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Variation in free water intake in lactating ewes

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Abstract

The aim of this study was to investigate individual free water intake (FWI) in lactating ewes, with two suckling lambs. Eighteen ewes were housed in single experimental pens from the time of lambing to two weeks after lambing. The ewes had free access to water from a drinking bowl and water meters were used to record the daily FWI. On average, the FWI for the ewes was 14.42 l/day. The variation between individuals was large (CV 27.6 %) and varied between 8.16 l/day to 21.88 l/day. It was also large variation within individuals (CV 19.2 %). Hay DM intake were the factor that affected the FWI the most. Due to the large variation between and within ewes, FWI are not a stable individual characteristic. This study is useful for farmers to understand water supply needed for lactating ewes.

Key words: free water intake, individual variation, lactating ewes

1. Introduction

Several animal and environmental factors affect free water intake (FWI) by drinking in sheep, such as dry matter (DM) intake (Forbes 1968; More et al. 1983; Bøe 1984; Baumont et al. 1997), the animals physiological stage (growing, pregnancy or lactation) (Forbes 1968), body weight (NRC 2007), ambient temperature (Macfarlane et al. 1958; Forbes 1968) and wool length (Macfarlane et al. 1958). Correspondingly, Appuhamy et al. (2016) reviewed and developed models for predicting FWI by dairy cows and confirmed that DM intake, dietary DM, crude protein (CP), Na and K concentrations, and daily mean ambient temperature were positively and independently related to FWI.

Bøe et al. (2012) did a study on pregnant ewes and found that FWI varies between 2.56 ± 0.15 and 4.93 ± 0.11 l/day/ewe, which is comparable to previous studies (Forbes 1968; Bøe 1984). In lactating ewes, Forbes (1968) reports that water intake per kg DM intake the first seven weeks of lactation varies from 3.40 – 4.41 kg whereas Davies (1972) reports a variation from 3.33 – 3.47 kg/kg the first three weeks of lactation. Because these studies were looking at total water intake (sum of FWI and water contained in the feed) as weekly mean for all the ewes neither Forbes (1968) nor Davies (1972) provide data on actual FWI and individual variation. Hence, there seem to be very limited data available on individual FWI in lactating ewes.

Recommendations in general (e.g. (NRC 2007)) underline the importance of adequate access to drinking water. When ewes are given water every 72 hours compared to daily watering, an increase in abortion rates in pregnant ewes, as much as 50% drop in milk production in lactating ewes and increased lamb mortality have been observed in the cool and dry season in Nigeria with temperature varying between 19 and 30 °C (Aganga et al. 1990).

The aim of this study was to investigate the variation in individual FWI in lactating ewes with two suckling lambs from the time of lambing to two weeks after lambing.

2. Materials and methods

2.1 Animals, experimental pens and feeding

The experiment was conducted during the lambing season in April and May at the Norwegian University of Life Sciences at Ås, Norway. The experimental period was 14 days for each ewe, starting directly after lambing. Twenty-two ewes of the Norwegian Nor-X breed with twin lambs from the University herd were selected for the experiment. Four of which had to be removed from the experiment. One ewe had to be removed because of veterinary treatment over a longer period. Additional two ewes were afraid of putting their head into the feed container; therefore, the hay DM intake was unrealistically low. The lambs of the fourth ewe used the feed container as creep area, making the quality of the hay poor and, consequently, also had an unrealistic low hay DM intake. Hence, the experiment involved 18 ewes with a mean age of 2.4 years (range 2–5 years).

Every morning at approximately 08:00, ewes that had been lambing during the previous night were moved into an uninsulated experimental room with single experimental pens. The mean daily air temperature was 13.6 ± 0.2 °C in this room and the variation during the experimental period was negligible. Each experimental pen measured 1.63 m x 1.88 m (3.06 m^2) and had expanded plastic flooring. Two small containers were accessible at the front of the pen; one with hay and one with straw bedding to create a creep area for the lambs. A standard drinking bowl (Suevia modell 12 P, Suevia GmbH, Kirchheim, Germany) was positioned at the back wall 0.60 m above floor level. The flow rate of each drinking bowl was checked before and after the experiment in order to assure that the flow rate was between 4.0 and 6.0 liters per minute. The water bowls were cleaned whenever necessary.

The animals were weighed on an electronic balance and the mean body weight of the ewes was 84.1 ± 2.0 kg at Day 2, 81.8 ± 2.1 kg at Day 7 and 79.7 ± 1.8 kg at Day 14. Mean body weight of the lambs was 5.5 ± 0.1 kg at Day 0, 8.5 ± 0.2 kg at Day 7 and 11.5 ± 0.3 kg at Day 14.

The composition of the hay fed to the ewes was: DM, 889 g/kg; CP, 90 g/kg DM; NDF, 668 g/kg DM; Net energy lactation (NEL), 4.7 MJ/kg DM. The ewes were offered hay for *ad libitum* intake twice daily, in the morning and afternoon (approximately 10% hay residues). To record the actual daily hay DM intake, both hay provided and the remaining hay after feeding was weighed on an electronic balance. Eleven ewes had missing data for hay DM intake one day of the study because of missing registration. This data was removed before analysis because it was considered missing at random. The ewes were also offered 0.5 kg standard pelleted concentrate twice daily (Formel Sau, Felleskjøpet, Norway: DM, 920 g/kg; crude protein, 170 g/kg DM; NEL, 6,5 MJ/kg DM). In addition, the ewes had access to salt stone and mineral and vitamin mixture (Felleskjøpet, Norway). The DM content of the hay was obtained by oven-drying at < 60 °C to constant weight and weighed warm. Crude protein was determined by the Kjeldahl method on a Kjeltec Auto 2400/2600 (Tecator AB, Höganäs, Sweden), and NDF was determined according to Mertens (2002) using Na-sulphite, alpha amylase and ash correction. Rumen digestible organic matter (VOS) was determined according to Lindgren (1979), and used to calculate the concentration of metabolizable energy (ME) in the roughage according to Lindgren (1983). The concentration of NEL in hay was calculated from ME according to Van-Es (1978). Concentrate chemical and energy content were set as declared by the manufacturer.

2.2 Free water intake (FWI) and water quality

To record the daily FWI, water meters (ResidiaJet, Sensus, Stara Tura, Slovakia, accuracy ± 0.1 liter) were connected to the water pipelines of each water dispenser and the water meters were read at 08:00 every morning, before feeding, during the experimental period.

To examine the water quality, samples from each of the 18 water bowls were taken in the middle of the experimental period. A sterilized ladle was used to ladle water from a tap into sterilized and sealed plastic bottles that were analyzed for heterotrophic bacteria at 22 °C (cfu/ml), coliform bacteria (cfu/100 ml) and turbidity (FNU). To control the general water quality in the barn, a sample was also taken from a sterilized water tap and analyzed for heterotrophic bacteria, coliform bacteria, turbidity and *E. coli* (cfu/100 ml). The water quality differed between the water bowls but all were within the recommended limits for sheep drinking water.

2.3 Statistical analysis

To analyze the effect of number of days after birth (1–14), hay DM intake, age of the ewe and weight change (ewes' and lambs') on ewes' FWI, one single linear mixed-effects model was used (using nlme package in R; (Lenth 2015)). The same model was also used to analyze the effect of the same parameters (hay DM intake replaced with ewes' FWI) on the ewes' hay DM intake. All predictor variables were continuous, and were mean-centered prior to analysis. All ewes received and consumed the same amount of concentrates and consumption of concentrate is, therefore, not included in the statistical model. Normality of the residuals was confirmed for the models. The statistical significance of the parameters are reported using their regression coefficients (β), standard errors (SE) and P values. To find the best-fitting models affecting FWI and ewes' hay DM intake, we conducted model selection using a stepwise procedure, removing predictors with P values higher than 0.05 and evaluating the influence on Akaike's information criterion (AIC). The final models had the lowest AIC values by at least 2 points. Simple linear regression was used to analyze the correlation between water and hay DM intake and the RMSE, the R-square and the P value are reported. Individual variation was analyzed with the coefficient of variation (CV). Individual data from each ewe were used as experimental units. Statistical significance was set at $P < 0.05$.

3. Results

3.1 Free water intake and factors affecting free water intake

The total mean FWI was 14.42 liters per day and ewe during the experimental period. The ewe with the highest mean FWI drank 21.88 l/day whereas the ewe with the lowest mean FWI drank only 8.16 l/day. Hence, the variation between individuals was large (CV = 27.6%). The absolute lowest (minimum value) observed FWI for one day was 5.00 l whereas the absolute highest (maximum value) was 28.50 l.

In general, the mean FWI increased slightly from 12.39 l/day at Day 1 to 15.75 l/day at Day 14 (Figure 1).

Figure 1 here.

It is also to note the large variation (CV = 18.9%) in FWI within individuals over the 14-day experimental period. The minimum CV was 12.0% and the maximum CV was 33.0%. The ewe with the largest numerical difference consumed 9.00 liters on the day with the lowest FWI (Day 4) and 26.00 liters on the day with the largest FWI (Day 1), hence 17.00 liters in difference.

The best fitted model, with the lowest AIC value by at least 2 points, included the ewes' hay DM intake and weight change of the lambs (weight gain of 429 g/day) as predictor variables only (Table 1). In this model, the ewes' intake of hay was the most important factor affecting the ewes' FWI and increased hay intake increased the FWI. The weight change of the lambs was not significant but its removal from the model resulted in a less than 2 point improvement in AIC, so it was not removed from the final model.

Table 1 here.

When looking at the descriptive statistics, the weight of the ewes actually decreased by 314.3 g/day throughout the experimental period, but its removal from the regression model improved the AIC value so it was not included in the final model. Number of days after birth and age of the ewes had also no significant importance for the ewes' FWI, and its removal from the regression model improved the AIC value and was therefore not included in final model.

3.2 Hay DM intake and factors affecting hay DM intake

The total mean daily hay intake was 1.73 kg DM per ewe during the experimental period. The ewe with the highest mean daily hay intake consumed 2.18 kg DM whereas the ewe with the lowest mean daily hay intake consumed only 1.42 kg DM. The calculated CV between ewes was 13.42%.

The best fitted model, with the lowest AIC value by at least 2 points, included FWI and number of days after birth as predictor variables only (Table 2). FWI had effect on the ewes' hay intake. In general, the mean hay intake increased from 1.41 kg DM/day at Day 1 to 2.08 kg DM/day at Day 14 (Figure 2), and the number of days after birth had also significant effect on the ewes' hay intake.

Table 2 here.

Figure 2 here.

There was a weak relationship between mean hay intake (kg DM/day) and FWI (l/day) for each lactating ewe ($y = 0.02x + 1.39$, $R^2 = 0.17$, $P = 0.09$).

4. Discussion

The total mean FWI in lactating ewes in the present study was 14.42 l/day and, as expected, much larger than what has been found in non-lactating ewes (e.g. (Bøe et al. 2012)). Because previous studies on lactating ewes (Forbes 1968; Davies 1972) have looked at total water intake and not FWI it is hard to do direct comparisons. However, it seems like the ewes in the present study had a higher water intake than reported in the studies done by Forbes (1968) and Davies (1972).

It is interesting to note the large individual differences in FWI between ewes. The ewe with the highest mean FWI drank as much as 21.9 l/day while the ewe with the lowest drank only 8.2 l/day. Some of the factors that could have affected the individual differences can be different habits and consumption of salt stone. Unfortunately, to our knowledge, no other papers seem to have reported data on individual variation in FWI in lactating ewes.

Water intake and milk yield are shown to be correlated in a number of ruminant species (e.g.; sheep (Aganga et al. 1990), goats (Alamer 2009), cows (Economides & Mavrogenis 1998; Meyer et al. 2004)). The lactation curve in ewes increases during the first three weeks before it slowly decreases again (Torres-Hernandez & Hohenboken 1980). Also, growth rate of lambs is correlated to milk yield of ewes, especially in early lactation (Snowder & Glimp 1991). In the present study it could be expected that the ewes' mean FWI increased in line with the increase in milk yield because weight gain of the lambs seems to be important for FWI. However, number of days after birth had no significant effect on FWI. This is probably because lactation stimulates water intake to a greater extent than can be accounted for solely by the water in the milk. It may be due to the higher metabolic rate of the lactating ewe and the greater need for water in vaporization and excretion (Forbes 1968). Also, a study on dairy cows by Kramer et al. (2008), found a low correlation between milk yield and water intake the first 30 days of lactation, but an increased correlation over the course of lactation.

As expected, hay DM intake was the most important factor affecting FWI in the present study. This result corresponds well with previous studies in other ruminants (sheep: (Forbes 1968), cows: (Murphy et al. 1983; Khelil-Arfa et al. 2012; Appuhamy et al. 2014)) where feed intake was found to be closely related to water consumption. However, the peak feed intake generally occurs approximately four weeks after the peak of lactation (Treacher & Caja 2002), and therefore it is reasonable to beliveve that a prolonged experimental period could have detected an increase in FWI in the present study.

FWI does not seem to be a stable individual characteristic due to the large variation within individuals (mean CV = 18.9%). When looking at the most extreme ewe, she drank 26.0 liters the day she drank the most and only 9.0 liters the day she drank the least. The large individual variation in FWI within lactating ewes is hard to explain and no other research seems to have investigated in this topic. However, previous studies have shown that sheep have an ability to respond to periods of water deprivation (Meissner & Belonje 1972). Further, Cockram et al. (1997) reported that sheep, in absence of food, can be transported 24 h without becoming dehydrated. After 12 h transportation sheep choose to eat before drinking when offered food and water in a lairage (Cockram et al. 1997). These results might help explain the large day-to-day variation in the present experiment.

5. Conclusion

Mean free water intake (FWI) was 14.42 l/day and ewe for the first two weeks of lactation, but the individual variation FWI between the ewes (8.2 – 21.9 l/day) and the variation from day to day within individuals was large. Hay DM intake was the most important factor affecting FWI and an increase in hay DM intake increased FWI. This study is useful for farmers to understand water supply needed for lactating ewes.

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Table 1. Statistical output for the first linear mixed-effects model and the best fitted linear mixed-effects model (final model) on lactating ewes' FWI. The statistical significance of the parameters are reported using their regression coefficients (β), standard errors (SE) and P values.

	β	SE	P value
First linear mixed-effects model, AIC = 1234.239			
Number of days after birth	0.095	0.054	0.078
Hay DM intake	2.449	0.746	< 0.01
Age of the ewe	-1.024	1.087	0.360
Weight change of the ewes	0.062	0.061	0.314
Weight change of the lambs	1.313	0.628	< 0.05
Best fitted linear mixed-effects model, AIC = 1227.513			
Hay DM intake	3.185	0.620	< 0.0001
Weight change of the lambs	1.132	0.625	0.072

Table 2. Statistical output for the first linear mixed-effects model and the best fitted linear mixed-effects model (final model) on lactating ewes' hay DM intake. The statistical significance of the parameters are reported using their regression coefficients (β), standard errors (SE) and P values.

	β	SE	P value
First linear mixed-effects model, AIC = 85.122			
Number of days after birth	0.037	0.004	< 0.0001
FWI	0.019	0.005	< 0.001
Age of the ewe	0.047	0.061	0.456
Weight change of the ewes	-0.002	0.005	0.721
Weight change of the lambs	0.050	0.053	0.344
Best fitted linear mixed-effects model, AIC = 64.297			
Number of days after birth	0.037	0.004	< 0.0001
FWI	0.019	0.005	< 0.0001

Legends to figures

Figure 1. Mean ± SE, maximum and minimum FWI in lactating ewes during two weeks after lambing.

Figure 2. Mean ± SE, maximum and minimum hay DM intake in lactating ewes during two weeks after lambing.