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RESEARCH ARTICLE

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Access to reticulated water in late-pregnancy: impacts on ewe productivity, drinking behaviour and some physiological indicators of dehydration

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ABSTRACT

There has been industry debate regarding sheep access to waterways, although there is little information available on the impact of access to water on sheep productivity. It is theoretically possible for actively growing pasture to provide sufficient moisture to meet the daily water intake requirements of sheep. A study was conducted in the Manawatu region during winter across two years with single- (n = 40) and twin-bearing ewes (n = 40) in late-pregnancy. Ewes were restricted from accessing a reticulated water source (no water) or given access (water). Herbage moisture was 81.5 ± 0.7% and 84.8 ± 0.4% in 2017 and 2018, respectively. Of the 40 water treatment ewes, 45% and 55% in 2017 and 2018, respectively, were never observed to drink water. Packed cell volume and total protein concentrations remained within the normal range throughout each study. Ewe liveweight and BCS increased ($P < 0.05$) throughout the study period but did not differ between treatments except among single-bearing ewes in 2018. The litter weight of single- and twin-bearing ewes in the water and no water treatments did not differ ($P > 0.05$). These results suggest that under the conditions of the current study, ewes in late pregnancy did not require access to reticulated water.

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Introduction

Concerns about the health of New Zealand's natural waterways and the impact of agricultural livestock industries on water quality, resulted in legislation in 2020 that requires that farmed cattle, deer and pigs to be excluded from streams and drains greater than 1 m wide (New Zealand Government 2020). These changes may result in the fencing of water sources traditionally used by sheep. The New Zealand Animal Welfare Act (MPI 1999) requires that all animals have access to proper and sufficient food and water. To date in New Zealand, the use and impact of offering sheep access to reticulated water sources has had little investigation. Our previous research suggested that in summer in the Manawatu and Wairarapa regions of New Zealand the drinking behaviour of mature ewes

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was highly variable between individuals but was influenced by pasture moisture content and environmental conditions (Corner-Thomas et al. 2022).

Sources of water for sheep on New Zealand farms have traditionally included water drunk from reticulated troughs or from dams, creeks or rivers (Freer 2007). Moisture is also contained within and on the surface of forages from dew and guttation (Brown and Lynch 1972). Additionally, a small amount of water is produced in metabolic processes such as catabolism of body tissues and oxidation of nutrients (Brown and Lynch 1972; Freer 2007). The average daily water requirement of adult sheep has been reported to be between 2 and 9 L/day (Stewart and Rout 2007) but this value is dependent on animal live weight, physiological state, weather conditions and their feed type and intake (Freer 2007). The diet of sheep in New Zealand is made up of at least 95% pasture with small amounts of conserved forage or crops fed when there is a seasonal shortage (Hodgson et al. 2005). Sheep graze predominantly perennial ryegrass and white clover pastures which show a seasonal pattern of growth ranging from 8 to 50 kg DM/Ha/day (White and Hodgson 1999). In New Zealand, the moisture content of pasture varies throughout the year but is generally in the range of 78% to 89% (Rattray et al. 2017). It is therefore theoretically possible that a pregnant ewe offered pregnancy maintenance levels of pasture in winter could consume between 5.9 and 10.8 L of water per day. Under New Zealand conditions, however, the drinking behaviour of ewes and the impact of relying solely on the moisture contained in pasture during pregnancy has not been investigated.

The hypothesis of the current study was that in late pregnancy ewes that relied solely on moisture from actively growing pasture would have a similar level of production and physiological measures of hydration as ewes offered water from reticulated water trough.

Methods and materials

Experimental design

Experiments were conducted across two years at Massey University's Keeble farm, 5 km south of Palmerston North, New Zealand (40°24'12"S, 175°36'02"E). The first study was conducted between the 18th of July and 12th of September 2017 (Year 1). The second study was conducted between 17th July and the 11th of September 2018 (Year 2). The studies were approved by the Massey University Animal Ethics committee (MUAEC 16-136).

In each year, 80 mixed age Romney ewes (between 3 and 5 years of age) bearing either single (n = 40) or twin fetuses (n = 40) were selected for the study. All the ewes selected

Table 1. Summary of key dates for each experimental year.

Event	Year	
	2017	2018
Start of breeding	04 April	06 April
Pregnancy diagnosis	04 July	04 July
Start of study	18 July	17 July
Expected start of lambing	29 August	31 August
Start of lambing	28 August	30 August
End of recording period	12 September	11 September

were bred in the first oestrus cycle (first 17 days) based on ram harness marks (Table 1). Pregnancy rank was determined using trans-abdominal ultrasound by a commercial technician on day 92 of pregnancy in 2017 (P92) and day 90 in 2018 (P90).

In each year ewes were either provided access to reticulated water trough (water) or no access to a water trough (no water) treatment, using a stratified sampling procedure to balance each treatment for pregnancy rank (single or twin) and ewe live weight at pregnancy diagnosis. Treatments began on day 106 of pregnancy (P106) in 2017 and day 103 (P103) in 2018 and continued until the end of the lambing period in each year (Table 1). In each year, two paddocks between 1.8 and 2 ha in size were assigned to each treatment and a rotational grazing system used. The paddocks contained a ryegrass and white clover mix that was more than 5 years of age and had not been grazed for 1 month prior to the start of the study. Ewes were managed in a rotational grazing system to ensure that pasture masses remained above 900 kg DM/ha throughout each study. One week prior to lambing ewes were spread across both paddocks until the end of the lambing period. The water treatment paddocks (n = 2) contained a single permanent water trough that was supplied with water from the Palmerston North town supply. The water troughs were not cleaned prior to or during the study but had no observable algae or faecal contamination. The no water treatment paddocks (n = 2) contained no other sources of free water and the permanent trough was covered with a solid plywood sheet to prevent ewes from drinking. Once ewes had lambed and their lambs were mobile, they were moved to an adjacent paddock that contained a water trough and ceased to be monitored.

During the lambing period lambing observations were conducted twice daily at approximately 8 am and 3 pm to identify newly lambed ewes. New born lambs were identified to their dam, ear tagged with a uniquely numbered tag (Flexi Tag, Allflex, Palmerston North, New Zealand) and had their sex and live weight recorded.

Animal measures

Ewes were weighed within 1 h of removal from pasture on study days 1, 14, 28 and 42 in both 2017 and 2018 (D1, D14, D28 and D42; Figure 1). Ewe body condition score (BCS) was also recorded on each occasion except D42 in 2018. Ewe BCS was evaluated by the same assessor using a 0–5 scale (Jefferies 1961; Kenyon et al. 2014).

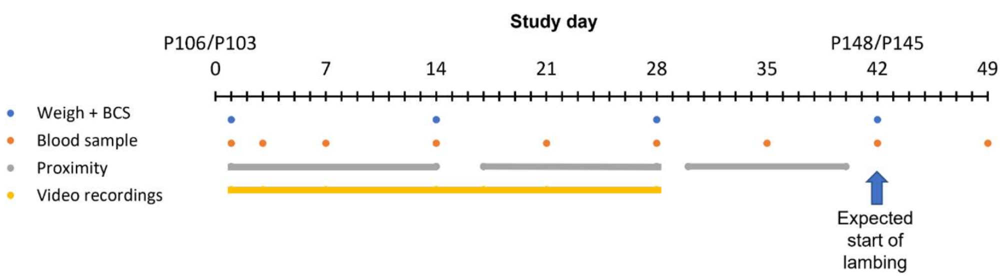

Figure 1. Timeline showing day of pregnancy (P) and study day of animal measurements in 2017 and 2018 including weighing and body condition scoring (blue dots), blood sample collection (orange dots) and recording of proximity to the water trough (grey bars) and video recording of trough behaviour (yellow bars) with the expected start of lambing indicated.

Blood samples were collected on study days 1, 3, 7, 14, 21, 28, 35, 42 and 49 to determine packed cell volume and total protein concentrations for a subset of ewes (n = 10 of each pregnancy rank in each treatment) to detect signs of dehydration (Figure 1). Blood samples were collected by jugular venepuncture using 20 G needles (BD Vacutainer Systems, Plymouth, UK) into two 10 ml vacuum tubes (BD Vacutainer, Preanalytical solutions, Franklin Lakes, USA) one containing no additive (total protein; TP) and the other sodium heparin (packed cell volume; PCV). The packed cell volume was determined using a microhaematocrit centrifuge (Haematospin, Hawksley, UK) and haematocrit capillary reader (7.5 mm Micro haematocrit reader, Hawksley, Lancing, United Kingdom). Total protein was determined using a handheld refractometer (Shoof, Cambridge, New Zealand).

All ewes were fitted with a halter to which a triaxial accelerometer (wGT3X-BT Actigraph, Pensacola, FL, USA) was attached. A receiver was placed within 1 m of the water trough in both the water and no water paddock. The devices remained on the ewes for two weeks (D1 to D14) after which they were removed to be downloaded and recharged before being returned (D17 to D28) and again for a final period (D30 to D42; Figure 1). The devices contained Bluetooth® technology (Trondheim, Norway) which were programmed to be either a beacon (ewes) or receiver (trough). Beacons sent signals containing their ID number at 10 s intervals. Receivers recorded the received signal strength indicator (RSSI) and identification number of any devices within its detection range once per minute. The distance between the receiver and each beacon was estimated using the RSSI as described by Sohi et al. (2017). Proximity was summarised into the minutes per week that each ewe was within 3 m of the receiver.

Surveillance video cameras (Essential E2, Bushnell, USA) were placed near each water trough to capture ewe drinking behaviour between D1 and D28 in 2017 and D1 and D30 in 2018. 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 30 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 the recorded footage were used to determine the frequency and duration of sheep drinking behaviour. Behaviours observed included; (i) sniffing water in which the ewe was observed to touch the water with its muzzle without ingesting water and (ii) drinking where water was ingested.

Herbage measurements

Herbage pluck samples were collected weekly from D1 to D42 to determine the herbage moisture content. Two samples per paddock of at least 100 g was hand plucked throughout the paddock to simulate ewe grazing. The samples were then weighed to determine their wet weight prior to being oven dried at 70°C for a minimum of 72 h. The samples were then re-weighed and the percentage loss of mass was recorded. The pasture moisture content was then calculated for each sample.

Weather data

Weather data for each study period from D1 until the end of the lambing period (18 July to 12 September 2017 and 17 July to 12 September 2018) 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. Data included daily means for wind direction (°), wind speed (m/s), relative humidity (%), solar radiation (MJ/m^2), minimum and maximum temperature (°C) and total rainfall (mm). The maximum temperature humidity index (THI) was calculated daily using the equation below where T_{Dry} and T_{Wet} were the dry and wet bulb temperatures, respectively (McDowell 1972).

$$THI = 0.72 \times (T_{Dry} + T_{Wet}) + 40.6$$

Statistical analyses

All statistical analyses were conducted using SAS 9.0 (SAS for Windows, SAS Institute Inc., Cary, NC, USA). Pasture moisture was analysed for each year separately using the Mixed procedure for repeated measures. The model contained the fixed effects of study day and treatment (water vs. no water) and their two-way interaction. If the interaction was non-significant it was removed, and the model was re-run. Data are presented as the least square means ± the standard error of the mean (SEM).

Ewe live weight, PCV, and TP were analysed for each year separately using the Mixed procedure for repeated measures. The models contained the fixed effects of study day (1, 14, 28 and 42), treatment (water vs. no water) and litter size (single vs. twin) and their two- and three-way interactions. The model also included ewe as the subject of the repeated measures. Any non-significant interactions were removed and the model re-run until either all interactions were significant or only the main effects remained.

The duration in minutes per week that ewes were estimated to be within 3 m of the water trough was analysed using the Mixed procedure for repeated measures. The models contained the fixed effects of study week (1–6), treatment (water vs. no water) and litter size (single vs. twin) and their two- and three-way interactions. Any non-significant interactions were removed and the model re-run until either all interactions were significant or only the main effects remained.

Results

Weather data

In 2017, maximum daily temperatures ranged between 9.8 and 20.4°C and with minimum temperatures between −2.2 and 11.2°C (Figure 2). In 2018, maximum temperatures ranged between 10.1 and 17.5°C and minimums between −1.2 and 12.1°C. During the 56 d recording period in 2017 and 2018 rainfall was recorded on 31 and 35 days, respectively. The total rainfall in the month of August was 74 and 108 mm in 2017 and 2018, respectively. Daily rainfall volumes ranged between 0.2 and 23.4 mm in 2017 and 0.2 and 22.0 mm in 2018. The calculated temperature humidity index ranged between 43.1 and 59.8 in 2017 and 46.7 and 59.5 in 2018.

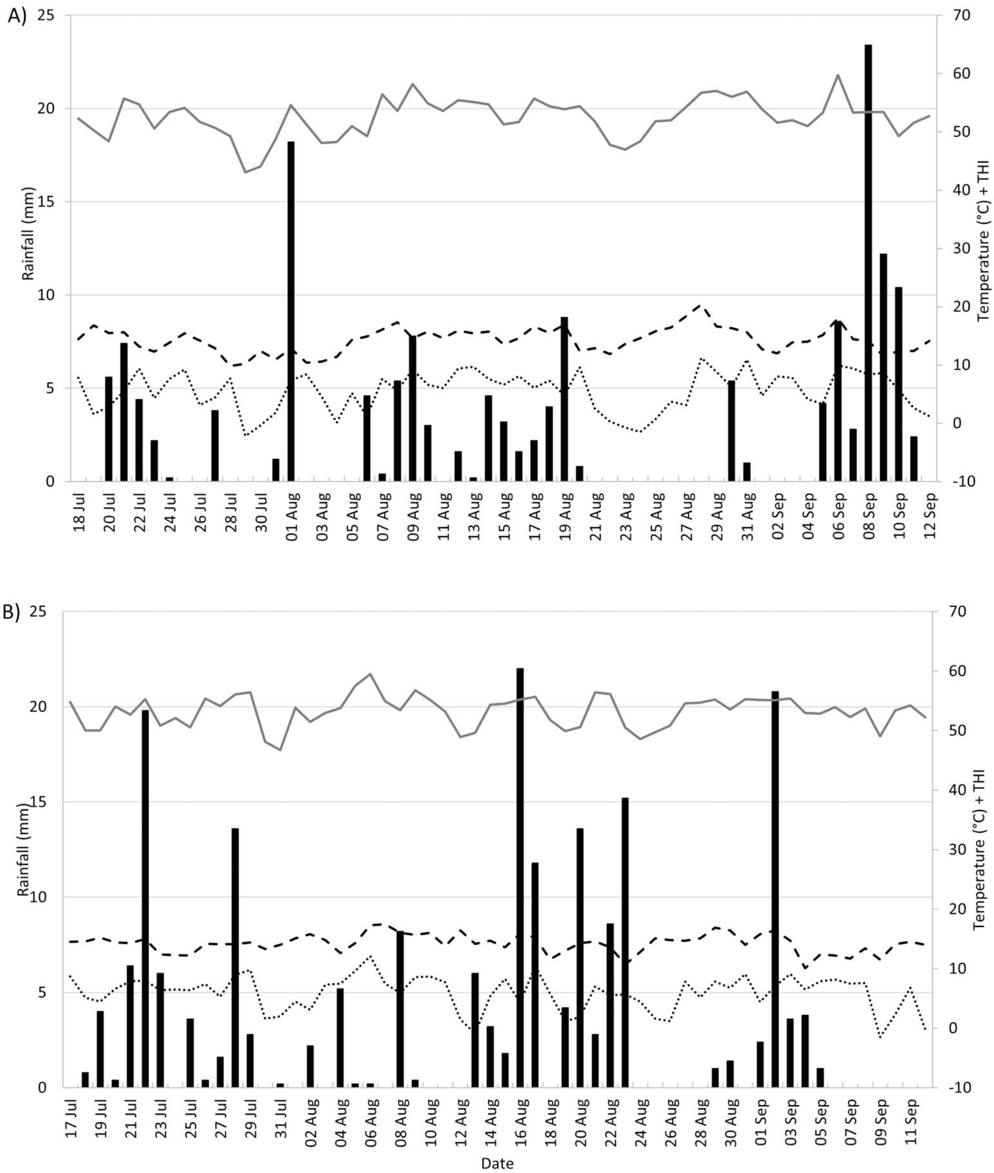

Figure 2. Weather data showing daily rainfall (mm; bars), minimum (dotted line) and maximum (dashed line) temperatures and the calculated temperature humidity index (THI, solid line) during the 2017 (A) and 2018 (B) study periods.

Pasture moisture content

The moisture content of the pasture offered to ewes ranged from 74% to 86% with a mean of 81.5 ± 0.7% in 2017 and 84.8 ± 0.4% in 2018 (Table 2). In 2017, the moisture content of the pasture differed between ewes in the no water and water treatments on study days 22 and 36. In 2018, the moisture content differed between treatments on days 4 and 22.

Table 2. Moisture content (%, mean ± SEM) of pasture offered to ewes in the no water and water treatment on study days 4, 8, 15, 22, 29 and 36 in 2017 and 2018.

Study Day	n *	2017 No water	2017 Water	n *	2018 No water	2018 Water
4	2	84.6 + 1.0 [d]	85.4 + 1.0 [d]	2	86.7 + 0.7 [d]	83.9 + 0.7 [bc]
8	2	78.9 + 1.0 [b]	79.7 + 1.0 [bc]	2	84.9 + 0.7 [cd]	86.0 + 0.7 [cd]
15	2	83.9 + 1.0 [d]	84.7 + 1.0 [d]	2	86.4 + 0.7 [d]	86.1 + 0.7 [d]
22	2	83.2 + 1.0 [d]	78.9 + 1.0 [b]	2	84.9 + 0.7 [cd]	84.9 + 0.7 [cd]
29	2	82.5 + 1.0 [cd]	79.3 + 1.0 [b]	2	82.1 + 0.7 [b]	79.7 + 0.7 [a]
36	2	74.3 + 1.0 [a]	82.5 + 1.0 [cd]	2	85.7 + 0.7 [cd]	86.9 + 0.7 [d]

[abcd]Within each year different letters indicate significant differences ($P < 0.05$). * n = the number of samples.

Ewe live weight and BCS

In each of the two years twin bearing ewes were heavier than singles throughout each study period ($P > 0.05$; Table 3). Among twin-bearing ewes there was no difference ($P > 0.05$) in live weight in the no water and water treatments in either 2017 or 2018. There were no differences in ewe liveweight among single ewes in 2017 but in 2018 single ewes in the water treatment were lighter than those in the no water treatment at D28 and D42 ($P < 0.05$). Ewe body condition scores did not differ ($P > 0.05$) between litter size or treatment at any time in either 2017 or 2018 (Table 4).

Litter weight

In both 2017 and 2018, within each pregnancy rank, there were no treatment differences in litter weight ($P > 0.05$; Table 5). In both years of the study, twin litters were heavier than singles ($P < 0.05$).

Total protein and packed cell volume

Overall, total protein and packed cell volume varied throughout each study but remained below the upper limit of the normal range in both treatments (Figure 3). In 2017, on D42 the total protein concentration of single- and twin-bearing ewes in the water treatment dropped below the lower limit of the normal range and on D49 twin-bearing ewes in the

Table 3. Live weight (± SEM, kg) of ewes bearing single and twin litters assigned to the water or no water treatment in 2017 and 2018.

Pregnancy rank	Treatment	n	D1	n	D14	n	D28	n	D42
					2017				
Single	No water	19	68.6 ± 1.5 [a]	20	75.7 ± 1.5 [bcd]	19	78.2 ± 1.5 [cde]	18	83.6 ± 1.6 [f]
Single	Water	18	67.3 ± 1.6 [a]	20	73.6 ± 1.5 [b]	19	75.3 ± 1.5 [bc]	19	82.5 ± 1.5 [ef]
Twin	No water	20	74.1 ± 1.5 [bc]	20	80.0 ± 1.5 [def]	19	83.2 ± 1.5 [f]	20	89.7 ± 1.5 [g]
Twin	Water	18	71.5 ± 1.5 [ab]	20	80.4 ± 1.5 [ef]	20	82.8 ± 1.5 [f]	19	88.4 ± 1.5 [g]
					2018				
Single	No water	19	56.6 ± 1.5 [ab]	20	64.3 ± 1.5 [cd]	19	70.9 ± 1.5 [efg]	19	73.8 ± 1.5 [ghi]
Single	Water	20	54.8 ± 1.5 [a]	20	61.7 ± 1.5 [c]	19	62.2 ± 1.5 [cd]	20	66.5 ± 1.5 [de]
Twin	No water	20	61.0 ± 1.5 [bc]	20	69 ± 1.5 [ef]	18	75.5 ± 1.6 [hi]	19	77.2 ± 1.5 [i]
Twin	Water	20	61.5 ± 1.5 [c]	20	70 ± 1.5 [efg]	20	71.2 ± 1.5 [fgh]	20	76.2 ± 1.5 [i]

[abcdefghij]Different letters indicate significant differences ($P < 0.05$) within each year.

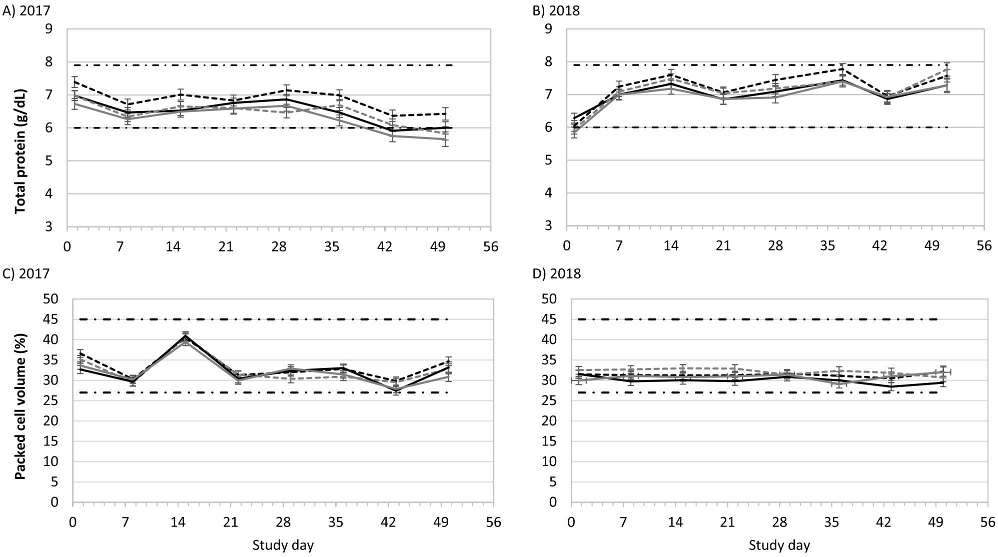

Figure 3. Mean serum total protein concentration (±SEM; g/dL panel A and B) and packed cell volume (±SEM; %, Panel C and D) of ewes in the water (solid) and no water treatment (dashed) bearing either single (black) or twin lambs (grey) in 2017 and 2018 showing the respective upper and lower normal ranges (dash dot)

no water treatment also dropped below the lower limit (Figure 3A). In 2018, total protein concentrations on study D1 for twin-bearing ewes in both the water and no water treatments were below the normal range but thereafter remained within the normal range (Figure 3B). In both years packed cell volumes remained within the normal range throughout the study period for both single- and twin-bearing ewes in both treatments (Figure 3C and D).

In 2017, the total protein concentration of single-bearing ewes in the no water treatment was greater ($P < 0.05$) than the water at D15 (7.0 ± 0.2 and 6.5 ± 0.2 g/dL, respectively) and D36 (7.0 ± 0.2 and 6.5 ± 0.2 g/dL, respectively; Figure 3A). Among twin-bearing ewes total protein concentrations were greater ($P < 0.05$) for ewes in the no water compared to water treatment at D36 (6.7 ± 0.2 and 6.2 ± 0.1 g/dL, respectively). No other differences ($P > 0.05$) were observed. In 2018, differences ($P < 0.05$) in total protein were observed among single-bearing ewes in the no water and water treatments at D29 (7.4 ± 0.2 and 7.1 ± 0.1, respectively; Figure 3B). Among twin-bearing ewes differences ($P < 0.05$) in total protein concentrations ($P < 0.05$) were observed between the no water and water treatments at D50 (7.8 ± 0.2 and 7.3 ± 0.2 g/dL, respectively).

In 2017, packed cell volumes of single-bearing ewes were greater ($P < 0.05$) in the no water than water treatment at day 1 (36.6 ± 1.0 and 32.7 ± 1.0%, respectively; Figure 3C). In 2018, no differences in packed cell volume were observed between treatment groups at any time ($P > 0.05$; Figure 3D).

Proximity to the water trough

The total time that individual ewes were within 3 m of the water trough ranged between 0 and 6.9 h across the 49 days of observation in 2017 and 0–7.9 h in 2018. Trough proximity showed a 2-way interaction of treatment with hour of the day ($P < 0.05$; Figure 4) whereby ewes in the water treatment showed a higher frequency within proximity to the trough between midday and 4 pm than the no water treatment ($P < 0.05$). In 2018, the ewes in the water treatment showed a less clear pattern with a greater frequency of ewes

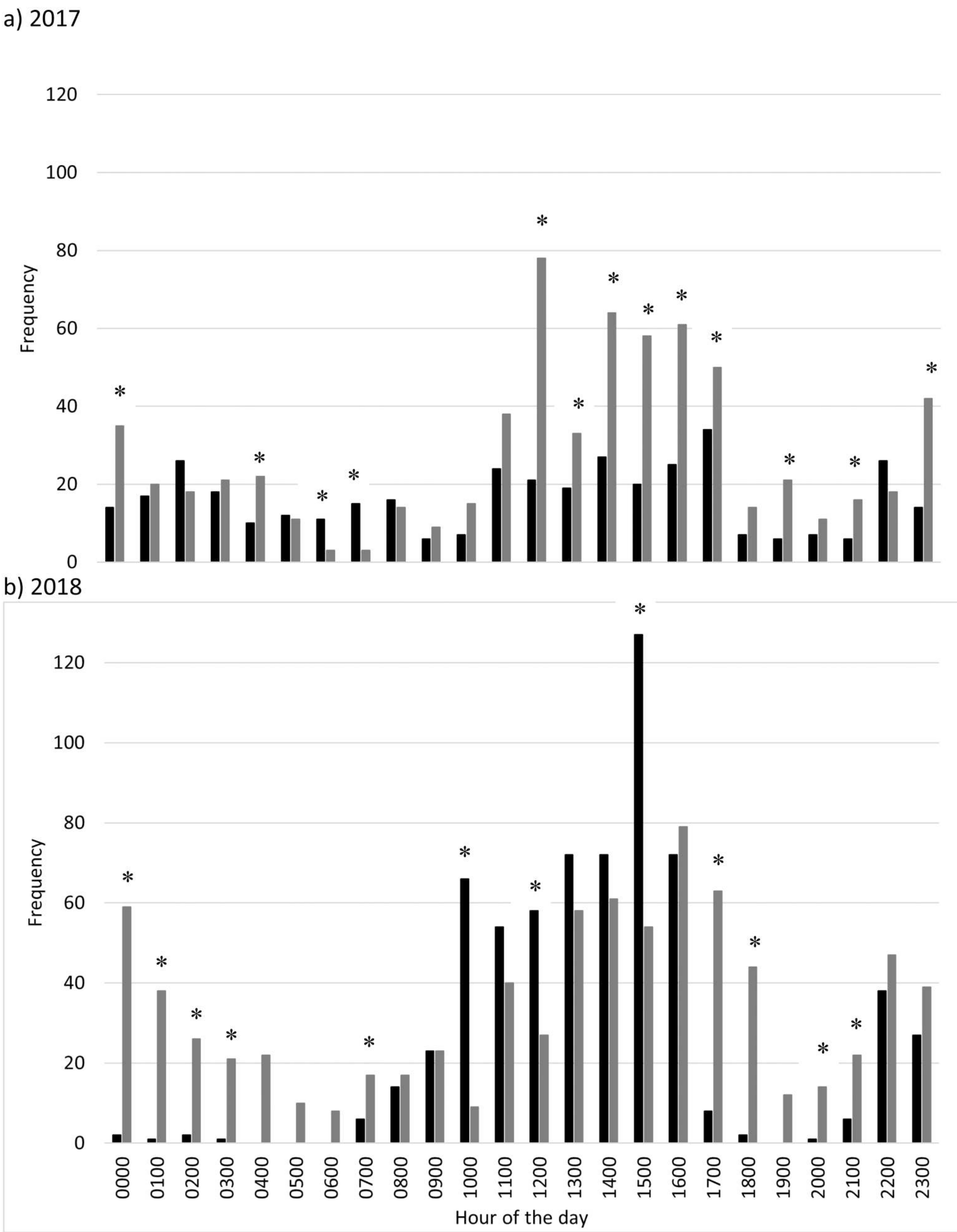

Figure 4. Frequency of ewes in the no water (black bars) and water (grey bars) treatments that were detected within 3 m of the water trough by hour of the day in (a) 2017 and (b) 2018. * indicates differences between treatments was significant ($P < 0.05$).

in proximity to the trough during the night (midnight to 0300 h; $P < 0.05$) than the no water treatment and fewer ewes at 1000, 1200 and 1500 h ($P < 0.05$).

Ewe drinking behaviour

Observations of ewe interaction with the water trough were made for those ewes in the water treatment between D1 and 28 in 2017 and D1 and D30 in 2018. Sixty-three video files in 2017 and 50 in 2018 showed ewes interacting with the trough by either drinking or sniffing the water. The number of trough interactions varied widely between ewes in both years with the majority of ewes visiting either once (n = 8 of 40 ewes in 2017 and n = 12 of 40 ewes in 2018) or not at all (n = 18 of 40 ewes in 2017 and n = 22 of 40 ewes in 2018) during each 49-day study period each year (Figure 5). The predominant ewe trough interaction behaviour was drinking (n = 59 of 63 observations in 2017 and n = 34 of 50 observations in 2018), however, some ewes were also observed to sniff the water (n = 4 observations in both 2017 and 2018).

Trough interactions were observed between 1000 and 1600 h in 2017 and between 1000 and 1700h in 2018. In both years the majority of trough interactions were observed between 11 am and 1 pm (n = 45/63 in 2017 and n = 35/50 in 2018; data not shown).

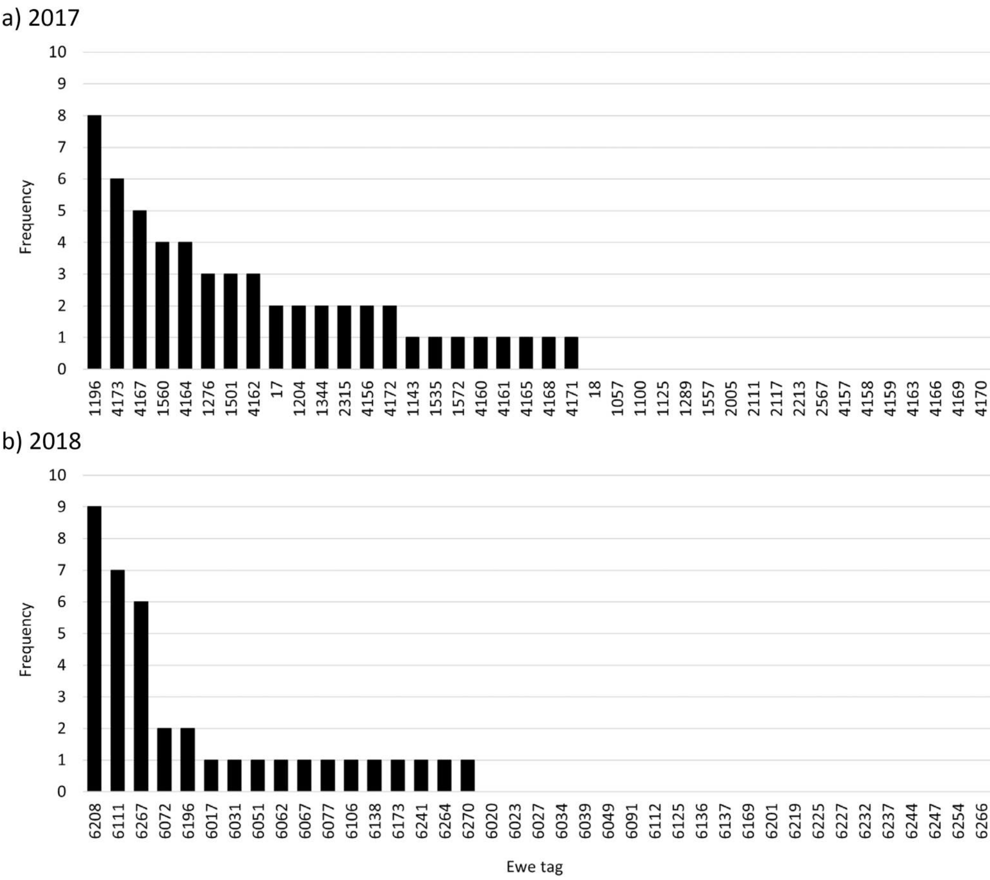

Figure 5. The frequency (n) of trough interactions for each ewe in the water treatment in (a) 2017 and (b) 2018.

Table 4. Body condition score (BCS) with 95% confidence interval in parentheses of ewes bearing single and twin litters assigned to the water or no water treatment in 2017 and 2018.

Pregnancy rank	Treatment	n	Body condition score D1	n	D14	n	D28	n	D42
					2017				
Single	No water	18	3.7 (3.5-3.9)	20	3.6 (2.8-4.5)	19	3.7 (3.0-4.7)	18	3.5 (2.8-4.5)
Single	Water	17	3.6 (3.4-3.8)	20	3.5 (2.8-4.5)	19	3.5 (2.8-4.5)	19	3.4 (2.6-4.3)
Twin	No water	19	3.6 (3.4-3.7)	20	3.6 (2.8-4.5)	19	3.6 (2.8-4.5)	20	3.3 (2.6-4.2)
Twin	Water	19	3.4 (3.2-3.7)	20	3.6 (2.9-4.6)	20	3.5 (2.7-4.4)	19	3.3 (2.6-4.2)
					2018				
Single	No water	19	2.9 (2.2-3.7)	20	3.3 (2.5-4.1)	19	3.4 (2.7-4.3)	-	-
Single	Water	17	2.8 (2.1-3.6)	20	3.1 (2.4-3.9)	18	3.1 (2.4-4.0)	-	-
Twin	No water	19	3.1 (2.4-3.9)	20	3.2 (2.5-4.1)	18	3.5 (2.7-4.5)	-	-
Twin	Water	19	3.1 (2.4-4.0)	20	3.3 (2.6-4.2)	20	3.5 (2.7-4.4)	-	-

Table 5. Litter weight (± SEM, kg) of ewes bearing single and twin litters assigned to the water or no water treatment in 2017 and 2018.

Birth rank	n	Treatment No water	n	Water
		2017		
Single	16	6.8 ± 0.4 [a]	18	6.7 ± 0.4 [a]
Twin	18	11.0 ± 0.4 [b]	19	11.6 ± 0.4 [b]
		2018		
Single	17	6.4 ± 0.4 [a]	15	6.4 ± 0.5 [a]
Twin	15	9.8 ± 0.4 [b]	19	9.6 ± 0.4 [b]

[ab]Different letters indicate significant differences ($P < 0.05$) within each year.

Discussion

The aim of the current study was to determine if providing access to a reticulated water trough influenced the behaviour, productivity and physiological indicators of hydration in mature ewes in late pregnancy under pastoral grazing conditions. The provision of a reticulated water trough in the current study, compared to no access, had no impact on single or twin ewe live weight in 2017 or twin ewes in 2018. Among single ewes in 2018, however, ewes offered reticulated water were lighter by 7 kg at weaning than those with no access. The reason for the difference in live weight is unclear as pasture masses recorded on D22 and D28 and were in excess of 1200 kgDM/ha which is considered sufficient to allow unrestricted intake for ewes in pregnancy (Morris and Kenyon 2004). The birth weight of lambs was unaffected by the treatment group of the dam indicating there was no impact on fetal growth. In late-pregnancy fetal growth is exponential resulting in a sharp increase in ewe energy demand (Koong et al. 1975; Mellor 1983; Bazer et al. 2012), therefore, if feeding was insufficient during this time an impact on lamb birth weight would be expected. The ewe live weight and body condition score also suggest that the ewes in the study were gaining more weight than the conceptus alone, further supporting the conclusion that their feeding was in excess of pregnancy maintenance requirements.

Packed cell volume and serum total protein concentrations are often used to provide an indication of the hydration status of animals (Hamadeh et al. 2006). Throughout the study period in both years both PCV and TP remained within the normal range for sheep (Cork and Halliwell 2019; MSD Veterinary Manual 2024). This is perhaps unsurprising given the moisture content of the pastures grazed in the current study ranged between

75% and 86% and pasture masses were at least 900 kg DM/ha. Theoretically, using the metabolisable energy equations of Nicol and Brookes (2007) and ewe live weights recorded for single-bearing ewes in the current study they would be likely eating 3.1 and 2.9 kgDM/d of pasture with an metabolisble energy content of 11 MJ/kgDM on D1 (~P106) and D42 (~P142), respectively. If this level of green herbage with a moisture content of 75% is eaten, the ewe would also likely consume 9.4 and 8.8 L of water per day which is in excess of the daily water requirements of 3.1–7.6 L suggested for ewes in late pregnancy (Agricultural Research Council 1980; Schlink et al. 2010; Meehan et al. 2015).

Trough interactions of ewes offered access to a reticulated water trough were highly variable between ewes in both years of the current study. In 2017, 45% of ewes and in 2018, 55% of ewes did not visit the trough at any time during the 28- and 30-day observation periods. A small number of ewes were observed to visit somewhat frequently with five ewes visiting four or more times in 2017 and two or more times in 2018, although this was less than daily. These findings were in agreement with our previous observations of ewe drinking behaviour in the Manawatu and Wairarapa regions of New Zealand in summer whereby the majority of ewes were not observed to drink during observation periods of between 15 and 30 days in length (Corner-Thomas et al. 2022). Further Bunyaga et al. (2023) reported that over winter ewes with access to a natural waterway in the Manawatu region had less than 1% of their GPS location fixes within 3 m of the stream which made up 9% of the paddock area and only 5 ewes were observed to drink during the 15 d study period.

The observed low incidence of drinking observed in the current study is in agreement with Wilson (1974) and Macfarlane et al. (1966) who reported that sheep were not observed to drink free water after rainfall events or when pasture contained a high moisture content, respectively. Water intake, however, can be greatly influenced weather conditions, fleece length and the provision of shade when temperatures are above the animal's thermoneutral zone as they result in physiological changes to dissipate heat such as panting and sweating (Marai et al. 2007; Silva et al. 2024). Extreme care, therefore, should be taken in the extrapolation of the results of the current study as ewes were offered pasture masses that allowed unrestricted intake of pasture with a high moisture content and the weather conditions were cool.

The results of current study suggest that if sheep in New Zealand were to be restricted from accessing natural water sources on large extensive properties, reticulated watering points could be small and still meet their water intake needs and the farmers' obligations under the Animal Welfare Act (Anon 1999). Before this can be confirmed, however, further studies throughout the year and in varying locations and under differing environmental conditions are required.

Conclusion

There were no negative production or physiological effects when ewes had no access to a reticulated water trough in late pregnancy under conditions in which they were offered minimum pasture masses of 900 kg DM/ha with a moisture content of between 74% and 86%. It is likely that ewes were able to meet their daily water requirements through the consumption of pasture alone as drinking behaviour was infrequent and in many cases absent.

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No potential conflict of interest was reported by the author(s).

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References

Agricultural Research Council. 1980. Requirements for energy. In: Nutrient requirements of ruminant livestock. Ed. Working Party on Nutrient Requirements of Ruminants. Slough: Commonwealth Agricultural Bureaux; p. 351.

Anon. 1999. Animal Welfare Act. https://www.legislation.govt.nz/act/public/1999/0142/latest/whole.html.

Bazer FW, Spencer TE, Thatcher WW. 2012. Growth and development of the ovine conceptus. J Anim Sci. 90(1):159–170.

Brown GD, Lynch JJ. 1972. Some aspects of the water balance of sheep at pasture when deprived of drinking water. Aust J Agric Res. 23(4):669–684.

Bunyaga A, Corner-Thomas R, Draganova I, Kenyon P, Burkitt L. 2023. The behaviour of sheep around a natural waterway and impact on water quality during winter in New Zealand. Animals. 13(9):1–20.

Cork SC, Halliwell R, editors. 2019. The veterinary laboratory and field manual, 3rd ed. Sheffield, U.K: 5m Books Ltd; p. 711.

Corner-Thomas RA, Bunyaga AS, Draganova I, Burkitt L, Kenyon PR. 2022. Drinking behaviour of ewes with access to a water trough during summer and autumn-a preliminary examination. N Z J Anim Sci Prod. 82:69–76.

Freer M. 2007. Nutrient requirements of domesticated ruminants. Melbourne, Australia: CSIRO publishing; p. 270.

Hamadeh SK, Rawda N, Jaber LS, Habre A, Said A, Barbour M, K E. 2006. Physiological responses to water restriction in dry and lactating Awassi ewes. Livest Sci. 101(1):101–109.

Hodgson J, Cameron KC, Clark DA, Condron LM, Fraser T, Hedley MJ, Holmes CW, Kemp PD, Lucas RJ, Moot DJ, Morris ST. 2005. New Zealand's pastoral industries: efficient use of grassland resources. In: Reynolds SG, Frame J, editors. Grassland developments opportunities and perspectives. Enfield, New Hampshire, USA: Science Publishers, Inc; p. 181–205.

Jefferies BC. 1961. Body condition scoring and its use in management. Tasman J Agric. 32(1):19–21.

Kenyon PR, Maloney SK, Blache D. 2014. Review of sheep body condition in relation to production characteristics. N Z J Agric Res. 57(1):38–64.

Koong LJ, Garrett WN, Rattray PV. 1975. A description of the dynamics of fetal growth in sheep. J Anim Sci. 41(4):1065–1068.

Macfarlane WV, Dolling CHS, Howard B. 1966. Distribution and turnover of water in Merino sheep selected for high wool production. Aust J Agric Res. 17(4):491–502.

Marai IFM, El-Darawany AA, Fadiel A, Abdel-Hafez MAM. 2007. Physiological traits as affected by heat stress in sheep—a review. Small Rumin Res. 71(1–3):1–12.

McDowell RE. 1972. Improvement of livestock production in warm climates. San Francisco, USA: W. H. Freeman and Company; p. 711.

Meehan MA, Stokka GL, Mostrom MS. 2015. Livestock water requirements. NDSU Extension Service; https://ucanr.edu/sites/nichemarketing/files/341002.pdf.
Mellor DJ. 1983. Nutritional and placental determinants of fetal growth-rate in sheep and consequences for the newborn lamb. Br Vet J. 139(4):307–324.
Morris ST, Kenyon PR. 2004. The effect of litter size and sward height on ewe and lamb performance. N Z J Agric Res. 47(3):275–286.
MSD Veterinary Manual. 2024. https://www.msdvetmanual.com/.
New Zealand Government. 2020. National policy statement for freshwater management. Ministry for the Environment. https://environment.govt.nz/publications/national-policy-statement-for-freshwater-management-2020-amended-january-2024/.
New Zealand Government, Ministry for Primary Industries. 1999. Animal Welfare Act. https://www.legislation.govt.nz/act/public/1999/0142/latest/whole.html.
Nicol AM, Brookes IM. 2007. The metabolisable energy requirements of grazing livestock. In: Rattray PV, Brookes IM, Nicol AM, editor. Pastures and supplements for grazing animals. Occasional publication No. 14. Hamilton, New Zealand: The New Zealand Society of Animal Production; p. 151–172.
Rattray PV, Brookes IM, Nicol AM, editors. 2017. Pastures and supplements for grazing animals. Christchurch, New Zealand: New Zealand Society of Animal Production; p. 339.
Schlink AC, Nguyen ML, Viljoen GJ. 2010. Water requirements for livestock production: a global perspective. Rev Sci Tech. 29(3):603–619.
Silva RdS, Furtado DA, Ribeiro NL, Neto JPL, Rodrigues RCM, Oliveira Ad, Silva JdC, Silva Md, Mascarenhas NMH, Marques JI, Morais Fd. 2024. Physiological variables and estimates of heat exchange in sheep kept at thermoneutral and thermal stress temperatures. Small Rumin Res. 237:1–8.
Sohi R, Trompf J, Marriott H, Bervan A, Godoy BI, Weerasinghe M, Desai A, Jois M. 2017. Determination of maternal pedigree and ewe–lamb spatial relationships by application of Bluetooth technology in extensive farming systems. J Anim Sci. 95(11):5145–5150.
Stewart G, Rout RS. 2007. Reasonable stock water requirements: guidelines for resource consent applications. Horizons Regional Council; p. 37.
White J, Hodgson JG. 1999. New Zealand pasture and crop science. South Melbourne, Victoria, Australia: Oxford University Press; p. 323.
Wilson AD. 1974. Water consumption and water turnover of sheep grazing semiarid pasture communities in New South Wales. Aust J Agric Res. 25(2):339–347.