The effects of early access to meal on the behaviour of artificially reared dairy lambs

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Abstract

Many large-scale dairy sheep producers use lamb-rearing systems providing milk replacer (MR) *ad libitum* and grain-based meal to accelerate rumen development to support early weaning. Replacing meal with pre-weaning access to pasture has not been evaluated. We hypothesised that lambs provided access to meal would initiate rumination earlier and spend more time grazing than would lambs without meal. Sixty East Friesian crossbred ewe lambs were randomly allocated to treatments; MR *ad libitum* with access to meal (M) or MR *ad libitum* without meal (NM). Both groups had access to pasture at the beginning of week 4. Behaviour was visually recorded during weeks 2, 3, 5, 7, 10 and 12 (nine hours / week). Meal access accelerated onset of rumination, while NM lambs spent more time consuming wood shavings and playing during week 3 ($P<0.001$). Once outside, NM lambs spent more time grazing during weeks 5 ($P<0.05$), 7 and 12 ($P<0.001$), and increased rumination time compared to M lambs by week 12 ($P<0.001$). These findings may allow refinement of lamb-rearing practices.

Keywords: lambs; feeding behaviour; rumination; artificial rearing; weaning transitions

Introduction

The New Zealand sheep dairy industry is growing (Peterson & Prichard 2015). Several large commercial sheep dairy farms remove lambs from their dams within the first four days of life. In some systems, lambs have access to milk replacer (MR) *ad libitum* and a grain-based solid feed (Bimczok et al. 2005). 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) to allow early weaning off MR (Bimczok et al. 2005). Earlier rumen development through access to meal may also encourage earlier grazing of pasture and greater rumination, thereby supporting early weaning. The potential to replace meal with early pasture access as the sole solid feed source to support early weaning has not been evaluated.

Understanding how behaviours (e.g., rumination, grazing, play) develop under different rearing systems is important to improve performance and welfare of artificially reared lambs. In young lambs, feeding behaviour can be influenced by feed availability and nutritional characteristics of the feed (De Araújo Camilo et al. 2012; Simeonov et al. 2015), physical environment and housing (Filho et al. 2014), birth weight (Yildirim et al. 2013) and social interactions (Leme et al. 2013; Simeonov et al. 2015). The development of lamb feeding behaviour, especially in artificial-rearing systems, has received little attention.

The aim was to compare the behaviours of lambs reared indoors over the first three weeks of life with or without meal, their transitions from indoors to outdoors onto pasture, and at weaning off MR and meal. We hypothesised that while inside, lambs with early access to meal would initiate rumination earlier and, once outside, would spend more time grazing than lambs without access to meal.

Materials and methods

All procedures were approved by the Animal Ethics Committee of AgResearch Grasslands, Palmerston North.

Animals, experimental design and feed management

Sixty commercially-sourced female East Friesian-cross ewe lambs were removed from their dams at 2-3 days of age and transported to AgResearch Grasslands (Palmerston North, New Zealand). On arrival, lambs were weighed and randomly allocated to either a treatment (MR *ad libitum* without access to meal; no meal; NM) or control (MR *ad libitum* and meal from weeks 1-9, M) group. Lambs were identified using ear tags and spray-painted numbers. Groups were balanced for initial live weight (M: 4.3±0.15 kg; NM 4.4±0.15 kg for NM) and birth rank.

The study was conducted from 20th August to 11th November 2016 and was divided into four main periods based on feeding and management conditions, with behaviour observations recorded between each transition.

In period 1, the lambs were group-housed (n=30/treatment) for three weeks, with un-treated kiln-dried pine wood shavings as bedding. MR (230 g/L; AnLamb, RD1 Ltd., New Zealand) was offered *ad libitum* via automatic feeders (CalfMOM ALMA Urban Feeder, PPP Industries, Tuakau, New Zealand) with one teat per pen. In period 2, lambs were randomly allocated to three cohorts per treatment group (n=10/cohort) and moved into paddocks at the beginning of week 4 with unrestricted access to good-quality pasture (pasture mass on offer of 1700-5000 kg/DM/ha; metabolisable energy (ME), 11.4 MJ/kg dry matter (DM); crude protein (CP), 212 g/kg DM; white clover (*Trifolium repens*) and perennial ryegrass (*Lolium perenne*) mix). MR was provided twice daily (8 am and 4 pm) in each paddock via a cafeteria milk feeder with four teats.

Meal was offered *ad libitum* to M lambs via feed troughs and consisted of soy, canola meal, maize, barley, molasses, vegetable oil, and lamb additive mineral mix containing 17% CP and 14 MJ ME/kg, and recorded daily by refusals. Lambs were abruptly weaned off MR at the beginning of week six, with unrestricted access to pasture thereafter and M lambs had access to meal *ad libitum* until the beginning of week nine. In period 3, M lambs were gradually weaned over nine days by decreasing meal allocation by 10% per day until completely weaned by the middle of week ten. In period 4 (weeks 10-12) all lambs had unrestricted access to pasture. Water was provided *ad libitum* throughout.

Behaviour observations

Behaviour measures were undertaken during three transition phases: (1) indoor housing to outdoor pasture transition between period 1 and 2 with observations during week 2, 3 and 5; (2) MR weaning transition between period 2 and 3 with observations during week 5 and 7; and (3) M lamb meal weaning transition to a pasture-only diet between period 3 and 4 with observations during week 7, 10 and 12. Behavioural traits (Table 1) were selected based on previous behaviour and rumination research in lambs and calves (Chapagain et al. 2014; Filho et al. 2014; Overvest et al. 2016).

All behaviours were recorded by a trained operator in consecutive 10-minute intervals for 2-4 hours per day over 2-3 consecutive days and collated to give a total of nine hours of data (8 am to 5 pm) in each observation week. Each behaviour was recorded based on visual observation of presence or absence of the behavioural trait. Data are presented as the percentage of time the lambs in each group demonstrated the observed behaviour in each observation week, or the number of events and/or animals expressing the observed behaviour.

Statistical analysis

Repeated-measures ANOVA was used with a linear mixed-effects model consisting of diet (NM *vs*. M) and observation week as fixed effects, lamb as random effect, and behavioural traits as the response variables (Table 1). Except for grazing pasture and lying, response variable data required logarithmic transformation. Analyses were carried out using R software (R Core Team 2016).

Results

Rumination was observed in 3 and 9 M lambs by week two and three respectively, while rumination in NM lambs was first observed in week three (3 lambs). All lambs expressed play behaviour with a time-by-diet interaction ($P<0.001$), whereby from week two to three, M lambs decreased play events (190 *vs*. 127) and decreased the time spent playing (Table 2), while NM lambs increased play events (101 *vs*. 223) and increased the time spent playing (Table 2). Only 11 events of aggressive behaviour were observed during weeks two and three involving 10 lambs across both treatment groups. The number of events where lambs were observed expressing other oral behaviours decreased from week two (43 *vs*. 59) to week 3 (19 *vs*. 36) in M and NM lambs respectively. The time observed expressing other oral behaviours was low in both groups (<3%) but decreased from week 2 to week 3 in both groups and was greater in NM compared to M lambs in both week 2 and 3 (Table 2) Play, aggressive and other oral behaviours were not observed once lambs were moved outside. There was a time-by-diet interaction for lying behaviour

Table 1 Type, description and recording period of behaviours observed during the trial.

Behaviour	Description	Recording period
Standing	On all four feet	1
Lying	Belly firm on the ground	1
Consumption of meal	Actively eating from the meal troughs	1 to 3
Consumption of wood shavings	Actively chewing and ingesting wood shavings	1
Other oral behaviours	Suckling or chewing objects other than the automatic-feeder teat	1
Play	Frolicking, jumping, rolling and/or running	1
Aggressive	Charging and head-butting another lamb	1
Grazing	Head down and actively chewing and ingesting pasture	2 to 4
Rumination	The bottom jaw expressing a circular rigorous motion and regurgitation, either standing or lying down	1 to 4

Table 2 Percentage (%) of time observed lying, expressing other oral behaviours (suckling or chewing objects other than the automatic-feeder teat), consuming wood shavings, and playing for lambs with (M) and without meal access (NM), during a nine-hour observation period (8 am to 5 pm) during weeks 2 and 3, and the significance of differences.

Percentage (%) of total time observed							
	Week 2		Week 3		p values		
Behaviour	M	NM	M	NM	Diet	Week	Diet x week
Lying	53	58	62	55	<0.001	<0.001	<0.001
Other oral behaviours	2	3	1	2	0.014	0.001	0.685
Consuming wood shavings	2	3	1	5	<0.001	0.306	0.001
Consuming meal	9	-	14	-	-	<0.001	-
Play	12	7	6	13	0.165	0.746	<0.001

(P<0.001), whereby M lambs increased their time spent lying from week two to three while NM lambs decreased lying time (Table 2).

There was a time-by-diet interaction for consumption of wood shavings (P<0.001), where during week three, NM lambs spent more time consuming wood shavings than M lambs (Table 2). For M lambs, the time spent consuming meal increased with advancing age (P<0.001) and time spent consuming meal increased from week two to three (Table 2).

There was a time-by-diet interaction for rumination (P<0.001), where during week five, NM lambs spent less time ruminating than did M lambs (5% *vs*. 8%), but by week twelve, NM lambs spent more time ruminating than did M lambs (26% *vs*. 17%), (Figure 1). There was no difference in rumination between groups at weeks seven and ten. There was a time-by-diet interaction for grazing pasture (P<0.001) whereby NM lambs spent more time grazing than M lambs, during weeks five (36% *vs*. 32%), seven (72% *vs*. 39%) and twelve (68% *vs*. 60%) (Figure 2). The grazing time for NM lambs increased from 36% to 72% from week five to seven and remained constant to week twelve. In contrast, there was only a small increase in grazing time of M lambs from week five to seven (32% to 39%) which was associated with increased meal intake (130 g/day to 610 g/day), and an increase in time spent consuming meal (8% to 15%), with a later increase in grazing from weeks seven to ten (39% to 73%). In both NM and M lambs, grazing decreased from week ten to twelve (73% to 68%, and 73% to 60% respectively).

Figure 1 Percentage (%) of time the lambs in each treatment group (n=30/group) were observed ruminating during a nine-hour observation period (8 am to 5 pm) during weeks 3, 5, 7, 10 and 12 respectively. The two treatments groups were; lambs without meal access (NM) ●— and lambs with meal access (M) ▲- - -. Observations of lambs ruminating were undertaken across three transition periods - - - ; (T1) transition from indoors to outdoor housing (week 4); (T2) transition from MR to solid feed by abruptly weaning lambs off milk replacer (mid-week 5); and (T3) transition to pasture only diet by gradually weaning M lambs off meal over a nine day period (mid-week 9 to mid-week 10).

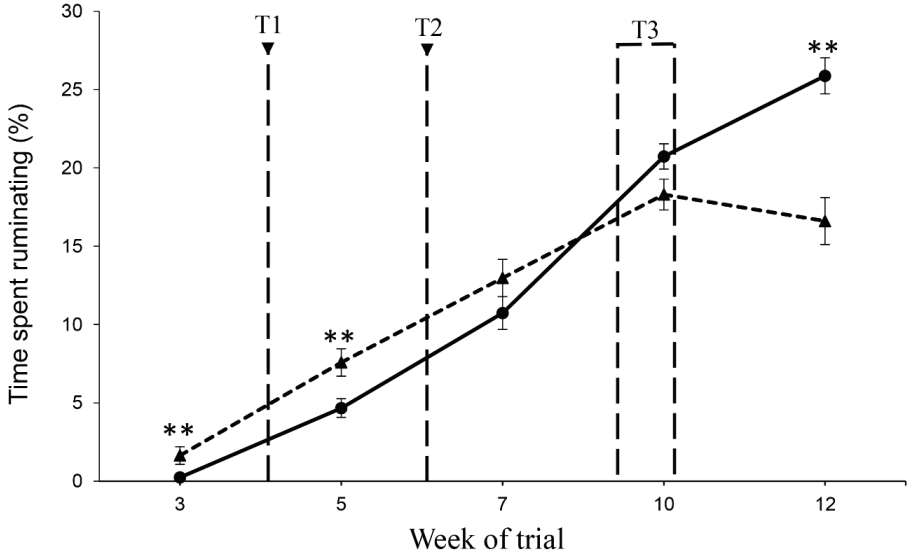
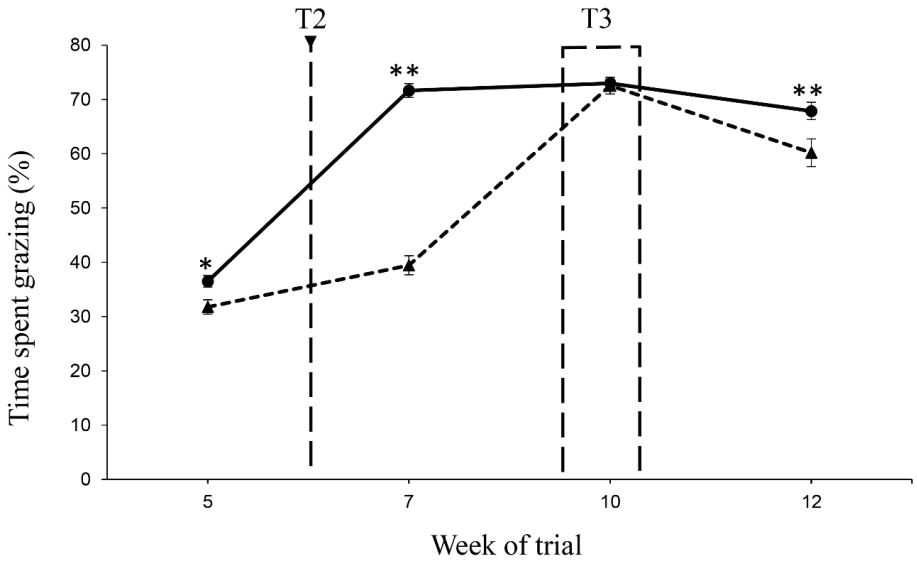


Figure 2 Percentages (%) of time the lambs in each treatment group (n=30/group) were observed grazing pasture during a nine-hour observation period (8 am to 5 pm) during weeks 5, 7, 10 and 12 respectively. The two treatments groups were; lambs without meal access (NM) ●— and lambs with meal access (M) ▲- - -. Observations of lambs grazing pasture were undertaken across two transition periods - - - ; (T2) transition from milk replacer to solid feed by abruptly weaning lambs (week 6); and (T3) transition to a pasture-only diet by gradually weaning M lambs off meal over a nine-day period (mid-week 9 to mid-week 10).



Discussion

The objective of this study was to the compare development of behaviours associated with dietary (introduction to pasture, weaning off MR and meal) and environmental (movement from indoors to outdoor) transitions in artificially reared lambs with or without early access to meal. The key findings were, lambs provided with early access to meal initiated rumination earlier

while lambs not offered meal spent more time grazing and had more consistent grazing behaviour up to 12 weeks of age.

Initiation of solid-feed intake triggers rumination (Baldwin et al. 2000), which occurs around ten days of age and by two to three weeks of lambs age can be observed ruminating (Stephens & Baldwin 1971). The drive to ingest solid feed increases with age, even with access to large quantities of milk (Khan et al. 2011). In this study, early consumption of meal enabled M lambs to begin ruminating by two weeks of age. Rumination behaviour was observed by three weeks in NM lambs receiving no solid feed, likely resulting from consumption of wood shavings, which in the absence of solid feed, would help stimulate rumination (Khan et al. 2011). Both groups were observed actively consuming wood shavings, consistent with the notion that that young ruminants actively forage for a fibre source (Khan et al. 2016), suggesting that the absence of a dietary fibre source triggered ingestion of wood shavings in the current study.

Simeonov et al. (2015) found lambs deprived of roughage spent more time standing and playing compared to lambs with roughage in their diet. Similar observations are evident in this study where lambs without access to meal spent less time lying but more time consuming wood shavings and play during week three. These behaviours are consistent with the notion that young ruminants start looking for solid feed and, if not available, they crave for it (Forbes, 2007). The shorter time spent lying by NM lambs could have led to more-engaging activities such as social interaction and play. Once outside, both groups were not observed expressing other oral behaviours, potentially due to the new environment (pasture) being more natural than the indoor environment (Phillips, 2004). Less time spent at play by lambs in both groups outdoors compared to indoor could be due to change in environment, diurnal play patterns (outside the observation period), and age.

Diet selection and feeding behaviour of ruminants is influenced by nutritional and physical characteristics of the diet (Miller-Cushon & DeVries, 2015). Grazing time in both groups was initially low indicating a preference towards MR and/or an adaptation to a new environment and diet source. The increase in time spent grazing by NM compared to M lambs is consistent with pasture being the only solid feed available. The preference for meal consumption by M lambs is highlighted by the small increase in grazing pasture in this group following MR weaning which was associated with increased meal intake, compared to the dramatic increase in grazing time in NM lambs from weeks 5 to 7. A preference by M lambs toward meal compared to pasture could be ascribed to a higher energy density of meal compared to pasture (De Araújo Camilo et al. 2012) and lamb's previous experience eating meal (Miller-Cushon & DeVries, 2011). The results of this study are consistent with observations in calves (Vendramini et al. 2006) in which both grazing and rumination time were negatively correlated with greater concentrate allowance.

This study indicates that M lambs' ability to transition to pasture was hampered by their preference for meal. When meal was removed, their time spent grazing decreased with a concomitant decrease in time spent ruminating compared to NM lambs, which in turn exhibited a sharp increase in the time spent grazing, indicating a smoother transition onto pasture. These differences may be due to the inability of M lambs to ingest and utilise pasture to fulfil their nutrient requirements (Brandano et al. 2004), may reflect a stress response to the change in diet, or a diurnal change in grazing behaviour not captured in the nine-hour observation period employed in this study. Although meal inclusion was associated with early rumination, the transition off meal was related with less grazing. The impact of the treatment regimens on intake and growth performance is detailed by Jensen et al. (2017). Furthermore, early unrestricted access to good-quality pasture did not adversely affect the establishment of rumination in lambs provided access to MR *ad libitum*. This may provide an alternative feeding management system for lamb-rearing operations.

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