Long-term effects of size and nutrition of the pregnant ewe on mammogenesis and lactation performance of offspring and growth of the grand offspring

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April Marie Adiletta

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Abstract

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Undernutrition of fetal sheep has resulted in conflicting reports on fetal mammary development. A cohort of such underfed offspring produced greater milk, lactose and crude protein yields at their first lactation, and their lambs grew faster to weaning, than offspring that ate *ad libitum*, but these effects were not repeated at their second lactation. This thesis reports continued studies of that cohort to examine potential fetal programming effects of maternal size and plane of nutrition during pregnancy on mammary gland development and subsequent lactational performance of the female offspring. Light (L) and heavy (H) twin-bearing dams (G0) were fed either *ad libitum* (A) or maintenance (M) nutritional regimens from day 21 until day 140 of pregnancy under pastoral grazing conditions. Fetal mammary glands from female offspring were collected at day 140 of gestation (H: n=16; L; n=19; A: n=17; M n=18) and were assessed by histological and imaging analysis, recording number and total area of ducts and the size, total area and total number of secretory cells. Milk yield and composition of ewe offspring (G1) were recorded weekly for the first six weeks of their third (n=52) and fourth (n=45) lactations. The birth weights and growth of the grand-offspring (G2) were also measured once weekly until the lambs were 42 days old.

Fetal offspring from *A*-dams had greater body weights (5.9 ± 0.1 kg *vs.* 5.2 ± 0.1 kg; $P<0.01$) and tended to have heavier mammary glands at day 140 (14.9 ± 0.9 g *vs*. 13.0 ± 0.7 g; $P<0.1$) compared to those from M-dams. There was a tendency for LA-fetuses to have a greater number of mammary ducts than all other treatment groups (LA: 5.8 ± 0.23 g *vs.* HA: 5.6 ± 0.23 g, HM: 5.4 ± 0.21 g, LM: 5.2 ± 0.21 g; $P<0.1$). An interaction between nutritional treatment and rank, single (S) or twin (T), was found ($P<0.05$) for mammary gland weight such that twin fetuses carried by M-dams had lighter mammary glands compared to all other nutrition by rank groups (TM: 10.66 ± 1.06^{a}; SM: 15.24 ± 0.99^{b}; TA: 14.87 ± 1.18^{b}; SA: 15.08 ± 1.13^{b}, g; $P<0.05$). Dam size had no significant effect on fetal mammary gland dimensions.

At the third lactation, there was an interaction ($P<0.01$) between dam size and nutrition such that LA-ewes had lower lactose percentages than HA-ewes and LM-ewes. Compared to H-ewes, L-ewes had higher milk fat percentages (6.3 vs. 6.8 ± 0.13% respectively; $P<0.05$) and yield (177.3 vs. 187.8 ± 3.8 g/day respectively; $P<0.05$) over the six-week trial period. There was a significant ($P<0.05$) effect of grand-dam size on grand-offspring weight during the third lactation, but not the fourth. During the third lactation, the lambs (G2) of H-ewes and A-ewes grew faster than G2 lambs from L-ewes and M-ewes, respectively (11.20 and 11.05 vs. 10.56 and 10.72 ± 0.17 kg respectively; $P<0.05$). At their fourth lactation, H-ewes had higher lactose percentage (5.39 vs. 5.32 ± 0.02%, $P<0.05$), lactose yield (132.45 vs. 125.11 ± 2.4 g/day, $P<0.01$), and higher crude protein yield (126.08 vs. 119.54 ± 2.24 g/day, $P<0.05$) than L-ewes. There was no effect of G0 nutrition on G1 milk yield, milk fat or lactose and crude protein overall percentages or yields during the third and fourth lactations.

In summary, poor dam nutrition increased fetal mammary gland development but effects reported in the first lactation of the offspring were not repeated in the second to fourth lactations. Grand-dam nutrition also has inconsistent intergenerational influence when comparing the offspring's first, second and third parity. In the first parity, a grand-dam maintenance diet accelerated grand-offspring growth, whereas it inhibited grand-offspring growth for the second and third parities. Development of strategies to overcome constraints imposed by size and nutrition has the potential to enhance lamb growth and production by offspring, thereby increasing the profitability of the lamb-production enterprise.

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