JOURNAL OF AGRICULTURAL SCIENCE IN FINLAND
Maataloustieteellinen Aikakauskirja
Vol. 60: 481—491, 1988

The accumulative effect of Finnsheep breeding in crossbreeding schemes

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Abstract. Finnsheep (F) was used in a crossbreeding project to improve overall productivity of the DLS breed. Productive and reproductive traits of seven crossbred combinations ranging from 1/8F to 7/8F breeding were compared to those of the two parental breeds. Suffolk rams were used to mate all ewes (361) for five parturitions (1312 records). Ovulation rate (OR) and litter size (LS) at birth for all the groups increased progressively as F breeding increased. The 4/8F ewes weaned the heaviest litters. Percentage of ova lost per ewe mated ranged from 18 % to 29 %. Preweaning mortality rate was highest in F ewes. Total kg of lambs weaned per ewe exposed was highest in 4/8F followed by F whereas that of DLS was lowest. The 4/8F exhibited 25 % heterosis (H) in kg of lambs weaned per ewe exposed. The linear regressions of OR (b = .24), of LS at birth (b = .14) and at weaning (b = .08) on proportion of F breeding in crosses were significant. The regressions were quadratic for percent ova lost and lamb mortality at weaning. The crosses showed positive H in grease fleece weight (GFW), the highest being expressed by the 4/8F and 5/8F crosses. Significant linear relationships were observed between F breeding and GFW (2nd shearing), fiber thickness and variability in both fiber length and fiber thickness, whereas the relationships of F breeding with GFW (3rd and later shearings), clean wool percentage and fiber length were quadratic. Most of the crosses exhibited positive H particularly in clean wool percentage and in staple and fiber length. H was often highest in the 4/8F cross. Genetic group of dam had a significant effect on age at slaughter, leg, loin and kidney fat as a percent of the carcass, lean, fat and bone percent of the 12th rib and fat thickness over loin-eye muscle. A significant linear relationship existed between most of these carcass measurements and the proportion of F breeding in the lambs' dam.

Index words: Finnsheep, crossbreeding, heterosis, reproduction, wool production, lambs

Introduction

Improving prolificacy in local breeds through crossbreeding is frequently the main reason for importing prolific breeds. When the crossing is to develop a prolific composite, the important question is to determine the proper proportions of the breeds involved which produce the highest returns. Although Finnsheep (F) have been used intensively in crossbreeding programs, only first and backcrosses have been widely investigated (12). No research has reported on the accumulative effect of F-genes in crosses with other breeds. This report presents the performance of a wide range of combinations between F and the DLS breed (a composite population resulting from combining genes of Australian Dorset, Border Leicester and Suffolk which has been selected since 1969 for an extended breeding season). The information summarized in this report were reported in detail by FAHMY (4, 5) and FAHMY and DUFOUR (6).

Material and methods

A total of 361 ewes born in 1979, 1980 and 1981 were involved in the present study. They were the progeny of F, DLS, 2/8 F—6/8 DLS (2/8 F) and 4/8 F—4/8 DLS (4/8 F) rams mated to F, DLS, 2/8 F, 4/8 F and 6/8 F—2/8 DLS (6/8 F) ewes. The composition of these ewes ranged from 1/8 F to 7/8 F. The ewes were exposed to Suffolk rams for the first time when they were 7 to 8 mo old, then at yearly intervals. Each ewe had an opportunity to contribute five records except those born in 1981, which contributed only four records. Ovulation rate (OR) in these ewes was determined by laparoscopy at their 2^{nd}, 3^{rd} and 4^{th} parities following synchronisation with vaginal sponges impregnated with 60 mg medroxyprogesterone acetate. The number of corpora lutea were counted on both ovaries.

Conception rate (CR) was determined in terms of percentage of ewes lambing, aborting or dying while pregnant to those exposed to rams. Different measures of prolificacy were calculated using the number of lambs born, born alive and weaned per ewe lambing. Other measurements were litter weight at birth and weaning (total lamb weight at these two stages), ova loss which was the difference between number of corpora lutea counted at laparoscopy, and lambs born and preweaning lamb mortality.

The data on wool characteristics and grease fleece weight (GFW) at the first shearing were collected on 273 yearlings. A sample of wool was obtained by using a 2 cm hair pin callipers. The wool fibers growing on two square centimeters of skin were separated from the rest of the fibers at the shoulder region and clipped as close to the skin as possible, using electrical clippers. The sheep were shorn and fleeces weighed after the sample was taken. GFW was recorded on additional 90 other yearlings on which wool samples were not available. GFW was recorded at yearly intervals on the 363 ewes until 1985. Shearing was customarily completed during March. Age of the yearlings at sampling varied between 12.6 and 16.6 mo for DLS and the different crosses and 16.4 to 20.5 mo for F.

The wool production traits studied were: (1) staple and fiber length: average length of 200 fibers, measured by stretching the fibers against a ruler; (2) fiber density: calculated from weighing 200 clean fibers and extrapolating for the total weight of the sample, then dividing by 4; (3) clean wool percentage; the clean weight (xylene-washed) of a sample as a percentage of the grease weight of that sample before dusting and washing; (4) fiber diameter: average diameter of 200 fibers (using a projection microscope); (5) GFW: weight of the fleece as yearlings and at 12 months intervals thereafter and (6) variability in fiber length and fiber thickness expressed as the standard deviation within each sample.

Male and female lambs from multiple birth litters (mainly twins) born in 1982 and 1983 were raised to market weight in order to study growth and carcass quality of the progeny of crossbred ewes and to compare them to those of F and DLS. One lamb from each set of twins was assigned to receive a high energy (HE) ration consisting of a grain mixture offered free choice in addition to 250 g of grass silage. The other lamb received a low energy (LE) ration based on grass silage offered free choice supplemented with 20 % of the amount of grain consumed by lambs on the HE ration to a maximum of 250 g. The same silage and grain mixture was used in the two feeding regimes. The amount of grain offered to the LE group was adjusted weekly according to the previous week's consumption of the HE group.

The sets of twins were equally assigned at random to a slaughter weight of either 32 ± 1 kg, or 41 ± 1 kg. After a 72 h chill, the carcasses were weighed and body length, heart girth and circumference of leg were recorded. The carcasses were then split into shoulder, loin-rack and leg and each was expressed as percentage of the whole carcass weight. Kidney and pelvic fat was removed and weighed. The 12th rib was removed and the area of loin-eye muscle, fat thickness at 6 points over that muscle and color of the muscle were measured. The 12th rib was then dissected into fat, bone and muscle. Each of these tissues was expressed as a percentage of the total weight of the rib cut.

Average daily gain (ADG) from the start of the feeding period to 32 kg live weight was calculated for all animals and from 32 to 41 kg for animals slaughtered at 41 kg live weight. Age at slaughter and live body weight per day of age were also studied.

The income generating potential of the different genetic groups was calculated as number of lambs weaned per ewe lambing (assuming no mortality between weaning and marketing) × weight of lambs at 200 d of age (weight per day of age × 200) × dressing percentage × price of the carcass (price of whole-sale cut × percentage of that cut in the carcass). The prices per kg of the whole-sale cuts were $9.90 for leg, $13.22 for loin-rack and $4.83 for shoulder. To account of differences in ewe body weight the monetary returns were then divided by ewe body weight to obtain returns per kilogram of ewe ($/kg). The value of carcasses was calculated for each lamb individually then subjected to the same statistical procedures as the other traits.

Statistical analyses

Data were analysed by the least squares method. Different models were used to handle the different traits studied.

Percent deviations of the seven crosses from the theoretically expected means of the parental breeds, assuming complete additive gene action, were calculated and referred to as »heterosis». Linear and quadratic regressions of means on proportion of F in the seven crosses were computed for each trait.

Results

Reproduction Performance

The results showed that only 61.5 % of DLS yearlings exposed to rams at 7 to 8 mo of age conceived compared to 89.0 % of F-yearlings. This wide difference can be explained in part by differences in age at puberty, F is considered an early maturing breed. At later parities, conception rates were generally high (94 %) and with few exceptions, similar among the different genetic groups.

OR was lowest in DLS and 1/8 F groups and highest in F, 7/8 and 6/8 F groups, (Fig. 1). OR increased with age from 2.36 at 1.5 yr of age to 2.64 and 2.90 at 2.5 and 3.5 yr of age, respectively. DLS ewes averaged 1.44 lambs at birth and 3 % of these were born dead. Comparatively, F averaged 2.86 lambs and 8 % born dead (Fig. 1). Litter size (LS) at birth increased progressively from 1.63 for 1/8 F to 2.42 lambs for 7/8 F ewes. DLS ewes weaned 1.22 and F 2.03 lambs (Fig. 1). The averages for the two purebred groups were .70 and 1.68 at 1 yr of age, respectively. LS at birth of ewes with 4/8 or higher F breeding was significantly higher than those with lower than 4/8 F breeding. The tendency for increased LS with increased proportion of F was evident.

The difference in litter weight at birth between DLS, the lightest, and F, the heaviest was 1.35 kg. Litter birth weight of the seven crosses were intermediate. At weaning, the heaviest litters were those raised by 4/8 F ewes (31.7 kg) followed by 7/8 F (30.8 kg), while the lightest were from those raised by DLS and

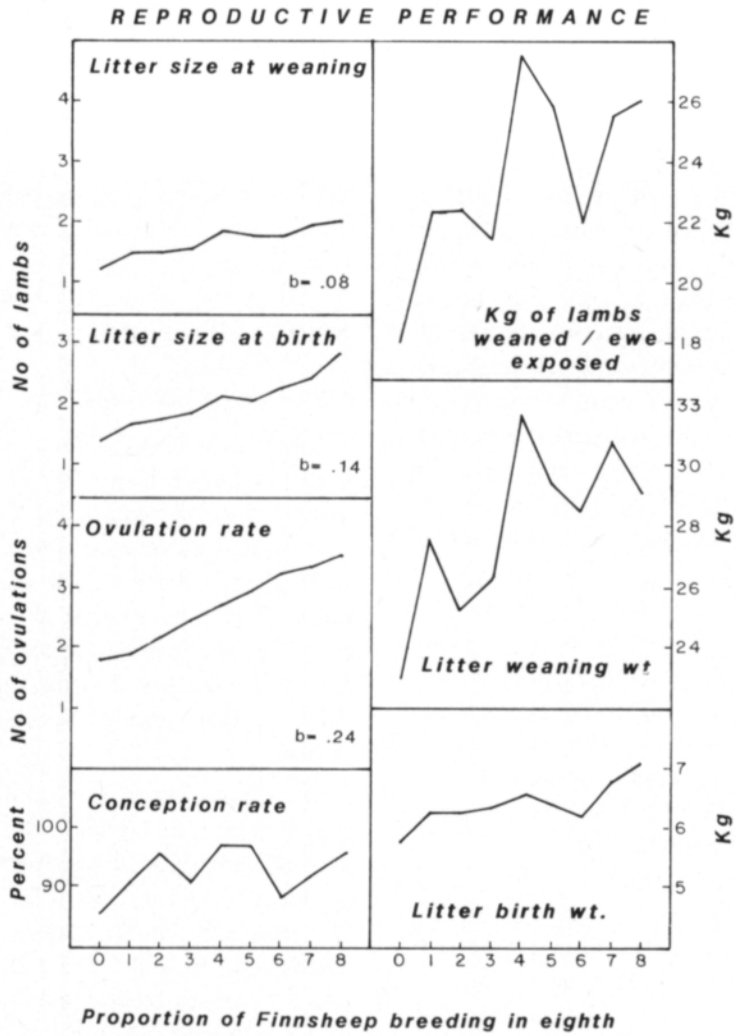

Fig. 1. Changes in reproductive performance in the different genetic groups with changes in proportion of Finnsheep breeding, b refers to significant linear regression.

2/8 F. Preweaning ADG ranged from 182 g for lambs from F ewes to 217 g for those raised by 4/8 and 1/8 F ewes. Lamb weaning weight was similar for those raised by DLS, 1/8, 2/8, 3/8, and 4/8 F groups; it was 1 to 2 kg heavier than those raised by 5/8, 6/8 and 7/8 F ewes.

Number of ova not resulting in lambs per ewe mated varied among the different genetic groups and ranged from 18.2 % in 1/8 F to 29.4 % in 6/8 F crosses. Crosses exceeding 2/8 F, lost between 26.0 and 29.4 % of their ova, in spite of the wide range in OR among these crosses. About 3.6 % of all lambs born were either born dead or died within a few hours after birth and a further 13.8 % died before weaning. The highest proportion of lambs born dead was observed for 6/8 F ewes (5.2 %) whereas the lowest rate (0.8 %) was observed for the 5/8 F. Preweaning mortality rate was highest (22.9 %) in F and lowest in 3/8 F (9.4 %).

The overall average number of lambs weaned per ewe mated was 1.50 and the weight was 23.4 kg. LS ranged from 1.89 (F) to 1.06 (DLS), litter weight from 27.6 kg (4/8

F) to 18.1 kg (DLS). Lamb production of DLS ewes was markedly low (5.2 kg) at 1 yr of age as a result of their low fertility at 7 mo of age (61.5 %) when they were first mated. At an older age, their performance approached that of 1/8, 2/8 and 3/8 F ewes.

The 4/8 F showed the highest heterosis (H) in LS and weight and lamb weight at weaning (13.2, 21.7 and 9.5 % respectively) and the second highest H in OR and CR (3.5 and 6.6 % respectively). The 4/8 F ewes produced 25 % more kilograms of lambs at weaning than the average of the parental breeds (Fig. 5).

Linear regressions of average performance of the seven crosses on proportion of F breeding were positive and significant for OR ($b = .24 \pm .01$, $P < 0.01$), LS at birth ($b = .14 \pm .01$, $P < 0.01$) and at weaning ($b = .08 \pm .02$, $P < 0.05$). This indicated that these traits increased progressively with an increase in F proportions. Significant quadratic relationships were calculated for percent ova lost and lamb mortality at weaning. Either the half-way crosses between the two breeds had the highest performance or that the crosses with high or low proportions of F breeding tended to change slightly causing curvilinear relationships. No linear or quadratic relationship could be fitted between kilograms of lambs weaned and an increase in F proportions. The general observation was that crosses with low proportions of F (1/8 to 3/8 F) produced at the level of 22 kg, those with higher proportions (5/8 to 7/8 F) produced at about 24.5 kg whereas the 4/8 F cross reached the highest performance of 27.6 kg.

Wool production and fiber characteristics

F yearlings had 1.4 cm ($P < 0.05$) longer staple and 3.3 cm ($P < 0.05$) longer fibers than DLS yearlings (Fig. 2). Variability in fiber length was significantly higher in F than in all the genetic groups studied (except for the 5/8 F). Among the crosses, the 4/8, 5/8 and 6/8 F had the longest staple (13.9—14.3 cm) and wool fibers (18.5—20.1 cm). The means of these crosses were close to those of pure F (13.4 and 19.1 cm, respectively).

Fiber density was 1551 fibers/cm^2 in DLS compared to 1950 in F ($P < 0.05$). It ranged in the crosses between 1642 fibers/cm^2 in 7/8 F to 1856 fibers/cm^2 in 6/8 F ($P > 0.05$, Fig. 2).

DLS yearlings had the lowest percentage of clean wool (61.2 %) which was significantly different from all other genetic groups except 1/8 F, 3/8 F and pure F. The highest percentage of clean wool was obtained in 7/8 F (66.2 %) and 4/8 F (66.1 %), which was statistically non-significant from all other crosses.

F and 7/8 F yearlings had fleeces with the finest fibers and the lowest variability in fiber thickness, whereas DLS yearlings had the coarsest fleeces with the highest variability in fiber thickness among the nine genetic groups (Fig. 2). The difference of 5 μm between the yearlings of the two pure breeds was highly significant.

F and the crossbred ewes with high proportions of F breeding were generally lower in wool production than DLS ewes and ewes from crosses with high proportions of DLS breeding. Wool production generally increased with advances in age (Fig. 3).

The regression analyses of the traits studied on the proportion of F in the genetic groups indicated that the relationship was linear for fiber thickness ($b = —.48 \pm .08$, $P < 0.01$), variability in fiber thickness ($b = —.11 \pm .03$, $P \pm 0.05$) and variability in fiber length ($b = .17 \pm .04$, $P < 0.01$) and curvilinear for clean wool percentage and fiber length. The tendency was for fiber thickness, and its variability to decrease and the variability in fiber length to increase with the increase in the proportion of F in the genetic group. The relationship between the proportion of F and GWF was linear for the second shearing ($b = .06 \pm .02$, $P < 0.01$) and curvilinear for the subsequent shearings.

Only the 3/8 F showed moderate estimates of positive heterosis (H) in all the traits stud-

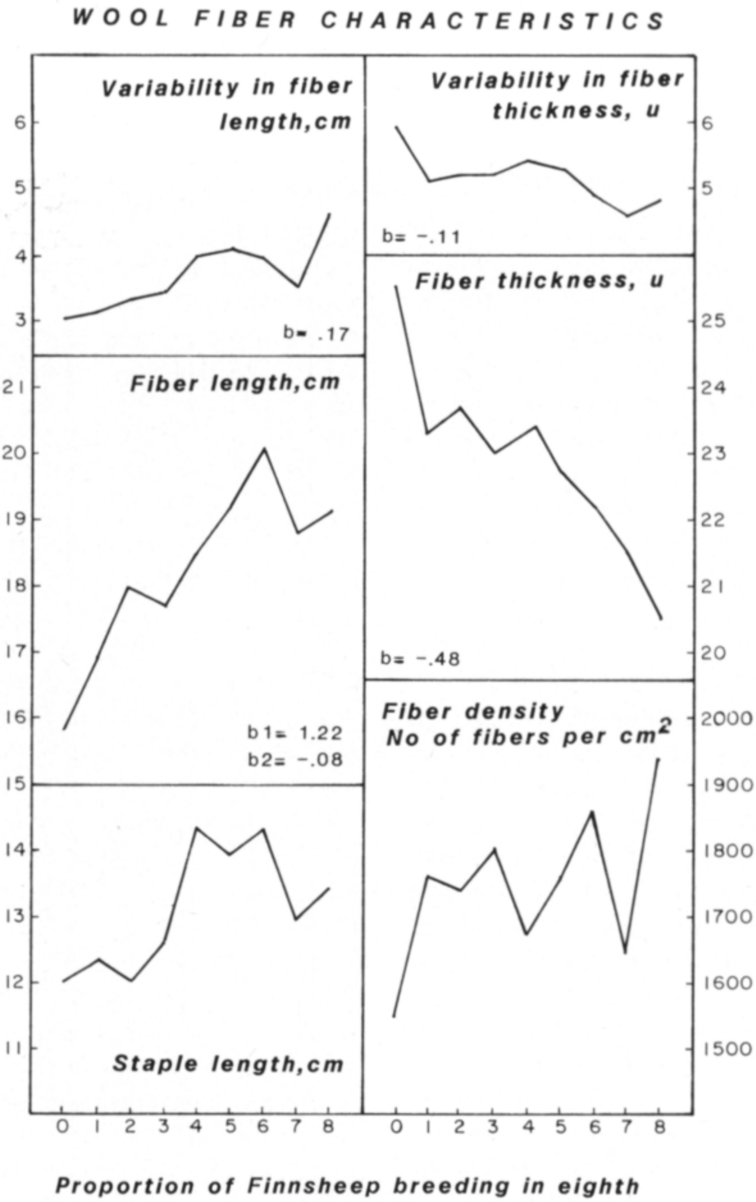

Fig. 2. Changes in wool fiber characteristics in the different genetic groups with changes in proportion of Finnsheep breeding, b refers to significant linear regression and b_1, b_2 refer to significant quadratic regression.

ied. The other crosses showed positive H in some traits and negative estimates in others. Most of the crosses showed positive H for the first and second shearings and all the crosses showed high positive H in third and later shearings (Fig. 5). The highest expression of H was observed in the 4/8 F and 5/8 F crosses. The fleeces of the 1/8 F cross ewes were consistently heavier than those of the DLS ewes.

Ewe body weight at lambing:

At first lambing, F ewes weighed 44 kg, which was 8 kg heavier than DLS ewes (Fig. 3). However, this difference in weight disap-

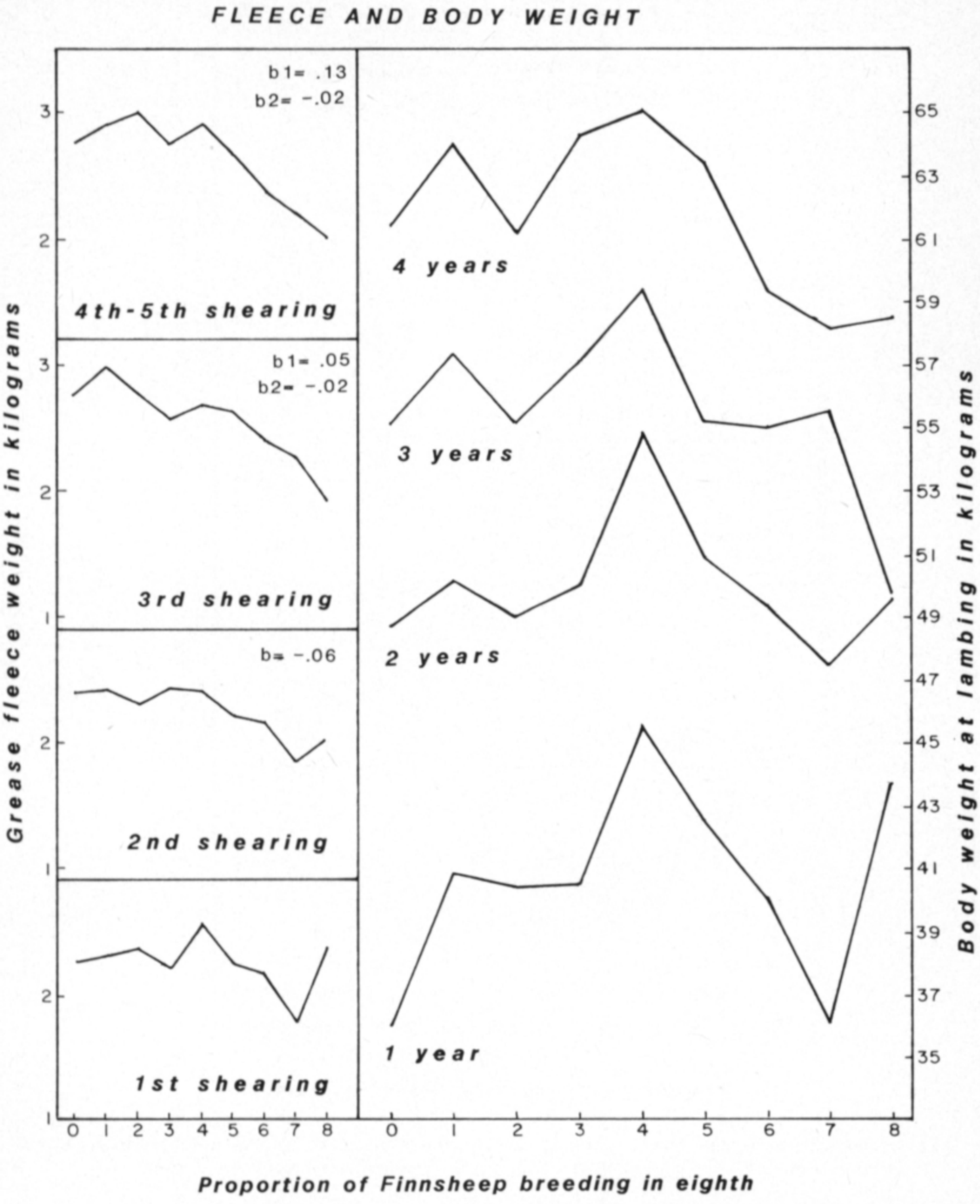

Fig. 3. Changes in fleece and body weight in the different genetic groups with changes in proportion of Finnsheep breeding, b refers to significant linear regression, b_1, b_2 refer to significant quadratic regression.

peared with age and at 5 years of age DLS ewes were 2.7 kg heavier. The heaviest cross at 1 year was the 4/8 F averaging 46 kg whereas the lightest was the 7/8 F cross. Weights of all genetic groups increased with age. The heaviest mature weights were those of 3/8, 4/8 and 5/8 F crosses, however the differences with other crosses were rather small.

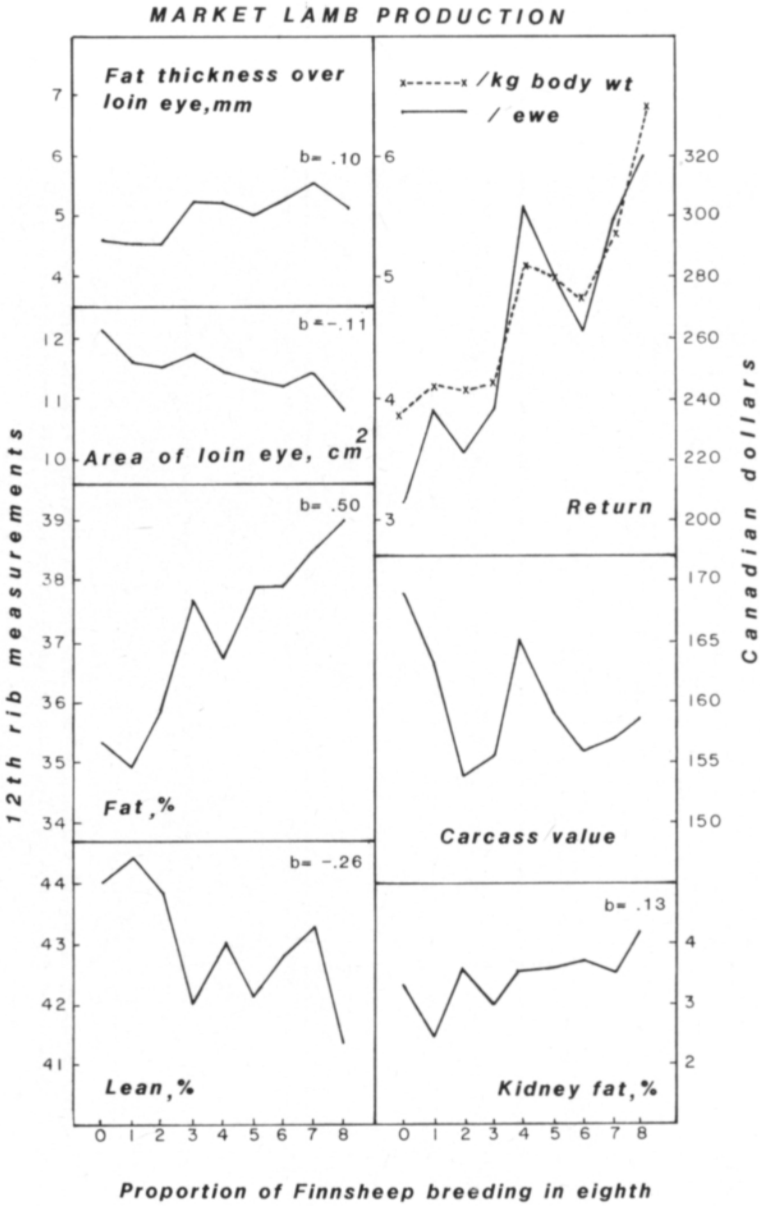

Fig. 4. Changes in carcass characteristics of progeny and monetary return per ewe in different genetic groups with changes in proportion of Finnsheep breeding, b refers to significant linear regression.

Market lamb production

Lambs produced by crossing Suffolk rams with DLS, F and the seven crosses between DLS and F ranged between .166 and .180 kg/d in live weight gain. Growth rate from 32 to 41 kg live weight averaged .244 kg/d and was highest in lambs from 7/8 F ewes (.287 kg/d). The differences with other genetic groups were, however, non-significant.

Dressing percentage was generally similar among the offspring of the different crosses. Percent shoulder was limited in its variation among the different genetic groups. As expected, lambs from F ewes had the highest percentage of kidney and pelvic fat (4.2 %, Fig.

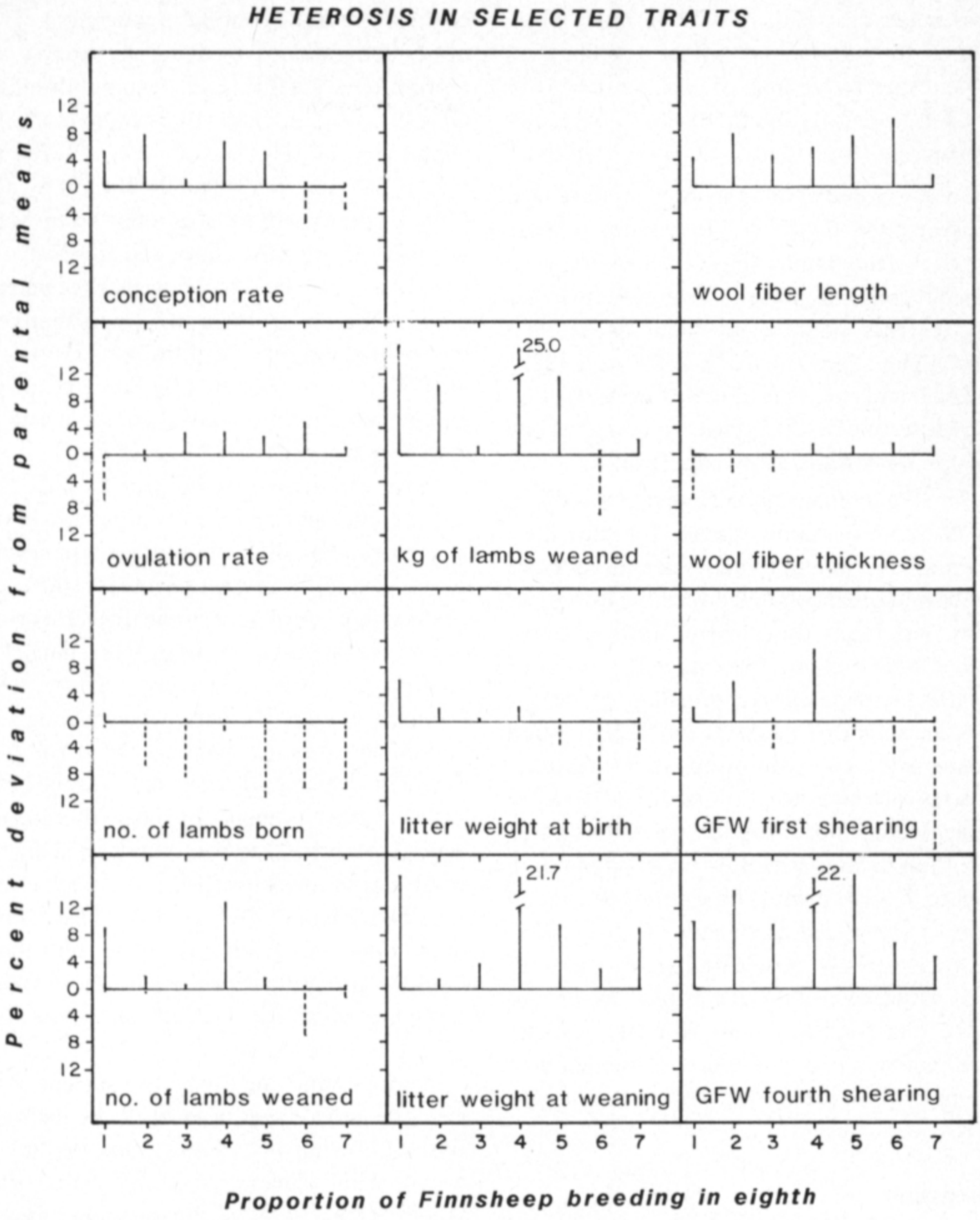

Fig. 5. Heterosis in selected traits in different crosses between DLS and Finnsheep.

4). Lambs from 1/8 F ewes had the highest percentage of lean and bone and the lowest percentage of fat in the 12th rib and lesser fat cover over that rib, as compared to the other genetic groups. The area of loin-eye muscle was largest in S × DLS lambs (12.1 cm^2) and smallest in S × F (10.8 cm^2) lambs. The area of loin-eye ranged from 11.2 to 11.7 cm^2 in the other genetic groups (Fig. 4).

Little differences in carcass dimensions were observed among the genetic groups. None of the quadratic regressions was found to be significant. Significant linear regressions were observed for leg percentage ($b = -0.13 \pm 0.05$ $P < 0.05$), percent kidney fat ($b = 0.13 \pm 0.05$, $P < 0.05$), percent lean, fat and bone in the 12th rib ($b = -0.26 \pm 0.10$, $P < 0.05$; 0.50 ± 0.07; and -0.24 ± 0.06, $P < 0.01$, respectively), area of loin-eye ($b = 0.11 \pm 0.02$, $P < 0.01$) and fat thickness over loin-eye muscle ($b = 0.10 \pm 0.03$, $P < 0.05$).

Carcass value of an individual lamb ranged between $154 for S × 2/8 F lambs to $169 for S × DLS lambs (Fig. 4). The effect of genetic group was non-significant. Returns per ewe (carcass value × no of lambs weaned) were highest for F, 4/8 and 7/8 F ewes ($298 to $320) and lowest for DLS ewes ($207, Fig. 4). Most of the differences among genetic groups were statistically significant.

Pure F ewes mated to Suffolk rams produced $6.39 worth of retailed lambs for each kilogram of live weight. The greater number of lambs marketed combined with the lower ewe body weight in the present study and the higher lamb dressing percentage as a result of greater fat deposition more than offset the heavier weight of lambs from DLS or other crosses with low proportions of F breeding. Crosses with high proportions of F (4/8 to 7/8 F) generated more revenue per kilogram of ewe than crosses with low proportions of F (1/8 to 3/8 F). It must be mentioned that all lambs were priced as Canada Al. Some carcasses, especially those with high proportions of F breeding could have graded lower and hence sold for less (about $0.22/kg less per grade). Therefore, the figures presented here are just approximations.

Discussion

The performance of F and its crosses with native breeds of many countries was reported in over 600 scientific publications. The most comprehensive research reports on reproductive performance were published by OLTENACU and BOYLAN (13), MAGID et al. (9), COCHRAN et al. (1), FOGARTY et al. (7), ERCANBRACK and KNIGHT (3) and INIGUEZ et al. (8). Most of these authors also reported on wool production and fiber characteristics of F and its crosses. Studies involving market performance of lambs from terminal sires mated to F crossbred ewes included those of THOMAS et al. (14), DAHMEN et al. (2), KEMP et al. (9) and MAGID et al. (11). All these studies dealt with F and its first and backcrosses.

In an exhaustive review by MAIJALA (12) the average performance of purebred F and its crosses from different studies was reported in graphical presentations to show the changes in performance of the different crosses with varying proportions of F breeding. The relationships were linear for fertility, OR, prolificacy with purebred F showing the highest performance and curvilinear for litter weight at weaning: the first cross was the heaviest. For body weight and growth rate the highest performance was manifested in the first cross followed by the 2/8 F, 6/8 F crosses and pure F in that order (12). The relationships obtained from averaging numerous studies were similar in general to those found in the present study in which four more combinations were used.

It can be concluded from the present data, that the advantage in prolificacy brought about by using F at higher proportions in crossbreeding schemes, offset the slight reduction in carcass value of the resulting progeny and the reduced returns from slightly lighter fleeces.

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