#1 Mineral composition and buffering capacity of sheep, cow and goat milk.

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Minerals are key micronutrients for several important biological functions and health (protection against oxidative stress, energy production, immune system and bone health). The present study investigated specific elements in cow (n = 10), sheep (n = 6) and goat (n = 5) milk collected at mid-lactation. The buffering capacity of each milk was also investigated. Sheep milk had significantly (P < 0.05) higher calcium, phosphorus, magnesium, sulphur, iron, chromium and zinc contents compared to cow and goat milk. Sheep and cow milk had similar potassium, copper and manganese contents and these were lower than goat milk (P < 0.05). Cow and sheep milk had higher sodium content than goat milk (P < 0.05). The buffering capacity of sheep milk was higher than either cow or goat milk. The present results indicate sheep milk is a good source of minerals which may provide potential health benefits. Within our current Dairy sheep research programme, further studies on the seasonal variation in the mineral composition of sheep milk will be undertaken with samples collected over the 2014/15 and 2015/16 seasons from early-, mid- and late-lactations.

#2 In-depth proteomic characterisation of sheep (Ovis Aries) milk whey

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An in-depth proteomic study of sheep milk whey is reported and compared to the data available in the literature for the cow whey proteome. A combinatorial peptide ligand library kit (ProteoMiner) was used to normalize protein abundance in the sheep whey proteome followed by an in-gel digest of a 1D-PAGE display and an in-solution digestion followed by OFFGEL isoelectric focusing fractionation. The peptide fractions obtained were then analyzed by LC-MS/MS. This enabled identification of 669 proteins in sheep whey that, to our knowledge, is the largest inventory of sheep whey proteins identified to date. A comprehensive list of cow whey proteins currently available in the literature (783 unique gene products) was assembled and compared to the sheep whey proteome data obtained in this study (606 unique gene products). This comparison revealed that while the 233 proteins shared by the two species are significantly enriched for immune and inflammatory responses in gene ontology analysis, proteins only found in sheep whey in this study were identified that take part in both cellular development and immune responses, whereas proteins only found in cow whey in this study were identified to be associated with metabolism and cellular growth.

#3 Potential benefits of sheep milk on health

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The composition of milk differs greatly between species. Furthermore, processing can change the composition of milk-derived products. These compositional differences lead to different physiological and health effects in the consumer. For example, allergy to milk is primarily an immune response to one or more milk proteins, which in cow milk are most commonly beta-lactoglobulin and alpha S1-casein. However, sheep milk contains alternate forms of these proteins, which may make sheep milk a viable alternative dairy source for those with allergy to cow milk. Other important milk components include oligosaccharides and lipids. These differ in structure between sheep and cow milks, leading to different impacts on consumer health. Within the New Zealand government-funded research programme “Boosting exports of the emerging NZ dairy sheep industry”, the physiological consequences of consuming sheep milk and sheep milk fractions are being investigated. Sheep milk will be compared to other ruminant milks, and effects of milk processing will be taken into account. Initially, animal models will be used to study changes in growth, gene expression, plasma metabolomics profiles, and intestinal microbial communities to gain an overall understanding of how sheep
milk affects gastrointestinal health. Effects of sheep milk and sheep milk fractions on immune function will also be assessed using cell culture models. As our knowledge of sheep milk composition, and the effects of processing, develops over the course of this programme, further studies will be undertaken focusing on understanding how these identified components contribute to the beneficial effects of sheep milk on human health.

#4 Food Innovation Waikato - goat industry to sheep milk
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Processing difficulties of low off-farm volumes and the actual volumes required to commercially produce at FoodWaikato. How FoodWaikato assisted during the early stages of the goat industry and the similar low-volume challenges now facing the sheep milk industry.

#5 Important influences on sheep dairy milk production
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Results are presented from a series of sheep milking experiments at the Templeton Research Station in the late 1970s. Milk production of ewes suckling lambs showed large variation within and between breeds. Dairy milk production in unselected Dorset ewes averaged around 72% of suckled production. Average dairy yields were generally in the range 120-160 litres/ewe with lactation periods 150-180 days. Dairy yields were highest with lambs removed at birth or weaned early at four weeks of age. Other factors influencing dairy production included nutrition with liberal pasture allowances of 5 kg DM/ewe/day giving 20% increased yields and udder stimulation with a 20% response. Milking ewes once a day after week 10 of lactation only reduced milk yield by 15%. Whether ewes had single or twin lambs had little influence on dairy yield and use of the let-down hormone oxytocin had mixed results. Udder volume had a weak positive ($r^2 = 0.16$) relationship with dairy yield and post lambing oestrus intervals with dairy ewes averaged four months. The results are discussed in relation to some overseas work.

#6 Boosting exports of the emerging New Zealand dairy sheep industry
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The aim of the programme, which is currently in its second year, is to grow exports from the NZ dairy sheep industry. This will be achieved by providing science-based evidence of the nutritional and functional characteristics of sheep milk, optimal feeding and animal nutrition systems to increase the net volume and value of harvested milk, and criteria to ensure environmental sustainability of sheep dairying in New Zealand. AgResearch is working together with University of Otago, Callaghan Innovation Ltd and The Ferrier Institute at Victoria University of Wellington to conduct the research, and in close partnership with major NZ sheep milk producers to ensure industry relevance and uptake. The expected outcomes are high-value sheep milk products for export, increased milk production per ewe, and environmental sustainability for the NZ dairy sheep industry.

#7 Improving milk production through feeding: a research programme for dairy sheep
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The dairy sheep industry can expand by increasing milking sheep numbers and by increasing the milk production of individual sheep. The latter option provides a long-term sustainable option that increases milk volume, decreases costs, and increases on-farm efficiency. Many of the principles of nutrition for lactation in sheep are already known. An MBIE research programme, “Boosting exports of the emerging NZ dairy sheep industry”, has been initiated to build on current knowledge in a NZ grass-fed context to design cost-effective feeding systems that capture the value of both sheep milk and the lamb that is produced in the process. Research has begun into developing early weaning systems to add value to dairy sheep systems by reducing the feeding costs, increasing days in milk of the ewe and providing cost-effective production of lambs for the meat industry. Research into the impacts of the growth profiles of ewe lambs until puberty on their lifetime milk production has also been initiated. Further work into the value of different forages for dairy sheep systems is proposed. Also under consideration is the impact of potential interactions between growth hormone genotype and nutrition on lifetime productivity.
## #8 Opportunities and pitfalls of early weaning
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Current dairy sheep systems use a range of approaches to the dilemma of raising the lamb while getting a significant milk yield from the ewe. Some leave the lamb with the ewe and, through training, milk the ewe after separation from the lamb. Other leave the ewe and lamb together for 3-6 weeks before early weaning the lamb and then introducing the ewe to the milking flock. A further option practiced by some is the immediate removal of the lamb into an artificial rearing and early weaning system. Each option has its own advantages and disadvantages for the lamb rearing and sheep milking outcomes. Some systems forgo as much as 40% of the ewes milk production, significantly affecting the productivity of the milking operation. Furthermore, high mortality and poor growth performance of early weaned lambs can compromise income from the sale of lambs and influence the performance of ewe lamb replacements. Improving rearing and/or weaning practices has the potential to enhance the profitability of the dairy sheep operation. Sharing of knowledge, current practices, pitfalls and opportunities will be discussed.

## #9 Effluent management on an intensive dairy sheep farm
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Milking sheep, as with cows, can produce a considerable waste water stream from the milking parlour, which is either applied directly to land via irrigators, or is stored in a pond prior to land application. Research has shown that such farm dairy effluent (FDE) systems from cattle have contributed to the increase in nutrient loads in waterways and considerable work has been done on improving the application of such FDE to land to limit these losses. In order for the dairy sheep industry to have the ability to limit the environmental impact of, and maximise the value of sheep FDE, information is required on the volumes and nutrient content of the effluent generated. This presentation highlights the issues and introduces a study which was set up to characterise such an effluent stream and to develop some best management practises for the land application of sheep FDE.

## #10 On-farm ewes’ milk-production statistics 2014
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Andy and Kat Gunson milk 85 ewes in Hawkes Bay NZ. One of the frustrations with starting up a sheep-milking operation is to find data and bench-marking information. The presentation shares the data from our small pilot operation in Hawkes Bay. Topping occurs over four-week window in early February. Lambs are reared by the dam and weaned at between 45-51 days and sold store at 20-24 kg early October at 69-75 days old. Average daily weight gain to docking is 0.37-0.41 kg/day. Milking commenced after weaning in early September. Forty-eight percent of the flock is milked to 147 days and 52% of the flock is milked to 192 days. A second flock lambing in November is used to top up the numbers late in the season and to even out milk composition variations in late lactation. Top 50% ewes-first flock milk yield 208 litres plus rearing lambs at average ~350-400 g/day (birth to tailing). Top 50% ewes milk revenue: $416.00. Production on land area basis: 332 kgMS/ha. Production per ewe basis: 37 kgMS/ewe.

## #11 Nutrition’s role in optimising genetic production potential
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Sheep are not small cows or woolly goats but what can we use from these milking industries and farming operations to improve ewe milking performance? Is genetic merit the Holy Grail? What makes a quality pasture and what two aspects are often overlooked when assessing quality? - What nutritional support if any might be needed for optimal flock milk performance?

## #12 Video clip of mobile sheep milk plant and second clip on sheep selection model.
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Six-minute video clip showing mobile sheep milk unit in action. The design will reduce investment for new entrants and allow a number of CO-OP farms to use the same unit and staff. It also mitigates effluent issues associated with concrete pads. A second video clip shows results from milk sheep selection since 2007. Production selection uses simple formula of 2/3 milk volume 1/3 lamb weaning weight. Traits other than production (TOP) selection uses 1-9 scoring udder centre ligament and teat placement using simple modification of NZ dairy cow model.
#13 Seasonal effect on milk yields of ewes
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In Romney sheep, season or photoperiod controls breeding season, wool growth, live weight, birth weight, growth rate, organ weights and milk yields. In spring, milk yields for the first week of lactation were about 40% higher than in autumn despite being fed the same diet and spring-born lambs were 0.5 kg heavier and grew faster. Lambing in June produced greater milk yields than did lambing in March or January. In East Friesian x Romney ewes studied in the STAR system (lambing five times per year), milk yields were highest following June lambing followed by November, August, January and March. Single- and twin-bearing ewes responded differently to seasonal differences; ewes with twins increased milk yield proportionately more than ewes with singles in June, November and January. Changing diet, shearing and internal parasites can reduce milk yields markedly. Ewes bearing triplets produce little or no more milk than those bearing twins. Triplets suffer a relative lack of available milk nutrients compared to twins and are not able to completely compensate for this by increasing grazing time.

#14 High milk production in milked sheep grazed in large flocks in New Zealand
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Current interest in alternative dairy production systems and products in New Zealand focuses on dairy sheep and goats. New Zealand is pioneering large-scale pastoral sheep milk production based on East Friesian cross ewes, although there is very limited data available on the capacity of such ewes to produce high levels of milk production when grazed in large flocks. This paper reports preliminary results from the daily milk records of high performance dairy-cross ewes and hoggets milked twice a day for a minimum of 5-6 months. Ewes and hoggets grazed together on pasture from lambing in average flock sizes of 2,800 animals without any preferential treatment. Mean daily milk production in 235 ewes peaked at 3.09 litres in Week 1 and remained within 10% for 5 weeks. Daily decline in milk yield from the peak until Day 160 of lactation was 0.015 litres. From Day 160 to 220, the daily decline in milk yield was 0.013 litres. Peak daily milk yield for 140 hoggets was 1.66 litres during Week 5, remaining within 10% from Day 11 to 53. Daily decline in milk yield from the peak until Day 160 of lactation was almost half that of ewes. Average cumulative milk yield at Day 160 in ewes and hoggets was 325 and 200 litres, respectively. These results demonstrate the presence of ewes and hoggets, respectively capable of sustaining average daily milk yields in excess of 2.0 and 1.25 litres for at least 6 months under grazing in large flocks. These performance levels are on a par with many intensively managed small flocks overseas. The ewes appear well adapted to New Zealand pastoral conditions and are likely to form the foundation breeding stock for a successful New Zealand dairy sheep industry.

#15 The Importation of dairy sheep
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Jock gave a brief history of importation or dairy sheep; he extolled the benefits of the Awassi which had been selected by the Israelis for hundreds of years and mentioned the extra lambs obtained from the ASAF Breed. He described the problems of obtaining protocols for importation. The Awassi was difficult to get embryos but he obtained 48 lambs. EF were imported from Sweden were originally sourced in Switzerland. Eleven ewes and four rams produced 200 animals in first year and 400 in second year and 2200 lambs by ET. Inseminated 50,000 ewes with EF semen in one year. Early milk results from EF. Lambs run with ewes, killed at 8 or 9 kg LWT (production of beta lambs (5.5-5 kg ccwt). The only sheep available is the EF Awassi is owned by Saudis. The Lacaune is excellent - much progress in recent years. Importation protocol being negotiated now with EC since scrapie can’t be transmitted on embryos. A starting milker should start with half EF – upgrade first. Don’t milk British breeds. Compared ½ EF 1113 litres ½ Romney x Border Leicester 103 litres first half 250 L and some produce more than 300 L upgrade to EF and then cull them for production.

#16 Genetic evaluation in a large flock of milking sheep in New Zealand
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This report describes early progress in the Blue River Dairy sheep genetic improvement programme. Animals mate first as yearlings and lambing takes place all-year-round. Daily milk records in dairy-cross ewes commenced in June 2009 with over 67,000 completed lactations by early 2014. Genetic evaluation of milk production and lactation length uses BLUP, random regression, and Test Day Model procedures on records from the individual
and its relatives. Average breeding values are set at zero. The genetic index for selection of sires and dams of sires includes 6-month total milk yield and lactation length. Sire and dam parentage verification in the nucleus flock is through DNA testing. Considerable genetic variation exists in the 27,000 ewes evaluated to date. Breeding values for cumulative milk yield to 180 days of lactation and lactation length increased by 9.3 litres and 3 days per year, respectively. The correlation between breeding value for milk yield and lactation length is low and positive, suggesting genetic progress in milk yield is possible but slow when selecting indirectly using lactation length. In summary, early progress is highly promising, with the highest milk production breeding values in excess of plus 200 litres. On-going developments include continued progeny testing and the inclusion of additional traits (live weight, milk components, somatic cell count, and udder traits).

#17 Estimation of breeding values for daily milk yield in dairy sheep using a random regression model

Nicolas Lopez-Villalobos and William McMillan

Abstracts – Ewe milk products and sheep dairy conference 2015

Estimated breeding values for lactation yield of milk and lactation length (LL) of all-year-round lambing crossbred East Friesian ewes from three flocks were estimated using a test day and animal model, respectively. Evaluations were based on over 8 million daily milk records from 26,603 lactating ewes and hoggets from Blue River Dairy Limited Partnership, Invercargill, New Zealand collected during 2009 to 2014. Breeding values for each ewe for accumulated yields of milk until day 180 (MY180) were obtained from breeding values for daily values predicted using a random regression model. The model included the fixed effect of contemporary group (year-flock-month), fixed effect of age at lambing, fixed effect suckling duration, fixed effect of number of lambs present at pregnancy scanning, fixed effect of day in milk modelled with a Legendre polynomial of order 3, random effect of additive genetic effect of an individual ewe for each day of the lactation modelled with a Legendre polynomial of order 3, random effect of permanent environment of ewe for each day of the lactation modelled with a Legendre polynomial of order 3, and the residual effects modelled with heterogeneous variance for each of the 7 months of lactation. Breeding values for LL were predicted for each ewe with an animal model that included the fixed effects of contemporary group, age at lambing and suckling duration and the random additive genetic effect of an individual ewe. Ninety per cent of LL estimated breeding values were between -61 and +48 days, and respective values for MY180 were -46 and +57 litres. A selection index can be implemented to select ewes for high lactation yields of milk and long lactation lengths.

#18 Opportunities for dairy sheep genomics in New Zealand: a global perspective

Suzanne Rowe, JC McEwan

Abstracts – Ewe milk products and sheep dairy conference 2015

Typically, greater than 50% of efficiency and productivity gains in agricultural production systems are derived from genetic improvement. Genomics can support genetic improvement by parentage assignment, identifying the level of genetic diversity and inbreeding within and across flocks and breeds, and accelerating genetic gain via the use of genomic selection. Typically the latter accelerates gain by reducing generation intervals, and increasing accuracy in difficult to measure traits. This technology has been successfully applied in livestock industries worldwide. Key prerequisites are pertinent selection objectives, adequate recording, and genetic evaluation systems in place. The international Committee for Animal Recording (ICAR) has a dairy sheep working group. The ICAR report from the dairy sheep and goat session held in Berlin (2014) provides detailed information about traits used in genetic evaluation worldwide, percentage of the populations recorded and productivity of the various breeds. Derived from the ovine genome and sheep hapmap projects, considerable genomic information now exists that would enable comparison of New Zealand dairy sheep with existing New Zealand maternal and overseas sheep dairy breeds. The same research could identify the level of inbreeding in the existing elite tier in New Zealand and inform future selection decisions. The superior productivity of the Lacaune breed was highlighted in the ICAR report, and we would recommend that importation of superior genetics into New Zealand should be considered as part of a long-term industry plan for upgrading and crossbreeding our predominantly East Friesian-based animals. Similarly, overseas work has already identified QTL affecting sheep dairy related traits, and genomic selection is either planned or commencing in many countries. If the New Zealand sheep dairying industry has a long-term future on the global stage, we will also need to rapidly develop and implement genomic technology.