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Reduced ovulation rate, failure to be mated and fertilization failure/embryo loss are the underlying causes of poor reproductive performance in juvenile ewes

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ABSTRACT

A ewe that is mated as a juvenile (producing a lamb at 1 year of age) will produce an average of only 0.6 lambs to weaning, compared to an average of 1.2 lambs in adult ewes. Understanding the underlying causes of this low reproductive efficiency and designing methods to improve or mitigate these effects could potentially increase adoption of mating juvenile ewes.

In Experiment 1, 2 Cohorts of ewes, born a year apart, were mated in order to lamb at 1 and 2 years of age and the performance of the ewes at each age was compared. Onset of puberty, mating by the fertile ram, ovulation rate, early pregnancy (day 30–35) litter size, number of lambs born and number of lambs weaned were measured. In juvenile ewes, by day 35 of pregnancy, 43% of ova had failed to become a viable embryo and this early loss was the largest contributor to the poor reproductive performance observed. Compared with young adult ewes, ovulation rate was lower ($p < 0.001$), fewer ova were exposed to sperm ($p < 0.001$) and fertilization failure/embryo loss was increased ($p < 0.001$) in juveniles.

In Experiment 2, the early pregnancy litter size of juveniles was shown to be greater ($p < 0.001$) in those ewes with a greater ovulation rate ($p < 0.001$). Attaining puberty prior to introduction of the fertile ram was associated with an increased pregnancy rate ($p < 0.001$).

In juvenile ewes, failure to mate with the ram, lower ovulation rate and increased fertilisation failure/embryo loss underlie their poor reproductive performance.

1. Introduction

The majority of ewes (66–85%) in New Zealand are mated for the first time at approximately 18–20 months of age (Stevens, 2010). Mating of juvenile ewes to produce a lamb at one year of age provides the opportunity to increase the lifetime production of each ewe. In addition to producing an extra lamb crop, ewes which lamb at one year of age wean more lambs over the subsequent three production years than those that do not (Levine et al., 1978). However, a juvenile ewe will produce on average only 0.6 lambs to weaning (Kenyon et al., 2004), compared with 1.2 lambs in adult ewes and this relative inefficiency is a barrier to wider adoption of lambing juvenile ewes.

For a juvenile ewe to produce offspring, there are critical steps that it must successfully complete: attain puberty, ovulate, mate successfully, produce a healthy embryo, maintain the pregnancy, give birth to a healthy lamb and raise that lamb. Identifying where the poor

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reproductive efficiency of juvenile ewes arises would provide an opportunity to intervene to improve efficiency or to select juveniles that have the greatest chance of reproductive success. Although some of the farmers surveyed by Kenyon et al. (2004) reported selecting juvenile ewes for mating based on various criteria, such selection did not increase the lambing rate. This suggests that the current criteria that are being used to select juvenile ewes for mating are of limited value.

Several studies have assessed the effect of different management practices on the success of lambing juvenile ewes and findings from these studies form the basis for industry best practice in New Zealand (Kenyon, 2012). Vaccination for toxoplasmosis and/or campylobacter, pre-mating shearing, and managing single and multiple bearing ewes separately during pregnancy increased the lambing percentage of juvenile ewes (Kenyon et al., 2004). Preferential feeding of juvenile ewes is recommended as live weight at mating is positively associated with lambing percentage (Kenyon et al., 2004) and the likelihood of being mated in the first reproductive cycle following introduction of the fertile ram (Kenyon et al., 2005). Live weight of juvenile ewes at the time of mating affects the birth weight and growth rate of singleton lambs (Kenyon et al., 2006b) and the survival of lambs to weaning (Moore et al., 1983).

Exposure to vasectomized rams prior to fertile ram introduction increased the number of juvenile ewes pregnant to the first cycle and the overall pregnancy rate (Kenyon et al., 2006a). First cycle conception rate and overall lambing percentage (Kenyon et al., 2004) are influenced by the age of the ram, with juvenile ewes exposed to mature rams having a 17% greater pregnancy rate than those exposed to a juvenile ram (Kenyon et al., 2007b). Additionally, both the ratio of rams to ewes and the length of exposure to fertile rams affect pregnancy rates (Kenyon et al., 2006a, 2007a).

The initial aim of this study was to mate juvenile ewes in accordance with industry best practice (Kenyon, 2012) and measure reproductive traits with particular emphasis on ovulation, pregnancy and lambing rates. We then assessed the effect of varying some of these traits on the reproductive performance of juvenile ewes.

2. Materials and methods

2.1. Animal ethics

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. Live weight of the ewes was monitored throughout the experiment as a requirement of the Animal Ethics approval and in accordance with animal husbandry good practice. Internal drug administration orders (IDAOs) were prepared, and veterinary approval obtained, before any drugs were administered to the animals.

Juvenile ewes were exclusively grazed on pasture with free access to water and live weight was recorded monthly. Young adult ewes were grazed on swedes for 8 weeks over winter (June and July). Body condition of the ewes was monitored monthly from approximately 5 months of age which was found to be the earliest age at which a body condition score (BCS) was accurately able to be determined due to the size of the animals. BCS was recorded on a scale of 1–5 as described by Jeffries (1961), with 1 being emaciated and 5 being obese. Rams received a health check prior to mating and were maintained at a BCS of approximately 3.

2.2. Experiment 1

For Experiment 1, two cohorts of juvenile Romney or Romney-cross ewes were selected. Cohort 1 initially comprised 70 juvenile ewes born at Invermay Agricultural Centre in September 2010. The research flocks had been selected on the basis of their fertility, and included animals with putative genes affecting ovulation rate and embryo survival. At the time of introduction of the fertile ram in May 2011 their average live weight was 45.1 ± 0.6 kg and their average BCS was 3.9 ± 0.1. At the time of introduction of the fertile ram in April 2012, their average live weight was 55.3 ± 1.0 kg and their average BCS was 3.0 ± 0.1. Prior to lambing in 2011, two ewes from this Cohort were culled due to vaginal prolapse. Prior to lambing in 2012, a further three ewes were culled for health reasons.

Cohort 2 comprised 83 juvenile ewes born in September 2011, of which 14 were born at Invermay Agricultural Centre and the remainder were Romney or Romney-cross and sourced from a commercial farm in the South Island of New Zealand shortly after weaning (January 2012). At the time of introduction of the fertile ram in May 2012, their average live weight was 41.9 ± 0.3 kg and their average BCS was 3.7 ± 0.0. At the time of introduction of the fertile ram in April 2013, their average live weight was 57.8 ± 0.6 kg and their BCS was 2.9 ± 0.1. Prior to lambing in 2012, one ewe lamb from this Cohort was culled due to vaginal prolapse and a second was culled due to injury. Prior to lambing in 2013, a further three ewes were culled for health reasons.

Prior to mating as juveniles, both cohorts received vaccinations for campylobacter (Campyvax4, MSD Animal Health), toxoplasmosis (Toxovax, MSD Animal Health), leptospirosis (Leptoshield, Zoetis), salmonella (Salvexin + B, MSD Animal Health) and clostridia (Coopers Multine 5-in-1, MSD Animal Health) in accordance with the manufacturer's recommendations. Young adults received a booster vaccination for campylobacter prior to mating and a booster of clostridia vaccine was administered to both juvenile and young adult ewes prior to lambing. Throughout the experiment ewes were treated for internal parasites according to detected worm burden.

Those animals with a live weight of $\geq$39 kg in the first week of May (2011 for Cohort 1 and 2012 for Cohort 2) were selected for inclusion in the trial. This weight was chosen to achieve a minimum weight at mating of 40 kg, in accordance with industry best practice (Kenyon, 2012). All ewes were mated at 8 months and 19 months of age in order to lamb at both 1 and 2 years of age, respectively, and phenotypic measurements were obtained.