Small Ruminant Research 123 (2015) 118–123

Contents lists available at ScienceDirect

Small Ruminant Research

journal homepage: www.elsevier.com/locate/smallrumres

Attainment of puberty by ewes in the first year of life is associated with improved reproductive performance at 2 years of age

S.J. Edwards*, J.L. Juengel, A.R. O'Connell[1], P.D. Johnstone, P.A. Farquhar, G.H. Davis

Animal Reproduction, AgResearch Ltd., Invermay Agricultural Centre, Puddle Alley, Mosgiel 9053, New Zealand

ARTICLE INFO

Article history:
Received 24 July 2014
Received in revised form 9 November 2014
Accepted 10 November 2014
Available online 18 November 2014

Keywords:
Sheep
Puberty
Production efficiency

ABSTRACT

This study was conducted to investigate the effect of attaining puberty in the first year of life on future reproductive performance in ewes. Records were collected from 2091 ewes born between 2005 and 2009. In the first breeding season of life, receptivity to the ram was monitored to determine whether ewe lambs attained puberty or not. Ewes were then mated in order to produce a lamb at 2, 3 and 4 years of age and the following traits were measured each year: ovulation rate (OR), number of foetuses present at scanning (NLS), number of lambs born (NLB) and live weight at various time points. The percentage of ewe lambs attaining puberty was highly variable between years ($p < 0.001$) and this variability was not explained by differences in live weight. Attainment of puberty in the first year of life increased NLB at 2 years of age ($p < 0.001$), largely due to an increase in OR ($p < 0.01$). Ewes that attained puberty in their first year were more likely to become pregnant at 2 years of age ($p < 0.01$) and produced more multiple births and fewer singletons ($p < 0.05$). These differences were not maintained at 3 and 4 years of age although differences in live weight remained ($p < 0.001$). These results demonstrate that attaining puberty in the first year of life improves reproductive performance as a 2 year old, increasing NLB by 20 lambs per hundred ewes and reducing the incidence of non-pregnant ewes. This has implications for improving the efficiency of sheep production on-farm.

1. Introduction

Strategies to increase the reproductive efficiency of the ewe are crucial to the future profitability of sheep farming. Tools such as genetic selection and nutritional flushing for increasing ovulation rate are increasingly being used to improve lambing rates and, thereby, reproductive efficiency. Further, some sheep farming systems include the breeding of ewes in their first year of life (Kenyon et al., 2004; Gaskins et al., 2005) so that they lamb at 1 year of age. Such practice can result in a reduced live weight at mating in their second year but this is recovered by the time the lambs are weaned (Kenyon et al., 2008). Ensuring adequate feed availability can limit such negative effects (Kenyon et al., 2014). In order to successfully breed these ewes, they must attain puberty by approximately 8 months of age. Hence, age at onset of puberty is a key event contributing to lifetime reproductive efficiency.

* Corresponding author. Tel.: +64 3 489 9043.
E-mail addresses: sara.edwards@agresearch.co.nz (S.J. Edwards), jenny.juengel@agresearch.co.nz (J.L. Juengel), peter.johnstone@agresearch.co.nz (P.D. Johnstone).
[1] Present address: Blue River Dairy LP, PO Box 1547, Invercargill, New Zealand.

http://dx.doi.org/10.1016/j.smallrumres.2014.11.006
0921-4488/

Older work showed that ewes that ovulated in the first breeding season of life had a higher ovulation rate as a 2 year old (Hight and Jury, 1976) and improved lifetime reproductive performance (Hulet et al., 1969). Ewes that lambed at 1 year of age were found to be more productive in the following 3 years (Levine et al., 1978). In contrast, Saoud and Hohenboken (1984) showed no correlation between age at first oestrus and later reproductive performance and Ch'ang and Rae (1972) suggested that selection on the basis of live weight (rather than oestrus) at one year of age had the highest predictive value for fertility of the ewe.

The number of breeding ewes in New Zealand has decreased by approximately 50% over the last 2 decades (Geenty, 2013), while the quantity of sheep meat exported has been maintained at around 350,000 tonnes per year (Statistics New Zealand). Hence the modern ewe is quite different to those studied 30 years ago. This is due, at least in part, to genetic selection for increased NLB, and increased lamb growth, thereby improving meat production efficiency. Under intensive farming conditions, ewes producing twin litters are more efficient than ewes producing single lambs. The aims of the current study were to determine the effect of attaining puberty by 1 year of age on future lifetime performance and understand the factors affecting the age of onset of puberty in the modern ewe.

2. Materials and methods

2.1. Animals

This trial was conducted at Invermay Agricultural Centre in the South Island of New Zealand (46°S, 170°E). Manipulations were carried out in accordance with the 1999 Animal Protection (Codes of Ethical Conduct) Regulations of New Zealand and were approved by the Invermay Agricultural Centre Animal Ethics Committee. All animals were sourced from Invermay research flocks and were of Romney or Romney-cross background. The research flocks had been selected on the basis of their fertility, and included animals with putative genes affecting ovulation rate (Juengel et al., 2013) and embryo survival (Juengel et al., 2012). All ewe lambs born in the research flocks at Invermay in September–October (Spring) between 2005 and 2009 that were retained for the purpose of breeding were included in the trial. Ewe lambs were exclusively grazed on pasture with free access to water for the period of oestrus monitoring and live weight was recorded monthly during this period. At the conclusion of oestrus monitoring, animals were either moved onto brassica crops or provided with supplemental feed (hay or silage) as needed to meet dietary requirements. Ewes were maintained according to normal farm practice and live weight was monitored. Ewes were bred to lamb at 2, 3 and 4 years of age and phenotypic measurements were obtained.

2.2. Oestrus monitoring and mating

In February each year (22nd February 2006, 20th February 2007, 19th February 2008, 17th February 2009, 16th February 2010) vasectomised Poll Dorset rams fitted with mating harnesses and crayons were introduced to the ewe lambs at a ratio of approximately 1 ram per 50 ewe lambs (Kenyon et al., 2007). Thereafter, crayon marks were recorded twice weekly and marked ewe lambs were removed from the mob. Monitoring continued until 2 weeks after the last crayon mark was observed (approximately mid-August) as this would indicate that no further ewes were likely to be marked because of the onset of seasonal anoestrous. Ram harnesses were checked twice weekly and crayons were changed as required. Ewe lambs were classified as having achieved puberty (AP) or not achieved puberty (NAP) in their first year of life according to whether or not mating marks were observed, during the monitoring period. Marked ewe lambs were removed from the mob to facilitate the identification of newly marked animals.

In subsequent years, ewes were bred in order to lamb at 2, 3 and 4 years of age. Ewes were exposed to a fertile ram for mating from mid-April (13–17 April) at a ratio of approximately 1 ram per 100 ewes for approximately 50 days. There was one mating period per calendar year.

2.3. Measurement of ovulation rate

Laparoscopic examination of the ovaries (Kelly and Allison, 1976) was used to determine ovulation rate (OR; i.e. the number of ova released in a single reproductive cycle) approximately 17 days after the fertile ram was introduced to the ewes (i.e. after 1 reproductive cycle). OR was determined from the total number of corpora lutea observed on the surface of both ovaries.

2.4. Measurement of live weight

Ewe lambs were weighed at birth and weaning (approximately 12 weeks of age) then monthly until approximately 10 months of age. In subsequent years, weight was measured at the time of fertile ram introduction to the mob (mating weight).

2.5. Determination of litter size

Pregnancy was diagnosed and litter size determined by commercial transabdominal ultrasound examination approximately 80 days after the fertile ram was introduced to the ewes. This measurement was termed number of lambs scanned (NLS). Ewes were closely shepherded during the lambing season (mid September–late October) with all ewes being monitored twice daily. Lambs born, alive and dead, were assigned to the mother and the NLB was recorded.

2.6. Statistical analysis

All data analysis was carried out using GLM or REML models implemented in GenStat 16.1. To determine which variables affected whether a ewe would be AP or NAP, a GLM with a binomial distribution and logit link was used to test the effects of year born, birth weight, birth day of year, live weight change from birth to May (LWC) and all two-way interactions. The live weight in May was chosen as a variable as this is the usual time for introduction of the fertile ram in most New Zealand yearling lambing systems. Birth weight did not have an effect on puberty class (AP or NAP) and was removed from the model. All other variables and interactions had an effect ($p < 0.001$) and were retained in the model as fixed effects to generate an adjusted proportion of AP ewes.

Analysis of birth weight, weaning weight, May weight and LWC was carried out using REML with year born as a fixed effect. The effect of achieving puberty in the first year of life on OR, NLS and NLB were obtained. Puberty class, year born and mating weight were included as fixed effects and sire was included as a random effect. Mating weights reported are from a model with puberty class and year born included as fixed effects. Significant interactions were retained in the models.

Analysis of the effects of puberty class on pregnancy rates and litter size distribution (in pregnant ewes, grouped into singles and multiples) was carried out by fitting a GLM with a binomial distribution and logit link. The effect of age and its interaction with puberty class was tested. The interaction was significant for pregnancy rate ($p < 0.05$) and approached significance for litter size distribution ($p = 0.09$). Therefore, the effect of puberty class on pregnancy rate and litter size distribution was analysed separately for each age group.

3. Results

3.1. General characteristics of animals

Records were collected from 2091 ewes born between 2005 and 2009 and bred to lamb at 2, 3 and 4 years of age (i.e. 2007–2012). The exception to this was records for 2009 born ewes at 4 years of age for which complete data were not available. In total, 1711 AP and 380 NAP ewes were recorded (Table 1). The proportion of NAP ewes varied among years ($p < 0.001$). Analysis of the variables influencing the proportion of AP ewes per year showed that the effect of LWC, the day of the year the ewe was