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The effect of nutrition during pregnancy on the in vitro production of embryos from resulting lambs

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Abstract

It is possible to produce offspring from FSH-treated lambs using in vitro maturation and fertilisation procedures but a major constraint is the high embryo wastage after transfer. It is postulated that this wastage is associated, at least in part, with the quality of the harvested oocytes. The aim of this study was thus to determine if nutrition during pregnancy influenced the quality of oocytes collected from resulting lambs. The study was a 2 × 2 × 2 factorial that examined the effect of a low (L; 0.7× maintenance) or high (H; 1.5× maintenance) diet provided during three periods (−82 to 70, 71–100 and 101–126 days relative to the date of conception). There were eight treatments namely LLL, LLH, LHL, LHH, HLL, HLH, HHL and HHH. Oocytes were harvested from 9-week-old lambs, matured and fertilised in vitro and the percentages of oocytes and embryos that developed into blastocysts were recorded. There were significant differences between treatments in oocyte and embryo yields and these resulted from complex interactions between diet and the stage of pregnancy. The efficiency of producing blastocysts from oocytes was highest when a H diet was provided between 71 and 110 and/or 101–126 days of pregnancy. These results demonstrate the need to manage nutrition during pregnancy in programs aimed at producing offspring from juvenile animals.

Keywords: Lamb; Oocyte; Embryo; Nutrition

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1. Introduction

Recent studies have demonstrated that it is possible to produce between 9.0 and 13.9 lambs per donor lamb when oocytes, harvested from 4 to 8-week-old lambs, are matured and fertilized in vitro and then transferred to adult recipients [1]. These results were obtained despite relatively low embryo survival rates of between 11.0 and 45.9%. The cause of this low survival rate is not known but it is speculated that it reflects an inability of many lamb oocytes to undergo adequate cytoplasmic and/or nuclear maturation in vitro and that this ultimately leads to an impaired activation of the embryonic genome.

The determinants of lamb oocyte quality are not known. In the adult, nutrition can influence the in vitro developmental capacity of oocytes [2–4] but extrapolating such a finding directly to the fetus/lamb is difficult. Nevertheless, evidence indicates that oocyte quality in the fetus can be affected by in utero nutrition. In the study of Gunn et al. [5], more multiple births were produced in sheep born to mothers that received a dietary supplement during late pregnancy compared with sheep born to mothers that did not receive the supplement. This result could not be explained by differences in liveweight, leading the authors to conclude that improved nutrition during late pregnancy leads to a lifetime reduction in embryo/fetal loss in resulting offspring. Such an effect could result if maternal nutrition influences the ability of the fetus to store, in ooplasm, stable ribosomal RNA, mRNA and other pre-requisites for normal embryogenesis.

During the first 70 days of pregnancy, germ cell numbers reach a maximum due to mitotic activity but this is followed by a period of substantial loss due to phagocytosis [14,15]. The first growing follicles are observed after 100 days with secondary follicles first appearing by 120 days [16]. Although maternal nutrition is known to influence the time of meiotic arrest in fetal germ cells and the rate of transition of follicles beyond the primordial stage [6,7], the effects of nutrition on germ cell development at these different stages of pregnancy are not well understood. It is postulated that nutrition during pregnancy is a determinant of oocyte quality in the newborn and, consequently, influences the yield of viable embryos produced in vitro following the aspiration of oocytes from lambs. The aim of this study was thus to determine what effect low and high diets, provided during three stages of pregnancy (−82 to 70, 71–100 and 101–126 days), have on the yield of oocytes from FSH-treated lambs and on the in vitro developmental capacity of these oocytes. These stages were chosen because of the developmental changes that occur in germ cells/follicles, as outlined above.

2. Materials and methods

2.1. Sheep

Lambs were generated from 4 to 5-year-old Merino ewes using AI. Both ewes and their lambs were managed as near as practicable to commercial practices with the exception that dietary treatments were applied to the ewes during pregnancy and animals were fed in pens during lactation. All experimental procedures were conducted according to guidelines of