Post-weaning performance of East Friesian cross ewe lambs grazing ryegrass or plantain-based pastures after rearing on two contrasting diets

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Abstract
Artificial rearing is used routinely on dairy sheep farms. Different strategies are used to optimise the growth and development of the young lamb with an economic ration of milk and other feed components. Early weaning, and early introduction to pasture can both reduce these costs, but may also reduce the liveweight gains of the growing lamb. Can differences in pre-weaning feeding strategies be mitigated using specialist pastures such as plantain/red/white clover? Lambs from an experiment investigating the impacts of rearing with and without meal access (n=30/group) and weaned at 12 weeks of age were grazed on either perennial ryegrass-based or plantain/red clover-based pastures in 3 replicates. Liveweight gain, animal health, feed supply and feed quality parameters were recorded over the following 5 weeks. Liveweights of the lambs reared on the different feeding regimens were similar at 12 weeks of age when the grazing study began (25.9 kg). Using plantain/red clover-based pastures provided no advantage to the liveweight gain of lambs reared under different milk and concentrate feeding regimens. Both feed types provided adequate nutrition to ensure growth rates of approximately 180 g/day over the 5 week measurement period in late spring. However, lambs reared under a high concentrate system has consistently lower liveweight gains (160 g/day) over the 5 weeks than those lambs reared with access to pasture (200 g/day; $P<0.05$). Feed quality was high on both pasture types. Symptoms of photosensitivity were recorded on both pasture types, but predominantly in lambs reared with *ad libitum* access to meal until week 10 of life, posing a question over functional liver development. This may have also affected liveweight gain.

Keywords: artificial rearing, lamb liveweight gain, ryegrass, plantain, post-weaning

Introduction
The sheep dairy industry in New Zealand is undergoing a resurgence with the emergence of several exporting enterprises (Stevens & Bibiloni 2014). Farms servicing these enterprises aim to harvest as much milk as possible by artificially rearing lambs from 2 days old, after they have received colostrum from their dams. A range of systems are in place, from group feeding several times a day to automatic on-demand feeder systems. Current practice also includes access to grain-based meal and fibre in the form of chaff or hay. Compared to young ruminants fed a milk only diet, early access to solid feed stimulates rumen development (Baldwin *et al*. 2004) and earlier onset of rumination (Khan *et al*. 2016) with the aim of early weaning off milk replacer (Bimczok *et al*. 2005). In lambs, earlier rumen development via access to meal may also encourage earlier grazing of pasture and increased rumination, thereby supporting early weaning and reduced cost.

Post-weaning intake and growth are a direct response to the ability of the rumen to process grass (Joyce & Rattray 1970). Thus, pre-weaning development of the rumen is paramount to subsequent success (Khan *et al*. 2016). Current practices are based on international research, where lambs are often kept within housed systems and fed grain-based total mixed rations both before and after weaning from milk. This is not the case in New Zealand where weaning to pasture only diets is most common and preferred. Given that the digestive microbial population for grain-based diets are different from those required to digest pasture (Hungate 1966), then is it wise to rear lambs on meal, but when do they then need to be transferred to pasture? Once these lambs are weaned, then does the type of pasture offered influence the liveweight of those lambs? The experiment reported here aimed to investigate the post-weaning liveweight gain of lambs reared with *ad-libitum* access to meal compared to those with access to pasture only during the pre-weaning phase, and then offered either a ryegrass or plantain-based pasture during the 5 weeks after transition to a pasture only diet.

Materials and methods
A study investigating two pre-weaning feeding

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strategies was conducted at AgResearch Limited Grasslands in Palmerston North, New Zealand (see Jensen *et al.* 2016 for details). Briefly, East Friesian cross-bred ewe lambs (n=60), aged 3 days, were reared indoors (average weight 4 ± 0.2 kg) using continuous access to milk (Anlamb, NZAgbiz Ltd, Timaru, New Zealand; mixed at 230 g/L) fed via an automatic feeder (CalfMom ALMA Urban Feeder, PPP industries, Tuakau, New Zealand) for 3 weeks. The lambs were grouped in two cohorts. One had *ad libitum* access to meal for 9 weeks, while the other had no meal. After 3 weeks both cohorts were transferred to outdoor pasture with continued access to milk replacer through a cafeteria system, replenished twice a day. Both groups were weaned from milk at 5 weeks of age (meal-fed lambs, 18 kg on average; no meal lambs, 17 kg). Meal access was removed over a 10 days at a rate of 10% per day in weeks 10 and 11. The measurement period continued until the end of week 12 when final liveweights were recorded (Jensen *et al.* 2016).

The lambs from meal or pasture treatments were allocated to two new feeding treatments, ryegrass or plantain-based pasture in three replicates, balanced for litter size. Lamb liveweight gain was measured weekly over the following 5 weeks. Herbage mass was estimated from uncompressed sward height using the equations developed by Haultain *et al.* (2014). Pre-grazing herbage mass averaged approximately 3000 and 2600 kg DM/ha on ryegrass and plantain-based pastures, respectively. Lambs were shifted weekly to a fresh allocation of pasture, leaving a residual herbage mass of 1400-1700 kg DM/ha. Pastures were sampled for botanical composition and feed quality. The chemical composition of pastures was analysed by Near Infrared Reflectance Spectroscopy (Nutrition Laboratory, Massey University, Palmerston North, New Zealand). This procedure was not calibrated for plantain-legume mixtures.

Lambs were assessed for health status daily. A preventative treatment for internal parasites was administered at 8 and 12 weeks of age with Zolvix Plus (monepantel 25 g/L, abamectin 2 g/L administered at 1 ml/10 kg LW). One outbreak of coccisidiosis was recorded at week 12 and all lambs were treated (Baycox C, 50 mg/ml Toltrazuril at 3 ml/10 kg LW). Five lambs were diagnosed to have spring eczema in early December after swelling and lesions on the ears and nose indicated photosensitivity. The ears and nose of all lambs were treated with FiltaBac (active ingredients: Titanium dioxide USP 14%, Zinc oxide BP 8%, Cetrimide BP USP 0.3%, Benzalkonium chloride 0.08%), a topical treatment for spring eczema, on December 2nd and 9th. One lamb died of torsion and displacement of the intestine (redgut) after 4 weeks on plantain.

Data were analysed using REML with pasture and rearing method as the main treatments applied in a factorial design with 3 replicates. Average daily liveweight gain for individual lambs was calculated by linear regression over 5 weeks to reduce week to week variation in individual liveweight measurements before being analysed.

Results

Lambs entered the experiment at an average of 25.2 kg at 12 weeks of age. Lambs that had been reared on meal had been losing weight at approximately 60 g/d in the 2 weeks before this (Jensen *et al.* 2016), despite being on high quality pastures of approximately 11.3 MJ ME/kg DM. Lamb liveweight gain during 5 weeks was unaffected by pasture type (Table 1) averaging approximately 185 g/day.

Table 1 Post-weaning average daily liveweight gains of ewe lambs from 12 to 17 weeks of age when offered either ryegrass or plantain-based pastures, and the botanical composition (% of DM) of those pastures.

	Post-weaning pasture			
	Ryegrass	**Plantain/clover**	**P**	**SED**
Average daily gain (g/d)	181	187	0.73	15.0
OMD (g/100g DM)	74.1	81.3	<0.01	1.6
ADF (g/100g DM)	25.1	21.2	<0.01	1.0
NDF (g/100g DM)	48.3	36.4	<0.01	1.6
CP (g/100g DM)	18.5	22.6	<0.01	1.3
White clover (%)	3	20	<0.01	1.2
Red clover (%)	0	11	<0.01	1.7
Grass/plantain leaf (%)	43	34	0.19	5.9
Grass/plantain stem (%)	40	4	<0.01	4.7
Dead material (%)	12	25	0.07	5.2
Other species (%)	1	6	0.39	5.0

Feed quality was high on both pasture types, though consistently higher on the plantain-based pastures (Table 1) with consistently higher organic matter digestibility (OMD), lower ADF and NDF, and higher crude protein (CP) concentrations. The percentage of both white and red clover were higher in the plantain than ryegrass pastures (Table 1). The percentage leaf on both ryegrass and plantain was similar, though ryegrass had much higher stem contents that plantain. There was a trend for plantain pastures to have more dead material than ryegrass pastures (P=0.068).

Lambs fed no meal were lighter than lambs from the meal treatment when measured at 12 weeks of age. This difference was no longer present at 17 weeks of age (Table 2). Previous rearing method significantly influenced lamb liveweight gain (Table 3). Lambs reared with *ad libitum* access to meal grew at approximately 160 g/day while those reared with no access to meal grew at 200 g/day (P=0.05).

Animal health records indicated that lambs reared on *ad libitum* access to meal were more vulnerable to problems (Table 3). Visual symptoms of coccidiosis were significantly greater in lambs reared on meal than on pasture. Clinical symptoms of summer eczema were numerically higher in meal-reared lambs than pasture-reared lambs (12 versus 5%; P=0.120), but did not differ in a statistical sense.

Discussion

The similarity of lamb growth on the ryegrass and plantain-based pastures was somewhat surprising given the large differences in clover content. However, Sinhadipathige *et al.* (2012) also found no increase in lamb liveweight gain of 11 month old lambs grazing these pasture types in spring. Other researchers have also noted little advantage to either of these types of high quality pastures during spring, when ryegrass quality is high (Semiadi *et al.* 1993; Stevens *et al*. 2012; Cranston *et al.* 2016). The high allowance and residual pasture mass will have ensured that lambs had an adequate diet selection ensuring high growth rates on both pasture types. However, the large amounts of grass stem in the ryegrass pasture, and dead material in the plantain/clover pasture are known to reduce lamb growth (Lambert & Litherland 2000).

This experiment has demonstrated that the rearing method of lambs can have an important influence on their performance post-weaning. Though liveweights of the lambs were slightly different at the start of the experiment, this does not suggest that compensatory gain was a cause of the difference in liveweight gain during the experiment. While previous studies have shown that meal feeding is advantageous to rumen development, this has often been for continuous rearing on, at least partial, concentrate diets. Cristobel *et al.* (2016) reported few differences in the volatile fatty acid composition of rumen contents at 4 or 12 weeks of age on restricted or *ad libitum* milk intakes, though ammonia concentration was higher in lambs with restricted access to milk. Rearing young calves with restricted access to milk and meal, and *ad libitum* access to pasture resulted in adequate weaning weights and subsequent high post-weaning performance on pasture (Muir *et al.* 2001).

Using a meal ration as the starting point for rumen development means that lambs must wean from milk, and then transition from meal. The meal intakes of lambs before removal from the diet were approximately 500 g/lamb/day, even when offered pasture of high quality (Jensen *et al.* 2016), and liveweight change of lambs during the transition from meal was negative (Jensen *et al.* 2016).

Of concern was the animal health responses of lambs reared with *ad libitum* access to meal. The outbreak of coccidiosis is a common occurrence in lambs reared on milk replacer when weaned to pasture (Foreyt 1990). One potential mechanism for the difference in incidence between the two rearing methods suggested by Hoblet *et al.* (1989), was that the potential, low exposure to the disease when the pasture only lambs had low intakes, may have provided some protection to later exposure to the disease.

The cause of spring eczema is still unknown (Collett

Table 2 Liveweight at 17 weeks of age of lambs reared with or without meal, and then placed on either ryegrass or plantain/clover pastures after weaning.

	Ryegrass		Plantain/clover		Pre-weaning Main effects	
	No meal	**Meal**	**No meal**	**Meal**	**P**	**SED**
Lamb liveweight (kg)						
12 weeks old	25.2	26.6	23.9	25.2	0.03	0.47
17 weeks old	32.2	32.3	31.0	31.2	0.14	0.69

Table 3 Post-weaning daily liveweight gain of ewe lambs from weeks 12 to 17 of age after rearing with or without *ad libitum* access to meal, and incidence of coccidiosis and spring eczema during that time.

	Pre-weaning treatment			
	No meal	**Meal**	**P**	**SED**
Average daily gain (g/day)	202	166	0.05	15
Coccidiosis (%)	5	33	0.02	8
Spring eczema (%)	3	12	0.12	5

2006). Putative causes include an acquired inability of the liver to process a high loading of chlorophyll after liver damage (e.g. sporidesmin poisoning), or immaturity of the liver (Collett 2006). However, in calves it is suggested that it is 'inherent'. Collett (2006) has suggested that it may be associated with dietary ingredients such as storksbill (*Erodium moschatum*). However, evidence from this study suggests that it may be related to high intakes of meal or low intakes of pasture during the rearing phase. Collett (2004) notes that the chemistry and histology of the liver do not show obvious signs in response to the disease. Combined with the results from this study, this would suggest that the development of the rumen may be more important. Exposure to pasture and chlorophyll during early rumen development may be a mitigating factor, and this may affect the health of the animal upon exposure to high pasture intakes.

This research provides some potential insights into the role of rumen development beyond the standard criteria of diet digestion and liveweight gain. Further research is required to build on these findings to improve understanding of the function and interaction between the rumen microbes and their host, the ruminant.

Conclusions

The processes of lamb rearing for large scale sheep dairy in New Zealand present many challenges. One of these is the ability to rear a lamb quickly and cost effectively to the point where it can achieve adequate nutrition from pasture. This study has identified one approach that may have merit. However, the logistics of providing fresh, clean pasture to hundreds or thousands of lambs each rearing season will have its own challenges. Therefore, while the early access to pasture provides some important benefits, those raising lambs should choose systems that allow a balance between cost, hygiene and nutrition that suits their needs.

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