenrych (1975) gives a full description of this flock which can be summarised as follows: The flock consists of 160 breeding ewes mated annually to 16 rams. The 16 ram replacements are randomly selected in such a manner that each ram is consistently represented by a son as sire. Rams are only used for one year. Each ewe is replaced by a second daughter to reach mating age. If one of the parents does not supply a replacement as a result of death, infertility or for any other reason, replacements are randomly selected from the progeny of the other parents. No parent is, however, allowed to contribute more than two members to the next generation. No individual having a conformation or serious wool fault is used as a parent.

Members of the Breed Society for Performance Tested Merinos make use of rams from this control flock to determine genetic progress in the different flocks. A group of 10 to 12 rams is selected at two-tooth on measured performance with regard to clean fleece mass, fibre diameter and body mass and selected in such a manner that the average values of this group do not deviate more than 1% from the average values of the unselected ram group. It is accepted that such a group is representative of the genetic merit of the genetic control flock.

These groups of control rams are then used for test matings in the different flocks. For this purpose the

Table 4

Rams and ewes subjected to selection since 1972/73

Year	Number of rams		Percentage selected	Number of ewes		Percentage selected
	Measured	Selected		Measured	Selected	
1972/73	672	130	19.3	2821	1989	80,5
1973/74	845	217	25,7	1787	1209	67,6
1974/75	1798	340	18.9	2906	1909	65,7
1975/76	1890	352	18.6	2685	1490	55,5

Table 5

Average for clean fleece mass, body mass and fibre diameter of rams for 1973, 1974 and 1975 in a number of flocks

Year	Clean fleece weight (kg)	Body weight (kg)	Fibre diameter (micron)
1973	4,16	39,39	19,46
1974	5,19	46,69	21,82
1975	4,99	45,72	20,92

Table 6

Control progeny test for flock 1 with regard to different production characteristics

	Number	Body mass (kg)	Greasy wool 12 mo. (kg)	Crimps per 25 mm	Skin folds front	Skin folds middle	Skin folds back	Staple length (mm)	Fibre diam. (μ)	Clean yield (%)	Clean wool 12 mo. (kg)	Selection index
Far. Prog.	88	47,40	8,910	8,990	3,94	2.475	3,57	96,255	22,395	73,610	6,535	3815,15
Cont. Prog.	113	47,50	8,455	9,495	4,02	2.440	3,45	98,465	22,695	75.435	6.365	3740.60
Difference	–	-0,10	0.455	-0,505	-0,16	0,035	0,12	-2,05	-0,30	1,825	0,17	74,55
Br. Val. dif.		-0,20	0,91	-1,01	-0,32	0,07	0,24	-4,10	-0,60	3,65	0,34	147,1
Exp. cont. ave.		47,60	8,00	10,00	4,26	2,405	3,33	100,45	22,995	77,26	6,195	3666.1
Br. val. dif. %		-0,42	11,38	-10,1	-7,51	2.91	7.21	4,08	-2,61	4,72	5.49	4,07

Far. prog. = Average of farm ram progeny
Cont. Prog. = Average of control ram progeny
Br. Val. dif. = difference in breeding value between the two ram groups (= 2 x difference)
Exp. cont. ave. = expected average of control flock on this farm
Br. val. dif. % = the difference in breeding value between the two ram groups expressed as a percentage of the expected production of the control flock

Table 7

Control progeny test for flock 2 with regard to different production characteristics

	Number	Body mass (kg)	Greasy wool 12 mo. (kg)	Crimps per 25 mm	Skin folds front	Skin folds middle	Skin folds back	Staple length (mm)	Fibre diam (μ)	Clean yield (%)	Clean wool 12 mo. (kg)	Selection index
Far. Prog.	163	30,360	4,425	10,410	2,650	2,345	2,405	67,56	18,995	69,81	3,080	1764,85
Cont. Prog.	118	30,585	4,180	11,055	2,315	2,165	2,195	68,28	18,660	70,74	2,945	1745,75
Difference		-0,225	0,245	-0,645	0,335	0,18	0,21	-0,72	0,335	-0,93	0,135	19,1
Br. Val. dif.		-0,45	0,49	-1,29	0,67	0,36	0,42	-1,44	0,67	-1,86	0,27	38,2
Exp. cont. ave.		30,81	3,935	11,70	1,98	1,985	1,985	69,00	18,325	71,67	2,81	1726,7
Br. val. dif. %		-1,46	12,45	-11,03	33,84	18,14	21,16	2,09	3,66	2,60	9,61	2,21

Far. Prog. = Average of farm ram progeny
Cont. Prog. = Average of control ram progeny
Br. Val. dif. = difference in breeding value between the two ram groups (= 2 x difference)
Exp. cont. ave. = expected average of control flock on this farm
Br. val. dif. % = the difference in breeding value between the two ram groups expressed as a percentage of the expected production of the control flock

Table 8

Control progeny test for flock 3 with regard to different production characteristics

	Number	Body mass (kg)	Greasy wool 12 mo (kg)	Crimps per 25 mm	Skin folds front	Skin folds middle	Skin folds back	Staple length (mm)	Fibre diam. (μ)	Clean yield (%)	Clean wool 12 mo. (kg)	Selection index
Far. Prog.	172	41.22	5,76	11,01	2,69	1,87	2,19	96,34	20,65	70,73	4,06	2641,4
Cont. Prog.	211	40,92	5,46	11,01	2,34	1,68	1,80	98,17	20,38	70,93	3,86	2566,9
Difference		0,30	0,30	0,0	0,35	0,19	0,39	−1,83	0,27	−0,20	0,20	74,5
Br. Val. dif.		0,60	0,60	0,0	0,70	0,38	0,78	−3,66	0,54	−0,40	0,40	149,0
Exp. cont. ave		40,62	5,16	11,01	1,99	1,49	1,41	100,00	20,11	71,13	3,66	2492,4
Br. val. dif. %		1,48	11,63	0,0	35,18	25,5	55,3	−3,66	2,69	−0,56	10,93	5,98

Far. prog. = Average of farm ram progeny
Cont. Prog. = Average of control ram progeny
Br. Val. dif. = difference in breeding value between the two ram groups (= 2 X difference)
Exp. cont. ave. = expected average of control flock on this farm
Br. val. dif. % = the difference in breeding value between the two ram groups expressed as a percentage of the expected production of the control flock

breeder's ewes are divided into two random groups comparable in age and identified. The control rams are mated to one group while the breeder's own rams are mated to the second group. After mating, all ewes receive identical treatment. The lambs are identified in each group and also receive identical treatment and are performance tested as two-tooth unselected groups.

The genetic merit of breeding value of a flock is then determined relative to the expected breeding value of the control flock on that specific farm. After a number of years this process is repeated in the same flock and the change in relative breeding value of the particular flock can be determined.

The method of determining the breeding value of a flock as a deviation from the control flock can shortly be explained as follows:

1. If one progeny group consists of two or more sub-groups (e.g. the control progeny consists of rams and ewes or single born and twins) the average for each characteristic of each sub-group is determined. Then the average of the whole progeny group is determined by taking the arithmetic mean of the two or more sub-groups averages (without weighting for numbers). E.G. control progeny average = $\frac{1}{2}$ (average of ram progeny + average of ewe progeny).
2. The difference is then calculated between the averages of the progeny of the farm bred rams (Far. prog.) and the progeny of the control flock rams (Cont. prog.). This difference is calculated as: Difference = Farm progeny − Control progeny.

   A positive difference, therefore, means that the farm progeny has a higher average than the control progeny and just the opposite for a negative difference.
3. The difference in breeding value (Br. val. dif.) between the two ram groups (farm and control) is calculated by multiplying the difference between the averages of the two progenies by two. Breeding value difference = 2 (farm progeny − control progeny). A positive difference in breeding value means that the farm rams have a higher breeding value than the control rams while the opposite holds true for a negative difference.
4. The expected average production of the pure control flock on the particular breeder's farm (Exp. Cont.) is calculated as the farm progeny average less the calculated difference in breeding value. Expected average of control = farm progeny − difference in breeding value.
5. The difference in breeding value between the two ram groups is now expressed as a percentage of the expected average production of the control flock on this particular farm, (Br. val. diff. %)

Difference in breeding value %

$$= \frac{\text{difference in breeding value}}{\text{expected aver. of control}} \times \frac{100}{1}$$

A positive figure of say 2% will, therefore, mean that the breeding value of the farm rams, for this characteristic is 2% above the breeding value of the control rams, and a figure of –2% will mean that the breeding value of the farm rams for this characteristic is 2% lower than the breeding value of the control rams.

At the present stage about 20 flocks have already done the first test mating. Of these, three control progeny tests have been fully completed and processed. The results of these are given in Tables 6, 7 and 8.

It is worth mentioning that the own-bred rams which were used in the progeny test were actually selected groups. It is the aim and also accepted that the selection intensity of own-bred rams in the different progeny tests is comparable. It is, therefore, not expected that the variation in selection intensity will be the cause of measured changes in breeding value of the flock.

(b) *Comparison of breeding systems*

The group breeding system which originated in New Zealand and Australia has also created interest in South Africa. Similar breeding groups for Merinos have been established in the Eastern Cape of which two are members of the Breed Society for Performance Tested Merinos.

The advantages of large numbers of breeding animals in these group breeding schemes for accelerated breeding progress over that attained in the smaller individual breeding flocks can be calculated theoretically.

There is, however, no practical evidence in this respect. The aim is to measure breeding progress in these group breeding schemes, which will make it possible to compare their breeding progress with the progress attained with selection within the smaller individual flocks.

(c) *Genetic variation between flocks and the direct comparison of breeding animals from diffferent flocks*

Seeing that the breeding values of the different flocks are expressed as a percentage deviation from the expected average of the control flock, environmental differences are eliminated and therefore, the flocks are directly genetically comparable. Assume the difference in breeding value for greasy wool mass for a flock (A) in a poor environment is calculated as + 1 kg with the expected average production of the control 5 kg. For another flock (B), in a good environment, the measured difference is + 2 kg while the control average is 10 kg.

The breeding value for greasy wool production in these two flocks A and B is exactly equal, as each, in its own environment, performed 20% better than the control. From Tables 6, 7 and 8 it can also be seen that the phenotypic flock average provide no indication of actual breeding values. The clean fleece masses from Tables 6, 7 and 8 can be taken as an example. The phenotypic averages for Flocks 1, 2 and 3 are 6,53; 3,08 and 4,06 respectively and the breeding value is + 5,49%; + 9,16% and + 10,93% , respectively.

With the average breeding values of flocks known, individual animals performance tested in different flocks can be compared directly irrespective of phenotypic differences.

The advantage of this is that specific breeding material can be exchanged between flocks on a planned genetic basis. In this way, additional breeding progress can be brought about above that which is possible by within-flock selection alone.

(d) *New group breeding schemes?*

If the breeding progress measured in existing group breeding schemes is more rapid than that attained in individual flocks based on selection within the flock and the planned exchange of breeding material, new group schemes can be formed on a well planned basis. Seeing that the breeding values of the different flocks belonging to the Breed Society for Performance Tested Merinos will be known, the proportional contribution of the individual flocks to the nucleus flock can be determined by the measured average genetic merit of each specific flock.

Presently the nucleus flocks are made up of equal contributions from participating flocks irrespective of their genetic merit, because this is unknown.

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