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TRIALS WITH CROSSBRED FINNSHEEP IN VARIOUS COUNTRIES

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INTRODUCTION

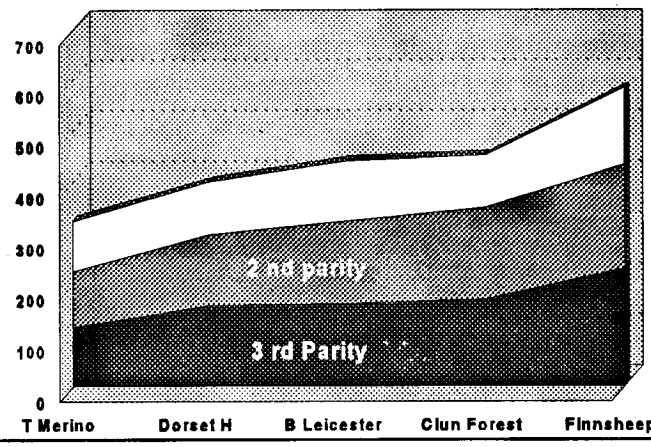
Finnish Landrace or Finnsheep (F) is the world most popular prolific breed. Since its recognition as such in the 1960's, F has been imported into over 40 countries all over the world and virtually is found in every continent. Finnsheep breed has been used intensively in crossbreeding studies with a variety of local breeds of all kinds and purposes with the objective of improving productivity of local breeds. These studies resulted in a wealth of information on performance of the crossbreds in productivity, and meat and wool production. Detail information on the results are reviewed in a series of articles published in Journal of Agricultural Science in Finland as the proceedings of a symposium on sheep and goats held in Helsinki and edited by professor Maijala (1988). And more recently in a book entitled "Prolific Sheep" authored by several contributors from various countries (Fahmy, 1996). The present article is a summary of the results of crossbreeding studies of F with local breeds in temperate regions. Only results on reproduction are presented since F is mainly used to improve this trait in local breeds. A brief description of several newly developed breeds with F ancestry is also presented

CROSSBREEDING STUDIES

WESTERN EUROPE

United Kingdom (UK) was the first country to import F from Finland and study their performance in crossing. The classical study of Donald *et al.*, (1968) reported on the prolificacy of ewes sired by F rams and by Border Leicester, Clun Forest, Dorset Horn and Tasmanian Merino rams out of Blackface ewes. F-cross was considerably higher in litter size than crosses of the other four breeds which were the main halfbred ewes in the UK industry at that time (Figure 1).

Figure 1. Lambing performance of crossbred ewes from Scotish Blackface ewes mated to five sire breeds



In another study, the F crossbred ewes had a 27% higher lambing percentage, 21% higher weaning percentage than non-F crossbred sheep (Table 1, Barker ,1975), .

They were lighter at mating than the average of non-F crossbreds by 10% at seven months, increasing to 24% at 31 and 43 months, an average difference of 18% for the first four years of life. In terms of lamb weight, over a four year period, single and twin lambs born to F crossbreds were respectively 16% and 20% lighter at birth and 11% and 12% lighter at 10 weeks than those born to non-F crossbreds.

Table 1
Reproduction during the first four years of life of crossbred ewes by F and non-F rams (Barker, 1975)

	Crossbred ewes by		Diff .%
	F	non-F	
Lambs			
born/100 ewes mated	171.4	135.4	+27
weaned/100 ewes mated	139.8	115.4	+21
birth weights (kg): singles	3.6	4.4	-16
multiples	2.9	3.6	-20
10-wk weights (kg): single	19.6	22.8	-11
multiples	17.3	19.9	-12
10 wk litter weight (kg):			
per ewe mated	23.5	23.0	+2
per 50 kg ewe mated	24.9	21.5	+16

Contemporary female progeny of F and non-F ram breeds (predominantly Border Leicester and Suffolk) were evaluated at 34 farms in England, Scotland and Wales (Barker, 1977). The results of these field trials showed that over a four year period, the F halfbreds reared more lambs than their non-F sired counterparts, especially as ewe lambs, assuming normal ewe wastage rates.

Various combinations of F and other breeds were subsequently considered as crossing sires. The prolific component of the cross breeding ram was halved to increase body size, conformation and improve lamb weights whilst maintaining a reproductive performance above that of non-F sired ewes (Barker, 1977).Three British breeds were used to combine with the F; Dorset Horn, because of its long breeding season and good conformation; Suffolk for its body size and conformation and Border Leicester because of its importance in the stratification system. Results for crossbred ewes sired by these three types of F halfbred rams were varied, (Table 2) and none found particular favour with the sheep industry at the time. Farmers were critical of the slower lamb growth rates from ewes sired by F x Border Leicester rams which was considered as an important drawback. However, arising out of the production of F x Dorset Horn rams, females of the same cross were evaluated for lamb production and quickly adopted by industry as the standard ewe for this

Table 2
Performance of mature crossbred ewes sired by F rams and by F X Suffolk (FS), F X Dorset Horn (FDH) and F X Border Leicester (FBL) crossbred rams relative to ewes sired by non-F rams (Barker, 1977)

	F	FS	FDH	FBL
No of lambs per 100 ewes to ram				
born	124	89	106	110
reared	114	81	110	113
Lamb weight at 10 wks (kg)				
single	86	100	97	98
multiples	85	103	95	94
10 wk litter weight per ewe to ram (kg				
Adjusted	94	90	102	106
Adjusted*	106	--	116	104

intensive lamb production system.

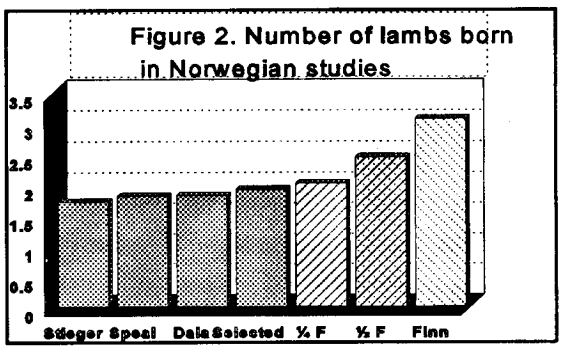
It became apparent during F crossbred ewe evaluation in UK that the first crosses would not be used by the industry because of problems of management of multiple births and relatively low lamb growth rates. While second cross ewes, particularly those by the F Border Leicester rams were more acceptable, however, the high cost of maintaining purebred flocks to create these crossbreds would limit development and uptake. The move towards the creation of a new prolific breed, the ABRO Damline was a logical progression (dealt with later in this paper).

Table 3
Litter size of Finnsheep (F), Galway (G) and F x G (Hanrahan 1974)

	Age of ewe			
	2	3	4	Avg
F	2.22	2.4	2.79	2.46
F x G	1.89	2.09	1.98	1.99
G	1.27	1.38	1.57	1.41

Sheep industry in Ireland is similar to that of UK in terms of breed utilization and the relative importance of crossbreeding. Hanrahan (1974) compared the performance of F, Galway and their cross (Table 3). The cross was halfway between the two pure breeds. The cross between F and Galway gained popularity and a line called Fingalway was developed, from which a new breed called Belclare was established.

. Crossbreeding experiments carried out in Norway with F indicated that an inclusion of 25% F blood into the Norwegian breeds would increase litter size by 0.20 - 0.25 lambs, without reduction in other traits of economic importance (Vabeno *et al.* 1974). The Norwegian system of ram progeny testing allowed the evaluation and utilization of new breeds in a systematic way. Consequently, 1/2 F rams selected on their own growth rate were progeny tested alongside Norwegian rams and those with satisfactory results were then more widely used in the breeding programme.



Texel, the main breed in The Netherlands is renown for its excellent slaughter characteristics, but at 1.5 lambs weaned per ewe lambing the reproductive performance is too low for economic lamb production in intensive grazing systems. A crossbreeding and selection experiment with F, Ile de France and Texel was instigated to investigate improvements in biological and economic efficiency derived from a system of 3 lambings in 2 years, compared to a traditional system of one lambing per year (Visscher, 1974). On average, the crossbred ewe doubled the lamb production per ewe per year compared with the traditional system with Texel ewes. However it was concluded that a 3-way cross would be difficult to organize in the small scale sheep farming structure of The Netherlands. Therefor, a synthetic and prolific dam line called the Flevolander was developed. At the same time, an alternative synthetic line, the Swifter was being developed from the Flemish x Texel and commercial trials between ewes of the two synthetic lines demonstrated higher prolificacy in favour of the Flevolander which lambed 3 times in 2 years, (2.49 vs 2.07 and 2.29 vs 1.95 for number of

lambs born and weaned, respectively) but superior growth and carcase traits for the Swifter when crossed with Texel rams (Hanekamp and de Boer, 1990). Also a cross of F with Texel appears to have been developed into another synthetic, the Noord-Hollander, with an average litter size of 2.8 (Visscher, 1990).

In Germany, the production of meat from sheep is mainly based on purebreds from heavy breeds in traditional systems. Crossbreeding experiments using the local Merinoland breed crossed with F were undertaken to develop lamb production systems utilising different sire and dam lines (Nitter, 1975). Merinoland x F ewes were superior in terms of their lambing frequency and litter size but much poorer in lamb viability. In the extensive systems common in southern Germany and in spring lambing system where lambs are naturally reared on their mothers the high lamb mortality of the F cross was considered as a serious disadvantage. Including a proportion of F genes in the development of a dam line was considered appropriate only if more productive systems were developed..

The sheep industry in Switzerland is small and geared to sheep meat production. Crossbreeding studies with F indicated that despite enhanced prolificacy from the F crosses with Weisse Schaf and Schwarzbraune Bergschaf over Swiss purebreds (1.77 lambs born per F x Weisse Schaf compared to 1.45 from the pure Weisse Schaf and 1.87 for the F x Schwarzbraune Bergschaf compared to 1.58 for the purebred Schwarzbraune Bergschaf), these benefits were insufficient to outweigh poorer growth and carcase traits (Fehse, 1976).

Finnsheep were imported into France in 1966 and were used in crossbreeding studies with Merino. (Table 4, Ricordeau, 1975). At the same time France imported Romanovs from Russia and conducted similar crossbreeding studies. The results indicated that Romanov crosses were superior to F crosses and the popularity and population of F declined progressively.

Table 4
Prolificacy of Finnsheep F and its crosses with Merino (M)

	1-yr-old	2-4-yr-old
F	1.79	2.68
F X M	1.08	1.70
M x F	1.24	1.70
M	-	1.00

EASTERN EUROPE

Table 5 presents the reproductive performance of first-cross ewes from mating F rams to ewes from native breeds in various East European countries. F crosses showed a 50% higher prolificacy rate than native breeds (avg, 1.8; range, 1.62-2.06). Fertility and lamb survival of F crosses were similar to those of native breeds. The final result is that crossbred ewes weaned about 1.5 lambs, 0.4 lambs (27%) more than ewes from native breeds.. Studies conducted in Eastern Europe indicated that F_1 crosses of Rv and F performed similarly.

Extending the breeding season to enable mating every 6-8 months, and thus shortening the the reproductive cycle, is an important trait for intensifying market lamb production. Crossbred ewes derived from F rams and Polish Merino ewes were reported to adapt well to a system of three parturitions in 2 years (Table 6). They averaged 1.92 lambs weaned/ewe/year, 0.5 lambs more than

Polish Merino ewes exposed to the same system. The effect of F on extending the breeding season is evident when they are crossed with Polish Wielkopolska and Kamieniecka (both are highly seasonal).

Table 3
Reproductive performance of first crosses of east European breeds with Finnsheep and the deviations(or percent deviation) of the averages of these crosses from the averages for the native breeds.

Country	Native breed crossed	Prolificacy, lambs born	% lambs weaned	Fecundity	References
Russia	Soviet Merino	2.00 (57.5)			Mutajev (1988)
Czecho slovakia	Merino	1.64 (30.2)			Slana et al.(1983b)
	Merino	1.62			Jakubec and Křižek (1988)
	Improved Valaska	1.71			
	Tsygai	1.76			
Latvia	Latvian Darkheaded	2.04 (22.9)	89 (8)	1.58 (31.7)	Norvele (1986)
Poland	Polish Corridale	1.84 (26.9)	86 (5)	1.56 (41.8)	Niżnikowski (1988)
	Wielkopolska	2.06 (52.6)	91 (-4)	1.82 (61.1)	Osikowski & Korman (1990)
	Kamieniecka	2.00 (34.2)	95 (2)	1.82 (52.9)	
	Polish Merin	1.76 (32.3)	88 (2)	1.49 (38.0)	Borys & Osikowski (1993)

In a system of three lambings in 2 years, F crosses of these two Polish breeds averaged 1.97 and 1.89 lambs weaned/ewe/ year, 0.71 and 0.91 lambs more than the averages for the two native breeds, respectively (Table 6).

Early sexual maturity is another important trait for inten-sifying market lamb production. Ewes from crosses of F with Polish breeds mated for the first time at 10-11 months of age, averaged 96% in fertility, 1.71 lambs in prolificacy, and weaned 1.25 lambs. Corresponding per-formance for the pure native breeds was 82%, 1.12, and

Table 6
.Reproductive performance of crossbred F x native Polish breeds ewes under an 8 months lambing interval system (percent deviation with the native breeds)

Season	Trait	F x PM	F x PLW	F x PLK
Jun-Jul	prolificacy	1.69 (16.6)	1.56 (34.5)	1.65 (63.3)
	lamb survival	87 (3)	94 (-3)	85 (-10)
	fecundity	1.07 (5.9)	0.85 (6.2)	1.03 (90.7)
Feb-Mar	prolificacy	2.03 (63.7)	1.84 (39.4)	1.74 (67.3)
	lamb survival	78 (-1)	78 (-7)	73 (-13)
	fecundity	1.39 (75.9)	1.20 (130.8)	1.17 (318)
Oct-Nov	prolificacy	1.89 (39.0)	2.10 (65.4)	1.96 (41.0)
	lamb survival	78 (-8)	92 (-3)	83 (-3)
	fecundity	1.37 (33)	1.88 (58.0)	1.57 (37.7)
Average ewe/year	fecundity	1.92(28.8)	1.97(56.3)	1.89 (92.8)

Borys et al. (1986b), Borys and Osikowski (1992), Osikowski et al. (1984), Osikowski and Korman (1991) Korman, (1994).

0.71 lambs, respectively. Polish Merino and 1/2 F ewes were successful in mating for the first time at 10-11 months of age, depending on the season: mating was highest in autumn and lowest in summer and winter.

USA

Several crossbreeding experiments were initiated at many research establishments across USA to compare the F with non-prolific breeds. Most compared reproduction of progeny sired by F or domestic rams. The first experiments were initiated at the U.S. Meat Animal Research Centre in which F and Rambouillet were compared (Laster *et al.*, 1972). Next the progeny of Border Leicester and F rams were evaluated for traits measured throughout the life cycle (Magid *et al.*, 1991a,b,c). Another study was also conducted to compare the productivity of ½ F and ¼ F ewes under three levels of management (Jenkins, 1986; Nugent and Jenkins, 1991, 1992). In 1983 a comparison between the progeny of F and Booroola Merino was initiated (Young and Dickerson, 1988, 1991a,b).

American universities were also implicated in research with the F breed. At the University of Minnesota, a series of crossbred combinations were produced to provide contemporary comparison of purebreds, F1, F2, and backcrosses involving the F, Suffolk, Targhee, and Minnesota 100 (Boylan, 1985; Boylan *et al.*, 1976 a,b; Oltenacu and Boylan, 1981a,b; Olthoff and Boylan, 1991a,b). At Oregon State University, progeny of F, North Country Cheviot, Dorset, and Romney rams were mated to Suffolk and Columbia-type ewes to evaluated their reproduction. Performance was evaluated under two production environments - irrigated or hill pasture (Cedillo *et al.*, 1977; Clarke and Hohenboken, 1983; Hohenboken, 1977; Hohenboken and Clarke, 1981; Lamberson and Thomas, 1982; Saoud and Hohenboken, 1984). Another experiment evaluated the production of a rotational crossbreeding system involving Columbia, Targhee, Hampshire, and F (Gallivan *et al.*, 1987). At Virginia Polytechnic Institute, F, F × Rambouillet, and Suffolk rams were mated to Rambouillet ewes to produce crossbred ewes which were evaluated under an accelerated breeding program with matings occurring in April, August, and November for five years (Notter and Copenhaver, 1980a,b). Also, crossbred ewes produced by mating F, F × Dorset, and Dorset rams to Dorset ewes were evaluated under an annual breeding program of matings in October (Cochran *et al.*, 1984). A third experiment involved comparison of ewe productivity and lamb performance of ½ Suffolk-½ Rambouillet ewes compared to ¼ F-½ Suffolk-¼ Rambouillet ewes (Notter and McClaugherty, 1991; Notter *et al.*, 1991a,b).

In Idaho, a study was conducted to evaluate the lifetime lamb and wool production and attrition rate of ½ F and ¼ F crossbred ewes with Rambouillet, Targhee, and Columbia ewes relative to the purebreds under extensive grazing conditions of western range production. (Drummond *et al.*, 1980, 1982; Ercanbrack and Knight, 1985, 1989). Also, reproduction of Panama (a cross of Rambouillet rams with Lincoln ewes) and F × Panama crossbred ewes was evaluated under dry lot conditions (Dahmen *et al.*, 1978, 1979). At Oklahoma State University, ¼ F ewes with varying percentages of Dorset and Rambouillet were compared to Dorset × Rambouillet ewes under fall, spring, or accelerated breeding schedules (Dzakuma *et al.*, 1982; Thomas and Whiteman, 1979a,b; Thomas *et al.*, 1976). Lewis and Burfening (1988) compared F crossbred ewes to Columbia, Rambouillet, and Targhee ewes on western range. Meyer and Bradford (1973) evaluated

reproduction of Targhee and F × Targhee ewes in California.

At the University of Illinois, F, Booroola Merino, St. Croix, Barbados Blackbelly, and Combo-6 rams (a synthetic developed with emphasis on high fertility from a foundation stock with genetic contributions from F, Suffolk, Border Leicester, Targhee, Dorset and Rambouillet) were mated to Suffolk and Targhee ewes. The resulting progeny were evaluated for survival and reproduction (Bunge *et al.*, 1993 a,b). At the University of Wisconsin survival and reproduction, of progeny from F and Romanov rams mated to Targhee ewes were evaluated (Berger and Lupton, 1994; Gallivan *et al.*, 1993).

Table 7 summarizes the results of prolificacy of the various studied mentioned earlier with means of prolific crosses compared with those of non-prolific genotypes. Ovulation rate of first-cross F ewe lambs was 0.7 to 0.8 eggs higher than first-cross St.

Table 7
Reproduction traits of prolific F crosses compared to non-prolific crosses or purebreds

Trait	Non-prolific	¾ F	½ F	¼ F	Reference
Ovulation rate					
2 year old	1.89		2.62		Meyer & Bradford (1973)
Mature	1.52		2.04		Lamberson & Thomas (1982)
No. born/ewe lambing					
Ewe lamb	1.18		1.62		Cedillo et al. (1977)
" "	1.06		1.53	1.22	Ercanbrack & Knight (1985)
" "	1.08		1.61		Laster et al. (1972)
" "	1.08			1.17	Thomas & Whiteman (1979a)
Mixed ages	1.27	2.03	1.92	1.62	Boylan (1985)
" "	1.36		2.03		Clarke & Hohenboken (1983)
" "	1.44		1.97	1.74	Cochran et al. (1984)
" "	1.53			1.66	Dzakuma et al. (1982)
2 year & older	1.48		1.86	2.19	Ercanbrack & Knight (1985)
Mixed ages	1.42		1.69		Iniguez et al. (1986)
" "	1.31		1.67		Lewis & Burfening (1988)
" "	1.36		1.77		Magid et al. (1981b)
2 year old	1.50		2.22		Meyer & Bradford (1973)
" "	1.76		2.27	1.81	Notter & Copenhaver (1980a)
1 & 2 year old	1.18	1.82	1.66	1.40	Oltenacu & Boylan (1981a)
Mixed ages	1.35			1.40	Ramdas et al. (1993)
" "	1.27		1.67	1.53	Snowder et al. (1986)
2 & 3 year old	1.56			1.65	Thomas & Whiteman (1979a)
Spring breeding	1.40			1.61	Thomas & Whiteman (1979b)
Mixed ages	1.39		1.91		Willingham et al. (1988)
" "	1.48		2.22		Mohd-Yusuff et al. (1992)
" "	1.55		1.65		Goode et al. (1983)
Number weaned/ewe lambing					
Ewe lambs	.64		1.27		Laster et al. (1972)
Mixed ages	1.19		1.50		Clarke & Hohenboken (1983)
" "	1.08			1.32	Lewis & Burfening (1988)
" "	0.93			1.22	Magid et al. (1981b)
1 & 2 year old	1.39	1.47	1.30	1.16	Oltenacu & Boylan (1981a)
Mixed ages	1.11			1.14	Ramdas et al. (1993)
" "	1.01		1.34	1.19	Snowder et al. (1986)
April. breeding	1.19		1.74		Mohd-Yusuff et al. (1992)
continuous breeding	1.22		1.27		Shelton (1983b)
7 year production					
Total no. weaned	3.77		5.52	5.04	Ercanbrack
Total wt. weaned, kg	138		191	179	& Knight (1985)
Wt. weaned + wool	193		236	231	" "
4 year production					
Total no. weaned	3.49		5.02		Hohenboken
Total wt. weaned, kg	108		139		& Clarke (1981)

Croix or Barbados Blackbelly and 0.2 to 0.4 eggs lower than first-cross Booroola Merino or Romanov. Ovulation rate of mature first-cross F ewes was 0.5 to 0.7 eggs higher than for non-prolific ewes.

Litter size at birth was approximately 0.50 and 0.25 lambs larger for ½ and ¼ F, respectively than for non-prolific genotypes at all ages. First-cross Booroola Merino ewes had approximately 0.15 lambs more than first-cross F when averaged across ages and experiments. Using a regression analysis, Gallivan *et al.* (1987) reported the breed effect of F to increase prolificacy by 0.5 and 1.0 lambs relative to whiteface (Columbia and Targhee) and Hampshire, respectively. First-cross Romanov ewe lambs average 0.4 more lambs than first-cross F ewe lambs. There were no differences in litter size at birth for ewes sired by Polypay, Coopworth, or Suffolk rams (Nawaz and Meyer, 1992). Results involving hairsheep were somewhat inconsistent. First-cross St. Croix and F ewe lambs had equal litter size at birth which was 0.2 lambs higher than for first-cross Barbados Blackbelly ewe lambs (Bunge *et al.*, 1993b). As mature ewes under accelerated breeding schedules, first-cross F still had 0.2 lambs more than first-cross Barbados Blackbelly (Goode *et al.*, 1983). F crosses weaned more lambs than the non-prolific genotypes, however,.comparisons among experiments should be made cautiously because of experimental differences in raising lambs born in litters larger than two.

Several measures of overall productivity such as number or weight of lambs weaned per ewe lambing or per ewe exposed, number or weight of lamb weaned in four or seven years of production, and value of lamb and wool produced per ewe exposed are presented for a few genotypes in Table 7. Generally these measures show an advantage of F crosses relative to non-prolific genotypes. This advantage is largest when based on per ewe exposed and for ewe lambs because of the considerable advantage in conception rate of F crossbred ewe lambs. The advantage is larger for ½ F than ¼ F. Only under spring breeding did the ¼ F ewes produce less weight weaned per ewe exposed than non-prolific genotypes (Thomas and Whiteman, 1979b).

CANADA

Reproductive performance of F crosses with Rambouillet, Columbia, and Suffolk was examined in an intensified production scheme and compared with the three non-prolific breeds (Rawlings *et al.*, 1987). F-cross ewes had a higher prolificacy (216%) than purebred ewes (165%). The highest number of ewes lambing resulted from breeding in October and January, whereas the lowest resulted from breeding in May. Annual lamb production was increased by intensified management and differed among genotypes. In general, the F crossbred ewes produced more lambs per year than the purebreds (231 *vs* 166). Lamb losses from birth to weaning were lower for lambs produced by purebred ewes (11%) than by F crossbred ewes (15%).

The reproductive performance of Dorset Horn (DH)- and F-sired ewes, under traditional versus accelerated and natural versus controlled light conditions, was compared (Vesely and Swierstra, 1985). The number of lambs born over a 4.5-year period was significantly higher in F-crosses (8.9) than in DH-crosses (7.4). However, as a result of higher preweaning mortality in the F-crosses (31.5 vs 13.6%), the number (6.4 vs 6.1) and weight (122.6 vs 100.9 kg) of lambs weaned and marketed

(256.8 vs 242.8 kg) was higher in the DH-crosses than in the F-crosses, respectively. The rate of attrition of F-crosses was much higher than that of DH-crosses (45 vs 26%). When all factors were combined, the higher production potential of crossbred F ewes was eliminated.

Reproductive traits of ewe lambs representing the following eight genotypes were compared: Dorset × 3/4 Dorset, Dorset × 3/4 F, F × 3/4 Dorset, F × 3/4 F, Romanov × 3/4 Dorset, Romanov × 3/4 F, Romanov × Western and Western × Western (Vesely and Swierstra, 1986, 1987). The ewe lambs born in February, March, and October, and March and June of the following year, were evaluated for ovulation rate, litter size, prenatal mortality, and age at conception. The aim of the study was to prove that production systems based on breeding ewes at 8-month intervals produce lambs that are born in practically every season of the year. Variation among the Dorset, F and Romanov sire breeds was significant for age at conception (238 vs 245 vs 231 days), ovulation rate (1.60 vs 2.31 vs 2.61) and litter size (1.36 vs 1.87 vs 2.12, respectively). Lambs raised by 3/4 F dams matured earlier, and were more prolific than those raised by 3/4 Dorset dams. Genetic additive effects in ovulation rate and litter size traits were the most powerful characteristics of the F and Romanov breeds, with indications that the Romanov may be slightly more prolific than the F.

Table 8
Reproductive performance of prolific crosses in Canada.

	7/8 F	3/4F	5/8F	1/2F	3/8F	1/4F	1/8F	R
Ovulation rate	3.3	3.2	2.9	2.7	2.5	2.1	1.8	2
L. born								
traditional		2.1		1.9		1.4		1
	2.42	2.26	2.05	2.12	1.81	1.67	1.63	2
Accelerated				1.86		1.44		4
	2.75	2.21	2.45	1.91	1.94	2.08	1.87	3
L. weaned								
traditional		1.6		1.6		1.3		1
	1.91	1.69	1.76	1.84	1.52	1.45	1.44	2
accelerated				1.64		1.40		4
	2.58	2.21	2.35	1.93	1.62	1.96	1.50	3
Litter wt, kg.		5.7		5.7		5.3		1
at birth	6.67	6.16	6.37	6.56	6.26	6.22	6.27	2
				5.52		5.02		4
Litter wt., kg		30		31		30		1
at weaning	31	28	29	32	26	25	28	2
				24		22		4
Mortality								
at birth, %				5.7		2.9		4
1-50 days, %				6.5		2.0		4
kg weaned / ewe/ year	25	55	53	42	33	37	31	2

1=Fahmy (1983), 2=Fahmy & Dufour (1988), 3= Fahmy (1990), 4= Fahmy (1996)

Maternal performance of 1/4 F, 1/2 F and 3/4 F crosses with DLS were compared (Fahmy, 1983). The three crosses were highly fertile. The number of lambs born and weaned, as well as lamb mortality, increased progressively with the increase in proportion of the F breed, with the 3/4 F cross showing the highest prolificacy (Table 8) but also the highest natal (12%) and preweaning (17%) lamb

mortality. Litter size at weaning for 3/4 F and 1/2 F ewes was similar: 26% larger than for 1/4 F. Date of lambing (following mating, which started on June 1 and continued to October 31) was earliest in 1/4 F, followed by 1/2 F and 3/4 F, in that order.

To extend these comparisons further, the reproductive performance over five parities (of seven combinations that ranged from 1/8 F to 7/8 F) was compared to that of the parental breeds (Fahmy and Dufour, 1988). Ovulation rate increased with age and was highest in F (3.42), 7/8 F, and 6/8 F groups and lowest in DLS (1.76) and 1/8 F groups (Table 8). Ova loss was 26% in F ewes and 18% in DLS and 1/8 F. Crosses with F exceeding 2/8 F lost between 26 and 29% of their ova, in spite of the wide differences in ovulation rate observed between these crosses. F ewes averaged 2.86 lambs born, of which 8% were born dead and 2.03 were weaned, as compared with 1.44, 3%, and 1.22 for DLS; and 2.12, 5.5%, and 1.84 for 1/2 F, respectively. Litter size at birth increased progressively from 1.63 for 1/8 F ewes to 2.42 lambs for 7/8 F ewes. Litter size at birth of ewes with 4/8 F or higher F breeding was significantly higher than those with a proportion lower than 4/8 F. At weaning, the heaviest litters were those raised by 4/8 F ewes (31.7 kg) followed by 7/8 F ewes (30.8 kg), whereas those raised by DLS and 2/8 F ewes were the lightest. Ovulation rate, litter size at birth, and weaning and preweaning mortality rate increased progressively with an increase in F proportions. Crosses with low proportions of F (1/8 F to 3/8 F) produced 22 kg of lambs weaned; those with higher proportions (5/8 F to 7/8 F) produced about 24.5 kg, whereas the 4/8 F cross gave the highest performance (27.6 kg). In general, the 4/8 F cross exhibited the highest performance in litter weight at weaning; the two crosses closest to the parental breeds (1/8 F and 7/8 F) were generally superior to the two crosses closest to the first cross (3/8 F and 5/8 F), whereas the two backcrosses (2/8 F and 6/8 F) ranked lowest.

Ewe productivity was also evaluated on F, DLS, and their crosses mated in April, December, and August (Fahmy, 1990b). The number of lambs born alive was 2.53 for F and 1.19 for DLS. The two most prolific crosses were the 7/8 F and 5/8 F (Table 8). Preweaning mortality was highest for the 1/8 F ewes (17.5%), followed by the pure F (11.2%). The largest litters at weaning were those of 7/8 F followed by 5/8 F ewes. The flock averaged 1.38 parturitions per year, which corresponds to one parturition every 264 days. A high rate of infertility was responsible for the 7/8 F ewes lambing only 1.1 times per year. The 5/8 F and 6/8 F ewes lambed every 8 months, whereas the other genetic groups had lambing intervals of 8.5 to 9 months. Ewe productivity per year (fertility × litter size at weaning × number of litters per year) was highest in the 6/8 F group (3.27 lambs, 55.3 kg) and lowest in the 7/8 F group (1.53 lambs, 24.6 kg). The pure F ewes produced 3.07 lambs weighing 43.9 kg per year compared with 1.71 lambs weighing 32.1 kg per year for the DLS ewes. Significant linear regressions were calculated between the proportion of F in the cross and number of lambs born alive ($b = 0.12$), and number of lambs weaned ($b = 0.16$). Crosses with various proportions of F breeding adapted well to a system of lambing every 8 months.

JAPAN

Yamaki (1988) compared the reproductive characteristics of Suffolk, Corriedale, F, and crossbred ewes of Suffolk × Corriedale ewes mated to F rams. Ewes were mated to rams of the same genotype to produce offspring. Reproductive performance of the various ewe types is shown in Table 9

Fertility (ewes lambing per ewe exposed) was highest for F ewes and lowest for Suffolk and Corriedale ewes whereas crossbred ewes were intermediate. F ewes had the largest litters, averaging 3.27 lambs per ewe lambing, 46% of the ewes had 4 or more lambs. Crossbred ewes ranked second in litter size, with an average lambing rate of 1.68. Fifty percent of the crossbred lambs had twins, and only 8% had 3 or more lambs. In contrast, litter sizes of Suffolk and Corriedale ewes were similar and averaged 1.31. Use of F crossbred ewes thus increased litter size by an average of 0.37 lambs over that obtained from nonprolific breeds. Survival rates to weaning were highest for crossbred lambs and similar for the three pure breeds. The advantage of the crossbred ewe over the two nonprolific breeds thus increased to 0.45 lambs weaned per ewe lambing.

Overall productivity (Table 9) was measured as total weight of lamb weaned or produced at 6 months per ewe exposed. F ewes were highest for both measures. They produced 73% more kilograms of lamb at 6 months than Suffolk ewes and 113% more kilograms of lamb than Corriedale ewes. The crossbred ewes correspondingly produced 34% more kilograms of lamb at 6 months than Suffolk ewes and 66% more kilograms of lamb than Corriedale ewes. Thus, in this environment, use of F ewes and their crosses yielded major increases in rate of lamb production.

Table 9 . Reproductive performance of Corriedale, Suffolk, Finnsheep and Finnsheep crossbred ewes in Japan.

Genotype	No. of ewes	Litter size	Lamb survival to weaning (%)	Litter size weaned
Corriedale	18	1.33	80	1.07
Suffolk	35	1.30	86	1.11
Finnsheep	40	3.27	83	2.70
F crosses	76	1.66	92	1.56

AUSTRALIA AND NEW ZEALAND

In 1985, three F rams were imported to Australia and crossed with Border Leicester and Border Leicester x Merino ewes in quarantine. Thirty six ram and 43 ewe progeny of these crossings were released from quarantine in 1992. In 1993, 12 rams and 60 ewes were imported to Australia from New Zealand. These sheep are still held under quarantine, but semen and purebred progeny, via embryo transfer, are being released to Australian breeders.

In New Zealand F from two importations were released from quarantine in October 1990. Some of the initial imported F embryos were from sheep in Finland selected solely on high litter size and the aim was to use this line to produce 1/8 F crosses (Baker, 1988). Rams released in 1990 included pure F, ½ F (crossed with Romney, Coopworth or Perendale) and ¼ F. The first 1.5 year old progeny were mated in 1993 and so far there are no data on the performance of F crosses.

SOUTH AMERICA

Two Finnsheep rams were imported and used to develop two prolific genotypes currently being used by breeders to improve fertility and lamb production. The Austral breed was developed from a cross between F and Romney, its with a fecundity rate of 146%, prolificacy rate of 157% and lamb weaned rate of 138%.The "Hidango" genotype (1/4 Finnish x 3/4 Mutton Merino), was developed in central

Chile, by the Instituto de Investigaciones Agropecuarias. Animals of this genotype have a high fertility rate (130% fecundity, 150% prolificacy), heavy weaning weights and good carcass qualities.

NEW BREED DEVELOPMENT UTILIZING FINNSHEEP

The wide interest in prolific sheep throughout the world has led to the establishment of a number of synthetic populations based on the F to incorporate the valuable reproductive potential of F in local breeds more adapted and suited for meat production. The origin and characteristics of some of the new breeds produced are summarised briefly as follows

ABRO Damline

This breed was developed at the Animal Breeding Research Organization in Edinburgh, Scotland, in the early Seventies to redress some of the deficiencies of the F and F crosses as sires of crossbred ewes.. Four breeds were involved, Finnsheep, East Friesian, Dorset Horn and Border Leicester, contributing 47, 24, 17 and 12% of the Damline genetic composition, respectively (Smith et al., 1979). The line was closed and selected for 8-week litter weight on a ewe lifetime index.

No reports are published on the performance of pure ABRO Damline. Barker (1977) reported that in 1975 the lambing percentage of the ABRO flock was 159 for ewe lambs, 193 for two-year-old and 2,35 for three-year-old

ARCOTT Outaouais and Rideau

The Outaouais and Rideau breeds were developed at the Animal Research Centre in Ottawa, Canada, as breeds capable of performing under intensive management. The development started in 1966 with a foundation stock consisting of ewes and rams from Shropshire, Suffolk and a composite population (developed from Leicester, North Country Cheviot, Romnelet and Suffolk breeds, each contributing approximately 25%). Further additions to the gene pool included purebred and crossbred ewes and rams of Leicester, North Country Cheviot, Canadian and N Z Southdown, Corriedale, Ile- de-France and Dorset breeds. Finnsheep contributed prolificacy to both breeds, while East Friesian contributed high milk production and prolificacy to the Rideau breed. The Outaouais breed consists of 49% F, 26% Shropshire and 21% Suffolk ancestry with minor contributions (4%) from Ile de France, East Friesian, Dorset, N.C. Cheviot, Leicester and Romnelet breeds. The Rideau breed consists of 40% Finnish Landrace, 20% Suffolk, 14% East Friesian, 9% Shropshire, 8% Dorset Horn with minor contributions (9%) from Leicester, N.C. Cheviot, Romnelet and Corriedale breeds.

Ovulation rate of Rideau ewes of different ages is between 2 and 6 ovulations (avg 3.25). On commercial or accelerated systems, Outaouais ewe lambs produce 1.8 lambs while adult ewes produce 2.6 lambs. Litters with multiple births account for 83% of births. Average litter size of 92 ewes is 2.9 lambs, in which, 15.2% are singles, 59.8%, twins or triplets, 31.5% quadruplets or quintuplets and 4.3% sextuplets. Rideau ewe lambs produce 1.7 lambs and adult ewes 2.5 lambs. In a recent study, adult ewes averaged 2.9 lambs. Multiple birth accounted for 82% of all litters.

Belclare

The development of the Belclare breed was initiated in 1978 in Ireland. Three genotypes were involved, Fingalway (interbred population from crossing F and Galway) contributed 18%, High

Fertility (high prolificacy sheep selected for litter size), contributed 32% and Lleyn (a Welsh breed selected in Ireland for high lifetime litter size), contributed 45%. Animals from reciprocal crosses of Fingalway and High Fertility were crossed with Lleyn to produce the foundation population of Belclare. Occasionally, genetic material from selected Galway and F was introduced into the composite, contributing the remaining 5% (Hanrahan, 1989).

Belclare sheep reach puberty at 229 days of age when they weigh 34.4 kg. The onset of the breeding season is around 15 September and it lasts for 168 days (Hanrahan, 1988). Belclare ewe are highly fertile, with conception rate ranging between 91 and 95% for ewes of different ages. Ovulation rate of ewes varies between 1 and 6 but some exceptional ewes ovulate up to 18. Ovulation rate at first estrus is 1.5 and for 2, 3 and >4 year old ewes ovulation rate is 2.2, 2.5 and 3.2 and litter size is 1.9, 2.0 and 2.4 lambs, respectively (Hanrahan, 1989). Lamb survival is high, ranging from 97% for single to 79% for triplet lambs.

The Cambridge Breed

Developed at Cambridge University in 1964, this breed was created as a new damline to produce rams capable of siring prolific crossbred ewes for mating with specialist terminal sires of meat breeds. The foundation group was selected by the screening of several British meat breeds for ewes of high prolificacy. The criterion of selection was that each ewe should have given birth to at least 9 lambs in three lambings. Screening was achieved initially by postal inquiry which 54 ewes from nine breeds and crosses (34 Clun Forest, 6 Llanwenog, 3 each of; Lleyn, Suffolk x Border Leicester-Welsh Mountain, and Suffolk x Border Leicester-North Country Cheviot, 2 Rendor, 1 each of ; Kerry Hill, Ryeland and Bluefaced Leicester. The contribution of the constituent breeds is presented in Figure 3.10.1, shows 63% from Clun Forest, 11% from Llanwenog,5.5% from Lleyn, 5.5% from Suffolk, 3.5% from Rendor, and the remaining 11.5% from the other six breeds.

The ewes were mated in their first season to seven F rams, Subsequently F1 rams and rams from backcrosses to the original foundation ewes, were used as sires, until the establishment of the composite breed, with an approximate genetic contribution of 20-25% from the Finnsheep.

Observing ovulation rate gave a strong indication that a gene or probably more than one gene with large effect on ovulation may be present in the Cambridge breed. Average number of lambs born is 1.8 for yearlings, 2.7 for 2-yr old and 3.0 for 3-yr old ewes. The ewes are good milkers with average daily production of 4.1, 3.7 and 2.2 kg at 20, 30 and 70 days of lactation, respectively

Dutch prolific breeds

Two breeds were developed in the Netherlands recently using the F breed, Noord-Hollander (North Holland), from a cross between Finnsheep and Texel and Flevoland from a cross between Finnsheep and Ile-de-France. The number of lambs weaned per ewe per year in an 8 month interval lambing system was reported at 2.78 and 2.13 for the two breeds, respectively (Wensvoort, 1984).

The development of the Flevoland started in 1975 by producing reciprocal crosses of Finnsheep with Texel. Between 1981 and 1986, the two reciprocal crosses were intermated and cross mated with each other to form the base population which consisted of 224 ewes from 22 sires from the two breeds of origin. Preliminary reports on prolificacy in an 8 month lambing system estimated litter size at birth and weaning at 2.5-2.6 and 2.1-2.2 lambs, respectively (Visscher, 1987).

Polypay

The development of the Polypay breed was initiated in 1968 at the Sheep Experimental Station in Dubois, Idaho, USA. The objective was to create a breed with high lifetime prolificacy, a large lamb crop at 1 year of age, ability to cope with intensive systems, rapid growth rate of lambs and desirable carcass quality, by combining genes from four breeds each contributing 25% (Hulet et al. 1984). First, the F x Rambouillet and Dorset x Targhee crosses were obtained then the Polypay was made from mating the two crosses.

Sexual maturity is early, many lambs can breed at 5 months of age and most conceive at 7 months and lamb for the first time at 1 year (Fahmy and Lavallée, 1989). Polypay ewes have an extended breeding season and can be bred successfully every 6, 7, or 8 months. Conception rate is high for ewes mated in the normal breeding season (97%, Nawaz and Meyer, 1992, 96%, Fahmy and Lavallée, 1990, 95%, Pope et al., 1989) and out of the breeding season (88%, Fahmy and Lavallée, 1990, 50%, Pope et al., 1989)). Conception rate of ewe lambs mated at 7-8 months is 89%.

Ovulation rate of 2.68 resulting in 2.08 lambs born (West et al., 1991) and 1.94 resulting in 1.88 lambs born have been reported (Nawaz and Meyer, 1992). Lambs born per mature Polypay ewe exposed was reported at 1.8 lambs for once-a-year lambing and 2.1 for twice-a-year lambing in the USA (46.5 and 57.1 kg weaned lambs at 120 days, respectively). Ewes exposed to intensive systems of 3 matings in 2 years averaged 1.5 lambing per year with production averaging 2.77 lambs born and 2.53 lambs weaned (Fahmy and Lavallée, 1990).

Milk production is high, ewes lambing singles and twins produced 2.88 and 3.54 kg/day at 28 days of lactation. Persistency is also high, at 56 days of lactation, ewes produced 1.95 and 2.52 kg/day and at 98 days, 0.41 and 0.87 kg/day, respectively (Snowder and Glimp, 1991).

Wealden four-quarter sheep

This breed was developed over a period of 22 years in the United Kingdom. The origin was a Romney Marsh ewe with four teats. This ewe was mated with a Clun Forest ram for 3 years and the three progeny had 4 teats. Friesian, Finnish Landrace, Booroola Merino and Suffolk inheritance was incorporated in developing this breed which is now a stable recognizable prolific type with 4 functional teats (Hope, 1993).

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