SHEEP PRODUCTION

Sheep Production Systems

The effects of maturity of maize at harvest and soyabean supplementation, grass silage feed value and concentrate feed level on ewe and subsequent lamb performance

Recent studies have shown that maize silage inclusion in the diet increases the performance of dairy and beef cattle and can replace high feed value of grass silage in the diet of pregnant ewes. The objective of the current study was to evaluate the effects of (i) maturity of maize at harvest (ii) protein supplementation, (iii) feed value of grass silage and (iii) potential concentrate sparing effects of high feed value grass silage and maize silages on the performance of pregnant ewes and their progeny.

High and low feed value grass silages were harvested on 3 May and 5 June, respectively, and ensiled precision chopped treated with an inoculant. Two maize silages were produced, either grown in the open (sown on May 10) or under the complete plastic mulch (CCPM) system (sown on April 10), and ensiled precision chopped treated with an inoculant-based additive. The grass silages were offered *ad libitum* supplemented with either 15 or 25 kg concentrate in late pregnancy. The maize silages were offered with either 0 or 200 g soyabean meal/ewe daily. The high feed value grass silage was also supplemented with 5 kg of soyabean/ewe during late pregnancy. The ewes offered the grass and maize silages received 20 and 30 g/ewe of mineral and vitamin mixture daily during late pregnancy, respectively. The 9 treatments were offered to 160 ewes (Belclare x S. Blackface, Charmoise x S. Blackface) during mid and late pregnancy, housed on slats. The data were analysed using Proc GLM, for ewe traits, and Proc MIXED, for lamb traits with ewe as random, of SAS.

The mean DM, crude protein and metabolisable energy concentrations of the low and high feed value grass silages and the low and high DM maize silages were 219, 250, 215 and 339 g/kg, 95, 132, 117 and 88 g/kg DM and 11.3 [DM digestibility (DMD) 730 g/kg DM], 12.2 (DMD 790 g/kg DM), 11.0 and 11.6 MJ/kg DM, respectively. For maize sown in the open and under the CCPM system forage yield was 10.6 and 15.0 t DM/ha respectively.

Table 1: The effects of maturity of maize silage, grass silage feed value and concentrate level on animal performance

	Maize silage (MS) dry matter				Grass silage feed value (GS)								
	Low		High		Low		High				Significance[3]		
Soya (S)[1]/conc (C)[2]	0/15	200/15	0/15	200/15	0/15	0/25	0/5	0/15	0/25	s.e.	MS	S	GS
Post lambing - CS[4]	2.96	3.53	3.29	4.15	2.66	3.03	3.87	4.06	3.96	0.152	**	***	***
- weight (kg)	63.0	68.6	68.2	76.6	61.2	61.6	70.4	73.6	73.6	2.15	**	**	***
Litter size	2.09	1.74	2.04	2.03	1.95	1.80	1.62	1.65	1.81	0.171	NS	NS	NS
Lamb weight (kg) - birth	4.62	4.92	4.65	5.29	4.60	4.56	4.85	5.13	5.13	0.168	NS	**	***
- weaning	33.4	32.8	34.1	34.3	33.6	32.1	34.0	35.0	34.3	1.05	NS	NS	*
Lamb weight gain (g/day)	296	289	303	299	300	284	301	309	302	10.17	NS	NS	NS

[1]Soya = g/day. [2]Concentrate = kg in late pregnancy. [3]There were no significant concentrate effect on maize silage x soyabean meal or grass silage x concentrate feed level interactions. [4] Condition score (scale 1 – 5; where 1 = thin, 5 = fat)

The effects of grass silage feed value, maturity of maize silage, protein supplementation of maize silage and concentrate feed level on ewe performance during mid and late pregnancy and subsequent lamb performance are presented in Table 1. Increasing maturity of maize at harvest increased ewe post lambing condition score (CS) and weight but did not alter (P>0.05) lamb performance. Supplementing maize with soyabean meal increased post lambing ewe CS and weight, and lamb birth weight but did not alter (P>0.05) lamb performance.

Increasing grass silage feed value increased post lambing ewe CS and weight and lamb birth and weaning weights. Concentrate feed level offered with the grass silage did not alter ewe or lamb performance. There were no significant maize silage by soyabean supplementations or grass silage feed value by concentrate feed value interactions. It is concluded that maize silage can replace high feed value grass silage in the diet of pregnant ewes. High feed value grass silage enables concentrate supplementation to be reduced by at least 80%.

Keady, T.W.J. and Hanrahan, J.P. *RMIS No. 5657*

The effects of supplementation of maize silage diets during pregnancy on ewe and subsequent lamb performance

Previous studies at Athenry have shown that maize silage, regardless of maturity at harvest, results in similar levels of ewe and subsequent lamb performance relative to high feed-value grass silage. The objective of the current study was to evaluate the effects level and type of concentrate supplementation of maize silage diets on ewe and subsequent lamb performance.

Maize which was sown on 5 April and grown under the complete plastic mulch system was harvested on 8 October and ensiled treated with a bacterial inoculant. A total of 36 ewes [(Belclare x Scottish Blackface, Charmoise x Scottish Blackface) (initial live weight = 69 kg, initial condition score = 3.7)] were offered maize silage *ad libitum* from mid pregnancy to lambing and were allocated at random to three concentrate treatments: 200 g soya bean daily during mid and late pregnancy plus 15 kg concentrate in late pregnancy (SC), 10 kg soya bean during late pregnancy (10S) and 5 kg soya bean during late pregnancy (5S). The ewes were moved to pasture within 3 days of lambing. Ewes rearing singles or twins, and their lambs, were offered no concentrate at pasture. Ewes rearing triplets received 0.5 kg concentrate daily for the first 5 weeks post lambing, whilst their lambs were offered up to 300 g concentrate daily until weaning at 14 weeks. The data was analysed using Proc GLM and Proc MIXED of SAS as appropriate.

The mean dry matter (DM), crude protein, starch and ME concentrations of the maize silage were 339 g/kg, 88 g/kg DM, 236 g/kg DM and 11.5 MJ/kg DM, respectively. The effects of concentrate supplementation on ewe and subsequent lamb performance are presented in Table 2. Ewes offered 5 kg soya bean during late pregnancy had significantly lower ($P<0.001$) condition at lambing. Otherwise level or type of concentrate supplementation did not alter ($P>0.05$) ewe or subsequent lamb performance.

Table 2: Effect of supplementation of maize silage on ewe and subsequent lamb performance

		Treatment				
		SC*	10S	5S	s.e.	sig
Ewe weight (kg)	- lambing	74.9	72.0	66.5	2.95	NS
	- weaning	68.2	69.3	66.4	2.55	NS
Ewe condition score at lambing		3.60	3.57	2.84	0.142	***
Litter size		2.05	2.07	2.00	0.198	NS
Number reared/ewe lambing		1.58	1.79	1.46	0.226	NS
Lamb weight	- birth	4.7	4.8	4.4	0.22	NS
	- weaning	30.4	30.9	29.7	2.05	NS
Lamb gain	- 0 to 5 weeks	280	274	241	25.0	NS
(g/day)	- birth to weaning	262	270	261	20.4	NS

*SC = 200g soya bean meal daily and 15 kg concentrate in late pregnancy, 10S = 10 kg soya bean meal in late pregnancy, 5S = 5 kg soya bean meal in late pregnancy

It is concluded that there is no benefit to supplementing ewes offered maize silage with protein in mid pregnancy. During late pregnancy concentrate supplementation can be reduced to approximately 10 kg of soyabean meal without having a negative impact on ewe or subsequent lamb performance.

Keady, T.W.J. and Hanrahan, J.P. *RMIS No. 5657*

The effects of herbage allowance and frequency of allocation to ewes in mid pregnancy on ewe and subsequent lamb performance

Previous studies at this centre have shown that extended grazing ewes in mid, late or throughout pregnancy increased lamb birth and weaning weights relative to progeny from ewes which were housed unshorn. Stocking rate needs to be reduced dramatically to facilitate year-round grazing as herbage availability during early autumn is the major limitation. A previous study at Athenry showed that increasing herbage allowance to ewes in mid pregnancy decreased herbage utilisation but increased forage intake, ewe condition and subsequent lamb birth and weaning weights. The aim of the current study was to evaluate the effects of herbage allowance and frequency of allocation to ewes in mid pregnancy on ewe and subsequent lamb performance. Furthermore the effects of extended grazing management on subsequent herbage yield and ground cover were also evaluated.

Crossbred ewes [(52 Belclare x Scottish Blackface and 20 Charmoise x Scottish Blackface) (52 1.5 year olds, 20 4.5 year olds) (initial liveweight 68.4 kg, initial condition score 3.7)] due to lamb in mid March were allocated at random, balanced with respect to breed and age to four treatments. The four treatments were extended grazed pasture offered at dry matter (DM) allowances of 1.0 or 1.8 kg per ewe daily and allocated either daily or twice weekly from 28 November to 30 January. From 31 January to lambing the ewes were housed in pens of 5 and offered grass silage *ad-libitum* supplemented with a total of 19 kg concentrate per ewe. A blood sample was taken from the jugular vein of each animal on four consecutive days during weeks 3 and 9 of the extended grazing period to correspond with 0, 24, 48 and 72 h after herbage allocation for animals moved twice weekly and after 24 h for the animals moved weekly. Ewes and their lambs were turned out to pasture within 3 days of lambing. Ewes rearing singles and twins received no concentrate post lambing. Ewes rearing triplets received 1 kg concentrate/head daily for 3 weeks and 0.5 kg concentrate/head daily for weeks 4 and 5 post lambing. Concentrate was offered to lambs reared as triplets, to a maximum of 300 g/lamb daily until weaning. All lambs were weaned at 14 weeks. The data were analysed using Proc GLM and Proc MIXED of SAS as appropriate.

Table 3: The effects of herbage allowance and frequency of allocation on ewe and subsequent lamb performance

	Herbage allowance (HA) (kg DM/d)							
	1.0		1.8			Signifance		
Frequency of allocation (F)	Daily	2 x weekly	Daily	2 x weekly	s.e.	HA	F	HAxF
Ewe condition score - end of EG[1]	2.97	3.00	3.24	3.15	0.094	***	NS	NS
- weaning	2.95	2.99	3.27	3.34	0.205	*	NS	NS
Litter size	1.90	1.75	1.84	1.98	0.170	NS	NS	NS
No born dead	0.20	0.13	0.00	0.04	0.105	P=0.06	NS	NS
Lamb - Birth weight (kg)	4.72	4.84	4.66	5.31	0.197	NS	*	NS
- Weaning weight (kg)	32.4	32.6	33.1	31.3	1.02	NS	NS	NS
Plasma - Total protein (g/l)	69.2	71.0	73.3	72.7	0.72	***	NS	NS
- NEFA (m mol/l)	0.84	1.12	0.67	0.87	0.045	***	***	NS

[1]EG = extended grazing

There were no herbage allowance by frequency of allocation interactions in the current study. The DM, crude protein, acid detergent fibre and ash concentrations of the extended grazed herbage were 123 g/kg, 200 g/kg DM, 263g/kg DM and 117 g/kg DM, respectively. The effects of herbage allowance and frequency of allocation on ewe and subsequent lamb performance are presented in Table 3. Increasing herbage allowance increased ewe condition score at the end of extended grazing and at weaning, and total protein concentration in plasma, decreased plasma NEFA concentration, and tended to decrease the number of lambs born dead. Herbage allowance did not alter lamb birth or weaning weights. Twice weekly herbage allocation increased lamb birth weight and NEFA. Neither herbage allowance nor frequency of allocation altered (P>0.05) silage intake during late pregnancy. The effects of extended grazing management on subsequent herbage yield are presented in Table 4. Increasing herbage allowance at grazing increased subsequent herbage yield and decreased the proportion of bare ground. Frequency of herbage allocation did not alter (P>0.05) subsequent herbage yield or the proportion of bare ground.

Table 4: The effects of extended grazing management on subsequent herbage yield

	Herbage allowance HA (kg/day)		Frequency of allocation (F)		Significance		
	1.0	1.8	Daily	2 weekly	HA	F	HAxF
DM yield (t/HA)	1.80	2.40	2.07	2.11	*	NS	NS
Bare ground (%)	14.1	5.9	9.9	10.1	*	NS	NS

It is concluded that to maximise stock carrying capacity and reduce labour requirement and herbage allowance of 1 kg DM offered twice weekly is adequate for ewes in mid pregnancy.

Keady, T.W.J. and Hanrahan, J.P. *RMIS No. 5682*

An on-farm evaluation of the effects of season of shearing on ewe and subsequent lamb performance

Previous studies at Athenry have shown that shearing ewes at housing increased subsequent lamb birth and weaning weights by up to 0.6 and 2.5 kg, respectively. Therefore, as a consequence of reducing age at slaughter by approximately 2 weeks. However, shearing at housing may increase management inputs as ewes are normally housed in smaller groups and need to be dry prior to shearing. Shearing in the autumn, prior to mating, enables the flock to be assembled under more favourable conditions. A previous study at this centre showed that shearing prior to mating tended to increase subsequent lamb birth weight (+0.3 kg) but did not alter litter size or lamb viability relative to lambs born from ewes which were shorn in late May. The aim of this study was to further evaluate the effects of season of shearing on fertility of March - lambing ewes and on subsequent lamb performance.

The study was undertaken on a commercial farm. A total of 353 ewes [(Belclare cross) (initial LW = 59.8 kg, initial CS = 3.5)] which had been allocated at random in September 2006 to one of three shearing treatments as follows: shorn prior to mating, at housing and conventional shorn (September 2006, December 2006 and June 2007, respectively). Subsequently the ewes on the prior to mating, at housing and shorn treatments were shorn 7 September 2007, 20 December 2007 and 13 June 2008, consequently all ewes had been shorn 12 months previously. All ewes were mated at a natural oestrus, as one flock, to a panel of 5 Charollais rams which was joined with the ewes on 21 October 2007. The ewes were housed on 15 December and offered hay until mid January. Subsequently the ewes were grouped according to litter size (ultrasonic scanning) and received a straw-based diet supplemented with concentrate. For weeks 8-7, 6-5, 4-3 and 2 to lambing, ewes carrying singles received 0.7, 0.8, 0.9 and 1.0 kg concentrate daily, ewes with twins received 0.8, 1.1, 1.3 and 1.4 kg concentrate daily and those carrying triplets/quads received 1.0, 1.2, 1.5 and 1.5 kg concentrate daily, respectively. Ewes were weighed and condition scored at shearing in September, December and June and at 10 and 14 weeks post lambing. Fleeces were weighed at shearing. Lambs were weighed at birth and 10 and 14 weeks post lambing. The data were analysed using Proc GLM and Proc MIXED of SAS as appropriate.

Table 5: The effects of season of shearing on ewe and progeny performance

		Treatment				
		June	Sept	Dec	s.e.	Sig.
Ewe weight (kg)	- housing	69.0	68.9	70.9	0.75	NS
	- weaning	68.0	68.5	70.3	0.89	NS
Ewe CS	- housing	2.9	3.0	2.9	0.03	NS
	- weaning	3.0	2.9	3.0	0.05	NS
Fleece weight (kg)		2.76[a]	2.56[a]	3.05[b]	0.061	***
Fertility		0.96[b]	0.90[a]	0.89[a]		*
Litter size		1.97	2.04	1.99	0.065	NS
Number reared / ewe lambing		1.52	1.64	1.48	0.078	NS
Lamb weight (kg)	- birth	4.21	4.35	4.45	0.094	NS
	- weaning	28.2	28.2	29.2	0.570	NS
Lamb gain birth – weaning (g/day)		234	235	243	5.46	NS

The effects of shearing treatment on ewe and subsequent progeny performance are presented in Table 5. Ewes shorn at housing had heavier fleeces than ewes shorn in June or September. Season of shearing did not alter (P>0.05) ewe live weight or condition score at housing or weaning, or on litter size or number reared. Shearing at housing tended (P >0.05) to increase lamb birth and weaning weights.

It is concluded that whilst the performance of the lambs from birth to weaning in the current on-farm study was moderate, ewes which had been shorn at housing produced heavier fleeces and lambs which tended to be heavier at weaning.

Keady, T.W.J. and Hanrahan, J.P. *RMIS No. 5674*

Effects of altering the plane of nutrition during the rearing phase and during pregnancy of 2-tooth ewes, of two genotypes, on ewe and subsequent lamb performance

The overall objective of this study is to evaluate the effects of plane of nutrition at different phases during the rearing regime of replacement ewes, differing in genotype on subsequent lifetime performance. The study was initiated in autumn 2006 and the last batch of 90 ewe lambs were allocated in the autumn of 2008. The study involves 8 treatments consisting of two planes of nutrition in the first winter period by two planes of nutrition in the second grazing season.

The information obtained during 2008, on the effects of plane of nutrition during the first winter, subsequent grazing season and during first pregnancy, and potential interactions, on ewe body size and productivity and subsequent lamb performance using two breed types with contrasting prolificacy potential, is summarised. Ewe lambs [60 Charmoise x S. Blackface, 34 Belclare x S. Blackface; mean initial live weight 34.8 and 39.9 kg, respectively] were allocated to two herbage dry matter (DM) allowances daily [0.75 kg (L) and 1.75 kg (H) per head] on winter grazing (winter-1), from 25 November to 29 March. From 29 March to 30 August half of the ewe lambs from each winter treatment were allocated one of two planes of summer nutrition by set stocking to maintain sward heights of 4 cm (L) or 6 cm (H) (summer). From 30 August to early December all ewes were grazed as one flock. At housing half of the ewes on each of the four treatments were allocated either high (H) or low (L) feed value grass silage (winter-2). Thus, there were eight treatment groups [(2 winter-1 treatments (H, L) x 2 summer grazing treatments (H, L) x 2 winter-2 treatments (H, L)]. During the last 6 weeks of pregnancy all ewes were offered 20 kg concentrate per head. Ewes and their lambs were turned out to pasture within 3 days of lambing. Ewes rearing singles or twins were offered 0.5 kg concentrate daily for 5 weeks post lambing while their lambs were offered up to 300 g/day until weaning. Lambs received no concentrate post weaning. The data were analysed using Proc GLM and Proc MIXED of SAS as appropriate.

Table 6: Effect of plane of nutrition during the rearing phase on ewe and subsequent lamb performance

	Winter-1 plane of nutrition (W1)												
	Low				High								
Summer (S)	Low		High		Low		High			Significance			
Winter-2 (W2)	Low	High	Low	High	Low	High	Low	High	s.e.	W1	S	W2	W1xS
Post lambing -condition	2.56	3.48	2.59	3.38	2.87	3.59	2.89	4.14	0.142	***	NS	***	NS
-weight (kg)	50.9	54.5	47.2	55.0	50.4	57.3	56.9	64.5	2.09	***	P=0.08	***	**
Litter size	1.89	1.50	1.60	1.52	1.50	1.61	1.57	1.59	0.152	NS	NS	NS	NS
Lamb weight (kg) - birth	4.6	4.6	4.2	4.9	4.7	5.0	5.1	4.9	0.19	**	NS	NS	NS
-weaning	27.7	29.3	27.8	29.5	30.4	31.2	28.6	30.6	1.19	NS	NS	*	NS
Lamb gain (g/day)	241	260	239	253	256	269	240	264	9.8	NS	NS	*	NS

[1]There were no (P>0.05) winter 1 x winter 2, summer 2 x winter 2 or winter 1 x summer 2 x winter 2 interactions

The effects of plane of nutrition at different stages during the rearing phase until lambing as 2-tooth ewes on ewe and subsequent lamb performance are presented in Table 6. Increasing winter-1 plane of nutrition increased ewe weight and condition at lambing, lamb birth weight and tended to increase (P=0.08) lamb weight at weaning. Increasing winter-2 plane of nutrition increased ewe condition and live weight at lambing and lamb daily gain from birth to weaning. Plane of nutrition during the summer did not affect (P>0.05) ewe performance or that of their lambs. The effects of ewe genotype on ewe and lamb performance are presented in Table 7. Relative to the Charmoise-X, the Belclare-X were heavier at lambing, produced larger litters and reared lambs which were heavier at birth and at weaning.

Table 7: Effect of ewe genotype on ewe and lamb performance

	Ewe genotype			
	Charmoise-X	Belclare-X	s.e.	Sig.
Post lambing -condition	3.03	2.72	0.075	***
- weight (kg)	51.7	57.5	1.06	***
Litter size	1.34	1.85	0.078	***
Lamb weight (kg) -birth	4.6	4.9	0.10	**
- weaning	28.1	30.7	0.62	***
Lamb gain (g/day)	239	266	5.5	***

It is concluded that whilst altering the plane of nutrition during different stages of the rearing phase increased ewe liveweight by up to 36%, there was no effect on litter size or number reared. Plane of nutrition during the first winter had the greatest effect on subsequent lamb birth and weaning weights. The weight of lambs weaned per ewe was 67% higher for the Belclare-X than the Charmoise-X due to a combination of higher litter size (0.51) and higher progeny growth rate (+30 g/day).

Keady, T.W.J. and Hanrahan, J.P. *RMIS No. 5682*

Effect of grass silage feed value and concentrate feed level on ewe and subsequent progeny performance and on potential concentrate sparing effect

Previous studies at Athenry showed that increasing silage feed value increases ewe condition and weight at lambing and lamb birth and weaning weights. Each 1 kg increase in lamb birth weight increases subsequent weaning weight by approximately 3 kg which is equivalent to reducing the age at slaughter by 3 weeks. Currently there is a paucity of data on the relationship between concentrate feed level and silage feed value.

The objective of the current study was to evaluate the effects of grass silage feed value, concentrate feed level and their interactions on the performance of ewes in mid and late pregnancy and on subsequent lamb performance. Furthermore the potential concentrate sparing effects of high feed value grass silage was determined. Finally the relationship between grass silage feed value and concentrate feed level was determined to enable the optimum diet combination to be determined depending on the price of concentrate and silage.

The study was established in autumn 2008 and involves 7 treatments consisting of 2 grass silage each offered at differing levels of concentrate supplementation to ewes in late pregnancy.

Keady, T.W.J. and Hanrahan, J.P. *RMIS No. 5657*

The effects of extended grazing on subsequent sward botanical composition

Previous studies at Athenry have shown that extended grazing ewes in mid, late or throughout pregnancy increased subsequent lamb birth and weaning weights relative to ewes which were housed, unshorn and offered grass silage. However, sheep production systems involving extended grazing required stocking rate to be reduced to a maximum of approximately 10 ewes/ha. During extended grazing, paddocks are soiled due to treating by the ewes. The amount of treading damage done to paddocks depends on herbage mass during extended grazing and herbage allowance which impacts on the area allocated for grazing, ewe weight and prevailing weather conditions. Previous studies have shown that extended grazing management impacts on the proportion of bare ground in swards the subsequent spring. There is anecdotal evidence from previous studies at Athenry which suggest that extended grazing changes the botanical composition of the sward.

The objective of the present was to evaluate the effects of date of extended grazing and stocking rate during extended grazing on botanical composition and the proportion of bare ground in the sward. The study was established in autumn 2008 and involves four treatments including two stocking rates during extended grazing, and two dates of herbage removal by clipping.

Keady, T.W.J. and Moran, J. *RMIS No. 5682*

Athenry Research Centre

Hill Sheep

Environmental impact of hill sheep systems: Un-improved hill vegetation, excluding holding areas, Leenane Hill Sheep Farm, 1995, 1999 & 2008

A number of research projects have been carried out on the Hill Sheep Farm in Leenane Co. Mayo, to monitor the impact of grazing. The farm consists of mainly blanket bog and wet heath habitats. Hanrahan and O'Malley, *Research Report 2008,* calculated the average annual stocking rate of the unimproved hill from 2006 to 2008 at 0.7 ewes per ha. The current projects include an assessment of (i) changes in the frequency and composition of the un-improved vegetation (ii) sustainable agro-environmental management of hill and mountain peatland and (iii) the impact of hill sheep activity on the population dynamics and diet of small mammals.

The background, including objectives and methods, are described in *Research Report 1995, p. 12.* Monitoring of the un-improved hill vegetation which began in the summer 1995 and repeated on a number of occasions since then was also completed in summer 2008 using the same methodology. Results for three of those years are presented in Table 8. The largest change occurred in the incidence of 'No vegetation', mainly bare soil with outcropping rock, which decreased from 35.5 to 17.2%. While all vegetation groups increased over the period, grasses, which consisted mainly of *Molinia,* were dominant throughout and had the highest percentage point increase – 24.6 to 30.2%.

Table 8: Frequency of un-improved hill vegetation, excluding holding areas, 1995, 1999 and 2008

Vegetation	1995	1999	2008
No vegetation	35.5	27.0	17.1
Grass	24.6	25.9	30.1
Sedge	22.4	26.4	25.3
Heather	3.3	4.5	8.0
Rush	0.6	0.6	0.3
Bryophyte	7.2	8.4	9.0
Other	6.4	7.2	10.2

Overall mean vegetation height in 1999 and 2008 was almost static at 21.4 and 21.9 cm respectively. Preferential grazing undoubtedly influences both the frequency and change in the incidence and height of the vegetation. As the hill was under relatively consistent grazing pressure and management throughout, frequency and change were examined in association with variations in the physical factors, physiography, altitude and soil.

Six physiographic units, an alluvial toe-slope (alt), a truncated moraine (trmo), a moraine-backed hollow (mbho), a lower colluvial slope (cols) (9º gradient), an upper mid-slope (msgr) (23º gradient) and a narrow, elongated crest (crst) were present. Three altitude categories, <150, 150-225 and >225 m, and four soil categories (peat <50 cm and ≥50 cm, mineral soils and lithosols) were defined.

Physiographic unit was significantly associated (P <0.001) with the frequency of vegetation in both 1995 and 1999 but not in 2008. There was no significant associated with the changes in the intervening periods. Mean vegetation height in 1999 and 2008 and the change in the intervening period were all significantly associated (P<0.01) with the variations in physiography. The variation in altitude was limited on the farm and had no significant association with the frequency of vegetation but the height of the vegetation was significantly lower (P<0.01) at the highest altitude.

The variation in soil had a significant association ($P<0.05$) with vegetation frequency in all years but, similar to the physiographic units, not with the changes in the intervening periods (Table 9).

Table 9: Least square means (s.e.) for frequency of vegetation (%) in 1995, 1999 and 2008 by soil category

Soil category *(n)*	1995	1999	2008
Lithosol *(72)*	57.0 (3.1)	65.2 (2.45)	74.1 (2.24)
Mineral soil *(22)*	55.2(4.0)	63.0 (3.23)	77.0 (2.95)
Peat <50 cm *(27)*	63.1 (3.67)	70.0 (2.93)	83.3 (2.67)
Peat ≥50 cm *(89)*	65.2 (2.63)	85.6 (2.10)	85.6 (1.91)

The change in vegetation height from 1999 to 2008, was significantly ($P<0.001$) associated with the differences soil. The association consisted of increases in all except the lithosols, which exhibited a 10% (2.3 cm) decrease. The frequency of vegetation occurrence increased overall but was smallest at the higher altitudes while the height of the vegetation which remained generally static throughout contained a 10% (2.3cm) decrease on the shallow soils - lithosols.

Grazing management of the unimproved vegetation in this landscape requires continued vigilance to minimise the endemic risk of erosion.

Walsh, M. *RMIS No. 5080*

Sustainable agro-environmental management of hill and mountain peat land - the role of erosion pins in monitoring the environment

The details and some preliminary results of the project, which is part of a larger EPA-funded programme are outlined *Research Report 2007, p. 167-168*. Changes in the soil surface due to micro-erosion and deformation were assessed using reference marker pins as well as a number of other methods including soil detachability trays, Gerlough troughs, splash cups, and micro-topographic pin profilers. The reference marker pins included 157 mm nails, inserted horizontally, to measure the retreat of bare soil in the risers of terracettes and 326 galvanised steel rods placed vertically and secured in the mineral sub-soil in bare soil patches in the experimental sites.

There was a high loss, *c.* 80%, of nails in the locations with medium and high stocking rates due mainly to animal disturbance, which included the chewing of the plastic ID tags. Those in the location with near zero stocking rate survived but were few in number due to the rarity of bare soil in the risers of the terracettes in this area. Although the method had to be abandoned it provided an indirect indication of the impact of grazing animals under different stocking rates and demonstrated that useful data can be obtained in locations with near zero stocking rates.

The galvanised steel rods, known as erosion pins, also suffered some loss due to sheep activity especially in the Upper Slope of the location with high stocking rate. The low number of pins in the location with low stocking rate is an indication of the scarcity of suitable patches 50 x 50 cm containing at least 50% bare ground in this location (Table 10).

Table 10: Distribution of erosion pins and data observations by location, slope and activity

Location (stocking rate) [1]	Slope[2]	Activity[3] (No. sites)	Obs. (Total Pins)	Data observations (n values)			
				Seasonal		Half-year	Year
				su[4] to au '07[4]	wi[4] '07/8 to sp '08	au[4] '07 to sp '08	su[4] '07 to sp '08
Commonage (high)	LS	HA (2)	39	8	0	8	32
		LA (2)	10	0	0	0	8
		RA (2)	11	8	0	7	8
Leenane (medium)	LS	HA (3)	61	58	0	57	57
		RA (3)	44	36	0	35	33
	US	HA(3)	61	0	0	0	34
		LA (3)	60	23	0	24	53
		RA (3)	24	11	0	10	19
Nat. Park (low)	US	HA(2)	16	0	14	0	12

[1] stocking rate (ewes per ha): high = *c.* 2-3, medium = 0.7, low = *c.* <0.1
[2] LS = Lower Slope; US = Upper Slope; [3] HA = High Activity, LA = Low Activity, RA = Rest Area
[4] su = summer, au = autumn, wi = winter, sp = spring

Up-slope and down-slope readings from the top of the pin to the ground surface were taken twice and averaged. The changes on a seasonal, half-yearly and yearly basis were assessed using the mean of the up- and down-slope readings, their difference and the up-slope readings separately. In the case of the latter two routines, because of the irregularity of the micro-topography, data were organised so that the initial reading representing the higher elevation was placed in the up-slope category. Considerable variation (Table 11) occurred throughout with the largest changes occurring in the location of high stocking rate.

Table 11: Changes (mm) in elevation at the erosion pins over the full period Spring/Summer 2007 to spring 2008 by location and activity

Location (Stocking rate)	Activity[1]	*n*	Mean[2] (s.d.)	Difference[3] (s.d.)	Up-slope[4] (s.d.)
Commonage (high)	HA	32	-6.4 (16.1)	16.5 (29.2)	-14.6 (25.8)
	LA	8	4.1 (2.6)	32.7 (33.8)	-10.4 (17.3)
	RA	8	13.8 (32.1)	19.5 (23.8)	4.1 (39.9)
Leenane (medium)	HA	91	3.7 (22.8)	6.4 (18.7)	0.8 (23.9)
	LA	53	0.5 (6.2)	4.6 (17.9)	-1.8 (13.0)
	RA	52	1.0 (9.7)	6.7 (14.3)	-2.4 (12.8)
National Park (low)	HA	12	4.5 (12.3)	4.6 (20.1)	2.2 (13.8)

[1] See Table Y; [2] mean = (down-slope + up-slope)/2; [3] difference = down-slope minus up-slope; [4] up-slope = measurement of higher elevation beside erosion pin and generally up-slope from it.
Note: plus and minus symbols denote erosion and deposition, respectively

The change in the mean indicated a general lowering of the surface in the area of high activity under high stocking rate. Elevation changes up-slope of the erosion pin mainly indicated surface lowering while those in the differences between the down-slope and the up-slope were consistently positive indicating that surface lowering also continued down-slope of the pins. Although significant differences occurred between the various activities at seasonal level (P<0.05) the overall changes in the mean or differences were not significant.

Table 12: Changes (mm) in elevation at the erosion pins over the full period Spring/Summer 2007 to spring 2008 by activity

Activity[1]	*n*	Mean[2] (s.d.)	Difference[3] (s.d.)	Up-slope[4] (s.d.)
HA	135	1.4 (21.0)	8.6 (22.1)	-2.7 (24.4)
LA	61	1.0 (6.0)	8.3 (22.4)	-3.0 (13.9)
RA	60	2.8 (14.9)	8.4 (16.2)	-1.5 (18.3)

[1, 2, 3, 4] and 'Note': See Table 11

This was reflected in the elevation changes of the up-slope, but, over the full period the change was significantly higher under high stocking rate than under low stocking rate (Table 12).

Erosion pins have been used under a wide variety of land use systems and environments to monitor soil erosion. Loss of monitoring points related to the type of land use is endemic but was exacerbated by repeated failure of electronic measuring and metering equipment, which was used for data capture. This would appear to have been due to continued exposure of the equipment under very humid field conditions.

While the minimum period for this methodology is generally two years the results, where bare soil was present, indicated active removal and accretion of surface soil at local level and a significant difference between high and medium stocking rates.

Lynch, G., Walsh, M., Schulte, R. and Moles, R.[1] *RMIS No. 5547*
[1]*Chemical and Environmental Science Department, University of Limerick*

The impact of hill sheep activity on the population dynamics and diet of small mammals
The project is based on the Teagasc Hill Sheep Farm, and the background is outlined in *Research Report 2005, p. 119.* The overall aim is to integrate biodiversity-promoting strategies and general agricultural practices. The objective is to assess the impact of hill sheep activity on the diet and populations of small mammals especially the wood mouse and the pygmy shrew.

Activities pertaining to wood mice were reported in *Research Report 2006, p. 163-164* and those for pygmy shrews from June to August 2007 were reported in *Research Report 2007, p. 166-167.*

Table 13: Numbers of pygmy shrews trapped during September and October 2007

Habitat	September	October
Wet heath grazed	12	13+12 (2 trapping sessions)
Wet heath un-grazed	21	17
Woodland	25	18

A total of 118 shrews were removed during the removal phase of the study in September and October 2007 (Table 13). Details of sex, body weight, length of body, tail, hind foot and shin bone, breeding condition, the presence of ectoparasites and reproductive measurements were recorded.

Table 14: Weight of pygmy shrews by location, sex and month

		Mean weight (g)	95% CI
Location	Hill Sheep Farm	3.38	0.19
	Connemara National Park	3.81	0.20
	Coole Park	3.90	0.19
Sex	Male	4.01	0.18
	Female	3.86	0.24
	Unknown	3.34	0.21
Month	June	4.86	0.45
	July	3.67	0.25
	August	3.61	0.35
	September	3.48	0.16
	October	3.56	0.1

The mean body weight (Table 14 and Figure 1) of individual pygmy shrews captured from June to October was 3.8 g. Location had a significant effect on the weight of individual pygmy shrews ($P<0.01$). Pygmy shrews in Connemara National Park were significantly heavier than the pygmy shrews captured on the Hill Sheep Farm (Mann-Whitney test, $P<0.05$). There were also significantly heavier pygmy shrews captured in Coole Park than on the Hill Sheep Farm (Mann-Whitney test, $P<0.05$). There was no significant difference between the weights of male pygmy shrews compared with female pygmy shrews. However, male pygmy shrews had a greater weight range than female pygmy shrews. The month in which shrews were captured had a significant effect on their weight ($P<0.001$). The mean body length of shrews was 49.3 mm. Location had a significant effect on the body length of shrews ($P<0.001$). Shrews in Connemara National Park are significantly longer than shrews on the Hill Sheep Farm ($P<0.05$) and in Coole Park ($P<0.05$). A total of 239 fleas were recovered from these animals. *Doratopsylla dasycnema* was recovered at all three study sites. Two other species were recovered in Coole Park, *Palaeopsylla soricis* and *Cenophthalmus nobilis*.

One hundred and thirteen pygmy shrew bladders were examined for parasitic worms. Twenty two bladders were positive for parasitic worms. Parasitic worms present in the bladders of the shrews examined were identified as *Capillaria* species. All pygmy shrews, removed from Coole Park, were negative for bladder parasites. Bladder parasites were found in 24 % of shrews removed from the Hill Sheep Farm. Of the bladders examined from 33 shrews that were removed from Connemara National Park 39 % were positive for bladder parasites.

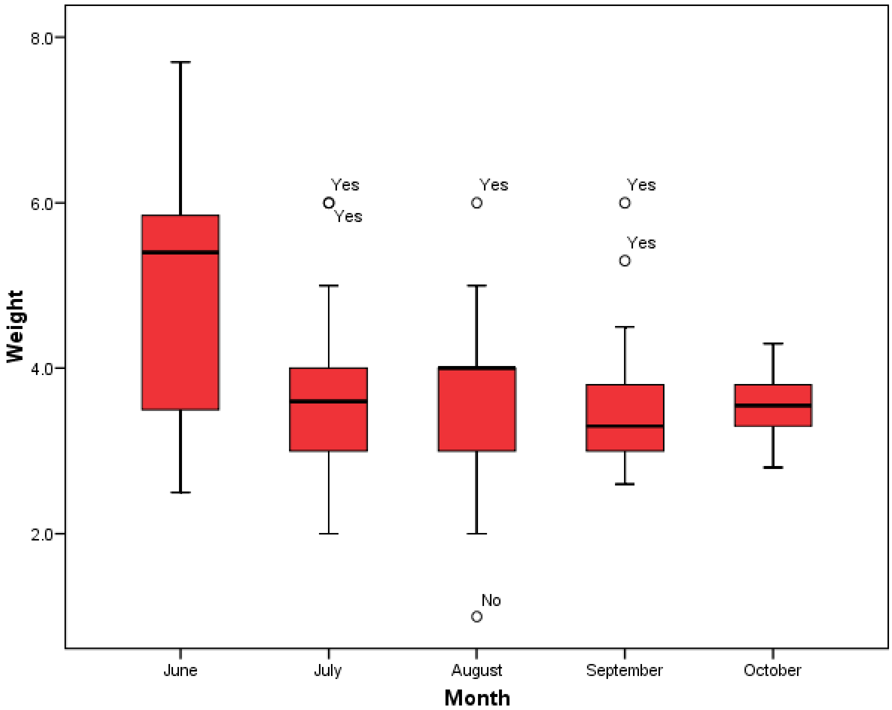
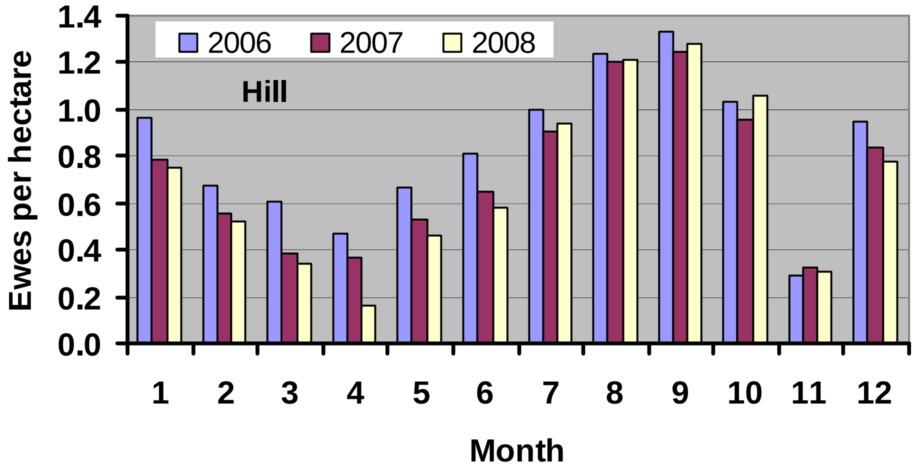


Figure 1. Weight of pygmy shrews by month. ***The upper and lower ends of a box represent the 25th percentile and the 75th percentile, the vertical bar represents 1.5 times the interquartile range and the solid horizontal bar within each box represents the median. Outliers and their breeding condition are also shown.***

One hundred and three complete skulls and mandibles were available for assessment to assess whether the three studied populations were morphologically distinct. Fifteen skulls and mandibles were discounted from the original sample due to damage sustained during the removal phase in the field and during subsequent dissection. Univariate analysis of variance showed that the effect of location on 16 of the 29 cranial and mandibular measurements was significant. Initial results indicate a significant association between location and the measured variables. Shrews from Coole Park had significantly larger values than shrews from the Hill Sheep Farm and Connemara National Park. There were eight instances where shrews from the Hill Sheep Farm were significantly different from shrews from Connemara National Park. Only once did shrews from Connemara National Park have significantly larger values than shrews from the Hill Sheep Farm. In all of the seven other significant results, shrews from the Hill Sheep Farm had significantly larger values than those from Connemara National Park. Diverse small mammal populations with particular characteristics enhance the bio-diversity of landscapes that are dominated by wet heath habitats.

Quinn, N., Walsh, M. and Lawton, C.[1] *RMIS No. 5382*
[1]Department of Zoology, NUI Galway

Stocking rate for the sheep systems at Hill Sheep Farm (Leenane)
The flock at the hill sheep farm near Leenane is managed as two separate sheep flocks corresponding to a pure-breeding hill system (HILL), based mainly on the unimproved hill grazing and a cross-breeding lowland system (LOW) which is managed on the reclaimed lowland for most of the year. Ewes on the HILL system are on the hill grazing except during mating (Nov/Dec) and from just prior to lambing until to mid May, but in the case of ewes with single males or twins, until weaning in late July. Ewes in the LOW flock are on the hill between weaning (early July) and joining (late October) and again from the beginning of December until early January. The ewes in this flock are housed from beginning of January until just prior to lambing. Flock replacements are on the hill grazing between April and November and are housed between December and April.



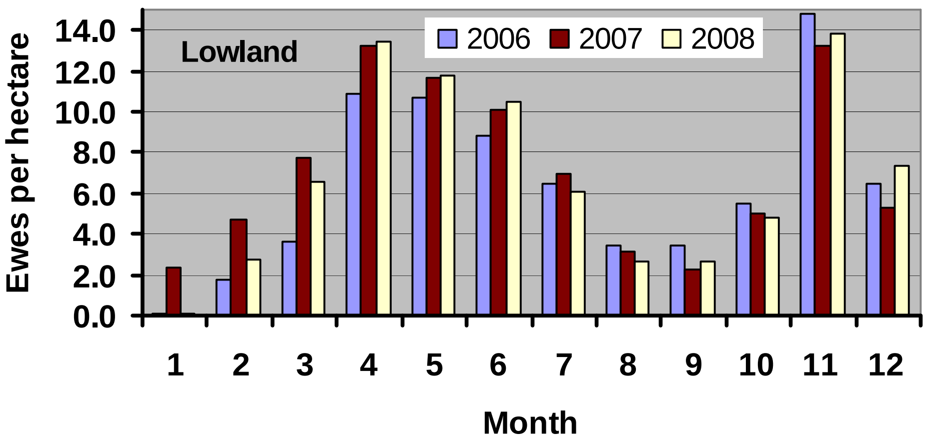


Figure 2. Ewes per hectare for hill and reclaimed lowland for the years 2006 to 2008.

The results for each year are shown, in Figure 2, for the hill and the reclaimed green land and expressed as average number of ewes per hectare each month. It is evident that the pattern was the same across years. Consequently, overall average values were calculated and these are shown in Figure 3.

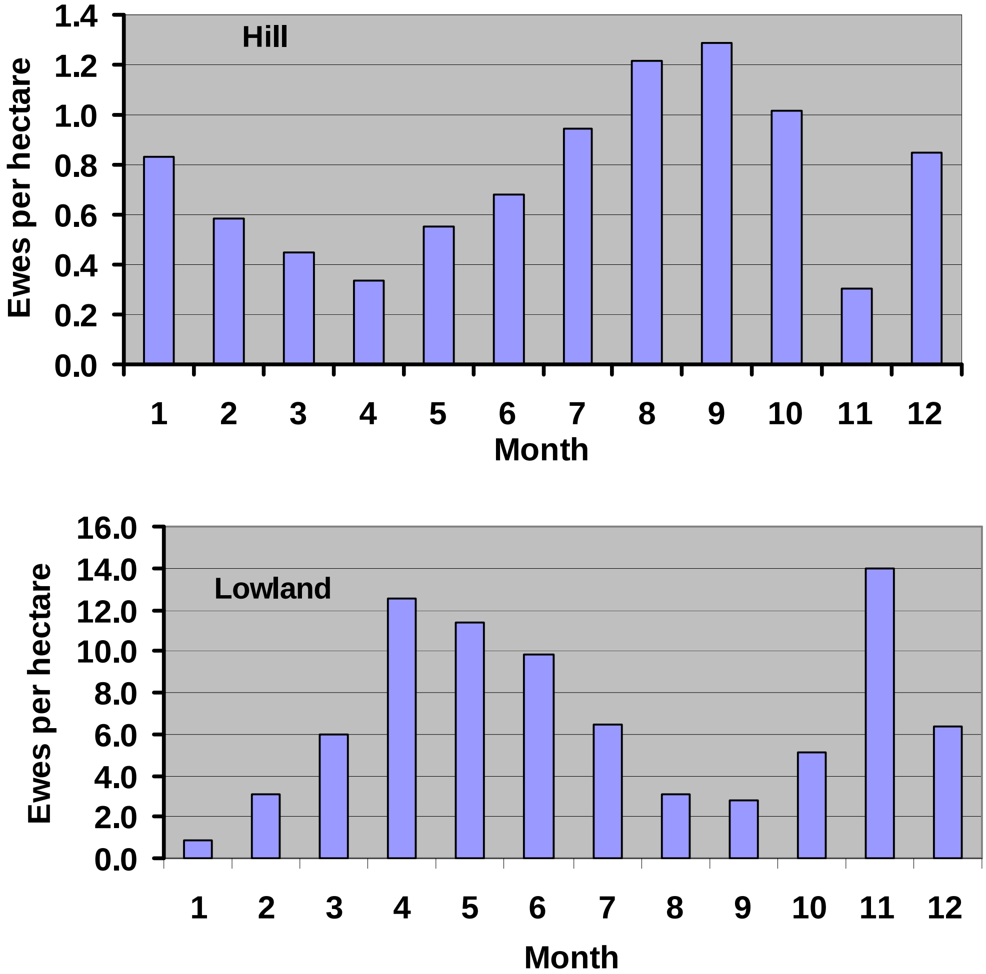


Figure 3. Average number of ewes per hectare for hill and lowland areas over the years 2006 to 2008.

The results show that the grazing pressure on the hill varies between a low point of ~0.3 ewes per hectare in November to a high of between 1.2 and 1.3 ewes in August/September when all the ewes and replacements are on the hill. In the case of the green land the stocking rate is very close to zero in January when ewes are either housed (LOW flock) or on the hill and is between 10 and 12 ewes per hectare in April/June. A maximum of 14 ewes per hectare occurs in November as all ewes are on the green land for mating at this time. The average annual grazing pressure on the hill is 0.7 ewes per hectare. These results provide an essential background to on-going work on the hill vegetation at Leenane as well as providing one of the key descriptors of the systems on the farm.

Hanrahan, J.P. and O'Malley, L. *RMIS No. 5080*

Factors affecting incidence of dental defects in hill sheep

The predominant reason for culling ewes in hill flocks is generally reported by farmers to be 'broken mouth' which means that some of the incisor teeth are lost or broken. This is consistent with data from the Teagasc hill sheep farm at Leenane as indicated by the data on culling reasons over the years 2005 to 2008 (Table 15). These show that "broken mouth" accounted for 60% of all culling decisions.

Table 15: Reasons for culling ewes from S. Blackface flock at Leenane

Reason	Percent of total
Broken mouth	60
Mastitis/udder	33
Prolapse	5
Other[1]	2

[1]Including poor condition, bad feet, age

It is considered that the risk of loss of incisor teeth (i.e. broken mouth) is increased by mal-occlusion of the incisors and the dental pad. The state of occlusion of incisors and dental pad is recorded at around mating in autumn, and again at weaning for ewes at Leenane. The presence of impacted herbage around the incisors is also recorded. These observations have been analysed to identify the factors associated with the position of the incisors relative to the dental pad. Observations for the years 2005 to 2008 were used for this analysis. Sheep were classified into one of the following categories at each examination time point:-

- Normal = incisors and dental per occlude normally
- Forward = incisors occlude with labial surface of the dental pad
- Overshot = top of incisors and dental pad do not occlude
- Broken = one or more incisors missing

Cases where ewes are classified as 'broken mouth' there are usually at least two incisors missing and the incisors are typically overshot. Thus 'broken mouth' can be considered as progression from 'Overshot'.

The proportion of observations in each of these classes over all years and observation time points is given in Table 16. The incidence of herbage compaction is also indicated.

Table 16: Overall summary of observation on incisor teeth in hill sheep

Category	Incidence (%)
Normal	0
Forward	44 (2%)[1]
Overshot	49 (7%)
Broken	7

[1]Proportion of cases in this category with impacted herbage

The results show that cases were almost evenly divided between the 'forward' and 'overshot' categories. To facilitate overall data summarisation the observations of 'overshot' or 'broken' were coded as '1' and all others were coded as '0' (Table 17). The presence/absence of herbage compaction was not considered important as the incidence was very low although significantly associated with incisor category. The incidence of incisor score = 1 was significantly associated with ewe age; 10% in 2-year old ewes and increasing to 67% in ewes that were ≥5 years of age. Incidence also varied significantly among years (43, 40 and 53% for 2006 to 2008, respectively). The difference between the hill and low land sub flocks was statistically significant ($P<0.01$) and was higher for the hill flock (50% vs. 41%). The incidence was higher at weaning (49%) than at mating (42%) which is probably a reflection, in part, of the fact that ewes are 6 months older at weaning.

Table 17: Incidence of ewes with incisors that were overshot or 'broken mouth'

Ewe age[1] (years)	Incidence (%)
2	10 ± 2.1
3	42 ± 2.3
4	65 ± 3.5
5	68 ± 3.4
6	61 ± 4.3

[1]At lambing

The stability of the state of the incisors was initially examined by estimating the repeatability of the score assigned. The result yielded surprisingly low estimate regardless of whether young animals were included or not. Thus, the repeatability estimates was 0.09, when all age groups were included compared with 0.09 when observations on 2-year old ewes were omitted and 0.03 when observations on 2- and 3-year old ewes were omitted. These low estimates suggest that the differences among individuals are not especially consistent between observation time points.

Table 18: Incidence (± s.e.) **of overshot incisors for age-by-season categories**

Age	Season	Incidence (%)
2	Mating	0 ± 2.7
	Weaning	20 ± 2.8
3	Mating	33 ± 2.9
	Weaning	51 ± 3.0
4	Mating	53 ± 3.3
	Weaning	71 ± 3.3
5	Mating	76 ± 4.1
	Weaning	60 ± 4.1
>6	Mating	87 ± 4.1
	Weaning	34 ± 5.2

There is clearly a major interaction between age group and season with respect to incidence of ewes with classified as having "overshot" incisors (Table 18). Up to 4 years of age the incidence clearly increases with age and is greater at weaning than at mating for a given age group. This pattern clearly does not apply to the two oldest age groups when most ewes are being managed in the low flock. This is partly a reflection of the practice of culling ewes with 'broken mouth' which is predominantly associated with age.

The consistency of the classification scores was examined at for specific annual intervals (i.e. between mating in one year and the same time point in the subsequent year; and likewise for observations at weaning). This showed a clear progression from 'forward' to 'overshot' but also showed that a relatively high proportion of ewes classified as 'overshot' in one year head reverted to 'forward' in the subsequent year. The incidence of reversion was significantly higher in 3-year old ewes than in older ewes (31% v 14%). This may reflect the progressive development of the condition over time and suggests that some redefinition of the 'forward' category may be useful. There is a highly significant association between occlusion score at weaning and the likelihood being classified as 'broken mouth' at weaning in the next season. The risk is also significantly affected by ewe age. The values are set out in Table 18. There was no evidence for an interaction between the effects of age and occlusion score.

Table 18: Risk of emergence of broken mouth condition in relation to age and occlusion score

Factor and level at weaning	Probability of broken mouth at same stage in the following season
Occlusion score	
Forward	0.04 (0.02 – 0.08)[1]
Overshot	0.54 (0.40 – 0.67)
Age	
2	0.01 (0.002 – 0.03)
3	0.09 (0.05 – 0.15)
4	0.39 (0.26 – 0.55)
5	0.80 (0.56 – 0.93)

[1]95% confidence interval

These results confirm the hypothesis that ewes with 'overshot' incisors are much more likely to develop broken mouth than ewes where the incisors occlude with the dental pad. Ewes are moved from the hill grazing onto the reclaimed lowland just prior to joining with rams. In the 2005 season incisor scores were recorded at this stage (autumn 2004) and again at the end of the joining period (~35 days later). Comparison of the scores at these time points was used to provide evidence on the consistency of dental occlusion scoring as well as on the effect of grazing on reclaimed lowland on the incidence of herbage compaction.

Table 19: Incidence of change in the incisor score during the joining period

Ewe age	Probability of change during mating season	
	From 'forward' to 'overshot'	From 'overshot' to 'forward'
3	0.17	0.33
4	0.24	0.12
≥5	0.37	0.02

The likelihood of change in score was significantly affected by the pre-joining score but this effect interacted with age (P<0.001) as is evident in Table 19. Two-year old ewes are not included here because all 2-year old ewes were classified as 'forward at the first examination in autumn 2004. The results confirm the evidence from inter-year comparisons that the reversal from 'overshot' to 'forward' is relatively high in young sheep but has a very low probability in older animals. There was no observed case of herbage compaction upon removal of ewes to the reclaimed lowland in autumn 2004. However, when ewes were examined ~35 days later the incidence of ewes with compaction was 19% and was significantly associated with age (47% in ewes ≥ 5 years v 3% in ewes aged 2 and 3 years). However, when these ewes were examined post weaning (July) no case of compaction was detected. Consequently, compaction is associated with older ewes on autumn pasture. The dentition status at joining did not significantly affect the presence of compaction at the end of the joining period.

The results from a preliminary analysis of the genetic variation in incisor occlusion score are summarised in Table 20. While the set of data available is modest the heritability estimates were of the same order of magnitude at each age examined. Estimates were calculated separately for scores at mating and at weaning and averaged. The estimates indicate that the heritability of incisor occlusion score is significantly greater than zero and an average value of 0.1 (s.e. 0.04) represents a realistic summary of the heritability of a singe score at any age from weaning at 2 years of age. The incidence of "overshot" cases at mating at 1.5 years was too low to justify a genetic analysis.

Table 20: Heritability estimates (± s.e.) for incisor occlusion score

Ewe age	Number of		Heritability
	Ewes	Sires	
2	324	22	0.11 ± 0.103
3	297	18	0.10 ± 0.090
4	263	12	0.15 ± 0.072
Average	-	-	0.12 ± 0.040

The results in Table 20 indicate that selection on dentition score in ewes can be used to reduce the incidence of mal-occlusion of incisors and the phenotypic data summarised above supports the concept that reducing the incidence of mal-occlusion would reduce the emergence of 'broken mouth' condition and thus increase the productive life of ewes in the hill flock.

Hanrahan, J.P. and O'Malley, L. *RMIS No. 5080*

Comparison of home-bred and bought-in ewes in a Scottish Blackface hill flock

It is well established that where hill flocks have access to relatively extensive hill area for grazing ewes form well defined groups that share a common home range within the larger area. Thus sub-groups of a flock occupy different parts of the hill and this can affect performance through inherent differences in the vegetation resource on different parts of the hill. The hill grazing at Leenane has a perimeter fence but is large enough in area (250 ha) to accommodate a number of home range groups as the typical extent of a home range is of the order of 30 to 40 ha.

A related proposition to the existence of well established home ranges within a flock is that ewes not born and reared on the same hill will be disadvantaged, if introduced to that hill, compared with ewes born and reared on the hill. A further proposition is that ewes not born and reared in a particular environment will be less able to cope with disease challenges in that environment. Evidence on the likely validity of these hypotheses was extracted form the accumulated performance files at Leenane where most ewe replacements are home bred but in some years additional replacement ewes were purchased to augment the available purebred replacement stock. Purchased ewes were always 18 months of age and introductions were made in 1992, 1993, 1994, 1996, 1997, 1999 and 2000. The total number of introduced ewes was 162 and the average per year was about 25. The typical number of home-bred replacements introduced over the same period was around 75.

The ewes in the flock between 1994 and 2004 were coded as either homebred or purchased and key performance traits were evaluated. These included fertility (1 if ewes lambed and 0 otherwise), litter size, live weight at joining and post joining. Ewe mortality was also examined.

Table 21: Comparison of homebred and purchased ewes under a hill environment

Trait	Source of ewes	
	Homebred	Purchased
Fertility	0.89 ± 0.008	0.91 ± 0.015
Litter size	1.29 ± 0.013	1.37 ± 0.023
Live weight (kg) at joining	45.7 ± 0.15	46.4 ± 0.29
Live weight (kg) post joining	44.7 ± 0.16	46.1 ± 0.30

The least squares means for the performance traits are summarised in Table 1 and do not reveal any evidence for under-performance by the purchased stock. In fact the purchased were significantly heavier at around mating and litter size was also higher. There was no evidence for significant effect on fertility. The data on ewes mortality did not yield any evidence for a significant difference.

Thus the evidence from this flock does not support the hypothesis that the performance of ewes born and reared on a hill farm is superior to that of ewes introduced to a hill flock from outside sources

Hanrahan, J.P. *RMIS No. 5680*

Technology Evaluation and Transfer

Technology evaluation and transfer for sheep production

The objective of the Technology Evaluation and Transfer (TET) programme is to develop focal points for on-farm adoption, evaluation and development of technologies that can enhance the profitability of the sheep enterprise and serve key elements in getting adoption of effective technologies by the sheep sector. The cornerstone of this initiative is active collaboration between the farmer and Teagasc Research and Advisory services with a close linkage through Discussion groups with a wider network of farmers. From an initial screening process of applicants, 3 hill sheep flocks were recruited to the programme (see Research Report 2007 p 164). Similarly, applications from lowland farms were solicited and from these applicants, 3 lowland farms were selected from a shortlist of 14 applicants.

Table 22: Hill flocks - performance details 2007/2008 season

Farm	Location	Hill ewes		Crossbred ewes	
		No. of ewes	Lambs reared per ewe joined	No. of ewes	Lambs reared per ewe joined
Hill 1	Donegal	228	1.05	60	1.90
Hill 2	Sligo	175	0.86	.	.
Hill 3	Mayo	156	1.10	54	1.10

Table 23: Lowland flock details 2007/2008 season

Farm	Location	No. of ewes	Lambs reared per ewe joined	Stocking rate LU/ha
Lowland 1	Roscommon	185	1.58	1.52
Lowland 2	Kerry	314	1.36	1.29
Lowland 3	Wicklow	337	1.21	1.10

The production details for the Hill and Lowland Flocks involved in the programme in the 2007/2008 season are summarised in Tables 22 and 23, respectively. The initial phase in the programme involved electronic identification (EID) of all ewes, replacements and rams present in the flocks to facilitate the comprehensive capturing of individual animal performance data. This will also allow for the generation of pedigree information for these flocks and their replacements. In conjunction with the EID tagging process an inventory of animal age, breed, weight and body condition score was compiled. For the Hill flocks this occurred prior to joining and in the Lowland flocks in mid pregnancy, this also included details of replacement ewe lambs present

The analysis of flock age structure indicated that the introduction of flock replacements did not follow a consistent pattern across years and that the there was no clear breed policy in place on lowland farms or for the crossbred component of the flocks on hill farms.

For both the Lowland and Hill flocks analysis of the information collected in regard to live weight, condition score, age and breed provided an insight into the replacement policy and management of the replacements in each flock. The results collected on ewe live weight, as summarised in Table 24, indicate that a number of the age groups were below the desired weight. Further analysis of the data indicated a significant Flock by age interaction ($P < 0.001$) in ewe live weight in the various age groups; this indicates that the management practices vary amongst flocks for different age categories.

Table 24: Mean live weight (± s.e.) Lowland flocks and Hill flocks including replacements

Flock	Age Class			
	Ewe lambs	2-tooth	4-tooth	Mature
Hill 1	31.9 ± 0.56	48.7 ± 0.61	49.3 ± 0.72	50.8 ± 0.47
Hill 1 crossbred	52.7 ± 0.77	.	.	71.9 ± 0.77
Hill 2	28.4 ± 0.84	45.3 ± 1.17	47.1 ± 0.75	52.7 ± 0.50
Hill 2 crossbred	.	44.4 ± 0	54.1 ± 1.18	60.0 ± 1.31
Hill 3	34.0 ± 1.12	39.7 ± 0.86	48.0 ± 0.80	47.7 ± 0.63
Lowland 1	.	.	.	.
Lowland 2	39.3 ± 0.43	55.7 ± 0.68	63.5 ± 0.94	72.1 ± 0.83
Lowland 3	42.0 ± 0.49	57.1 ± 0.83	63.7 ± 2.05	78.5 ± 1.58

The mean body condition scores of the ewes and replacements are summarised in Table 25 for the lowland flocks. Similar to the results for live weight significant differences were found amongst flocks in the body condition score of animals in the various age categories with the younger replacements tending to have the lowest condition score.

Table 25: Mean (± s.e.) body condition score Lowland flocks

Flock	Age Class			
	Ewe lambs	2-tooth	4-tooth	Mature
Lowland 1	2.7 ± 0.04	3.0 ± 0.06	3.0 ± 0.05	3.0 ± 0.03
Lowland 2	3.2 ± 0.10	3.0 ± 0.03	3.3 ± 0.04	3.0 ± 0.03
Lowland 3	2.6 ± 0.03	2.7 ± 0.04	2.8 ± 0.04	3.0 ± 0.03

Details on flock age structure are summarised in Table 26 and indicate that there is large variation in the number of replacements being retained annually. For the hill flocks all ewes and replacements are purebred Scottish Blackface.

Table 26: Flock age structure of Lowland and Hill Flocks (%)

Flock	Total	Proportion of		
	Ewes	Ewe lambs	2-tooth ewes	Mature
Hill 1	320	26.5	21.9	51.6
Hill 1 crossbred	62	21.0	0	79.0
Hill 2	166	13.8	21.7	64.5
Hill 2 crossbred	54	0	1.9	98.1
Hill 3	213	17.8	8.9	73.3
Lowland 1	243	23.5	13.2	63.3
Lowland 2	396	22.7	10.9	66.4
Lowland 3	378	20.4	25.4	54.2

The breed composition of the Lowland flocks and the crossbred ewes on two of Hill farms are summarised in Table 27 and highlights the variety of sire breeds used on these farms over recent years; the great variety of bred types suggests the absence of any conscious breeding policy for production of flock replacements. These were below what was requirement due to insufficient numbers of ewes bred for this purpose and therefore the remainder stemmed from the main section of the flock. The choice of terminal sire breeds particularly in the lowland flocks is variable as is evident from the information summarised in Table 28.

Table 27: Breed composition (%) of Lowland flocks and of the crossbred component of Hill flocks

Flock	Lowland 1	Lowland 2	Lowland 3	Hill 1	Hill 3
Belclare-x	31.2	36.2	.	.	.
Suffolk-x	35.0	15.7	80.9	27.4	25.9
Texel-x	22.8	15.7	13.9	51.6	74.1
Cheviot-x	9.3	17.0	5.2	.	.
Charollais-x	0.8	14.6	.	.	.
Bleu du Maine-x	.	0.8	.	17.7	.
Beltex-x	0.8	.	.	3.3	.

Table 28: Breed and number of rams used for mating in autumn 2008

Ram breed	Farm					
	Lowland 1	Lowland 2	Lowland 3	Hill 1	Hill 2	Hill 3
Suffolk	1	2	.	.	.	.
Texel	2	1	4	1	1	1
Charollais	1	3	1	.	.	1
Belclare	1	2	2	.	.	.
Beltex	.	.	.	2	.	.
S.Blackface	.	.	.	4	4	3

One of the key objectives in the programme was to develop a well defined replacement plan in conjunction with the farmer to generate sufficient of replacements of known parentage on an annual basis. For the Hill flocks this process began where recorded single sire matings were used to produce lambs for the 2008/2009 season with known parentage. A secondary objective of the replacement plan is to ensure that these replacements are managed to ensure optimal live weight at mating.

Lynch, C.O., Hanrahan, J.P., O'Malley, L., Walsh, H. and Joyce, P. *RMIS No. 5726*

Procedure used for measuring grass height using a plate meter

One of the methods used to monitor herbage supply on grazing pastures is to measure sward height using a rising-plate meter. The usual protocol for measuring sward height on a paddock at research sites is to record height at 50 points (drops) that are representative of the paddock. Representative sampling is accomplished by walking a 'W' pattern through the paddock and making drops at appropriate intervals that encompass the full 'W' formation. It appears that the use of the rising-plate meter under on-farm conditions is often based on as few as 10 drops and a 'W' pattern of sampling may not be involved. This approach risks compromising accuracy and will certainly reduce precision of the estimates.

In order to quantify the effects on precision of variations in the number of drops a study was undertaken at Athenry during the grazing season involving permanent sheep-grazed pastures. Three operators measured the same paddock, using 20, 30 or 50 drops, on the same day and this process was replicated across 4 measurement occasions. The resulting data were analysed using mixed model procedures to establish the magnitude of measurement error. The differences among operators were also evaluated. The paddocks used were typically ~1.5 ha and sward height varied among used paddocks (confounded with occasion).

The mean height and the range among operators are shown in Table 29.

Table 29: Sward height (cm) variation among paddocks and operators

Paddock	Mean sward height (±s.e.)	Range among operators
1	6.1 ± 0.38	5.8 to 6.3
2	8.8 ± 0.37	8.1 to 9.6
3	4.1 ± 0.37	3.7 to 4.4
4	5.4 ± 0.36	4.8 to 6.3

Differences among operators were not significant (P>0.6). The measurement error representing the random effects remaining after eliminating effects due to paddock and operator yielded CVs of 15.5, 11.7 and 9.8% for measurements based on 20, 35 and 50 drops. An exponential curve fitted this relationship quite well and yielded an estimate of 18.7% for the CV expected if measurements were based on 10 drops. The implications of this level of inherent variation for the precision of estimates of sward height are set out in Table 30 in terms of the probability that the actual measurement is within either 0.5 or 1.0 cm of the true value for a paddock.

Table 30: Likelihood (%) that a sward height is within specified range

No. of measurement drops	Range around true value	
	± 0.5 cm	± 1.0 cm
10	30	55
20	38	68
35	48	80
50	56	90

The results in Table 30 show that the estimate of sward height is not very precise, especially if only 10 drops are used. It is also evident that 10 to 20 drops per paddock is not adequate. The risk of bias due to failure to measure a representative sample of the sward is also likely to increase as the number of drops declines and especially when the sampling pattern does not follow a ‘W’ pattern. Furthermore it is likely that measurement errors will be greater for cattle-grazed pastures than for sheep-grazed pastures due to the different sward surface profiles reflecting the grazing behaviour differences between cattle and sheep.

Hanrahan, J.P. and Lynch, C. *RMIS No. 5726*

Genetics, Breeds and Breeding

Examination of ram effect on hill ewes
The pattern of lambing in the crossbreeding flock at Leenane in 2007 revealed evidence of a peak of lambing in mid April. This could be explained by a ram effect when ewes were joined on 27 October 2006. If ewes were responsive to a ram effect at this stage a peak of mating would be expected around 18 November. This in turn could lead to a lambing peak at about 14th April – in 2007 there was a clear peak of lambing between 11 and 13 April (30% of the ewes lambed over this 3 day interval). The peak was about 1 to 2 days earlier than that predicted from the patterns expected from the typical ram effect but this depends on precise timing of ram exposure and also accurate gestation length information. The hypothesis of susceptibility to the ram effect in this flock was tested in 2007/8 season. A set of 40 ewes from the Low flock was taken from the hill on 12 October 2007 and penned in visual and olfactory contact with rams overnight (24 h). These ewes were returned to the hill on the following day.

The distribution of lambing in this flock in 2008 was examined for evidence of a difference in the lambing pattern between the "exposed" and "non exposed" groups. The timing of the exposure would be predicted the result in a peak of lambing around 26 March and/or 1 April. The results are summarised in Table 31 where the lambing date information is categorised into 6 day intervals centred around the predicted peaks.

Table 31: Distribution (%) of lambing

Date interval	Exposed	Not Exposed
≤ 23 March	10.2	8.9
24 to 29 March	38.5	25.3
30 March to 4 April	5.1	16.5
5 April to 10 April	23.1	266
>10 April	23.1	22.8

The difference in distribution between the two groups was not significant (P=0.23) despite the apparent concentration of lambing in the period 24 to 29 March for the ewes exposed to rams pre joining.

Evidence from studies on the onset of the breeding season indicate that there can be large differences between years and thus, the pattern seen in 2007 lambing season may have been an atypical result. Thus in 2006 lambing season there was no evidence for a concentration of lambing around dates that would reflect a ram effect at joining.

Hanrahan, J.P. and O'Malley, L. *RMIS No. 5080*

Observations on the incidence of lambing assistance
Ewes experiencing difficulty in completing the lambing process are seen as a major challenge by the sheep farmer because of the demands required to deal with the difficult births and the risk of mortality of lambs and ewes. The costs associated with lambing difficulty are not easy to estimate, but will include increased mortality, cost of veterinary assistance in severe cases and the time demands on the farmer, which can mean other issues may not get the attention required. In order to arrive at an informed understanding of the issue of "lambing difficulty" it is essential that we have evidence on the incidence of the phenomenon, and especially the incidence of serious lambing difficulty. The latter is where delivery is very unlikely to be achieved without substantial human intervention – e.g., two lambs in the birth canal, a breech presentation or a really oversized lamb. Other situations include mal-presentation, where one

or both legs are retracted, the head is turned back, or a ewe has given up trying to expel her lambs.

Data from the sheep research flocks at Teagasc Athenry and Leenane (Teagasc Hill Sheep farm) were examined to provide information on the incidence of assistance at lambing and the associations between incidence of assistance and factors such as litter size, ewe breed and flock. It is hoped that this will provide a starting point for further enquiries and discussion about this issue as lambing difficulty is likely to be included in future breeding programme systems for pedigree breeders.

All animals Teagasc research flocks are electronically tagged and for the last 4 seasons any assistance provided at lambing has been recorded for all ewes. The scoring system is used is as follows: ***'None'*** where ewe lambed without any human intervention; ***'Some'*** where a minor degree of human intervention was involved, e.g., both legs not presented, head not in correct position, slow delivery; and ***'Major'*** where a substantial degree of human intervention was involved – e.g., two lambs presented together, breech presentation, lambs dead in utero, severely oversized lamb, caesarean.

Information was available for 2436 parturitions and involved data from 4 sub flocks which represent either different personnel and breed composition (Athenry_A and Athenry_B) or different management systems (Hill_flock and Low_flock at the Teagasc Hill sheep farm, Leenane). The details on flock composition are as follows:

Athenry_A Crossbred ewes out S. Blackface mothers and bred to terminal sire rams

Athenry_B Pure breeding flocks including Suffolk, Texel, Belclare and Cambridge

Hill_flock S. Blackface ewes mated with S. Blackface rams

Low_flock S. Blackface ewes mated with crossing rams

The incidence of lambing assistance are summarised in Table 32 for each of the sub flocks described above. The difference in incidence between the flocks at Athenry and those at Leenane is very pronounced especially for the proportion of ewes recording as getting *'Some'* assistance. It should be noted that all of the ewes at Athenry are housed for the winter and lambed indoors whereas at Leenane all ewes are outdoors at lambing, although Low_flock ewes are housed until just prior to the start of lambing. The somewhat higher incidence of assistance in the Low_flock compared with the Hill_flock is probably associated with the fact that all of the lambs are crossbred in the case of the Low_flock and that litter size is also considerably higher (1.5) than for the Hill_flock (1.1). It can be concluded from the evidence summarised in Table 32 that the incidence of cases requiring major assistance is no greater than about 5%.

Table 32: Incidence (%) of lambing assistance

Sub-flock	**Assistance score**	
	Some	**Major**
Athenry_A	30.5	5.6
Athenry_B	35.6	4.2
Low_flock	2.0	1.7
Hill_flock	1.0	0.4

The variety of breeds in the flocks at Athenry allows some evaluation of the role of this factor along with litter size in the risk of lambing difficulty. The evidence on these issues is summarised in Tables 33 and 34. The evidence from the crossbred flock at Athenry shows that Belclare-cross ewes have a lower incidence for both categories of assistance than contemporary Charmoise ewes.

Table 33: Association of assistance with litter size and crossbred ewe type in crossbred flock at Athenry

Crossbred ewe type	Litter size	Assistance (%) Some	Severe
Belclare-x- S. Blackface	1	27.1	4.3
	2	22.9	3.8
Charmoise-x- S. Blackface	1	36.9	13.1
	2	33.3	5.7

The results for purebred ewes (Table 34) clearly indicate that breed of ewe is directly associated with the incidence and type of assistance given – Texel ewes present a particular challenge with very high levels of assistance in the case of ewes with singles. There is a striking and highly significant difference in the incidence of *"Major"* assistance between the Belclare ewes and the other purebred ewes. The effect of litter size depends on the breed involved – to some extent. In the case of single pregnancies the Belclare ewes received much less assistance than either Texel or Suffolk ewes. This may indicate that birth weight is disproportionately high in the latter two breeds. The purebred results for Belclare ewes are consistent with the relatively low incidence of *'Major'* assistance recorded for Belclare-x-S. Blackface ewes (Table 33).

Table 34: Association of assistance score with litter size and ewe breed in pure breeding flocks at Athenry

Ewe breed	Litter size	Assistance (%) Some	Major
Belclare	1	14.5	0.0
	2	25.3	2.0
Suffolk	1	25.8	6.0
	2	17.6	6.8
Texel	1	45.9	5.4
	2	33.3	12.7

Belclare ewes were the only purebred with a high proportion of triplet births and for this set of ewes the incidence of *"Major"* assistance was only 4.1%. In the case of crossbred ewes at Athenry the Belclare-x-S. Blackface ewes also had significant level of triplet births and the incidence of *"Major"* assistance was 7.3%.

These much lower incidence of assistance at Leenane, and especially in the *'Some'* category raises a question about the meaning of the high incidence of *'Some'* assistance recorded at Athenry. It may be that many of the cases assisted at Athenry did not really require assistance and/or that the indoor lambing situation provides the opportunity for assistance. It is also possible that the indoor system impacts negatively on the ability/fitness of the ewe to complete delivery in the absence of any real obstetrical complications.

It can be safely assumed that the incidence of *'Major'* assistance is well founded because of the substantial effort required. Thus, this aspect is definitely breed dependent and of the order of 7 to 10% in breeds like Suffolk and Texel for the delivery of twins but is more like 2 to 3% in Belclare ewes. S. Blackface ewes lambing outdoors presented a very low incidence (~1%) of ewes requiring *'Major'* assistance – even when lambs were crossbred.

The chance of survival into the subsequent year's breeding flock (Table 35) was 17 percentage points lower (statistically significant) for ewes that had a score of *'Major'* assistance compared with cases with a score of *'None'*. Ewes having a score of *'Some'* were 4% less likely to be present in the following year's flock - not significantly different from the '*None'* category'.

Table 35: Effect of lambing assistance score on subsequent ewe survival

Assistance score	Survival probability†	
	Mean	95% Confidence interval
None	0.72	0.69 to 0.75
Some	0.68	0.63 to 0.71
Major	0.55	0.44 to 0.66

† Survival = present in the flock for the subsequent production year

The assistance scores were mapped on to the numerical values of 0, 1 and 2 and these values used to examine whether ewes differed consistently in likelihood of assistance. The repeatability of assistance score analysis was confined to the records at Athenry because the incidence of assistance at Leenane was very low. For this analysis litter size was included as a fixed effect along with sub-flock-by-season effects and involved 1566 records involving 996 ewes. The estimate of repeatability was 0.38 and is significantly different from zero. Thus some ewes are more likely to receive assistance and this propensity is likely to have a genetic component. Culling ewes that are assisted at lambing would reduce the incidence of assistance in a flock and contribute to genetic improvement in level of assistance required provided information becomes available to select rams for this trait.

Hanrahan, J.P. *RMIS No. 5389, 5674, 5080, 4785, 5685*

Pedigree Belclare flocks – lamb performance

Pedigree and performance records are collected by Belclare breeders using agreed protocols and submitted to Teagasc Athenry for annual processing to generate genetic estimates of breeding values for early growth rate. The lamb performance records consist of two live-weight measurements; one on the day of birth or very shortly thereafter and one taken at around 50 days of age. The proportion of lambs used for the growth rate analysis that were aged between 35 and 79 days was 92%, while 88% of lambs were within 14 days of the modal age (50 days). Records were screened to eliminate outliers and, in the case of growth rate, values where the age at the second weight was <15 days or >95 days were declared as missing. Records where dam age was 1 were excluded and if birth type was >4 it was set = 4. In the case of growth rate lambs with birth type >3 had birth type set = 3. Flocks with fewer than 20 valid records were also excluded. The final dataset had 10814 birth weight records and 8761 records for growth rate.

The accumulated data (1995 to 2008) on lamb weight traits (birth weight and growth rate) were analysed to provide estimates of the effects of flock, dam age, birth type and sex as well as annual trends in performance. The model included random terms for dam and for flock-x-year interaction. The latter component was included to provide information on the magnitude of variation among flocks that is 'unpredictable' and to be used in generating models that accommodate random differences among farms in lamb growth.

The least squares estimates for birth weight and growth rate are presented in Table 36 for birth type and age of dam. The differences are consistent with those observed in research flocks. The annual trend for growth rate (Figure 4) was a significant (P<0.05). This is at least partially due to the genetic gain for this trait reported previously (see Research Report 2007, pages 169-170).

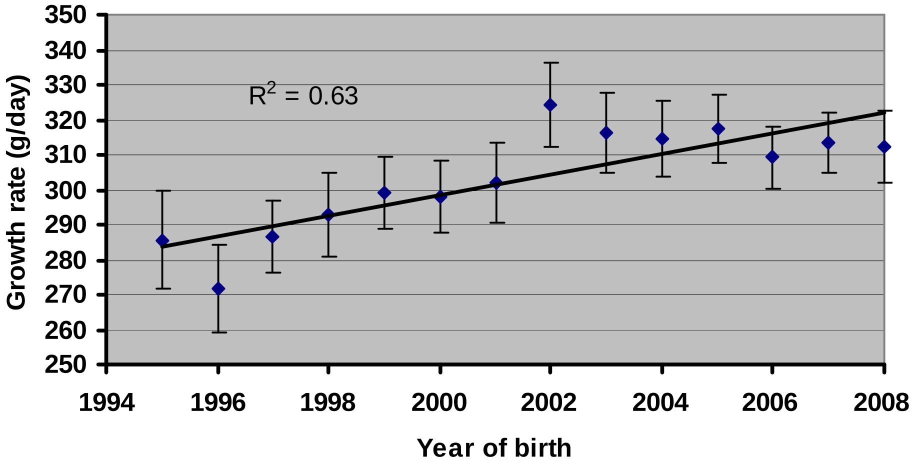


Figure 4. Phenotypic trend in lamb growth rate in pedigree Belclare flocks.

The estimates of variation, as the corresponding standard deviation, in birth weight due to dam effects and due to flock*year interaction, were expressed using birth weight of twin lambs as base. Variation among dams within flocks was 8.4% while the variation due to specific effects due to flock*year was 9.0%. The residual variation within flocks was equivalent to 14.6% of the mean. Thus, year-to-year variation for any given flock with respect to average birth weight is substantial. The corresponding relative values for the standard deviation for growth rate were 9.6% due to the dam and 12.2% for year-specific flock effects. The within-flock residual variance for growth rate was 18.9%. The latter figure is substantially greater than the relative variability of birth weight. In summary the within flock estimates for the phenotypic coefficient of variation for birth weight and growth rate are equivalent to 16.8% and 21.2%, respectively. The large variation for growth rate is in part due to the fact that the available information did not allow any reliable correction for rearing type and also it was not feasible to accurately account for any management group effects on growth rate.

Table 36: Estimates (± s.e.) of the effects of birth type and age of dam on growth performance of pedigree Belclare lambs

Factor	Birth weight (kg)	Growth rate (g/day)
Birth type		
1	4.8 ± 0.04	341 ± 4.3
2	4.1 ± 0.04	297 ± 4.0
3	3.6 ± 0.04	270 ± 4.1
≥ 4	3.1 ± 0.05	-
Dam age		
2	3.6 ± 0.04	293 ± 4.1
3	3.9 ± 0.04	308 ± 4.1
4	3.0 ± 0.04	308 ± 4.2
≥ 5	4.0 ± 0.04	301 ± 4.1

Based on the estimates set out above it can be calculated that the standard deviation due to flock specific year effects is of the order of 2.5 kg where average live weight at 50 days is 20 kg for twins. This means that the 80% conference interval estimate around the long-term flock mean is approximately 17.8 to 22.2 kg.

This wide range indicates the scope for improvement if the factors that contribute to this unpredictability of lamb performance at the level of the individual flock could be identified. It is likely that the differences observed above would tend to become larger as lambs reach weaning age.

Hanrahan, J.P. and Curley, A. *RMIS No. 4785*

Evidence for segregation of a third gene with a major effect on ovarian function in Cambridge sheep

Normal development of ovarian follicles leading to ovulation depends on interactions between the oocyte and somatic cells in the follicle as well as the general physiological *milieu*. The oocyte-secreted molecules bone morphogenetic protein 15 (BMP15) and growth differentiation factor 9 (GDF9) are essential for normal ovarian follicle growth and function. Mutations in both BMP15 (*Fec*X^G) and GDF9 (*Fec*G^H) have been shown to be segregating in the Cambridge breed and ewes that are heterozygous carriers of either of these mutations have greatly increased ovulation rate while homozygous carriers of either mutation are sterile with a typical ovarian hypoplasia (see Research Report 2004, p 154-155). The sterility is due to failure of follicular development to progress beyond the primary follicle stage. However, not all cases of ovarian hypoplasia in Cambridge ewes could be explained by these mutations and sequencing of the entire coding regions for these genes did not reveal any mutations that could account for their typical sterile phenotype. It was suggested, based on pedigree analysis of the four 'unexplained' sterile ewes, that another gene was responsible. The present report concerns the available evidence concerning this hypothesis.

The data being reported here were obtained from ongoing observations on the self-contained flock of Cambridge sheep maintained at Teagasc, Athenry. Following the original discovery of 'unexplained' sterile sheep, subsequent selection of flock replacements was designed to increase the likelihood that the putative gene responsible was maintained in the flock. All animals surviving to weaning in this flock are genotyped for the BMP15 and GDF9 mutations known to be present in this population. Ovarian examination by mid-ventral laparoscopy is routinely done on all ewe lambs kept for breeding plus any ewe lambs suspected of having the sterile phenotype based on external examination (teat development). Additional ewes with ovarian hypoplasia that could not be explained by the genotype for either BMP15 or GDF9 have been identified. These observations were used to identify the male and female carriers of the putative gene. The female progeny from matings involving these carriers were used for proband analysis to test the hypotheses that the putative gene was X-linked. This involved calculating the probability for the observed incidence of 'unexplained' sterile daughters, after excluding the ascertainment cases, under the hypothesis that the putative gene was X linked and the alternative.

A total of 21 ewes with ovarian hypoplasia that cannot be explained by the genotype for BMP15 or GDF9 have been identified in this population, up to and including animals born in 2007. These cases were the offspring of 17 different ewes and 12 rams. The 'unexplained' sterile ewes and the carrier parents are classified according to genotype for BMP15 and GDF9 in Table 37. It is evident from these results that there is no association with either GDF9 or BMP15 status. Thus, the putative mutation cannot involve either the BMP15 or GDF9 loci.

Table 37: BMP15 and GDF9 genotypes for 'unexplained' sterile ewes and for carriers of the putative gene

Genotype for		Ewe category		Ram‡
BMP15	GDF9	Sterile	Carrier	Carrier
*Fec*X$^+$/*Fec*X$^+$	*Fec*G$^+$/*Fec*G$^+$	7	4	3
*Fec*X$^+$/*Fec*X$^+$	*Fec*G^H/*Fec*G$^+$	3	3	4
*Fec*X^G/*Fec*X$^+$	*Fec*G$^+$/*Fec*G$^+$	4	7	3
*Fec*X^G/*Fec*X$^+$	*Fec*G^H/*Fec*G$^+$	7	3	1
*Fec*X^G/*Fec*X$^+$	*Fec*G^H/*Fec*G^H	-	-	1

‡ Note that in the case of rams only the first allele shown under BMP15 is carried since this locus is X linked

When the ascertainment cases were omitted, a total of 7 joinings were available for proband analysis. These joinings yielded 13 females which could be classified as either normal or sterile due to 'unexplained' ovarian hyperplasia (sterile ewes that were homozygous for either of the known mutations were excluded). Three cases of 'unexplained' ovarian hyperplasia were observed among this set of 13 progeny. The null hypotheses that the gene responsible is X linked was rejected (P = 0.019). The probability of observing 3 or fewer cases under the hypotheses of autosomal inheritance was 0.39. The rejection of the X-linked hypotheses is consistent that the fact that the putative mutation was not associated with BMP15 which is on the X chromosome. Based on the incidence of 'unexplained' sterile ewes over the period 1997 to 2007 the frequency of the putative gene in this population is approximately 0.3.

It is concluded that mutation in a gene other that BMP15 or GDF9 is responsible for the 'unexplained' cases of ovarian hypoplasia observed in this Cambridge flock. Thus, 3 loci with major effects on ovarian function are segregating in the Cambridge breed and the putative third gene is inherited in an autosomal fashion.

Hanrahan, J.P. *RMIS No. 4785*

Artificial insemination in sheep using fresh ram semen stored at 5°C for up to 72 h

Cervical AI in sheep using fresh semen yields a higher pregnancy rate than that achieved from frozen-thawed semen. However, fresh semen is used only on the day of collection due to a decrease in pregnancy rate with storage. The availability of a protocol allowing the use of fresh ram semen in conjunction with cervical AI beyond 24 h post collection would facilitate more effective exploitation of AI in genetic improvement programmes. This study was designed to assess the fertilizing ability of fresh ram semen *in vivo* after storage at 5°C for up to 72h.

Semen was collected from a panel of rams (n=7) using an artificial vagina. Each ejaculate was assessed for wave motion, concentration and volume. Acceptable ejaculates were pooled and diluted to a final sperm concentration of 800×10^6/ml in a commercially available diluent, INRA 96 (IMV, L'Aigle, France). The diluted semen was allowed to adjust to room temperature for 20 min, then loaded into 0.25 ml Minitub straws, sealed at both ends (anaerobic conditions) and stored at 5°C until insemination.

Multiparous ewes (n=186) of various breed types (S Blackface, Belclare × S Blackface, Suffolk, Texel, Cambridge and F700-Belclare) were inseminated at a synchronised oestrus. Synchronisation of oestrus involved insertion of an intravaginal progestagen (Cronolone, 25 mg) pessary for 12 days followed by eCG (400 IU) at pessary removal (52 h prior to AI). Ewes were randomly assigned, within breed type, to one of 4 management groups and within each group were randomly assigned, within breed type, to one of the following treatments: inseminated with fresh semen (stored for 0 h) or with semen stored for 24, 48 or 72 h. Ewes were cervically inseminated in a standing position, by an experienced inseminator.

The motility of a random sample of the semen from excess straws was assessed post insemination to determine motility and proportion alive for each treatment. The experiment was repeated twice. In replicate 1, pregnancy rate was determined by failure to return to oestrus within 25 days of AI following exposure (from day 14 post AI) to a panel of mature rams fitted with crayons. Pregnancy was terminated by i/m administration of prostaglandin analogue and after an interval of at least 8 days all ewes were re-synchronised as for replicate 1 and re-randomised to semen treatments to form replicate 2.

In replicate 2, pregnancy rate was determined after the recovery and examination of reproductive tracts (slaughter at ~30 days post AI). Data were analysed using Proc GENMOD of SAS (SAS, 2000) with a logit link function to fit a model that included effects for treatment, ewe breed and replicate.

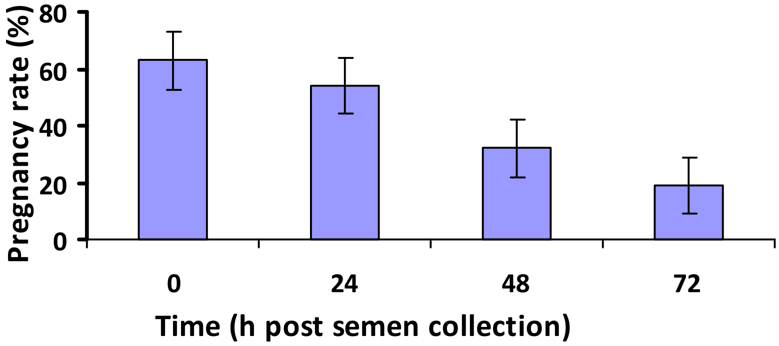


Figure 5. Pregnancy rate after cervical AI using fresh semen stored for 0, 24, 48 or 72 h (vertical bars represent the 95% confidence interval for the mean).

Sperm motility was lower at 48 and 72 h compared with 0 and 24 h and the decline was consistent with previous work (O'Hara *et al.* 2008) Pregnancy rate for each treatment, adjusted for effects of breed and replicate, are presented in Figure 5. The results show that pregnancy rate decreased up to 72 h post semen collection ($P<0.001$). The decline was essentially linear ($P<0.001$) as the quadratic term did not approach significance ($P=0.48$). The effects of ewe breed and replicate were also significant ($P<0.001$, $P=0.05$, respectively). There was no evidence for any breed by treatment or replicate by treatment interactions. The significant breed effect was unexpected as generally ewe breed has not been reported as a source of variation in conception rate following AI with fresh semen.

Fresh ram semen diluted in INRA 96 and stored at 5 °C resulted in the expected pregnancy rate on the day of collection (0 h). The pregnancy rate after 24 h of storage was also acceptable. However, pregnancy rates after storage for 48 and 72 h were unacceptably low.

RMIS No. 5696
O'Hara, L.[1], Hanrahan, J.P., Richardson, L.[1], Donovan, A., Fair, S.[2], Evans, A.C.O.[1] and Lonergan, P.[1]
[1]UCD, School of Agriculture, Food Science and Veterinary Medicine, Belfield, Dublin
[2]Department of Physiology, NUI Galway

The occurrence of neutral and acidic mucins in the cervical mucosa of Belclare and Suffolk ewes

In sheep the success of cervical AI using frozen-thawed semen is breed dependent with pregnancy rates ranging from 77% for Finn ewes, 44% for Belclare ewes to 18% for Suffolk ewes. Such breed differences are eliminated when laparoscopic AI is used indicating the cervical barrier is most likely the basis for the low pregnancy rate. Differences in the nature of cervical mucus may be responsible for the breed effects on pregnancy rate. The objective was to define the characteristics of mucin produced by cervical tissue of Belclare and Suffolk ewes during the peri-ovulatory period.

Oestrus was synchronized in multiparous Belclare (*n* = 14) and Suffolk (*n* = 10) ewes using an intravaginal progestagen sponge for 12 days and 500 IU eCG at sponge removal. Ewes were slaughtered at 42 or 56 (when AI is normally performed) h post progestagen withdrawal. The reproductive tracts were removed and the cervix was cut longitudinally. Tissue samples were taken and placed in 4% paraformaldehyde. They were subsequently dehydrated, cleared, embedded in paraffin and sectioned at 5 μm. Tissue samples were stained for the presence of neutral and acidic mucin. Acidic mucin was visualised using alcian blue stain at pH 2.5. Sections were immersed in alcian blue for 5 min, after which they were counterstained with neutral red in order to visualise the epithelium. Neutral mucins were stained using periodic acid Schiffs (PAS). Sections were treated with 1% PAS for 7 min, after which sections were treated with Schiff's reagent for 15 min. Sections were counterstained with Harris's haematoxylin.

Following histochemical staining, tissues were examined under a light microscope (x20, Nikon Labophot 2) using image analysis software (Image-Pro Plus version 6.2.1, Media Cybernetics USA) that visualised stained material and analysed the tissue. The portion of cervical mucosa that positively stained for the specific mucin type was determined by colour segregation. This was performed for 5 fields of view per animal and the average value was used for statistical analysis. Data were analysed using SAS (2003) to fit a model with effects for breed, time and their interaction. Arcsine transformation was used on the data prior to analysis.

The breed and time effects on mucus are shown in Figure 5 and 6 as percentage of the area stained by alcian blue and Schif's reagent, respectively. There was a significant effect of time on the proportion of the mucosa that stained positively for acidic mucin (P<0.05). There was no evidence for any effect of breed or breed x time interaction. The effect of time on the proportion of cervical mucosa which positively stained for neutral mucin approached significance (P=0.07). There was no significant effect of time on neutral mucin presence. There was no significant difference between the breeds in neutral mucin presence at either of the time points.

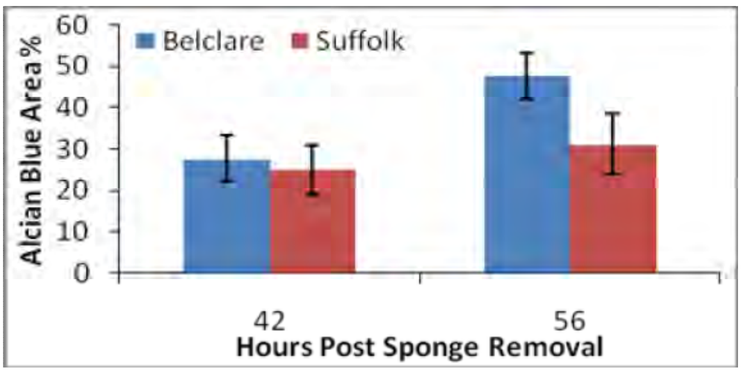


Figure 5. Percentage area of cervical mucosa positively stained for acidic mucin (± s.e.).

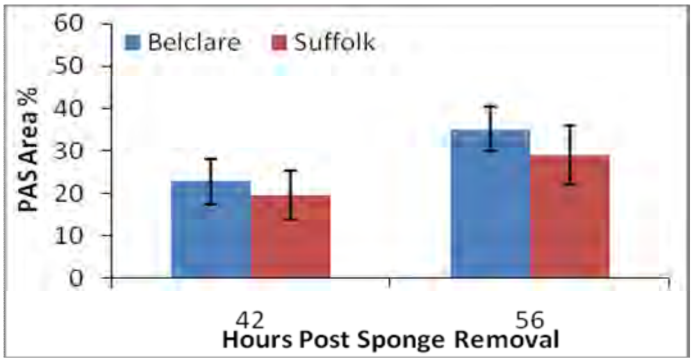


Figure 6. Percentage area of cervical mucosa positively stained for neutral mucin (± s.e.).

The occurrence of neutral and acidic mucin both increase during the oestrus period, with a more pronounced increase in acidic mucin occurrence. However the presence of these mucin types does not appear to be affected by breed.

RMIS No. 5696

Richardson, L.[1]*, Hanrahan, J.P., O'Hara, L.*[1]*, Fitzpatrick, E.*[1]*, Lonergan, P.*[1] *and Evans, A.C.O.*[1]

[1]UCD School of Agriculture Food Science and Veterinary Medicine, Belfield, Dublin

Effect of ewe breed on ovulation rate and litter size associated with cervical AI of fresh semen and on scores for cervical penetration and mucus secretion

Ovulation rate and litter size were recorded after slaughter after the second round of AI in late 2008. A total of 76 ewes had valid litter size data while ovulation rate information was available for 169 ewes. A small number of ewes that were pregnant at the time of AI were excluded. The ewe breeds involved included a small number of Cambridge purebreds and these have been included with the Belclare types in the analysis. The Belclare types used in this study were mostly from the F700-Belclare line in which major genes for ovulation rate are segregating *(see Research Report, 1999, p 26).* The results for ovulation rate and litter size are summarised in Table 38.

Table 38: Ovulation rate and litter size for ewes in AI study 2008

Factor	Ovulation rate[+]	Litter size
Treatment (time)		
0	2.37 ± 0.179	1.85 ± 0.193
24	2.21 ± 0.158	1.76 ± 0.188
48	2.49 ± 0.162	1.80 ± 0.239
72	2.07 ± 0.176	1.48 ± 0.339
F-test	n.s.	n.s.
Ewe breed		
F700-Belclare	3.43 ± 0.176	2.21 ± 0.260
Texel	1.79 ± 0.294	1.48 ± 0.362
Suffolk	2.07 ± 0.263	1.07 ± 0.415
Scottish Blackface	1.72 ± 0.112	1.56 ± 0.132
Belclare x Scottish Blackface	2.28 ± 0.110	1.68 ± 0.143
F-test	P<0.001	P = 0.09

[+]Adjusted for pregnancy status

The above data show that there was no significant association between treatment and ovulation rate at *post mortem*. Also no evidence that treatment affected the litter size of ewes that conceived to AI. Pregnancy status significantly associated with ovulation rate recorded at slaughter – as expected - mean ovulation rate for pregnant ewes was 2.63 (s.e. 0.127) compared with 2.18 (s.e. 0.103) for the non-pregnant ewes. The breed effects on ovulation rate are expected – in particular the high value for the Belclare-F700 group as many of these are carriers of a major gene affecting ovulation rate (either BMP15 or GDF9). The failure to detect any significant breed effect on litter size is partly a reflection of the low numbers that were pregnant and the fact that PMSG is involved in all of the pregnant cases.

Information on score for mucus secretion (0 = none to 3 = copious) evident at insemination and the depth to which it was possible at insert the insemination pipette into the cervical canal (penetration score 0 = no penetration to 3 = deep penetration) were recorded at the time of AI. The distribution of these scores is shown in Figure 7. The analyses of the scores are summarised in Table 39 for all valid record from the two rounds of AI. There was no evidence for any effect of breed or treatment on either mucus or penetration scores.

The repeatability estimates for mucus and penetration scores were 0.23 and 0.22, respectively ($P<0.01$). There was no evidence for any association between either mucus score on penetration and pregnancy to AI. The mucus score for pregnant ewes was 2.13 (s.e. 0.042) compared with 2.05 (s.e. 0.036) for non-pregnant ewes ($P=0.11$).

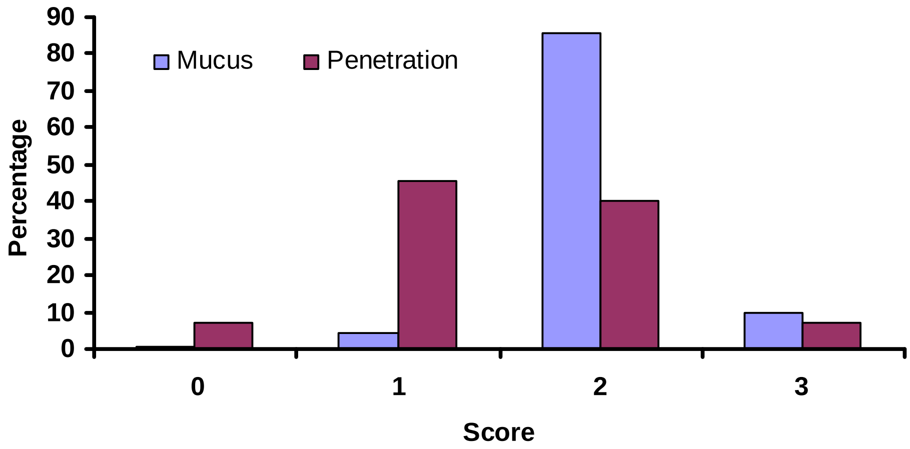


Figure 7. Frequency distribution for mucus and penetration scores at time of insemination.

Table 39: Ewe breed effects on scores from mucus and penetration at AI

Ewe breed	Penetration score	Mucus score
Suffolk	1.8 ± 0.17	2.2 ± 0.09
Texel	1.4 ± 0.20	1.9 ± 0.10
F700-Belclare	1.4 ± 0.20	1.9 ± 0.07
S. Blackface	1.4 ± 0.08	2.0 ± 0.04
Belclare x S. Blackface	1.8 ± 0.07	2.1± 0.04
F-test	n.s.	n.s.

Donovan, A., O'Hara, L.[1] *and Hanrahan, J.P.* *RMIS No. 5696*
[1]UCD School of Agriculture Food Science and Veterinary Medicine, Belfield, Dublin

Effect of sperm dose on pregnancy rate to cervical AI

Additional information was obtained on the effect of sperm dose on pregnancy rate (see Research Report 2007, pp174-175). The doses used were the standard dose of 200 x 10^6 sperm plus doses of 50 and 100 x 10^6. The estimates of pregnancy rate are in Table 40 and show that pregnancy rate declined as the dose was reduced.

Table 40: Pregnancy rate of cervical AI with fresh diluted semen

Sperm dose (x 15^6)	Pregnancy rate
200	66.5 (52.6 – 78.9)[1]
100	56.4 (34.5 – 78.2)
50	48.9 (28.5 – 72.2)

[1]95% confidence interval

However, because of the relatively small number of ewes available for this evaluation the precision of the estimates was low. These data will be combined with information from 2006 and 2007 to provide more precise estimates of the effect of sperm dose on pregnancy rate. A final round of evaluation is planned for autumn 2009.

Donovan, A., Lally, T. and Hanrahan, J.P. *RMIS No. 5696*

Carcass weight of ewes

There is a paucity of information on the carcass weight of cull ewes. Such information is needed in developing evaluations of alternative culling policies and related flock management options such as selling ewes because they prove to be barren. It is also relevant to development of economic weights for genetic evaluation programmes. Information from various sources was used to provide estimates of carcass weight and factors that influence this trait. The major source of data was a complete set of ewe carcass data from one export abattoir for 2004. Other data were obtained from 5 commercial flocks over a 3-year period (2006-2008) and a set of data on cull ewes from the flocks at Athenry and Leenane slaughtered at the end of 2008.

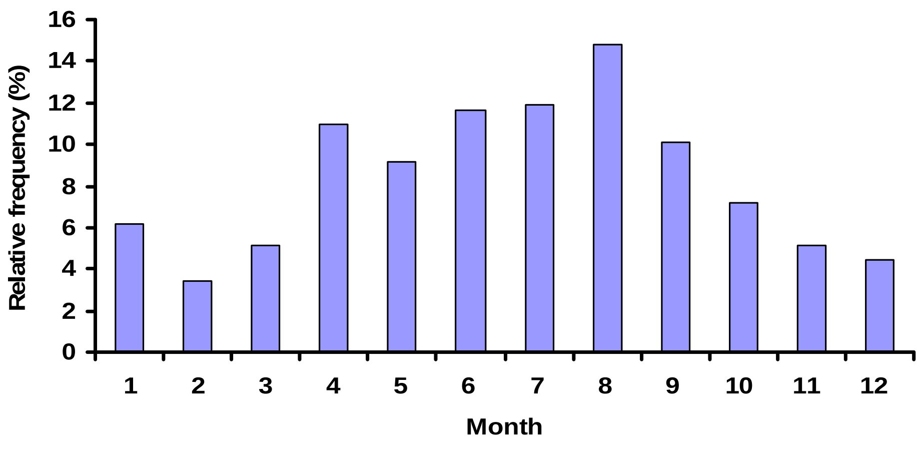


Figure 8. Monthly frequency of ewe carcasses in the selected data file.

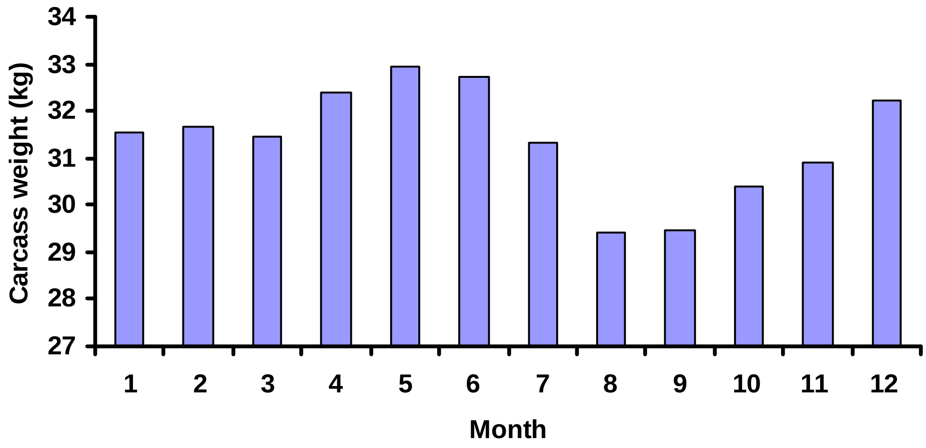


Figure 9. Least squares mean carcass weight of ewes by month of slaughter.

The carcass data from the export abattoir were screened to eliminate suppliers who supplied more than 150 ewes in order to eliminate dealers; suppliers of less than 10 ewes were also excluded. Further edits were designed to minimise the representation of S. Blackface ewes. This was done by eliminating suppliers from counties Kerry, Mayo, Leitrim, Sligo, Northern Ireland and suppliers from whom the mean carcass weight of all ewes supplied was less than 20 kg. The resulting data set contained 29089 animals. Individual records where carcass weight was <10 kg were also excluded. The annual pattern of disposals for the resulting flocks (n=950) included in the final data set is shown in Figure 8 while the average carcass weight data are summarised in Figure 9. Most ewes are culled between April and October. Average carcass weight was lowest in the months of August to October and highest in the April to June period.

The average carcass weight for the set of 5 commercial lowland flocks that were involved in a ram progeny testing project was 34.9 kg although this varied considerably among flocks (28.2 to 44.4 kg). Month of slaughter was also a significant source of variation in this data set; the lowest mean was in August.

The effect of ewe breed on carcass weight and kill-out proportion are summarised in Table 41 for the data collected on Teagasc ewes. All the ewes in this data set had been used for an AI study and had been grazed together for about 3 months prior to slaughter. The S. Blackface ewes had been culled from the flock at the hill sheep farm at Leenane while other breeds were from flocks at Athenry.

Table 41: Mean (± s.e.) values for carcass weight and kill-out proportion by ewe breed

Ewe breed	No. of ewes	Carcass weight (kg)	Kill-out (kg/kg)
Suffolk	13	36.7 ± 1.20	0.45 ± 0.0084
Texel	19	34.2 ± 0.95	0.46 ± 0.0066
Belclare	20	32.8 ± 0.95	0.45 ± 0.0067
S. Blackface	61	21.2 ± 0.53	0.43 ± 0.0037
Belclare x S. Blackface	74	31.4 ± 0.48	0.46 ± 0.0034
F test		P<0.001	P<0.001

Hanrahan, J.P. *RMIS No. 5389*

Athenry Research Centre

Parasitology

Performance of Suffolk and Texel lambs under contrasting levels of gastrointestinal nematode challenge

A large and consistent difference between Suffolk and Texel sheep in resistance to gastrointestinal parasite challenge has been demonstrated (*see for example Research Reports 1999, pp 23-24 & 2000, pp 21-23)* based on faecal egg count (FEC) measurements. The difference in faecal egg count is a reflection of differences in the number of adult worms in the abomasum and small intestine. A two year study was established in 2008 to determine whether the growth rate difference between Suffolk and Texel lambs depended on whether the animals were exposed to significant larval challenge from the pasture. Under all-sheep grazing systems on permanent grass swards at Athenry pasture larval challenge is a constant feature of the lamb's environment, and under these circumstances Suffolk lambs are ~1.5 kg heavier at around weaning than co-grazed Texel lambs (*see Research Report 1999 pp20-23).* A newly reseeded pasture without any exposure to sheep and on a block of land that had not been grazed by sheep in the years prior to reseeding was used to provide 'clean' grazing and pasture in the permanent grassland area devoted to sheep provided 'contaminated' grazing and was expected to provide a level of pasture larval challenge typical of permanent pastures grazed by sheep only.

Prior to lambing in spring 2008 (early March) purebred Suffolk and Texel ewes were assigned at random within breed and expected lambing date to be turned out post lambing to either 'clean' or 'contaminated' pasture. All ewes had been housed together on silage with standard concentrate supplement prior to lambing. Ewes were put onto the assigned grazing area about 2 days post lambing and all ewes assigned to the 'clean' grazing area were treated with an anthelmintic (ivermectin type) on the day prior to turn out to minimise any deposition of nematode eggs on the 'clean' pasture. Lambs were dosed for Nematodirus control at 5 weeks of age (this is part of the routine parasite control practised at Athenry). No further anthelmintic was administered until the lambs were 17 weeks old (about 3 weeks post weaning).

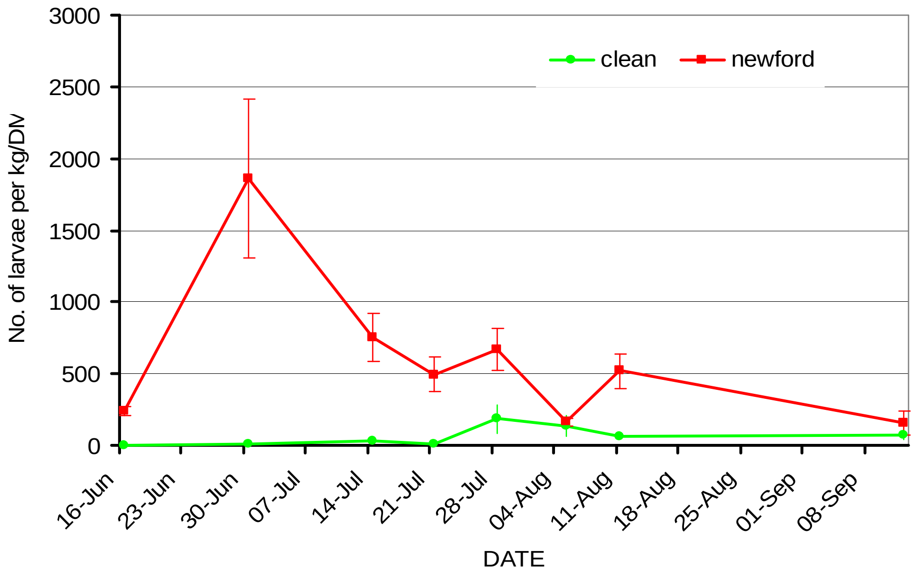


Figure 10. Arithmetic mean number of larvae recovered from herbage in paddocks from the clean and contaminated grazing areas.

Herbage larval counts were carried out at 2-week intervals from mid June until early August to confirm the absence of significant larval challenge on the clean pasture; the results are shown in Figure 10 and confirm the expected difference between the two pastures. 'Contaminated' pasture was also monitored at the same time. It is clear from this that up to mid July when the lambs were ~17 weeks of age pasture larval count was essentially zero for the 'clean' pasture whereas the 'contaminated ' pasture displayed the expected seasonal rise in the number of larvae per 1 kg dry matter.

Flock values for FEC were monitored using FECPAK and individual FEC measurements on lambs were performed at 14 and 18 weeks of age and the results are shown in Figure 11.

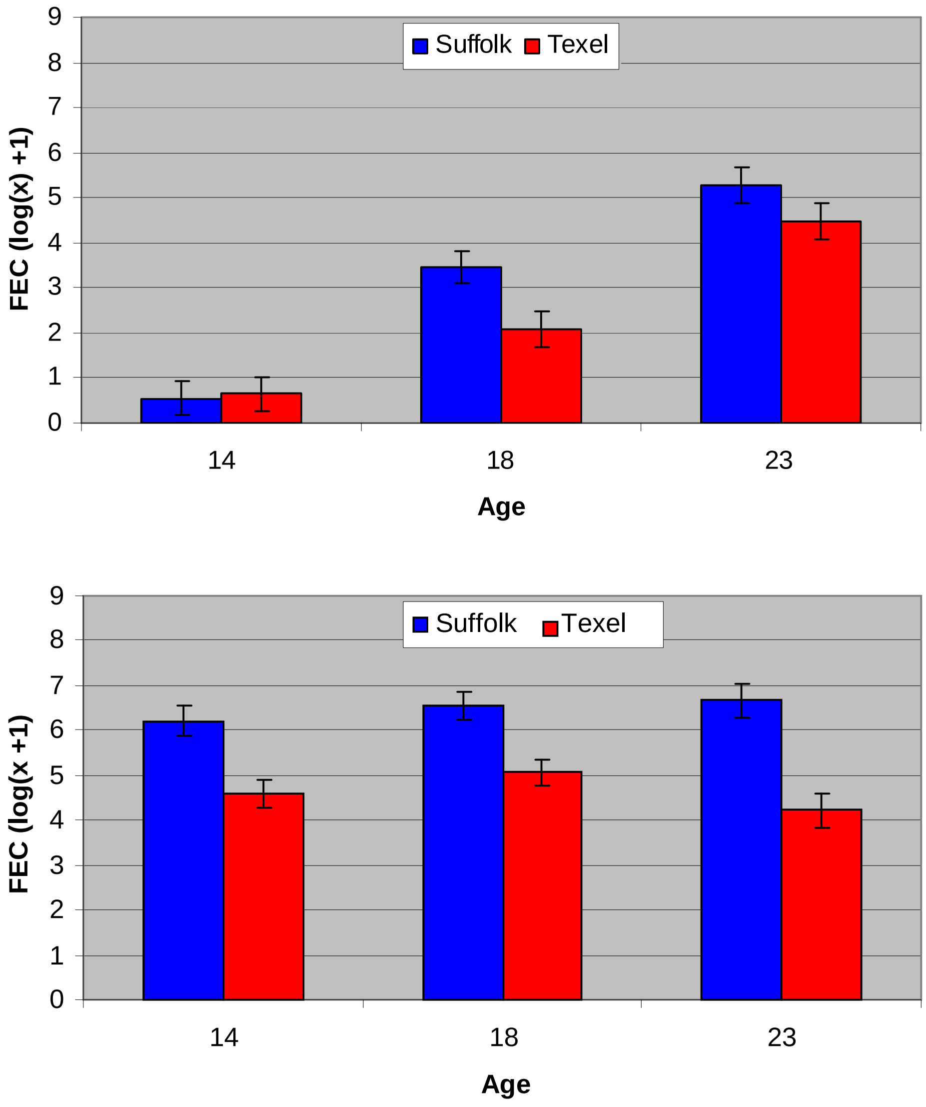


Figure 11. Least squares means (log scale) of FEC_{OT} in lambs grazing clean pasture (top panel) and contaminated (lower panel) pasture.

These show that FEC values differed radically between lambs on the two pasture types at both age points at 14 and 18 weeks of age. There was a clear increase in FEC for lambs on the ‘clean’ grazing between 14 and 18 weeks of age indicating that the some infective larvae were present on the ‘clean’ sward. However, the number of eggs per gram was only 23 (back transformed mean) for Suffolk lambs and 6 for Texels at 18 weeks and increased to around 150 eggs per gram at 23 weeks.. The difference between Suffolk and Texel lambs is clearly evident at all time points for lambs on the ‘contaminated’ pasture and is also evident at 18 weeks for lambs on the ‘clean’ pasture.

The parasitological data clearly show that there was the expected difference between the two grazing treatments in terms of exposure to larval challenge up to weaning. The information on lamb growth to weaning (135 lambs) is summarised in Table 42 based on statistical analyses using a linear model with fixed effects for breed, sex, pasture type and rearing type (single/twin) and dam as a random term.

Table 42: Least squares means (± s.e.) for lamb growth traits on ‘clean’ and ‘contaminated’ pasture

Breed	Pasture type	Growth rate		Weaning weight (kg)
		0 to 5 weeks	0 to 14 weeks	
Suffolk	Clean	334 ± 10.8	333 ± 8.3	37.4 ± 0.87
	Contaminated	331 ± 11.3	309 ± 8.6	35.3 ± 0.91
Texel	Clean	349 ± 11.1	327 ± 8.5	37.2 ± 0.90
	Contaminated	329 ± 12.6	302 ± 9.7	34.4 ± 1.02

Breed did not have a significant effect on growth traits although Suffolk lambs were grew somewhat faster (333 v. 305 g/day) and were heavier at weaning. There was a significant effect of pasture type on growth ($P<0.01$) due to a better performance by lambs on the ‘clean’ pasture. However there was no evidence for any breed-by-pasture type interaction ($P>0.5$) for any growth trait.

The results suggest that the higher FEC burden of Suffolk lambs under normal contaminated grazing conditions do not impair their growth performance relative to that of co-grazed Texel lambs.

Hanrahan, J.P. and Good, B. *RMIS No. 5389*

The influence of breed and grazing history on larval establishment in tissue from the ovine abomasum

The escalation of anthelmintic resistance in nematode populations threatens the sustainability of the anthelmintic-dominated approach to parasite control in sheep production systems. Strategies to manage the development of resistance are needed. Breeding sheep resistant to parasite infection is one such option. Previous work at this Centre has identified large differences in resistance among breeds to gastrointestinal nematode infection (Hanrahan and Crowley, 1999, Good et al., 2006). Purebred Suffolk sheep consistently demonstrates larger FEC and worm burdens than co-grazed purebred Texel sheep. The aim of this experiment is to investigate the tissue association phase of larval establishment between animals from two breeds and two contrasting parasite exposure histories (grazing clean or contaminated pasture). Purebred Suffolk and Texel ewes were assigned pre-lambing, at random within expected lambing date, to either a ‘clean’ grazing area (reseeded pasture not grazed by sheep) or a ‘contaminated’ (permanent grassland grazed by sheep over many years) grazing area. To maintain the ’clean’ status of the grazing area ewes dosed with Cydectin (Whelehan Animal Health) prior to their entry to the ‘clean’ grazing area. Ewes grazing the conventional area were not dosed. All lambs were dosed at 5 weeks of age (Chanaverm, Chanelle Pharmaceuticals Manufacturing Ltd. No further anthelmintic treatments were administered until 17 weeks of age when all lambs were treated with Oramec (Merial Animal Health Ltd) according to manufacture's recommendations.

Strongyle faecal egg counts were determined for each lamb at 14 and 17 weeks of age. Faecal egg counts were distinguished as *Nematodirus* (FEC_N), *Strongyloides papillosus* (FEC_S) and 'other trichostrongyles' (FEC_{OT}). The number of larvae per 1 kg of herbage dry matter was determined for each paddock every 2 weeks (approx) from 16 June. Larval counts were distinguished as *Nematodirus (*LC_N*) and* 'other trichostrongyles' (LC_{OT})

On the 11th of August (approx 22 weeks of age) lambs from the 'clean' grazing group joined the animals on the contaminated grazing area. Three animals per breed (all males) and grazing group were chosen at random, faecal sampled (for FEC determination), treated with Oramec (Merial Animal Health Ltd) according to manufacturer's recommendations and housed on slats, given concentrates *ad libitum* with free access to water. These animals were faecal sampled on 3 consecutive days (30 Sep to 02 Oct) to establish infection status. As 4 animals were positive (range 1 to 3 epg) all lambs were treated again with Oramec (Merial Animal Health Ltd). Lambs were resampled at 20 days post infection to establish infection status and all had a zero faecal egg count.

Animals were slaughtered over 2 consecutive days at about 34 weeks of age. The abomasum was removed and opened along the greater curvature. Abomasum folds were excised (right and left of the midline) and placed in warm Hank's medium (with 20 mmol L-1 Hepes (2ml phenol red) added to 1 L of sterile H_20 and brought to pH of 7.6 with NaOH) prior to return to the laboratory for use in an *in vitro* larval challenge study. The *in vitro* challenge of tissues with nematode larvae was done according to method described by Jackson et al. 2002. For each animal the abomasal folds collected at the factory were cut in approximately 1 cm^2 sections and each section was placed in a separate well containing 0.5 ml medium (warm Hank's medium with 20 mmol L-1 Hepes (2 ml phenol red) added to 1 L of sterile H_20 and brought to pH of 7.6 with NaOH). An isolation cylinder was placed on top of the tissue to which the either exsheathed *Teladorsagia circumcincta* (1500 L_3) or *Haemonchus contortus* larvae (2000 L_3) were added. Plates were transferred to the CO_2 incubator at 38 ^oC and incubated in darkness for 3 h. Following incubation, tissues underwent a separate rinse, then a wash step prior to being digested in 50 ml of 1% pepsin/1% HCL solution at 38 ^oC for 12 h; helminthological iodine (2 ml) was added to all tubes and the volume made up to 50 ml with distilled water. For each tube (rinse, wash and digest) four aliquots (2%) were aspirated, placed on 60 mm x 15 mm culture dish (with 2 mm Grid) (Corning®) and the number of L3 recovered determined using a dissecting microscope. The proportion of the larval population associated with the mucosa was calculated using the standard formula (number of larvae in digest / total larval population)*100

The FEC data were analysed using Proc GLM. The model had fixed effects for breed grazing and breed*grazing interaction. Prior to analysis, the FEC data were transformed to logarithms (ln (x +1)) to normalise the distribution.

The tissue associated larvae data were analysed using Proc MIXED with animal within breed-by-grazing as a random effect. The initial model had fixed effects for breed (Texel/Suffolk), grazing ('clean' / contaminated), treatment (*T. circumcincta, H contortus*) and all 2-way interactions. The final model contained all main effects and any significant interactions. Prior to analysis, the data were transformed using the to arcsine√ function to normalise the distribution.

A summary of FEC in lambs by breed and grazing regime are shown in Table 43. FEC was negative in all animals at time of slaughter. The proportion of tissue associated larvae exhibited a significant breed-by-treatment interaction (P<0.05). *T. circumcincta* establishment in tissues was greater than *H. contortus* establishment in Suffolk lambs but vice *versa* in the Texel (Table 44). The effect of grazing on the proportion of tissue associated larvae approached significance (P=0.08) with lambs from the contaminated grazing area having a greater level of tissue establishment compared to lambs from the 'clean' pasture. Neither breed nor grazing nor breed-by-grazing had a statistically significant effect on FEC_{OT} observed.

Table 43: Least squares means and 95% confidence intervals (back transformed values) for FEC_{OT} in Suffolk and Texel lambs at housing (22 weeks of age)

Grazing	Suffolk	Texel
'Clean'	217.3 (4.4-8844)	66.0 (0.7-2720)
Contaminated	107.2 (1.7-4384)	7.0 (-0.8-324)

The proportion of larval establishment in tissues is summarized in Table 44.

Table 44: Least squares means and 95% confidence intervals (back transformed values) for larval establishment in Suffolk and Texel lambs

	Larval establishment (%) in tissue	
Parasite treatment	Suffolk	Texel
T. circumcinta	67.7 (43.7-90.0)	39.0 (22.9-59.3)
H. contortus	56.3 (33.3-90.0)	47.8 (30.6-75.9)

The establishment data indicate a difference between breeds which is influenced by the type of infection. It might be expected that the nature of the parasite establishment response in these temperate breeds would differ between parasite species of distinct geographical origin. Being temperate in origin, the Suffolk and Texel would not have coexisted /coevolved with *H. contortus* (unlike *T. circumcinct*a) which would be more tropical and subtropical in distribution.

Good, B. and Hanrahan, J.P. *RMIS No. 5685*

Preliminary work towards the development of an alternative method to diagnosing nematode infection in sheep

The principal method to diagnosing infection in sheep is faecal egg counts (FEC) which is underpinned with species identification gleamed from coprocultures. These methods are labour intensive, time consuming, and identification to species requires highly trained personnel. Molecular techniques to differentiate and identify nematode species have the potential to increase the reliability (and speed) of diagnosing infection in sheep. Moreover it will also have application for herbage larval studies. In order to developing species specific test, the availability of ovine nematode material for DNA extraction is a prerequisite. Monospecific infections of *Teladorsagia circumcincta*, *Trichostrongylus colubriformis, T. vitrinus* and *Haemonchus contortus* (received as a gift from Moredun, Scotland) were administered to 2, 2, 1 and 2 lambs respectively on 14 Jul with the aim of having species specific material for DNA extraction. Once infection had been established, each male lamb (n=5) was fitted with faecal collection harness and 24 h faecal collections were undertaken.

Faeces from each lamb were incubated separately and larvae (L3) recovered. Lambs were slaughtered 67 days post infection, tracts recovered and placed in the freezer for subsequent nematode recovery.

Good, B., Hanrahan, J.P., Glynn, A . and Nally, J. *RMIS No. 5687*

Cytokine expression in the abomasal mucosa of lambs carrying the ovar-*DRB1*0203* allele after experimental challenge with *Teladorsagia circumcincta*

Resistance to gastrointestinal nematodes depends on an effective Th-2 immune response, while susceptibility to chronic infection is propagated by a Th-1 response. In order to elucidate the protective immune response elicited, the gene expression profile of a panel of cytokines and inflammatory regulators was chronologically characterised in the gut mucosa of sheep artificially infected with *Teladorsagia circumcincta*. This study involved a group of 20 twin pairs, where each twin pair consisted of a carrier and a non-carrier of the ovar-DRB1*0203 allele (associated with reduced faecal egg count). The lambs were reared in isolation facilities and at 12 weeks of age were given a single oral dose of *Teladorsagia circumcincta* L3. Four lambs from each genetic background were slaughtered at 0 (un-dosed control), 3, 7, 21, and 35 days post infection. Lambs carrying the DRB*0203 allele had a lower worm burden ($P<0.05$). Abomasal cytokine expression was evaluated by quantitative real-time PCR. The expression data were normalised by reference to 3 housekeeping genes using Genorm®. The data at days 3, 7, 21 and 35 were expressed relative to values at day 0. The response generated varied through the course of infection and was affected by genotype. Carriers of DRB1*0203 had an up-regulation of IL-1 and IFN-γ at day 7, but this was replaced by expression of IL-13 and IL-10 by day 21. Conversely, in the non-carriers the expression of these cytokines was delayed until days 21 and 35, respectively, suggesting that resistance in influenced by an early onset Th-2 immune response.

RMIS No. 5685
Hassan, M.[1]*, Good, B., Hanrahan, J.P., Mulcahy, G.*[1] *and Sweeney, T.*[1]
[1]UCD School of Agriculture Food Science and Veterinary Medicine, Belfield, Dublin

Ovine *DRB1*203* allele as a marker for increased resistance to gastrointestinal nematodes

Differences in susceptibility to gastrointestinal nematode infection have been observed between and within sheep breeds, and these differences have a genetic basis. An allele at the ovar-MHC-DRB1 locus (*DRB1*203)* has been associated with reduced faecal egg count in the Suffolk breed. To investigate the potential of this allele as a marker for nematode resistance, we used Suffolk rams heterozygous for DRB1*203 to produce carrier and non-carrier progeny. Twin lambs (carrier and non-carrier), reared in isolation facilities, were used. At 12 weeks of age, these lambs received a single oral dose (30,000) of *Teladorsagia circumcincta* L3. Faecal samples were collected twice per week from day 23 and worm burden was determined following necropsy at 3, 7, 21, or 35 days post infection. Prior to analysis, FEC and worm count values were log transformed and the GLM procedure of SAS® was used to fit a model with effects for genotype and day post infection. Lambs carrying the DRB1*203 allele had lower worm count ($P<0.03$) and faecal egg counts were also lower (day 35 group, $P<0.14$). Furthermore, a reduction in worm count was observed by day 21 post infection in lambs carrying the DRB1*203 allele whereas there was no observable change in worm burden in non-carriers up to day 35 post infection. These results indicate a role for the ovar-DRB1*203 allele GI nematode resistance in the Suffolk breed.

Hassan, M.[1]*, Good, B., Hanrahan, J.P., Mulcahy, G.*[1] *and Sweeney, T.*[1] *RMIS No. 5685*
[1]UCD School of Agriculture Food Science and Veterinary Medicine, Belfield, Dublin

The effect of DRB1*0203 allele on ovine response to gastrointestinal nematode infection

Lambs (twin) identified as carrier or non carrier of the DRB1*0203 allele were housed at 6 weeks of age, faecal sampled and administered anthelmintic (Oramec, Merial Animal Health) according to manufacturer's recommendations. At approximately 12 weeks (10 June) of age lambs (n=32) were administered a monospecific challenge of T. *circumcincta per os* and 8 lambs remained unchallenged. At days 0, (control lambs no challenge) 3, 7, 21 and 35, four sets of twin lambs (carrier and non carrier) were slaughtered, abomasum removed from the gastrointestinal tract and worms recovered.

Data for worm burden was analysed using Proc Mixed (SAS v9.1) with day, genotype and genotype*day interaction. Day was highly significant (P<0.001). A significant difference the number of worms recovered between carriers (less worms) and non-carriers of the DRB1*0203 allele was evident from post day 3 of infection (P<0.05). Day-by-genotype was significant (P<0.05) (Figure 12).

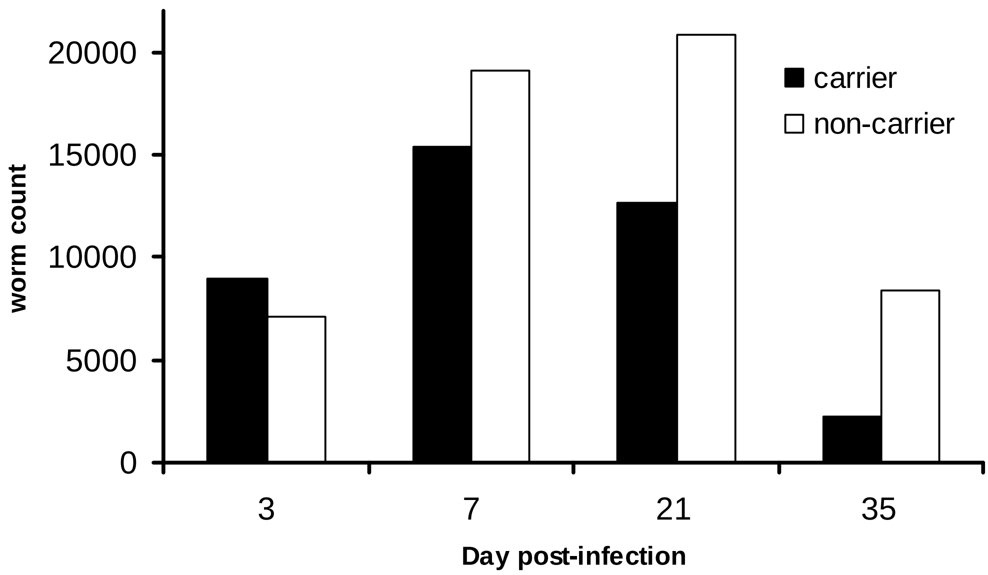


Figure 12. *Teladorsagia circumcincta* worm burden in lambs post-infection.

Hassan, M.[1], Good, B., Hanrahan, J.P. and Sweeney, T.[1] *RMIS No. 5685*

[1]UCD School of Agriculture Food Science and Veterinary Medicine, Belfield, Dublin

***Fasciola hepatica* infection in tracer lambs grazing the hill on the Teagasc hill sheep farm in Ireland**

Despite the absence of suitable habitats in the hill to support Galba (*Lymnaea) truncatula*, previous evidence has indicated exposure to *F. hepatica* in tracer Scottish Blackface lambs grazing the hill area exclusively (Research Report 2007, p 188-189). With areas on the hill exposed to flooding, it was proposed that metacercariae may be washed up to the hill area from the reclaimed greenland area bordering the river on the farm. In 2008, the flood plain encroaching the hill area fenced off prior to putting 16 tracer (uninfected) animals on the hill area (May '08). The animals chosen included the 6 tracer lambs used last year plus an additional 10 animals in the hill flock of similar age (2007 born). Animals were checked for infection in March and April 2008 (0 % and 20% positive, respectively) and treated with a flukicide on 24 April (Trodax 34%, Novartis Animal Health) according to manufacturer's recommendations, prior to being put to the hill. Faecal (FEC coproantigen) and blood samples (to detect anti-*F. hepatica* antibodies in serum). were taken on a monthly basis (May to Jan '09). Results completed to date indicate that up to Nov, no lambs were positive using the coproantigen test. Results remain to be completed for the other tests.

Relf, V. [1], Good, B., Hanrahan, J.P.[1], O'Malley, L. and de Waal, T. [1] *RMIS No. 5493*
[1]UCD School of Agriculture, Food Science and Veterinary Medicine, Belfield, Dublin

Evidence for *Fasciola hepatica* in *Radix peregra* found in acidic habitat- a new intermediate host?

Molluscs of the genera *Lymnaea, Galba, Pseudosuccinea* and *Stagnicola* act as intermediate hosts of the common liver fluke, *Fasciola hepatica*. *Galba* (*Lymnaea) truncatula is* the only recorded intermediate host of *F. hepatica* in Ireland and is the principal intermediate host in Europe. Given the high prevalence of infection with *F. hepatica* in sheep grazing the Teagasc hill farm (Research Report 2007, p 188-189), prior knowledge of habitat preference for and environmental tolerances of *G. truncatula* and the absence of *G. truncatula* in the hill area, implied that perhaps some other intermediate molluscan host was present. The aim of this study was to determine if there was evidence of *F. hepatica* infection in a *Radix* sp. observed on hill grazing, using a *F. hepatica* specific PCR.

Snails were collected from a drainage ditch (lat. 53°38'0.22"N, long. 9°37'36.55"W) located in the hill area of the Teagasc hill sheep farm, Co. Mayo, in March, April and May 2008 (n= 78, 53, 36, respectively) following the 10 m transect method (Malone, 1984/85) Snails were morphologically identified, measured (length: apex to anterior margin of shell) using digital calipers (±0.01 mm) and stored at -20 °C until further processing. Genomic DNA was extracted using a Wizard™ genomic DNA purification kit (Promega). Amplification of the 18S gene and ITS-2 region of rDNA were performed (as described by Bargues and Mas-Coma (1997) and Jouet *et al.* (2008), respectively). A subsample of PCR products (20 µl) of the 18S gene (n = 12) and the ITS-2 region (n = 5) were commercially sequenced (GATC Diagnostics, Germany) using forward primers 5′-ctggttgatcctgcca-3′ and 5′-caagccgcgccgttgtccg-3′, respectively. A BLAST search was performed and sequences were aligned, with those identified as the closest snail species from the GenBank database, using CLUSTAL-W. To identify snails infected with *F. hepatica*, a PCR was performed on all snail DNA (n = 167) with forward (5′-tatgttttgattttacccggg-3′) and reverse (5′atgagcaaccacaaaccatgt-3′) primers as described by Cucher *et al*. (2006). A subset (n = 9) of these PCR products (20 µl) were sent for commercial sequencing (GATC diagnostics, Germany) using forward primer (5′-ctaataatgattctttgtttgg-3′) to confirm that the 405 bp band visualised following gel electrophoresis, was the amplification of *F. hepatica* DNA. Sequences were aligned using CLUSTAL-W.

Snails were morphologically identified as a *Radix* species. Amplification of the 18S gene revealed a 99% similarity with *Radix auricularia* (accession number Z73980) and 98% with *R. peregra* (accession number Z73981). However, *R. auricularia* has a distinct aperture shape which was not observed in these snails. The ITS-2 region revealed a 100% similarity with *R. peregra* genotype 3 (accession number AJ319635), previously identified in France, and 84% similarity with *R. auricularia* (accession number AJ319632.1). Sequencing of the 405 bp PCR product revealed a single base pair change (G to A at residue 2814) resulting in a 99% similarity to that of the *cytochrome c oxidase subunit 1 gene* of *F. hepatica* (accession number X15613.1). Overall, PCR identified *F. hepatica* DNA in 10 % (n = 8), 41% (n = 22) and 61% (n = 22) of the *R. peregra* snails (length range 4.70 to 12.35 mm) in March, April and May, respectively. While it is not possible to determine from the available information if *F. hepatica* successfully penetrated and multiplied within these snails and shed cercariae, previous work has shown, under experimental laboratory conditions, that *R. peregra* (= *Radix*

(Synonym *Lymnaea*) *ovata*) is a potential intermediate host of *F. hepatica* (Bargues and Mas-Coma, 2005; Dreyfuss *et al.*, 2000). The prevalence of *F. hepatica* in *R. peregra* was greater than that recorded in *G. truncatula* observed on the lowland pasture of this study farm using similar methods (14%, n = 974, Relf *et al.*, unpublished data) and in *G. truncatula* in other countries, for example Switzerland (7%). This represents the first evidence for *F. hepatica* in snails other that *G. truncatula* in Ireland. The evidence suggests that *R. peregra* is an intermediate host of *F. hepatica*. This observation may in part explain the presence of infection in animals grazing acidic upland areas. Given the high prevalence of *F. hepatica* infection observed in *R. peregra*, the role that *R. peregra* plays in the transmission of liver fluke warrants further evaluation.

Relf, V. [1]*, Good, B., McCarthy, E.*[1] *and de Waal, T.* [1] *RMIS No. 5493*
[1]UCD School of Agriculture, Food Science and Veterinary Medicine, Belfield, Dublin

Evidence for *Fasciola hepatica* infection in another mollusc found in the same habitat as *G. truncatula*

As part of a study involving the routine collection of *Galba* (*Lymnaea*) *truncatula* (Research reports 2006, p182-184, 2007, p187-188) snails other than *G. truncatula* (*n* = 23) were collected from a track area entering field 2 (lat. 53°38′52.53″N, long. 9°37′42.29″W) on the greenland pasture in May 2008.

Snails were morphologically identified, measured (length: apex to anterior margin of shell) using digital calipers (±0.01 mm) and stored at -20 °C until further processing. Genomic DNA was extracted using a Wizard™ genomic DNA purification kit (Promega). Samples were processed adopting similar methodology as described above with the exception that a smaller number of PCR products (20 µl) (n=9) of the 18S gene were commercially sequenced (GATC Diagnostics, Germany) using forward primers 5′-ctggttgatcctgcca-3′ and 5′-caagccgcgccgttgtccg-3′, respectively. The chosen primer set did not amplify the ITS-2 region of this snail. A BLAST search was performed and sequences were aligned, with those identified as the closest snail species from the GenBank database, using CLUSTAL-W.

All of snails were morphologically identified as a *Succinea* species (4.98 to 7.54 mm in length), similar to *Succinea putris* based on the presence of rapidly enlarging whorls, a pear shaped aperture pointed at the top and a meaty protruding foot. Amplification of a 658 bp PCR product from purified DNA of this snail and subsequent sequencing of a subset of PCR products (*n* = 9) revealed that the 18S rDNA sequence had a 99% similarity with *Omalonyx matheroni* (Succineidae) (accession number AF047199) following a BLAST search of the GenBank database. Base changes were evident between *O. matheroni* and sequences obtained from this snail at positions 55, 220 and 595 with T, G and W substituted with A, A and A, respectively.

F. hepatica DNA was identified in 73.9% (*n* = 17) of snails (of the family Succineidae) ranging in size from 3.20 to 7.40 mm. Whether *F. hepatica* successfully penetrated and subsequently multiplied within these snails remains to be determined. To our knowledge, no snails from the family Succineidae have been identified as a potential intermediate host in either laboratory or field studies; however, this snail is often found in drier areas surrounding heavily infected *G. truncatula* populations on the Teagasc hill sheep farm and would, therefore, be exposed to *F. hepatica* miracidia. While this snail was identified morphologically as a *Succinea* sp., identification to species level was not possible. Sequencing of the 18S region of this snail revealed a 99% similarity with *O. matheroni*—a species which has not been recorded in Ireland.

Very little information is available on the 18S gene and ITS-2 region of species within the family Succineidae. The need for further investigation into this mollusc's potential to act as an intermediate host to *F. hepatica* is warranted

Relf, V. [1]*, Good, B., McCarthy, E.*[1] *and de Waal, T.* [1] *RMIS No. 5493*
[1]UCD School of Agriculture, Food Science and Veterinary Medicine, Belfield, Dublin

Liver fluke in lambs grazing greenland on the hill sheep farm Leenane

As part of study reviewing the epidemiology of liver fluke, the prevalence of fasciolosis in ewes and lambs grazing the greenland or hill area in the Teagasc hill sheep farm was monitored over 2 years (Research Reports 2006, p182-184 and 2007, p188-189) A sub sample of lambs from this group, from the HILL and LOW flock grazing greenland were slaughtered at the end of each year (Oct 2006 and Nov 2007). Prior to slaughter faecal and blood samples were taken from each lamb. Faecal samples were stored at 4º C in self-seal polyethylene bags until the number of *F. hepatica* eggs per gram of faeces could be determined using the sedimentation technique. The sera were assayed for anti-*Fasciola hepatica* antibodies using an in house ELISA Kit (Ildana ELISA). Results were expressed as a 'sample' to 'positive' ratio. A ratio > 17.99 was considered positive. Livers were collected at slaughter placed in polyethylene bags and frozen prior to dissection to determine the number of adult and juvenile fluke per lamb.

Differences in FEC (positive/negative), serology (positive/negative), liver fluke burden (positive/negative) were analysed using a generalised linear model that included year, flock (hill or lowland) and year-by-flock as fixed effects. Differences in FEC (epg) and liver fluke burden (number) were evaluated using mixed model procedures. Prior to the statistical analyses, egg and worm counts were transformed log (x+1) where x represent FEC or the total number of fluke per liver respectively, to normalise the distribution.

A summary of the FEC, serological and fluke burden data collected in lambs by flock and year is shown in Table 45. The percentage of fluke positive lambs as indicated by FEC, serology and fluke burden is illustrated on Figure 13. Neither year (P>0.05) nor flock (P=0.06) nor year-by-flock (P>0.05) had significant effects on the proportion of lambs with positive FEC. A greater proportion of lambs in the lowland flock than in the hill flock had positive serology (P<0.02). The proportion of animals positive for *F. hepatica* antibody was higher in 2007 than 2006 (P<0.001). Year-by-flock interaction, on the proportion of animals positive for *F. hepatica* antibody was not statistically significant. There was no significant difference in the proportion of fluke positive animals between flock (lowland/hill) (P>0.05) or year (P=0.09). Year-by-flock was not significant.

Table 45: Summary of FEC, serological and fluke burden results in lambs from both flocks by year

Variable	Summary†	Hill 2006	Hill 2007	Low 2006	Low 2007
FEC (epg)	n	9	8	20	14
	Median	0.0	0.0	0.5	0.8
	90th percentile	3.3	3.0	14.7	163.3
Serology (SP ratio)	n	9	8	21	14
	Median	5.5	79.0	37.3	90.7
	90th percentile	75.1	121.7	76.1	102.3
Fluke burden (number)	n	9	8	23	14
	Median	0.0	1.0	0.0	1.5
	90th percentile	1.0	3.0	5.0	14.0

† n = no. of lambs

Least squares means for FEC and fluke burden by year and flock are shown in Figures 13 and 14. Fluke burden was greater in 2007 than 2006 (P<0.001). Lambs from the lowland flock had significantly greater fluke burdens than lambs from the hill flock (P<0.05).There was no difference observed in mean FEC between years (P>0.05). Lambs from the lowland flock had higher FEC compared to lambs from the hill flock (P=0.05). There was no significant year by flock interaction (P>0.05). The ratio of juvenile to adult fluke was lower in 2006 (0.7:1) than in 2007 (5.2:1).

Overall while the evidence for exposure to fluke was high the fluke burden observed in these lambs would be considered low. The observation of a greater and more mature fluke burden in 2007 compared to 2006 is most likely explained by the time of slaughter (lambs were killed one month later (November) in 2007 compared to 2006). While flock had no statistical significant effect on the proportion of lambs infected in either flock (as indicated by positive FEC) lambs from the LOW flock had significantly higher FEC and fluke burden. This support our previous data on the greater suitability of the LOW land pastures for the snail intermediate host and therefore greater potential contamination of the greenland pastures. Moreover the identification of triclabendazole resistant fluke population on this farm (Research report 2007, p189-193) also contributed to an overall contamination of this pasture for 2008.

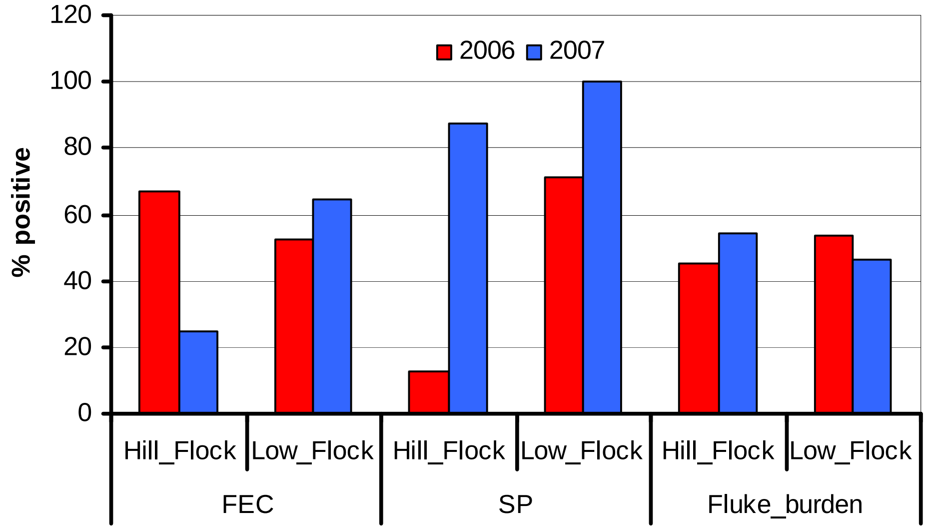


Figure 13. Percentage of FEC, SP ratio and fluke burden positive lambs by flock and year.

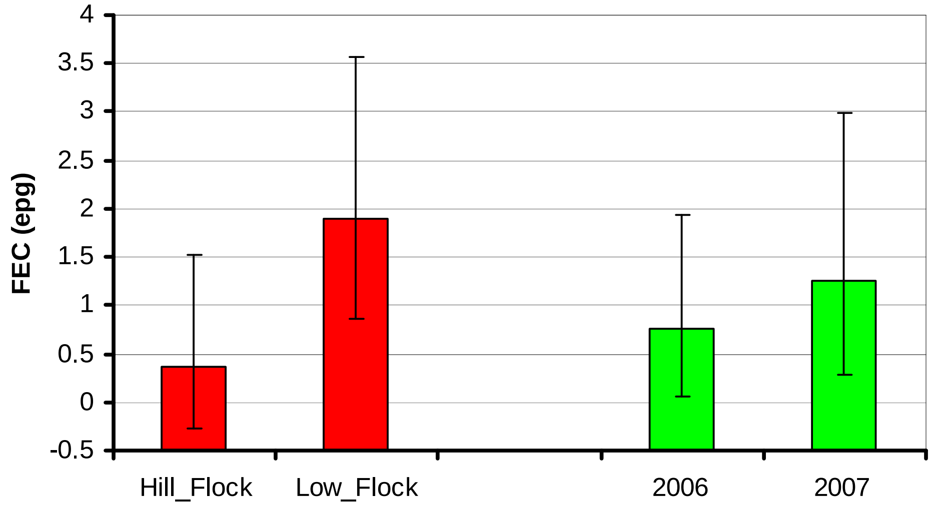


Figure 13. Least squares means (with upper and lower confidence intervals) for FEC in lambs by year and flock.

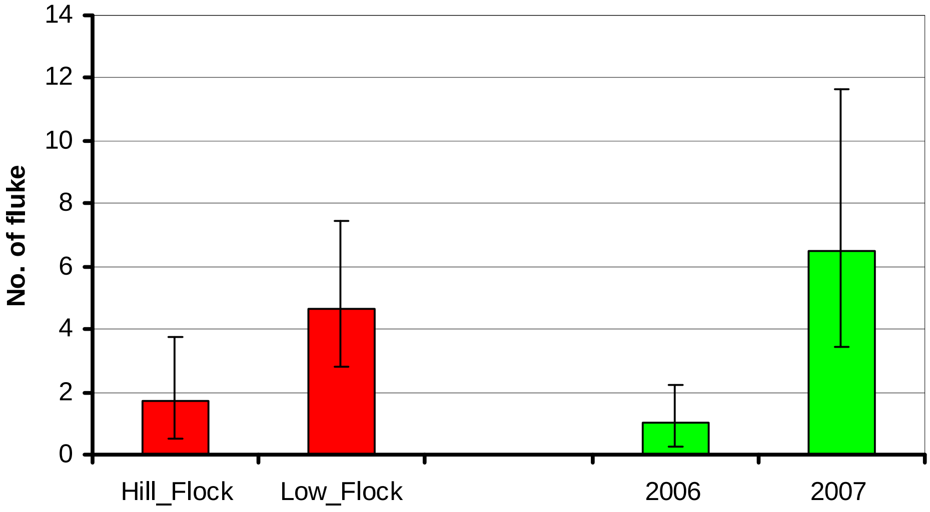


Figure 14. Least squares means (with upper and lower confidence intervals) for fluke burden in lambs by year and flock.

Relf, V. [1]*, Good, B., Hanrahan, J.P. and de Waal, T.* [1] *RMIS No. 5493*
[1]UCD School of Agriculture, Food Science and Veterinary Medicine, Belfield, Dublin

Parasite levels in the organic sheep flock

Roundworm parasite levels were monitored weekly in ewes and lambs during the grazing season and in hoggets ewes (April and May) using the FECPAK© method from pooled faecal material from at least 15 animals per group. Ewes were dosed at turnout to minimise pasture contamination and hoggets dosed prior to entry to the grazing area. In contrast to other years, ewes and lambs were turned out on the same paddocks as used last year. Lambs were moved to aftergrass at weaning. The pattern of FEC values for the ewes and lambs and are shown in Figures 15 and 16, respectively. The FEC in replacement hoggets was low (data not shown). The FEC pattern in lambs this year was in sharp contrast to other years (see Research report 2006 pg 158-159, 2007 p193-194). FEC rose earlier (mid May) and both *Nematodirus* and other trichostrongyle FEC reached high values (>1000 epg). On the basis of escalating FEC, levamisole was administered to all lambs according to manufacturer's recommendations. The high FEC is consistent with the lack of 'safe' pasture at turnout in the current season.

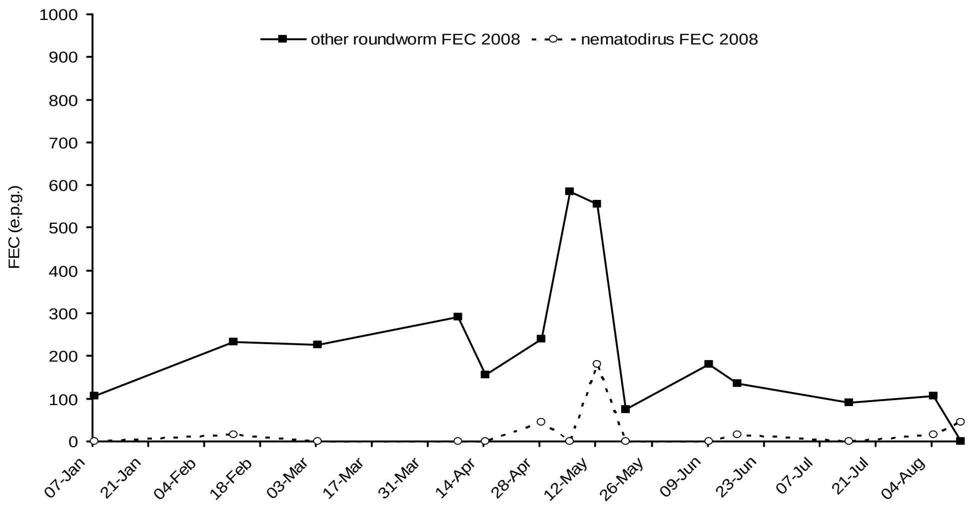


Figure 15. FEC in ewes from the organic flock in 2008.

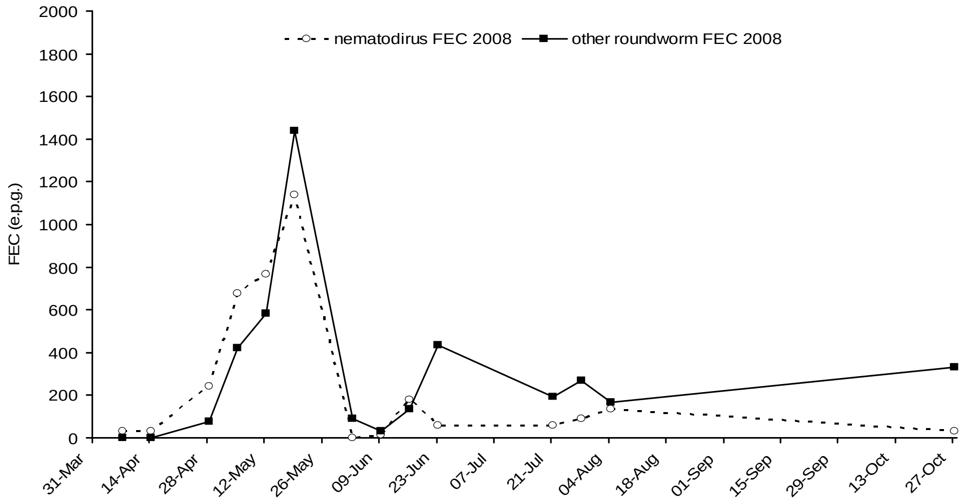


Figure 16. FEC in lambs from the organic flock in 2008.

Good, B., Hanrahan, J.P. and Kelly, F. *RMIS No. 5681*