Drinking behaviour of ewes with access to a water trough during summer and autumn - a preliminary examination

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Abstract

Three observational studies were conducted to determine the water intake behaviour of ewes during the summer of 2017 and autumn of 2018 in the Manawatū and summer of 2021 in the Wairarapa. In each study, ewes were offered *ad-libitum* access to water from reticulated water troughs with video cameras recording footage of ewe drinking behaviour. Ewes were fitted with a uniquely numbered collar and spray marked with an identification number on their flank. Proximity of ewes to the water trough was determined using Bluetooth technology. Maximum daily temperatures ranged between 17.2 and 25.5°C in study 1, 9.9 and 23.6°C in study 2 and 16.0 and 28.1°C in study 3. Pasture moisture content was greater than 70% in both the Manawatū studies and less than 60% in the Wairarapa. Eighty percent of ewes in 2017 and 45% in 2018 were not observed to drink from the water trough at any time in the Manawatū, although, there was considerable intra-animal variation. In the Wairarapa, all ewes were observed to drink during the study on between one and 14 occasions. These studies suggest that ewe drinking behaviour showed considerable variation between individuals and is likely dependent on the environmental conditions and pasture moisture content.

Keywords: drinking; Romney sheep; extensive production; behaviour

Introduction

In New Zealand, sheep are managed under pastoral farming systems in fenced paddocks with water provided either from reticulated water troughs or landscape features such streams and dams (Cichota & Snow 2009). In New Zealand and elsewhere, the farming of dairy cattle has been linked with the degradation of the water quality in natural water habitats (Scarsbrook & Melland 2015; Schütz 2012) resulting in recognition of the negative impacts that livestock can have on water quality (Julian et al. 2017; Zonderland-Thomassen et al. 2014). In response to this, the dairy industry established the Sustainable Dairying Water Accord in July 2013 (DairyNZ 2013). This was further expanded by changes to the Resource Management Act (RMA) by the NZ government in 2020 to include the exclusion of farmed cattle, deer and pigs from streams and drains greater than 1 m wide (New Zealand Government 2020). Currently sheep are not required to be excluded from waterways. If similar restrictions were to be imposed on the sheep farming industry this would require increased fencing of waterways and may require the provision of reticulated water, both likely be at significant cost to farmers (Collins et al. 2007; Ministry for the Environment 2001; Schütz 2012).

In New Zealand, the need for drinking water for sheep has received little attention. The New Zealand Animal Welfare Act (1999) vaguely outlines "proper and sufficient water" as a necessity for all animals (New Zealand Government 1999). Sources of water for extensively managed sheep can include free water drunk, moisture ingested from within and on forage from dew and rainfall and metabolic water generated from the oxidation of the products of digestion and the catabolism of body fat reserves (Freer & Dove 2002). The water requirements of sheep can be influenced by genotype, environmental conditions, feed type and physiological state (Freer & Dove 2002). Australian data on the water turnover of wethers and non-pregnant ewes has been reported to range between 4.3 and 13.7 L/day (Freer 2007) whereas in New Zealand, water requirements were between 2 and 9 L/day (Stewart & Rout 2007). These differences were likely due to environmental and dietary differences between the locations. Pastures in New Zealand can contain high levels of moisture. For example in autumn, the moisture content of perennial ryegrass and herbs such as chicory and plantain, have been reported to be in excess of 80% (Anon. 2017). It is therefore possible that an adult sheep can meet their entire daily water requirement from the moisture contained in the forage consumed. For example, a non-pregnant ewe with a maintenance energy requirement of 9.0 MJ of metabolisable energy, grazing pasture with metabolisable energy of 11 MJ/kgDM and moisture content of 82% will consume 5.47 kg of pasture, which equates to 0.82 kg of DM and 4.65 L of moisture per day (Rattray et al. 2017).

In order to understand the potential impact of sheep on natural waterways, the drinking behaviour of sheep must be firstly understood. The drinking behaviour of sheep, however, has not been studied in New Zealand production systems. The current study was designed to determine the drinking behaviour of sheep when given free access to water from a reticulated water trough.

Materials and methods

Observational studies were conducted in the summer of 2017 (study 1) and autumn of 2018 (study 2) at Massey University's Keeble farm and summer of 2021 at Riverside farm (study 3). Keeble farm is located 5 km south of Palmerston North, New Zealand (40°24'10"S, 175°36'09"E) and Riverside 10km north of Masterton (40°50'31"S 175°37'04"E) on the North Island of New

Zealand. The studies were conducted with the approval of the Massey University Animal Ethics Committee.

Study 1 included mature non-pregnant Romney ewes (n=37) which were weighed prior to the start of the study (11 Jan 2017; study day 1) and again at the end of the observation period (15 Feb 2017; study day 36). All ewes were placed in a 2ha paddock that contained a single water trough. The paddock contained no other water sources and had a shelter belt of trees along the southern boundary fence. Study 2 included mature non-pregnant Romney ewes (n=20) weighed prior to the start of the study (27 Mar 2018; study day 1) and again at the end (15 Apr 2018; study day 20). All ewes were placed in a 2.1 ha paddock that contained a single water trough. The study paddock contained a shelter belt of trees along the southern boundary fence. Study 3 included mature non-pregnant Romney ewes (n=20) weighed prior to the start of the study (1 Mar 2021; study day 1) and again at the end (16 Mar 2021; study day 16). Ewes were placed in one 1.5 ha paddock from study day 1 to 8 and then moved to an adjoining paddock of the same size for the remainder of the monitoring period. Both study paddocks contained a shelter belt of trees along the northern boundary fence.

Data recording

Across all three studies ewes were fitted with a halter to which a Bluetooth-enabled triaxial accelerometer (wGT3X-BT, ActiGraph, FL, USA) was attached on study day 1. The accelerometers were initialised using proprietary software ActiLife (Version 6.13.4) as beacons to transmit a signal with their serial number at 10 second (s) intervals. An accelerometer was also placed beside any water trough in the paddock which was initialised to be a receiver which recorded signals at 1-minute intervals. Receivers recorded and stored time-stamped received signal strength values (Received Signal Strength Indicator; RSSI) detected from nearby beacons. Devices were downloaded at fortnightly intervals, recharged and if required, were reattached.

Surveillance video cameras were placed on either side of each water trough to capture ewe drinking behaviour. Cameras were downloaded weekly at which time the batteries were checked and replaced if necessary. Video cameras were programmed to record for 30 s after being triggered by movement near the trough. After 30 s there was a non-recording period of 10 s; if movement was detected after this time, an additional 30 s of video was recorded. Video surveillance cameras contained an infrared LED flash to allow night-time recording. Observations of sheep drinking behaviour from the footage recorded was used to determine the frequency and duration of sheep drinking behaviour. To allow for identification from video footage ewes had large ear tags with a visual number (Allflex, Palmerston North, NZ), a plastic collar with a visible number and the ewe was painted with their collar number on their side with stock spray (Donaghy Ltd, Christchurch NZ). Behavioural observations were made by as single observer for all three studies. Behaviours observed included: sniffing water in which the ewe was observed to touch the water with the muzzle without ingesting water and drinking where the muzzle was in contact with the water and water was ingested. Ewes that were observed to sniff the water and then proceeded to drink were classified as drinking due to the difficulty in distinguishing between the behaviours. To determine drinking duration the time stamp of the videos was considered. If drinking for a particular ewe was observed across two videos recorded within one minute of each other the duration was the sum of the two videos.

Weather data was recorded for the duration of each study. Weather data for studies conducted at Keeble farm were downloaded from the National climate database (www.cliflo.niwa.co.nz). The Palmerston North EWS recording station (agent number 21963) was located 21m above sea level 1km from the research site at 40°22'55"S, 175°36'32"E. Weather data were downloaded and included daily minimum and maximum temperatures (°C), and total rain (mm). Weather data for the study conducted at Riverside was recorded using an onsite weather station installed within 500m of the research site (EnviroMonitor station, Davis Instruments, CA, USA). Hourly weather data was retrieved from the proprietary web interface Weatherlink.com (Davis Instruments, CA, USA) and summarised into daily minimum and maximum temperature (°C) and total rainfall (mm).

Pasture moisture content was determined from pasture grab samples collected by hand to simulate sheep grazing. Samples were collected at the start, mid-point, and end of each study. The samples were weighed prior to and after oven drying at 70°C for a minimum of 48 hours. The moisture percentage was determined using the following equation: moisture (%) = 100 - (dry weight / wet weight) ×100).

Statistical analysis

All analyses were conducted using SAS version 9.4 (SAS Institute, Cary, USA). Descriptive statistics (mean and range) were generated for variables including ewe live weight, live weight gain, pasture moisture content and weather variables. The frequency of sniffing water and drinking and the mean duration of drinking were calculated.

Proximity data from three ewes in study 1 and one ewe in study 3 was not recorded by the receiver at the trough which indicates that either the device worn by the ewe did not send a signal or was never within range of the receiver. The maximum detection distance has been reported to be 10 to 20 metres indoors and line of sight outdoors up to 100m (Actigraph Support Centre 2014), therefore it is unlikely that ewes with outside of this distance for the entirety of a study. Ewe proximity to the water trough was determined from RSSI data recorded by accelerometers attached to the water trough. Proximity of the beacons to the receiver was estimated using the equation reported by Sohi et al. (2017):

$$\text{Received signal strength indicator (RSSI)} = -65.5817 + 20\log_{10} \text{distance (m)}$$

The RSSI value is not directly related to Bluetooth signal strength and should not be used to assess distance between devices (Actigraph Support Centre 2014; Kuzik & Carson 2018). Thus, proximity was defined as an animal being within 3m of the trough. Using the equation above the RSSI for a proximity of 3m was -56, therefore, any minute that had a RSSI value less than -56 was coded as '1' (within 3m) and a RSSI value greater than -56 was coded as '0' (not within 3m). Proximity data was summed to minutes per hour.

Results

A summary of each study including start and end date, duration, weather conditions, pasture moisture and ewe live weights are provided in Table 1. Across all three studies the weather conditions were mild with maximum daily temperatures between 9.9 and 17.2°C (Table 1). In the Manawatū studies, study 1 had rainfall recorded on 16 days with a mean daily volume of 5.5mm and in study 2 on 10 days, with a mean volume of 10mm. In the Wairarapa, rain was recorded on 11 days with mean daily volume of 0.7mm. During the Manawatū studies, the pasture moisture content remained above 70% in both studies, whereas the Wairarapa moisture content was less than 60%.

Drinking observations

Observations of ewe behaviour around the water trough were made from 18 videos in study 1, 44 videos in study 2 and 132 videos in study 3. In the Wairarapa (study 3), all ewes were observed to drink during the observation period whereas in the Manawatū studies 80% of ewes in study 1 and 45% in study 2 were not observed to drink (Table 1). Across the three studies, a small number of ewes were observed to only sniff the water. In each study there were a small number of videos in which ewes could not be identified due to being obscured by other sheep or poor image quality (Study 1 n=1 (0.5%), Study 2 n=1 (0.2%) and Study 3 n=7 (0.5%).

The mean duration ewes were observed to drink was similar between all the three studies (15 to 19s). If ewes were observed to drink across consecutive videos the sum of drinking durations was determined, however, this was uncommon across the three studies (Study 1 n=0, Study 2 n=2 and Study 3 n=8).

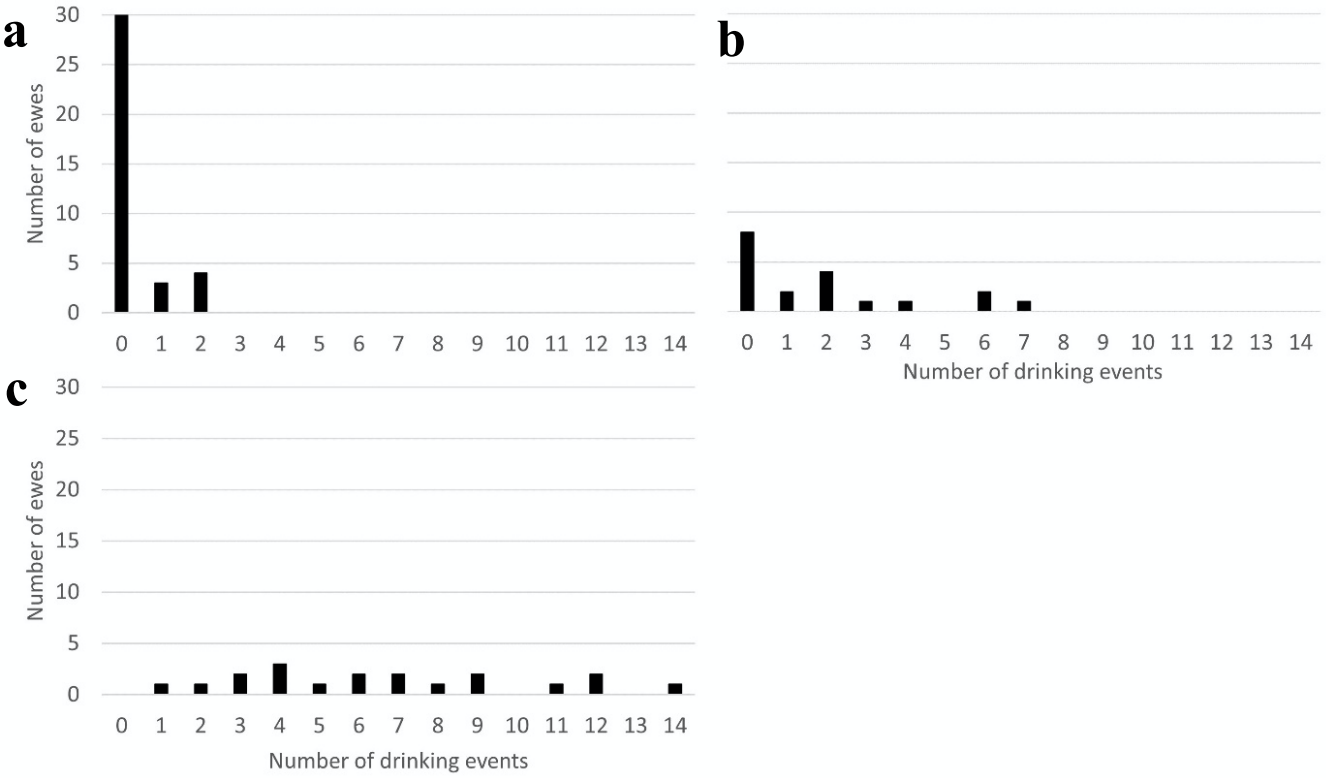
The frequency of drinking behaviour in study 1 showed that the majority of ewes were observed to drink on one or two occasions during the 30-day observation period (Fig. 1a). In study 2, ewes were observed to drink between one and seven times over the 15-day period (Fig. 1b). In the Wairarapa (study 3) one ewe was observed to drink on one occasion whereas another drank on 14 occasions over the 27 days of the study (Fig. 1c). The frequency of ewes drinking each day showed considerable variation in all three studies and visually did not appear to be related to the weather conditions of the study (Fig. 2a and b).

Table 1 Summary of the conditions of each study including the mean with range in parentheses of daily minimum and maximum temperature (°C), rainfall (mm), and pasture moisture content (%). Ewe proximity to the water trough during the entire study period including number of ewes that had proximity data, ewes that were detected within 3m of the trough and the duration they were near the trough during the study period (median and range in parentheses). Ewe drinking behaviour during the entire study period including the number of ewes observed to drink or sniff water, the number of drinking events per ewe (median with range in parentheses) and the estimated mean drinking duration (s).

	Manawatū				Wairarapa	
	n	Study 1	n	Study 2	n	Study 3
			Conditions during the study period			
Start date		11/01/2017		27/03/2018		17/02/2021
End date		10/02/2017		11/04/2018		16/03/2021
Study duration (d)		30		15		27
Pasture moisture (%)	16	79 (71-85)	4	78 (76-79)	10	59 (53-64)
Pasture mass (kgDM/ha)		NR	4	1303 (1206-1380)	4	1347 (1012-1608)
Min temp (°C)	31	13.4 (5.1-16.0)	21	10.6 (2.1-16.0)	16	11.3 (6.8-17.3)
Max temp (°C)	31	20.9 (17.2-25.5)	21	19.0 (9.9-23.6)	16	22.7 (16.0-28.1)
Rain (mm)	16	5.5 (0.2-36.2)	10	10.0 (0.8-40.8)	11	0.7 (0.2-2.6)
			Proximity to the trough and drinking behaviour			
Ewes (n)		37		20		20
Ewes with proximity data (n)		35		20		19
Ewes in proximity (n)		35		13		19
Proximity duration (min/day)		0 (0-2)		5 (0-18)		19 (8-33)
Ewe drink (n)		7		11		20
Ewe sniff (n)		1		4		6
Drinks per ewe (n)		2 (0-2)		2.5 (0-4)		6.5 (4-10)
Drinking duration (s)		19		18.2		15.6

NR = Not recorded

Figure 1 Histogram of the number of times ewes were observed to drink in study 1 (n=37 ewes over 30 days, panel a), study 2 (n=20 ewes over 15 days, panel b) and study 3 (n=20 ewes over 27 days, panel c).



Proximity to the water trough

Bluetooth proximity in studies 1 and 3, showed that all ewes were detected within 3m of the water trough at some time during the study period, however, in study 2, seven ewes were not detected at any time (Table 1). The median duration per day ewes were detected within 3m of the trough was 0 min in study 1, 5 min in study 2 and 19 min in study 3.

Effect of time of day on trough proximity and drinking behaviour

Across the three studies, there was a temporal pattern of proximity with more time spent near the trough in the early morning hours (03:00 to 05:00) and late evening (21:00 to 22:00) during studies 1 and 3 (Figure 3). During study 2, there was an additional peak between midnight and 2am.

In studies 1 and 2 all drinking events occurred during day light hours whereas in study 3 three ewes drank at 23:00, one at 12:00 and two at 02:00 (Figure 4). In study 1 ewes were observed to drink between 09:00 and 13:00 whereas in study 2 drinking was observed between 11:00 and 18:00. In study 3 drinking times were clustered between 11:00 and 19:00.

Discussion

The drinking behaviour of mature non-pregnant ewes across the three studies showed a high degree of variability both among ewes and between studies. Drinking observations in the Manawatū studies (study 1 and 2) showed that 80% and 45% of ewes, respectively, did not drink at all from the water trough. Of those ewes that were observed to drink they did so only once or twice during the entire period of study 1 and between one and seven times in study 2. In the Wairarapa (study 3), all ewes were observed to drink between one and 14 times over the entire study period. Sheep generally have been reported to drink once or twice daily, however, the majority of studies that have reported drinking behaviour have been conducted in dry or semi-arid environments and with maximum temperatures between 24 and 45°C (Brand 2000; Daws & Squires 1974; Squires 1976). In a Slovenian study, Bojkovski et al. (2006) observed that sheep grazing grass pastures with daily temperatures ranging between 9.2 to 18.5°C had a daily drinking frequency of 0.8 which suggests that on a daily basis some ewes were also not observed to drink. Their results, however, did not report the variability in frequency of drinking events between animals nor the moisture content of the forage or frequency and volume of rainfall.

The infrequent observation of drinking behaviour of some ewes in study 1 and 2 may be explained by the moisture content of the pasture which was more than 70%. In study 1, pasture masses were not recorded, although, in study 2 masses ranged from 1206 to 1380 kgDM/ha. Pastures masses in excess of 1200 kgDM/ha are considered sufficient to allow *ad libitum* feed intake for mature ewes (Morris & Kenyon 2004). Voluntary dry matter intake (VDMI) of sheep can be estimated using the equation VDMI = 75g/kgDM $BW^{0.75}$ (Sauvant et al. 2018). The VDMI of

Figure 2 Frequency that ewes were observed to drink on each day (yellow bars) of the observation period with daily minimum temperatures (°C; orange line) and maximum temperatures (°C; blue line) and rain fall (mm; grey bars) in study 1 (panel a, n=37 ewes), study 2 (panel b, n=20 ewes) and study 3 (panel c, n=20 ewes).

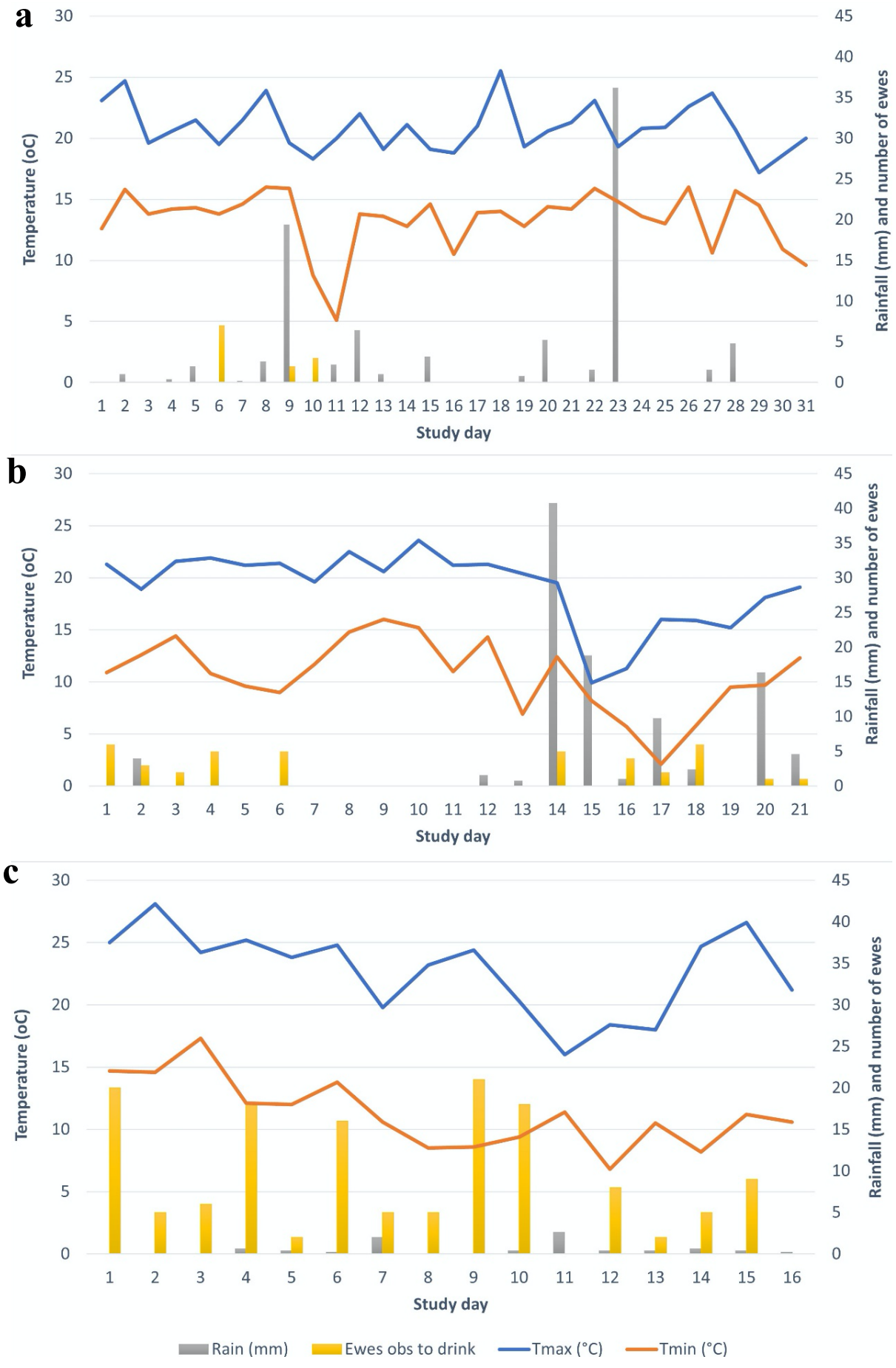


Figure 3 Effect of time of day on mean minutes per hour (±SEM) that ewes that were detected within 3m of the trough during study 1 (blue bars; n=35 ewes over 30 days), study 2 (orange bars; n=20 ewes over 15 days) and study 3 (grey bars; n=19 ewes over 27 days).

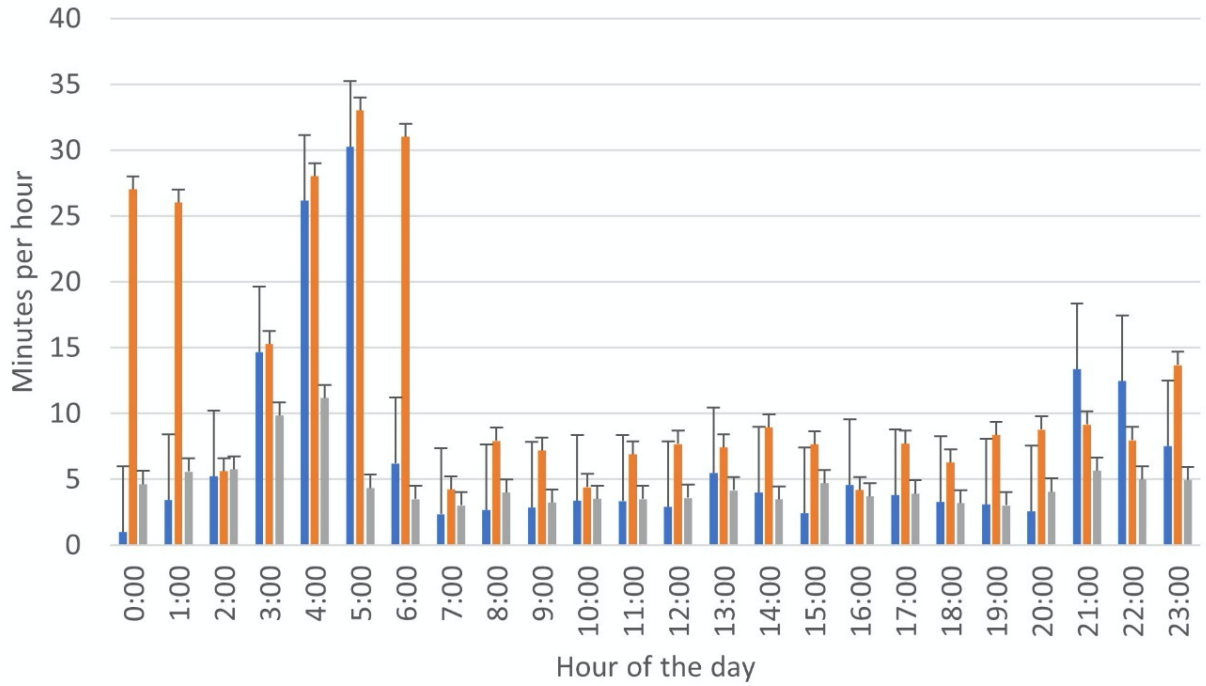
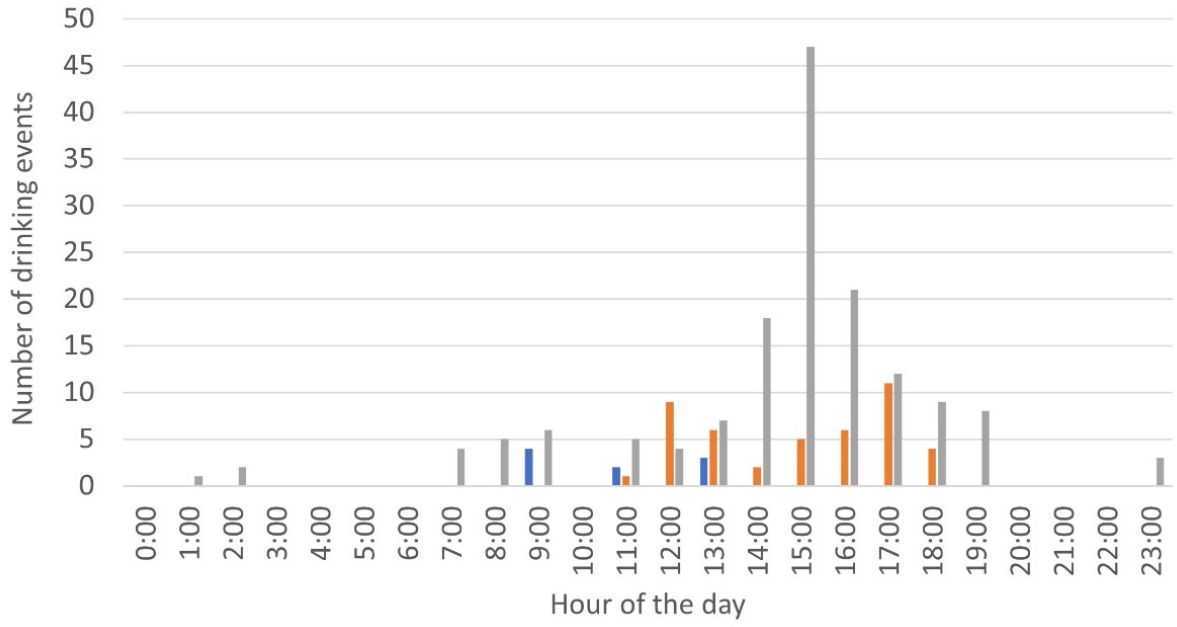


Figure 4 The effect of time of the day on the number of individual drinking events observed during the entire study period in study 1 (blue bars, n=37 ewes over 30 days), study 2 (orange bars; n=20 ewes over 15 days) and study 3 (grey bars, n=20 ewes over 27 days).



ewes in each of the studies was estimated to be 1.9, 1.8 and 1.8kgDM/day which equates to a wet weight of pasture of 9.0, 8.7 and 8.6kg and total moisture intake of 7.1, 6.8 and 5.1L. The reported daily water demand suggests that peak daily demand for a 65kg adult ewe in New Zealand is 5L/day, therefore, the forage conditions in study 1 and 2 likely allowed for water intake requirements to be met.

In study 3, the frequency of drinking was more consistent across the observation period, with greater numbers of ewes drinking per day. This increase in drinking behaviour was likely due to the combination of the lower pasture moisture content, less frequent rainfall and the consistently greater maximum temperatures recorded during the study compared with study 1 and 2. In New Zealand, a study of dairy cattle water intake reported a 62% decrease in the volume of water drunk from water troughs on a day when 26.4mm of rain was recorded compared to subsequent dry days. Further, studies in Australia observed

sheep that walked 3.2km between food and water sources in semi-arid conditions and showed a positive relationship between water intake and air temperature up to 38°C (Daws & Squires 1974). Fischer et al (2017) reported that water consumption increased with temperature, however, this was confounded with reproductive status as ewes weaned their lambs in the period when temperature began to increase. To these authors knowledge, no studies have reported the drinking frequency of sheep in temperate conditions.

The daily pattern of drinking varied between each of the three studies, but generally occurred during daylight hours with the exception of 6 events. These findings are in agreement with Brand (2000) who reported that in South Africa sheep drank between 09:00 and 18:00, whereas Daws and Squires (1974) found that in a semi-arid environment, sheep that had to walk 3.2km a water source, did so before 10:00 and between 17:30 and 20:00 if they visited the water source a second time in the day. Interestingly, the pattern of drinking and proximity to the water trough showed little commonality. In the current studies, proximity to the water trough suggested that ewes spent the greatest duration near the trough in the late evening and early morning. Given that proximity was determined from ewes being within 3m of the trough, this suggests that sheep were likely grazing or camping within range of the trough during these times.

Conclusion

The drinking behaviour of ewes in the temperate conditions experienced in the current studies showed that across all three studies ewes did not drink daily and in studies 1 and 2 some ewes were not observed to drink at any time during the study. The frequency of drinking appeared to be related to the moisture content of the pasture and rainfall events. There was a daily pattern of drinking which generally occurred during daylight hours but that varied between studies. These results were generated from small scale preliminary studies in neighbouring regions of New Zealand. Their applicability to the range of climatic conditions experienced across New Zealand is still to be determined.

Acknowledgements

This research was funded by the C Alma Baker Trust and L A Alexander Agricultural Trust.

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