Presence of inbreeding during a selection experiment with Merino sheep

G.J. Erasmus,* A.O. de Lange,[1] G.J. Delport[2] and J.J. Olivier[3]

Department of Animal Science, University of the Orange Free State, P.O. Box 339, Bloemfontein 9300, Republic of South Africa

* Author to whom correspondence should be addressed.

Present addresses: [1] ARDRI, University of Fort Hare, Alice, 5700 Ciskei; [2] SA Fleece Testing Centre, ADSRI, Agricultural College, Middelburg 5900, Cape Province; [3] Grootfontein Agricultural College, Middelburg 5900, Cape Province.

Received 14 August 1990; accepted 30 April 1991

Individual inbreeding coefficients were computed in three lines of a selection experiment by using the algorithm of Quaas (1976). The mean inbreeding was about 2% at the end of the experiment and no significant difference was found among lines selected for increased fleece mass and visual overall excellence, and an unselected control. Evidence suggests that inbreeding could have had no appreciable effect on selection response or level of production and reproduction in the three lines.

Individuele inteeltkoëffisiënte is beraam in drie lyne van 'n seleksie-eksperiment deur gebruik te maak van die algoritme van Quaas (1976). Die gemiddelde inteelt aan die einde van die eksperiment was ongeveer 2% en geen betekenisvolle verskil tussen lyne geselekteer vir verhoogde vagmassa en visuele algemene voortreflikheid, en 'n ongeselekteerde kontrole is waargeneem nie. Beskikbare gegewens dui daarop dat inteling geen merkbare invloed op seleksieresponsie of peil van produksie en reproduksie in die drie lyne kon gehad het nie.

Keywords: Inbreeding, selection, Merino.

Knowledge of the rate of inbreeding is important in the analysis of selection experiments. When comparing the realized response in different lines (of which one could be a control), it is normally assumed that the rate of inbreeding in the different lines is identical. High levels of inbreeding can also lead to possible inbreeding depression with a resulting decreased phenotypic expression of the trait(s) under selection.

An even greater possibility is decreased fitness due to inbreeding depression, which results in a lower selection intensity. The algorithm reported by Quaas (1976) provides an efficient method for computing the inbreeding coefficient of each individual. It can also be used to compute the inverse of Wright's (1922) numerator relationship matrix when animals are inbred for use in mixed model analyses. Such a program is currently available for use on a variety of computers.

The purpose of this study was to test the validity of the assumption of equal inbreeding in the three lines of the Klerefontein Merino sheep selection experiment and to investigate the possibility that inbreeding depression was responsible for the low rates of response in clean fleece mass reported by Olivier (1980) and Erasmus (1988). A 'realized heritability' of only 0,187 was reported in the line selected for increased clean fleece mass (Erasmus, 1988).

The Klerefontein selection experiment, initiated in 1962, consisted of two selection lines, one of which was selected objectively for high clean fleece mass and one subjectively for overall excellence, and an unselected control line. Parents in each line were randomly mated. The number of breeding ewes in each of the two selection lines was kept at about 200. The size of the control line had been gradually enlarged from an initial 100 in 1965 to the eventual number of 200 breeding ewes. Initially, each line was restricted to contain 10% rams, but this was decreased to 5% of the number of ewes from 1967 onwards. No lambs were available in 1969 since all ewes were used for the development of the Afrino breed. A more detailed description of the experiment is given by Erasmus *et al.* (1990).

Inbreeding coefficients were computed for each animal, by using the algorithm of Quaas (1976). The inbreeding coefficient of the i-th animal was calculated as $F_i = d_{ii} - 1$, where F_i is the inbreeding coefficient and d_{ii} is the diagonal element of the i-th animal in the numerator relationship matrix (Wright, 1922). The base population was assumed to be non-inbred.

The mean annual inbreeding percentages and standard deviations are depicted in Table 1.

Table 1 Mean annual inbreeding percentage (*F*) and standard deviation (*SD*) in the three lines (years 1962 to 1964 were omitted because of zero inbreeding. Subjectively selected line terminated in 1978)

	Objective		Subjective		Control	
Year	*F*	*SD*	*F*	*SD*	*F*	*SD*
1965	0,0	0,0	0,2	1,6	0,2	1,7
1966	0,9	3,9	0,0	0,0	0,7	2,4
1967	0,3	1,4	0,3	1,8	0,8	2,5
1968	1,0	3,9	0,4	1,8	0,6	1,6
1970	0,5	2,3	0,9	2,9	1,1	2,6
1971	0,9	2,7	0,7	2,6	0,7	2,0
1972	1,2	2,2	1,0	2,4	1,5	3,3
1973	1,4	2,2	0,8	2,0	1,2	1,5
1974	2,1	4,1	1,0	2,1	1,5	2,6
1975	1,5	2,1	1,4	1,9	1,6	1,9
1976	1,5	2,4	1,8	4,0	1,4	1,4
1977	2,4	4,2	1,6	2,0	2,0	3,9
1978	2,3	2,4	1,9	2,4	2,5	2,2
1979	1,5	1,4	–	–	2,6	2,3
1980	2,0	2,4	–	–	2,3	1,6

For comparison, the predicted average level of inbreeding was calculated for each line from the following formula, and accumulated over years:

$$\Delta F_a = \frac{100}{8 N_m I^2}$$

where

ΔF_a = annual increase in inbreeding coefficient (expressed as percentage inbreeding),

N_m = number of new males added each year, and

I = generation interval.

The average generation interval, calculated as the actual average age of the parents of the lambs born, is given in Table 2.

Table 2 Average generation interval (years) in the three lines

Lines	Rams	Ewes	Average
Objectively selected	2,1	4,5	3,3
Subjectively selected	2,1	4,3	3,2
Control	2,1	4,3	3,2

The average predicted and actual annual increases in inbreeding (ΔF) were calculated as the linear regressions of level of inbreeding on year of birth. Tests of equality of slopes were carried out by an analyses of covariance as described by Sokal & Rohlf (1969). The results are presented in Table 3.

Table 3 Predicted and actual annual increase in level of inbreeding (ΔF) in the three lines

		Objective	Subjective	Control
Predicted				
	ΔF	0,109	0,114	0,114
	SE	0,003	0,003	0,003
	R^2	0,989	0,989	0,989
Actual				
	ΔF	0,126	0,137	0,141
	SE	0,022	0,012	0,015
	R^2	0,723	0,919	0,876

The differences in inbreeding coefficients among the three lines were non-significant. Inbreeding could therefore not have had a significant influence on the differences in response reported by Erasmus (1988). There was, however, an inevitable increase in the level of inbreeding, as is expected in any closed population of finite size. Table 1 shows that no distinct plateau of the percentage inbreeding values was obtained. First-order regression analysis of the data generally produced a good fit (Table 3). Although the method of prediction tended to underestimate the actual levels of inbreeding encountered, the differences were non-significant in all three lines.

A mean inbreeding coefficient of about 2% during the last year may be considered to be low, but the relatively large standard deviations (Table 1) suggest that the influence of individual inbreeding coefficients on natural and artificial selection cannot be ruled out. The effect of inbreeding on production and reproduction traits in Merino sheep has been the subject of many studies and reviews (Morley, 1954; Doney, 1957; Lax & Brown, 1967; Turner & Young, 1969; Dolling, 1970; Lamberson & Thomas, 1984). These studies show a decline of varying degree in all production traits with an increase in inbreeding. As is to be expected, however, the largest decline found was that in lambing performance, a decrease of about 1% lambs weaned with every 1% increase in inbreeding of the ewes. The average levels of inbreeding obtained in this study were similar in the three lines, and inbreeding could therefore not have contributed to the results of the selection experiment reported by Olivier (1980) and Erasmus (1988). Although the production levels of a minority of individuals could have been affected by inbreeding, it appears to be unlikely that inbreeding could result in an appreciable decline in the overall production and reproduction of the three lines.

References

DOLLING, C.H.S., 1970. Breeding Merinos. Rigby Ltd., Adelaide.

DONEY, J.M., 1957. Effects of inbreeding on four families of Peppin Merinos. *Aust. J. Agric. Res.* 8, 299.

ERASMUS, G.J., 1988. A mixed model analysis of a selection experiment with Merino sheep in an arid environment. Ph.D dissertation, University of the Orange Free State, Bloemfontein.

ERASMUS, G.J., DE LANGE, A.O., DELPORT, G.J. & OLIVIER, J.J., 1990. Genetic and phenotypic parameter estimates of production traits of Merino sheep in an arid environment. *S. Afr. J. Anim. Sci.* 20, 31.

LAX, J. & BROWN, G.H., 1967. The effects of inbreeding, maternal handicap and range in age on ten fleece and body characteristics in Merino rams and ewes. *Aust. J. Agric. Res.* 18, 689.

LAMBERSON, W.R. & THOMAS, D.L. 1984. Effects of inbreeding in sheep: a review. *Anim. Breed. Abstr.* 52, 287.

MORLEY, F.H.W., 1954. Selection for economic characters in Merino sheep. IV. The effect of inbreeding. *Aust. J. Agric. Res.* 5, 305.

OLIVIER, J.J., 1980. Die invloed van objektiewe en subjektiewe seleksiemetodes en omgewingsfaktore op produksie- en reproduksie-eienskappe van Merinoskape op die Carnarvon-proefplaas. M.Sc.(Agric.)-treatise, Univ. Stellenbosch.

QUAAS, R.L., 1976. Computing the diagonal elements and inverse of a large numerator relationship matrix. *Biometrics* 32, 949.

SOKAL, R.R. & ROHLF, F.J., 1969. Biometry. W.H. Freeman, San Francisco.

TURNER, HELEN N. & YOUNG, S.S.Y., 1969. Quantitative genetics in sheep breeding. Macmillan, Sydney.

WRIGHT, S., 1922. Coefficients of inbreeding and relationship. *Am. Natur.* 56, 330.