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The influence of the number of lambs present on the suckling behaviour of triplet-rearing ewes at pasture

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ABSTRACT

This study examined the suckling behaviour of triplet-rearing ewes for three days post-parturition. Twenty-six ewes were enrolled with 11 being observed for the entire 3-days post-lambing. The behaviour of the ewe, number of lambs present at the end of the event and the behaviour that terminated the event were recorded for each suckling event. The mean suckling event duration increased when additional lambs were present at the end of the suckling event. Ewes that had observations across all three days showed no change in the number of suckling events over time, but suckling events tended to be shorter on day 3 than on days 1 or 2. On day 1 more suckling events were terminated by the ewe walking away from her lambs than on days 2 and 3. The odds of a ewe walking away to terminate the suckling event were greater when three lambs were present compared with two. Ewes showed more inactive behaviours when more lambs were present at the end of the suckling event. The results partially supported the hypothesis that the ewe would be more likely to terminate a suckling event when three lambs were attempting to suck compared with one or two lambs.

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Introduction

Over the last three decades, New Zealand farmers have been striving for greater lambing percentages. The average reproductive performance of the national flock has increased from 101% in 1988 to 133% in 2021 (Statistics New Zealand 2022). The drive towards greater lambing percentages has resulted in a concurrent increase in the proportion of ewes conceiving triplet fetuses. As lambing percentages approach 150%, fewer ewes have single lambs and more have triplets (Amer et al. 1999) and while there are advantages in a greater number of lambs born mortality rates increase with litter size. The reported mortality rate for triplet lambs has been consistently greater (35%–54%) than for both single- (7%–19%) and twin-born lambs (15%–33%; Hinch et al. 1985; Owens et al. 1985; Scales et al. 1986; Kerslake et al. 2005; Hatcher et al. 2009).

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The high triplet lamb mortality rate is due, in part, to low birth weights. Thomson et al. (2004) reported that at birth triplet lambs in New Zealand were on average 33% lighter (3.6 kg) than singles (5.9 kg) and 17% lighter than twins (4.8 kg). The optimal lamb birth weight for lamb survival in New Zealand has been reported to be between 3.5 and 4.5 kg (Dalton et al. 1980). More recently, an analysis of records from the Sheep Improvement Limited (SIL) national database estimated that optimal lamb birth weight was between 5.0 and 6.5 kg (Everett-Hincks and Dodds 2008). Lambs with birth weights less than the optimum are at greater risk of death due to starvation and exposure than lambs with optimal birth weights (Hight and Jury 1970).

Triplet lamb birth weight alone, however, does not fully explain the increased mortality compared with singles and twins. The mortality rates of triplet lambs with the same birth weight as single and twin lambs remain greater (Hinch et al. 1985). This increased risk of death is likely due to competition for a milk resource that is normally suitable for rearing twin lambs (Hinch 1989). Van Welie et al. (2016) reported that the heaviest lamb of the triplet litter was more efficient at extracting milk compared to its lighter siblings. In addition, the lightest born lambs achieved lower milk intakes and competed with the medium-born lambs for the teat not preferred by the heaviest lamb. There is, however, little information available about the suckling behaviour of the ewe. The ewe plays an important role in facilitating lamb suckling by showing appropriate behaviours such as standing still and slightly arching her back to allow easier access to the udder (Lynch et al. 1992). The aim of this study was to investigate whether the suckling behaviour of triplet-bearing ewes over the first three days post-partum varied depending on the number of lambs that were attempting to suck. It was hypothesised that more suckling events would be terminated by the ewe when a greater number of lambs were attempting to suck.

Materials and methods

This study was conducted at Massey University's Keeble farm, 5 km south of Palmerston North, New Zealand (40°24′10″S, 175°36′09″E). The study was approved by the Massey University Animal Ethics Committee (MUAEC 16/61).

Animals

Forty-three mature triplet-bearing Romney ewes, between 3 and 5 years of age, were identified at the time of pregnancy diagnosis. Pregnancy diagnosis was conducted using transabdominal ultrasound by a commercial operator 90 days after the start of the breeding period.

Ewes were maintained outdoors on pasture according to normal husbandry practices in New Zealand. Throughout the study, ewes were offered pasture masses in excess of 1400 kg DM/ha which provided unrestricted access to pasture (Morris and Kenyon 2004). Beginning two days prior to the expected start of the lambing period (30th August 2016, day 145 after the mid-point of the breeding period) ewes were observed twice daily to identify those that had newly lambed. Ewes that had given birth to three live lambs were then enrolled in the study (n = 26).

Once lambs had been cleaned by their dam and were mobile (a minimum of 4 h of age) they were ear tagged (FlexiTag, Allflex, Palmerston North, New Zealand),

weighed (Super Samson 10 kg tubular scale, Saler Australia Pty Ltd, Victoria, Australia) and had their sex recorded. Lamb identification numbers were randomly allocated at the time of tagging. At 1200 h each day any ewes whose lambs had been tagged after 1000 h on the previous day (<30 h of age), or prior to 1000 h on the same day (>6 h of age), were moved with their lambs into yards in preparation for behaviour observations. This allowed lambs adequate opportunity to develop an exclusive bond with their dam. Ewes develop an exclusive bond with their lambs and frequently reject any alien lamb that attempts to suck for the remainder of the lactation (Nowak and Poindron 2006).

The ewe was identified with her ear tag number sprayed in large numbers on her side with stock marker (Sprayline, Donaghys Ltd, Christchurch, New Zealand). Each lamb was identified in the same way. Within a litter, the lamb with the lowest identification number was marked with red colour, the middle number with green and the highest number with blue to allow easy identification of each lamb. In addition, each lamb of a litter was marked with a dot of the same colour as the identification number on either the top of the tail, middle of the back or top of the head to indicate which set it belonged to.

Behavioural measurements

Behaviour was observed for each ewe and her three lambs beginning when lambs were between six and 30 h post-partum for up to three days. Observations were only made of ewes with complete litters. Observations ceased if a lamb died (n = 7) or was removed from the study due to welfare concerns (n = 8).

Video recordings were made using two cameras (Handycam HDR-PJ230E, Sony Corporation, Tokyo, Japan) from 1300 until 1600 h daily. The observation paddock was 0.1 ha in size and located beside a covered yard to allow observations to be made in all weather. All ewes and lambs observed each day were introduced to the observation paddock between 1200 and 1300 h and removed at 1600 h with a maximum of three ewe and lamb sets observed on any given day. Ewes that had been observed on previous days were introduced to the observation paddock first followed by any ewes being observed for the first time. After 1600 h, all ewes and lambs were moved to a nearby paddock and allowed to graze until the following day.

The two cameras were placed in the covered yards 3 m outside the observation paddock at a height of 2 m to allow coverage of at least half the paddock. Each camera was manually operated by an observer who adjusted the position and zoom to allow all ewes and lambs in the paddock to be captured in the frame of one of the cameras. Any ewe or lamb that moved from one side of the paddock to the other was allowed to leave the view of one camera to be then recorded by the other.

The ewe suckling behaviour was assessed from the video footage collected each day. Only footage from between 1400 and 1600 h was assessed to ensure that there was no impact of pre-observation handling which included spraying identification marks on the ewe and lambs on day 1 and yarding on all three observation days. The number and duration of suckling events, duration of ewe behaviours during the suckling event, number of lambs present at the termination of the suckling event and behaviour that terminated the suckling event were scored using BORIS (Behavioural Observation Research Interactive software; Friard and Gamba 2016) according to the ethogram provided in Table 1.

Table 1. Ethogram of ewe suckling behaviour and type of measure observed from video footage.

Variable	Measure type	Definition
Suckling event	Duration (s)	Start of event when lamb approaches within 0.5 m of the ewe and shows active searching behaviour anywhere on the ewe or begins sucking. Events were terminated when no lamb was searching or sucking for more than 10 sec.
Number of lambs	1, 2 or 3	Number of lambs within 0.5 m of the ewe at the termination of an event regardless of the lamb's behaviour.
Ewe behaviour during suckling event		
Standing	Duration (s)	Ewe stands stationary to allow lamb(s) to suck
Walking	Duration (s)	Ewe takes two or more steps
Grazing	Duration (s)	Ewe has head down and is harvesting grass, may take the occasional step and lift head to chew and swallow
Ruminating	Duration (s)	Ewe regurgitates rumen content and chews while either standing or sitting, no grass harvesting is observed
Suckling event termination behaviour		
Ewe sit	Event (n)	Ewe transitions from a standing to sitting position which prevents the lamb(s) from sucking
Ewe kick	Event (n)	Ewe uses hind foot to prevent lamb(s) from suckling or to displace lamb from teat
Ewe walk	Event (n)	Ewe walks away from lamb(s) when they attempt to initiate or continue sucking
Ewe butt	Event (n)	Ewe uses her head to forcefully push or knock a lamb down or away. Includes her own or foreign lambs
Lamb ends	Event (n)	The suckling event terminated by all lambs in the suckling event either ceasing to search for the teat for 10 s or the lamb moving more than 0.5 m from the ewe

Weather data

Weather data for the study period (30 August–27 September 2016) were downloaded from the National climate database (www.cliflo.niwa.co.nz). Observations from the Palmerston North EWS recording station located at 40°22′55″S, 175°36′32″E (1.3 km from the study site) were downloaded and included mean wind direction (°), wind speed (m/s), temperature (°C), relative humidity (%) and total rain (mm) and solar radiation (MJ/m^2) recorded every 10 min. Mean wind direction was categorised into four wind compass directions (N = 315–45, E = 45–135, S = 135–225 and W = 225–315). Rainfall was categorised into 'None' = 0 mm/10 min, 'Light' = 0.2–0.5 mm/10 min and 'Moderate' = ≥0.6 mm/10 min based on the Manual of surface weather observations (Anonymous 2021). The chill factor was calculated from the daily rainfall, wind speed and mean temperature as an indicator of cold stress as described by Nel et al. (2021).

Data analysis

All statistical analyses were conducted using SAS version 9.4 (SAS Institute, Cary, NC, USA). Due to the removal of ewes and lambs from the study, the data were separated into two sets: (1) data from all ewes on day 1 (n = 26) and (2) data from ewes that were observed on all three days (Days 1, 2 and 3; n = 11).

Day 1 data were analysed to investigate the relationships between the number of lambs present at the end of the suckling event and the total days observed (one versus three) with the number of suckling events, the duration of the suckling events, ewe behaviour during the suckling events and suckling event termination behaviour. For ewes that were observed across all three days, the data were analysed to investigate the relationships between observation day and number of lambs present on the same behaviour variables. The association between weather variables and the frequency suckling events and ewe behaviours during the suckling events were also investigated.

Frequency data including the number of suckling events (Table 3), suckling events terminated by the ewe butting or kicking the lamb, sitting or walking away or by the lamb (Table 5) and suckling events in which ewes stood, walked, ruminated and grazed (Table 7) were analysed using the chi^2 test using the Freq procedure. Day 1 analyses contained the number of lambs present at the end of the suckling event and total number of days observed as factors. Days 1, 2 and 3 analyses contained either number of lambs or day as a factor. Results are presented as the number of suckling events with the percentages in parentheses (Tables 3, 5 and 7).

The total duration of suckling events was tested for normality using the Kolmogorov–Smirnov test and was found to be non-normally distributed. A $\log_{10}$ transformation was used to normalise the distribution. Analyses were conducted using the log-transformed data and the Mixed procedure. Day 1 analyses included the fixed effects of the number of lambs present and the total days observed and their two-way interaction. Days 1, 2 and 3 analyses included the fixed effects of number of lambs and day of observation and their two-way interaction. All two-way interactions were not significant and removed from the models which were then re-run. Results are presented as the back-transformed log mean and 95% confidence interval (Table 3). The effect of the duration of the suckling event on the frequency of suckling events terminated by the ewe walking away, butting the lamb or the lamb ending the suckling event was determined by rerunning the model with duration as a covariate.

Due to the variability in suckling event duration, the percentage of each suckling event that ewes were observed to spend time standing, walking, grazing or ruminating was analysed rather than raw duration data. Ewe behaviour was analysed in two ways, firstly for only for those suckling events during which the ewe showed the behaviour and secondly as a percentage of the total time that the ewe was observed to suckle her lambs. For those suckling events in which the behaviour was seen, the percentage of the suckling event the ewe spent showing each behaviour (standing, walking, grazing or ruminating) was not normally distributed, and no transformations were identified that could normalise the distribution. The association between the number of lambs present (on Day 1 and Days 1, 2 and 3) or day of observation (Days 1, 2 and 3) on the percentage of the event in which each ewe behaviour was observed was analysed using the Wilcoxon test. In addition, the association with weather variables was also investigated. If there was a significant effect ($p < 0.05$) of the number of lambs present, contrasts were conducted using a Wilcoxon two-sample post hoc test with a Bonferroni adjustment. The results are presented as the median percentage and inter-quartile range (IQR) in parentheses (Tables 7 and 8).

The percentage of the entire time that the ewe was observed to suckle her lambs in which she stood, grazed, walked or ruminated was calculated for each ewe by dividing the total duration each behaviour was observed by the total suckling event duration. The data were analysed using a logistic regression model to determine the odds of an ewe showing each behaviour at any time during any suckling event. Two models were created the first with the fixed effect of day of observation and the second with the number of lambs present at the end of the suckling event.

The odds of a suckling event being terminated by the ewe walking away or by the lamb were determined using a logistic regression. The Day 1 model included the fixed effects of the number of lambs present at the end of the suckling event and the total days observed

and their two-way interaction. The Days 1, 2 and 3 model included the fixed effect of number of lambs, day of observation and their two-way interaction. Due to low frequencies of observations of ewe sit, ewe kick and ewe butt analyses could not be conducted. Results are presented as the odds ratio point estimate with the 95% Wald confidence interval (Table 6).

The relationship between weather variables recorded every 10 min (mean wind direction, wind speed, temperature, relative humidity and total rainfall and solar radiation) and the $\log_{10}$ of suckling event duration was investigated using a repeated measures analysis of variance. Two models were run; the first on data collected on Day 1 which contained the fixed effect of the number of lambs present at the end of the suckling event and wind direction and rainfall category with the weather variables as covariates. The second model was run on data collected from ewes observed on all three days and included the fixed effects of the day of observation, number of lambs present, wind direction and rainfall category with weather data included as covariates. For each model any non-significant variables were removed and the model re-run. The results are presented in Table 4.

The relationship between weather variables and the odds of a suckling event being terminated by the ewe walking away or the lamb ceasing to search for the teat was investigated using general estimating equations. As for duration, two models were run on data collected on Day 1 or from ewes observed over all three days. For each model any non-significant variables were removed and the model re-run.

Results

Weather data

During the 23-day study period, the weather was highly variable with minimum daily temperatures ranging from 3.1 to 14.6°C and maximums between 8.7 and 18.5°C (Figure 1). There were 13 days during which rainfall was recorded with total rain

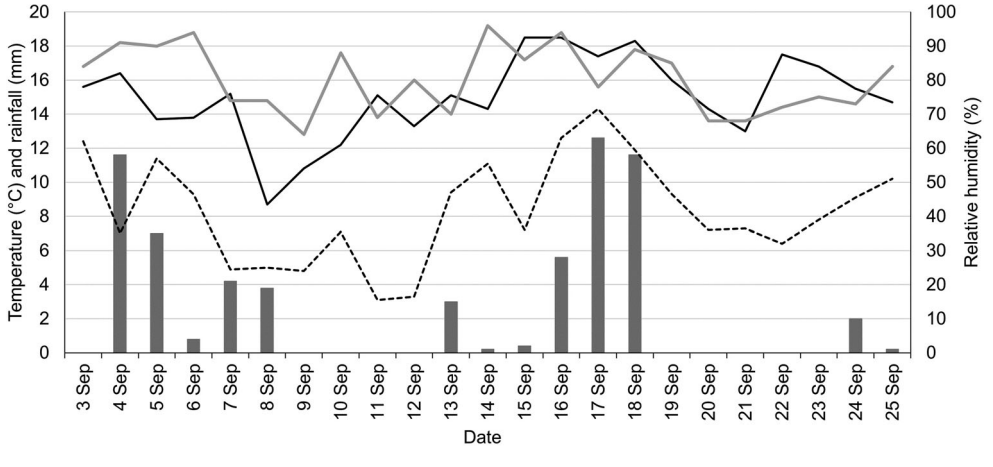

Figure 1. Summary of weather data showing daily minimum temperature (°C, dashed black line), maximum temperature (°C, solid black line) and mean relative humidity (%, solid grey line) and total rainfall (mm, black bars) recorded during the study period.

Table 2. The number of suckling events, events with rain recorded and events with a chill index of greater than 1000 KJ/m^2 for each wind direction (north, east, south and west). Median and interquartile range in parentheses of wind speed (m/s), temperature (°C), rain rate (mm/h), relative humidity (%), solar radiation (MJ/m^2) and chill index (MJ/m^2) when wind was from each direction.

	Wind direction			
	North	East	South	West
Suckling event (n)	128	229	236	621
Rain (mm/h)	1.2 (1.2–2.4)^a	6.6 (1.2–16.8)^b	2.4 (2.4–2.4)^{ab}	2.4 (1.2–4.2)^b
Rain > 0 mm (n, %)	39 (30.5)	28 (12.2)	3 (1.2)	64 (10.3)
Wind speed (m/s)	2.5 (1.6–3.4)^b	4.2 (1.6–4.8)^c	1.5 (1.1–2.4)^a	5.5 (3.6–7.1)^d
Temperature (°C)	15.6 (14.6–15.9)^d	15.8 (11.8–16.3)^c	11.6 (11.5–16.0)^a	12.8 (12.6–14.8)^b
Relative humidity (%)	81 (79–84)^b	68 (63–86)^a	76 (67–78)^a	80 (69–88)^b
Solar radiation (MJ/m^2)	0.05 (0.03–0.05)^a	0.17 (0.10–0.23)^c	0.07 (0.06–0.12)^b	0.10 (0.06–0.16)^b
Chill index (MJ/m^2)	883 (862–929)^a	919 (855–987)^c	905 (872–918)^b	967 (934–1023)^d
Chill index >1000 (n, %)	0 (0)	8 (3.5)	0 (0)	225 (36.2)

volumes per day of between 0.2 and 11.6 mm. Mean daily windspeed ranged from 0.7 to 7.6 m/s and sunshine hours 0–11.1 h (data not shown).

During the suckling events, the air temperature ranged from 9.3°C to 18.3°C with relative humidity between 54% and 97% and solar radiation between 0 and 0.48 MJ/m^2. Rain was recorded during 11.0% (134/1214) of suckling events with total rainfall in each 10 min period of between 0.2 and 3.4 mm. Of the suckling events with rain, 65.7% (88/134) had light and 34.3% (46/134) moderate rainfall. The chill index during suckling events ranged from 826 to 1160 MJ/m^2 with 19.2% (233/1214) of suckling events with a moderate index (value greater than 1000 MJ/m^2; Alexander 1962; Fogarty et al. 1992). The weather conditions when the wind was from each direction are summarised in Table 2.

Suckling event: frequency and duration

A total of 26 ewes and their lambs were enrolled in the study and generated 1214 suckling events. Of these suckling events, 584 were recorded on day 1 (n = 26), 368 on day 2 (n = 15) ewes and 262 on day 3 (n = 11). The total time ewes spent suckling their lambs, as a percentage of the entire period they were observed, ranged from 7.9 to 55.1% (median 27.6; IQR 21.0–34.0%).

On day 1 of the observation period, most suckling events were terminated with one lamb present (40%) with a similar percentage of suckling events being terminated with two or three lambs (~30%, Table 3). The total duration of suckling events on day 1 was greater when more lambs were present at the termination of the suckling event ($P < 0.05$; Table 3). Of the suckling events that terminated with one lamb present, 90% (208/232) of the suckling events were less than 60 s in duration (Figure 2). In contrast, when two or three lambs were present, 70% (123/178) and 67% (118/174) of suckling events were less than 60s, respectively.

The number of events observed on Day 1 did not differ for ewes with a total of 1 or 3 days of observation ($P > 0.05$), however, ewes with three days of observations had more ($P < 0.05$) suckling events with one lamb present (116/240 (48.3%) vs. 78/234 (33.3%), respectively) and fewer with three lambs present (44/240 (18.3%) vs. 79/234 (33.8%), respectively) but did not differ when two lambs were present (80/240 (33.3%) vs. 77/234 (32.9%), respectively).

Table 3. The frequency of suckling events (with the percentage in parentheses) and their duration (s, back-transformed mean with 95% confidence interval in parentheses) on Day 1 by number of lambs present at the end of the event (one, two or three) and on Days 1, 2 and 3 by lambs present at the end of the event or by day of observation.

	Suckling events	
	n (%)	Duration (s)
Day 1 only (n = 26 ewes)		
Number of lambs present		
One	232 (39.7)[b]	25.9 (22.2–30.1)[a]
Two	178 (30.5)[a]	47.5 (39.9–56.4)[b]
Three	174 (29.4)[a]	62.0 (52.0–73.8)[c]
P-value	0.004	<0.0001
Days 1, 2 and 3 (n = 11 ewes)		
Number of lambs present		
One	305 (39.3)[b]	21.6 (18.6–25.1)[a]
Two	249 (32.1)[ab]	38.3 (32.5–45.1)[b]
Three	222 (28.6)[a]	61.4 (51.6–73.2)[c]
P-value	0.004	<0.0001
Day of observation		
Day 1	234 (30.4)	39.5 (33.3–46.8)
Day 2	280 (36.1)	39.9 (34.0–46.8)
Day 3	262 (33.8)	32.2 (27.5–37.8)
P-value	ns	0.11

ns = *p*-values greater than $P = 0.1$, [a,b,c]within columns mean with different superscripts are significantly different $P < 0.05$.

For ewes with all three days of observations (n = 11) there were a total of 776 suckling events recorded across the three days (Table 3). Across the three days, more ($P < 0.05$) suckling events ended with one lamb present than with three lambs but there was no effect of day ($P > 0.1$).

The total duration of suckling events across the three days was greater when more lambs were present at the termination of the suckling event ($P < 0.05$; Table 3) but day had no effect ($P > 0.1$). There was no interaction of day and number of lambs on suckling event duration. There was no overall effect of day on suckling event duration, although, there was a tendency for suckling events to be longer on days 1 and 2 than on day 3 ($P = 0.08$ and 0.06, respectively). The duration of suckling events was not associated with the total days of observation (one versus three) nor was there an interaction of total days with the number of lambs present at the end of the event ($P < 0.05$, data not shown). On day 1 the majority of suckling events occurred when the wind was from the west followed by the south and then the north and east (Table 4). On day 1, there were no associations of any of the weather variables with suckling event duration ($P > 0.1$). For ewes with three days of observations, again the greatest number of suckling events occurred when the wind was from the west and fewest from the north but more from the east than the south. For ewes with three days of observation wind direction was associated with suckling event duration (Table 4; $P < 0.05$). The duration of suckling events was longer when the wind was from the north than the east and west which were in turn longer than from the south ($P <$ 0.0.5). In addition, there was an association with relative humidity whereby every 10% increase in humidity showed a 1.20 ± 0.96 s decrease in duration ($P < 0.05$).

Suckling event termination behaviour: frequency

On day 1, suckling events were most often terminated by the ewe walking away (n = 307, 52.7%) followed by the lamb(s) ceasing to suck or search for the udder (n = 249, 42.6%).

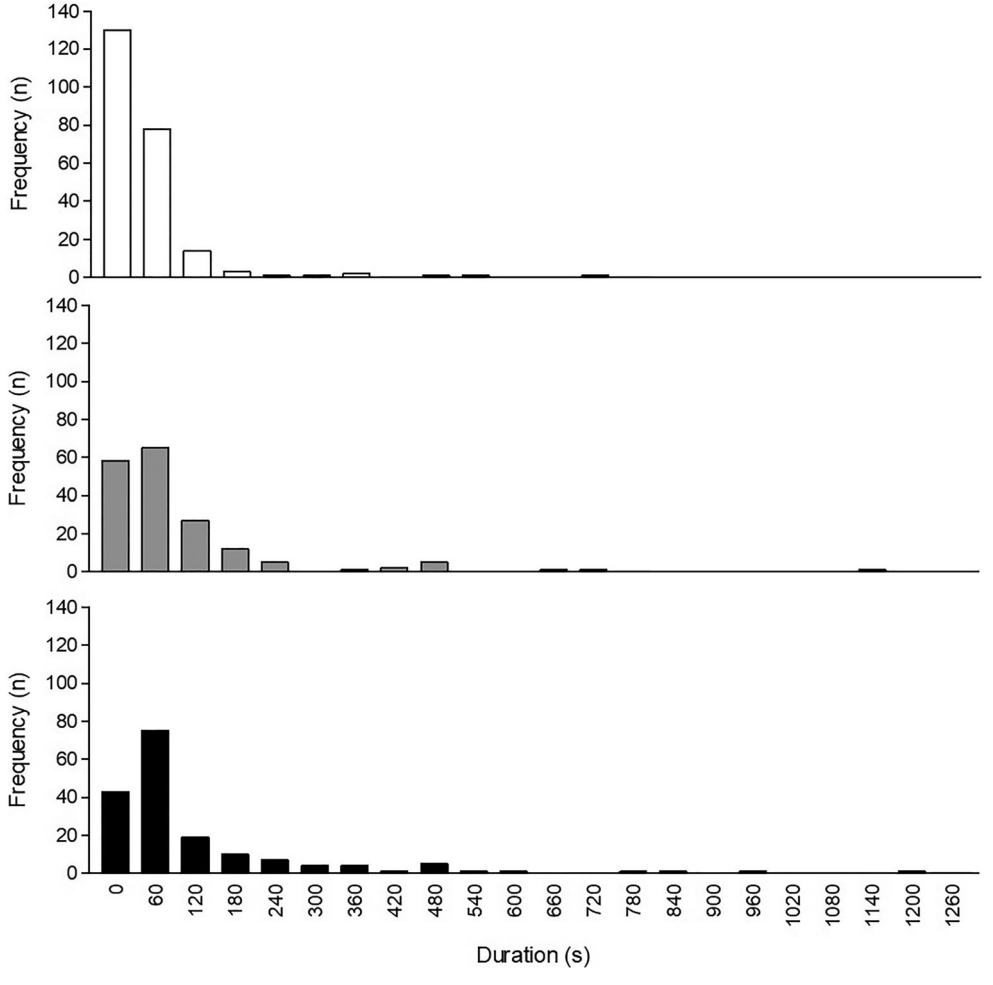

Figure 2. Histogram of suckling event duration on day 1 when one (white bars), two (grey bars) or three (black bars) lambs were present at the termination of the event.

Few suckling events were terminated by the ewe butting (n = 15, 3.0%), kicking the lamb (n = 3, 0.5%) or sitting down (n = 9, 1.5%). There was no effect of the number of lambs present on the frequency of any of the termination behaviours on day 1 ($P < 0.05$; Table 5). Suckling event duration was not significant when included as a covariate in the model for any of the termination behaviours ($P > 0.1$). Ewes with a total of one day of observation, however, terminated more events by walking away and fewer by butting the lamb on day 1 compared with ewes with three days of observation ($P < 0.05$; Table 5).

For ewes with three days of observation, the majority of suckling events were terminated by the ewe walking away (n = 455, 58.6%) followed by the lamb ceasing to suck or search for the udder (n = 286, 36.5%). The frequency of suckling events terminated by the ewe butting or walking away from the lamb or by the lamb ceasing to suck or search for the teat was associated with the number of lambs present at the termination of the suckling event (Table 5). More suckling events were terminated by the ewe butting the lamb

Table 4. The frequency of suckling events (with the percentage in parentheses) and their duration (s, back-transformed mean with 95% confidence interval in parentheses) on day 1 only and on days 1, 2 and 3 by wind direction.

Wind direction	Suckling event	
	n (%)	Duration (s)
	Day 1 only (n = 26)	
North	68 (11.6)[a]	51.2 (33.3–78.7)
East	88 (15.1)[a]	56.4 (34.3–92.8)
South	120 (20.6)[b]	30.3 (20.7–44.5)
West	308 (52.7)[c]	43.8 (34.2–55.9)
P-value	0.04	ns
	Days 1, 2 and 3 (n = 11)	
North	71 (9.2)[a]	69.9 (51.3–95.3)[c]
East	184 (23.7)[c]	38.9 (32.1–47.2)[b]
South	117 (15.1)[b]	24.2 (19.0–30.8)[a]
West	404 (52.1)[d]	36.6 (32.1–41.7)[b]
P-value	<0.0001	0.0004

when one lamb was present compared with three lambs ($P < 0.05$). More suckling events were terminated by the ewe walking away when three lambs were present compared with two lambs ($P < 0.05$). More suckling events were terminated by the lamb(s) ceasing to suck if two lambs were present compared with three lambs ($P < 0.05$). The inclusion of suckling event duration as a covariate in the models of ewe termination behaviour frequency was not significant for any ewe behaviour ($P > 0.1$).

For ewes with three days of observations, day was associated with the frequency of suckling events terminated by the ewe butting or walking away from the lamb or the by lamb walking away ($P < 0.05$; Table 5). More suckling events were terminated by

Table 5. The frequency and percentage (in parentheses) of suckling events that were terminated by the ewe (kick, sit, butt and walk) or lambs (walk) on Day 1 by number of lambs present (one, two or three) and Days 1, 2 and 3 by lambs present or by day of observation (Day 1, Day 2 or Day 3).

		Suckling event termination behaviour				
Suckling events (n)		Ewe kick[#]	Ewe sit[#]	Ewe butt	Ewe walk	Lamb end
Day 1 (n = 26 ewes)						
Number of lambs present						
One	232	0 (0)	0 (0)	8 (3.4)	121 (52.2)	103 (44.4)
Two	178	1 (0.6)	4 (2.2)	2 (1.1)	94 (52.8)	77 (43.3)
Three	173	2 (1.1)	5 (2.9)	5 (2.9)	92 (52.9)	69 (39.7)
P-value		-	-	ns	ns	ns
Total days of observation						
One	240	1 (0.4)	4 1(.7)	2 (0.5)[a]	140 (58.3)[b]	93 (38.8)
Three	234	1 (0.4)	5 (2.1)	12 (5.0)[b]	115 (49.2)[a]	102 (43.6)
P-value		-	ns	0.004	0.04	ns
Days 1, 2 and 3 (n = 11 ewes)						
Number of lambs						
One	306	1 (0.3)	2 (0.7)	11 (3.6)[b]	175 (57.4)[ab]	117 (38.4)[ab]
Two	250	1 (0.4)	5 (2.0)	6 (2.4)[ab]	136 (54.6)[a]	102 (41.0)[b]
Three	223	2 (0.9)	7 (3.2)	3 (1.4)[a]	144 (64.9)[b]	67 (30.2)[a]
P-value		-	ns	0.003	0.08	0.001
Day of observation						
Day 1	235	1 (0.4)	5 (2.1)	12 (5.1)[b]	115 (49.1)[a]	102 (43.6)[b]
Day 2	281	1 (0.4)	7 (2.5)	3 (1.1)[a]	175 (62.5)[b]	95 (33.9)[a]
Day 3	263	2 (0.8)	2 (0.8)	5 (1.9)[a]	165 (63.0)[b]	89 (34.0)[a]
P-value		-	ns	0.01	0.03	0.002

ns = *P*-values greater than $P = 0.1$. [a,b,c]within columns mean with different superscripts are significantly different $P < 0.05$, [#]insufficient observations were made to allow a Chi^2 analyses to be conducted.

Table 6. The odds (with 95% confidence interval in parentheses) of suckling events being terminated by the ewe walking away or by the lamb on Day 1 by number of lambs present (one, two or three) and on Days 1, 2 and 3 by the number of lambs present or by day of observation.

	Event termination behaviour	
Comparison	Ewe walk	Lamb end
Day 1 (n = 26 ewes)		
Lambs 1 vs. 2	0.97 (0.66–1.44)	1.07 (0.72–1.58)
Lambs 1 vs. 3	0.95 (0.64–1.41)	1.24 (0.83–1.84)
Lambs 2 vs. 3	0.98 (0.64–1.48)	1.16 (0.76–1.77)
P-value	ns	ns
Days 1, 2 and 3 (n = 11 ewes)		
Lambs 1 vs. 2	1.15 (0.81–1.64)	0.86 (0.60–1.24)
Lambs 1 vs. 3	0.74 (0.50–1.10)	1.52 (1.02–2.28)
Lambs 2 vs. 3	0.65 (0.44–0.96)	1.76 (1.18–2.65)
P-value	0.09	0.02
Day 2 vs. 1	1.83 (1.26–2.66)	0.60 (0.41–0.87)
Day 3 vs. 1	1.78 (1.23–2.59)	0.67 (0.46–0.97)
Day 2 vs. 3	1.03 (0.71–1.48)	0.90 (0.62–1.31)
P-value	0.002	0.02

ns = *p*-values greater than $P = 0.1$.

the ewe butting the lamb, or the lambs ceasing to suck, on day 1 than days 2 or 3 ($P < 0.05$). In contrast, fewer suckling events were terminated by the ewe walking away on day 1 than days 2 and 3 ($P < 0.05$). The inclusion of the suckling event duration as a covariate in the models of the suckling event termination behaviour was not significant for any behaviour ($P > 0.1$).

Wind direction and rainfall category during each suckling event did not influence the frequency of suckling events terminated by either the ewe walking away ($P < 0.05$), ewe

Table 7. The frequency (with the percentage in parentheses) of suckling events during which ewes were observed to walk, stand, ruminate or graze on Day 1 by number of lambs present (one, two or three) and on Days 1, 2 and 3 by lambs present (one, two or three), day of observation or total days of observation (one or three).

		Ewe behaviour during event			
	Suckling events (n)	Walk	Stand	Ruminate	Graze
Day 1 (n = 26 ewes)					
Number of lambs present					
One	232	15 (6.5)	78 (33.6)^{a}	62 (26.7)^{a}	155 (66.8)^{b}
Two	178	19 (1.7)	85 (47.8)^{b}	81 (45.5)^{b}	97 (54.5)^{a}
Three	173	20 (11.5)	93 (53.4)^{b}	74 (42.5)^{b}	111 (63.8)^{ab}
P-value		ns	0.0002	0.0001	0.04
Days 1, 2 and 3 (n = 11 ewes)					
Number of lambs present					
One	306	15 (4.9)^{a}	65 (21.3)^{a}	51 (16.7)^{a}	255 (83.6)^{b}
Two	250	35 (14.1)^{b}	87 (34.9)^{b}	108 (43.4)^{b}	170 (68.3)^{a}
Three	223	36 (16.2)^{b}	98 (44.1)^{c}	92 (41.4)^{b}	153 (68.9)^{a}
P-value		<0.0001	<0.0001	<0.0001	<0.0001
Day of observation					
Day 1	235	24 (10.3)	96 (41.0)^{b}	89 (38)^{b}	154 (65.8)^{a}
Day 2	281	25 (8.9)	78 (27.9)^{a}	82 (29.3)^{a}	219 (78.2)^{b}
Day 3	263	37 (14.1)	76 (29.0)^{a}	80 (30.5)^{ab}	205 (78.2)^{b}
P-value		ns	0.003	0.08	0.001
Total days of observation					
One	240	21 (8.8)	125 (52.1)	82 (34.2)	147 (61.3)
Three	234	24 (10.3)	96 (41.0)	89 (38.0)	154 (65.8)
P-value		ns	0.016	ns	ns

ns = *p*-values greater than $P = 0.1$. ^{a,b,c}within columns mean with different superscripts are significantly different $P < 0.05$.

Table 8. The frequency (with the percentage in parentheses) of suckling events during which ewes were observed to walk, stand, ruminate or graze on Day 1 and Days 1, 2 and 3 by wind direction during the event.

		Ewe behaviour during event			
Wind direction	Suckling events (n)	Walk	Stand	Ruminate	Graze
Day 1 (n = 26 ewes)					
North	68	5 (7.4)	19 (28.0)[a]	54 (38.6)[b]	48 (54.6)[a]
East	88	7 (8)	46 (52.3)[b]	53 (22.1)[a]	52 (76.5)[b]
South	120	8 (6.7)	52 (43.3)[ab]	73 (39.2)[b]	67 (55.8)[ab]
West	308	34 (11)	139 (45.1)[b]	187 (39.3)[b]	195 (63.3)[b]
P-value		ns	0.02	0.06	0.02
Days 1, 2 and 3 (n = 11 ewes)					
North	71	43 (10.6)	62 (33.7)	130 (70.7)	32 (45.1)[c]
East	184	10 (14.1)	23 (32.4)	50 (70.4)	54 (29.4)[ab]
South	117	20 (10.9)	34 (29.1)	96 (82.1)	23 (19.7)[a]
West	404	13 (11.1)	131 (32.4)	302 (74.8)	142 (35.2)[bc]
P-value		ns	ns	ns	0.001

ns = *P*-values greater than $P = 0.1$. [a,b,c]within columns mean with different superscripts are significantly different $P < 0.05$.

butting the lamb ($P < 0.05$) or the lamb ceasing to search for the udder on day 1 or all three days ($P < 0.05$; data not shown).

Suckling event termination behaviour: odds

On day 1, the odds of a suckling event being terminated by either the ewe walking away or by the lamb ceasing to suck or search for the udder were not influenced by the number of lambs present at the end of the suckling event ($P > 0.1$; Table 6). Ewes observed for a

Table 9. The median percentage (with interquartile range in parentheses) of the total suckling event duration that ewes were observed to walk, stand, ruminate or graze by the number lambs present at the end of the event or day of observation.

		Ewe behaviour (% of event)*			
Suckling events (n)		Walk	Stand	Ruminate	Graze
Day 1 only (n = 26 ewes)					
Number of lambs present					
One	232	6.7 (1.6–11.1)	70.2 (33.9–100.0)[b]	76.6 (33.1–100.0)	100.0 (88.9–100.0)[b]
Two	178	3.8 (2.2–7.0)	66.1 (20.3–99.7)[b]	70.7 (33.5–100.0)	94.0 (42.7–100.0)[a]
Three	173	3.8 (1.9–10.0)	41.4 (16.2–92.1)[a]	78.6 (34.6–98.5)	81.7 (41.4–100.0)[a]
P-value		ns	0.01	ns	<0.001
Days 1, 2 and 3 (n = 11 ewes)					
Number of lambs present					
One	306	7.0 (1.3–19.8)	68.0 (33.9–100.0)[b]	46.0 (27.0–77.2)[a]	100.0 (98.1–100.0)[b]
Two	250	3.4 (1.9–11.7)	48.5 (17.9–87.23)[a]	67.4 (34.9–99.5)[ab]	100.0 (48.3–100.0)[b]
Three	223	3.4 (1.8–6.5)	25.1 (11.0–73.23)[a]	81.0 (52.7–98.5)[b]	96.8 (44.1–100.0)[a]
P-value		ns	<0.001	<0.001	<0.001
Day of observation					
Day 1	235	3.8 (2.6–9.3)	49.1 (17.9–100.0)[b]	65.8 (33.1–98.1)[ab]	99.3 (57.7–100.0)[a]
Day 2	281	3.2 (1.8–8.3)	40.0 (15.1–98.2)[a]	60.7 (28.7–87.1)[a]	100.0 (88.5–100.0)[b]
Day 3	263	3.2 (1.8–8.5)	36.5 (11.7–71.8)[a]	78.8 (51.5–98.7)[b]	100.0 (79.9–100.0)[ab]
P-value		ns	0.05	0.05	0.01

ns = *p*-values greater than $P = 0.1$. [a,b,c]within columns mean with different superscripts are significantly different $P < 0.05$.
* Ewe behaviour duration (% of the event) was calculated from events in which the ewe was observed to show the behaviour.

Table 10. The median percentage (with interquartile range in parentheses) of the sum of the suckling events that ewes were observed to walk, stand, ruminate or graze by the number of lambs present or the day of observation.

		Ewe behaviour while suckling (%)			
	Ewes (n)	Walk	Stand	Ruminate	Graze
All ewes	26	0.5 (0.2–0.9)	16.5 (9.2–21.7)	37.0 (30.7–45.1)	37.2 (22.7–54.5)
Number of lambs present					
One	24	0.4 (0.0–1.2)	8.1 (3.3–16.8)	18.3 (6.7–42.8)[a]	68.8 (38.9–87.3)[b]
Two	26	0.4 (0.0–1.1)	12.9 (5.0–25.3)	42.3 (25.9–54.4)[ab]	44.7 (20.0–55.7)[a]
Three	22	0.6 (0.3–1.2)	17.8 (8.1–26.6)	43.8 (14.0–57.2)[b]	32.4 (16.3–49.4)[a]
P-value		ns	ns	<0.05	<0.05
Day of observation					
Day 1	26	0.3 (0.1–1.0)	19.2 (10.5–27.5)[b]	39.0 (25.7–49.8)	40.0 (13.9–54.8)
Day 2	15	0.5 (0.4–0.8)	7.5 (4.8–23.6)[ab]	45.8 (25.7–93.1)	40.3 (23.7–63.6)
Day 3	11	1.1 (0.4–1.7)	8.3 (6.1–19.2)[b]	38.3 (29.3–60.2)	35.2 (22.9–60.5)
P-value		ns	0.07	ns	ns

ns = *p*-values greater than $P = 0.1$. a,b within columns means with different superscripts are significantly different $P < 0.05$. * Ewe behaviour duration (% of the sum of all events) was calculated only from events in which the ewe was observed to show the behaviour.

total of one day had a 1.45 (1.01–2.08) greater odds of walking away than ewes with three days of observation ($P < 0.05$). There was no effect of total days of observation on the odds of the lamb walking away (0.82 (0.57–1.18), $P > 0.05$).

For ewes and lambs with three days of observations the odds of a suckling event being terminated by the ewe walking away or by the lamb ceasing to search for the udder were influenced by both day of observation ($P < 0.05$; Table 6) and the number of lambs present at the termination of the suckling event ($P < 0.05$) but there was no interaction of these factors ($P > 0.1$). The odds of the ewe walking away were lower when two lambs were present compared with three lambs ($P < 0.05$). The odds confidence interval for one lamb compared with three included one which indicates that the odds ratio was not statistically significant ($P > 0.1$). The odds of a suckling event being terminated by the lamb were greater, when one or two lambs were present compared with three lambs ($P < 0.05$). The odds of the ewe walking away were greater, and the odds of the lamb ending the suckling event were lower on days 2 and 3 compared to day 1 ($P < 0.05$).

On day 1 weather variables had no effect on the odds of a suckling event being terminated by the ewe walking away or the lamb ceasing to search for the udder ($P > 0.1$, data not shown). For ewes with three days of observations the odds of a ewe walking away and lamb ceasing to search for the udder were associated with the relative humidity at the

Table 11. The odds (with 95% confidence interval in parentheses) of a ewe being observed to walk, stand, ruminate or graze at any time during all periods they were observed to suckle their lambs by number by the number of lambs present or day of observation.

	Ewe behaviour while suckling			
Comparison	Walk	Stand	Ruminate	Graze
Lambs 1 vs. 2	1.15 (0.41–3.24)	0.76 (0.29–2.02)	0.04 (0.01–0.13)	3.88 (1.41–10.72)
Lambs 1 vs. 3	0.91 (0.31–2.73)	0.19 (0.06–0.55)	0.04 (0.01–0.14)	10.23 (3.32–31.52)
Lambs 2 vs. 3	0.80 (0.27–2.38)	0.25 (0.09–0.71)	0.97 (0.35–2.67)	2.63 (0.94–7.37)
P-value	ns	0.006	<0.0001	<0.0001
Day 1 vs. 2	0.64 (0.18–2.21)	2.52 (0.71–8.98)	0.32 (0.09–1.14)	1.06 (0.31–3.65)
Day 1 vs. 3	0.12 (0.3–0.53)	4.04 (0.96–17.1)	0.23 (0.6–0.99)	2.70 (0.65–11.14)
Day 2 vs. 3	0.19 (0.04–0.81)	1.61 (0.39–6.57)	0.73 (0.18–2.96)	2.56 (0.62–10.55)
P-value	0.017	ns	0.09	ns

time of the suckling event ($P < 0.05$). For every 10% increase in humidity there was a 1.22 (1.09–1.37) greater odds of the ewe walking away and a 0.89 (0.80–0.99) lower odds of a lamb ceasing to search. The duration of a suckling event had no effect on the odds that the suckling event would be terminated by the ewe walking away or sitting or by butting or kicking the lamb(s) or on the lamb terminating the suckling event ($P > 0.1$; data not shown).

Ewe behaviour during suckling events: frequency

On day 1, the frequency of suckling events during which ewes were observed to stand, ruminate and graze was associated with the number of lambs present ($P < 0.05$; Table 7). There were fewer suckling events than expected due to chance during which ewes were observed to stand and ruminate when one lamb was present at the end of the suckling event compared with two or three lambs ($P < 0.05$). Conversely, there were more suckling events during which ewes were observed to graze when one lamb was present at the end of the suckling event compared with two lambs ($P < 0.05$). On day 1, ewes with a total of one day of observation stood in a greater percentage of events than ewes with three days of observation ($P < 0.05$), however, there was no difference in the frequency of ewes that grazed, walked or ruminated.

For ewes with three days of observations, the frequency of suckling events during which ewes were observed to walk, stand, ruminate or graze was associated with the number of lambs present ($P < 0.05$; Table 7). There were fewer suckling events than expected due to chance ($P < 0.05$) in which ewes were observed to walk or ruminate when one lamb was present at the end of the suckling event compared with two or three lambs. There were also fewer suckling events during which ewes were observed to stand when one lamb was present compared to two lambs which in turn was fewer than when three lambs were present ($P < 0.05$). Conversely, there were more suckling events during which ewes were observed to graze when one lamb was present compared to two or three lambs ($P < 0.05$).

Day of observation was associated with the frequency of suckling events during which ewes were observed to stand and graze ($P < 0.05$) and showed a tendency for rumination ($P = 0.08$; Table 7). There were more suckling events than expected in which ewes were observed to stand on day 1 compared with days 2 and 3 ($P < 0.05$). Similarly, ewes were observed to ruminate in more suckling events on day 1 compared to day 2 ($P < 0.05$). Conversely, there were fewer suckling events during which ewes were observed to graze on day 1 compared with days 2 and 3 ($P < 0.05$).

On day 1, wind direction was associated with the frequency of suckling events in which the ewe was observed to stand, ruminate and graze ($P < 0.05$; Table 8). When the wind was from the north there were fewer suckling events than expected due to chance ($P < 0.05$) in which ewes were observed to stand and graze than when the wind was from either the east or west. Ewes were observed to ruminate in more suckling events than expected when the wind was from the east compared to all other directions ($P < 0.05$). For ewes with three days of observation wind direction was associated only with grazing behaviour ($P < 0.05$; Table 8) where there were fewer suckling events than expected in which ewes were observed to grazewhen the wind was from the north than the east or south.

On day 1, rainfall was associated with the percentage of suckling events in which ewes were observed to graze ($P < 0.05$) with more ewes observed to graze when there was no (336/530, 63.4%) or light rainfall (22/39, 56.4%) compared with moderate (4/15, 26.7%). For ewes with three days of observation rainfall was associated with the percentage of suckling events in which ewes were observed to walk and graze ($P < 0.05$). Ewes were observed to walk in more suckling events when there was no (10.6%, 73/686) or light rainfall (22.0%, 11/50) compared with moderate (5.0%, 2/40). Similarly, ewes grazed in more suckling events when there was no rainfall (577.1%, 29/686) compared with light (64.0%, 32/50) which in turn was greater than moderate rainfall (42.5%, 17/40).

Ewe behaviour during suckling events: percentage of event

On day 1, ewes that were observed to graze during the suckling event did so for a median of 99.3% (IQR: 57.7%–100.0%) of the suckling event, indicating these ewes spent almost the entire suckling event grazing. During suckling events that ewes stood or grazed, the percentage of the suckling event for which the behaviour was observed was associated with the number of lambs present at the end of the suckling event ($P < 0.05$; Table 9). Ewes that stood during the suckling event spent a greater percentage of the suckling event standing when one or two lambs were present at the end of the suckling event compared with three lambs ($P < 0.05$). Similarly, ewes spent a greater percentage of the suckling event grazing when one lamb was present compared with two or three lambs ($P < 0.05$). There was no effect of the total days of observation on the proportion of the event that were observed to graze, stand, walk or ruminate ($P > 0.05$, data not shown).

For ewes with three days of observations, the percentage of the suckling event that ewes were observed to stand, ruminate and graze was associated with both the number of lambs present and the day of observation ($P < 0.05$; Table 9). The two-way interaction was not significant for any of the ewe behaviours (data not shown). The percentage of suckling events during which ewes stood was greater when one lamb was present at the end of the suckling event compared with two or three lambs ($P < 0.05$). Similarly, ewes grazed for a greater percentage of the suckling event when one or two lambs were present compared with three lambs ($P < 0.05$). During suckling events that ewes ruminated they did so for a greater percentage of the suckling event when three lambs were present compared with one lamb ($P < 0.05$).

During suckling events that ewes stood, they did so for a greater percentage of the suckling event on day 1 compared with days 2 and 3 ($P < 0.05$; Table 9). Ewes spent a smaller percentage of suckling events ruminating on day 2 than day 3 ($P < 0.05$), with day 1 being intermediate ($P > 0.1$). The percentage of the suckling event ewes grazed was lower on day 1 than day 2 ($P < 0.05$) with day 3 being intermediate ($P > 0.1$).

Wind direction at the time of the suckling event had no effect on the proportion of a suckling event that a ewe was observed to walk, stand, ruminate or graze on either day 1 or all 3 days of observation ($P > 0.1$, data not shown). For ewes on day 1 and those with three days of observations, rainfall was only associated with the percentage of the suckling event ewes were observed to ruminate ($P < 0.05$). On day 1, ewes were observed to ruminate for a smaller percentage of suckling events when there was no rain (70.7%, IQR: 33.3–99.2) compared with moderate rainfall (100.0%, IQR: 92.8–100.0), with light rain was intermediate (98.6%, IQR: 32.3–100.0; $P > 0.1$). The same pattern was seen for

rumination for ewes with three days of observations whereby all three categories differed ($P < 0.05$); no rainfall (64.2%, IQR: 33.1–89.3), light (87.1%, IQR: 32.5–99.9; $P > 0.1$) and moderate rainfall (100.0%, IQR: 87.7–100.0).

Multivariate regressions of weather variables with the proportion of the suckling event that a ewe was observed to walk, stand, ruminate or graze had R^2 values of between 0.005 and 0.052 indicating the model explained between 0.5 and 5% if the variation in the behaviour data indicating that the weather variables did not have a not biologically significant impact (data not shown).

Ewe behaviour during suckling events: percentage of total suckling events observed

The generation of a percentage of the total suckling duration that each ewe was observed to walk, stand, ruminate or graze allowed all ewes to be included in the same analysis regardless of the duration they were enrolled in the study. The greatest percentage of suckling events was spent grazing and ruminating with a lower percentage of suckling events spent standing and walking (Table 10). The time spent ruminating and grazing across all observations was influenced by the number of lambs present at the end of the suckling event ($P < 0.05$). When one lamb was present ewes were observed to spend a smaller percentage of their time ruminating than when three lambs were present. In addition, when one lamb was present ewes spent a greater percentage of their time grazing than when either two or three lambs were present. Day of observation was associated with the percentage of time standing with ewes standing more on day 1 than day 3 with day 2 being intermediate.

The odds of an ewe being observed to graze at any time while suckling was more than three times greater when one lamb present at the end of the suckling event compared with two lambs and 10 times greater than three lambs ($P < 0.05$; Table 11). Conversely, the odds of an ewe being observed to ruminate when one lamb was present at the end of a suckling event was 96% lower than when two or three lambs were present ($P < 0.05$). The odds of an ewe standing during suckling when one lamb was present at the end of the suckling event was 24% lower compared with two lambs and 81% lower than with three lambs ($P < 0.05$). In addition, the odds of a ewe standing were 75% lower when two lambs were present compared with three ($P < 0.05$). There was no effect of the number of lambs present on the odds of a ewe walking during a suckling event ($P > 0.1$).

The day of observation influenced the likelihood of a ewe walking during a suckling event ($P < 0.05$). On day 3, a ewe had 88% and 81% lower odds of walking at any time during a suckling event than on days 1 or 2, respectively ($P < 0.05$; Table 11). There was a tendency for day to influence the likelihood of a ewe ruminating at any time while suckling ($P = 0.09$). The odds of a ewe ruminating during a suckling event was 77% greater on day 3 compared with day 1, but the odds did not differ between days 1 and 2 or days 2 and 3. Day had no effect on the odds of a ewe standing or grazing at any time while suckling ($P > 0.1$).

Discussion

The current study tested the hypothesis that the suckling behaviour of triplet-rearing ewes would change depending on the number of lambs attempting to suck. To test

this hypothesis the behaviour of triplet rearing ewes was observed for two hours per day for three days after the birth of the lambs. As the focus of this research was the interaction of ewes with their three lambs, ewes were removed from the study if a lamb died or was removed due to welfare concerns. During the study period, the weather conditions resulted in more than half of the ewes being removed from the study due to one or more of their lambs dying or being removed. Newborn lambs have a lower critical temperature of 27°C and begin to shiver at an ambient temperature around 10°C (Symonds and Lomax 1992). The impacts of cold ambient temperatures are further exacerbated by wet and windy conditions. McCutcheon et al. (1983) reported that at 10°C the metabolic rate (W/kg) of dry Romney lambs in still conditions was less than half that of wet lambs subjected to air moving more than 1 m/s. Given the conditions in the current study, lambs that lacked vigour or were poor at accessing the teat were at risk of becoming hypothermic. Of the 15 ewes that were removed from the study, 14 had lambs that died or were removed while one ewe gave birth to a lamb with an incomplete digestive tract. As a result, 11 ewes had observations for all three days and four had observations on both days 1 and 2. Two distinct datasets were created: the first included observations of all ewes on day 1 (n = 26) and the second included data only from ewes with observations across all three days (n = 11).

On both Day 1, and over the entire observation period, suckling events were longer when more lambs were present at the end of the suckling event. In the current study, a suckling event was defined as one or more lambs within 0.5 m of the ewe that were actively seeking the teat, therefore, each suckling event was likely made up of a number of lamb-sucking bouts. Suckling events were likely longer when more lambs were present due to more opportunities for a lamb to return to sucking which would extend the length of the suckling event. To these authors' knowledge, neither suckling event duration of ewes with multiple lambs nor the impact of the number of lambs on suckling event duration has been previously reported. Van Welie et al. (2016) reported a summed sucking duration for triplet lambs during a 15-min observation period, however, this is unlikely to reflect the duration that a ewe would allow lambs to suckle.

The number of lambs present at the end of the suckling event influenced ewe behaviour during the suckling event. Ewes were observed to stand and ruminate in more suckling events, and grazed in fewer suckling events, when more lambs were present. In addition, during suckling events in which ewes were observed to ruminate, they did so for a greater percentage of the suckling event when more lambs were present. Conversely, during suckling events that ewes were observed to stand and graze they did so for a smaller percentage of the suckling event when more lambs were present. Grazing behaviour among sheep includes searching for food by walking slowly across an area whilst harvesting herbage (Lynch et al. 1992) while rumination is observed while the animal is at rest either sitting or standing (Ekesbo and Gunnarsson 2018). It appears, therefore, that the ewe was more likely to be inactive during suckling when more lambs were present. This finding suggests that there may be potential to select ewes that show more stationary behaviours when three lambs are attempting to suck in order to facilitate lamb sucking, however, a link to lamb suckling behaviour and survival first needs to be investigated.

Ewe behaviour on day 1 showed that ewes that were observed for all 3 days had more suckling events with three lambs present and fewer with one lamb than ewes that were

only observed only on day 1 although there was no difference in the duration of the suckling events. This suggests that ewes with only one day of observation had the potential to have a lamb that was more likely to miss out on a suckling opportunity than ewes with three days of observation. Hinch (1989) reported that among triplet litters there was a high degree of variation in the percentage of suckling bouts which litter members missed but that triplet lambs with the highest percentage could miss more than one-third of suckling opportunities. It is possible, therefore, that the ewe could have a significant influence on the frequency that a lamb misses a suckling opportunity if she has a high number of suckling events with only one or two lambs. Unfortunately, as the focus of the observations in the current study was the ewe, the number of missed suckling opportunities experienced by the lambs was not recorded.

The results of the current study partially supported the hypothesis that the number of lambs present at the end of the suckling event would influence the behaviour of the ewe. On day 1 the odds of a ewe walking away to terminate the suckling event were not influenced by the number of lambs present. This may have been due to ewes being more tolerant of their lambs' attempt to suck to ensure that their lambs had an opportunity to ingest colostrum. On days 2 and 3 more suckling events were terminated by the ewe walking away if three lambs were present compared with two lambs. While this may have been partially due to the greater length of suckling events, these findings support the observation that among triplet litters, two lambs often initiated sucking but when the third lamb attempted to compete for the teat the ewe would terminate suckling (Hinch 1989).

For ewes with three days of observations, the frequency of suckling events did not differ between days, although, suckling events tended to become shorter on day 3 than the previous days. Van Welie et al. (2016) reported that heavier triplet lambs between 8 and 17 days of age were more efficient at extracting milk than lighter lambs as they sucked less often and for shorter periods but gained more live weight. It is possible, therefore, that lambs in the current study became more efficient at locating the teat and extracting milk resulting in shorter suckling events on day 3 than on the previous two days.

Suckling bout duration and frequency have been reported to decrease as lambs age (Munro 1956; Ewbank 1964; 1967; Gordon and Siegmann 1991). These findings have been generalised to a statement that ewes allow their offspring to suck as often and as long as they want in the first week of lactation (Lynch et al. 1992; Dwyer 2008). The lack of a change in frequency of suckling events during the observation period in the current study supports this observation, however, just over half of the suckling events in the current study were terminated by the ewe walking away. This suggests that ewes did not allow the lambs to suck for as long as they wanted. Atroshi and Österberg (1984) also reported that highly fecund Finnsheep ewes did not accept all suckling attempts of their lambs during the first six hours after birth. Dwyer and Lawrence (2000) and Pickup and Dwyer (2011) also reported that approximately half of the sucking bouts were terminated by Suffolk and Blackface ewes in the first two hours after birth or when lambs were two weeks of age, respectively. In the current study, the focus of the observations was the behaviour of the ewe when her lambs were attempting to suck. As such the duration of the suckling event was determined which allowed for multiple suckling bouts to be combined and the cumulative effect on the behaviour of the

ewe to be assessed. The duration of the suckling events, therefore, could be influenced by a number of factors including the timing of the initiation of suckling by each lamb of the litter, the duration of sucking by each lamb and the behaviour of the lamb that was unable to secure a teat if all three lambs were attempting to suck.

Ewes have been reported to facilitate sucking by orientating themselves towards their lambs (Alexander and Williams 1964), adopting a hunched posture and remaining still (Lynch et al. 1992). In the current study, fewer ewes were observed to graze, and grazed for a smaller percentage of suckling events, on day 1 than both days 2 and 3. Conversely, more ewes stood, and for a greater percentage of the suckling event, on day 1 than both 2 and 3. Although more ewes were observed to ruminate on day 1 than day 2, the percentage of the suckling event spent ruminating was lower on day 2 than 3. When ewe behaviour was analysed as a percentage of the total time observed to suckle, the odds of a ewe walking or ruminating were lower on day 1 than day 3, however, there was no effect on standing or grazing. Combined these results suggest, that on the first day after birth, ewes showed more inactive behaviours that would likely facilitate lamb sucking.

The influence of weather variables on day 1 of observation suggests that ewe behaviour during the first 24 h after lambing was focussed on facilitating lamb sucking. On day 1 there was no association of any of the weather variables with suckling event duration or suckling event termination behaviour. Wind direction and rainfall were associated with the frequency of suckling events in which ewes were observed to show some behaviours but there was no association with the percentage of the suckling events that each behaviour was displayed. This lack of association suggests that ewes do not alter their suckling behaviour in response to the weather. This is perhaps not surprising given that ewes in the current study were unlikely to experience cold stress as all ewes had a least 6 months of fleece growth and the lower critical temperature of well-fleeced ewes is −20°C (Alexander 1962).

Most lamb deaths occur during the first three days of life (Dalton et al. 1980; Smith and Knight 1998; Hinch and Brien 2014). To ensure lamb survival ewes not only need to provide suckling opportunities but the lamb must become efficient at consuming milk to meet their energy needs before the suckling event is terminated. Once a lamb is through this critical period, the frequency of suckling is likely related more to ensuring lamb growth occurs within the restrictions of ewe milk production. In the current study, 40% of suckling events were terminated by the lamb across all three days of observation. This finding is in agreement with Stapleton et al. (1980) who reported that at three days of age 36% of sucking bouts were terminated by Border Leicester×Merino lambs which decreased to 2.5% by four weeks of age. It is unclear from this study what impact lamb competition had on lambs terminating the suckling event. Further research is required to examine lamb behaviour and competition for the teat on lambs ceasing to actively suck or search for the teat.

During the current study, just over 50% of all suckling events took place when the wind was from the west, which was the prevailing wind direction of the Manawatū region of New Zealand (Chappell 2015). Wind direction was associated with the frequency of suckling events, but not the proportion in which, ewes were observed to stand, graze and ruminate, although there was no clear pattern. There were more suckling events in which ewes stood and grazed when wind was from the east or west than the

north whereas ruminating was more frequent when the wind was from the east than all other directions. In general, suckling events when wind was from both the east and west had a higher chill index than when wind was from the north or south. The wind chill was likely to have a greater impact on lamb than ewe behaviour, however, no association was identified between wind direction or volume of rainfall on the proportion of events that were terminated by the lamb. Alexander (1962) reported that a chill index of greater >1000 MJ m^2/h resulted in compromised thermoregulation of lambs, however, in the current study ewes had sufficient wool to limit the impact of weather variables on their behaviour.

Moderate rainfall in the current study was associated with fewer suckling events in which ewes were observed to graze (day 1 and all 3 days) and walk (all 3 days only). In addition, when rainfall was moderate most ewes spent the entire suckling event ruminating compared with 60%–70% of the suckling event when there was no rain recorded (day 1 and all 3 days), although, there was no difference in the frequency of suckling events in which ewes ruminated. This finding is in partial agreement with Champion et al. (1994) who observed that among nine full-fleeced yearling ewes both grazing and ruminating behaviour per hour were reduced by heavy rainfall (>1 mm/h). Manno et al. (2019) reported that there was a positive correlation between rainfall and rumination time in both the dry and rainy seasons in a tropical rainforest environment (Manno et al. 2019). It was also observed that during high-intensity rainfall sheep remained idle, however, this rainfall rate was not defined. In the current study, rainfall was not associated with ewe standing behaviour during suckling events.

Conclusion

The results of this study indicate that the suckling behaviour of triplet-bearing ewes was influenced both by the number of lambs present at the end of the suckling event and by day of observation. The mean suckling event duration was increased when more lambs were present at the end of the event. Ewes were more likely to terminate a suckling event by walking away and were less likely to spend time grazing when three lambs were present compared with one or two lambs. On day 1 ewes appeared to show more behaviours that facilitated suckling than on Days 2 or 3. Weather variables were associated with some ewe behaviours but no clear pattern was observed.

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