Lamb Rearing Technical Manual

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About the authors

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Dr. Sue McCoard is a senior scientist in the Animal Nutrition & Physiology Team and Science Impact Leader for Animal Science based at the Grasslands Campus of AgResearch in Palmerston North, New Zealand. Sue was born and raised on a sheep and beef farm near Taihape in the North Island of New Zealand and has 25 years' experience as a research scientist. She undertakes research into understanding how nutrition and management practices of pregnant and young animals affects lifetime performance of sheep and cattle including survival, growth, health and the production and quality of meat and milk. Her current research includes development of early life nutrition strategies to increase the survival, growth, and lifetime productivity of lambs and calves for applications in sheep and cattle red meat and dairy farming systems, in partnership with industry. Outcomes of this research include the development of new technologies/strategies with a focus on strategic feeding and management to enhance the productivity and efficiency of livestock production. Sue has led numerous lamb rearing studies including those conducted within the research programme described in this technical manual. She has authored 48 internationally-referred publications, over 60 conference publications, 2 book chapters and holds 2 patents.

Frederik Willem Knol

Frederik Willem Knol has spent over 7 years working in the agricultural research sector as a research technician. He has had many years' experience working with sheep and lambs in a research setting as well as on farm. Since 2014 Fred has been involved with numerous lamb rearing trials and early life nutrition research projects for AgResearch. This work is funded by their Strategic Science Investment Fund, MBIE as well as by commercial industry partners. Fred is passionate about improving the productivity and welfare of the sheep industry in New Zealand to meet its future needs.

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Dr. David Stevens is a senior scientist who has worked researching farming systems; genetic interactions with nutrition; promoting and contributing to the implementation of new technologies which will enhance on-farm productivity. He has authored over 70 referred publications, over 60 conference publications and 6 book chapters. He has a documented record of engagement with industry through successful implementation of new technologies on-farm. He has been recognised throughout the farming sector for his communication skills with awards from both the NZ Grassland Association and NZ Society of Animal Production.

Introduction

Optimising the survival and growth of lambs is important for both dairy and meat production systems. Artificial rearing is important in some dairy sheep production systems to increase the harvest of commercial milk for dairy product manufacture. It is also important for rearing orphans or lambs that are not reared naturally in both dairy sheep and meat sheep production systems to improve profits and meet market- and consumer-driven expectations on animal welfare.

In temperate climates like New Zealand, pasture-based production systems offer a lower-cost farming system to produce high quality food for human consumption (McCoard et al. 2019). Globally, dairy sheep and many meat sheep production systems are fully or partially housed management systems which use high inputs of concentrate or conserved forages and many of these systems are relatively small (<500 sheep). Therefore, artificial rearing systems commonly available, have been developed to suit these management systems rather than where animals are largely managed in outdoor pasture-based grazing systems.

Reducing feed and labour costs, without compromising growth, health and wellbeing of lambs both pre- and post-weaning are key contributors to profitability of lamb rearing systems. The Ministry of Business Innovation and Employment funded an Endeavour Research Programme led by AgResearch from 2013-2019 to support the emerging dairy sheep industry. Stakeholder engagement early in this research programme identified that knowledge of lamb rearing systems and methods to support a range of farming systems that employ natural and artificial rearing was needed that are relevant to New Zealand production systems. Using a co-innovation approach (Stevens et al. 2017), a series of studies were undertaken to develop a suite of rearing systems and methods to support farmers. Lamb rearing studies have concentrated on ensuring that both female and male progeny can be reared cost-effectively, and that a range of different rearing systems can be implemented in commercial settings. These have been targeted at both small and large-scale rearing operations where 3-4000 lambs may be reared by a single producer each year in a short timeframe (lambing over ~2 months) due to the seasonal nature of New Zealand production systems. This contrasts with many global sheep production systems. One study was also undertaken to evaluate opportunities to implement early weaning in naturally reared lambs in a smaller commercial outdoor pasture system (~300 ewes) to improve the harvest of commercial milk without compromising survival and performance of the progeny. Uptake of the protocols and solutions generated has been rapid, with associated increases in lamb survival and decreases in rearing costs.

This guide provides information to maximise the success of lamb rearers. It is structured to aid planning and operational management.

The aim of this technical manual is to provide an overview of current best practice knowledge for successful lamb rearing that is underpinned by scientific evidence from the literature and our research programme. While this research was focused on dairy sheep as a model system, the knowledge generated is equally useful for meat sheep systems, particularly for rearing of orphans or lambs that their dams are not able to rear.

- Choosing your rearing system
- Understanding legislative obligations
- Preparing your infrastructure and housing

- Feeding the ewe to get the best lamb
- Choosing your feeding system
- Making sure your team is prepared

- Getting the lamb to the shed
- Is my lamb healthy?
- Keeping my lambs healthy
- Managing feed
- Managing facilities
- Recognising and treating health problems
- Managing interventions

- Successful weaning
- Learning from experience and planning for next year

Further Reading:

- McCoard SA, Stevens DR, Whitney TR. 2019. Sustainable sheep and goat production through strategic nutritional management and advanced technologies. Chapter 13 in "Animal Agriculture: Sustainability, Challenges and Innovations" Ed. Bazer FW, Lamb GC, Wu G. Academic Press. (Invited book chapter).
- Stevens D, Samuelsson L, McCoard S, Day L, Young W, Bartlett N, Konui W, Gatley P, Hammond N, Macdonald T, King M, hewittson J. 2017. Using a co-innovation approach to accelerate the development of dairy sheep enterprises in New Zealand. 13th European IFSA Symposium, 1-5 July 2018, Chania (Greece).

Which rearing system to use?

Making the decision on which rearing system to use is challenging and influenced by multiple factors. For example, for new dairy sheep operators, decisions can be influenced by flock size and level of experience with milking ewes without the additional task of rearing lambs. There is no one size fits all approach for deciding what system to use. Financial pros and cons will also play an important part in the decision-making process which is a factor that cannot be easily predicted as it can depend on whether the cost, work, stress and/or risk provide a net benefit.

Some things beyond infrastructure and labour requirements that you may like to consider when deciding on which rearing system to use are as follows:

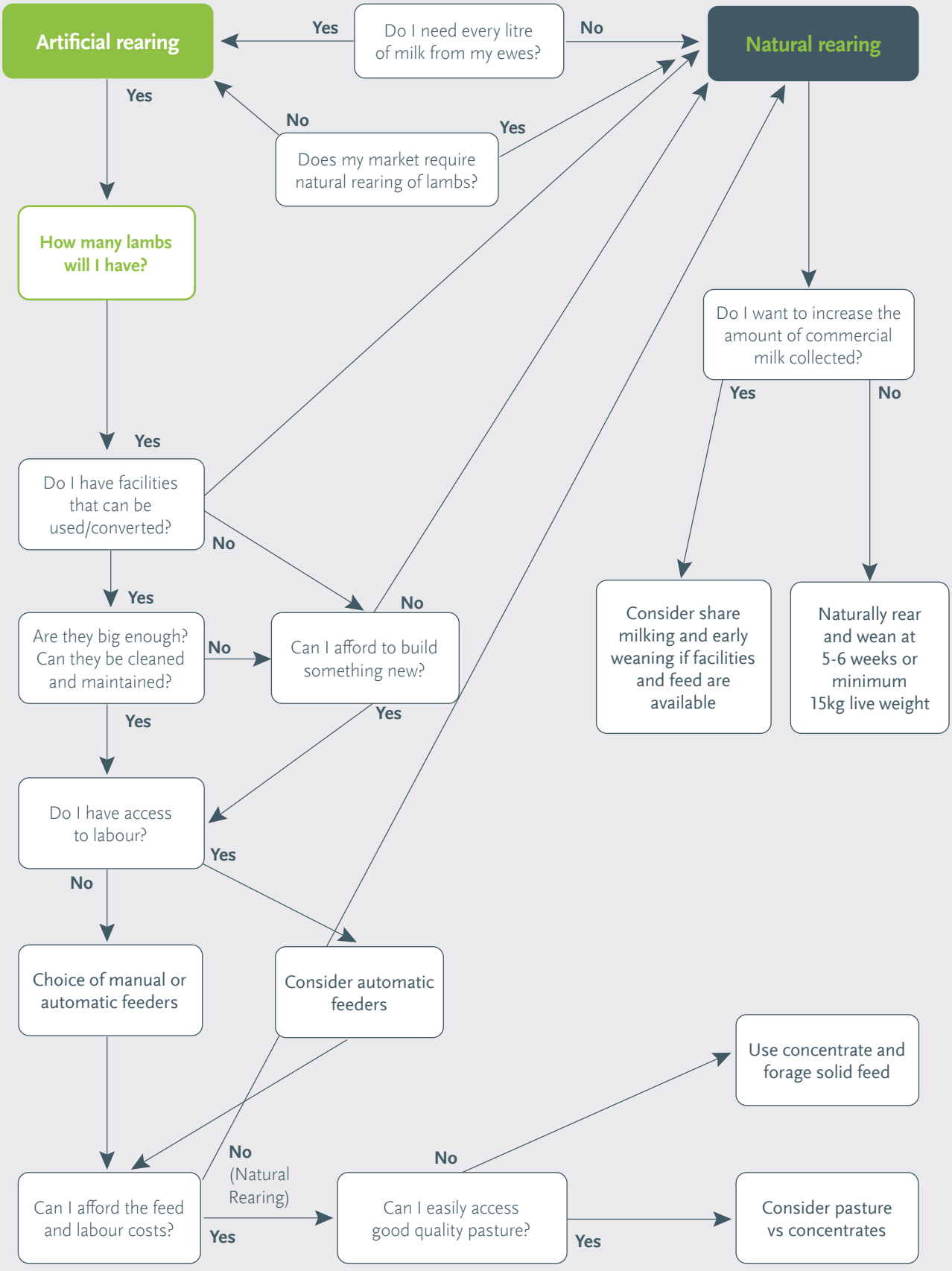
Specifically, for dairy sheep operators:

- How much milk is likely to be forgone in a move to natural rearing? Cost-benefit between commercial milk foregone and cost of artificial rearing?
- What costs are avoided by natural rearing (capital and operating)?
- How long do lambs need to be on mum? Current industry working model is ~30 days to reduce teat damage (based on advice from French producers) but optimum time in pasture-based systems is yet to be established.
- How much value is put on reduced density in the lamb rearing facility by rearing single lambs only, or by giving away/selling males to reputable rearers? This is an option to reduce stress and/or mitigate disease in the rearing facility.
- How keen is the farmer to simply avoid the stress they associate with lamb rearing? Especially applicable to farmers converting from cow to sheep dairying who therefore have limited experience handling many lambs.
- Do the ewe lambs reared on mum get a better start in life and have better lifetime performance? If so, what value do we put on that? This is currently being investigated in research trials by AgResearch.
- What are the pros and cons of a mixed system where singles and one triplet are artificially reared and twins and the remaining triplets are naturally reared and weaned at ~30 days lactation? This is an option to reduce the number of lambs to be reared and allow earlier training of a smaller number of ewes onto the milking platform – an important consideration for new operators.

For both dairy and meat sheep operators:

- What is the value of the weaned lambs and does the farmer have capacity to graze and finish them or would they have to be sold store?
- What's the hidden cost of ewes that come in dry after losing lambs (if not spotted) and milked earlier either by machine (dairy sheep operations) or by mothering on lambs?
- How much value is placed on natural rearing by the consumer?

There are many different scenarios that greatly differ between farming/business systems and consumer desires. A working example is provided of a potential decision tree approach to help work through a process to decide which system to use. This working example is not intended to be suitable for all applications but may provide some insights into how to decide on the system that is right for you and your business goals.



Codes of Animal Welfare

Owners or people in charge of animals must comply with:

- The Animal Welfare Act 1999
- Minimum standards for animal care and management in codes of welfare.

In 2015, changes to the Animal Welfare Act expanded the ability to make regulations under the Act. A first set of regulations made under these new provisions came into force in August 2016, and the second in 2018. More are planned. It is important for operators to understand their obligations under the Animal Welfare Act and associated codes of welfare, and to keep up-to-date with changes to regulations and codes. This can be achieved by subscribing to:

https://www.mpi.govt.nz/news-and-resources/subscribe-to-mpi/

More information on your obligations under the Animal Welfare Act 1999 and minimum standards for animal care and management in codes of welfare can be found on the Ministry of Primary Industries website and via the following links:

https://www.mpi.govt.nz/protection-and-response/animal-welfare/codes-of-welfare/

https://www.mpi.govt.nz/dmsdocument/1450-sheep-and-beef-cattle-animal-welfare-code-of-welfare

While the information provided in the New Zealand codes is helpful general guidance, in many cases detailed practical information on best practice management and procedures for lamb rearing cannot be found. This technical manual aims to provide a resource that can provide information and guidance to operators to contribute to successful lamb rearing. The guidelines provided are generated from a range of sources including national and international codes of welfare, the latest scientific literature, and research findings and practical experience of the researchers and commercial lamb rearing operation managers and staff.

Animal welfare is complex. For example, there are a number of adaptive changes that are used by animals in an attempt to cope with environmental changes (see below). These have been used as indicators of animal welfare and may be useful to consider in the context of your farming operation.

A recent internationally peer-reviewed publication by Richmond et al.(2017) provides an evaluation of animal-based indicators to be used in a welfare assessment protocol for sheep. This uses adult ewes as a model system, but the animal-based indicators outlined provide a useful resource to help develop an assessment protocol for sheep. Extracts from this publication have been provided in the following sections addressing the following welfare principles:

- Good feeding
- Good environment
- Good health
- Appropriate behaviour

Challenges	Pain, anxiety, handling, novel situations, proximity of people or predators, transport, social isolation, crowding, thermal stress, aggression.
Behavioural responses	Orientation, startle and reflexes, flight, struggle.
Physiological responses	Heart rate, blood pressure, respiration rate, body temperature, hormonal and metabolic changes, appetite.
Long-term responses	Changes in live weight, reproductive success, longevity, susceptibility to disease and injury, inappropriate or pathological behaviour (e.g. stereotypes).

Source: Mark Fisher (2018) Animal Welfare Science, Husbandry and Ethics – an evolving story of our relationship with farm animals. 5M Publishing Ltd, Sheffield, UK.

01. Lamb Survival & Performance

01. Lamb survival & performance

Lamb survival is a complex trait and is strongly influenced by the genotype, nutrition and management of the ewe and the surrounding environment. Good breeding is important to provide the production potential – nutrition is critical to realise that potential!

Important traits that can influence lamb survival are:

- **Litter size** – losses increase as litter size increases.
- **Embryo survival** – influences litter size.
- **Nutrition/health** – of both the ewe and her lambs.
- **Birth weight** – greater losses at birth weight extremes (heavy or light).
- **Thermoregulation** – especially important in the first 3 days of life.
- **Behaviour** – e.g. formation of the ewe-lamb bond.
- **Lactation (colostrum/milk**) – the lamb is 100% reliant on colostrum/milk to survive.
- **Stress** – can influence health, metabolic function and immunity in the dam and lamb.
- **Weather and shelter** – influences utilisation of body reserves in the dam and lamb.
- **Topography** – can provide challenges and opportunities.
- **Genotype** – influences litter size; lamb survival has poor heritability but other traits are influenced by genetics e.g. birth weight.

1.1 Pregnancy scanning is a valuable tool for nutritional management

It can be used to:

- Identify dry ewes that can be culled/managed separately to reduce feed and labour inputs.
- Identify the number of lambs each ewe is carrying to calculate total lamb numbers thus feed requirements (for feed budgeting) and feeding management (see figure below).
- Calculate feed to requirements based on the number of fetuses especially in the last 6 weeks of pregnancy. Feed requirements are ~50% greater for triplet- and ~20% greater for twin-bearing ewes compared to single-bearing ewes in the last 6 weeks of gestation. Feed requirements also increase during lactation.
- Estimate lambing dates – at minimum first and second cycle but fetal aging in 10-day increments can be possible if a skilled technician is used. Knowing when ewes will lamb enables separation of lambing mobs and feeding based on pregnancy stage to enable strategic and efficient use of feed resources, i.e. targeting the right feed to the right animals at the right time.
- Inform management of ewes around lambing, e.g. separate management of triplet-bearing ewes to give more space and additional husbandry at lambing.

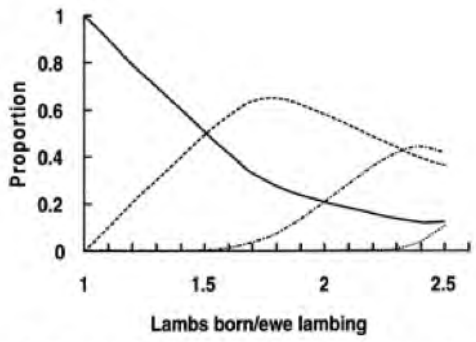
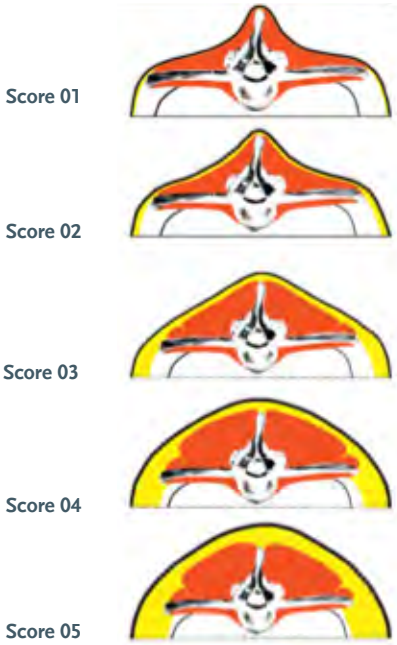


Fig. 1. Model prediction of proportions of ewes lambing singles (solid), twins (dashed), triplets (chain) and quadruplets (dotted) as flock mean prolificacy increases.

Source: Amer et al 1999. Livestock Production Science 58:75-90

1.2 Use body condition scoring as a nutritional management tool

Body condition score is a useful monitoring tool that is easy to use to evaluate the effectiveness of feeding and management regimes being applied on-farm, and as a tool to support feed budgeting. Body condition is a function of muscle (red) and fat mass (yellow) in the animal (see figure opposite), and thus reflects their level of nutrition and health. Under-feeding, either through insufficient feed allowance, imbalanced diets (e.g. protein, energy or mineral/vitamin deficiency), physiological state (e.g. pregnancy) and health issues (e.g. parasitism) affect ewe body condition score. This in turn influences her health and wellbeing (e.g. reserves to cope with short-term feed shortages like snow fall).



Left Five point body condition scoring system.

Source: Kenyon et al. NZ J. Agric. Res. 57(1):38-64
http://dx.doi.org/101080/00288233.2013.8576998

Key points

- Maintain a good body-condition score year-round - 3-4 is ideal to meet the needs of the animal and improve feed resource use by targeting the right feed to the right animal at the right time.
- Ewe live weight is not a good indicator for nutritional management unless it is undertaken regularly and live weight changes over time are monitored for individual animals.
- A fat ewe with a small frame can have a similar live weight to a larger but skinny ewe!
- Wool hides a lot of sins! Eyeball analysis of body condition is very risky unless the ewes have a small amount of wool (e.g. at shearing). The best approach is to physically determine body condition score through palpation.
- Consider body condition scoring pre-mating to establish which ewes need additional feeding before joining with the ram.
- Draft off light ewes (below condition score 3) and preferentially feed and/or consider supplements (e.g. grain). When enough pasture is available to meet animal requirements, it is only the poorer condition ewes that will benefit from grain supplementation (i.e. to increase ewe condition and lamb survival).
- Consider body condition scoring at mating, pregnancy scanning and set stocking to monitor changes and to identify any ewes that need to be preferentially fed.

Source: ncvets.co.nz

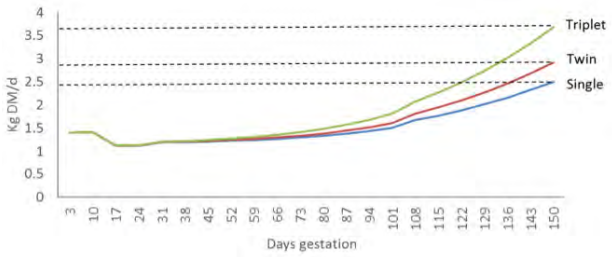
The most important consideration now is to determine the condition of your ewes and develop a feed plan to maintain their condition. Loss of body condition in mid-late pregnancy (last 4-6 weeks) negatively affects lamb survival and pre-weaning growth rates, even in good condition ewes. A 1-unit change in body condition score (e.g. drop from 4 to 3) in mid-late pregnancy can increases lamb losses by 8% in singles and twins, 15% in triplets and 20% in quads. The impacts are even greater for older ewes (i.e. > 5 years old). Therefore, irrespective of the condition of the ewes, the key is to develop a feeding plan to avoid further loss of condition as it is the loss of condition not just the condition score that is dangerous even for ewes in good condition. If you have ewes at condition score 2-2.5, preferentially feed to try and help them maintain or gain some condition. Maintain good care of ewes with condition score 3 and above to avoid condition losses. For ewes at condition score 1 then you need to intervene as this is a welfare standard issue.

1.3 Ewe pregnancy nutrition and management

Key points

- Meeting nutrient requirements = better ewe lactation, better survival and bigger lambs.
- Nutrient requirements increase with advancing gestation, especially in the last 6 weeks before lambing – this is not the time to reduce feed allowance or feeding low quality feeds.
- Restricting nutrition in the last 6 weeks of pregnancy (amount and quality), especially in multiple-bearing ewes, can negatively affect:
  - Fetal growth – resulting in lower birth weight lambs.
  - Lamb vigour – this affects the time taken for the lamb to stand up and feed and ewe-lamb bond formation.
  - Thermoregulation – by reducing brown fat deposition (specialised fat store used to generate 50% of the heat that the lamb needs to survive in the first day of life) and muscle mass (used for shivering thermogenesis).
  - Ewe colostrum and milk production (see next section).
- Nutrient requirements are higher in bigger ewes.
- Nutrient requirements increase with litter size (see graph below).
- If using crops, measure yield/quality to inform your feed budget and make sure to factor in the need for diet transitions on and off crops to avoid metabolic issues.

Gestation feed requirements (kg/DM/d)



- Don't let animal health management slip – keep up with pre-lambing vaccinations.
- Ensure any ewes grazed on fodder crops are protected with relevant vaccinations and other nutrients (e.g. iodine supplements).
- Good nutrition (quality and quantity) is particularly important during pregnancy and lactation to get the best survival and growth of lambs as well as ongoing reproductive performance of the ewes (next season).
  - For example - a 70 kg twin-bearing ewe requires ~1.8 kg of dry matter per day at 100 days pregnancy and steadily increases to 3-3.3 kg of dry matter per day up to lambing (based on pasture energy content of 12 MJ metabolisable energy per kg of dry matter). Lactation requirements for the same ewe is around 2.2 kg of dry matter per day at birth and increases to 3.5 kg dry matter per day in the first 100 days of lactation to support 300 g/d growth of her lambs.
  - Ideally ewes should not be grazed on covers below 1500 kg of dry matter per hectare (~5cm) especially in the last 4-6 weeks of pregnancy and ewes require a crude protein content in the diet of 15-18% in the last 4-6 weeks of pregnancy. Both diet quantity and quality are important!

Feed requirements calculated as the theoretical requirement based on live weight and a fetal number of 1, 2 or 3, taken from an officially authorized advisory manual from the Agriculture and Food Research Council Technical Committee that implements the recommendations on the energy and protein requirements of cattle, sheep and goats (AFRC 1993). This figure is for illustrative purposes only, to demonstrate the variation in intake requirements with increasing litter size as gestation advances. Actual requirements will depend on the live weight of the ewe.

FeedSmart app can be used for working out requirements (B+LNZ website).
https://beeflambnz.com/news-views/feedsmart-app-making-feed-management-easier

1.4 Lamb Thermoregulation

In New Zealand production systems, the majority of lambs die in the first 3 days after birth (Everett-Hinks and Dodds 2008). and the major cause of lamb deaths is hypothermia, especially in adverse weather conditions. Hypothermia is a dangerous drop in body temperature that occurs when the body loses heat faster than it can generate heat. There are several causes including inability of the ewe to produce colostrum, ewe rejection of the lamb(s) or vice versa, low birth weight of lambs which increases the surface to volume ratio and thus accelerates heat loss, vigour of the lamb and adverse climatic conditions.

Immediately after birth, before their first feed, a lamb generates heat by burning brown fat. Brown fat is a specialised fat store that is used to generate 50% of the total heat produced and supports adaptation to the cold challenge of the extra-uterine environment and to help prevent hypothermia. During cold exposure, the lamb rapidly loses heat (McCoard et al. 2014). Brown fat stores are formed during mid-late gestation and are reduced when ewes are underfed, therefore meeting the feed requirements of ewes is important. A reduction in the amount of brown fat reduces the time that the newborn lambs can burn brown fat to maintain their body temperature and thus avoid hypothermia (McCoard et al. 2017).

Lambs also generate heat through shivering thermogenesis which is initiated only after body temperature falls significantly. During cold exposure, shivering thermogenesis provides up to 50% of the heat produced by the newborn lamb and is the main source of heat production after the first few days of life (McCoard et al. 2017).

Beyond providing shelter, the most effective way to support the lamb to thermoregulate after birth is to ensure the feed requirements of the ewes are met during pregnancy. This will support the deposition of brown fat reserves in the lamb, but also support muscle deposition (used in shivering thermogenesis) and to increase birth weight. A small lamb has a greater surface to volume ratio and therefore more readily loses heat to the environment compared to a heavier birth weight lamb. For lambs removed from their dam in the first week of life, providing a warm and draft-free environment (e.g. woollen jackets, heat lamps etc.) is essential to improve survival.

1.5 Ewe lactation – importance of nutrition

Key points

- Nutrition during pregnancy influences colostrum yield and quality.
- Ewe requirements are highest in the first 6-8 weeks of lactation.
- Ewes should have body reserves (fat) for optimum performance – feed to requirements.
- Energy and protein requirements increase by 30 and 55% respectively.
- Inadequate energy intake increases protein requirements.
- Lots of clean fresh water is required for lactating ewes.

Further Reading:

- Everett-Hincks JM, Dodds KG (2008) Management of maternal-offspring behaviour to improve lamb survival in easy care sheet systems. Journal of Animal Science 86, E259–E270. doi:10.2527/jas.2007-0503.
- McCoard S, Henderson HV, Knol FW, Dowling SK and Webster JR 2014. Infrared thermal imaging as a method to study thermogenesis in the neonatal lamb. Animal Production Science 54, 1497–1501.
- McCoard SA, Sales FA and Sciascia QL. 2017. Invited review: impact of specific nutrient interventions during mid-late gestation on physiological traits important for survival of multiple-born lambs. Animal doi:10.1017/S1751731117000313

1.6 Plan feeding for ewes and lambs

Make a feed budget and monitor

- Pasture yield and quality varies throughout the year. Understand what you have including amount (e.g. measure pasture length) and quality (consider feed testing). Over time you will build up a profile of your feed resources on farm and if/when you may need additional supplements.
- Create a feed budget to understand what the feed requirements are for your animals throughout the year and plan feeding management and stocking rates, based on your feed available.
- Use pregnancy scanning data to predict feed requirements for pregnancy and lactation. The greater the scanning percentage, the greater the feed requirements to meet the needs of multiple-bearing ewes during pregnancy and lactation, and for the growing lambs (see Section 1.1).
- Feed requirements are ~50% greater in triplet and ~20% greater in twin- compared to single-bearing ewes.
- Good nutrition (quality and quantity) is particularly important during pregnancy and lactation to get the best survival and growth of lambs, as well as ongoing reproductive performance of the ewes (next season).
- If using crops, measure yield and quality to inform your feed budget and make sure to factor in the need for diet transitions on and off crops and wastage.
- Estimate feed requirements based on:
    - Ewe size (maintenance requirements are higher in bigger ewes).
    - Number of lambs carried (i.e. number of singles, twins, triplets etc).
    - Number of sheep and cattle/other stock.
    - Feed quality and quantity available.
    - Age of the ewes (hoggets and older ewes (>5 years) are worst affected by feed shortages especially if they are in poor condition).
    - Lambs start eating grass from 1 week old and lambs from 4-6 weeks consume 50% of the nutrients they need from pasture - plan feeding for both the ewe and her lambs.
    - Climate and soil fertility – use your knowledge of your farm and region to estimate pasture growth.
    - In the last 4-6 weeks of pregnancy protein requirement are high. Therefore, even when feeding a lot of supplement (including fodder crops) giving the ewes additional protein (16-18% CP content of the diet is recommended) is essential to help the ewe maintain condition and support lactation, as well as support the development and growth of the lamb to support survival and pre-weaning growth rates.
    - Note: Inadequate energy intake increases protein requirements.

Consider the nutrient requirements of your stock as an investment not a cost!

1.7 Ewe udder health

Udder health is an important but often overlooked aspect of lamb survival and growth. Lambs rely solely on colostrum and milk from the dam to survive. Therefore, udder health is critical to support the newborn lamb irrespective of the rearing system employed.

To support lamb survival and growth, key physical attributes of the udder include: Production of good quality colostrum and milk

- This is heavily influenced by ewe health and feeding (see above; protein should be 16-18% of the diet because underfeeding protein in late gestation can result in reduced or delayed colostrum production).
- It may be necessary to remove the waxy plug at birth to enable the lamb to access colostrum. This waxy plug inside the teat canals keeps the colostrum from leaking out and bacteria from getting in. In some cases it is very thick and hard for the lamb to remove.
- If the ewe has mastitis or insufficient milk for any reason, it may be necessary to feed the lamb colostrum first and then milk.

Absence of disease

Notably mastitis and "hard/frozen udder" but other issues including pregnancy toxaemia, teat lesions (lacerations from lamb suckling or orf) and retained fetal membranes can disrupt milk production.

For mastitis/hard udder:

- Risk of mastitis is influenced by environmental conditions including infective-micro-organisms (*Staphylococcus aureus* is most common, *Mannheimia haemolytica, Coagulase-negative staphylococci, Pasturella spp., Escherichia coli* and *Klebsiella*), ewe age, feed type, number of suckling lambs and udder characteristics.
- It can lead to both clinical and sub-clinical conditions that cause excruciating pain that affects the performance and welfare of the ewe and her lambs, including the ewe potentially refusing to feed her lambs due to the pain. In the worst case the lamb will stave to death.
- Incidence varies widely across farms and farming systems.

- Symptoms may include a change in gait to avoid pressure on the udder (could appear like lameness), red or hot udders or swelling of the udder and associated pus or lumps in the milk which sometimes contains blood, presence of fever/depression/lack of appetite etc.
- Hard udder is different to the common mastitis and can be referred to as "frozen udder". This is not always associated with inflammation/pain in the udder, but no colostrum/milk is produced.
- "Black udder" or "blue bag" is severe mastitis that results in gangrene of the udder turning it dark red first, then blue. Often requires euthanasia.
- Seek veterinary advice for treatment.

To improve access to the teats for the lambs – select ewes to avoid:

- Pendulous udders caused by damage to the lateral and/or medial suspensory ligaments such that the teats hang near the ground. These are more likely to be damaged (bruising, lacerations), develop mastitis and be difficult for lambs to nurse.
- Udders with very large or downward pointing teats can prevent the lamb from being able to access the udder.
- Asymmetric or uneven udders. This can be due to:

  i. Genetic defect in the suspensory ligaments.

  ii. Uneven milk production due to subclinical mastitis, or asymmetric feeding by lambs, or presence of fibrous tissue caused by previous mastitis or trauma causing a "blind half" that does not produce milk.

02. Environment & Housing

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Mammals have a range of behavioural and physiological mechanisms that enable them to adapt to a variety of situations to maintain an internal temperature within a narrow range of environmental limits to survive. Young lambs, especially in the first few weeks of life are particularly vulnerable to environmental factors that can influence their survival, health and wellbeing.

Some of the welfare criteria and indicators associated with the Welfare Principle of a "Good Environment" as described by Richmond et al. (2017)are shown below. These may be useful animal-based indicators of the quality of the environment provided for the lambs during rearing. Some of these may be useful indicators within the context of practical farming environments.

Welfare Principle	Welfare Criteria	Welfare Indicators
Good Environment	Comfort around resting	Lying time
		Lying synchrony
		Coat cleanliness
	Thermal comfort	Respiration rate/panting
		Shivering
		Rectal temperature
		Blood or urine measures of haematocrit, plasma protein etc
		Access to shade and shelter
	Ease of movement	Stocking density
		Floor slipperiness
		Aggression and displacements
		Hoof overgrowth

Source - Richmond SE, Wemelsfelder F, Beltran de Heredia I, Ruiz R, Canali E and Dwyer CM. 2017. Evaluation of animal-based indicators to be used in a welfare assessment protocol for sheep. Frontiers in Veterinary Science Volume 4, Article 210 doi: 10.3389/fvets.2017.00210 – supplementary information

General principles to consider for a good lamb rearing facility:

- Clean, dry, warm, well ventilated (to minimise ammonia build-up) and free from drafts and dust.
- Air quality is essential. Monitor at the lamb level (not human level), i.e. get on your hands and knees in the pen and check the environment the lambs experience.
- Minimise overcrowding. Consider grouping lambs according to age and/or feeding ability. Group pens should provide a minimum of 0.5-0.6 m^2 per lamb (Department for Environment Food and Rural Affairs (DEFRA, United Kingdom) Guidelines for lambs up to 12 weeks of age – more space is better. Area per lamb may need to increase over time depending on the initial pen size and stocking density, and duration of housing.
- AgResearch trials have indicated that providing 0.9 m^2 per lambs in the first 3 weeks of rearing is associated with improved growth and health compared to 0.5 m^2. Based on experience in commercial rearing units, small group sizes (e.g. 10-15 lambs) are recommended for the first 2-3 weeks of rearing to reduce competition at the milk feeder, for ease of handling of lambs to support training onto feeders and for animal health checks. Pen size can be increased after 3 weeks.
- Aim to keep lambs in the same pen throughout rearing – mixing of lambs can increase the risk of spreading disease and aggressive behaviours due to changes in social structure.
- If multiple groups of lambs go through the same pen during the season, clean out the pen between groups (i.e. change bedding and disinfect).
- Pens constructed from inorganic materials (e.g. aluminium, steel, plastic) rather than organic material (e.g. wood) will reduce pathogen load in the pens and are easier to clean and disinfect than organic materials.

2.1 Nursery Pens

- A warm, clean, dry area for very young lambs (<3 days of age) is recommended especially for newborn or weak lambs.
- Pens should be fitted with heat lamps to provide warmth and/or coats provided for the lambs. Take care lambs don't overheat (watch for panting).
- Good ventilation is important (see housing above). Air flow is important but avoid cold drafts.
- Replace bedding and disinfect pens between groups of lambs.
- The number of lambs per pen should be small (e.g. 10-15) for ease of handling and to reduce the risk of smothering/crowding.

2.2 Hospital Pens

- Have a separate isolation pen available for any sick lambs that need to be separated to minimise the spread of disease (this needs to be separate to the other lamb pens). These pens should be equipped with a heat source for sick lambs and/or coats for sick lambs to reduce thermal stress.
- Strict hygiene protocols should be applied to reduce the risk of spread of disease/infection from the sick pens to the other pens, as well as to reduce the risk to staff (see Chapter 05, Lamb Health).

2.3 Bedding

- Ideally bedding should be clean and dry at all times. When setting up pens, ensure good drainage to minimise moisture build up where possible. Alternatively, use a deep litter-type system with frequent top-ups to reduce moisture and soiling. Consider using free-draining gravel (e.g. small river stone) or slatted flooring as a base, a matting over that (e.g. road matting) with the bedding material (e.g. kiln-dried wood shavings, dry bark or post peelings) over the top (see photo below).

Above: Lambs in a nursery pen

- All bedding should be as free as possible of dust because this is an irritant to the eyes and respiratory system.
- If bedding needs to be replaced due to excessive moisture build-up or soiling, avoid disturbing the bedding material when lambs are in close proximity. Remove lambs from the pens to limit exposure to dust/ammonia.
- Order bedding supplies early in the season to avoid the risk of shortages during the rearing season.
- Damp and heavily soiled bedding is a source of pathogens that can cause health issues. A sign of a healthy pen environment is clean dry bedding and lambs that do not have soiled wool. The wool of the lambs should be clean and bright. A practice method to test if the bedding is dry is the "knee test". Kneel down on the bedding for 10 seconds and if it is damp enough to soak through your pant knees, more dry bedding is required.

Above: Example of bedding setup to enable drainage with a concrete floor; Lambs using the "microclimate" created by overhead insulation.

2.4 Shade/Shelter

- For indoor rearing units where the environment is cold and/or drafty, creating additional shelter within the lambing pens should be considered. In addition to having solid panels for the walls of the rearing pens, mesh can be installed along the side of the pen with the prevailing wind and good quality grass hay placed on the mesh. This creates a micro-environment for the lambs that is warm as well as a freely available fibre source for the young lambs to eat.
- When outdoors, shelter should be provided for the lambs especially when young. This should be adequate shelter from wind, rain and sun. It is particularly important for dairy breeds to provide shade to reduce sun exposure and photosensitivity. Provide sufficient space for all lambs to minimise crowding, and maintain good hygiene.

2.5 Water

- All pens should have clean water freely available. Clean out water troughs regularly (at least weekly or more frequently if soiled).
- It is important to ensure that the smallest lambs can reach the water source but lambs are not able to climb into the water source and drown.
- Water troughs/buckets should be secured to the side of pens (the corner is ideal) to reduce the risk of it tipping over.
- If using buckets, consider tying one bucket into the corner of a pen and using a second bucket inside that for the water for ease of cleaning.

Above: Indoor rearing barn; Outdoor rearing pens with shelters.

2.6 Transport

The code of welfare for transport of animals in New Zealand can be found here.

If transportation of lambs to a rearing facility is required, it is important to ensure the safety and welfare of the lambs and compliance with the Animal Welfare Regulations. There are no specific practical guidelines for transportation of young lambs from their birth site to a rearing facility. This section aims to provide some guidance on a best practice for transport of young lambs. These procedures have been based on international guidelines, feedback from veterinarians and practical experience of researchers and farm operators.

Transportation times/distances should be minimised to reduce the impact on animal health and welfare. Below are some key points to consider.Lambs for transport off-farm should have a dry navel (minimum of 48 hours old), be healthy and able to stand unaided. All lambs need to be individually inspected and comply with the check list (see example 'lamb passport" below).

This can be adapted to suit individual animals or groups. The lambs should be fed within 2 hours of transport, especially neonatal lambs (e.g. 2-7 days old) and when transportation time is greater than 2 hours to minimise the risk of dehydration.

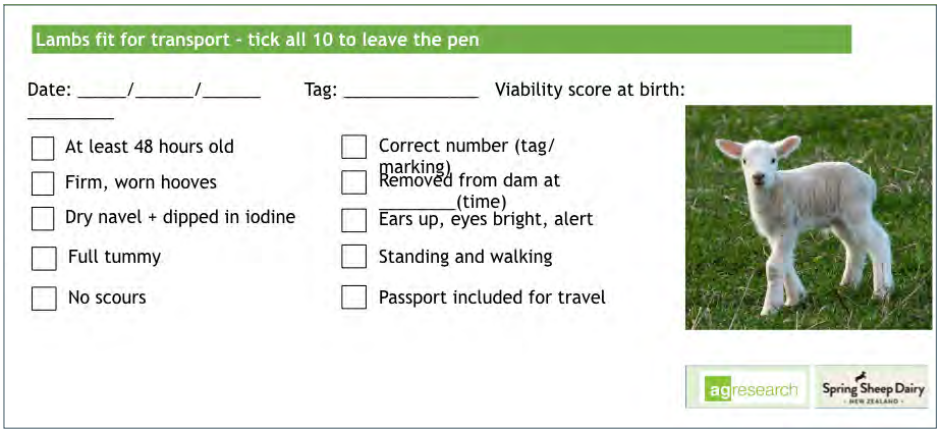
When lambs are being transported between farms, where the management of the animals will be undertaken by different staff, it is recommended that a "lamb passport" is completed for each batch of lambs. This will enable animal health/welfare information to be transferred to the new staff to support a smooth transition into the new rearing unit and maintain a high level of animal welfare and care. This should include information relating to animal traits (e.g. date of birth, sex, tag numbers etc.) as well as animal health information (e.g. notes on any lambs that have required animal health treatments, any health issues the new rearers need to be aware of etc.).

Before entry into the transport vehicle/trailer, and upon entry into the new rearing facility, whether the navel is wet or dry, dip lamb navels in concentrated iodine solution (right down to base) to reduce the risk of infection.

A dedicated trailer should be used with partitions to create small pens. Ensure enough space for all lambs with partitions (recommend 6-8 lambs/pen) to minimize crowding and risk of smothering. All lambs should have plenty of space to stand and lie down. The trailer should have good ventilation but be free of drafts and contain suitable clean, dry, dust-free bedding material. Ideally the trailer should be steam cleaned and sprayed with a suitable high-grade disinfectant (e.g. Virkon or Vetsan) and allowed to dry prior to lamb transport and between batches of lambs to maintain a high level of hygiene.

Check lambs regularly during the trip to ensure all in good health.

Persons responsible for the loading and transport of animals need to have a good basic knowledge of the animals behavioral and physical needs. Planning the entire journey well in advance will allow adequate time for stock to be loaded and unloaded quietly and with care.



Right: Example lamb passport/ checklist for use prior to transport and/or entry to a rearing unit.

03. Feeding

03. Feeding

The purpose of this section is to provide guidance on best practice for feeds and feeding management required for young lambs to support their survival, growth, health and wellbeing. The welfare criteria and indicators associated with the Welfare Principle of a "Good Feeding" as described by Richmond et al. (2017) are shown below. These may be useful animal-based indicators of good feeding practices during rearing.

Welfare Principle	Welfare Criteria	Welfare Indicators
Good feeding	Absence of prolonged hunger	Body condition score
		Lamb survival
	Absence of prolonged thirst	Skin pinch test
		Plasma/urine sample, plasma proteins etc
		Access to water

Source - Richmond SE, Wemelsfelder F, Beltran de Heredia I, Ruiz R, Canali E and Dwyer CM. 2017. Evaluation of animal-based indicators to be used in a welfare assessment protocol for sheep. Frontiers in Veterinary Science Volume 4, Article 210 doi: 10.3389/fvets.2017.00210 – supplementary information

Good nutrition is one of the easiest strategies to support health, production and welfare of lambs. It is important to note that the growth performance and health of lambs will be influenced by many factors other than the amount of milk or milk replacer offered. Such factors include, breed, birth rank (single, twin, triplet etc), quality of the ingredient used in milk replacer formulations, the frequency of feeding, animal health issues, stocking density, the amount and quality of starter diets (solid feeds) and rearing environment (e.g. climate).

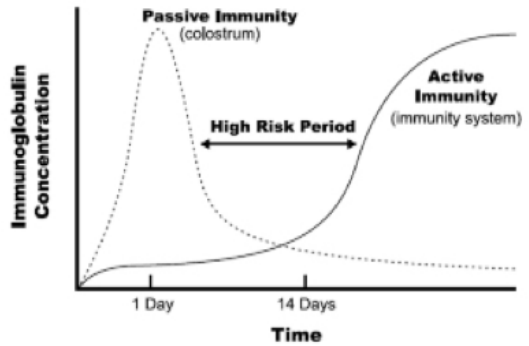
Nutrition provides fuel for growth and development, and is a key determinant of the immune response. Undernutrition, or inadequate nutrition, can impair growth and development including immune function, with lifelong consequences for health, productivity and welfare.

Newborn ruminants have 3 critical periods affecting their immune system in the first 3 months of life:

1. Colostrum feeding
2. Milk feeding
3. Weaning

3.1 Colostrum Feeding

Colostrum is the first milk produced by the ewe and has high levels of nutrients, bioactives, energy and immunoglobulins which play crucial roles in defence against external pathogens. It is essential that lambs receive an adequate amount of colostrum within the first few days of life. This is because lambs are born with no natural immunity as the ruminant placenta prevents transfer of immunoglobulins from the dam to the fetus. These immunoglobulins protect lambs until their own immune systems are fully functional which is not until they are 3-4 months old. The amount of immunoglobulins within the colostrum and the concentration of nutrients decreases as the time post-lambing increases. Further, the gut of the lamb loses the ability to absorb immunoglobulins from colostrum over the first day of life. Therefore, consumption of sufficient colostrum soon after birth is critical. Insufficient neonatal absorption of colostral immunoglobulins within the first day of life is associated with failure of passive transfer of immunity, leading to increased risk for neonatal diseases, mortality and lasting negative effects on health, longevity and performance. Higher mortality and morbidity rates have been observed in colostrum deprived lambs (up to 80%) compared with colostrum-fed lambs (up to 20%).



Transition from passive to active immunity; Source ad.ndsu.org

Recommended Colostrum Feeding Regimes

- Data generated to date from our research indicates good levels of colostral transfer when lambs remain on the ewes for at least 48 hours.
- It is essential for lambs to get sufficient colostrum early (within 6-8 hours of birth). The colostrum must be of good quality, and continue to be given for at least 2 days, preferably 3-4 days.
- If lambs are removed from the mother at birth, it is essential to feed gold colostrum (first colostrum produced in the udder on the day of birth) on day 1, followed by a transition from colostrum to milk by day 4 (mixing gradually).
- If they need to be fed artificially, ideally colostrum would be fed at a level of 15% of birth weight split into 5-6 feeds for the first few days.
- If fresh sheep, goat or cow colostrum is used, it is essential to ensure the colostrum is of good quality (Brix value greater than 22; a Brix meter is available from veterinary supply stores), and that it is stored appropriately to minimise microbial contamination. Colostrum must be mixed well (the components can settle during storage) and warmed to body temperature prior to feeding. Colostrum can also be frozen in small quantities and thawed (do not microwave!) in warm water, mixed well and fed warm. Powdered colostrum is also available from rural supply stores for use when fresh colostrum is not available.
- Quality will decline substantially within 24 hours even if refrigerated, so prioritise feeding the freshest colostrum to the youngest lambs for best results.
- Experience in the dairy sheep industry indicates that hoggets often have very thick colostrum on day 1 of lactation which can be hard for the lambs to extract from the udder. Therefore, extra care is required to ensure that newborn lambs from hoggets receive sufficient good quality colostrum.
- It is also important to remember that competition for the udder between littermates (i.e. in triplets and quads) or poor mothering ability and/or ewe-lamb bond, can affect the ability of all lambs to receive sufficient colostrum. It is important to carefully check newborns for signs of hunger and if required, manually feed colostrum.

3.2 Milk Feeding

The newborn relies completely on milk to provide the nutrients and energy required to support growth and development. At birth, the rumen is non-functional so the small intestine plays a key role in driving nutrient metabolism, immune function and thus survival and growth until the rumen is fully developed.

It is essential that lambs receive adequate levels of milk. In naturally reared lambs, competition between littermates (e.g. triplets and quads) and poor lactation performance of ewes as a result of underfeeding and/or animal health issues, can reduce milk intake. In such cases, lambs may require assistance with feeding in the first few days of life, or artificial rearing. There are many different options for milk feeding of artificially-reared lambs from restricted milk feeding to ad libitum milk feeding systems with both manual and automatic feeding equipment. Explore which system fits your budget, facilities, staff availability and skill level of the staff you have available (do this in advance of the lambing season so you can be prepared).

General key points:

- Always ensure milk replacer is prepared and fed fresh.
- Feed warm milk replacer (skin temperature, i.e. no more than 37°C), especially to very young lambs as this reduces the requirement to partition energy towards heat production. Mix to a consistent temperature for each feed.
- Always follow the manufacturer's instructions for milking of milk replacer and do not mix at levels below the recommendations. It is important to note that if an instruction states "200g/L", this means 200g of powder made up to a total of 1 L of reconstituted milk replacer. Milk replacer can be concentrated (up to no more than 250 g/L) to reduce milk volume and increase nutrient delivery to the lamb especially in restricted milk feeding systems.
- Do not over feed lambs – a maximum of 350ml per feed depending on the size of the lamb. Monitor the stomach of the lamb and stop feeding if the stomach begins to protrude beyond the ribs. Overfeeding can cause animal health issues such as scours and bloat (see Chapter 05, Animal Health).
- Ensure all equipment is thoroughly cleaned with warm soapy water and rinsed after use.
- Always feed lambs either standing or held in a position where their head is in the natural position when feeding naturally (see photos below). Do not place the lamb on its back and feed like a human baby. This can cause milk to go into the lungs and for the lamb to develop pneumonia or drown.
- Always ensure ad libitum fresh water is available, even when feeding milk.

3.3 How much milk to feed?

The amount of milk fed, will largely depend on the feeding system (e.g. restricted versus ad libitum milk allowance) and equipment (e.g. bottles/cafeteria vs automatic feeder) used.
In general, it is recommended to feed lambs milk at a minimum of 20% of their birth weight (e.g. 1L per day for a 5kg lamb split into multiple feeds) to meet the minimum requirements for growth. It is advisable to weigh lambs on entry to the rearing unit to determine how much milk they should be fed if individual bottle feeding. This can be achieved by using a set of small scales with a box on top or putting the lamb in a bucket on its rump (do not leave in this position for more than 1 minute) and using a hand-held luggage or fish scale, or in a container placed on top of a flat scale (see photo insert for ideas).

In general, the more milk a lamb is fed, the faster it will grow. However, care must be taken not to overfeed lambs when feeding with bottles or cafeteria feeders as this may cause scours or bloat (see Chapter 05, Animal Health). As stated in the previous section, a general rule of thumb is that no more than 350ml of milk should be offered in a single feed to bottle-fed lambs.

Above: Can weigh newborn lambs in a bucket with a portable hand-held scale (minimise time in this position).

Above: Ad libitum vs restricted milk fed lamb (both 5kg at birth) at 5 weeks of age.

3.3.1 Study 1
Restricted vs ad libitum milk feeding systems?

International studies have shown that *ad libitum* feeding can increase growth rates compared to restricted milk feeding but effects on post-weaning performance of lambs grown in pasture-based production systems had not been evaluated.

In our MBIE-funded research program, we undertook a study to compare the performance of artificially reared lambs from two systems:

1. *Ad libitum* milk feeding for 5 weeks followed by gradual weaning over 7 days (group 1), and
2. Restricted milk feeding (20% of entry body weight per day) with a 3-week weaning process to wean at 4 weeks (group 2).

Thirty (n=15/group) mixed sex single and twin-born Romney x East Friesian lambs of 2-4-days old (average weight of 5.2 kg, range from 2.8 – 7.7kg) were enrolled in the study and reared using automatic feeders where individual intake was recorded. A commercially available 100% milk protein-based milk replacer (25% crude protein, 25% fat) was used. Concentrate starter, chopped meadow hay and water were available ad libitum during rearing. Lambs were reared indoors in a temperature-controlled room (~18°C) that was well ventilated, and lambs were managed in 3 x 6m pens on kiln dried untreated pine wood shavings.

Lambs in group 1 were weaned using a system where milk allowance was reduced by 14% per day (programmed for each lamb using a computer-controlled system) to enable weaning over a 7-day period by the end of week 6. Milk allowance of group 2 was restricted to 20% of their initial body weight (on trial entry) offered in 4 equal periods during the day. They were weaned over 3 weeks by reducing milk replacer allowance by 25% per week (computer-controlled) with complete weaning at the end of week 4. This system was designed to mimic the restricted milk-feeding and weaning system in our other studies (see Chapter 04, Solid Feeds and Weaning).

One week after weaning (week 7 for group 1 and week 5 for group 2), the lambs were moved outdoors onto a ryegrass-white clover mixed sward pasture with shelter available. Solid feed supplements (concentrate and hay) were gradually removed over 10 days by week 9 of rearing. The animals were monitored until 18 weeks of age. All lambs were vaccinated against clostridial infections at week 4 and a booster provided at week 8. Anthelmintic was administered to all lambs 2 weeks after moving onto pasture and every 3 weeks thereafter to control internal parasites.

Average milk intake of the ad libitum group pre-weaning was 91 L (range of 63-107 L) per lamb compared to 21 L (range of 12-26 L) per lamb in the restricted group. All lambs were healthy during the trial with minimal antibiotic use in both groups.

Pre-weaning growth rate was much higher in the ad libitum compared to restricted group which reflects the greater milk intake. Post-weaning growth rate however did not differ between the groups. These differences in growth rate were reflected in the live weight profile, with a divergence in growth up to 6 weeks of rearing, with these live weight advantages remaining at 18 weeks of age. The cost to rear the lambs in the ad libitum group was higher due to the greater level of milk intake (91 vs 21 L per lamb on average) and the extra labour associated with care of the animals for a further 2 weeks of milk feeding prior to weaning.

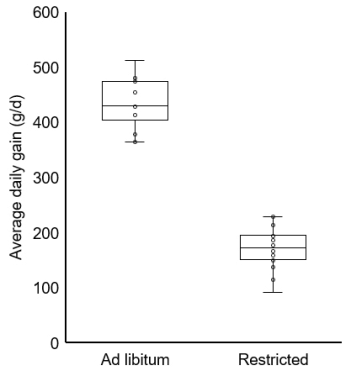
The long-term benefits of ad libitum vs restricted milk feeding systems on growth, health and meat/milk production have not been quantified. The selection of feeding system depends on multiple factors such as the availability of skilled labour, capital costs (sheds, pens, automatic feeders etc.) and needs to be considered on a farm by farm basis. Furthermore, the availability of good quality feed post-weaning is an important consideration as lambs weaned at lower live weights will require greater post-weaning growth rates to achieve target weights for hogget mating (if used) or to reduce the time to slaughter (meat production systems).

3.4 Which milk replacer to use?

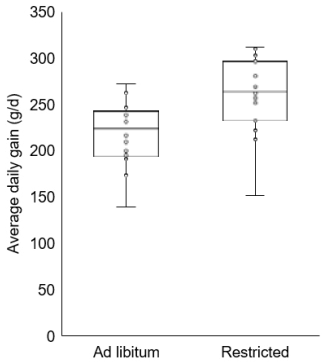
There are wide range of lamb milk replacers commercially available. These vary in quality and price. The high cost of milk proteins has driven the development of cheaper formulations of lamb milk replacer. These formulations use whey proteins (by-product of cheese making) and/or vegetable proteins and oils as cheaper alternatives to casein milk proteins and milk fat. Spray-dried milk proteins are recommended for formulation of milk replacers. Some research trials have suggested that non-milk protein sources such as soy protein can be used but high inclusion rates (up to 40%) can depress growth and ad libitum feeding should be avoided due to sedimentation issues with inclusion rates above 30% soy bean concentrate or full-fat soy flour. Most published research evaluating lamb milk replacer protein sources on lamb performance are over 30 years old and have focused on soybean protein. Inclusion of hydrolysed wheat protein as a cheaper alternative to soy protein is not common in commercially available milk replacer.

We have undertaken two commercial-scale trials (at least 100 lambs per formulation) to evaluate the impact of substituting of high-quality casein protein with whey protein (Study 1) or hydrolysed wheat protein and whey protein (Study 2).

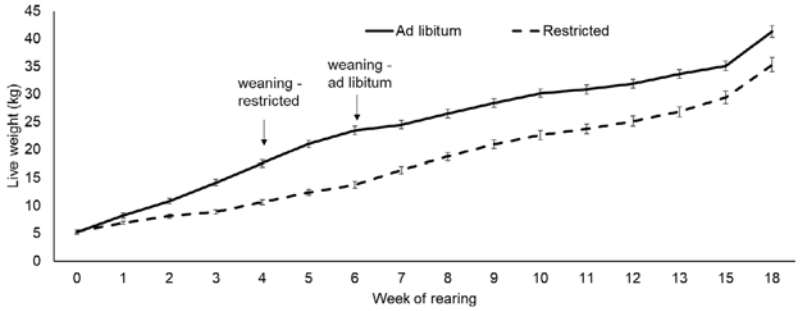
Effect of milk feeding level on pre-weaning average daily gain



Effect of milk feeding level on post-weaning average daily gain



The effect of milk feeding level on lamb live weight from birth to 18 weeks of rearing



3.4.1 Study 2
100% milk protein (casein-based) and fat vs. milk protein (whey) + hydrolysed wheat + vegetable oil

In study 1, we compared a 100% milk protein commercially available milk replacer made from 100% milk protein and fat (mostly casein with some whey protein; 100% milk protein and fat; MR1) with a commercially available milk replacer containing milk protein (mostly whey with a very small amount of casein), hydrolysed wheat protein and 100% vegetable oil (MR2). East Friesian 2-3-day-old cross-bred mixed-sex lambs were randomly allocated to eight replicated pens (16-20 lambs/pen per treatment). Milk replacer was mixed at 230g/L and was fed ad libitum using automatic feeders. Concentrate starter diet was freely available and intake did not differ between the groups. During the first three weeks of rearing (study period), lambs fed MR2 compared to MR1 had lower growth rates independent of birth rank, i.e. single, twin, triplet, greater mortality, required greater antibiotic treatment and had poorer feed conversion efficiency.

	MR1	MR2
Milk replacer composition		
Crude protein (%)	**25.9**	**22.8**
Fat (%)	**27.1**	**23.5**
Performance traits (all lambs)		
Average daily gain (g/d)	**356**	**236**
Mortality (%)	**4**	**10**
Antibiotic treatment (% of lambs)	**4**	**18**
Feed conversion efficiency (kg intake/kg weight gain)	**2.1**	**2.8**

Further Reading:

- McCoard SA, Ryrie J, Macdonald T, Hea S-Y, Khan A, Stevens D. Growth and health of lambs artificially reared with casein- or whey-based milk replacer. Presented at the International Symposium on Ruminant Physiology 3-6 September 2019, Leipzig, Germany.

3.4.2 Study 3
100% milk protein (casein-based) and fat vs. milk protein (casein + whey) + hydrolysed wheat + vegetable oil

In this study we compared a commercially available 100% milk protein (casein; MR1 – the same formulation used in study 1) formulation with a commercially available formulation containing casein, whey and hydrolysed wheat protein and vegetable oil (MR2). For each formulation. Male East Friesian 2-4-day-old lambs were randomly allocated to eight replicated pens per treatment (10-12 lambs per pen). Milk replacer was mixed at 230g/L and was fed ad libitum using automatic feeders. Lambs were given free access to hay but no concentrate starter feed was offered.

Overall, lamb growth was lower, and a greater percentage of lambs failed to reach the minimum weaning weight of 13.5 kg by 5-6 weeks of age (16 vs 4%) with MR2 compared to MR1. Mortality was similar, as was milk replacer intake, but poorer feed conversion efficiency was observed in MR2 compared to MR1 lambs. Incidence rate of several health issues were also greater in lambs fed MR2 than MR1: 7.6 times higher rate of scours, 1.9 times higher rate of pink eye, 2.5 times higher rate of pneumonia, 3.7 times higher rate of external infections, and 12.6 times higher rate of adverse behaviours such as navel sucking. As a result of these health issues, antibiotic use was 2.4 times higher in lambs fed MR 2 than MR1 as were the costs for animal health-related interventions.

Antibiotic use is an indicator of animal health and welfare and reducing antibiotic use is desirable in modern markets. Therefore, we also looked at the performance of the lambs not treated with antibiotics. Growth rates of lambs fed the milk replacer containing the hydrolysed wheat and whey protein and vegetable oil was reduced. This was associated with a lower proportion (48 vs 73%) of lambs that reached a minimum 13.5 kg live weight (commercial target for weaning).

The digestive system of the young ruminant is poorly developed at birth and can only digest a limited amount of carbohydrates, fats and proteins. The results of these studies illustrate that very young lambs have greater growth and better health when fed milk replacers formulated with 100% milk proteins (casein-dominant) and that milk replacer formulations containing mostly whey protein, or a combination of whey and hydrolysed wheat protein should be avoided. The impact of variable inclusion rates of these cheaper milk protein sources on animal performance has not been scientifically evaluated and requires further study.

It is interesting to note that in this study, a commercially available compound that claimed to prevent scours and optimise growth in young livestock, was available for all lambs. The incidence rate of scours was 23.5 vs 3.1 in lambs fed MR2 than MR1. Therefore, there was no evidence that this compound prevented scours in the lambs.

	MR1	MR2
Milk replacer composition		
Crude protein (%)	**25.3**	**23.0**
Fat (%)	**26.9**	**24.3**
Performance traits (all lambs)		
Average daily gain (g/d)	**295**	**242**
Average daily gain (g/d) of lambs not treated with antibiotics	**331**	**305**
Mortality (%)	**8**	**10**
Antibiotic treatment (% of lambs)	**<1**	**28**
Feed conversion efficiency (kg intake/kg weight gain)	**1.4**	**1.7**
Labour, antibiotics and bedding costs associated with health interventions ($/head)	**$7.32**	**$17.20**

The key message from this work is that selection of milk replacer for lamb rearing should consider not just the cost, but also health and welfare implications of slower growth, increased use of antibiotics, impact on mortality and costs associated with animal health interventions when feeding different milk replacer formulations. Long-term benefits or trade-offs on lifetime performance have not been studied.

Does casein-based milk replacer cause abomasal bloat?

One health issue commonly observed in artificial lamb rearing systems is abomasal bloat. Anecdotally, claims have been made in both small and large-scale rearing systems that casein-dominant milk replacer formulations cause bloat. The potential cause is thought to be the absence of curd formation that occurs in formulations based on whey or vegetable proteins prevents bloat. In both the studies described above and all other studies undertaken in our research program, no cases of abomasal bloat were observed with any of the milk replacers used. This suggests that factors other than milk replacer formulation or protein source likely causes abomasal bloat. Such factors to reduce bloat include preventing overfeeding, and maintaining good hygiene associated with feed preparation (see Chapter05, Animal Health).

3.5 Milk feeding equipment:

There is a wide variety of milk feeders available. The choice of milk feeding equipment depends on the number of lambs reared, infrastructure available and the feeding system choice (see feeding system section).

Some general recommendations are as follows:

- To reduce the risk of infection and animal health issues (e.g. bloat), all feeding equipment should be cleaned regularly. If using bottles or cafeterias, all equipment for mixing and feeding milk should be cleaned after each feed with detergent and rinsed thoroughly before drying.
- If using automatic feeders, these should be cleaned and calibrated at least weekly. Cleaning needs to include the mixing bowl as well as the milk lines that lead to the teats as milk residues can build up in the lines providing the perfect environment for pathogens. It is recommended to have two sets of milk lines so that the used set can be removed and replaced with the clean set. Between changes, the clean lines can either be dried and stored or remain soaking in a bucket (with a lid) containing sterilisation solution to keep them clean before use. Keep milk lines as short as possible.
- The area around the teats mounted on feeding panels need to be kept clean and the teats themselves require regular cleaning. Monitor teats for damage daily and replace when required.
- When using automatic feeders or cafeterias, often the area around the milk feeders becomes soiled with milk. It can be useful to have rubber matting or mesh under the feeding area to enable drainage and ease of regular cleaning to avoid pathogen build-up.

- Automatic feeders require teats to be mounted inside the pens to provide lambs with free access to milk. AgResearch trials have found that teats mounted within a feeding stall where other lambs cannot bully them away from the teat is desirable compared to mounting teats directly to the side of the pens. Competition between lambs when feeding from automatic feeders, especially when young, can reduce intakes and growth rates which in turn can affect health. If teats are mounted directly to the side of pens, it is recommended that they are mounted set back from the wall of the pen to reduce teat damage from lambs chewing the teats, and to ensure that there are no sharp edges as this can cause facial injuries to the lambs.

Above: Examples of feeders.

Above: Lambs competing for the feeder.

Right: Lamb at feeder stall.

04. Solid Feeds & Weaning

04. Solid Feeds & Weaning

At birth, the rumen is a non-functional compartment of the digestive tract and lambs function as a monogastric. In lambs, the rumen does not start to develop until 2-3 weeks of age which is why the amount and quality of milk fed is so important in the first few weeks of life.

Lambs start to consume solid feed from about 1 week of age. At this stage, the solid feed consumed (e.g. pasture, leaves, bedding in rearing pens, hay, meal etc.) does not provide any nutritional value. However, this solid feed provides a substrate for the physical and microbial development of the rumen. As solid feed intake increases, the functional development (physical, microbial and metabolic) of the rumen increases which is required to support the transition from liquid (milk) to solid feeds.

The cost of artificial lamb rearing systems (especially milk and labour) has driven the development of feeding systems that restrict milk intake to promote rumen development to enable early weaning. These approaches may affect lamb performance (e.g. growth and health) if key changes in the structure and functionality of the rumen are not achieved prior to weaning.

Rumen development is driven primarily by the intake and fermentation of solid feed which can be affected by rearing practices including:

- Milk intake volume
- Age at weaning
- Method of weaning
- Time of introduction of solid feeds

The success of transition from milk to solid feed is inextricably linked to both solid feed intake as well as weaning methods. Therefore, these aspects are considered together in this section.

4.1 What type of solid feed should I use?

Lambs require solid feed to develop the rumen. Grain-based concentrate starter diets (also known as meals), hay, ensiled feeds and pasture can all be used.

Concentrates/Meal

- Often used in indoor rearing systems due to the ease of use.
- Good option when good quality pasture is not available and rearing infrastructure does not allow pasture introduction at a young age.
- Growth rates of lambs fed meal vs. pasture can be greater due to the nutrient density of the feed (i.e. amount of nutrients in every mouthful) if a good quality meal is used.
- Meal should be fed for at least 3-4 weeks after lambs are weaned off milk and transitioned off meal onto pasture/forage diets over a 3-week period to allow the microbes in the rumen and metabolic systems in the lamb time to transition from a grain-based to pasture diet.
- Meal should be included in the diet for lambs when milk intake is restricted, to provide sufficient nutrients to support growth and development.
- Some meals contain coccidiostats – check the label.
- Check the ingredients used to formulate the meal – some ingredients can negatively affect the palatability of meal, e.g. palm kernel, copra.
- Nutritional value of meals vary between products and formulations and as such can affect performance – use meals with a minimum protein content of 18%.
- Avoid meals with a high molasses content (e.g. those designed for calves or where you can visibly see molasses coating on the grain). These can cause scouring in lambs.
- Always ensure an effective fibre source (e.g. hay, silage, pasture) is fed in conjunction with meals to provide a balanced solid feed diet to support rumen development. This is particularly important for lambs that will be weaned onto pasture as lambs need to develop the fibre-degrading microbes to support this transition.

Hay

- Can be provided in the form of meadow hay or Lucerne – Lucerne hay is more palatable than meadow hay and will promote faster development of the rumen.
- Feeding chopped hay (shorter fibre length) is ideal for very young lambs to support greater intake.
- Hay is a good source of effective fibre for lambs to support the physical development of the rumen.
- Nutritional value of hay is much lower than meal and pasture and should not be considered as a sole solid feed for young lambs.

Silage

- Silage can be fed to lambs, however it is not recommended to feed silage from large bales as it can easily become contaminated with bacteria and fungi which can cause health issues (e.g. listeriosis).
- Silage from small bales (e.g. ensiled chopped Lucerne) can be used provided it is regularly checked for mould and offered fresh daily.

Pasture

- Should be good quality and in unlimited supply.
- Take care to keep the pasture clean from dirt and faecal matter. This may mean keeping some in reserve in case of wet weather, or when stocking rates are high.
- Can replace meal feeding when lambs are given early unlimited access to good quality pasture, provided milk is not restricted (see below for more information on animal performance with meal vs pasture feeding trial results).
- Herbs and legume mixes may be used, though diets wholly composed of legumes such as red clover or lucerne should be avoided.
- Grasses, which contain long fibres, should be included.
- If lambs are to be weaned onto herb and legume-based diets, these must be available for at least 2-3 weeks before weaning.
- Plan pasture requirements in advance of the lambing season to ensure that sufficient quality feeds are available for young lambs without competition from other classes of livestock (e.g. ewes).

4.2 Managing dietary transitions

- Changing from one feed to another, such as from meal to pasture, requires careful attention to the transition. A poor transition can result in metabolic dysfunction resulting in negative energy balance and weight loss.
- Each transition takes at least 14-21 days to achieve (the longer the better) and should be done by reducing one component and increasing the other component by 7-10% per day.
- Each transition will have a productive cost so it needs to be planned.
- If lambs have been reared using grain-based solid feeds and are to remain on a total mixed ration diet (e.g. still a high component of grain), a shorter transition can be used (e.g. 10-14 days). Our experience indicates that when meal is a major component of the diet, weight loss (as a result of negative energy balance) can occur with a transition to pasture of 10-14 days. This may be addressed by a longer transition (e.g. 3-4 weeks).

4.3 Meal/fibre feeders

- Ensure sufficient space for all lambs to have free access to feed (at least 20cm each and more for older lambs – ewes require 30-45cm depending on their size).
- Feeders should be mounted to fences or pen walls and elevated from the pen floor, rather than have them at ground level inside pens. This reduces the risk of them being tipped over (wastage) and to reduce soiling from lambs climbing into the feed troughs. It can also make it easier for cleaning and topping up the feeders from outside the pens. Where possible, feeders can be mounted outside of the pen with head access for the lambs (see photo).
- Clean regularly (at least weekly or more frequently if soiled).
- Ensure fresh feed is provided daily as this will encourage intake and reduce the risk of contamination by birds etc. Discard old feed to avoid the risk of contamination with pathogens. Monitor intake closely so feed allocations match what the animals are eating to minimise waste.

4.4 How early can I wean lambs?

Weaning age depends on:

1. Solid feed intake
2. Level of rumen development
3. Quality of solid feeds available to support growth and health post-weaning.

In general, weaning should not be initiated any earlier than 4 weeks of age provided lambs have been given prior access to solid feeds and are consuming sufficient solid feed prior to weaning (at least 200-300g/head/day).

Feed conversion efficiency reduces with age and capitalising on this in young lambs can reduce feed costs.

4.4.1 Study 4

Impact of early weaning on performance of lambs fed restricted milk volumes

Restricted milk feeding systems where lambs are fed a limited amount of milk several times a day using bottles or cafeterias, is a rearing system that can be used at any scale. International literature suggests that lambs can be weaned as early as 4 weeks of age without detrimentally affecting lamb growth. However, these rearing systems often maintain the lambs indoors on grain-based feeds or continue to feed grain post-weaning, which differs to many of the systems employed in New Zealand. Furthermore, the effects on the development of the digestive tract (important for supporting growth and health), metabolic function and immune system development were not reported. Therefore, we undertook a study to address these gaps in knowledge.

Feeding frequency used in Study 4

	Early weaned (4 week); n=16	Control (6 week); n=16
Week 1	4x Daily	4x Daily
Week 2	3x Daily	3x Daily
Week 3	2x Daily	3x Daily
Week 4	1x Daily	3x Daily
Week 5	0	2x Daily
Week 6	0	1x Daily

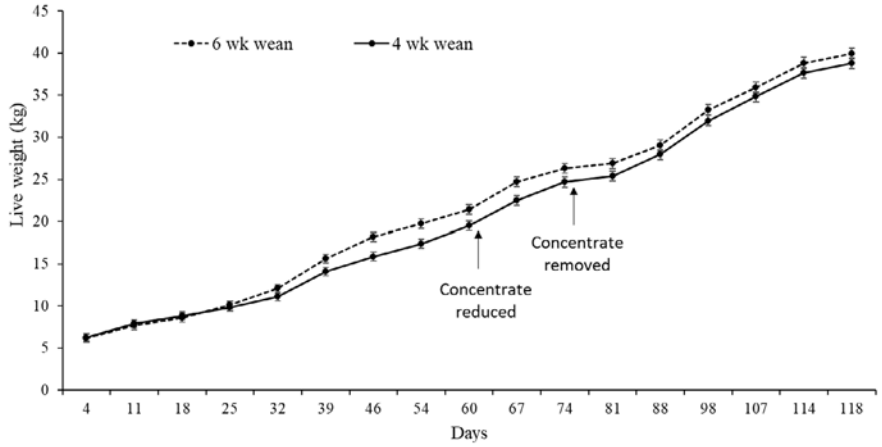
Thirty-two mixed sex Romney lambs of 2-4 days old were enrolled in the study. The lambs were housed in individual pens to enable measurement of solid feed intake. Bedding was kiln-dried untreated wood shavings. The lambs were fed warm milk replacer (AnLamb, NZAgBiz, Auckland, New Zealand) reconstituted at 200g/L. The frequency of feeding is shown in the Table above. In week 1 they were fed four times a day (8am, 12pm, 4pm and 10pm) and three times daily in week 2 (8am, 12pm and 4pm). Weaning was achieved by removing one feed per day over 2 weeks from the end of week 3 to none by the end of week 4 (early weaned group) or week 6 (control group). The lambs were moved outdoors onto pasture in week 7. A summary of the feeding regime, and chemical composition of the diets is outlined below. Growth, body composition, rumen and small intestine development, immune and metabolic function were evaluated.

Chemical composition (% of dry matter) of the milk replacer, grain-based concentrate and fibre fed to the lambs during the first 6 weeks of rearing and of the mixed ryegrass and white clover pasture grazed during the postweaning period.

	Milk Replacer	Starter	Fibre	Pasture
Dry matter	94.9	88.9	88.2	12.7
Crude protein	24.0	20.1	11.1	31.7
Acid detergent fibre	-	6.4	35.9	31.7
Neutral detergent fibre	-	15.7	55.2	18.1
Organic matter	94.5	88.9	91.0	87.0
Soluble sugars	40.5	5.8	5.4	7.3
Starch	-	35.6	-	-
Ether extract (fat)	25.0	2.7	1.6	5.7
Ash	5.5	11.1	9.1	10.9

Treatment	Week 1 - Week 4	Week 5 - Week 6	Week 7 - Week 8	Week 9 - Week 16
Weaning Week 4	Milk, Concentrate and Fibre	Concentrate and Fibre	Grass, Concentrate and Fibre	Grass
Weaning Week 6		Milk, Concentrate and Fibre		

Live weights of lambs reared on a restricted milk diet with step-down weaning at 4 weeks or 6 weeks of rearing

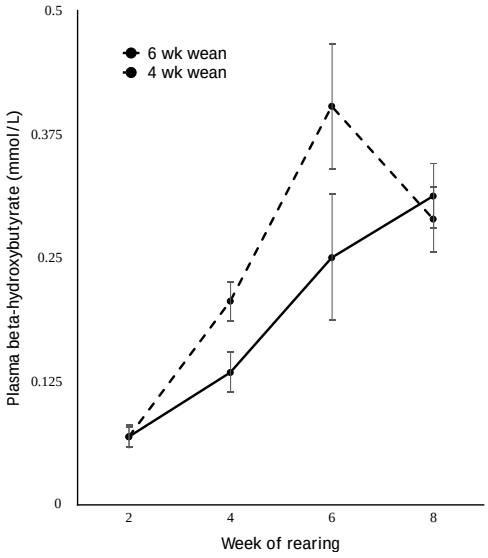


The key results were:

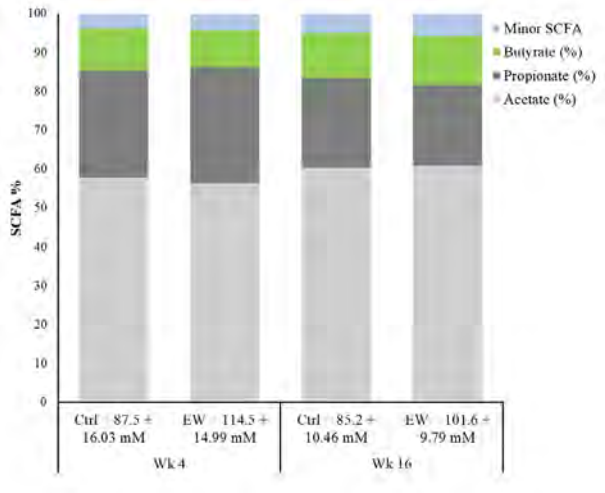
- **Growth and body composition:** The early weaned lambs had lower body weights from weeks 5-10 of rearing due to lower pre-weaning growth rates (~170 vs 200 g/d). Post-weaning growth rates did not differ (~300 g/d). Live weight did not differ significantly after 10 weeks of age. Body composition (muscle, fat and organ weights) was not different between the groups at either week 4 or week 16.
- **Solid feed intake:** Intake of fibre (<6 g/hd/d) and meal (<50 g/hd/d) was low in the first 3 weeks of rearing. Meal intake steadily increased between 21 and 42 days in both groups reaching ~650 g/hd/d in both groups. Fibre consumed (chopped hay) also increased in both groups and was greater in the control than early weaned lambs (182 vs 48 g/hd/d). Early weaning did not affect solid feed intake. Therefore, the difference in growth was due to the increased consumption of milk in the control group between week 2 and 6 of rearing.
- **Rumen development:** Early weaned lambs had greater metabolic development of the rumen wall which is needed for the lamb to use the short chain fatty acids produced during fermentation of solid feed as an energy source (beta-hydroxybutyrate was used as a marker; see graph below. Adult-like rumen fermentation patterns were evident from 4 weeks in both groups and similar between week 4 and week 16 (see graph above right). This highlights the ability of early solid feed intake to promote rumen development.

- **Small Intestine Development**
  There was no effect of early weaning on the morphological development of the small intestine at week 4 or 16.
- **Metabolic Function**
  There was no evidence of metabolic stress at weaning based on non-esterified fatty acid in the blood. There

Plasma beta-hydroxybutyrate levels in lambs reared on a restricted milk diet with step-down weaning at 4 weeks or 6 weeks of rearing



Rumen short chain fatty acid (SCFA) profiles in lambs reared on a restricted milk diet with step-down weaning at 4 weeks or 6 weeks of rearing



was also no difference in metabolic function based on other blood biomarkers (glucose, urea, total protein, triglycerides).

- **Immune Function**
  Early weaning had no effect on immune function between the groups as measured by a functional response to a standard 5:1 clostridial vaccine.

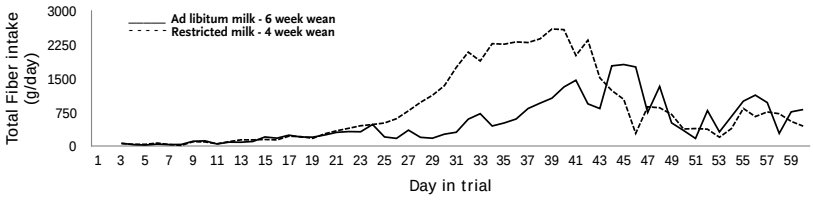
Conclusions

- Artificially-reared lambs fed a restricted amount of milk and weaned at 4 vs 6 weeks of age using a gradual removal of milk did not adversely affect growth, rumen development, rumen fermentation or intestinal development with the feeding system and diets used in the study.
- Ruminal fermentation can be established in lambs weaned off milk by four weeks by a gradual weaning in restricted milk-fed lambs.
- Early weaning with a restricted milk and meal system has the potential to reduce costs while maintaining sufficient growth and health.

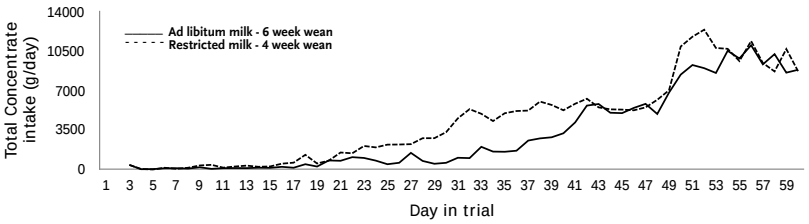
4.5 Will feeding lambs ad libitum milk restrict solid feed intake and rumen development?

In the milk feeding section, a study (4.4 Study 1) was described where lambs were reared on ad libitum milk and weaned over 1 week to wean at 6 weeks vs restricted milk (20% of body weight) with gradual weaning over 2 weeks to wean at 4 weeks of age. In this study, group intake of concentrate and fibre (chopped meadow hay) and concentrate was measured. Intake of solid feed (fibre and meal) (see graph below) was low in the first 3 weeks of rearing in both groups and rapidly increased thereafter. Solid feed intake was lower in the ad libitum versus restricted milk-fed lambs from week 3 to 5 while consuming milk, but by weaning it was similar, and remained so after weaning. Rumen metabolic development, as indicated by beta-hydroxybutrate levels in the blood (see graph below), were also similar but by weaning it was similar throughout the rearing period in both groups. These results indicate that both groups of lambs had good levels of rumen development despite the ad libitum milk fed lambs having lower solid feed intake a few weeks prior to weaning. This is also reflected in the similar growth rates of the lambs after weaning.

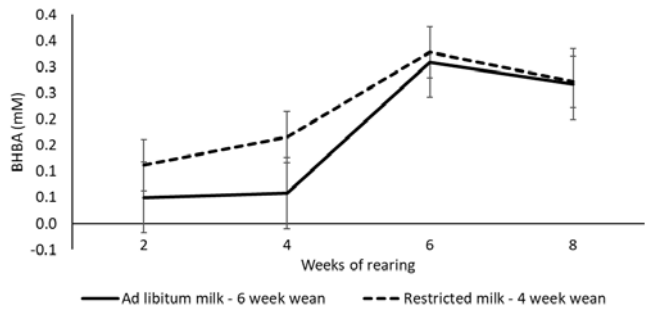
Total daily fiber intake for 15 lambs



Total daily concentrate intake for 15 lambs



Beta-hydroxybutyrate (BHBA) - indicator of functional rumen development



Further reading:

- McCoard SA, Cristobal-Carballo O, Knol FW, Heiser A, Khan MA, Hennes N, Johnstone P, Lewis S, Stevens DR. 2020. Impact of early weaning on small intestine, metabolic, immune and endocrine system development, growth and body composition in artificially reared lambs. J. Anim. Sci. 98(1). Doi:10.1093/jas/skz356.
- Cristobal Carballo O, Khan MA, Knol FW, Lewis SJ, Stevens DR, Laven RA, McCoard S. 2019. Impact of weaning age on rumen development in artificially reared lambs. J. Anim. Sci. 97:3498-3510.
- Cristobal-Carballo O, Khan MA, Knol FW, Lewis SJ, Stevens, D, McCoard SA. 2017. Impact of early-weaning on rumen fermentation profiles of artificially reared lambs. Proceedings of the New Zealand Society of Animal Production 77: 49-54.

4.6 Concentrate vs pasture diets

Concentrates (also known as meal) are a nutrient dense feed option. Many feed suppliers recommend the use of concentrates to accelerate rumen development to support weaning. However, there is limited scientific evidence to support this claim. This recommendation mostly reflects international calf rearing practices where feeding concentrates is recommended to enhance rumen development to support early weaning when low milk volumes are fed. However, we have recently published data from New Zealand studies that indicate calves can be successfully reared with a forage only starter diet (i.e. no concentrates) when fed either high or low milk volume with no negative effects on lifetime performance, health and meat production in dairy-beef heifers. This research led us to ask the question of whether the same applies to artificially reared lambs. The ability to remove concentrates from the diet may have the potential to simplify the rearing system as well as reduce feed costs.

4.6.1 Study 5
Can lambs be successfully reared with a pasture-only solid feed diet?

Thirty 2-3-day-old East Friesian cross ewe lambs (mix of singles, twins, triplets and quadruplets) were sourced from a commercial farm and randomly allocated to one of two treatment groups: ad libitum milk replacer with or without meal. The study was split into 4 periods as outlined in the table below to reflect the different housing and feeding conditions commonly observed in rearing units. The milk replacer used was AnLamb (NZAgBiz; 25.6% crude protein and 25.5% fat; 21.6 MJ/kg metabolisable energy; 100% milk protein-based formulation) and was reconstituted at 230 g/L and fed fresh and warm using automatic feeders in week 1-3 and bucket feeders in weeks 3-5.

Lambs were abruptly weaned at 5 weeks to reflect current industry practice when using automatic feeders as most commercially available systems do not have the ability to implement gradual weaning. The meal was a textured meal without forage consisting of soy and canola meal, maize and barley grain, molasses, vegetable oil and lamb additive mineral mix (metabolisable energy of 14.0 MJ/kg; crude protein 17%). When outdoors, the lambs were grazed on pasture at an allowance of 1700-5000 kg/DM/ha (metabolisable energy 11.4 MJ/kgDM; 21% crude protein).

Key results:

Growth performance:

- Average daily gain was lower in the lambs not offered meal while indoors (week 1-3) which reflects the lower level of nutrient intake.
- Average daily gain did not differ in week 4-5 when both groups of lambs were outside and had access to pasture despite the meal-fed lambs having access to supplementary meal.
- Post-weaning (week 6-10) growth rates of both groups declined due to removal of milk. A greater reduction in growth was seen in the lambs not offered meal reflecting the lower nutrient intake.
- When meal was removed from the group fed meal (week 9-10), growth rates declined quickly and some of the lambs gained no weight or lost weight (see graph below). This was the result of the lambs going into negative energy balance (i.e. mobilising body reserves) causing them to lose weight. This was confirmed by blood biomarkers (non-esterified fatty acids).
- Live weight of the lambs at 12 weeks did not differ. (see graph on following page).

Time	Housing	Feeding
Week 1-3	Indoors - auto feeders	Ad litbitum milk Ad libitum meal (meal group)
Week 3-5	Outdoors - paddock with wind break and bucket feeders	Ad litbitum milk Ad libitum meal (meal group) Unrestricted good quality ryegrass/white clover pasture
Week 5-9	Outdoors - paddock with wind break Transitioned off meal week 9-10 (decrease 10% per day)	Ad libitum meal (meal group Unrestricted good quality ryegrass/white clover pasture
Week 10-12	Outdoors - paddock with wind break	Unrestricted good quality ryegrass/white clover pasture

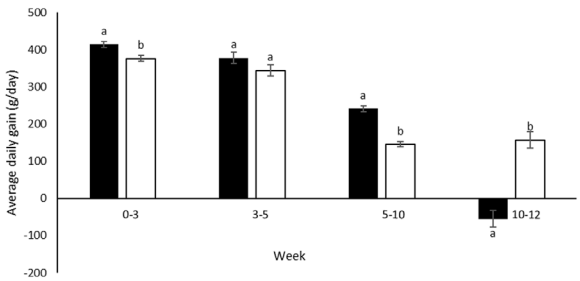
Above: Lamb grazing on pasture that were reared with (bottom image) or without (top image) access to meal.

Feed intake and costs:

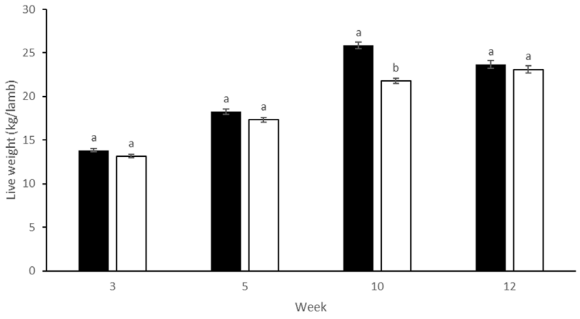
- Milk replacer intake was greater in the lambs fed meal during the indoor period (week 0-3: 2.4 vs 2.2 L/hd/day) but similar in the outdoor period (week 4-5: 1.9 vs 1.8 L/hd/d).
- Meal intake was 24 g/hd/d in weeks 0-3 (consistent with our other studies), 100 g/hd/d from week 3-5, 570 g/hd/d in week 6-9.
- Pasture intake could not be measured while grazing but the lambs fed pasture spent more time grazing and ruminating than those fed meal which is consistent with the enhanced rumen development (see below).

Total feed costs were lower in the group fed pasture, largely due to the cost of concentrate.

Average daily gain of lambs reared with (solid bars) or without (open bars) access to meal to 9 weeks of age



Live weight of lambs reared with (solid bars) and without (open bars) access to meal



	Meal Group	Pasture Group
Total milk intake (L)	71 L	66 L
Total milk dry matter intake (kg)	16 kg	15 kg
Total milk cost (@$3.5/kg)	$57	$53
Total meal cost ($1/kg)	$15	$0
Total feed cost	$72	$53

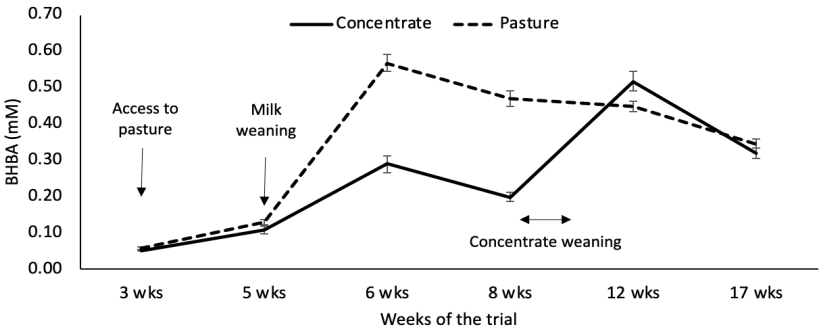
Rumen development:

- Functional rumen development was low (<0.1 mM) in both groups when they moved outdoors at 3 weeks of age. This is consistent with low solid feed intake in the first 3 weeks of life.
- Both groups had limited levels of rumen development at the time of weaning from milk (abrupt weaning at 5 weeks).
- The pasture fed lambs had adult-like levels of rumen development by 6 weeks of age (i.e. 1 week after milk weaning) compared to lambs fed meal which did not reach similar levels of rumen development until 12 weeks of age. (See graph below).

Key messages:

- In this study, feeding meal increased growth rates compared to lambs only offered pasture, however this advantage was lost by 12 weeks of age as a result of poor metabolic transition from meal onto a pasture diet.
- Rumen development was accelerated in the lambs fed pasture compared to those fed meal and those fed pasture had improved ability to process grass to support growth.
- Lower labour and feed costs associated with the pasture.
- No mortality in either group in this study.
- Good quality pasture is essential to support lamb growth and health - do not attempt to exclude meal until you have a good quality alternative solid feed source.
- If feeding meal, consider a much longer transition to pasture (e.g. 3-4 weeks).

Plasma Beta-hydroxybutyrate levels - indicator of rumen function



Further reading:

- Jensen AC, Khan MA, Knol FW, Peterson SW, Morel PCH, McKenzie C, Stevens DR, McCoard SA. 2017. How does feeding meal affect growth of artificially reared East Friesian-cross dairy lambs? Proceedings of the New Zealand Society of Animal Production 77:13-17.
- Nieper BA, Khan MA, Ganesh S, Knol FW, Peterson SW, Stafford KJ, Stevens DR, McCoard SA. 2017. The effects of early access to meal on the behaviour of artificially reared dairy lambs. Proceedings of the New Zealand Society of Animal Production 77: 18-22.

4.7 Does forage type offered to lambs after weaning affect growth?

Growth rates after weaning are a direct response to feed intake, feed quality and the ability of the rumen to process forage. The microbial populations in the digestive tract are different in ruminants fed a grain-based compared to forage-based diet. We have shown above that rearing lambs on meal and pasture versus pasture alone affects growth performance, rumen and metabolic function. However, once lambs are weaned, does the type of forage offered influence the live weight of the lambs?

4.7.1 Study 6
Post-weaning performance on ryegrass vs plantain-based pastures

Using the lambs from the study described in 5.7, we randomly allocated the lambs to one of two treatment groups: pasture based on ryegrass or plantain with red clover from 12 to 17 weeks of age. The composition of the diets offered and lamb performance traits are shown in the tables below.

Key results:

- Using plantain and red clover-based pastures provided no advantage to the live weight gain of the lambs (see table below).
- Readers should note that feed quality was high on both pasture types (see table below).
- Both feed types provided adequate nutrition to ensure growth rates of ~180 g/hd/d over the 5 week period.
- Lambs reared on the meal system had consistently lower live weight gains (160g/d) over the 5 weeks than lambs reared with access to only pasture (200 g/d).
- Symptoms of photosensitivity were recorded on both pasture types, but predominantly in those reared with ad libitum access to meal until week 10 of life, posing questions over functional liver development. This may have also affected weight gain (see table below).

	Post Weaning Pasture Composition			
	Ryegrass	Plantain/clover	Significance	SED
Average daily gain (g/d)	181	187	NS	15.0
OMD (g/100g DM)	74	81	<0.01	1.6
ADF (g/100g DM)	25	21	<0.01	1.0
NDF (g/100g DM)	48	36	<0.01	1.6
CP (g/100g DM)	19	23	<0.01	1.3
White clover (%)	3	20	<0.01	1.2
Red clover (%)	0	11	<0.01	1.7
Grass/plantain leaf (%)	43	34	NS	5.9
Grass/plantain stem (%)	40	4	<0.01	4.7
Dead material (%)	12	25	Trend	5.2
Other species (%)	1	6	NS	5.0

SED, standard error of the difference; OMD, organic matter digestibility; ADF, acid detergent fibre; NDF, neutral detergent fibre; CP, crude protein; NS, not significant

Further reading:

- Stevens D, Knol FW, Neiper BA & McCoard SA. Post-weaning performance of East Friesian cross ewe lambs grazing ryegrass or plantain-based pastures after rearing on two contrasting diets. J. NZ Grasslands 79, 49-54 (2017).

	Post-weaning pasture		Plantain/clover		Pre-weaning main-effects	
Lamb liveweight (kg)	No Meal	Meal	No Meal	Meal	Significance	SED
12 weeks old	**25.2**	**26.6**	**23.9**	**25.2**	**<0.05**	**0.47**
17 weeks old	**32.2**	**32.3**	**31.0**	**31.2**	**NS**	**0.69**

	Post-weaning treatment			
	No Meal	Meal	Significance	SED
Average daily gain (g/d)	**202**	**166**	**0.05**	**15**
Coccidiosis (%)	**5**	**33**	**<0.05**	**25.82**
Spring eczema (%)	**3**	**12**	**NS**	**31.25**

4.8 Natural rearing – impact of early weaning?

With one quarter of the total milk yield of a dairy ewe produced in the first 30 days of lactation, removing lambs soon after birth and artificially rearing them to increase the harvest of commercial milk is an option used by some producers. However, in many global dairy sheep production systems, lambs are naturally reared by their dams until 30 days of age and then weaned and the ewes then moved to the milking platform. These farming systems are commonly employed across Europe to meet the consumer demand for more natural production systems.

Mixed management systems combining lamb suckling and machine milking have also been developed. In these systems, ewes are fully or partially housed indoors and both ewes and lambs are predominantly fed concentrates. In New Zealand, natural rearing systems are employed in some dairy sheep operations using our cost-effective and natural outdoor farming system based on pasture. However, in these systems, lambs remain with their dams until 5-6 weeks of age which reduces commercial milk harvest. Previous New Zealand studies have shown that single-born Poll Dorset lambs can be effectively reared with restricted access to their mothers (day or night separation) in a pasture-based system with only a small reduction in the total milk yield. However, Poll Dorsets are a non-traditional dairy breed and there was little data on the impact on ewe and lamb performance in more traditional dairy breeds that have higher milk yield and greater litter sizes when managed in outdoor pasture-based systems.

4.8.1 Study 7: Impact of early weaning on performance of naturally-reared lambs

We undertook a case study to merge science and practice to determine the practicality of a mixed suckling and milking system compared to a traditional natural rearing system, and their effect on lamb growth at commercial scale in an outdoor commercial pasture-based farming operation. East Friesian dairy sheep (n=118) that were twin- and triplet-bearing were used in the study. The ewes lambed outdoors, and at 2 weeks after lambing, they were allocated randomly to either the treatment or control group:

Treatment (share-milking): Lambs were separated from the ewes for 8 hours during the day (~8am to 4pm) and housed in a pen with free access to shelter, water and concentrate feed (16% crude protein and 13.3 MJ/kg DM metabolisable energy). The ewes were grazed as per standard practice, milked once a day (afternoon) and reunited with their lambs following milking. Weaning criteria included: minimum of 4 weeks of age, good health, minimum live weight of twice their birth weight for twins, three times their birth weight for triplets (~12-13kg), good body condition (fat cover over the spine and hip bones), observed consuming solid feed and ruminating.

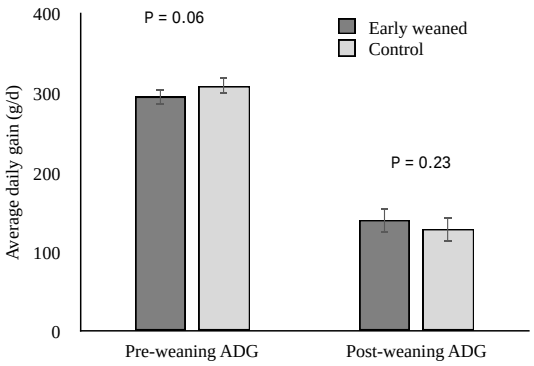
Control: Ewes and lambs remained together until weaning. The control lambs had access to a restricted amount of concentrate (same formulation as the treatment group) feed before weaning (~250 g/hd/d). Lambs were weaned at a minimum of 5 weeks old, 15 kg live weight and in good health and body condition (current farm practice).

Both groups had access to concentrate feed once daily after weaning (~300 g/hd/d; 17.5% crude protein and 13.4 MJ/kg DM metabolisable energy). Pasture quality on average was 21-24% crude protein and 11.1-11.4 MJ/kg dry matter metabolisable energy before weaning and 26% protein and 11.2 MJ/kg DM metabolisable energy after weaning.

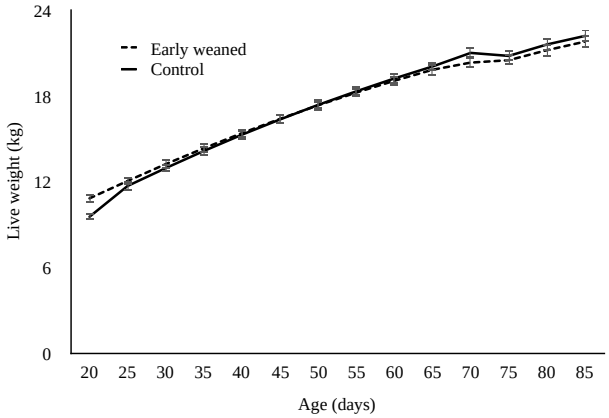
Key results:

- Animal health (ewes and lambs) was largely good in both groups. Incidence of pneumonia and pink eye (common in artificial rearing systems) was very low.
- The average age at weaning was 35 days in the group weaned early (range of 28-67 days) and 40 days in the control group (range of 28-72 days).
- Average daily gain (see graph below) was slightly lower in the group reared using a share-milking approach.
- Growth rate did not differ between the groups after weaning.
- Live weight of lambs did not differ up to 85 days of age.

Average daily gain of early weaned compared to control lambs



Live weight of early weaned compared to control lambs up to 85 days of age



Conclusions

This study highlights that a mixed system of suckling and once-a-day milking (share-milking) from 14 days after lambing to weaning at ~35 days of age, compared to no machine milking of the ewe prior to weaning of her lambs at ~40 days of age, has no negative effects on lamb growth, health up to at least 85 days of age. Harvest of milk for cheese production was also increased when lambs were weaned early. A share-milking system can be a practical option for milking flocks up to 800 ewes if good quality and quantity of forage and facilities available.

05. Animal Health - Lambs

05. Lamb Health

Maintaining animal health is not only important for animal welfare, but also for production performance of the animals and reducing labour and animal health costs. Prevention is better than intervention so developing an animal health plan (preparation, diagnosis and intervention strategies) for your rearing unit is highly recommended. This will enable staff to become familiar with how to support good animal health management and to protect themselves from zoonotic diseases. Using this plan to identify equipment and supplies ahead of the lambing season, and ensure they are prepared and onsite before lambs enter the rearing unit reduces stress and enables staff to intervene early to improve health outcomes.

The aim of this section is to provide an overview of best practice management procedures as well as information on commonly experienced animal health issues. This technical manual does not replace the valuable services of your veterinarian. Engage early with your veterinarian to identify supplies that can be held within the rearing unit, and to ensure that they are aware of your needs in case veterinary intervention is required. Intervention options can change over time as a result of new knowledge and products on the market. Therefore, it is important to consult with your veterinarian regularly.

Good lamb health in the rearing unit starts with a healthy vigorous lamb. A key contributor to lamb health at birth is ewe nutrition and health during pregnancy. Maintaining good body condition score (minimum of 3) of breeding ewes throughout the year through strategic feeding improves fecundity, lamb survival, lamb birth weight, ewe lactation and colostrum production (see Chapter 01, lamb Survival). Additional benefits are accrued through providing ewes with body reserves to buffer against nutritional challenges associated with feed shortages and unexpected animal health challenges. Maintaining good nutrition and health of the ewe also reduces problems around lambing (e.g. metabolic issues) that can impair lamb vigour. Improved animal husbandry around lambing can also improve lamb health and vigour through provision of assistance with lambing and/or feeding if required, and animal health interventions (e.g. treatment of metabolic issues). This is especially important for ewes carrying more than one lamb.

5.1 Signs of a healthy lamb

Appetite is a strong indicator of health and a lamb that comes to the feeder readily is generally a healthy lamb that is eager to eat. Lack of appetite is one of the most common symptoms of a sick lamb. Lambs also spend a lot of time sleeping (8-12 hours a day) and when they rise they often urinate (sometimes defecate) and stretch. A lamb that is reluctant to stand is probably lethargic or in pain. Healthy lambs are also very active and enjoy playing, especially in the early morning and late afternoon. Increasing the space available for expressing natural play behaviour as lambs get older is recommended.

The welfare criteria and indicators associated with the Welfare Principle of a "Good Health" and "Good Behaviour" as described by Richmond et al. (2017) are shown below. These may be useful animal-based indicators of good animal health practices for the lambs during rearing.

Welfare Principle	Welfare Criteria	Welfare Indicators
Good Health	Absence of injuries	Skin alterations/lacerations
	Absence of disease	Fecal soiling of breech area (dag score)
		Wool and skin condition/irritation
		Mucosa colour (e.g. anaemia)
		Eye conditions
		Eye discharge
		Altered respiration
		Coughing
		Nasal discharge
		Lameness (gait score)
		Udder symmetry (ewes)
		Udder lesions (ewes)
		Udder temperature (ewes)
		Milk somatic cell count (ewes)
	Absence of pain induced by management procedures	Ear damage caused by identification procedures
		Tail docking – absence of full tail
		Teeth grinding (non-specific pain)
	Expression of social behaviours	Social withdrawal
		Pain facial expression
		Pain postures (abnormal, hunched, trembling)
		Social withdrawal
		Vocalisations
		Behavioural synchrony
Appropriate Behaviour	Expression of other behaviours	Abnormal behaviour
		Vigilance
		Response to surprise
	Good human animal relationship	Human approach test
		Fear test
		Response to milking (ewes)
	Positive emotional state	Play behaviour

Source - Richmond SE, Wemelsfelder F, Beltran de Heredia I, Ruiz R, Canali E and Dwyer CM. 2017. Evaluation of animal-based indicators to be used in a welfare assessment protocol for sheep. Frontiers in Veterinary Science Volume 4, Article 210 doi: 10.3389/fvets.2017.00210 – supplementary information

The following assessment sheet may be useful to help to identify unhealthy animals and can be used as a tool in rearing facilities to determine when action needs to be taken to ensure the health and wellbeing of the animals.

Health Score Assessment of Sheep

General Health Status	Score	Action to be taken
Generally bright and alert, moves freely, actively feeds, responds to stimulus, and shows interest in its environment.	**5**	No further action required. Continue scheduled monitoring.
Moving slower or lagging, still feeding normally, generally alert and active although some subtle changes may be noted.	**4**	Record ID or mark, score on daily record sheet. Continue scheduled monitoring. Inform the facility manager or senior animal advisor.
Reduced interest in feed, depressed, able to lie down and rise but with some difficulty, not as alert or active, less interested in the environment.	**3**	ID noted on the daily sheet or marked for identification, and closely monitored for further deterioration. Consult with facility manager or senior animal advisor. Further treatment/monitoring should be based on presenting signs and treatments implemented, but generally the animal should be closely monitored at least 3 times a day for further deterioration.
Loss of interest in feed, excessive time lying down and reluctance to move; shows little interest in the environment, lethargic and severely depressed.	**2**	ID noted on daily sheet and immediately consult with facility manager, or senior animal advisor or vet. A monitoring and/or treatment plan should be in place, with animals regularly monitored for further deterioration at least every 3 hours for a maximum period of 8 hours. This animal must be either: monitored through the night or euthanised before the end of the day if it does not improve to a score of 3 or above.
Lacking energy, dull and listless, recumbent, may not be able to raise head off the ground; cannot get up, may be kicking hind legs.	**1**	Euthanise immediately using approved humane procedures by a certified operator.

Source: Richmond SE, Wemelsfelder F, Beltran de Heredia I, Ruiz R, Canali E and Dwyer CM. 2017. Evaluation of animal-based indicators to be used in a welfare assessment protocol for sheep. Frontiers in Veterinary Science Volume 4, Article 210 doi: 10.3389/fvets.2017.00210 – supplementary information

5.2 Hygiene and shed setup

- Ensure that the rearing facility is clean and tidy and designed well. (See Chapter 02, Environment and Housing).
- Ensure the rearing unit has good air quality, ventilation and is free from drafts.
- Regularly clean and disinfect all equipment.
- Ensure bedding material in the pens is clean, dry and dust free – ensure good drainage below the bedding and regularly top-up as required. A sign of unhygienic conditions in rearing pens is soiled wool – lambs wool should be clean and bright.
- Use personal protective equipment (see section 6.5 below).
- Use foot baths containing disinfectant (e.g. Vetsan or Virkon) and position boot rubbing units at the entry to the rearing unit for staff to use.
- Allocate a hospital pen that has complete isolation from all other lambs. Also use foot baths (and ideally a change of boots and overalls) when accessing hospital pens to avoid transfer to other pens (attend sick animals last to minimise transfer of pathogens).
- Regularly clean overalls and boots.

5.3 Animal Health Plan – plan ahead, be prepared!

- Identify and source equipment required for the lambing season, e.g. pens, feeding equipment, personal protective equipment, feeds (e.g. milk replacer, colostrum, solid feeds), animal health kit (see below), and hot box, woolen jackets or heat lamps for hypothermic/sick lambs.
- Identify and source animal health treatments (consult your veterinarian) including systemic and topical antibiotics, anti-inflammatories/pain relief, electrolytes etc.
- Train staff to maintain hygiene (i.e. cleaning equipment, washing hands, sick pen use, disinfection) and be confident with animal health checks/ interventions – have a copy of the health plan in the shed for easy access.
- Have a daily routine of feeding for the lambs by trained staff, at the same time each day to reduce stress.
- Good access to fresh clean water for lambs.
- Dip navels with iodine on entry to the shed.
- Develop and implement a vaccination program wtih your veterinaian.
- Dry, warm, ventilated environment in transport and in the shed. (See Chapter 02, Environment and Housing).
- Design a good nutrition and management plan. (See Chapters 04 & 05).

Plan for the worst and aim for the best!

5.4 Staff Training

Staff training and attention to detail is paramount to enable them to identify what to look for and how to intervene if required. Ensure all staff working in the rearing unit are familiar and comfortable with the animal health plan including diagnosis and treatment of health issues. Consider identifying roles for each staff member so that they are aware of their responsibilities, and if helpful, use a roster on a whiteboard in the rearing facility for easy reference. Consider including a section on the white board for notes, e.g. to identify animals that require specific attention. Consider having a copy of the Animal Health Plan in the rearing facility for easy reference for staff. While having clear protocols in place, and a great rearing environment for the animals is paramount, the importance of staff training and continual observation of animals, and appropriate and timely interventions is crucial to success.

5.5 Keeping you and your staff safe – zoonotic diseases

Animals can sometimes carry harmful germs that can spread to people and cause illness. These are known as zoonotic diseases or zoonoses. Zoonotic diseases are caused by viruses, bacteria, parasites and fungi, and can cause serious illness. Animals can sometimes appear healthy even when carrying germs that can affect humans, so prevention is key.

Many zoonoses are contractible through direct animal contact, handling animal samples (e.g. urine, blood, saliva, tissues) or handling animal waste. Common forms of transmission are through broken skin or mucous membranes (i.e. eyes, nose and mouth), aerosols and ingestion.

Minimising exposure can be achieved through:

- Avoiding eating, drinking or smoking in the work area.
- Wearing personal protective equipment (e.g. gloves, overalls, boots) where appropriate. Do not wear protective equipment in areas where food and drink are consumed.
- Maintaining good hygiene practices is also essential, notably washing your hands in warm soapy water after handling sheep and their body fluids. Also wash and disinfect equipment after use.
- Treating all animal material as potentially infective.
- Disposing of sharps (needles, blades etc) in a safe manner and ensure cuts and abrasions are covered with waterproof dressing before commencing work.
- Keeping animal handling areas clean and tidy.
- Avoiding inhalation of aerosols from urine splash and when washing down equipment/yards etc.
- Extra care should be taken with animals obviously diseased and animal samples.

Examples of sources of infection

- **Diarrhoea** – sourced through contact with faeces from sheep with diarrhoea infections such as Cryptosporidium, Giardia, Campylobacter, Salmonella or E. coli 0157:H7. Pregnant women, children and those with compromised immune systems are particularly at risk. Good hand washing reduces risk.
- **Risks for pregnant women** include exposure to chlamydia, campylobacter and toxoplasmosis. Domestic cats are the common carrier of toxoplasmosis. Sheep can be vaccinated against chlamydia, campylobacter and toxoplasmosis.
- **Leptospirosis** – contracted from contact with contaminated urine, water, pasture or soil, and stock feeds and hay contaminated with rodent urine. Exposure is common through handling urine, body fluids associated with aborted fetuses and afterbirth, handling infected offal (especially kidneys) and gut contents. Sheep can be vaccinated against Leptospirosis.
- **Scabby mouth** (ORF or contagious ecthyma). This is the most common skin disease in sheep and is caused by a virus in the pox family. It causes painful sores on the hands, arms and face when transmitted to humans. Infection occurs through handling affected sheep or by contact with the live vaccine.
- **Ringworm** (club lamb fungus) – appear as a red thickened rash.
- **Listeriosis** – contracted from exposure to affected sheep, fetuses and fetal membranes.

5.6 Vaccinations

It is highly recommended that ewes are vaccinated for common diseases (e.g. clostridial diseases, toxoplasmosis, campylobacter, salmonella, leptospirosis). This reduces the risk of abortions, reduces ewe and lamb losses and provides protection for the lamb in the first few weeks of life. It is also recommended to vaccinate lambs against clostridial diseases (see Chapter 05, Lamb Health). Furthermore, vaccination against scabby mouth (orf, or scabby nose) is recommended if this is prevalent on your farm or on the farm the lambs are sourced from. This can be administered on entry into the rearing unit because symptoms can develop as early as 2-3 weeks of age. The vaccine is administered by scratching the skin surface (do not draw blood). For lambs in artificial rearing systems, it is advisable to do this under the foreleg rather than the hindleg to reduce the risk of transfer of the live vaccine to other lambs as some lambs demonstrate adverse behaviours (e.g. scrotal/navel sucking) which involves close contact near the hindlegs.

5.7 Nursery pens

For lambs that enter the rearing facility as newborns or within the first 48 hours after birth, use a nursery pen. The nursery pen should contain clean and dry bedding, be free from drafts and have a heat source (overhead heat lamp or heat mat) that can be accessed by all lambs without smothering. Also consider using woollen jackets for the lambs in cold weather if the lambs do not utilise the heat lamps or mats. Newborns require additional care with regular colostrum feeding (see Chapter 03, Section 3.1 Colostrum Feeding).

5.8 Lamb health checks

Prior to entry into the rearing facility it is important to complete a health check of all lambs to identify any pre-existing issues of health, welfare and performance. This may include behavioural attributes (e.g. lethargy or depression, lameness), dehydration, presence of scours, swollen/infected navels or joints, eye or skin infections or elevated temperatures which is an indicator of infection. If any potential infections are identified, isolation in a hospital pen may be required and/or early treatment intervention.

The highest risk time for lamb losses and animal health problems is within the first week of life. Therefore, careful attention to animal health during this time is important. It is highly recommended to complete individual health checks for lambs for at least the first 3-4 days after entry into the rearing facility. This will enable issues to be identified and treated early to minimise production losses through death or ill-thrift, and to reduce the risk of spreading infection. It is recommended one staff member is dedicated to this role for consistency. It is also recommended to keep stocking density low in pens, especially in the first few weeks, to make it easier to complete health checks.

5.9 Animal health kit

- Rectal thermometer (rapid-read version) – from your local pharmacy or rural/vet supply store.
- Vaseline/lube (for putting on the thermometer).
- Disinfectant wipes (for cleaning the thermometer between use).
- Systemic drugs (e.g. Metacam, Penicillin, Engemycin as per the health plan developed with your veterinarian) and syringes, needles and needle waste disposal container.
- Topical antibiotic spray and/or iodine (for infected navels, skin infections etc).
- Treatments for pink eye (topical antibiotic in an ophthalmic ointment).
- Gloves.
- Dettol solution and soft cloth (for wiping eyes if weepy/crusty).

Note: make sure any drug treatments used are locked away between uses in appropriate storage areas or refrigerated if required.

5.10 Daily individual health checks

Note: physical check once a day, visual checks 2-3 times a day:

From outside the pen, visually check all the lambs for signs of depression (e.g. ears and head down), isolation, pain (hunched body position and/or grinding of teeth), lethargy and/or lameness and hunger (early indicators of illness). Identify and check these lambs first.
Confine the lambs to a corner of the rearing pen (e.g. using a portable gate) and place the animal health "kit" in an easy to access location (e.g. in an over the fence feed bin or tool belt). This makes the lambs easy to catch and avoid missing or injuring them while chasing them around the pen to catch them.

Pick up each lamb and check eyes (e.g. for presence of pink eye), nose and mouth, navel (for presence of swelling/infection) and tail (for presence of scours).

See images below for examples of how to hold lambs for taking rectal temperatures or for interventions (e.g. tagging/drug administration).

Hold the lamb under the chest during the health check and take note of the breathing for evidence of "crackling" which can indicate pneumonia. Handling animals this way can also help to identify lambs with an elevated temperature as they will feel hot (under the legs and on the ears).

For lambs with scours, check hydration levels by skin pinch – if the skin remains "tented" the lamb is dehydrated and requires electrolyte therapy (see image below).

Treat any health issues before placing the lamb back in the main pen.

Consider using a colour system to identify treated lambs (e.g. red dots on the rump for penicillin treatment – one dot per treatment so it is easy to identify a treated lamb and how many days of treatment they have received).

Consider using other colours for marking hungry lambs or poor feeders for easy identification. Also consider recording health interventions in a health register for easy reference and for record-keeping to establish the types of issues and prevalence during the season to assist with planning for the next season.

Record all deaths, including cause of death if known, and keep a tally to calculate mortality rates to help with future season planning.

From 4-5 days of age onward, visual checking of lambs in each pen several times a day should be sufficient to identify problems and enable intervention.

5.11 What is a normal rectal temperature?

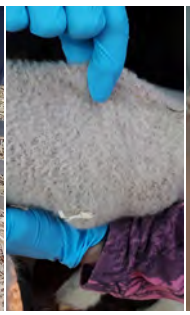
Any animals with suspected high temperature, signs of infection, disturbed breathing, lethargy or depression should have their rectal temperature taken. Guidelines to help interpret rectal temperatures.

- Newborn lambs have a high rectal temperature (39-41.5°C) is normal within 30 min of birth.
- 2 hours post-birth - 38.5-41°C is normal.
- 24+ hours post-birth – 38.5-40°C is normal.
- Temperatures above 39.5°C should be monitored, with treatment intervention recommended for temperatures above 40°C as appropriate according to the diagnosis.
- Temperatures below 38.5°C are at risk of hypothermia and intervention may be required.

Toolkit for tagging

Taking rectal temperature

Hold for tagging



Pinch to test hydration

Hold for health check

5.12 Avoiding injuries

Healthy lambs are very active, enjoy playing and group play is common up to 4 months of age. They also love to climb and are naturally curious of their surroundings. This can lead to accidents and injuries. Ensure pens do not have sharp objects or surfaces that can cause injury (e.g. exposed wire or sharp steel). This is not only painful for the lamb but can lead to secondary infections like scabby mouth. Also avoid using netting (e.g. hay nets) where lambs can injure themselves through ripping ear tags out or hang themselves. Also ensure water troughs are high enough for them to reach to drink but not low enough for them to fall into and drown as described earlier.

5.13 Painful procedures

There are a number of common management practices/procedures that cause pain for lambs. These include tail docking, castration and ear tagging. It is important to follow best practice procedures for any painful manipulations (https://www.mpi.govt.nz/dmsdocument/1443/direct), and where possible, consider pain relief. In some cases, tail docking may not be required, e.g. breeds such as East Friesians that have little/no wool on their tail.

06. Common Lamb Health Issues

06. Common Lamb Health Issues

A number of animal health issues can arise in lambs during their first weeks of life. These can include:

- Hypothermia
- Pneumonia
- Pink eye
- Navel ill
- Pizzle ill
- Crusty ears
- Lameness
- Clostridial disease
- Parasites
- Coccidiosis
- Bloat
- Scours
- Constipation

6.1 Hypothermia

Orphaned lambs have a high risk of mortality from hypothermia and starvation, especially during poor weather.

Symptoms

- Hunched up and weak (may be unconscious).
- May be too weak to suckle and their ears and mouth might feel cold.
- Lambs are considered at risk of hypothermia if they have rectal temperatures below 38.5°C with temperatures at or below 37.5°C considered hypothermic.

Treatment

- Get warm colostrum into a newborn hypothermic lamb as soon as possible, using tube feeding if necessary.
- Warm the lamb by moving it into a warming box, under a heat lamp or submerge in a warm bath. Warm the lamb up slowly – a rapid increase in temperature can kill a hypothermic lamb.
- 10ml of Ketol (or similar product) can help to give a cold lethargic lamb extra energy. An intraperitoneal injection with dextrose may also be considered if staff are trained with this procedure.

See the B+LNZ Fact Sheet "Reviving newborn lambs" for further information.

6.2 Navel ill

Umbilical infection is common in young lambs born into unhygenic conditions and where navel treatment (e.g. iodine dipping) is inadequate. It is often more common in male lambs due to urination delaying drying of the umbilical cord and where urination removes some of the iodine solution.

Symptoms

- Navel feels lumpy/swollen beneath the skin/around the base of the navel.
- Pus may be secreted from the area, and it may be warm and red.
- Lamb may have a high temperature.

Treatment

- If infected, treat with Penicillin or another antibiotic recommended by your veterinarian, consider anti-inflammatories/pain relief in severe cases.
- Apply topical antibiotic or iodine to the infected area.

Prevention

- Ensure lambs are born in sanitary environments where possible.
- Dip (not spray) the navel in iodine (down to the base) at birth (if lambing indoors) or on entry to the lamb rearing facility. Use an alcohol-based iodine solution to speed up drying of the navel.

Above: Navel ill.

6.3 Pizzle/scrotal/navel injury

Cause

- Injury to the pizzle, scrotum or navel can occur due to suckling from other lambs. This can be an indication of boredom or hunger.

Symptoms

- Wet and inflamed skin.
- Abrasions and cuts that can become infected.

Treatment

- Ensure all lambs are well fed, and supply fibre in the pens to minimise adverse suckling behaviours.
- Where possible, transition to bigger pens or outdoors by 2-3 weeks of age to avoid this behaviour.
- Some products are available from Shoof (shoof.co.nz or vet.shoof.co.nz) that may assist (e.g. pepper-based sprays) in reducing these behaviours but data on effectiveness is limited.
- Spraying the affected area with iodine can also help to reduce suckling (lambs don't like the taste) and help to prevent infection.

6.4 Pink Eye

Pink eye (infectious keratoconjunctivitis) is inflammation of the cornea and conjunctiva of the eye. It is caused by one of three kinds of highly contagious bacteria – Chlamydia psittaci (ovis), Mycoplasma conjunctiva, and Moraxella ovis. In addition to close contact with affected animals, stress can play a part in contracting the bacteria (e.g. poor nutrition, over-crowding, new surroundings, extreme weather, transport). Poor ventilation, flies and dust can also help to transfer the bacteria from one animal to another.

Symptoms

- The infected eye membranes will be pink/red and inflamed.
- Tears and wet stains below the eye is common.
- The animal will blink frequently and may half or fully close their eye(s) due to pain.
- The eyes are more sensitive to irritants and can be bothered by bright sunlight.
- An opaque appearance can overcome the eye.
- Temporary or permanent blindness can occur in severe cases.

Treatment

- Follow veterinary advice if the eye appears cloudy. This is likely to include a topical antibiotic in an ophthalmic ointment, and an anti-inflammatory for pain relief.
- Wipe with a clean cloth with mild disinfectant used for cleaning wounds (do not use the same cloth between lambs as infection can spread).
- Maintain thorough hygiene standards – unsanitary conditions in the pens can increase the prevalence of the infection.

Above: Pink eye.

6.5 Scabby Mouth (orf, contagious ecthyma)

Scabby mouth is a highly contagious, viral disease. Infections occur through skin abrasions, e.g. cuts to the mouth from vigorous feeding on milk feeders, cuts from hard feeds and/or skin injuries.

Symptoms

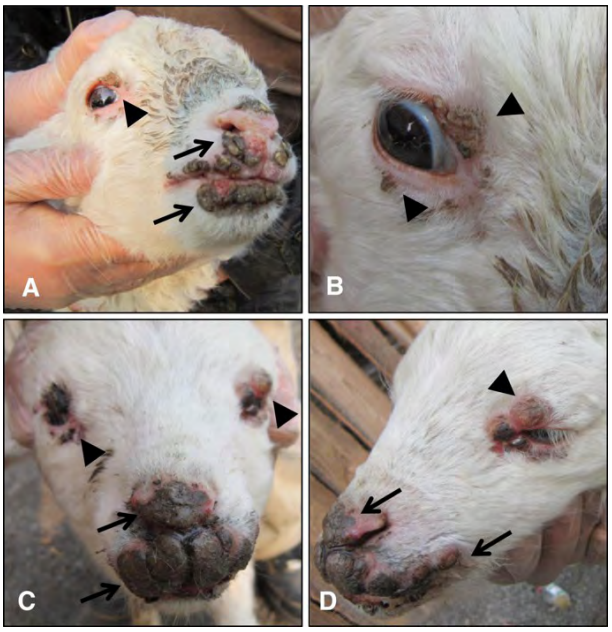
- Starts with small, reddened areas that begin to weep a clear fluid.
- Sores and scabs then form.
- In the early stages, the scab is firmly attached and if removed forcibly, a raw bleeding area is exposed.
- After 2-3 weeks, the scabs dry up and drop off and the underlying skin heals rapidly.
- Commonly affected areas are cool non-woolled areas including the mouth, legs, feet, teats.
- This disease spreads very rapidly, and once a farm or facility is infected it will remain so.

Treatment

- Wear gloves while handling animals with scabby mouths as humans can also be infected.
- Spray with topical antibiotic spray (or iodine) to reduce secondary infection.
- In severe cases, lambs may require bottle/tube feeding if the mouth is too sore to allow them to feed.
- Lambs that recover have lifetime immunity.

Prevention

- Vaccination – consider vaccinating with a scratch under the foreleg rather than the hindleg to reduce exposure to other lambs that demonstrate adverse behaviours (e.g. scrotal/pizzle/navel sucking). Consult your local veterinarian.
- Avoid exposure of lambs to anything that will break the skin and allow entry of the infection. This includes skin injuries from wire, sharp edges on steel pens, nails etc., as well as injury from prickly plants/weeds such as thistles, gorse etc.



Above: Scabby mouth.
A-D Source: Li et al. BMC Veterinary Research 2012, 8:229

6.6 Pneumonia

Pneumonia is a result of complex interactions between the sheep, environment and microorganisms. Associated microorganisms include bacteria (Mannheimia haemolytica), Mycoplasma (Mycoplasma ovipneumoniae) and viruses (PI3 virus). Dust inhalation can irritate the lung mucosa and predispose them to infection.

Symptoms

- Lamb will appear hunched, have droopy ears and dull eyes.
- May have a cough, runny nose or fever.
- Breathing is laboured and short.

Treatment

- Isolate the animal as pneumonia may be infectious.
- Treat with antibiotics and anti-inflammatories as directed by your veterinarian. Provide electrolytes in case of dehydration.
- Identify for follow up treatment.
- Minimise ammonia build up and deal with dirty bedding, poor ventilation etc.

Prevention

Aimed at minimising stress and optimising animal health. Some suggestions/reminders:

- Avoid sudden diet changes.
- Avoid dusty feed.
- Have small mob sizes to reduce animal stress and dust inhalation.
- Avoid yarding stock in extremes of temperature (high or low).
- Minimise yarding time.
- Provide appropriate shelter from extremes of temperature.
- Minimise stock movement in the middle of the day when dust levels are highest.
- Ensure good internal parasite control and appropriate vaccinations.
- Avoid and address any nutritional or mineral deficiencies.
- Avoid shearing lambs at weaning.

For more information please refer to the B+LNZ Fact Sheet "Pneumonia and Pleurisy in Sheep"

6.7 Entropion (in-turned eyelids)

Entropion (in-turned eyelid) is a common hereditary problem in many breeds. Inversion of the eyelid is present at birth or can be observed soon afterwards. Discharge from the affected eye(s) rapidly becomes thick and yellow. Severe irritation and ulceration and ultimately blindness in advanced cases occurs from direct contact between the eyelashes and the surface of the eye.

Above: Entropion

Symptoms

- Either the lower eyelid or both eyelids will be rolled in causing redness and weeping, and associated with pain.

Treatment

- Roll eyelid out by rolling down the skin immediately below the lower eyelid (opposite for the upper lid) and firmly wipe the eye with a clean cloth or finger from the inner to outer edges of the eye to ensure the lid is turned fully out.
- Pinch the lower eyelid firmly to cause swelling as this will help hold the eyelids out.
- If this is unsuccessful, an injection 0.1ml of saline solution into lower lid (by a competent operator) can be effective.
- If the eye is cloudy, discuss treatment with your vet, which may include topical antibiotic in an ophthalmic ointment to control potential secondary infection and provides lubrication to reduce inversion of the lower lid. Depending on severity, other methods such as temporary surgical tacks may help conformation of the eye area.

Prevention/contol

Regularly inspect all newborn lambs and treat if required. The genetic component of entropion should be carefully investigated and in cases where the condition can be attributed to particular rams, they should not be retained or sold for breeding.

Above: Crusty nose.

6.8 Crusty nose and ears

Lambs in rearing shed often form scabs or crusts on their nose, eyes and ears as a result of dried milk, other lambs chewing/sucking ears, and build-up of residues from solid feeds and powder-based supplements.
In severe cases, these areas can be come dried and inflame or /infected causing pain and providing sites for infection from other diseases such as scabby mouth.

Treatment

- Wipe with warm water and a soft cloth.
- Apply topical antibiotic spray or iodine in severe cases where the skin is inflamed or broken to reduce the risk of secondary infection.

Prevention

- Avoid the use of powder-based supplements and powdery dried feeds.
- Ensure lambs are well nourished and are not overcrowded to reduce the incidence of sucking/ chewing from other lambs.

6.9 Dehydration/Starvation

Symptoms

- Hunched with a hollow stomach and prominent hip bones (hungry).
- When pinched, skin will not relax back to normal quickly (dehydrated).

Above: Hungry lambs.

Treatment

- Provide assistance with feeding and ensure the lamb has had good feed (no more than 350ml in one feed for an average size lamb).
- If the lamb refuses to suckle and is not dehydrated, consider tube feeding.
- If the lamb is dehydrated, administer electrolytes.
- Make the lamb identifiable so it can be retrained onto teat.

6.10 Scald

Scald is the most common cause of lameness in lambs. If left untreated it can lead to footrot which is caused by the pathogen Dichelobacter nodosus. Scald causes the skin between the claws to become inflamed (pink/ red) and to produce a pasty "scum" on the skin that can have a bad smell. It is thought to be caused by abrasion of the skin (e.g. from thistles, hard stalky grass, sharp wood chips) or prolonged exposure to moisture (e.g. in damp weather conditions or soiled lamb rearing pens where the bedding is damp). It can affect appetite and weight gains.

Above: Scald.

Symptoms

- Kneeling or severely limping.
- Red/pink inflamed skin between the hoof claws that is often smelly.

Treatment

- Remove any foreign objects.
- Spray with topical antibiotic spray or foot bath with zinc sulfate-based or formalin products if many animals are affected, carefully following the label recommendations.
- If severely lame, treat with Penicillin or other antibiotics as directed by your veterinarian.

6.11 Abomasal Bloat

Abomasal bloat can affect artificially reared lambs. It is caused by a build-up of bacteria in the stomach (abomasum). Bacteria such as Clostridium perfringens type A and species of Sarcina, have been identified in the stomachs of affected animals. As the bacteria multiply, the sugars found in the milk ferment with excess gas production, and the stomach becomes more acidic which is detrimental to other good bacteria. Bloat develops as the gas cannot escape the abomasum. Death from abomasal rupture is rapid and unpleasant.

Symptoms

- Lambs with abomasal bloat will have a swollen belly and will be dull and lethargic.
- Abdominal pain (colic) and teeth grinding (sign of pain) is common.
- Onset can be rapid, within 30 minutes of feeding and sometimes death is the first sign (i.e. found dead).

Risk factors

- Occurs most commonly at 2-4 weeks of age.
- Infrequent milk feeding (e.g. twice daily).
- Overfeeding (do not feed more than 350ml per feed when feeding by bottle).
- Improper mixing of milk replacer. Mix according to manufacturer's instructions as diluted milk can cause lambs to gorge, especially on automatic feeders.
- Hot milk – milk replacer should be fed at body temperature (37-39°C). When Sarcina bacteria are present feeding cold milk may help.
- However, if Sarcina bacteria are not present, feeding chilled milk or cold milk replacer can increase the risk of abomasal bloat.
- Feeding too rapidly (e.g. when teats are damaged or have a large hole) – check frequently and replace when damaged.
- Poor hygiene (e.g. when bottles/teats and other milk feeding equipment including automatic feeder hoses are not kept clean). Regardless of milk feeding system, good sanitation is required for all equipment.
- Milk lines, mixing bowls and teats on automatic feeders should be cleaned at least twice a week.

Tips for preventing bloat

Maintain good levels of hygiene, avoid overfeeding, and do not feed milk at temperatures higher than 37°C. If good feeding practices, and high hygiene standards are maintained, bloat should be minimal when feeding lambs by bottle, cafeteria or automatic feeder. In multiple AgResearch trials in either research or commercial rearing facilities, when good hygiene practices (e.g. twice weekly cleaning and calibrating of automatic feeders or cleaning feeding equipment after every bottle feed), regular checking of the teats for damage and proper mixing of milk replacers has been applied, bloat was not observed in either restricted milk-fed lambs (bottle/cafeteria) or ad libitum milk-fed lambs (automatic feeders). AgResearch trials have also found no evidence for milk replacer composition (e.g. casein vs whey protein) to influence the incidence of bloat.

One intervention that can help is to add yoghurt that contains probiotics and prebiotics to the milk. This can be achieved by either adding yoghurt directly to the milk (1 tablespoon per 100 ml milk mixed well, or 1L pottle per 10 L of milk). Alternatively, milk can be yoghurtised by adding one packet of probiotic natural yoghurt powder to 10L of warm milk. Keep the mix in a bucket with a lid at 37°C (e.g. in hot water cupboard) until the mixture thickens, and then keep in the fridge for up to 7 days. Add this mix to the milk at a ratio of 1:7 (1 part yoghurt to 7 parts milk). Feed cold or warm. Milk with yoghurt should not be introduced until after 5-7 days of age. This may be an option when feeding a small number of lambs but is not suitable for large-scale rearing units and should not be used as a way to reduce hygiene practices and poor feeding methods.

Treatment

- Dissolve as much baking soda as possible in 10ml of water and administer orally (e.g. with a syringe). This helps to neutralize the acid.
- Oral dose of cooking oil (10ml) or antacids may help.
- Powdered ginger may also help for mild cases (2 tablespoons of ginger mixed in a small amount of warm water administered by syringe).
- Contact your veterinarian for more advice, especially for pain medication and timely euthanasia if this is not able to be performed on farm by a competent operator.

Prevention is the best medicine, because 75-100% of cases end in death!

Further Reading :

- https://nzagbiz.co.nz/nz/en/help-and-advice/resources/bloat-in-lambs.html
- https://newprairiepress.org/cgi/viewcontent.cgi?referer=https://www.google.com/&httpsredir=1&article=1790&context=kaesrr#:~:text=Sarcina%2Dlike%20bacteria%2C%20possibly%20Sarcina,the%20cause%20of%20abomasal%20bloat.

6.12 Clostridial Disease in Lambs

Clostridial diseases are common on New Zealand farms and are bacteria that can cause animal welfare compromise, death, decreased profitability. Sheep are susceptible to Clostridial disease at any age, so protection through vaccination prior to birth is important.

What are clostridial diseases and what are their symptoms?

Common Clostridial diseases that can cause illness and death in lambs are:

- Pulpy Kidney – well fed and fast growing young lambs suffer sudden death. It can also affect grown sheep, particularly when grazing high-quality feed.
- Tetanus – results from spores entering a wound. Signs appear 10-14 days' post injury, lambs appear stiff and undergo spasms due to muscle contraction. Can be common following docking.
- Blood Poisoning diseases; (Animals suffering from the following three diseases are most often found dead. Carcass may be gassy and decompose quickly).
  - Malignant Oedema
  - Black Disease
  - Blackleg

Vaccination Regimes

- Preventative action in consultation with your veterinarian is best. Ewes should be given a booster vaccine 2-4 weeks prior to lambing.
- Following birth, artificially-reared lambs should be vaccinated with a 5-in1 vaccine. AgResearch used Covexin 10:1 in trials. First vaccination should take place at 3-4 weeks of age, followed by two boosters, four weeks apart. Following this, all ewes should receive an annual booster.

6.13 Scouring in Lambs (Diarrhoea)

Causes

Scours in lambs can be caused by many different factors:

- Bacterial
- Viral
- Parasites
- Diet

During the first few weeks of life, scouring is likely to be caused by nutrition or infection.

Infectious scours caused by bacteria, protozoa and viruses will likely have an increased body temperature, depression, dehydration, smelly faeces and perhaps blood in the faeces.

Rehydration should be first and foremost for scouring lambs. Use electrolytes to provide energy, water and to replace salts lost during scouring. This will only maintain the lamb so put the lamb back on milk as soon as possible. Medication might be required for serious infections in addition to electrolytes.

Nutritional Scours

- This is the most common form of scours in artificially-reared lambs.
- Results from poor milk replacer quality, poor mixing of milk replacer and/or over-feeding.
- Avoid diet changes in milk feeding routine (timing, temperature and amount), maintain regular feeding.
- Don't allow lambs to drink too quickly.
- Check that teats don't allow too much flow that lead to gorging and scouring.
- High energy diets, and large amounts of molasses in supplement formulations designed for calves can also result in nutritional scours in older lambs.

Above: Scouring.

E. Coli Scours

- E-coli bacteria thrive in dirty environmental conditions and areas of poor hygiene practices.
- Occurs when lambs are less than 10 days of age.
- Lambs salivate and have a cold mouth.
- Incidence is decreased by good colostrum intake.

Rotavirus Scours

- Occurs at 2–14 days of age.
- Symptoms include depressed and dehydrated lambs.

Cryptosporidium Scours

- Occurs at 5-10 days of age.
- Causes diarrhoea like that of rotavirus.
- Very liquid and yellow scouring.
- Animals that are affected may remain active and continue feeding.

Salmonella Scours

- Can cause scours at any age
- Animals that are affected at less than 1 week of age may not show clinical signs and sudden death can occur.

Coccidiosis

- A protozoan parasite that lambs are susceptible to at 1-4 months of age.
- Exposure to coccidiosis at a very young age promotes immunity later in life.
- Disease can be sub-clinical and result in lack of weight gain.
- Clinical signs usually occur following stressful events such as transport, weaning or changes in feed.
- Scours may contain blood or mucus, but this is not common. Scours are very watery.
- Consider feeding solid feeds containing a coccidiostat or monitor animals closely and treat with a long-acting coccidiostat if symptoms arise (check the requirements of the market your lambs are entering if selling for meat).

Prevention

- Maintain clean and hygienic conditions within the lambing area, the rearing shed and all personnel working with the lambs.
- Ensure footwear is clean and only use gumboots dedicated to the facility.
- Walk through the foot bath and refresh this with Virkon/Vetsan daily.
- Remove or cover clothing that has been in contact with other livestock since it was last laundered and use dedicated overalls that are kept within the facility.
- Ensure hands are clean and wear gloves when handling the animals.
- Feed lambing ewes well to promote the birth of healthy lambs and to promote good colostrum quality and production.
- Ensuring each lamb receives the recommended number of colostrum feeds.
- Sterilize all equipment regularly.
- Avoid overcrowding of pens.
- There is no scientific evidence that providing lambs access to supplements such as clay, or organic-based powders will prevent scours.

Treatment

- Scours can cause lambs to lose a large amount of fluids each day. It is important to ensure lambs are well hydrated (see above for how to check hydration levels).
- Remove any lambs suffering from infectious scours from the pen and place in hospital pen. Samples of scours can be collected and processed by your local veterinarian/vet lab, to determine the cause which can inform treatment options.
- Treat affected lambs with electrolytes (Scourban not usually recommended as it contains an antibiotic) and supply milk replacer as recommended by the manufacturer's instructions.
- At day four, if the lamb has recovered it can return to a self-feeding group.
- If the lamb has not recovered at day four, seek veterinary advice.
- Lambs with nutritional scours are non-infectious and do not require isolation.
- Ensure all bedding in the lamb rearing pens remains clean and dry – this may require topping up frequently with fresh bedding.
- Ensure that any contaminated surfaces (e.g. walls and feeders) are regularly cleaned and treated with disinfectant to reduce pathogen loads and risk to other lambs.

6.14 "Pinning" and constipation

In the first 2-3 days after birth it is common for faeces to "gum up" around the tail and anus– a condition called "pinning". This can easily be eliminated by removing the fecal material.

Constipation can also occur in young lambs, usually in the first week after birth in artificially reared lambs.

Symptoms

- Lack of appetite.
- Straining when trying to defecate.
- Over-filled stomachs (can be mistaken for bloat).

Treatment

- A warm mineral oil enema (10-15 ml) can bring relief if done carefully with a drenching syringe through the rectum. Do not use too much pressure.
- A 10ml oral dose of olive oil or castor oil, or milk of magnesia (half a teaspoon per 5kg body weight) – mixing with milk and feeding with a bottle can avoid problems with drenching (e.g. inadvertently having the oil go into the lungs).

6.15 Parasites

Internal and external parasites can cause serious problems in sheep grazed on pasture. Routine drenching with anthelmintic is recommended from two weeks after lambs are given access to pasture. Parasite management is dependent on the risk factors which can vary between farms and regions. It is advised to consult your local veterinarian for advice and to become familiar with the symptoms, risks and treatment or prevention options using readily available information online such Wormwise.

http://wormwise.co.nz/

6.16 Spring eczema

Spring eczema is a problem that occurs sporadically in weaned calves and adult cattle in September-November in many parts of New Zealand and can also occur in sheep. Affected sheep develop photosensitivity lesions on unpigmented parts of the skin (e.g. ears) and/or udder.

Causes of spring eczema are still unknown but putative causes include acquired inability of the liver to process high loads of chlorophyll after liver damage (e.g. sporidesmin poisoning), or immaturity of the liver (Collett MG, et al. 2006). However, dietary ingredients (e.g. storksbill, Erodium moschatum) have also been suggested as a cause in calves. An AgResearch study has also suggested that it may be related to high intakes of grain-based concentrate feeds, low intakes of pasture or poor rumen development during the rearing phase (Stevens et al. 2017). Furthermore, that study suggested exposure to pasture and chlorophyll during early rumen development may be a mitigating factor.

Early detection and treatment are essential with immediate removal from sunlight being particularly important.

Above: Spring eczema.

Treatment

- Provide shade.
- Reduce pasture intake.
- Provide supplementary feed.
- Apply sun blocks and disinfectant creams and/or anti-inflammatories (consult your local veterinarian).

Further Reading:

- Collett MG 2006. Spring eczema: the search for the cause(s) continues. New Zealand Veterinary Journal 54:50.
- Stevens DR, Knol FW, Neiper BA, McCoard SA. 2017. Post-weaning performance of East Friesian cross ewe lambs grazing ryegrass or plantain-based pastures after rearing on two contrasting diets. Journal of New Zealand Grasslands 79:55-60.

6.17 Acidosis

Acidosis, or grain poisoning, occurs when sheep eat large amounts of grain. The bacteria in the rumen produce lactic acid which causes acidosis, slows down the gut, damages the gut lining and causes dehydration and often death. Wheat and barley are the most common causes, but it can also occur with oats and lupins. The chances of grain poisoning increase when grains are crushed or cracked by a hammermill as a result of faster release of carbohydrates in the rumen.

Risks

- Sudden change to grain feeding (including meal/concentrates) without gradual introduction to the grain or meal/concentrates .
- Sudden change to the type of grains or feeding regim.e
- Stock grazing paddocks where grain has been harvested providing access to spilled grain.
- Unplanned access of sheep to grain or pellets.

Symptoms

- Depression
- Lying down
- Diarrhoea
- Dehydration and thirst
- Bloating (left side of the abdomen, i.e. rumen)
- Stagger or tender gait
- Death

Treatments

- Consult your veterinarian – treatment options vary with the severity of the disease.
- Treatments may include intravenous fluids, bicarbonate solution or milk of magnesia via drenching, thiamine or steroid injections, antibiotic injections etc.
- Secondary infections can develop including abscesses in the liver and other organs – these animals often suffer from ill-thrift and require culling.

Prevention

- Introduce animals gradually to grain or meal/concentrate. The time required depends on availability of roughage, time of year, type of grain fed and the aim of feeding (e.g. young lambs or lactating ewes). For young lambs this should take at least 2-3 weeks or longer based on research experience.
- Feed grain daily during the introduction phase (small amounts at a time, e.g. 50 g/head/day for adult animals).
- Ensure roughage is always available in addition to grain.
- Monitor animals closely for signs of scouring, depression, lethargy and lameness as this may indicate the amount of grain fed is being increased too fast.
- Check pulpy kidney vaccinations are up to date and vaccinate before grain feeding if required.
- Ensure sufficient space for all lambs to feed to avoid competition and overeating.

For more information see:

- https://beeflambnz.com/knowledge-hub/PDF/rumen-acidosis-ewes

6.18 Red gut

Red gut can be caused by rapid passage of high-quality feed (e.g. Lucerne or clover dominant pasture) through the digestive system of the lamb. It usually shows up as sudden death and can be mistaken for pulpy kidney. Autopsies show torsion of the intestines and lack of blood flow. It can be caused by low fibre content of high-quality feed causing rumen capacity to shrink. In addition, higher levels of protein fermented in the large bowel can cause it to expand and twist.

Prevention

- Provide fibre (straw/hay).
- Graze on these pastures 2 out of 7 days.
- Mowing and wilting Lucerne prior to grazing.
- Consult your veterinarian regarding clostridial vaccines as these may help to reduce the incidence.

Further reading:

- https://beeflambnz.com/knowledge-hub/PDF/growing-great-lambs
- https://beeflambnz.com/knowledge-hub/PDF/400-plus-guide

6.19 Toxins

Poisonous plants

Ensure that lambs managed outdoors do not have access to the following plants (whole plant or cuttings from your garden) as these are deadly to sheep of all ages:

1. **Foxglove (Digitalis purpurea)**
2. **Rhododendrons**
3. **Camelia**
4. **Yew (Taxus baccata)**

1. 

2. 

3. 

4. 

Endophyte

Endophytes are naturally-occuring fungi that live within grasses. They can help protect plants from insect damage, however naturally-occuring endophytes can negatively affect livestock performance. Notably, standard endophytes produce high levels of the toxins lolitrem B and ergovaline which can cause ryegrass staggers and severely affect stock performance in the summer and autumn. Therefore, endophytes can be problematic for lambs during this time, including young lambs managed on pasture in autumn-lambing systems. Novel endophytes have been developed with little or no animal-production limiting toxins. Therefore, choosing the right endophyte is important.

For more information please see:
https://beeflambnz.com/knowledge-hub/PDF/endophyte-update

Facial eczema

Facial eczema is a disease that affects sheep, cattle, deer, goats, llamas and alpacas but not horses. It is considered to be the most serious production-limiting disease of New Zealand pasture-fed farm animals, second only to parasites. It is caused by a spore from a fungus called Pithomyces chartarum which grows on dead material found at the base of pasture. It is found mostly in perennial rye grass. Spores are released during the summer months, usually January-May. Therefore, careful management of ewes and lambs grazing on pasture is important during this time.

Spore numbers rise rapidly under warm and humid conditions. High spore counts are common around urine patches, sheltered areas near hedges, and northern and western facing slopes. When consumed by the animal, the fungal spores release a toxin called sporidesmin which causes damage to the bile system of the liver. This liver damage causes accumulation of other toxins in the bloodstream of the animal which leads to poor health, low production and sometimes death.

Photosensitisation is a secondary effect of liver damage and is visible as a severe and painful inflammation of unpigmented areas, e.g. udder, teat, ears and face. It is important to recognise that visual symptoms do not always accompany the disease, with around 70% of a mob being affected if just 5% show symptoms of facial eczema.

Symptoms include dullness, weakness, lack of appetite, ill-thrift, sun sensitivity, sunburn, redness and swelling on unpigmented or areas free of hair (e.g. ears, nose). Liver failure leads to risk of metabolic disease the following season and sudden death can occur.

Prevention is the best cure. Monitor spore counts in your area and when levels get high intervene with zinc bolus, zinc in water, supplementary feeds such as hay, silage or forage crops, spraying fungicide prior to elevation of spore counts etc.

Consult your veterinarian for advice on a management plan.

More information can be found at:
https://beeflambnz.com/knowledge-hub/PDF/facing-facial-eczema

Copper toxicity

Copper is one of the most common inorganic poisonings of domestic ruminants. Lambs are more susceptible to high levels of copper in the diet than adult sheep, or in supplements/animal health treatments (e.g. vaccines and drenches). This is of note when feeding concentrate diets as the mineral mixes contain copper, especially with ad libitum access to these feeds. Calf concentrate starter diets have high levels of copper and should not be given to lambs due to the risk of copper toxicity. There are breed variations in the susceptibility to high copper intake (due to variation in ability to absorb dietary copper), with Texels, Finnish Landrace, Suffolks, Lacaune and East Friesian breeds being particularly susceptible. However, this has not been well researched and so a precautionary approach should be applied.

Copper is an essential mineral for life to support physiological functions including iron metabolism, keratin (wool) collagen and elastin synthesis, production of melanin, and the integrity of the central nervous system, and effective immune response. Signs of deficiency can include anaemia, brittle or fragile bones, loss of hair/wool pigmentation and poor wool growth.

In general sheep require about 5 parts per million (ppm) or mg/kg of copper in their diet. Generally copper toxicity occurs above 25 ppm. Cattle can tolerate ten times more copper in the diet than sheep and non-ruminants (e.g. pigs and chickens) tolerate even higher levels. However, toxicity can also occur at much lower levels due to multiple factors including animal age (lambs are more efficient at absorbing copper), breed, and dietary molybdenum levels which influences copper requirements as it forms an insoluble complex with copper to prevent copper absorption. Sheep are more susceptible to copper toxicity when molybdenum levels are low (less than 1 ppm). Copper deficiency can occur when molybdenum intake is greater than 10 ppm even on diets that would normally be considered adequate. Sulphur can further complicate the copper to molybdenum relationship as sulphur binds with molybdenum. There are two forms of copper toxicity: chronic and acute.

Chronic copper poisoning

Chronic copper poisoning occurs after the sheep's capacity for copper storage has been exceeded resulting in sudden release of copper into the circulation. This results in liver damage, destruction of red blood cells and jaundice. Accumulation of excess copper can occur over a period of weeks to more than a year with no clinical signs. Sudden release of this stored liver copper causes the toxicity (rapid breakdown of red blood cells).

Poisoning can result from:

- Excessive intake of copper.
- Low intake of molybdenum, sulphur, zinc, calcium.
- Following liver damage (e.g. from facial eczema).
- Stresses including weather, environment, poor nutrition, transportation or handling which can cause liver cells to die and release stored copper into the bloodstream.

Symptoms

- Sudden onset of increasing weakness/lethargy.
- Incessant grinding of teeth.
- Extreme thirst.
- Walking aimlessly or head-pressing.
- Jaundice (yellowing of the gums, eyes and skin), shallow and rapid breathing as the disease progresses.
- Anaemia.
- Urine often appears black due to red blood cell breakdown.
- Most animals die following a short period of recumbency within 1-2 days after onset of clinical symptoms.

Diagnosis

- Housing and feeding history.
- Clinical signs and post-mortem findings (pale to dark yellow tissues, pale tan to bronze-coloured liver and dark red or black kidneys).
- Lab identification of high kidney copper concentrations.

Management

- Treatment response in clinical animals is commonly poor and very expensive.
- Direct resources to identifying the cause immediately. Consider treating at-risk animals (e.g. oral or subcutaneous injection of ammonium tetrathiomolybdate to strip copper from the liver – note this can be prohibitively expensive).
- Consult your veterinarian for advice and to confirm diagnosis.

Prevention

- Poisoning is caused by a combination of efficient absorption and high dietary availability of copper.
- Avoid feeding copper-rich diets to susceptible animals.
- Take care with young animals as they more efficiently absorb copper.
- Presence of dietary copper antagonists such as iron, sulphur and molybdenum can influence the efficiency of absorption.
- Copper content of diets differs. Some diets with high levels of copper can include: pasture, silage, root crops grown where high amounts of pig or poultry manure have been applied, distillery by-product feeds, concentrate feeds containing palm oil or molassed sugarbeet pulp. Whole grain cereals are usually poor sources of copper.
- Other sources can include access to minerals designed for cattle, copper sulphate foot baths, fungicide-treated timber.
- Prolonged feeding of diets with relatively low copper content (e.g. in feedlot fed sheep).
- Do not give any form of copper supplementation before or during housing unless required based on testing.

Further reading:

- http://www.merckvetmanual.com/mvm/toxicology/copper_poisoning/overview_of_copper_poisoning.html
- http://ag.ansc.purdue.edu/sheep/articles/coppertox.html
- http://veterinaryextension.colostate.edu/menu2/sm%20rum/Copper%20Poisoning%20vm-knight-engle.pdf
- http://www.nadis.org.uk/bulletins/copper-poisoning-in-sheep.aspx
- https://www.sheepandgoat.com/cutox

Selenium toxicity

Selenium is an essential trace mineral. It is required by animals for optimal health. In New Zealand, large areas of farmed land are marginally to markedly deficient in selenium. Selenium is highly toxic to livestock in high doses and the margins of safety are low, i.e. small margin between health and poisoning.

There are many commonly used products on-farm that contain selenium as sodium selenate which is licenced for use in livestock. These include products that are 'pour-on', injected, orally drenched or top-dressed onto pasture. These are often delivered in combination with vaccines, vitamin and /mineral supplements. In these combinations, selenium can be up to four times more toxic than the same amount of selenium administered orally.

The most commonly affected age group in sheep for selenium toxicity is 3 to 4-week-old lambs. Selenium supplementation at tailing/docking is common. No more than 1-2 mg of sodium selenate should be given at any one time.

Symptoms

- Often found dead 24-48 hours after dosing.
- Frothing at the mouth with breathing difficulties.
- Post-mortem will show marked lung oedema with fluid in the airways.

Diagnosis

- Liver concentrations of selenium diagnosed by a veterinarian – toxic concentrations are usually above 30,000 nmol/kg.

Prevention

- Avoid using injectable products containing selenium in young lambs – drenches are safer.
- Do not use more than one selenium containing product on the same lamb.
- Do not exceed a total dose of 1-2 mg/lamb by any method.

Further reading:

- https://www.gribblesvets.co.nz/wp-content/uploads/2019/08/Mineral-Check.pdf
- https://www.gribblesvets.co.nz/selenium-toxicity-in-lambs/
- https://www.msdvetmanual.com/toxicology/selenium-toxicosis/overview-of-selenium-toxicosis
- https://beeflambnz.com/knowledge-hub/PDF/trace-element-nutrition-sheep

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