NUTRIENT UTILISATION, GROWTH AND CHEMICAL BODY COMPOSITION OF PRE-WEANED LAMBS REARED ARTIFICIALLY

Effects of feeding milk replacer and pellets

A thesis presented in partial fulfilment of the requirements for the degree of

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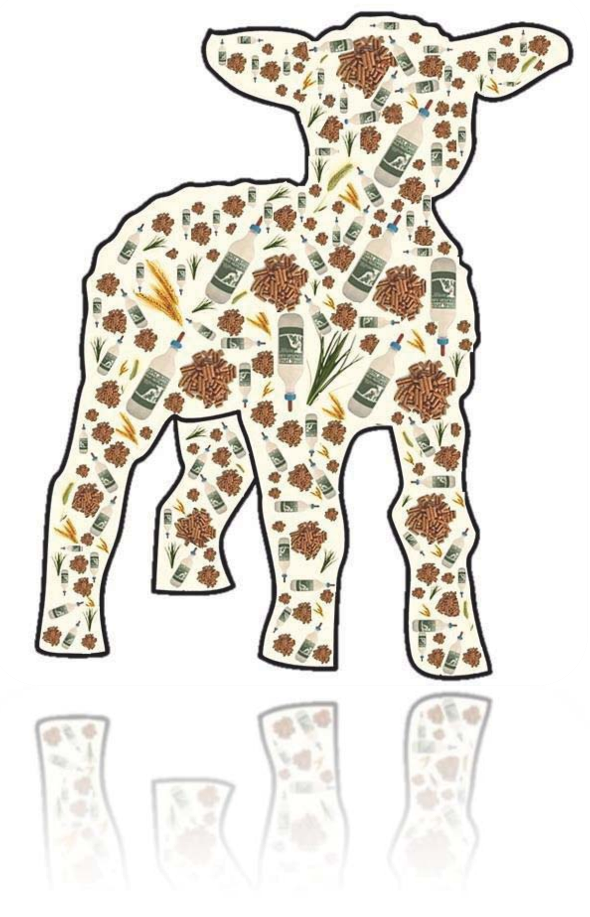

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“Dietary inputs are of value only as long as they increase kilograms of lamb weaned, improve fibre quality or quantity, or positively impact lifetime production”

(Hatfield *et al*, 1995)

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ABSTRACT

Understanding how nutrient supply controls lamb growth is important in improving the efficiency of nutrient utilisation. Estimation of metabolisable energy (ME) requirements for lamb maintenance and growth pre-weaning has been limited to milk-only fed lambs. This is due, at least in part, to the difficulty of measuring pasture intake in pre-weaned lambs, which restricts the determination of nutrient balances and nutrient use efficiencies. The aims of this thesis were to: 1) evaluate the effect of various milk and pellets combinations on lamb growth, organ development, body composition and utilisation of energy for maintenance and growth, 2) derive equations for predicting feed intake, and 3) develop a growth simulation model for use as a tool to develop feeding strategies for lambs. Lambs were offered various diet combinations from age one day until slaughter at 18 kg live weight (LW). Addition of solid feed to the milk diet of pre-weaned lambs improved their growth rates, efficiency of gain and enhanced rumen development. Increasing daily ME intake from 1.5 times maintenance to *ad libitum* at a constant protein to energy ratio did not alter the total chemical body composition of the lambs fed to a fixed LW. Increasing the crude protein content of milk replacer, and therefore the corresponding protein to energy ratio, increased average daily gain and efficiency of gain in lambs. Further, the protein content in the empty bodies of lambs increased whilst fat content decreased. Growth and body composition of lambs were unaffected by altered pellet protein content. The study also showed that lambs fed in excess of their protein and energy requirements reached maximum potential protein deposition rates. Based on a model developed, overestimating the maintenance energy requirements of milk-only fed lambs underestimated their daily fat deposition rates and underestimating the maintenance requirements of lamb offered milk and *ad libitum* access to pellets over estimated their daily fat deposition. A greater percentage increase in fat deposited in gain increased the energy requirements for gain in the lambs. This study has contributed to the knowledge on rearing lambs artificially with various combinations of milk and pellets. The findings will provide a useful platform for future studies aiming to develop feeding strategies to improve pre-weaning lamb growth.

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Figure 8.6 Comparison of the actual and simulated average daily gain of pre-weaned lambs consuming different milk and pellets combinations based on the proposed model. MO'13 = milk only (2013); MO'14 = milk only (2014); MP30'14 = milk + 30% of *ad libitum* pellets intake (2014); MP60'14 = milk + 60% of *ad libitum* pellets intake (2014); MPad'13 = pellets offered *ad libitum* (2013); MPad'14 = pellets offered *ad libitum* (2014); NMLP = normal-protein milk + low-protein pellet (2015); NMHP = normal-protein milk + high-protein pellet (2015); HMLP = high-protein milk + low-protein pellet (2015); HMHP = high-protein milk + high-protein pellet(2015). Error bars = standard error of means. *Simulated mean differs from actual mean at P < 0.05. 255

Figure 8.7 Comparison of the actual and simulated daily fat deposition rates of pre-weaned lambs consuming different milk and pellets using maintenance energy requirement values of 0.34 MJ ME / kg $LW^{0.75}$ for lambs with restricted access to pellets and 0.45 MJ ME / kg $LW^{0.75}$ for lambs with *ad libitum* access to pellets. MO'13 = milk only (2013); MO'14 = milk only (2014); MP30'14 = milk + 30% of *ad libitum* pellets intake (2014); MP60'14 = milk + 60% of *ad libitum* pellets intake (2014); MPad'13 = pellets offered *ad libitum* (2013); MPad'14 = pellets offered *ad libitum* (2014); NMLP = normal-protein milk + low-protein pellet (2015); NMHP = normal-protein milk + high-protein pellet (2015); HMLP = high-protein milk + low-protein pellet (2015); HMHP = high-protein milk + high-protein pellet (2015). Error bars = standard error of means. *Simulated mean differs from actual mean at P < 0.05. 256

Figure 9.1 Live weights of lambs in the first 60 days of life from the three artificial rearing studies conducted in this thesis. MO'13 = milk only; MPad'13 = pellets offered *ad libitum*, MO'14 = milk only; MP30'14 = milk + 30% of *ad libitum* pellets intake; MP60'14 = milk + 60% of *ad libitum* pellets intake; MPad'14 = pellets offered *ad libitum*, NMLP = normal-protein milk + low-protein pellet; NMHP = normal-protein milk + high-protein pellet; HMLP = high-protein milk + low-protein pellet; HMHP = high-protein milk + high-protein pellet ('number = year of study). 271

Figure 9.2. The effect of different metabolisable energy intake levels on protein deposition in lambs during the pre-weaning phase of growth. "A" represents protein deposition response in lambs to increasing ME intake, "B" and "C" = represents protein deposition response in lambs at similar ME intake but higher protein to energy intake ratio. MO'13 = milk only; MPad'13 = pellets offered *ad libitum*, MO'14 = milk only; MP30'14 = milk + 30% of *ad libitum* pellets intake; MP60'14 = milk + 60% of *ad libitum* pellets intake; MPad'14 = pellets offered *ad libitum*, NMLP = normal-protein milk + low-protein pellet; NMHP = normal-protein milk + high-protein pellet; HMLP = high-protein milk + low-protein pellet; HMHP = high-protein milk + high-protein pellet ('number = year of study). Error bars = standard error of means. 275

Figure 9.3 The relationship between CP:ME ratio and protein deposition in lambs during the pre-weaning phase of growth. MO'13 = milk only; MPad'13 = pellets offered *ad libitum*, MO'14 = milk only; MP30'14 = milk + 30% of *ad libitum* pellets intake; MP60'14 = milk + 60% of *ad libitum* pellets intake; MPad'14 = pellets offered *ad libitum*, NMLP = normal-protein milk + low-protein pellet; NMHP = normal-protein milk + high-protein pellet; HMLP = high-protein milk + low-protein pellet; HMHP = high-protein milk + high-protein pellet ('number = year of study). Error bars = standard error of means. 276

Figure 9.4. The effect of different metabolisable energy intake levels on fat deposition in lambs during the pre-weaning phase of growth. “A” and “B” represents fat deposition response in lambs to increasing ME intake in Romney and Suffolk lambs, respectively “C” represents fat deposition response in lambs at similar ME intake but different protein to ME ratios in Romney lambs. MO’13 = milk only; MPad’13 = pellets offered *ad libitum*, MO’14 = milk only; MP30’14 = milk + 30% of *ad libitum* pellets intake; MP60’14 = milk + 60% of *ad libitum* pellets intake; MPad’14 = pellets offered *ad libitum*, NMLP = normal-protein milk + low-protein pellet; NMHP = normal-protein milk + high-protein pellet; HMLP = high-protein milk + low-protein pellet; HMHP = high-protein milk + high-protein pellet (’number = year of study). Error bars = standard error of means. 277

Figure 9.5 The effect of varying the crude protein to metabolisable energy (CP:ME) ratio on fat deposition in lambs during the pre-weaning phase of growth. “A” and “C” represents fat deposition response in lambs to increasing CP:ME intake ratios in Romney lambs. “B” represents fat deposition response in lambs to increasing CP:ME intake ratios in Suffolk lambs. MO’13 = milk only; MPad’13 = pellets offered *ad libitum*, MO’14 = milk only; MP30’14 = milk + 30% of *ad libitum* pellets intake; MP60’14 = milk + 60% of *ad libitum* pellets intake; MPad’14 = pellets offered *ad libitum*, NMLP = normal-protein milk + low-protein pellet; NMHP = normal-protein milk + high-protein pellet; HMLP = high-protein milk + low-protein pellet; HMHP = high-protein milk + high-protein pellet (’number = year of study). Error bars = standard error of means. 278

Figure 9.6 The relationship between CP:ME ratio and fat:protein deposition rate in lambs during the pre-weaning phase of growth. MO’13 = milk only; MPad’13 = pellets offered *ad libitum*, MO’14 = milk only; MP30’14 = milk + 30% of *ad libitum* pellets intake; MP60’14 = milk + 60% of *ad libitum* pellets intake; MPad’14 = pellets offered *ad libitum*, NMLP = normal-protein milk + low-protein pellet; NMHP = normal-protein milk + high-protein pellet; HMLP = high-protein milk + low-protein pellet; HMHP = high-protein milk + high-protein pellet (’number = year of study). Error bars = standard error of means. 279

Figure 9.7 Comparison of the observed and predicted average daily gain of pre-weaned lambs consuming different milk and pellets using a maintenance energy requirement of 0.34 MJ ME/kg $LW^{0.75}$ across treatment groups MO’13 = milk only; MPad’13 = pellets offered *ad libitum*, MO’14 = milk only; MP30’14 = milk + 30% of *ad libitum* pellets intake; MP60’14 = milk + 60% of *ad libitum* pellets intake; MPad’14 = pellets offered *ad libitum*, NMLP = normal-protein milk + low-protein pellet; NMHP = normal-protein milk + high-protein pellet; HMLP = high-protein milk + low-protein pellet; HMHP = high-protein milk + high-protein pellet (’number = year of study). Error bars = standard error of means *, **, ***Simulated mean differs from actual mean at P < 0.05, P < 0.01, P < 0.001. 280