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Research with Finnsheep in Canada

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Cover illustration
The dots on the map represent
Agriculture Canada research
establishments.

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FOREWORD

Sheep may be the first domesticated animals in the history of mankind. Biblical stories with reference to sheep are numerous and the majority of Prophets were reported to have raised sheep. In many parts of the world sheep are still raised the same primitive way used by our ancestors centuries ago. During the 18^{th} and 19^{th} century many new breeds of sheep were developed with emphasis on improving conformation, wool and meat production. Little attention was paid to improving prolificacy. However, the need to intensify sheep production to conform to today's systems of concentrated farming necessitated the use of prolific sheep to increase returns per unit of production. Until recently, little has been known on the existence of such prolific breeds since they are found in rather remote locations and were rarely studied.

Finnsheep was the first breed to be recognized as prolific and probably no one single breed has revolutionized sheep production as did the Finnsheep.

In 1991, Finnsheep will have been in Canada for 25 years. It was thought proper to celebrate this occasion with this document summarising the Canadian contribution to research with that breed. In this review, each study was summarized to highlight the role of, or the results obtained by the Finnsheep. Many irrelevant details were eliminated. The studies were grouped by institution according to an East to West geographic distribution. A subject index was prepared to make an easy reference to different studies working on the same subject. The review ends with a bibliography of all the articles presented in this review.

The author made intensive efforts to collect all Canadian scientific publications on Finnsheep, if however, some references escaped his attention, he apologizes for this oversight.

SUMMARY

Since its importation into Canada in 1966 the Finnsheep breed has been involved in numerous research projects to study its performance as a pure breed and evaluate its crosses with other domestic sheep breeds. Most of the studies were conducted at three centers, namely, the Lennoxville and Lethbridge Research Stations and Animal Research Centre of Agriculture Canada. Other institutions working on the Finnsheep has been the universities of Laval, Manitoba and Saskatchewan. The studies demonstrated the advantage in reproductive traits brought about by using Finnsheep and/or Finnsheep crosses. Studies on carcass evaluation indicated that Finnsheep carcasses, although slightly inferior in quality as compared to meat-type breeds have been acceptable by consumers. Studies also showed how Finnsheep and its crosses adapt to different intensive systems of management. Finnsheep were also involved in developing two new Canadian breeds namely the Arcott Outaouais and Rideau.

RÉSUMÉ

Depuis l'importation au Canada en 1966 de la race ovine Finnoise, plusieurs études ont été réalisées afin d'étudier les performances de la race pure et d'évaluer ses croisements avec les autres races domestiques. La plupart des études ont été effectuées dans trois centres de recherches d'Agriculture Canada, à Lennoxville, à Lethbridge et au Centre de recherches zootechniques à Ottawa. D'autres recherches ont été effectuées à l'Université Laval, à l'Université du Manitoba et à l'Université de la Saskatchewan. Les études ont démontré la supériorité de la race Finnoise et de ses croisements pour les caractères de reproduction. Les études sur l'évaluation des carcasses ont démontré que, même si la qualité des carcasses des moutons de race Finnoise est légèrement inférieure à celle des races de boucherie, la viande des moutons de race Finnoise est bien acceptée par les consommateurs. Les études ont également démontré que les moutons de race Finnoise et ses croisements s'adaptent bien aux différents systèmes intensifs de régie. La race Finnoise a également contribué au développement de deux nouvelles races canadiennes, l'Arcott Outaouais et Rideau.

1. INTRODUCTION

Although the Finnsheep breed has been established in Finland for centuries, its "discovery" by the rest of the world goes back to only 1963. During a casual conversation with Dr. Kalle Maijala, a Finnish geneticist, scientists at the Animal Breeding Research Organization in Edinburgh, Scotland learned of its existence and became interested in acquiring some of these prolific sheep. Following the publication of the results on the performance of Finnsheep in Britain, many countries became interested and the importation wave of these sheep started. Over the years, Finnsheep have been introduced to over 40 countries all over the world including Canada. Studies on Finnsheep prior to 1963 received little attention and readership because they were written in Finnish and published in local journals. However, after the wide expansion, the Finnsheep became probably one of the most studied breed in the literature. A survey of the articles published and abstracted in Animal Breeding Abstracts revealed that performance of pure Finnsheep and crossbreeding studies with Finnsheep were reported in over 250 publications since 1967.

Canada has had its share of research with the Finnsheep which was concentrated in a few centers. The University of Manitoba, the first to import the breed, worked on crossing the Finnsheep with Rambouillet, Suffolk and a synthetic line. Animal Research Centre used Finnsheep to develop two dam line strains with Finnsheep contributing up to 50% of the ancestry. The Lennoxville Station crossed Finnsheep with the DLS breed to produce different combinations. Other institutes used Finnsheep either in crossbreeding programs (Lethbridge Station) or as an animal model (University of Saskatchewan) to test different nutritional and physiological treatments.

2. ORIGIN OF FINNSHEEP

2.1 Early history

In a recent publication, Maijala (1988) reported on the origin of the Finnsheep (F) in Finland. The following are extracts from his article. Very little facts are available about the earlier history of F and also of sheep as farm animals in Finland. It has been claimed by historians that sheep have been kept in Finland since the later Iron Age.

There are two alternative main hypotheses concerning the source of F: east or west. The eastern origin is supported by the fact that the arrival of Finns to Finland is claimed to have taken place from the area of present Soviet Union at the beginning of the first millenium A.D. It can be assumed that they had the ancestors of F with them and that their relatives which stayed in the north-central Russia may have had ancestors of Romanov breed which is also short-tailed and prolific and has some other common features with F.

For the western origin, the fact is that short-tailed native breeds occur in all the other Scandinavian countries and in some other parts of Northern Europe. Newer theories consider that Finland got its inhabitants partly from the west. It is natural to assume that these people also brought farm animals with them. It is generally believed that Finland has received its sheep a good thousand years ago from its southern and western neighbours, and that the breed descends from the Mouflon sheep.

Finnish sheep husbandry long served mainly home needs of wool and furs hence the animals were kept in very small self-sufficiency flocks. Meat was an important by-product. Ewes were also milked. The production system may have affected selection and mating systems. Close inbreeding may have been common. It can be assumed that the biggest ram lambs, probably born as singles, were slaughtered for meat early in the autumn, while the small ones from big litters were saved for further growth and thus allowed to breed the ewes. This could be one alternative explanation to the maintenance of high prolificacy. In many other countries where sheep were economically important for the owner, rams were selected on the basis of their size, and hence mainly from single-born lambs.

2.2 Recent history

More is known about Finnish sheep husbandry from the 16th century onwards. The Swedish king Gustav Vasa tried to widen and revive it by having big sheep flocks on his royal estates and by importing foreign breeds. In the middle of the 18th century the government imported Merino sheep and tried to expand it, in order to develop textile industry. The impact of the importations on the native sheep remained small.

2.3 History of Finnsheep in Canada

The first exportation of Finnsheep from Finland took place in 1962 with the importation by Scotland of 10 ewes and five rams. Selection of the animals was made mainly on their record of fertility. Most sheep were born in large litters and little attention was paid to body size or any other trait. The first Canadian importation was made in 1966 by the University of Manitoba. Four rams and eight ewes born in 1966 from animals previously imported by Scotland were the source of the Finnsheep in Canada. Progeny of these animals were moved to Ontario (Animal Research Centre), Quebec (Laval University) and USA (Meat Animal Research Center) for research purposes and many were sold to sheep breeders.

2.4 History of Research with Finnsheep in Canada

An undated 10-page mimeograph written around 1972 by Dr. M.E. Seale of the University of Manitoba entitled: "Evaluating the Finnish Landrace breed of sheep" is probably the first written document on the performance of Finnsheep in Canada. Growth, prolificacy, wool characteristics and carcass measurements, during the years 1968-71 were compared between Finnsheep, Finnsheep crosses and other breeds and their crosses. The author also projected the role of the Finnsheep breed in Canada and its possible effect on the sheep industry.

3. MARITIMES

3.1 Nova Scotia Agricultural College, Truro, Nova Scotia

3.1.1 Mathewson, Maynard and MacKenzie (1986) used Finnsheep x N.C. Cheviot, Suffolk x N.C. Cheviot, Hexham Leicester x N.C. Cheviot and Western ewes to compare two systems of management: traditional, where ewes lambed in spring and nursed their lambs on pasture, or intensive where lambing was scheduled each eight months under complete confinement and following a light control system. The results (Table 1) indicated that little differences between genetic groups in lambing rate were observed under the traditional system, while under the intensive system the Finnsheep cross showed the lowest lambing rate. Ewes were slightly more fertile under the traditional compared to the intensive system. The number of lambs marketed per ewe exposed per year under the traditional system averaged 1.26 compared to 1.72 under the intensive system. Finnsheep cross had the highest productivity under either system, the differences were however, small. Lamb mortality on traditional system (18%) was slightly higher than on the intensive system (15%). Little differences were observed among genetic groups in lamb mortality.

Table 1. Performance of ewes of four genetic groups under two mating systems

Lambing system & genetic groups	Fertility	Productivity†	Lamb mortality	Cost/ ewe $	Revenue/ ewe $
Traditional					
Finnsheep x NCC	87.6	1.35			
Suffolk x NCC	90.1	1.32			
Leicester x NCC	81.8	1.08			
Western	88.1	1.31			
Mean	86.8	1.26	18.0	56.5	97.7
Intensive					
Finnsheep x NCC	77.7	1.88	16.0		
Suffolk x NCC	85.9	1.62	13.0		
Leicester x NCC	82.4	1.66	17.0		
Western	91.0	1.76	18.0		
Mean	84.4	1.72	15.0	136.2	121.2

† Lamb marketed/ewe exposed.
NCC = N.C. Cheviot.

4. QUEBEC

4.1 Research Station, Lennoxville

At Lennoxville, Finnsheep were used mainly in a crossbreeding program with DLS sheep. Different combinations of Finnsheep-DLS were produced ranging from 1/8F 7/8 DLS (1/8F) to 7/8F 1/8 DLS (7/8F). The source of the F sheep was the flock of Animal Research Centre in Ottawa.

4.1.1 Fahmy (1979) published the results of a study comparing body and carcass measurements of DLS and F x DLS lambs slaughtered at 23, 32 or 41 kg liveweight. Selected results are presented in Table 2. Finnsheep cross grew at a faster rate which resulted in younger ages at slaughter and heavier weights per day of age. The crossbred lambs were longer and had larger rounds when slaughtered at 23 kg but were generally smaller than the DLS lambs at heavier slaughter weights. Little differences were observed in the other carcass traits studied with the exception that the crossbred lambs were generally fatter with less lean than pure DLS lambs at all three slaughter weights.

Table 2. Body dimensions and carcass measurements of DLS and Finnsheep x DLS lambs slaughtered at three body weights (8 lambs per treatment)

	Genetic groups					
	DLS Slaughter weight (kg)			Finnsheep x DLS Slaughter weight (kg)		
	23	32	41	23	32	41
Live measurements						
Body length (cm)	38.3	47.4	51.8	40.9	46.1	50.0
Heart girth (cm)	68.6	77.9	86.5	67.6	78.3	84.6
Circumf. of round (cm)	24.3	34.7	36.2	28.2	28.2	34.9
Carcass measurements						
Dressing out (%)	43.7	45.6	46.8	43.2	45.2	46.8
Leg (%)	34.8	34.6	34.2	34.5	34.6	32.7
Loin-rack (%)	23.3	24.4	25.1	23.7	23.1	24.6
Shoulder (%)	41.8	41.0	40.7	42.1	42.3	42.7
12th rib measurements						
Fat thickness (mm)	2.0	3.7	4.6	2.6	3.4	5.1
Loin-eye area (cm^2)	8.4	10.5	13.3	7.7	10.6	11.9
Ether extract (%)	6.4	7.7	9.6	6.3	7.4	9.1
Fat (%)	25.2	34.2	35.8	30.8	34.0	41.8
Bone (%)	20.1	16.0	16.8	17.8	15.6	12.4
Muscle (%)	54.7	49.8	47.4	51.4	50.3	45.7
Weight/day of age (g)	177	214	227	181	231	246

The author concluded that carcass of F cross with DLS was not inferior to that of DLS and it compared fairly well with carcass of other domestic breeds in Canada.

4.1.2 Fahmy (1983) compared the maternal performance of three F crosses with the DLS (1/4F, 1/2F and 3/4F) to that of pure DLS. The results (Table 3) showed that the four genetic groups were extremely fertile (between 96 and 99%). The number of lambs born and weaned increased progressively with the increase in proportion of the F breed. The 3/4F group had the highest prolificacy at birth (2.2 lambs born), 75% higher than DLS, but 0.3 lambs (12%) of these lambs died at birth or were born dead. The lowest mortality at birth was that of 1/4 F cross at 3.6%. Of 1.9 lambs born alive to 3/4F ewes, another 0.3 lambs (17%) died before weaning. This high natal and preweaning mortality rate of 3/4F cross resulted in similar litter size at weaning for 3/4F and 1/2F ewes which was significantly larger than in 1/4F and DLS ewes (by 26 and 50% respectively). Finnsheep crosses produced heavier litters at birth and at weaning than DLS (between 6 and 9% at birth, and 11 and 14% at weaning). Date of lambing (following mating starting in June 1 to October 31) was earliest in DLS followed by 1/4F, 1/2F and 3/4F in that order. The relation was linear between date of lambing and proportion of F sheep breeding in the cross.

Table 3. Productivity of DLS and Finnsheep (F)-DLS crosses and superiority of the crosses (%) relative to DLS

	Genetic groups				Superiority of the crosses		
	DLS	1/4F	1/2F	3/4F	1/4F	1/2F	3/4F
No. of animals	193	166	273	29			
Fertility (%)	98[a]	99[a]	97[a]	96[a]			
Lambs born/litter total	1.23[a]	1.42[a]	1.89[b]	2.15[c]	15.4	53.6	74.8
Lambs born/litter alive	1.17[a]	1.37[a]	1.75[b]	1.92[c]	17.1	49.6	64.1
Lambs weaned/litter	1.09[a]	1.29[a]	1.61[b]	1.64[b]	18.3	47.7	50.4
Litter birth wt total (kg)	5.05[a]	5.32[a]	5.68[a]	5.69[a]	5.3	12.5	12.7
Litter birth wt alive (kg)	5.07[a]	5.41[a]	5.54[a]	5.36[a]	6.7	9.3	5.7
Litter weaning wt (kg)	27.1[a]	30.1[a]	30.9[a]	30.4[a]	10.8	13.7	11.8
Lambing date	28/12[a]	30/12[b]	7/01[c]	15/01[c]			

[a-c] In this, and in other tables presented in this bulletin, means followed by different letters are statistically significantly different.

The conclusion drawn from this study was that although F crosses may be decisively superior to local breeds in prolificacy, however, when measuring ewe productivity in terms of kilograms of weaned lambs, the advantage of the F crossing become less evident due to high mortality and slower growth rate of their lambs.

4.1.3 Fahmy (1985) reported on a population of 139 entire male lambs born in 1980 and 1981 and fed ad libitum for eight weeks a ration of grass and legume silage supplemented with grain mixture. The lambs represented the DLS breed and six of its crosses with the Finnsheep ranging from 1/8F to 6/8F. The lambs were slaughtered at about 43 kg liveweight and measurements of length, heart girth and circumference of leg were taken on the chilled carcasses. The carcasses were then divided into leg, loin-rack and shoulder cuts and each was expressed as a percentage of the whole weight. Kidney and pelvic fat were separated and weighed. The 12th rib cut was dissected into fat, bone and muscle and the percentage of each was calculated. The area of the two loin-eye muscles of the 12th rib and three measurements of backfat over that muscle were measured and averaged. The percent fat in the loin-eye muscle was determined by ether extraction.

Table 4. Least-square means for growth and carcass characteristics of DLS and the different crosses of Finnsheep (F) x DLS

	Genetic groups							
	6/8F	5/8F	4/8F	3/8F	2/8F	1/8F	DLS	b
No. of lambs	20	18	20	20	19	19	23	
Weights and gains								
Birth weight (kg)	3.06^{d}	3.79^{c}	4.05^{bc}	3.41^{c}	3.87^{abc}	4.37^{ab}	4.48^{a}	-0.19*
Weaning weight (kg)	20.2	21.8	23.2	27.1	21.4	22.9	22.6	-0.27
Preweaning ADG (g/day)	245	259	271	264	252	264	257	-0.89
Gain on test (g/day)	137^{a}	141^{a}	128^{b}	119^{b}	114^{b}	122^{b}	119^{b}	+3.6*
Age at slaughter (day)	264	268	243	269	264	276	264	-1.67
Weight at slaughter (kg)	43.0	44.6	44.4	42.5	43.2	43.8	43.2	
Carcass dimensions								
Body length (cm)	64.8	64.3	64.4	62.7	63.6	64.1	64.0	+0.10
Heart girth (cm)	70.7	72.1	70.5	72.3	72.7	71.4	71.0	-0.06
Leg circumference (cm)	32.7	33.6	34.4	34.1	33.9	34.3	34.2	+0.18
Carcass percentages								
Dressing (%)	42.8^{ab}	42.8^{ab}	42.4^{ab}	42.2^{ab}	44.1^{a}	41.2^{b}	41.8^{b}	+0.16
Leg (%)	32.4^{d}	32.4^{d}	32.8^{cd}	33.3^{b}	32.8^{cd}	34.7^{a}	34.4^{a}	-0.38
Loin (%)	28.1	28.3	28.7	27.6	28.4	27.0	28.0	+0.14
Shoulder (%)	39.3	39.1	38.3	38.7	38.8	38.5	37.7	+0.18
Kidney fat (%)	3.15^{ab}	2.99^{abc}	3.31^{a}	2.79^{abc}	2.60^{c}	2.41^{c}	2.45^{c}	+0.15**
12th rib measurements								
Lean (%)	42.8	41.4	40.1	42.6	44.6	45.1	45.3	-0.73
Fat (%)	33.4^{ab}	34.7^{a}	36.4^{a}	34.2^{a}	32.8^{ab}	29.8^{b}	28.3^{b}	‡
Bone (%)	22.0	22.7	21.9	22.1	21.2	23.8	25.3	-0.39
Area of loin-eye muscle (cm^2)	10.7	10.7	11.4	11.3	12.4	11.2	12.0	-0.19
Fat over loin-eye muscle (mm)	3.86	3.80	3.92	3.76	3.86	3.06	3.18	+0.14*
Ether extract (%)	10.5	11.4	12.1	12.3	10.7	11.2	10.6	+0.06
Feed conversion ratio	6.34	6.56	7.00	6.84	7.19	6.66	6.51	

b Regression coefficient on proportion of F in the cross.
‡ Quadratic regression, b_2 = -3.11*, b_2 = 0.42**
*, ** In this, and in other tables * and ** refer to significance ($P<0.05$ and $P<0.01$, respectively).

DLS and 1/8F lambs were the heaviest at birth (Table 4). Birth weight seemed to decrease almost linearly with the increase in the proportion of the F breeding (b=-0.19 kg). Preweaning average daily gain ranged from 245 g (6/8F) to 271 g (4/8F), the differences being nonsignificant. The differences among the seven genetic groups in weaning weight were also small and nonsignificant. The highest gains on test were made by the 6/8F and 5/8F crosses which were significantly higher than the five other genetic groups. The youngest lambs at slaughter were from the 4/8F cross (243 days) followed by DLS, 2/8F and 6/8F lambs (264 days). The differences among these genetic groups were, however, nonsignificant.

The feed conversion ratios were similar at about 6.8. No consistent differences were observed among the genetic groups though it may be mentioned that the crosses were either equal to or slightly less efficient than the pure DLS. DLS lambs and those from the six F crosses were very similar in carcass dimensions (Table 4).

Dressing percentages were rather low ranging from 41.2% for the 1/8F to 44.1% for the 2/8F, the difference being significant. The present study demonstrated that there were only slight differences, mostly nonsignificant, in favor of the crosses in dressing percentage. DLS and 1/8F lambs were more developed in the leg area, the differences in percent leg between these two genetic groups and the other crosses being significant. No significant differences were observed between the genetic groups in percent loin or shoulder of the carcass. The percent of fat around the kidneys and pelvis increased gradually and almost linearly with the increase in the F proportion (b=0.149). The 4/8F cross had the highest percentage of kidney and pelvic fat (3.31%), which was significantly different from DLS, 1/8F and 2/8F crosses. DLS lambs tended to have more lean and bone and less fat in the 12th rib than the other crosses. Significant differences were observed only in percent fat (Table 4).

The relation between proportion of F in the cross and fat percentage was curvilinear. The 4/8F cross was again the fattest followed by 5/8F and 3/8F. No significant differences among the genetic groups were observed in the area of loin-eye muscle, average fat thickness over the loin-eye muscle, or percent fat in the loin-eye-muscle (ether extract analysis).

The author concluded from this study that the characters which showed a linear trend with the increase in F proportion were those related to fat deposition in the body whether internally, externally or intramuscularly. And that, in general, crosses with various portions of F breeding produce lambs comparable in quality to those from DLS a population with no F ancestry.

4.1.4 Fahmy (1987) worked on wool production and fleece characteristics of DLS, Finnsheep and their crosses. The samples used were wool fibers grown on 2 cm^2 of skin removed from the shoulder region of 273 female yearlings over a period of three years. The yearlings represented nine genetic groups, F, DLS and seven combinations ranging from 1/8F to 7/8F. The traits studied were staple length, fiber density, clean wool percentage, fiber length and thickness and their variability. Grease fleece weight (GFW) was recorded at first shearing on the 273 yearlings and on an additional 90 female yearlings. GFW was subsequently recorded at yearly intervals up to the 5th shearing.

The results indicated that F yearlings had 1.4 cm longer staple and 3.3 cm longer fibers than DLS yearlings (Table 5). Variability in fiber length was significantly higher in F than in all the genetic groups studied (except for the 5/8F). Among the crosses, the 4/8F, 5/8F and 6/8F had the longest staple (13.9-14.3 cm) and wool fibers (18.5-20.1 cm). The means for these crosses were close to those for pure F (13.4 and 19.1 cm, respectively). Lambs sired by F rams or born to F ewes had the highest variability in fiber length and fiber thickness. Fiber density was 1551 fibers/cm^2 in DLS compared to 1950 fibers/cm^2 in F. It ranged in the crosses between 1642 fibers/cm^2 in 7/8F to 1856 fibers/cm^2 in 6/8F.

DLS yearlings had the lowest percentage of clean wool (61.2). The differences were significant with all other genetic groups except 1/8F, 3/8F and pure F (Table 5). The highest percentage of clean wool was shown by 7/8F (66.2) and 4/8F (66.1), the differences with the other crosses were nonsignificant. Finnsheep and 7/8F 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 (Table 5). The difference of 5 μm between the yearlings of the two pure breeds was highly significant.

Table 5. Least squares means for wool production and fleece characteristics of DLS, Finnsheep (F) and crossbred yearlings

	Genetic groups								
	DLS	1/8F	2/8F	3/8F	4/8F	5/8F	6/8F	7/8F	F
No. of yearlings	37	31	37	31	29	39	32	18	19
Staple length (cm)	12.0^{a}	12.3^{a}	12.0^{a}	12.6^{a}	14.3^{bc}	13.9^{bc}	14.3^{c}	12.9^{ab}	13.4^{abc}
Fiber density/cm2	1551^{a}	1757^{ab}	1740^{ab}	1798^{ab}	1675^{ab}	1756^{ab}	1856^{b}	1642^{ab}	1950^{b}
Clean wool (%)	61.2^{a}	61.4^{ab}	63.8^{bc}	63.6^{abc}	66.1^{c}	64.6^{c}	65.1^{c}	66.2^{c}	63.5^{abc}
Fiber length (cm)	15.8^{a}	16.9^{ab}	18.0^{bc}	17.7^{bc}	18.5^{bc}	19.2^{cd}	20.1^{d}	18.8^{cd}	19.1^{cd}
Variability in fiber length (cm)	2.96^{a}	3.06^{a}	3.26^{a}	3.43^{ab}	3.95^{bc}	4.04^{cd}	3.95^{bc}	3.52^{abc}	4.66^{d}
Fiber thickness (μm)	25.5^{d}	23.3^{c}	23.7^{d}	23.0^{bc}	23.4^{c}	22.7^{bc}	22.2^{bc}	21.5^{ab}	20.5^{a}
Variability in fiber thickness (μm)	5.9^{b}	5.1^{a}	5.2^{a}	5.2^{a}	5.4^{a}	5.3^{a}	4.9^{a}	4.6^{a}	4.8^{a}
1st shearing (kg)	2.27^{a}	2.32^{a}	2.37^{a}	2.20^{b}	2.55^{a}	2.24^{b}	2.18^{b}	1.78^{c}	2.35^{a}
2nd shearing (kg)	2.40^{a}	2.45^{a}	2.30^{ab}	2.44^{a}	2.39^{ac}	2.21^{bc}	2.16^{b}	1.84^{d}	2.02^{bd}
3rd shearing (kg)	2.81^{ab}	2.97^{a}	2.78^{ab}	2.58^{cd}	2.67^{ac}	2.62^{bc}	2.39^{ce}	2.25^{de}	1.89^{e}
4-5th shearing (kg)	2.77^{ab}	2.88^{a}	2.98^{a}	2.74^{ac}	2.92^{a}	2.57^{bcd}	2.36^{de}	2.22^{de}	2.02^{e}

Finnsheep and the crossbred ewes with high proportion of F breeding were generally lower in wool production than DLS ewes and ewes from crosses with high proportion of DLS breeding. Wool production generally increased with advance in age. Most of the crosses showed positive heterosis in first and second shearings and all the crosses showed high positive heterosis in third and later shearings. The highest expression of heterosis was observed in the 4/8F and 5/8F crosses (Table 5). The fleeces of the 1/8F cross ewes were consistently heavier than those of the DLS ewes. The relationship between the proportion of F breeding and grease fleece weight was linear for the second shearing and curvilinear for later shearings.

The regression analyses of the traits studied on the proportion of F in the genetic group indicated that the relation was linear for fiber thickness. The relation was also linear for variability in fiber thickness and variability in fiber length and curvilinear in 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 author concluded from the study that crossing the DLS with F resulted in an improvement (often significant) in wool production and fleece characteristics in the crosses as compared to the DLS. Crosses with equal and near equal proportions of the two breeds (4/8F, 5/8F and 3/8F) seem to be the best combinations between these two breeds for GFW and wool characteristics.

4.1.5 Fahmy and Dufour (1988) reported on reproductive performance and body weight of 361 ewes, representing Finnsheep, DLS and seven combinations ranging from 1/8F to 7/8 F breeding. Data were collected on conception rate, ovulation rate, gestation length, prolificacy (number of lambs born, born alive and weaned), litter weight at birth and weaning, ova loss and preweaning lamb mortality. Weight of lambs at birth and at weaning and ewe weight at lambing were also studied. Weight of lambs weaned per ewe exposed was considered as a representative measurement of overall ewe productivity.

The results indicated that only 61.5% of DLS yearlings exposed to rams at 7-8 months of age conceived compared to 89.0% of F yearlings. This wide difference was explained in part by differences in age at sexual maturity, F being an early-maturing breed. This explanation was also supported by the progressive increase in conception rate in the crosses with an increase of F breeding. At later parities, conception rates were generally high (avg. 94%) and with a few exceptions, similar in the different genetic groups. Differences between genetic groups were generally small, across parities.

Ovulation rate was lowest in DLS and 1/8F groups and highest in F, 7/8F and 6/8F groups (Table 6). Ovulation rate increased with age from 2.36 at 1.5 to 2.64 and 2.90 at 2.5 and 3.5 years of age, respectively. DLS ewes averaged 1.44 lambs at birth of which 3% were born dead as compared to 2.86 lambs and 8% for F. Litter size at birth increased progressively from 1.63 for 1/8F to 2.42 lambs for 7/8F ewes. DLS ewes weaned 1.22 and F, 2.03 lambs. The averages were 0.70 and 1.68 at one year of age, respectively. Litter size at birth of ewes with 4/8F or higher F breeding was significantly higher than those with proportion lower than 4/8F breeding (Table 6).

The difference in litter weight at birth between DLS, the lightest, and F, the heaviest group, was 1.35 kg. Litter birth weight of the seven crosses was intermediate (Table 6). Average birth weight of lambs derived by dividing litter weight by the number of lambs born (thus not adjusted for sex or type of birth), showed that the heaviest lambs born were to DLS ewes (4.15 kg) whereas lambs from F ewes were the lightest (2.65 kg).

At weaning, the heaviest litters were those raised by 4/8F ewes (31.7 kg) followed by 7/8F (30.8 kg), while those raised by DLS and 2/8F ewes were the lightest, the differences being significant (Table 6). Preweaning average daily gain of lambs ranged between 182 g for F to 217 g for those raised by 4/8F and 1/8F ewes. Lamb weaning weight was similar for DLS, 1/8F, 2/8F, 3/8F, and 4/8F groups, 1 to 2 kg heavier than those raised by 5/8F, 6/8F and 7/8F ewes. Finnsheep-raised lambs were the lightest at weaning, weighing 15.4 kg.

Number of ova not resulting in lambs per ewe mated varied in different genetic groups and ranged from 18.2% in 1/8F to 29.4% in 6/8F crosses (Table 6). Crosses with F exceeding 2/8F, lost between 26.0 and 29.4% of their ova, in spite of the wide differences observed between these crosses in ovulation rate. 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 (Table 6). The high proportion of lambs born dead was observed for 6/8F ewes (5.2%) whereas the lowest rate (0.8%) was observed in the 5/8F group. Preweaning mortality rate was highest (22.9%) in F and lowest in 3/8F group (9.4%).

Average gestation period of DLS ewes was 146.2 days, one day longer than that of F, 7/8F and 3/8F ewes (Table 6). Gestation period of 6/8F ewes was 144.9 days, whereas 1/8F ewes carried their litters for 146.0 days. Average number of lambs weaned per ewe mated extended from 1.89 (F) to 1.06 (DLS) weighing from 27.6 kg (4/8F) to 18.1 kg (DLS).

Table 6. Least squares means for the reproductive traits studied according to genetic group

	Genetic groups								
	DLS	1/8F	2/8F	3/8F	4/8F	5/8F	6/8F	7/8F	F
Conception rate	86.3^{c}	91.3^{abc}	95.6^{ab}	90.6^{abc}	97.2^{ab}	96.9^{a}	88.5^{bc}	92.1^{abc}	96.0^{abc}
Ovulation rate	1.76^{a}	1.84^{a}	2.15^{b}	2.45^{bc}	2.68^{c}	2.88^{cd}	3.22^{d}	3.26^{d}	3.42^{d}
Litter size at birth	1.44^{a}	1.63^{b}	1.67^{bc}	1.81^{c}	2.12^{de}	2.05^{d}	2.26^{e}	2.42^{f}	2.86^{g}
Litter size at weaning	1.22^{a}	1.44^{b}	1.45^{b}	1.52^{b}	1.84^{cd}	1.76^{cd}	1.69^{c}	1.91^{cd}	2.03^{d}
Litter wt at birth (kg)	5.75^{a}	6.27^{a}	6.22^{ac}	6.26^{ac}	6.56^{bc}	6.37^{bc}	6.16^{a}	6.67^{bc}	7.10^{c}
Litter wt at weaning (kg)	23.0^{a}	27.7^{cf}	24.9^{ab}	26.3^{bc}	31.7^{e}	29.4^{def}	28.5^{cd}	30.8^{def}	29.1^{cde}
Avg. lamb birth wt (kg)	4.15^{a}	4.00^{ab}	3.87^{b}	3.68^{c}	3.28^{d}	3.25^{d}	2.97^{e}	2.96^{de}	2.65^{e}
Avg. lamb weaning wt (kg)	18.4^{ab}	19.2^{a}	18.1^{ab}	18.3^{ab}	18.5^{ab}	17.3^{bc}	16.5^{c}	16.3^{c}	15.4^{c}
Ova loss/ovulation (%)†	18.3^{a}	18.2^{a}	21.3^{ab}	26.0^{ab}	26.5^{ab}	26.2^{ab}	29.4^{b}	27.9^{ab}	26.2^{ab}
Ova loss/ovulation (%)‡	9.2^{a}	10.5^{ab}	16.8^{bc}	18.7^{c}	18.9^{c}	22.6^{c}	21.7^{c}	23.3^{c}	23.9^{c}
Lambs born dead/born (%)‡	3.04^{ab}	5.50^{a}	2.79^{ab}	4.24^{a}	5.50^{a}	0.82^{b}	5.18^{a}	2.87^{ab}	8.02^{a}
Lambs dead before weaning/ total born alive (%)‡	13.9^{ab}	10.3^{a}	10.7^{ab}	9.4^{a}	9.8^{a}	12.6^{ab}	17.4^{b}	17.0^{ab}	22.9^{b}
Gestation length (d)	146.2^{a}	146.0^{ab}	145.1^{c}	145.3^{c}	145.4^{bc}	145.1^{c}	144.9^{c}	145.2^{bc}	145.2^{bc}
No. of lambs weaned	1.06^{a}	1.26^{b}	1.36^{b}	1.34^{b}	1.72^{c}	1.67^{c}	1.45^{b}	1.74^{c}	1.89^{c}
kg of lambs weaned	18.1^{a}	22.3^{b}	22.2^{b}	21.4^{b}	27.6^{c}	25.8^{c}	22.0^{b}	25.5^{bc}	26.0^{bc}

†, ‡ Per ewe mated and per ewe exposed, respectively.
F = Finnsheep.

At first lambing, F ewes weighed 43.7 kg, 7.8 kg heavier than DLS ewes. This difference in weight disappeared with age and at five years of age DLS ewes were 4.5 kg heavier (61.9 vs. 57.4 kg). The heaviest ewes at one year were the 4/8F averaging 45.5 kg whereas the lightest were the 7/8F ewes (36.1 kg). The heaviest mature weights were those of 3/8F and 4/8F crosses (66.4 an 65.5 kg, respectively), however the differences with other crosses were rather small. The 4/8F cross showed the highest heterosis in litter size an litter and lamb weights at weaning and the second highest heterosis in ovulation and conception rates (Table 6). Ewes from 4/8F group produced 25% more kilograms of lambs at weaning than the average of their parental breeds.

Significant positive linear regressions were found for ovulation rate, litter size at birth and weaning and preweaning mortality rate, indicating that these traits increased progressively with increase in F proportions. On the other hand, significant negative linear relationships were found for average lamb weight at birth and at weaning suggesting the opposite tendency.

Significant quadratic relationships were calculated for percent of ova lost, lamb mortality at weaning and weight of ewe at lambing. Crosses with low proportions of F (1/8F to 3/8F) produced 22 kg of lambs weaned, those with higher proportions (5/8F to 7/8F) produced about 24.5 kg, whereas the 4/8F cross gave the highest performance (27.6 kg).

The authors concluded that each increase of 1/8 breeding contributed by F resulted in a 0.24 increase in number of ova shed. However, over 25% of these ova were lost in genetic groups with 3/8 and higher F breeding. The relation between F breeding and litter size at birth was linear. Preweaning mortality rate was similar in crosses with 1/8F to 4/8F breeding and increased markedly with the increase in F breeding above 5/8. The 4/8F cross showed a marked superiority in litter size at weaning (51% over DLS).

The 4/8F cross exhibited the highest performance in litter weight at weaning. Compared to the theoretical expectations, the two crosses closest to the parental breeds (1/8F and 7/8F) were generally superior to the two crosses closest to the F_1 (3/8F and 5/8F), whereas the two backcrosses (2/8F and 6/8F) ranked lowest.

4.1.6 Fahmy (1989a) collected data on growth and carcass on 252 multiple-born lambs representing 11 genetic groups, fed either high-energy mainly concentrate ration or low-energy mainly roughage ration and slaughtered at either 32 or 41 kg liveweight. The lambs were the progeny of Suffolk rams mated to Suffolk (S), F, DLS ewes and ewes from seven F-DLS crosses ranging between 1/8F to 7/8F in addition to DLS x DLS lambs.

Lambs produced by crossing S rams with DLS, F and the seven crosses between DLS and F ranged between 195 and 226 g/day in average daily gain (ADG) to 32 kg liveweight (Table 7). The differences among genetic groups were generally small and nonsignificant. Growth rate from 32 to 41 kg liveweight was highest in lambs from 7/8F ewes followed by those from 3/8F ewes (262 and 256 g/day, respectively).

Dressing percentage ranged from 43.2% in S to 46.6% in S x F lambs and was generally similar in crosses with differing proportions of DLS and F breeding in the dam (Table 7). The proportion of shoulder varied within a limited range in the different genetic groups. As expected, lambs from F ewes had the highest percentage of kidney and pelvic fat (4.1%). DLS lamb had higher kidney fat percentage than all but one F cross (Table 7). Suffolk lambs had the highest percentage of lean and bone and the lowest percentage of fat in the 12th rib and thinner fat cover over that rib, as compared to the other genetic groups. They also had the darkest loin-eye muscle color. The area of loin-eye muscle was largest in S x DLS lambs (12.6 cm^2) and smallest in S x 6/8F (10.6 cm^2) lambs. The area ranged between 11.1 to 11.6 cm^2) in the other genetic groups.

Significant linear regressions of traits on proportion of F breeding in the dam of the lamb were observed for leg percentage (b=-0.18) loin-rack percentage (b=0.16), percent kidney fat (b=0.12), area of loin-eye (b=-0.16) and color of loin-eye muscle (b=-0.07). Lambs with F ancestry were valued between $153 (2/8F) and $165 (4/8F) and those of pure S $156 (Table 7). Returns per ewe

Table 7. Least squares means for the different genetic groups

	S† DLS†	S 1/8F	S 2/8F	S 3/8F	S 4/8F	S 5/8F	S 6/8F	S 7/8F	S F	DLS	Suffolk (S)
No.	19(8)‡	18(6)	18(9)	21(9)	23(9)	24(10)	24(10)	12(3)	17(6)	18(13)	23(9)
Weight gain											
Gain to 32 kg (g/d)	204^{ab}	195^{ab}	212^{ab}	202^{ab}	226^{a}	207^{ab}	196^{ab}	202^{ab}	203^{ab}	177^{b}	178^{b}
Gain 32-41 kg (g/d)	225^{a}	244^{a}	228^{a}	256^{a}	242^{a}	195^{a}	189^{a}	262^{a}	238^{a}	193^{a}	218^{a}
Age at slaughter (d)	193^{ab}	194^{ab}	204^{ab}	198^{ab}	186^{a}	195^{ab}	203^{ab}	191^{ab}	206^{ab}	214^{b}	188^{a}
Weight/day of age (g)	201^{a}	196^{ab}	188^{ab}	193^{ab}	207^{a}	197^{ab}	189^{ab}	204^{ab}	185^{ab}	176^{b}	202^{a}
Carcass percentages											
Dressing (%)	45.3^{ab}	45.7^{a}	44.9^{ab}	44.9^{ab}	44.0^{bc}	44.7^{ab}	44.9^{ab}	44.0^{bc}	46.6^{a}	46.0^{ab}	43.2^{c}
Leg (%)	34.6^{b}	33.8^{bcd}	34.1^{b}	34.0^{b}	34.3^{b}	33.8^{bc}	32.9^{d}	33.0^{cd}	33.1^{cd}	33.8^{b}	35.7^{a}
Loin-rack (%)	29.7^{bc}	29.1^{c}	29.8^{bc}	29.4^{bc}	29.1^{c}	29.4^{bc}	30.5^{ab}	30.2^{abc}	31.0^{a}	30.5^{ab}	27.1^{d}
Shoulder (%)	35.3^{c}	36.8^{a}	35.7^{bc}	36.0^{ab}	36.4^{ab}	36.5^{ab}	36.4^{ab}	36.9^{ab}	35.5^{bc}	35.3^{c}	36.9^{a}
Kidney fat (%)	3.13^{c}	3.05^{c}	3.12^{c}	2.90^{c}	3.15^{c}	3.34^{c}	4.05^{b}	3.36^{bc}	4.09^{b}	3.48^{bc}	2.15^{a}
12th rib measurements											
Lean (%)	43.6^{b}	42.0^{b}	43.3^{b}	42.7^{b}	43.4^{b}	41.8^{b}	40.9^{b}	43.4^{ab}	41.7^{b}	40.4^{b}	47.6^{a}
Fat (%)	36.4^{b}	38.7^{bc}	37.0^{b}	36.9^{b}	36.5^{b}	39.1^{bc}	39.8^{bc}	37.8^{bc}	38.8^{bc}	42.3^{c}	29.2^{a}
Bone (%)	18.1^{b}	17.4^{bc}	17.7^{bc}	18.8^{b}	18.1^{b}	17.6^{bc}	17.2^{bc}	16.9^{bc}	17.5^{bc}	15.5^{c}	21.6^{a}
Color of loin-eye	8.76^{ab}	8.48^{ab}	8.51^{ab}	8.20^{ab}	8.12^{ab}	8.26^{ab}	8.22^{ab}	8.33^{ab}	7.97^{a}	8.31^{ab}	8.92^{b}
Area of loin-eye (cm^2)	12.6^{a}	11.5^{ab}	11.6^{ab}	11.4^{ab}	11.4^{ab}	11.2^{b}	10.6^{b}	11.1^{ab}	11.1^{b}	11.6^{ab}	11.2^{b}
Fat over loin-eye (mm)	4.78^{b}	5.44^{bc}	4.83^{b}	5.01^{bc}	5.02^{bc}	5.25^{bc}	5.10^{bc}	5.53^{bc}	5.24^{bc}	6.02^{c}	3.75^{a}
Carcass dimensions											
Heart girth (cm)	68.2^{ab}	69.2^{b}	68.3^{ab}	68.3^{ab}	67.5^{c}	68.8^{ab}	68.3^{ab}	67.9^{ab}	68.3^{ab}	69.2^{b}	66.1^{a}
Body length (cm)	64.0^{bc}	63.1^{bc}	63.8^{bc}	64.0^{bc}	63.4^{bc}	64.3^{b}	63.2^{bc}	64.4^{bc}	64.1^{bc}	62.8^{c}	66.8^{a}
Leg circumference (cm)	38.4^{a}	37.5^{abc}	37.2^{c}	38.0^{ab}	36.9^{c}	37.8^{abc}	37.4^{c}	36.5^{c}	37.7^{abc}	38.1^{ab}	37.3^{c}
Economic returns											
Value of carcass ($)	169.1^{a}	162.8^{ab}	153.8^{bc}	155.5^{ab}	165.0^{ac}	158.7^{ab}	156.1^{ab}	157.4^{ab}	158.4^{ab}	149.3^{b}	156.1^{ab}
Returns/ewe ($)	207.3^{b}	235.1^{c}	223.2^{bc}	236.7^{c}	302.6^{f}	279.0^{de}	263.6^{d}	298.5^{ef}	319.8^{f}	108.8^{a}	225.4^{bc}
Returns/kg ewe wt ($)	3.76^{de}	4.10^{d}	4.05^{d}	4.15^{d}	5.11^{bc}	5.05^{bc}	4.79^{c}	5.36^{b}	6.39^{a}	3.28^{f}	3.64^{ef}

† All these crosses were mated to Suffolk rams.
‡ No. of animals for gain 32-41 kg.

(carcass value x no. of lambs weaned) were highest for F, 4/8F and 7/8F ewes ($320-$298) and lowest for DLS ewes mated to DLS rams ($ 181). Most of the differences among genetic groups were statistically significant.

Pure F ewes mated to S rams produced $6.39 worth of retailed lamb for each kilogram of their liveweight, $2.75 (76%) more than pure S ewes. The greater number of lambs marketed combined with lower ewe body weight in the present study, and higher lamb dressing percentage as a result of greater fat deposition more than offset the heavier weights of S lambs when slaughtered at 200 days. Crosses with high F breeding (4/8F to 7/8F) generated on average, 39% (32-47%) more revenue per kilogram of ewe liveweight than pure S, whereas for crosses with low F breeding (1/8F to 3/8F), the advantage was about 12% (11 to 14%) and for S x DLS ewes it was only 3%.

The author concluded that crossbred ewes from different combinations between F and DLS mated to S rams produced lambs of comparable and generally acceptable quality. In spite of the presence of 50% S ancestry in the lambs, the tendency for greater fat deposition with increased proportion of F breeding was still apparent in the three-breed crossbred lambs.

In a report summarizing the different phases of this crossbreeding project Fahmy (1988) concluded that the advantage in prolificacy brought about by using high proportions of F in crossbreeding schemes more than offsets the slight reduction in carcass value of the resulting progeny destined for market. At low proportions of F breeding, the overall advantage over a standard breed such as the S was relatively small.

4.1.7 Fahmy (1989b) used ovulation records on 214 ewes laparoscopied in the fall of 1981 through 1985 together with corresponding lambing records to determine to what extent gradual change in ovulation level from low to high affects the repeatability of ovulation rate and the resulting number of lambs born. The ewes represented DLS, F and seven of their crosses ranging from 1/8F to 7/8F. Ovulation rate was determined by counting the number of corpora lutea (CL) present in the ovaries 3-5 days after mating. The total number of lambs born by ewes laparoscopied was recorded. Ova loss in terms of number of ovulations not resulting in lambs was also studied. For ewes which gave no birth following their latest laparoscopy, all ovulations were considered lost.

The results indicated that the intrayear repeatability estimated for each genetic group ranged from -0.20 for DLS to 0.93 for 5/8F cross (Table 8a). The interyear repeatability of ovulation rate calculated as product moment correlation was 0.46 between first and second, 0.58 between second and third and 0.56 between first and third seasons (avg. 0.53). The interseason intraclass correlation for each genetic group ranged between 0 for DLS and 0.54 for 3/8F ewes. Estimates were lower at both ends of the scale of F breeding in genetic groups and a curvilinear relationship could be fitted to these estimates as affected by F breeding.

Increase in ovulation rate brought about increase in variability. This variability showed a curvilinear tendency similar to that of repeatability. Number of lambs born increased linearly (b=0.12**) with increased proportion

Table 8a. Least squares means and repeatabilities (t) of ovulation rate for DLS, Finnsheep (F) and their crosses

Genetic group	Within-season ovulations				Between-season ovulations		
	No.	1st ovul.	2nd ovul.	t	No.	Mean ovul.	t
DLS	18	1.80	1.73	-0.20	28	1.78	0.00
1/8F	22	1.78	1.82	0.60**	29	1.73	0.21
2/8F	18	2.18	2.02	0.45	27	2.17	0.32
3/8F	20	2.26	2.64	0.55*	34	2.38	0.54**
4/8F	19	2.86	2.81	0.55*	21	2.87	0.50*
5/8F	15	2.80	3.15	0.93**	29	2.83	0.43*
6/8F	19	2.92	3.12	0.52*	23	3.10	0.31
7/8F†	12	3.50	2.97	0.31	23	3.15	0.28
Avg.	143	2.62	2.65	0.59**	214	2.58	0.38**

† Includes pure Finnsheep.

of F breeding. The repeatabilities of number of lambs born were generally small and mostly nonsignificantly different from zero. No definite trend could be established. Variability in number of lambs born increased with increase in its level.

Table 8b. Mean and repeatabilities for number of lambs born (LB) and ova loss (OL) of DLS, Finnsheep (F) and their crosses

	Means			Repeatability	
	LB	OL	%†	LB	OL
DLS	1.25	0.55	31	0.15	0.11
1/8F	1.30	0.52	30	0.48**	0.23
2/8F	1.50	0.76	35	-0.01	-0.09
3/8F	1.48	1.04	44	0.05	0.20
4/8F	1.48	1.35	47	0.10	0.14
5/8F	1.86	0.99	35	0.04	0.15
6/8F	1.78	1.34	43	0.03	-0.05
7/8F	2.14	1.08	34	0.18	0.22
All groups	1.59	0.91	35	0.15*	0.14*

† 100 ova loss/ovulation rate.

The number of ova lost ranged between 0.52 and 1.35 (Table 8b). In five genetic groups the percentage of loss relative to the number of CL counted at laparoscopy ranged between 30 and 35%. The repeatabilities of ova loss for the different genetic groups were generally small and nonsignificantly different from zero. The correlations between ovulation rate and ova loss averaged 0.58 whereas those between number of lambs born and ova loss averaged -0.62.

The author concluded that repeatability of ovulation rate increased with increased ovulation to a certain level after which the relationship was less evident. Also that the data did not suggest that repeatability was strongly associated with the variability within groups of different levels of performance. That although both ovulation rate and number of lambs born showed similar tendency for linear increase (with increase of F breeding for example), traits showed a marked difference in the magnitude and tendency of their repeatability estimates.

4.1.8 Fahmy, Flipot, Wolynetz and Comeau (1989) addressed the question of genotype x diet interaction effect on growth rate and feed efficiency. They examined the problem at two levels, by using different genetic groups and sets of twins within each genetic group. Sets of twin lambs were assigned to a feeding test from weaning until they reached approximately 32 kg liveweight. The lambs were crossbred progeny of five S rams mated to DLS and F ewes, and ewes from seven DLS-F crosses ranging from 1/8F to 7/8F. In addition, pure bred twin lambs from the S and DLS breeds were included.

One lamb from each set of twins chosen at random received a high-energy (HE) diet based on concentrate, the other received a low-energy (LE) diet based on roughages. The HE diet was a mixture of grain, offered free choice and 250 g of grass silage per lamb daily. The LE diet was composed of grass silage, offered free choice, supplemented with 20% of the amount of grain consumed by lambs on the HE diet but not to exceed 250 g per lamb per day.

Table 9. Least squares means and the ranking of the different genetic groups on high and low energy diets for average daily gain and relative average daily gain

Genetic group	Average daily gain				Relative average daily gain				No. of twin sets
	High-energy		Low-energy		High-energy		Low-energy		
	Rank	Means (g/d)	Rank	Means (g/d)	Rank	Means (g/d)	Rank	Means (g/d)	
S x DLS	5	246	11	136	6	10.21	10	6.01	3
S x 1/8F	4	252	10	141	2	11.63	9	6.09	8
S x 2/8F	3	258	5	168	4	11.80	5	7.54	8
S x 3/8F	6	241	9	144	5	11.02	7	6.84	7
S x 4/8F	1	276	1	195	3	11.52	2	8.49	9
S x 5/8F	9	223	3	188	7	9.81	3	8.18	7
S x 6/8F	8	226	4	171	10	9.28	6	7.51	8
S x 7/8F	7	228	6	156	9	9.58	4	7.83	3
S x F	2	264	1	195	1	12.39	1	9.90	6
DLS x DLS	10	214	8	150	8	9.60	8	6.53	7
S x S	11	210	7	151	11	8.27	11	5.58	5

S = Suffolk, F = Finnsheep.

The initial weight was recorded after an adjustment period of 7-21 days. Lambs were weighed every 14 days and a final weight was taken when the lambs reached close to 32 kg liveweight. To account for differences among animals in initial and final weights, relative growth rate (RADG) was calculated.

The results indicated that the genotype x diet interaction among genetic groups (breeds) and between individuals within a set of twins (among animals) was not important for ADG. The genetic group x diet was significant for RADG; the genetic groups which ranked highest and lowest on the HE diet also ranked highest and lowest, respectively, on the LE diet; some of the other genetic groups varied widely in their ranking on the two diets (Table 9). For the crossbred groups fed LE, RADG appeared to increase with the proportion of F in the animals; this trend was not apparent for lambs fed the HE. Differences in the least squares means estimates for RADG between the HE and LE fed lambs ranged from 1.63 g/day for the S x 5/8F group to 5.54 g/day for the S x 1/8F genetic group.

The combined among animals and twins x diet interaction was not significant implying that twin lambs ranked similarly within each diet in ADG and RADG. Genetic group and feeding treatment significantly affected feed conversion ratio.

The authors concluded that the rankings in growth performance of one twin lamb on a roughage diet and its twin on a concentrate diet do not differ greatly and that the procedures applied in test station of feeding lambs high energy, mainly concentrate rations, are justified for identifying lamb's genetic potential for growth.

4.1.9 Fahmy (1990a) studied ewe productivity under an accelerated lambing system of three lambings in two years on 145 ewes representing DLS, F and seven of their crosses. Ewes were mated in spring (April), autumn (August) and winter (December) on a farm located at St. Augustin in the Lac St. Jean region. The animals were born in 1979, 1980 and 1981 and were relocated at St. Augustin in 1985 and 1986. Regular lambing ewes had the apportunity to lamb at least four times. However, on average each ewe remained in the herd for 2.6 lambings. The traits studied were fertility, litter size at birth and at weaning, survival rate at birth and litter weight of lambs born alive. The interval in days between date of consecutive lambings was calculated and the corresponding number of lambings per year was obtained. Annual productivity was calculated by multiplying fertility x litter size at weaning x number of litters per year.

The author showed that fertility was highest in F, 6/8F and DLS (98, 97 and 94% respectively, Table 10). Nearly half of the 7/8F ewes failed to conceive. Mortality at birth was very low, averaging 1.1%. Number of lambs born alive was 1.19 for DLS and 2.53 for F. The two most prolific crosses were the 7/8F (2.75) and 5/8F (2.45). Preweaning mortality was highest for the 1/8F ewes (17.5%) followed by the pure F (11.2%). The largest litters at weaning were those of 7/8F followed by 5/8F ewes.

The flock averaged 1.38 lambings per year which corresponded to a lambing each 264 days (Table 10). A high rate of infertility was responsible for the 7/8F ewes lambing 1.1 times per year. The 5/8F and 6/8F ewes lambed every 8 months while the other genetic groups had lambing intervals between 8.5 and 9 months.

Ewe productivity per year was highest in the 6/8F group (3.27 lambs, 55.3 kg) and lowest in the 7/8F group (1.53 lambs, 24.6 kg). The pure F ewes produced 3.07 lambs weighing 43.9 kg per year compared to 1.71 lambs weighing 32.1 kg per year for the DLS ewes. Significant linear regressions were calculated between number of lambs born alive (b=0.12*), number of lambs weaned (b=0.16**) and the proportion of F in the cross.

Table 10. Least square means for ewe productivity traits of DLS, Finnsheep (F) and their crosses

	Fertility	Lambs born alive	Survival rate (%)	Litter birth wt	No of lambs weaned	Lambing interval (d)	No. of litters /yr	Ewe prod.	Kg of lambs prod.†
DLS	94.5	1.19[a]	100.9	5.47[a]	1.32[a]	267	1.37	1.71	32.1
1/8F	75.4	1.87[b]	99.4	7.29[b]	1.50[a]	260	1.40	1.58	30.5
2/8F	81.9	2.08[bd]	99.7	8.36[cd]	1.96[ab]	273	1.34	2.15	37.0
3/8F	84.0	1.94[bd]	96.7	7.44[b]	1.62[ab]	257	1.42	1.93	33.4
4/8F	87.2	1.91[bd]	99.2	7.39[bc]	1.93[abc]	254	1.44	2.42	41.6
5/8F	88.8	2.45[ce]	98.3	8.24[cd]	2.35[bd]	242	1.51	3.15	52.6
6/8F	97.3	2.21[be]	96.4	7.51[bc]	2.21[d]	240	1.52	3.27	55.3
7/8F	53.6	2.75[ce]	99.7	9.59[d]	2.58[cd]	330	1.11	1.53	24.6
F	97.9	2.53[cde]	100.1	7.89[bcd]	2.18[abd]	253	1.44	3.07	43.9
Avg.	84.5	2.10	98.9	7.69	1.96	264	1.38	2.29	38.7

Ewe productivity = fertility x lambs weaned x No. of litters/yr.
† Ewe productivity x average weaning weight.

The author concluded that crosses involving different proportions of F breeding conform well to the accelerated system of three lambings in two years without the need of artificially synchronizing estrus. Under normal farm conditions, the different combinations produced at a higher level than if subjected to the traditional system of one lambing per year.

4.1.10 Fahmy (1990b) reported on growth, fertility, prolificacy and fleece weight of yearlings representing Booroola Merino (B) Romanov (R) and F first cross and backcross with the DLS breed. The yearlings were born in February and March 1987 and 1988 out of DLS ewes and DLS, R, F and B rams (pure DLS and first crosses) and DLS ewes and R x DLS, F x DLS and B x DLS rams (backcrosses to DLS). In December, when the ewes were between eight and nine months of age, they were distributed equally into ten mating groups of similar size and exposed to rams for a 6-week mating period. The sires used were two each of DLS, R, F, B and Coopworth. The number of ewes exposed per genetic group per year was about 30. The traits investigated were body weights at birth, 50, 100 and 365 days of age, preweaning average daily gain, fertility, prolificacy, survival rates, total weight of lambs and greasy fleece weight at about 14-15 months of age.

Romanov and B first cross and backcross lambs were significantly heavier at birth than those of F (Table 11) while DLS ewe lambs (3.9 kg) were intermediate. The ranking observed at birth was the same up to 100 days of age. At one year of age R first cross ewes averaged 61 kg and were significantly the heaviest group followed by R backcross (56 kg). At the same age R and F crossbred ewes were significantly heavier than DLS ewes, which in turn were about 10% heavier than the B crosses.

Fertility in R crosses averaged 96% and was about 13% higher than in F crosses, which in turn were about 13% higher than in B crosses (Table 11). Almost half of the B first cross ewes failed to conceive at 8-9 months of age compared to about 25% of the DLS and only 2.4% of the R first cross ewes. Prolificacy at birth was highest in R crosses while the F and B crosses were comparable.

Litter weight at birth ranged between 5.2 and 5.5 kg for DLS and B and F crosses and between 19.4 and 21.3 kg 50 days later. Romanov first cross ewes produced litters averaging 6.4 kg at birth and 25.1 kg at weaning while for R back cross the litters averaged 5.8 and 23.1 kg. Greasy fleece weight was highest in B crosses followed by DLS and then by R and F crosses (Table 11).

Table 11. Least squares means for pure DLS, first crosses and backcrosses of Romanov (R), Finnsheep (F) and Booroola (B) with DLS

		First crosses			Back crosses		
	DLS	1/2B	1/2F	1/2R	1/4B	1/4F	1/4R
No. of yearlings	64	59	71	78	70	67	62
Weights in kg at:							
Birth	3.90abc	3.87bcd	3.69cd	3.98ab	4.06ab	3.76d	4.12a
50-day	15.7c	15.7c	16.7ab	16.7ab	17.0ab	16.2bc	17.4a
100-day	20.2c	20.2bc	23.8a	24.1a	21.3bc	21.6b	23.6a
365-day	50.1c	43.9d	54.9b	61.0a	49.6c	51.3c	56.4b
Reproduction							
Fertility (%)	74.5c	50.7d	88.2ab	97.6a	67.9c	78.1bc	93.7a
Prolificacy, birth	1.36c	1.85ab	1.84b	2.07a	1.49c	1.54c	1.79b
Prolificacy, 50 days	1.06c	1.50ab	1.41ab	1.71a	1.12c	1.25bc	1.53a
Litter wt, birth (kg)	5.36b	5.51b	5.35b	6.36a	5.29b	5.19b	5.76b
Litter wt, weaning (kg)	20.4bc	19.6c	21.3bc	25.1a	19.4c	19.4c	23.1ab
Wool Production							
Fleece wt (kg)	3.30bc	3.73a	3.23bc	2.98d	3.41b	3.14cd	3.11cd

The author concluded that R crosses excelled those of B and F in most of the productivity traits, with the performance of B and F crosses being very similar. Booroola crosses excelled in wool production but were markedly inferior in fertility at 8-9 months. The productivity of backcrosses was inferior to that of first crosses. Crossbreeding with either types of prolific breeds improved different aspects of performance of DLS sheep. Each, however, has revealed some disadvantages.

4.1.11 Fahmy, Boucher, Poste, Grégoire, Butler and Comeau (1991) studied growth rate, carcass characteristics and meat eating quality of Finnsheep, Romanov, Coopworth, DLS and Suffolk breeds together with first and backcrosses of Finnsheep, Romanov and Booroola Merino with DLS. The lambs were fed from an initial weight of about 23 kg to a slaughter weight of 43 kg rations based on grass silage, barley and corn supplemented with one of the following protein sources: fishmeal (60%), soybean meal (48%) or corn gluten (60%) -blood meal (80%). A fourth ration with no protein supplementation served as a control. The amounts offered and refused per each pen of 11 lambs (one from each genetic group) were weighed daily. Weights were taken every two weeks and the lambs were slaughtered when they reached near the 43 kg assigned slaughter weight. Routine measurements on the carcasses were taken and a sample from each lamb was evaluated for cooking and eating quality. The results of the study are presented in Table 12. Finnsheep lambs and crossbred F-DLS lambs were lighter at birth than other breeds and crosses. Pure F lambs grew slower than those from the other pure breeds and were the oldest to reach slaughter weight. Finnsheep lambs had higher dressing percentage and higher kidney fat percentage but lower leg percentage as compared to the other pure breeds.

Sensory evaluation of meat samples indicated that no significant breed effects were observed, only F meat had more intense lamb flavour than S meat. There were significant diet effect on average daily gain, percent kidney fat, percent lean, fat and bone of the 12th rib. Lambs fed fishmeal and corn gluten-blood meal grew faster than those fed soybean meal and the control diet. Lambs receiving protein supplement had generally less lean and more fat than those on the control diet.

Table 12. Least square means for the different genetic groups

	Pure breeds					First crosses†			Back crosses‡		
	Co	DLS	R	F	S	1/2R	1/2F	1/2B	1/4R	1/4F	1/4B
No. of animals	11	11	11	12	12	13	12	9	12	12	15
Birth wt (kg)	4.5	4.0	3.2	2.9	3.4	4.2	4.0	4.3	4.4	4.0	4.1
Weaning wt (kg)	18.7	18.5	16.6	12.8	14.3	18.5	19.0	16.6	18.8	18.4	17.4
Wt at 100 (d)	24.5	20.0	21.5	18.1	25.9	25.6	26.5	20.7	23.0	23.0	20.5
ADG on test	152	171	142	147	201	195	185	161	176	165	174
<u>Carcass percentages</u>											
Dressing (%)	38.8	41.8	41.6	42.2	39.5	41.9	41.6	40.6	39.7	42.5	41.1
Leg (%)	33.9	33.9	33.4	31.6	34.6	33.1	33.1	33.6	34.2	33.6	34.0
Loin (%)	29.4	29.3	28.1	29.1	28.6	29.5	29.0	28.3	28.9	29.6	29.0
Shoulder (%)	36.8	37.1	38.9	39.2	37.4	37.6	38.0	38.7	37.2	37.2	37.2
Kidney fat (%)	2.5	2.5	3.4	3.6	2.7	3.1	3.0	2.7	2.8	2.7	2.3
<u>12th rib measurements</u>											
Backfat (mm)	5.1	3.8	3.1	3.7	4.0	4.2	4.2	4.9	4.2	4.5	4.2
Loin-eye area (cm^2)	11.6	13.4	11.2	11.0	12.2	11.6	12.7	13.3	12.1	12.1	12.6
Muscle (%)	38.1	42.8	43.9	41.0	42.3	39.4	41.8	41.3	40.4	40.5	41.0
Fat (%)	37.6	36.3	31.8	37.5	34.4	39.6	36.6	40.0	36.1	37.3	35.8
Bone (%)	23.4	19.7	23.0	19.9	22.2	19.6	20.1	17.6	22.0	20.8	22.6

Co = Coopworth, R = Romanov, F = Finnsheep, B = Booroola Merino.
† 1/2 DLS.
‡ 3/4 DLS.

The authors concluded that with the exception of fat deposition, F and F crossed lambs produced carcasses which were comparable in quality and eating characteristics to lambs of other prolific and meat-type breeds. Protein supplementation had some effect on growth rate but little effect on carcass and meat quality.

4.2 Laval University, Ste.Foy

Studies at Laval University involved a flock of pure Finnsheep and Suffolk and crosses between these two breeds. Also semen from Booroola rams was used to produce Booroola crosses with Finnsheep and Suffolk.

4.2.1 Lirette, Seoane, Minvielle and Froehlich (1984) conducted an experiment using 20 castrate and 20 entire lambs slaughtered at 120 days of age to evaluate differences between Finnsheep, Suffolk and their F_1 cross in conformation, classification, tissue distribution, chemical composition and organoleptic characteristics of the carcasses.

The results (Table 13) showed that average daily gains of F lambs were lower than for other breed groups. Daily weight gains of crossbred lambs were superior to those of purebred F lambs and comparable with those of S lambs. Daily gains of noncastrated lambs were comparable with those of castrated lambs. Purebred F lambs had lighter slaughter weights than lambs of the other breed groups. In general, S produced heavier lambs than F. Carcass weights of F lambs were inferior to those of S and crossbred lambs. The S breed produced lambs whose weight, yield and classification of the carcasses were superior to lambs from the F breed.

Table 13. Performance† of castrate (C) and entire (NC) lambs representing Suffolk (S), Finnsheep (F) and their crosses

	Genetic groups							
	Suffolk		Finnsheep		S x F		F x S	
	C	NC	C	NC	C	NC	C	NC
Slaughter weight (kg)	31.1	35.0	27.2	24.9	32.9	33.5	32.9	32.9
Average daily gain (g/d)	245	278	212	196	255	264	255	254
Dressing (%)	50.2	49.9	48.0	47.4	49.6	47.9	49.8	47.9
Classification	2.8	3.0	1.6	1.0	2.8	2.2	2.4	2.0
Avg. backfat (mm)	6.7	7.6	5.2	3.7	5.2	4.1	5.8	4.2
Kidney fat (%)	1.0	1.0	2.0	1.7	1.6	1.2	1.6	1.1
Shoulder (%)	37.4	39.0	38.2	38.6	37.5	38.4	37.4	38.2
Loin-rack (%)	22.7	22.3	21.6	23.0	24.0	22.3	24.1	23.2
Leg (%)	33.6	32.5	34.4	33.5	32.9	33.3	32.8	32.7
Body muscle (%)	61.3	59.9	60.0	62.4	61.4	63.2	59.2	62.7
Body fat (%)	14.0	16.6	17.8	15.9	17.1	14.1	19.8	16.8
Body bone (%)	24.6	23.5	21.1	21.6	21.5	22.7	21.0	20.5
Warner-Bratzler (g)	1203	1083	906	1118	868	979	884	984
Sensory evaluation								
Flavor	6.5	7.2	8.0	6.7	7.4	8.6	6.0	7.0
Juiciness	8.0	7.3	8.3	7.7	7.7	8.5	8.7	8.8
Tenderness	8.2	7.5	8.9	7.5	9.7	7.9	9.4	9.8

† Based on five lambs per breed-sex subclasses.

Carcass classification of noncastrated F lambs was inferior to all other groups. Posterior limbs and carcasses of F lambs were longer than those of other breed groups. Crossbred lambs possessed intermediate values between the pure breeds for those variables. Classification was superior in lambs having S as one of the parents. Suffolk intact lambs presented a higher accumulation of fat at the level of the spinous process also showed thicker dorsal fat deposits above the longissimus muscle. On the other hand, F intact lambs accumulated more kidney fat than S lambs. Castration had an influence on the accumulation of dorsal fat at all levels measured. Castrated lambs also accumulated more kidney fat when expressed as percentage of body weight. Castration and breed did not influence the relative proportion of each cut in the carcass.

The longissimus muscle of noncastrated S x F lambs had a more intense lamb flavor than that of castrated F x S lambs. Castration produced meat with a less evident lamb flavor than that of noncastrated lambs. There was no significant difference in juiciness between any of the treatments. Although there were significant differences in tenderness between treatments, the results were difficult to interpret. The sensory characteristics of the meat were not related to the conformation of the carcasses or of the living animal.

The authors concluded that F can be used in crossbreeding for market lambs, because no major negative effects were demonstrated on carcass weights, carcass cutability and tissue distribution within each retail cut. Although carcasses from F lambs received a lower classification because of conformation, their carcass tissue distribution, chemical composition of retail cuts and organoleptic quality of the meat were similar to those of S lambs. Castration did not influence weight gains or any other important trait to a significant degree.

4.2.2 Chiquette, Minvielle and Dufour (1984) conducted a study to determine the association between prepubertal plasma LH concentration between two and 10 weeks of age and the subsequent ovulation rate and prolificacy of F, S and reciprocal crossbred (C) ewe lambs. The study was carried out using 17F, 14S and 26C lambs. The results indicated that F and S lambs had significantly higher mean plasma LH levels than C lambs at six and eight weeks of age. However, at 10 weeks of age the S lambs had higher level than those of F and C lambs (Table 14). When ewes within each genetic group were classified according to the number of ovulations or litter size, it was observed that mean LH levels were generally higher among more prolific ewes.

Number of ewes lambing as a percentage of those bred was 94, 86 and 81% for F, S and C respectively (Table 14). Finnsheep ewes were the oldest to reach puberty averaging 259 days compared to 234 days for S with C ewes being intermediate. They reached puberty at 39.5 kg liveweight. Ovulation rate differed significantly between the genetic groups (Table 14). The F ewe lambs had 2.7 ovulations at second estrus after puberty 1.5 (125%), and 0.9 (50%) more than S and C groups, respectively. Litter size in F ewes was 73% higher than in S and 19% higher than in C ewes.

Table 14. Performance of Finnsheep (F), Suffolk (S) and crossbred (C) ewes

	Genetic groups		
	F	S	C
Fertility (%)	94.1	85.7	80.8
Age at puberty (d)	259[a]	234[b]	250[a]
Weight at puberty (kg)	39.5	47.1	44.6
Ovulation rate	2.7[a]	1.2[c]	1.8[b]
No. of lambs born	1.9[a]	1.1[c]	1.6[b]
LH concentration† at:			
2 wk	0.54	0.52	0.56
4 wk	0.74	0.74	0.66
6 wk	0.70[a]	0.64[a]	0.52[b]
8 wk	0.59[a]	0.67[a]	0.54[b]
10 wk	0.65[a]	0.88[b]	0.66[a]

† Log of LH concentration.

The authors concluded that using LH concentration across breeds to identify more prolific females among prepubertal ewe lambs might not be feasible since at any given age between two and 10 weeks, ewe lambs with a significantly higher level of LH were not necessarily from the highest ovulating genetic group. However, within breed, LH levels at two and four weeks of age between ewe lambs with a potential for high ovulation rate were consistently but marginally higher than in those with a low potential. The authors also showed that crossing F with S resulted in positive heterosis in ovulation rate and litter size.

4.2.3 Castonguay, Minvielle and Dufour (1990a) crossed Booroola rams with Finnsheep and Suffolk and compared the progeny with contemporary Finnsheep and Suffolk ewes. The traits studied were weights and gains from birth to 100 days of age, weight and age at puberty and different reproductive characteristics. The objective of the study was to evaluate the effect of B gene in prolific and non prolific sheep.

The results of the study are summarized in Table 15. They showed that S and its cross were heavier than F and its cross at birth and up to puberty. Finnsheep reached puberty 27 days earlier than S and 22 days earlier than B crosses. Ovulation rate, embryonic mortality and litter size were highest in B crosses and lowest in S. Mortality at birth was 0 in F and S but was 23.7% in B x F cross. The total kilograms of lambs produced varied between 44.9 kg for F to 55.8 kg for B x S, the differences among the genetic groups being non significant.

The authors concluded that the B gene can increase ovulation rate and litter size in both prolific and non prolific sheep.

Table 15. Growth and reproductive performance of Finnsheep (F) and Suffolk (S) ewes and their crosses with Booroola Merino (B)

	Genetic groups			
	B x F	B x S	F	S
Number of ewes	19	18	14	26
Birth weight (kg)	2.3[c]	4.1[b]	2.1[c]	4.6[a]
Weaning weight (kg)	15.6[c]	23.0[b]	15.9[c]	26.6[a]
Weight at 100 days (kg)	27.0[c]	33.0[b]	25.1[c]	42.9[a]
Age at puberty (d)	233[a]	233[a]	211[b]	238[a]
Weight at puberty (kg)	36.8[c]	47.0[b]	36.7[c]	61.1[a]
Ovulation rate	3.5[a]	3.1[a]	2.3[b]	1.7[c]
Embryonic mortality (%)	31.0[a]	32.8[a]	23.8[ab]	12.8[b]
Conception rate (%)	94.7	94.4	85.7	92.3
Gestation length (d)	144.2[a]	143.4[ab]	142.3[b]	143.0[b]
Litter size at birth	2.5[a]	2.1[a]	1.6[b]	1.3[b]
Litter weight at birth (kg)	6.0[a]	6.3[a]	4.6[b]	6.3[a]
Mortality at birth (%)	23.7[a]	6.5[b]	0[b]	0[b]
Litter size at weaning	1.8[ab]	1.9[a]	1.5[ab]	1.3[b]
Litter weight at weaning (kg)	23.6[b]	26.7[a]	23.3[b]	29.0[a]
Total kg of lambs produced	54.5	55.8	44.9	51.6

4.2.4 Castonguay, Dufour, Minvielle and Estrada (1990b) studied follicular dynamic during breeding season in Booroola x Finn (BF), Booroola x Suffolk (BS), F and S mature ewes. All ewes were synchronized with sponges impregnated with progestagen. At sponge removal (D0), 14 days after insertion, ewes were assigned to one three groups: G1) destruction of all follicles visible on ovarian surface except the largest which was marked; G2) destruction of all visible follicles; G3) marking of the three largest follicles identified. Forty-eight hours after treatment (D2), follicular growth was evaluated. At D0, mean number of small follicles (1-3 mm) was higher ($P<0.05$) for BS, S and BF (35.8, 35.1 and 32.9) than F (24.9). Large follicles (≥4 mm) were more numerous in F (3.5) than in BF, S and BS (2.6, 2.4 and 2.1). Diameter of largest follicles was larger for S (7.5 mm) than F, BS and BF (5.8, 5.1 and 5.1 mm). In G1, ewes expressed estrus within four days after sponge removal and all largest follicles marked at D0 ovulated in BF, BS and S whereas in F ewes two of the six largest follicles regressed. In ewes ovulating, only the largest follicles ovulated except for one S where one more follicle reached ovulation. In G2, no follicle ≥4 mm were observed at D2 and none had ovulated at estrus following sponge withdrawal. First ovulation occurred for all ewes about 16 days after treatment and averaged 3.5, 2.0, 1.8 and 1.8 for BF, BS, F and S. In G3, proportion of largest and second largest follicles ovulating was higher for S (7/12) compared to BF, F and BS (3/8, 4/12 and 2/12).

The authors concluded from these data that selection of ovulatory follicles occurs in late follicular phase in F and B crossed ewes contrary to S. Small size follicles appear to induce atresia of largest follicle, specially in prolific ewes.

5. ONTARIO

5.1 Animal Research Centre (ARC), Ottawa

Finnsheep were used in the development of two Arcott breeds, the Outaouais and Rideau. Many of the research conducted at ARC was done with pure Suffolk, pure Finnsheep and the three Arcott breeds under intensive management system.

5.1.1 Walton and Robertson (1974) studied the reproductive performance of a small private flock of Finnsheep in which ewes were exposed to rams twice yearly in the fall and in the spring for five consecutive breeding periods. The results indicated that about one third of the ewes conceived at each of the five consecutive exposures and 72.2% conceived at least four times during the 2-year period. In another group of ewes born one year later and exposed for three times, 71% conceived at each of the three possible exposures. The mean conception-to-conception interval for ewes excluding those with interval exceeding eight months was 189.3 days (range 171-237). About 43% of all conceptions occurred within a 6-month period. Assuming a gestation length of 145 days, lambing to conception interval was calculated at 37 days or less for 46% of the ewes and 89% of the ewes had conceived by 59 days postpartum. Table 16 presents percentage of ewes that conceived and mean litter size for the different seasons. Fall breeding was consistently more fertile and prolific. Overall fertility of the F ewes in this study was calculated at 85% and average prolificacy at 1.77 lambs per ewe exposed. Annual productivity of F under such accelerated system was calculated at 3.54 lambs born per ewe exposed.

Table 16. The percentage conception and mean litter size of Finnsheep ewes exposed to rams on a twice-yearly breeding program

	Season and year of breeding					
	Fall 1968	Fall 1969	Spring 1970	Fall 1970	Spring 1971	Fall 1971
Ewe lambs bred at 8 months	100 1.87 (*n*=23)	92.9 1.38 (*n*=14)		84.0 1.82 (*n*=19)		100 1.72 (*n*=29)
Ewe lambs bred at 12 months						87.5 2.00 (*n*=8)
Ewes more than 12 months old		95.7 2.14 (*n*=23)	47.8 2.09 (*n*=23)	100 2.24 (*n*=34)	74.4 1.79 (*n*=39)	94.3 2.14 (*n*=53)

5.1.2 Shrestha, Peters and Heaney (1982) compared the progeny of Finnsheep, East Friesian (EF), Ile de France (IL) and Suffolk rams mated to different breeds (and crosses) of ewes. The traits studied were lamb birth, weaning, 100-day and 140-day weights. The objective of the study was to evaluate the merit of the four breeds for producing lambs.

The results presented in Table 17 indicate that significant breed-of-sire differences were observed for birth weight with ranking the sire breeds in decreasing order as follows: S, IL, EF and F. Although differences among the four breeds of sire were not significant in lamb weight at subsequent ages, several important trends were observed. Important, though not significant, the S surpassed the IL for lamb weight at 140 days of age. Suffolk-sired crossbred lambs tended to be heavier at 140 days of age compared to single-cross lambs sired by the three exotic breeds examined; however, this difference was not significant.

Table 17. Least squares means for lamb weights (kg) at birth, weaning, 100 days and 140 days of age according to breed of sire

Source	No. of lambs	Lamb wt in kg at:			
		Birth	Weaning	100 days	140 days
Breed of sire within single-cross					
(EF x SH) + (EF x MM)	77-54	3.9[ab]	13.0[a]	19.4[a]	28.7[a]
(F x SH) + (F x MM)	90-74	3.7[a]	13.0[a]	20.0[a]	28.9[a]
(IL x SH) + (IL x MM)	187-130	4.1[bc]	12.1[a]	18.5[a]	28.4[a]
(S x SH) + (S x MM)	111-64	4.3[c]	13.1[a]	18.4[a]	29.5[a]
Breed of sire within backcross					
EF (EF x SH) + EF (EF x MM)	16-8	3.6[abc]	13.8[a]	21.2[a]	32.4[a]
F (F x SH) + F (F x MM)	23-17	3.3[a]	14.7[a]	18.5[a]	27.9[a]
IL (IL x SH) + IL (IF x MM)	41-30	3.8[c]	14.1[a]	19.3[a]	30.0[a]
S (S x SH) + S (S x MM)	7-5	3.6[abc]	14.2[a]	21.0[a]	31.1[a]
Breed of sire (combined)					
East Friesian (EF)	93-62	3.7[a]	13.4[a]	20.3[a]	30.5[a]
Finnsheep (F)	113-91	3.5[ab]	13.9[a]	19.3[a]	28.4[a]
Ile de France (IL)	228-160	3.9[bc]	13.1[a]	18.9[a]	29.2[a]
Suffolk (S)	118-69	3.9[bc]	13.6[a]	19.7[a]	30.3[a]

† MM = Ottawa line. SH = Shropshire.

Backcross lambs by EF sires were slightly heavier at 100 and 140 days of age compared with Suffolk-sired lambs from backcross matings. Moreover, EF backcross lambs were the heaviest among all crosses at 140 days of age. The IL was similar in crossbred lamb weight to S. Finnsheep crosses from single-cross matings were comparable to Suffolk-sired single-cross lambs at weaning and at 140 days of age. However, backcross lambs by F sires were smaller at birth, 100 and 140 days of age to S, EF and IL.

Examination of the significant breed-of-sire x breed-of-dam interaction for weaning weight revealed that EF rams weaned heavier lambs than F rams when mated to Ottawa synthetic strain ewes, whereas F rams surpassed EF rams when mated to Shropshire ewes.

In evaluating the merit of each genetic group, the authors concluded that, the use of F with known prolificacy along with lamb weights comparable to Sufolk-sired crossbreds indicates suitability for inclusion into synthetic dam strains. East Friesian crossbred ewes appeared to have potential merit for lamb production. Crossbred progeny of IL, did not demonstrate any superiority in growth performance over Suffolk-sired progeny. The S breed showed considerable merit in lamb production comparable to EF, IL and F. Highly productive ewes from crosses of S and F appear to have potential for improving the efficiency of market lamb production.

5.1.3 Shrestha, Fiser, Langford and Heaney (1983) conducted a study to investigate the influence of breed among other factors on testicular measurements of growing rams. The comparisons were between the three Arcott strains (Canadian, Outaouais and Rideau), Suffolk and Finnsheep. The traits studied were scrotal circumference, testis length, testis width, scrotal skinfold thickness, and tonometer score measured at 6, 8, 10, 11-13 and 18-21 months of age.

Table 18 showed that Arcott Canadian and S rams were the heaviest breeds at all ages followed by the two maternal Arcott lines, Outaouais and Rideau. Finnsheep rams were significantly lighter than the four other groups.

Breed differences observed in scrotum circumference for rams at eight months and subsequent ages were not significant at six months. In general, scrotum circumference of Canadian and S rams were larger although Outaouais and Rideau were not significantly different from S; F rams had smaller scrotum circumference compared to all other rams examined.

Testis length for rams at eight and 10 months varied among breeds. However, no significant breed differences were observed for rams at 11-13 months. Subsequent breed differences for testis length occurred eight months later. In general, testis length of Canadian and S rams were larger than those of Outaouais and Rideau, F rams had the smallest testis length. At 18-21 months, S rams were similar to Outaouais and Rideau, while F rams were similar to Canadian. Breed did not influence testis width measurements for rams except at 10 months of age. Ranking of breeds for testis width tended to be similar to those described for scrotum circumference and testis length. There were no significant differences observed among breeds for scrotal skinfold thickness and tonometer score.

The authors concluded that breed differences likely due to susceptibility to changes in photoperiod suggest that meat type sire breeds such as S and Canadian have larger scrotum circumference, testis length and body weight compared to those of highly fecund breeds such as F or Outaouais and Rideau. Finnsheep rams had smaller testicular measurements compared to all other rams. However, the significance of these differences varied as the ram progressed in age. Scrotum circumference was not greater in the breed with higher fertility in this study, contrary to previous findings.

Table 18. Least squares means for body weight and testicular measurements by breed and age of ram

	Age of ram (months)				
Breed	6	8	10	11-13	18-21
Body weight (kg)					
Arcott Canadian	56.4^{a}	67.6^{a}	71.8^{ac}	76.1^{a}	91.4^{a}
Arcott Outaouais	54.3^{a}	64.7^{a}	66.5^{b}	71.4^{b}	88.7^{a}
Arcott Rideau	54.5^{a}	64.8^{a}	67.1^{ab}	68.7^{b}	86.5^{a}
Suffolk	56.6^{a}	69.1^{a}	74.4^{c}	74.0^{ab}	90.7^{a}
Finnsheep	46.8^{b}	54.9^{b}	57.6^{d}	60.0^{c}	77.3^{b}
Scrotal circumference (cm)					
Arcott Canadian	34.0	35.6^{a}	36.3^{a}	34.1^{a}	38.5^{a}
Arcott Outaouais	34.2	34.3^{b}	33.7^{b}	32.4^{b}	36.2^{b}
Arcott Rideau	34.6	34.3^{ab}	33.2^{b}	31.1^{c}	36.4^{b}
Suffolk	32.2	34.1^{abc}	36.7^{a}	33.1^{abc}	37.4^{ab}
Finnsheep	32.9	32.3^{c}	29.9^{c}	32.3^{abc}	34.2^{c}
Testis length (cm)					
Arcott Canadian	10.4	12.3^{a}	12.8^{a}	12.8	13.3^{a}
Arcott Outaouais	10.7	11.6^{b}	11.9^{b}	12.0	12.0^{b}
Arcott Rideau	11.0	11.6^{b}	12.0^{b}	12.1	11.7^{c}
Suffolk	10.4	12.5^{a}	13.2^{a}	13.1	12.3^{ab}
Finnsheep	10.1	10.8^{c}	11.2^{c}	11.9	10.6^{c}
Testis width (cm)					
Arcott Canadian	5.6	6.5	6.8^{a}	6.5	6.4
Arcott Outaouais	5.9	6.4	6.1^{b}	6.2	5.9
Arcott Rideau	5.7	6.3	6.0^{b}	6.3	5.9
Suffolk	5.7	6.6	7.0^{a}	6.4	6.0
Finnsheep	5.5	6.0	5.5^{c}	6.2	5.3
Scrotal skinfold thickness†					
Arcott Canadian	131	145	142	258	249
Arcott Outaouais	123	144	132	253	247
Arcott Rideau	114	142	135	252	246
Suffolk	136	141	138	251	247
Finnsheep	109	135	129	250	246
Tonometer score (mm)					
Arcott Canadian	13.8	13.9	14.2	16.0	14.3
Arcott Outaouais	13.8	13.7	14.6	15.7	13.3
Arcott Rideau	14.0	13.7	14.8	16.0	13.6
Suffolk	13.3	13.7	14.9	15.7	14.1
Finnsheep	14.7	14.7	14.5	16.3	13.2

†Transformation = 100 $\log_{10}$ (reading in 0.1 mm - 18).

5.1.4 Bernon and Shrestha (1984) conducted an experiment to study sexual behavior in sexually experienced rams from three synthetic breeds, Arcott Canadian, Outaouais and Rideau and two pure breeds (S and F). The Outaouais and Rideau contained principally F and S. Mating activity of rams was measured during a ten minute observation period. Rams were placed singly in a pen and flehmen, nosing, nudges, pawing, mount attempts, completed mounts and time to first mount were recorded.

The results showed significant differences among breeds for nosings. The F rams had 40.3% more nosings than the S and 25.9% fewer than the Canadian (Table 19). Although breed differences were nonsignificant for other behavior traits, F rams had 35.1%, 38.3% and 30.2% more flehmen, mounts and completed mounts respectively than the S rams, 43.2%, 62.4% and 58.7% more than the Canadian, 54.0%, 51.1% and 39.7% more than the Outaouais and 27.0%, 21.8% and 22.2% more than the Rideau breed.

The authors concluded that the high number of completed mounts, and the lowest time to first mount, when considered with the lower number of other behaviour traits indicate that the F rams are sexually agressive breeders.

Table 19. Means for incidence of behavior traits by breed

Breed	Number tested	Flehmen	Nosing	Nudge	Mount	Completed mount	Time to first mount†	Pawing
Canadian	29	0.21	6.34	1.72	0.50	0.26	10.11	0.28
Outaouais	54	0.27	4.18	0.71	0.65	0.38	8.06	0.15
Rideau	52	0.17	5.55	1.49	1.04	0.49	10.78	0.49
Suffolk	17	0.24	3.35	1.26	0.82	0.44	6.80	0.29
Finnsheep	23	0.37	4.70	0.85	1.33	0.63	3.28	0.13

† Time in minutes include only those animals that did mount.

5.1.5 Shrestha, Heaney, Fiser and Langford (1984) compared the three Arcott breeds of sheep with Finnsheep and Suffolk in different body measurements taken at 6, 8, 10, 12, 18 and 24 months of age. The measurements were: heart girth (HG), body length (BL), leg length (LL), metacarpal circumference (MC), withers height (WH) and hook width (HW). The body measurements increased from six to 10 months. The estimates calculated as percentages of 6-month values were: HG, 12.7; BL, 7.8; LL, 7.8; MC, 6.4; WH, 7.4; and HW, 5.0 percent. The increases in body measurements from six to 25 months calculated as percentages of 6-month values were: HG, 20.2; BL, 19.2; LL, 8.5; MC, 6.4; WH, 13.0; and HW, 5.0 percent.

The Arcott Canadian rams were larger in HG than the S rams, except at eight and 10 months where no significant difference was observed (Table 20). At 23-25 months HG of rams from Arcott Canadian was similar to that of Arcott Rideau. The F rams had the smallest HG from six to 13 months of age, thereafter, the F and S breeds did not differ significantly from one another. At six months, rams of Arcott Outaouais and Rideau were similar to those of the S breed with respect to HG. Later, at eight months, the S rams were larger in HG than those of Arcott Outaouais and Rideau. By 10 months the S rams were larger in HG than Arcott Rideau rams only. The HG of the S rams did not differ from those of the Arcott Outaouais and Rideau rams after 10 months of age. The HG of the Arcott Outaouais and Rideau rams were similar at all ages.

The Arcott Canadian rams were similar to S rams in BL (Table 20) except at 18-21 months when the Arcott Canadian rams were longer. The F rams had the smallest BL. Only at 18-21 months the F and S rams were similar in BL. At six months BL of rams from Arcott Canadian was longer than those in Arcott Outaouais, whereas, the S rams had a longer BL than did rams of Arcott Outaouais and Arcott Rideau. At eight months, BL of Arcott Canadian and S rams was similar to that of Arcott Outaouais and Rideau rams. This relationship tended to persist to 25 months. BL of the Arcott Outaouais and Rideau rams were not significantly different from one another at any age.

At six months, LL was shorter in the S rams than in the Arcott Outaouais rams but similar to those of the remaining breeds. The F rams had a shorter LL compared to that of Arcott Outaouais and Rideau. At 11-13 months of age, LL of the S and F rams were similar but significantly shorter than those of the synthetic dam Arcott Outaouais and Rideau. MC of the S rams was largest at eight and 23-25 months. In general, the S and Arcott Canadian rams did not differ significantly in MC but were larger than those of Arcott Outaouais and Rideau. The F rams always had the smallest MC. Breed differences with respect to WH were observed at 6, 10 and 18-21 months of age. The F rams were similar to S in WH but smaller than the synthetic Arcott lines. At six months, HW of the S rams was larger than that of the Arcott lines. The F rams had the smallest HW at all ages. In general, the Arcott lines and S had similar HW which was significantly larger than that of the F. In general, body weights of Arcott lines were similar to S. Finnsheep rams were lighter compared to all other rams. The body weight of Arcott Canadian, Outaouais and Rideau, S and F rams at 23-25 months were 94, 94, 96, 89 an 86 kg, respectively.

The authors concluded that in general, the Arcott Canadian rams, a synthetic meat-type sire breed with a large proportion of S background had a larger HG than that of the S, but was similar for the remaining body measurements. The F rams had smaller HG, BL, MC and HW than did the synthetic breeds and S rams, but were similar to the S in LL and WH. The Arcott Outaouais and Rideau rams, developed as synthetic dam strains with 50% F background, were similar to one another in body measurements. The synthetic dam lines did not differ from the Arcott Canadian and/or S rams with respect to HG, BL, WH an HW. However, the S rams had a larger MC and shorter LL than rams of Arcott Outaouais and Rideau.

Table 20. Least squares means for linear body measurements by breed and age of ram

Breed	Age of ram (months) 6	8	10	11-13	18-21	23-25
			Heart girth (cm)			
Arcott Canadian	89.1[a]	96.5[a]	102.8[a]	108.9[d]	115.2[a]	107.3[a]
Arcott Outaouais	86.8[b]	91.1[b]	96.4[bc]	101.4[b]	110.9[b]	104.3[b]
Arcott Rideau	86.5[b]	91.3[b]	92.8[b]	100.8[b]	110.3[b]	104.5[ab]
Suffolk	86.2[b]	94.6[a]	99.8[ac]	99.7[b]	108.8[bc]	101.8[bc]
Finnsheep	81.2[c]	85.3[c]	87.9[d]	94.3[c]	104.4[c]	98.2[c]
			Body length (cm)			
Arcott Canadian	71.2[ac]	76.0[a]	77.8	79.2[a]	82.5[a]	86.0[a]
Arcott Outaouais	69.3[b]	76.0[a]	76.6	77.7[a]	82.1[ab]	84.6[a]
Arcott Rideau	70.1[bc]	76.3[a]	75.3	77.5[a]	82.3[ab]	85.4[a]
Suffolk	73.2[a]	78.0[a]	76.9	76.6[a]	79.9[bc]	85.0[a]
Finnsheep	65.2[d]	71.7[b]	74.2	72.3[b]	78.0[c]	80.7[b]
			Leg length (cm)			
Arcott Canadian	32.3[ab]	32.8	34.6	34.6[ab]	36.0	35.4
Arcott Outaouais	32.9[b]	33.5	35.3	35.1[a]	35.9	34.9
Arcott Rideau	32.7[bc]	33.4	35.3	35.4[a]	36.3	35.4
Suffolk	31.4[ac]	32.7	34.3	32.6[c]	34.9	33.6
Finnsheep	31.3[a]	32.7	34.0	33.7[bc]	35.0	33.9
			Metacarpal circumference (cm)			
Arcott Canadian	10.3[a]	10.6[a]	11.3[a]	10.9[a]	11.3[a]	10.6[a]
Arcott Outaouais	9.2[b]	9.5[b]	9.7[b]	9.7[b]	9.8[b]	9.7[b]
Arcott Rideau	9.3[b]	9.6[b]	10.1[b]	9.7[b]	9.8[b]	9.6[b]
Suffolk	10.2[a]	11.0[c]	11.2[a]	11.3[a]	11.6[a]	11.3[c]
Finnsheep	7.9[c]	8.3[d]	8.8[c]	9.1[c]	8.8[c]	8.9[d]
			Withers height (cm)			
Arcott Canadian	62.1[a]	65.8	68.0[a]	68.6	71.1[a]	72.5
Arcott Outaouais	62.3[a]	66.0	67.8[a]	67.2	70.3[ab]	71.4
Arcott Rideau	62.5[a]	65.8	67.6[a]	67.0	70.5[ab]	71.1
Suffolk	61.9[ab]	65.4	66.5[ab]	67.2	68.6[bc]	71.3
Finnsheep	60.2[b]	63.6	65.0[b]	64.9	67.1[c]	68.9
			Hook width (cm)			
Arcott Canadian	18.8[a]	19.1[ab]	19.1	16.6	18.3[a]	19.8[a]
Arcott Outaouais	17.8[b]	19.0[a]	18.7	16.3	18.1[a]	19.1[b]
Arcott Rideau	18.0[b]	19.6[b]	19.0	16.2	18.4[a]	19.2[ab]
Suffolk	19.5[c]	19.6[ab]	19.2	16.6	18.3[a]	19.9[ab]
Finnsheep	16.0[d]	17.5[c]	17.9	15.5	16.8[b]	17.6[c]

5.1.6 Hackett and Wolynetz (1985) evaluated fertility and prolificacy of Finnsheep and Suffolk on an accelerated breeding program. Both breeds were contained in each of two separate flocks housed indoors year-round on expanded metal floors in windowless buildings. The two flocks were bred alternately at 4-month intervals in January, May and September. The sheep were exposed to either an abrupt or constant lighting regimen. Data from nine breedings during a 4-year period were evaluated.

The results showed that fertility was significantly higher for ewes maintained in the abrupt regimen (66%) than for ewes maintained in the constant regimen (46%; Table 21). Fertility was significantly lower for ewes bred in September (32%) than for those bred in January (67%) or May (70%). The 14% fertility observed in the September breedings for animals maintained in the constant regimen was significantly less than the fertility in the abrupt regimen. The lowest fertility in both lighting regimens was observed in the September breedings. The breed x ewe's previous reproductive performance and the ram age x ewe's previous reproductive performance interactions were significant. For ewes previously open, the fertility was approximately 55% for both breeds (Table 21); however, for the ewes which previously lambed, fertility of the F (83%) was significantly larger than that of the S (32%).

Table 21. Fertility and number of lambs born to Finnsheep (F) and Suffolk (S) ewes according to breeding season, light regimen, age of ram and previous record

	Genetic group				Light regimen		Age of ram				Average	
	Fertility		Lambs born		Abrupt	Continuous	Fertility		Lambs born		Fertility	Lambs
	F	S	F	S			≤	≥	≤	≥	(%)	born
Breeding season												
January	93	40	2.5	1.2	65	68					67	1.9
May	93	61	3.1	1.7	83	57					70	2.4
September	37	26	2.1	1.8	49	14					32	1.9
Previous record												
Did not lamb	56	53					62	47	2.7	1.8	54	2.3
Lambed	83	32					46	69	1.7	2.0	58	1.8
Average	70	42	2.6	1.6	66	46	54	58	2.2	1.9		

The low September fertility was evident in both breeds (Table 21) and the difference in fertility between the two breeds was smallest in this month. Only in the January breedings was the fertility of the F (93%) significantly higher than that of the S (40%). The prolificacy of the F ewes (2.6) was significantly greater than that of the S ewes (1.6). The difference in prolificacy between the two breeds was much larger in the January and May breedings than in the September breeding (Table 21). Overall, the probability of having more than one lamb/ewe lambing in the F (81%) was significantly higher than that for the S (40%).

The authors concluded that the difference in fertility between the F and S breeds is due primarily to the ewes which previously lambed. It is possible that many of the S ewes had not recuperated from their previous pregnancy. They also showed that as expected, the F ewes were more prolific than the S ewes. The levels of fertility observed in this study demonstrated the feasibility of an 8-month cycle for breeding sheep maintained indoors year-round with estrous cycle activity induced by the lighting regimen. It appears that altering the daylength every four months offers a better environment for higher fertility to one service than does a constant daylength.

5.1.7 Shrestha and Vesely (1986) evaluated daily gain and body weights of 6356 lambs from 12 different breeds of sheep from field data provided by breeders across Canada on the Record of Performance Programs (ROP).

Data from breeders with two or more breeds of sheep, each breed being represented by two or more sires of known pedigree were utilized. Performance varied from one geographical region to another and reflected a wide variety of management procedures from pastoral systems in Western Canada to intensive production from housed sheep in Ontario. Lambs were weighed between 21 and 69 days for 50-day lamb weight and between 70 and 115 days for 100-day lamb weight.

Significant differences were observed among breeds. The ranking of breeds in descending order, relative to the S for body weight at 50 days of age was as follows: N.C. Cheviot, Hampshire, Dorset, Oxford, Rambouillet, Leicester, Corriedale, Finnsheep, Columbia, Southdown and Lincoln. Corresponding rankings for body weight at 100 days of age were: Oxford, Finnsheep, Hampshire, N.C. Cheviot, Dorset, Rambouillet, Corriedale, Leicester, Columbia, Lincoln and Southdown. Lambs from the F breed grew as rapidly as those from the Oxford breed.

Suffolk lambs made the fastest gains between 50 and 100 days (339 g) followed by F and Oxford lambs (324 g) whereas the slowest gain was made by Lincoln (233 g) and Leicester (242 g) lambs.

Table 22. Number of lambs and least squares means and percent relative to Suffolk (PRS) for lamb weights at 50 and 100 days of age and daily gain from 50 to 100 days

Breed of lamb	No. of lambs	Lamb weights in kg at: 50 days		100 days		Daily gain 50-100 days	
		Mean	PRS	Mean	PRS	(g)	PRS
Suffolk	2175	20.6	100	36.8	100	339	100
Hampshire	976	18.7	91	32.8	89	298	88
Oxford	437	18.2	88	33.5	91	324	96
Lincoln	17	12.2	59	23.5	64	233	69
Columbia	370	14.1	68	27.0	73	277	82
Rambouillet	116	17.2	84	30.1	82	260	77
Dorset	1761	18.6	90	31.0	84	264	78
Corriedale	42	16.8	81	28.7	78	258	76
Leicester	109	16.7	81	28.0	76	242	71
N.C. Cheviot	225	18.9	92	31.7	86	266	78
Southdown	99	13.2	64	23.4	64	225	66
Finnsheep	29	15.1	73	33.3	90	324	96

The authors concluded that lambs of the Suffolk breed outranked all other breeds and were followed by the Hampshire and Oxford breeds which are also good meat-type breeds and are recommended for such production. Finnsheep, Dorset, N.C. Cheviot and Rambouillet breeds were intermediate and should be considered for production of lambs as dam breeds rather than sire breeds. Corriedale, Leicester, Columbia, Lincoln and Southdown had the lowest growth performance.

5.1.8 Ainsworth and Shrestha (1987) analyzed the data accumulated for nine years on Finnsheep, Suffolk, and three Arcott lines [Canadian, Rideau (40% Finnsheep) and Outaouais (50% Finnsheep)]. The main objective of the work was to evaluate reproductive performance of ewe lambs mated at 6.5 to 7.5 months of age after treatment with progestogen then injected with PMSG. Since the animals were bred in January, May or September, it was also possible to evaluate the effect of season of mating. The results are summarized in Table 23 and indicated that reproductive performance was highest for F, intermediate for Arcott Rideau and Outaouais and lowest for S and Arcott Canadian. Body weights showed the opposite tendency, i.e. was highest in Arcott Canadian and S and lowest in F. Ewe performance traits were significantly affected by season of breeding. Fertility and fecundity were significantly higher for ewes bred in January. The authors also calculated regressions of age and body weight at mating on fertility and fecundity. The estimates were negative [(-2.26** and -0.09) and (-3.83** and -0.07)] and only with age at breeding having a significant effect. The authors presented different possibilities to explain the low performance of the ewes in this study.

Table 23. Least square means for reproductive traits by genetic group and breeding season

	No. of ewes exposed	Age at breeding (d)	Body weight at breeding (kg)	Fertility (%)	Fecundity (%)
Genetic group					
Finnsheep	200	229^{ab}	40.2^{d}	61.6^{c}	109.7^{c}
Suffolk	100	234^{c}	48.1^{ac}	34.5^{a}	56.1^{a}
Canadian	670	230^{a}	48.7^{a}	37.8^{a}	59.3^{a}
Outaouais	871	230^{a}	46.1^{b}	52.0^{b}	87.0^{b}
Rideau	933	228^{b}	47.0^{c}	52.7^{b}	89.6^{a}
Breeding season					
January	932			48.4^{a}	82.9^{a}
May	762			39.8^{b}	64.2^{b}
September	1082			36.0^{b}	60.0^{b}

5.1.9 Ivan (1988) used 40 crossbred Finnsheep x Shropshire x Suffolk rams as an animal model to study the effect of faunation on ruminal solubility and liver content of copper in sheep fed low and high copper diets.

5.1.10 Shrestha and Heaney (1990) analyzed records on 7083 ewes representing Arcott Canadian, Outaouais and Rideau, Suffolk and Finnsheep to evaluate gestation length, prolificacy, multiple birth, body weight and total birth weight. The ewes divided into two flocks were mated in January, May and September under an 8-month breeding cycle. The results presented in Table 24 indicated that Arcott Canadian and S ewes (meat type) had gestation lengths of 147 and 146 days, respectively, compared to 145 days for Arcott Outaouais and Rideau ewes and 144 days for F ewes (prolific types). In all five breeds, there was a progressive reduction in gestation length with increase in litter size from one to five lambs.

The F ewes were the most prolific in this study. The frequency of multiple birth was similar among Outaouais, Rideau and F ewes and approximately 20% greater than Canadian and S ewes. At breeding, S ewes were 5.6 kg heavier followed by Canadian ewes, then by Outaouais and Rideau ewes which weighed less than Canadian ewes at breeding by 8.3 and 6.3 kg, respectively. Finnsheep ewes were significantly lighter at breeding than other ewes in this study. Total birth weight of lambs ranked by breed was as follows: Rideau, Canadian, Outaouais, S and F. Finnsheep lambs were 2 to 2.5 kg lighter in total birth weight than the other breeds.

Table 24. Least squares means for gestation length, prolificacy, multiple birth, body weight at breeding and total birth weight by breed

Trait	Breed				
	Canadian	Outaouais	Rideau	Suffolk	Finnsheep
Prolificacy	1.8^{a}	2.5^{b}	2.4^{c}	1.8^{a}	2.6^{d}
Multiple birth (%)	64.8^{a}	83.4^{b}	81.7^{b}	64.2^{a}	83.1^{b}
Body wt at breeding (kg)	78.2^{a}	70.2^{b}	71.9^{c}	83.8^{d}	60.4^{e}
Total birth wt (kg)	8.4^{abc}	8.2^{b}	8.5^{c}	8.0^{ab}	6.2^{d}
Gestation length (d)					
Avg. all animals	146.8^{a}	144.6^{b}	144.7^{b}	146.2^{c}	143.7^{d}
Single	148.3^{a}	145.6^{a}	147.0^{a}	147.5^{a}	145.4^{a}
Twin	146.3^{b}	145.0^{b}	145.1^{b}	145.9^{b}	144.3^{b}
Triplet	144.5^{c}	144.3^{c}	144.1^{c}	143.8^{c}	143.3^{c}
Quadruplet	143.8^{c}	143.9^{d}	142.7^{d}	--	142.7^{d}
Quintuplet	--	143.3^{e}	142.2^{d}	--	142.5^{d}

Total number of ewes lambing for the Canadian Arcott, Outaouais Arcott, Rideau Arcott, Suffolk and Finnsheep breeds were 1530, 2368, 2421, 211 and 553, respectively.

6. MANITOBA

6.1. University of Manitoba, Winnipeg

6.1.1 Sanford, Palmer and Howland (1977) studied the changes in profiles of serum luteinizing hormone (LH), follicle stimulating hormone (FSH), testosterone, in mating performance and ejaculate volume in Finnsheep and Managra Synthetic (Line-M) rams during the ovine breeding season. In early August, mid-September, early November and mid-December four rams of each breed were bled at 20-minute intervals for two 8-hour periods. Rams were bled while in the absence then presence of ewes in estradiol-induced estrus. An ejaculate was also collected from either five or six of the rams during these months.

The results showed that certain of the endocrine characteristics investigated were found to differ with breed (Table 25). Concentrations of FSH and the height of the testosterone peaks were consistently greater in F than in Line-M rams. Other characteristics such as mean levels of LH and testosterone and LH-peak height appeared to vary between breeds during only certain months of this study. Mating performances of F and Line-M rams were comparable during the months of this study. Episodic increases in serum levels of LH and testosterone were evident in all rams during each 8-hour period, while FSH fluctuated very little from baseline concentrations. Progressive changes in the profiles of serum LH and testosterone occurred in rams of both breeds as the breeding season advanced. Peaks in LH became more frequent and decreased in height, and the number and height of the testosterone peaks increased. Serum FSH concentrations were highest in September.

Table 25. Serum hormone concentration in Finnsheep (F) and Managra synthetic (LM) rams during the breeding season in absence or presence of ewes in estrus

		In absence of ewes in estrus				In presence of ewes in estrus			
		Aug.	Sept.	Nov.	Dec.	Aug.	Sept.	Nov.	Dec.
Mean LH level	F	2.8	3.1	1.7	2.0	5.2	2.5	1.1	1.7
(ng/mL)	LM	3.8	2.1	1.3	1.6	3.5	1.7	1.0	1.6
Mean FSH level	F	152	268	118	130	181	238	139	137
(ng/mL)	LM	109	132	96	117	122	129	110	113
Mean testoterone	F	3.6	8.1	20.4	16.2	7.0	13.6	19.2	15.3
level (ng/mL)	LM	3.5	8.9	14.3	11.2	4.8	11.0	14.3	9.8

Mating activity was associated with increases in the frequency of LH and testosterone peaks in August and September. The number of matings per eight hour and ejaculate volume increased between early August and early November; both were highest in November when the level of serum testosterone was maximal. Monthly changes in testosterone concentration in seminal plasma were moderate compared with those in serum.

6.1.2 Sanford, Beaton, Howland and Palmer (1978) used four 11 month-old Finnsheep rams as a model to determine the feasibility of producing two reproductive-endocrine cycles in the ram in a one-year period. This was achieved by exposing rams to consecutive 6-month "annual" photoperiod cycles. The intent of the study was to compare the sequence and timing of the changes in luteinizing hormone (LH), follicle stimulating hormone (FSH), prolactin (PRL) and testosterone secretion in rams exposed to the controlled photoperiod regime with those that occur in rams exposed to natural photoperiod variations. Two of the rams were put in a "light-proof" room with ewes, while the remaining two animals were put with other rams in a pen located in an open-front barn.

Rams in the "light-proof" room were exposed to three consecutive 6-month "annual" photoperiod cycles between 31 December and 21 June. During the first cycle, daylength was shortened from 17.5 to 13.5 hours and then lengthened to 17.5 hours at the rate of 15 minutes every 5th or 6th day. Daylength ranged from 17.5 to 8.0 hours and was changed at the rate of 15 minutes every 2nd or 3rd day during cycles two and three. From mid-June and for 12 months, all rams were bled on 12 occasions spaced 3-5 weeks apart. Samples were assayed to assess changes in LH- and testosterone-peak frequencies and heights. Serum PRL concentration was determined by radioimmunoassay.

The results showed that rams exposed to natural photoperiod exhibited increases in serum LH, FSH and testosterone concentrations and a decline in PRL concentration during the first three months (21 June-21 September) of diminishing daylength. Two distinct endocrine cycles per year were produced in rams exposed to 6-month "annual" photoperiod cycles. Periods of diminishing daylength were associated with increased in serum FSH and testosterone concentrations and a decrease in serum PRL concentration; these trends were reversed during periods of increasing daylength.

The authors concluded that in general the reproductive-endocrine changes that normally occur in the ram during a 12-month period can be reproduced in the same sequence in a 6-month period by photoperiodic manipulation.

6.1.3 Kennedy and Belluk (1987) conducted a study to evaluate the effect of continuously administered moderate doses of α-agonist clonidine on growth, feed efficiency and body composition of Suffolk and a Finnsheep crossed population consisting of approximately 50% Finnsheep blood. The animals were divided into three groups, animals of the first group served as a control, in the second group animals were implanted at days 1, 29 and 57 of the experiment, with amounts ranging between 4.7 and 8.0 μg clonidine-HCl per kilogram liveweight per day. Animals of the third group were implanted, on the same days, five times the amounts of clonidine administered in the second group. The results summarized in Table 26 showed that the F cross consumed more feed and grew faster than S, but feed efficiency was similar in both genetic groups. Significant differences between the two genetic groups were observed in kidney fat percent and area of longissimus dorsi of 10-12th ribs.

Table 26. Growth, feed efficiency and body composition of Suffolk (S) and Finnsheep (F) crossed FC lambs in control (C) and clonidine-administered groups (D and 5D)

	Breed						Means	
	Suffolk			Finnsheep cross			S	FC
	C	D	5D	C	D	5D		
ADG (kg)	0.21	0.27	0.28	0.33	0.30	0.29	0.26	0.31
Feed intake (kg)	1.58	1.69	1.48	1.81	1.81	1.64	1.59	1.75
Feed efficiency	0.13	0.15	0.19	0.18	0.16	0.17	0.16	0.17
Slaughter weight (kg)	43.6	45.1	43.7	46.1	46.8	42.5	44.1	45.2
Dressing (%)	49.8	47.3	48.7	49.4	48.7	46.7	48.6	48.3
Kidney fat (%)	0.82	0.72	0.66	1.36	1.23	0.65	0.73	1.08
			C	D	5D			
10-12th ribs								
Lean (%)			52.7	51.6	54.0		53.9	51.6
Bone (%)			19.4	19.5	21.3		19.7	20.4
Fat (%)			27.9	28.9	24.8		26.4	28.0
Longissimus dorsi area (cm^2)			17.7	16.8	17.4		18.3	16.3
Water (%)			74.2	72.7	74.3		73.1	74.4
Protein (%)			20.2	20.4	19.9		20.7	19.8
Fat (%)			2.55	3.42	2.52		2.96	2.71

The effect of clonidine implantation was significant on dressing percentage, kidney fat and fat composition of the longissimus dorsi. The interactions genetic group x treatments and genetic group x treatment x phase of implantation were significant on ADG.

The authors concluded from the study that continuous administration of clonidine to growing ram lambs was found to depress kidney fat percentage in a dose related manner with the effect more pronounced in F-crossed lambs. The effects of low and high doses of clonidine were positive in S lambs and negative in F-crossed lambs.

7. SASKATCHEWAN

7.1 University of Saskatchewan, Saskatoon

7.1.1 Jeffcoate, Rawlings and Howell (1984) examined the duration of the breeding season in five breeds or crosses of which two were Finnsheep crosses. The authors also studied fertility and endocrine responses of these genetic groups to estrus synchronization with or without PMSG administration during the breeding season. In addition the responses of ewes induced to breed out of season, with or without a photoperiod manipulation scheme designed to stimulate reproductive activity, were evaluated. The genotypes studied were Rambouillet (RL), Columbia (C), Suffolk, RL x Finnsheep (RLF) and C x Finnsheep (CF). The RL, C and S ewes were mated to F rams while the RLF an CF ewes were mated to Hampshire or S rams. In year 1, 22 ewes from each genetic group were treated with intravaginal sponges, half of these ewes received 500 IU PMSG. Ewes were placed with vasectomized rams and were tested for signs of standing estrus. Blood samples were obtained regularly from all ewes. In year 2, all synchronized ewes were injected with 500 IU PMSG and placed with rams for 40 days. While some ewes from each genetic group were exposed to ambient daylight up to the time of breeding, the remaining ewes were exposed to an artificial photoperiod designed to induce reproductive cyclicity.

The results showed that the breeding season was longest in the F crossbred ewes and shortest for the S ewes (Table 27). During the breeding season (October), 95% of all ewes treated with progestin sponges showed estrus following sponge removal. Administration of PMSG did not influence estrus response. Out of season (May), 93% of treated ewes showed estrus. All of the ewes treated in May received PMSG and photoperiod manipulation did not influence the number of ewes in estrus following sponge removal. During the breeding season, 16% of ewes bred by fertile rams were rebred at the estrus subsequent to the synchronized estrus. Out of season, none of the ewes under normal lighting were rebred, but 20% of the photoperiod-manipulated ewes were rebred.

During the breeding season 50 ewes housed with vasectomized rams gave an average time from sponge removal to estrus of 43.1 ± 1.8 hour. Time to estrus was significantly affected by PMSG treatment (PMSG-treated ewes 39.4 ± 1.8 hours, controls 48.0 ± 3.1 hours).

The overall gestation length for ewes bred in May was significantly shorter than for ewes bred in October (Table 27). This difference was apparent within breeds. Rambouillet ewes had longer gestations than S or crossbred ewes. In fall-bred ewes (October) PMSG did not influence the numbers of C and S ewes lambing. In spring-bred ewes (May) photoperiod manipulation improved the numbers of ewes lambing, but not the numbers of crossbred ewes lambing. Prolificacy was not consistently affected by PMSG treatment or season, but the crossbred ewes produced more lambs (Table 27). None of the endocrine parameters studied were affected by breed of ewe.

The authors concluded that the extended breeding season of RLF and CF ewes would facilitate the use of controlled breeding, that PMSG treatment did not affect fertility following fall breeding and that fewer purebred ewes lambed following spring breeding under natural day light.

Table 27. Reproductive performance of ewes of five genetic groups under different management procedures

	Estrus First	Estrus Last	Breed season (d)	Gestation length (d) Fall mating	Gestation length (d) Summer mating	Fertility (%) Oct. No PMSG Natural day light	Fertility (%) Oct. PMSG Natural day light	Fertility (%) May PMSG Natural day light	Fertility (%) May PMSG Photo	Prolificacy Oct. No PMSG Natural day light	Prolificacy Oct. PMSG Natural day light	Prolificacy May PMSG Natural day light	Prolificacy May PMSG Photo
RL	Aug. 7	Mar. 23	157	148.8	147.3	83	100	27	90	1.40	1.50	1.67	1.67
C	Aug. 18	Mar. 12	154	147.9	146.4	100	83	50	90	1.87	1.40	2.00	2.00
S	Aug. 19	Feb. 2	<126	145.3	145.0	100	100	8	80	1.50	1.40	1.00	1.38
RLF	Aug. 7	Apr. 6	210	146.6	145.4	100	100	80	80	1.83	2.33	2.13	2.25
RLC	Aug. 11	Apr. 9	217	146.5	144.6	100	100	92	80	2.00	2.83	2.09	2.25

RL = Rambouillet, C = Columbia, S = Suffolk, F = Finnsheep.

7.1.2 Rawlings, Jeffcoate and Howell (1987) conducted a study to examine the performance of Suffolk, Columbia and Rambouillet ewes and their Finnsheep half-crosses in an intensified production scheme.

The 288 ewes available were split into three groups; each contained 16 ewes of each of the three purebred and three crossbred ewe types. Group 1 served as a control, and ewes were bred naturally each October. Groups 2 and 3 were intensively managed, ewes in these two groups were bred every eight months, with the two groups lambing four months out of phase with each other. The breedings occurred in January, May and September. Over the 3-year study period, group 2 ewes lambed five times and group 3 ewes four times. Purebred ewes were placed with F rams, 50% of the crossbred ewes were placed with S rams and 50% with Hampshire rams.

Intensively managed ewes were bred at estrus synchronized by a 12-day treatment with intravaginal sponges. Each ewe received 500 IU PMSG. Rams were left with the ewes for 25 days. Ewes to be bred in May were subjected to 18 hours of light per day throughout the preceding January. This was followed by a reduction in daylength to eight hours of light per day at breeding.

Means for the number of ewes lambing of those put to the ram (fertility), prolificacy and lamb losses to weaning were calculated for each cycle. Data for management system and breed were combined to examine differences between purebred and crossbred ewes. To compare lamb production of the two management systems, the number of lambs born per year was calculated and compared.

The number of ewes lambing of those put to the ram was higher in extensively managed ewes than for the intensively managed animals (Table 28). Finn-cross ewes had a higher prolificacy (216 ± 10%) than purebred ewes (165 ± 8%). There was a significant interaction between breed and management system. The season in which ewes were bred affected both fertility and prolificacy. Breedings in October and January resulted in the highest numbers of ewes lambing while May breeding resulted in the lowest fertility. Annual lamb production was increased by intensified management and differed among breeds. Overall, the crossbred ewes produced more lambs per year than the purebreds (231 vs 166).

Table 28. Fertility, prolificacy and annual lamb production of Rambouillet (RL), Suffolk (S) and Columbia (C) breeds and their crosses with Finnsheep (F) under intensive and traditional managements.

Trait	Management	Genetic groups						Overall
		RL	S	C	FRL	FS	FC	
Fertility (%)	Intensive	76	79	77	78	94	80	81
	Traditional	93	82	74	95	93	99	90
Prolificacy	Intensive	1.65	1.74	1.74	2.01	1.73	2.30	1.86
	Traditional	1.41	1.86	1.49	1.94	2.30	2.25	1.89
Annual lamb production	Intensive	1.91	2.06	1.96	2.41	2.39	2.83	2.26
	Traditional	1.32	1.52	1.16	1.84	2.16	2.23	1.70

Lamb losses from birth to weaning were lower for lambs produced by purebred ewes (11%) compared with crossbred ewes (15%). Annual ewe replacement rate was 17% for the control flock and 25% for intensively managed ewes. The incidence of culling for infertility was greater in intensively managed ewes (15%) than in the controls (4%).

The authors concluded that the intensive management scheme increased ewe productivity. However, lamb output in most of the breed groups was not increased by the expected 50%. This discrepancy largely reflects the reduced fertility of ewes when bred out of season in May. They added that intensification did not produce higher lamb losses, but lamb losses from the more prolific F-cross ewes tended to be higher. F x C ewe would appear to offer the highest potential productivity under this intensive management regimen.

7.1.3 Rawlings (1987) used Finnsheep-Rambouillet crossbred ewes to determine if critical day length, simple contrasts in day length, or a photosensitive phase were important in reducing reproductive seasonality in the ewe. Starting in the fall when natural day length was 8.5 hours, the animals were divided into three groups. The groups were subjected to different patterns consisting of cycles of short to long to short days applied over periods of six months. The increase or decrease in day length were either gradual over periods of three months or abrupt, followed by constant day length for three months. In the cycles applied, the length of both the longest and shortest day was varied, as was the length of time to which the ewes were exposed to the change. The occurrence of periods of reproductive cyclicity was determined by measuring progesterone concentration in serum collected on Tuesdays and Fridays of each week.

The results indicated that increasing day length from short days to 15.75 hours, 17.5 hours, or 22 hours, resulted in ewes entering anestrus within 110, 108 or 96 days respectively, of the first day of the period of increasing day length. When day length was increased to 14 hours the response time for four ewes was 128 days, but a further four ewes did not enter anestrus until the following day length cycle (an increase in day length to 17.5 hours). None of the response times above differed significantly.

An abrupt decrease in day length resulted in a more rapid return to reproductive cyclicity than a gradual decrease. In addition, there appeared to be an inverse relationship between the length of the longest day of a treatment cycle and the length of time taken for ewes to return to reproductive cyclicity, following a subsequent and abrupt decrease in day length. When day length was abruptly reduced fron 22 hours to 16.5 hours no ewes cycled within 140 days. When day length was abruptly reduced from 17.5 hours to 15 hours, 12.74 hours, or 7.5 hours, all ewes resumed reproductive cyclicity. Introduction of one hour of darkness from the 12th hour after dawn, into a 17.5 hours day, resulted in the resumption of reproductive cyclicity with a response time similar to a reduction in day length from 17.5 hours to 12.75 hours or 7.5 hours. However, the variability in response time was quite large. The influence of the length of time of exposure to long days on the subsequent response of ewes to a reduction in day length indicated that when day length was gradually increased to 17.5 hours, addition of a further one month of 17.5 hours day did not affect the time taken for ewes to resume reproductive cyclicity, following a subsequent reduction in day length (95 days). However, when day length was gradually increased to 22 hours, then abruptly reduced to and held at 17.5 hours for 4.33 months, a subsequent reduction to 7.5 hours resulted in a rapid resumption of reproduction cyclicity (55 days). In addition, extending the time ewes were exposed to long days (17.5 hours) resulted in a minimal response time following a reduction of day length to 15 hours.

The author concluded that there is a circadian rhythm in photosensitivity in the ewe. In addition, the sensitivity of the photosensitive phase may undergo seasonal fluctuations. The day length cycles used would probably have masked long term refractoriness to increasing or decreasing day lengths. This has been suggested as an important component of the mechanisms leading to the cessation and onset of reproductive cyclicity in the ewe. However, data from this study suggested that a more positive mechanism initiates anestrus, at least in the breed of ewe used in this study.

8. ALBERTA

8.1 Research Station, Lethbridge

8.1.1 Vesely (1978) analyzed records of 1556 lambs accumulated over a 3-year period from mating Finnsheep and Dorset rams to purebred and crossbred ewes. The objectives were to evaluate weaning weights, weights per day of age to market and carcass grades of lambs fed to weight range between 43 and 50 kg. The results of the study are summarized in Table 29 and showed that average weaning weight of Dorset sired lambs averaged 26.8 vs 25.9 kg for 1/2 F, the difference being significant. Weight per day of age to market was similar for both sired breeds (236 g). Average carcass score of F-sired lambs was slightly, though significantly, better than that of Dorset-sired lambs. The authors concluded that both Dorset Horn and F rams produced crossbred lambs with satisfactory growth and carcass merit.

Table 29. Weight at weaning and carcass grade of lambs sired by Finnsheep (F) and Dorset (D) rams

Breed of sire	Breed of dam	No.	Weaning weight (kg)	Weight/ day of age (g)	Carcass grade
D x	Pure breeds	90	25.1	236	
F x	Pure breeds	100	25.6	236	
D x	2 breed crosses	317	27.1	245	
F x	2 breed crosses	290	26.1	236	
D x	3 breed crosses	233	27.1	241	
F x	3 breed crosses	254	26.8	241	
D x	4 breed crosses	141	27.5	241	
F x	4 breed crosses	131	27.5	241	
D		780	26.8	236	1.99
F		776	25.9	236	1.85

8.1.2 Mukhoty and Peters (1982) studied the influence of genetic group and sex on muscle weight distribution of 60 ram and ewe lambs representing crosses of Finnsheep or Ottawa MM strain with British breeds. The lambs were slaughtered between 37 and 48 kg liveweight, averaging 42 to 43 kg in each genetic group-sex subclass. Physical separations were made of eight joints from the left side of each carcass into muscle, bone and fat. Muscle weight distribution was then studied by three methods: expressing joint muscle as percentage of total side muscle; linearly adjusting mean weight of muscle in each joint with total muscle held constant; and considering all joint muscle weights simultaneously, utilizing a discriminant function technique. The results indicated significant genetic group differences only in the abdominal muscles. Sex exerted a strong influence in the muscles of the abdominal and neck regions. Genetic group x sex interaction was significant in the abdominal region.

8.1.3 Vesely and Swierstra (1985) compared prolificacy, lamb mortality, kilograms of lambs weaned and marketed per ewe exposed and rate of attrition over a period of 4.5 years of Dorset Horn- and Finnsheep-sired ewes under different breeding systems (traditional vs accelerated) and light control (natural vs controlled conditions). A group of ewes maintained under a synthetic light regimen (LT, 4 months long days - 16 hours light, 4 months short days - 8 hours light) and exposed to rams every eight months in January, September and May, was compared with two similar groups under natural light conditions, one group was exposed to rams once a year in the fall (C1) and the other every eight months (C2).

Prolificacies of crossbred F were higher than those of crossbred Dorset. On average, crossbred F ewes produced about 250 lambs compared to 180 lambs/100 ewes lambing for Dorset cross. Lamb mortality of crossbred F ewes was about 31% compared to 14% for Dorset crossed ewes (Table 30).

Table 30. Least-squares means for average lamb production per ewe over a period of 4.5 years from established flocks of 69 ewes (control I) in five lamb crops and 67 ewes (control 2) and 64 ewes (light treatment) in seven lamb crops

Factor	No. of lambs		Pre-weaning	Kg of lambs		Attrition (%)	
	Born	Weaned	mortality (%)	Weaned	Marketed	F	D
Cross of ewe							
Half-Dorset	7.4[a]	6.4	13.6	122.6[a]	256.8		26
Half-Finn	8.9[b]	6.1	31.5	100.9[b]	242.8	45	
Management							
Control 1	8.2	6.2	24.4	128.2[a]	242.8	35	26
Control 2	7.5	6.0	20.0	102.6[b]	241.0	44	27
Light treat.	8.9	6.6	25.8	104.4[b]	265.7	56	27

F = Finnsheep, D = Dorset.

The advantage of crossbred F ewes in lamb production due to higher prolificacies practically disappeared when comparing kilograms of lamb weaned or marketed/ewe exposed to ram. In the C1 group, the amount of lamb weaned or marketed/crossbred F ewe exposed was similar to, or less than, that from crossbred Dorset ewes in all cycles. In C2 and LT groups, crossbred F ewes exceeded crossbred Dorset ewes in only two of seven cycles in terms of kilograms of lamb marketed/ewe exposed to rams. During the two out-of-season breedings (cycles 3 and 6), LT ewes produced 76 kg more lamb at market than did C2 ewes. However, C2 ewes were more productive in cycles 1 and 2.

The overall assessment of the two genetic types of ewes and the three management systems (C1, C2 and LT) is presented in Table 30. It summarizes production traits accumulated over the duration of the experiment. This analysis took into consideration also the rate of attrition of ewes during the course of the experiment. When all factors were combined, the higher production potential of crossbred F ewes was eliminated. These ewes produced 1.5 more lambs over the 4.5-year period but raised equal numbers of lambs to weaning. Overall they produced about 14 kg less lamb marketed. This difference was not significant. The loss in advantage of the crossbred F ewes was also due, in part, to higher attrition of these ewes in all three management systems. Differences in attrition between the two genetic groups of ewes were significant in C2 and LT. However, these results may be misleading as far as lifetime production is concerned, because higher attrition of the F ewes occurred only during the last stages of the experiment as a result of a cumulative effect of management. No doubt ewes bearing 2.5 lambs/conception every eight months require a different level of management throughout their life and such was not the case.

The authors concluded that ewes exposed to rams every eight months without any agents inducing estrus did not conceive in satisfactory numbers. Crossbred ewes with 50% Dorset Horn blood did not exhibit higher conception rates in the spring than crossbred ewes with 50% F blood. Light control as applied in this experiment was a reliable agent for induction of estrus, but ewe and lamb management procedures must be optimized in order to capitalize on additional lambs.

8.1.4 Vesely and Swierstra (1986 and 1987) showed that production systems based on breeding ewes at 8-month intervals produce lambs that are born in practically every season of the year. They conducted a study to evaluate reproductive traits of ewe lambs representing eight genetic types born in winter, spring, summer and fall. Eight genetic types of ewe lambs [Dorset x 3/4 Dorset (DD), Dorset x 3/4 F (DF), F x 3/4 Dorset (FD), F x 3/4 F (FF), Romanov x 3/4 Dorset (RD), R x 3/4 F (RF), R x Western (RW) and Western x Western (WW)] born in February, March and October and March and June of the following year were evaluated for conception rate, ovulation rate, litter size, prenatal mortality and weight and age at conception.

Variation among the Dorset, F and R sires was found to be significant on conception (rate and age), ovulation rate and litter size (Table 31). Romanov, an early-maturing breed, reduced significantly the age at conception as compared with the ewe lambs sired by D or F rams; ewe lambs sired by F rams had significantly higher ovulation rate and litter size than the ewe lambs sired by D rams. Ewe lambs sired by R rams had significantly higher ovulation rate and litter size than the ewe lambs sired by F rams. Dam effect was found to be significant between the 3/4 D and 3/4 F ewes. Three-quarter F dams raised ewe lambs that matured earlier, were lighter and more prolific than those raised by 3/4 D dams. Genetic additive effects in ovulation rate and litter size traits are the most powerful characteristics of the F and R breeds. The results demonstrated that the R may be slightly more prolific than the F.

The youngest lambs at conception were the R crosses, particularly the RD and RF. The heaviest ewe lambs at conception were always those of Western background. The lightest were most often the F crosses (FF and RF). Crosses differed as to ovulation rate, with the FF and RF generally having the highest, and WW and DD the lowest. Month of birth of the ewe lambs significantly affected their reproductive performance. Only five of the 57 ewe lambs born in October showed sexual activity in late winter and early spring. Most of the various crosses had conception rates of ≥90%.

The authors concluded that additive genetic effects in ovulation rate and litter size of the R are similar to that of the F. Romanov crosses (RF, RD, RW) conceived at the lowest age (226, 227, 231 days). Ewe lambs of all genetic types, with the exception of the Western ewe lambs, had similar reproductive rates if born in February, March or June. Lambs born in October conceived not in their year of birth but in the following year, when they were about 11 months old.

Table 31. Least squares means of conception rate, age and weight at conception, ovulation rate, prenatal mortality and litter size for sire, dam and cross

Effect		At conception			Prenatal mortality	Litter size
		Age (d)	Weight (kg)	Ovulation		
Sire	Dorset Horn (D)	238[a]	47.8	1.60[c]	11.8	1.36[a]
	Finnsheep (F)	245[a]	46.7	2.31[b]	17.0	1.87[b]
	Romanov (R)	231[b]	46.7	2.61[a]	17.5	2.12[a]
Dam	3/4 Dorset Horn (D)	241[a]	48.3[a]	1.93[a]	16.8	1.55[a]
	3/4 Finnsheep (F)	234[b]	45.8[b]	2.41[b]	14.1	2.01[b]
Cross	DD	251[ab]	48.9[ab]	1.48[cd]	12	1.22[bc]
	DF	234[ab]	46.9[ab]	1.83[bcd]	10	1.61[abc]
	FD	247[ab]	49.1[ab]	2.16[abc]	21	1.70[abc]
	FF	242[ab]	45.6[b]	2.56[ab]	16	2.08[ab]
	RD	227[ab]	47.5[ab]	2.28[abc]	14	1.90[abc]
	RF	226[b]	44.5[b]	2.79[a]	16	2.35[a]
	RW	231[ab]	50.9[ab]	2.28[abc]	8	2.01[ab]
	WW	255[a]	53.3[a]	1.16[d]	4	1.06[c]

W - Western type ewes.

8.1.5 McClelland (1989) studied wool quality of ewe lambs nine to 11 months of age sired by Finnsheep, Romanov, Dorset and Western Range rams. The traits studied were staple length, mean fibre diameter, clean scored yield, presence of medullated fibres and quality number. The results are summarized in Table 32. Ewes sired by F and R sires were significantly discriminated against by Canadian classers.

Table 32. Wool characteristics of purebred and crossbred ewe lambs 9-11 months of age

Breed of sire	Dorset (D) x		Finnsheep (F) x		Romanov (R) x			Western (W) x
Breed of dam	3/4D	3/4F	3/4D	3/4F	3/4D	3/4F	W	W
Staple length (mm)	81	95	103	111	109	107	112	82
Mean fibre diameter (μ)	30	27	26	24	28	24	26	22
Clean scored yield (%)	65	71	67	72	71	73	69	59
Medullation (%)	0	0	0	0	50	50	30	0

Lambs with 7/8F blood (F x 3/4F) had the longest staple and third finest fleeces. None of the ewes sired by F, D or W rams had medullated fibres present in the fleece whereas R x 3/4F cross had 50% medullated fibres. Color fibres were present in three of the 36 R x 3/4F ewes.

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