final report

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Prepared by: N and S Williams
Forest Hill Consulting

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Locked Bag 1961
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Dough from Doe$, phase 1

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Abstract

The aim of this project was to investigate existing and potential advanced reproductive programs to optimise the productivity of does in goat meat enterprises in Australia. A combination of a literature review of reproduction in sheep, goats and deer, producer consultations and a review of existing extension material have identified possibilities to modify and improve reproduction systems. The project has highlighted the diverse range of goat meat production styles within Australia as well as a mixed appetite for improving doe reproductive performance. Current dry conditions are impacting significantly on many enterprises and the provision of adequate nutrition is the biggest challenge.

There is evidence that producers could improve their productivity, profitability and animal welfare standards by implementing some simple reproductive practices, including controlled joining and weaning, and improved nutrition. A number of advanced breeding programs have potential for use within the goat meat industry. There were no novel or contemporary ideas identified, and there is certainly no ‘one size fits all’ solution to improving reproductive outcomes. Some of the advanced breeding programs described would require intensive management and an advanced standard of nutrition and, in some cases, the use of hormones to overcome natural breeding limitations. It would only be appropriate to advise the use of these strategies in enterprises that have the capability and capacity to ensure that the appropriate monitoring and attention to detail can be provided.

There is limited extension material and limited research on the long-term effect of advanced breeding and this is an area requiring further work. Upgrading extension material to an interactive and contemporary format will improve its accessibility and useability and ensure that the important messages are not missed.

There are many options available to goat meat producers to improve their reproductive capacity and productivity. A thorough consideration of the management, animal welfare and financial benefits and costs are vital to first determine the feasibility of implementing such measures in any individual enterprise.

Executive Summary

The goat industry has identified that there are significant gains to be made through improved reproductive performance and management of the breeding doe. It was anticipated by MLA that this project would be the first of three phases of work addressing this issue in goats. The outcomes from this project will guide future phases including research and the preparation of extension material, where required.

The objectives of the project were:

- Literature review completed on advanced reproductive systems for small stock, focusing on learnings for the goat industry
- Review of existing extension materials/programs for suitability to be adapted to goats
- Publication of 6-10 producer case studies focused on advanced reproductive systems
- Final report delivered to and approved by MLA.

The first step was to perform an extensive literature review of reproduction in goats, sheep and deer. The main areas of research reviewed included doe management, frequency of kidding, ideal time of first joining and weaning management, to optimise reproductive success of does over their productive lifetime. There is a substantial body of literature on reproduction in sheep and to a lesser extent goats, and very little on deer. While there is some research material on goat breeds found in Australia much of the data has been generated from studies overseas. There are a diverse range of pure, cross and composite breeds of goats across the world and their reproductive performance varies in particular environments. Differences between breeds include seasonality of breeding (sensitivity to photoperiod), frequency of twinning (or more than two kids), growth rate, susceptibility to worms, response to nutritional enrichment and response to induction of oestrous.

The literature review has provided detail on advanced breeding strategies, but has not uncovered any novel or contemporary ideas not previously identified by industry. Most of the studies were in sheep and all require intensive management and advanced standards of nutrition programs and, in some cases, the use of hormones to overcome natural breeding limitations. Many were carried out over just a few years and without a control (annual) breeding group. There is a definite lack of long-term studies looking at doe/ewe lifetime productivity in accelerated breeding programs.

The second part of the project was a consultative process. The response to requests for producer interviews was disappointing, so an online survey was developed as an alternative, Sixty-three responses were received overall, and smaller producers appear to be over-represented. The consultants also interviewed 23 goat meat producers as well as other industry representatives and a dairy goat producer. The findings of survey and consultations have highlighted the diverse range of goat meat production styles within Australia as well as a mixed appetite for improving doe reproductive performance by using advanced breeding technologies. These technologies include artificial insemination (AI), (multiple ovulation) embryo transfer ((MO)ET), juvenile in-vitro ET (JIVET) and laparoscopic ovum pick-up (LOPU). Some of the goat meat producers interviewed were using AI or ET. The main purpose of AI was to improve the genetic quality of the herd (by introducing new genetics) and, of ET, to produce more superior animals for sale. ET was only used by producers whose main market was breeding stock. Due to the cost and increase in labour required it is unlikely that any of the assisted reproductive technologies except AI would be financially justifiable for commercial goat meat producers.

Current dry conditions are impacting significantly on many enterprises and the provision of adequate nutrition is the biggest challenge. It is of some concern that a number of producers are experimenting with reproductive management without the appropriate knowledge and skills.

The producer consultations also highlighted the fact that there is considerable room for improvement in many enterprises by doing the simple things better. This includes joining for a defined and preferably short time, weaning at a certain age (preferably by weight), providing additional feed to late pregnant and lactating does, condition scoring, weighing doelings before first joining (to ensure adequate weight), vaccination, parasite control, and providing nutrition of suitable quality and quantity to match the stage of the reproductive cycle.

Meanwhile the more complex and intensive reproductive programs have much less margin for error and require significant planning, adaptability and resources.

All existing extension material on reproduction for small ruminants was reviewed. MLA provides extensive extension material over a number of different formats including modules, fact sheets, best practice videos and webinars. Ideally, all the extension material would be redeveloped into a single contemporary media platform through which all of the information could be accessed by simple clicking between screens without the need to open new documents. Some extension material needs further development while accelerated breeding and assisted reproductive technologies needs to be developed from the beginning.

A three-tiered approach to develop reproductive capability within the goat industry is proposed. This approach would encourage producers to develop skills and knowledge within one tier before progressing to more complex and risky practices. The three tiers are:

1. Foundational reproductive management practices
2. Tools to improve reproductive performance
3. Advanced breeding programs.

A number of areas for future research have also been identified. The ones likely to deliver the greatest benefits are:

- Validation of the metabolisable energy requirement estimates and the pregnancy / lactation feed curve proposed by McGregor (2005);
- Evaluation of the benefits of supplementing does in late in pregnancy in order to boost colostrum production;
- Study of enterprises using shedding of does at around kidding time;
- Study of enterprises adopting accelerated breeding programs, and development of a ‘best-bet’ model for commercial application in Australia;
- Evaluation of the benefits of creep feeding/trail feeding kids before weaning;
- Evaluation of the use of the buck effect in more extensive enterprises; and
- Development of model(s) to estimate the benefit/cost ratio of various reproductive practices, including targeted nutritional interventions, the buck effect, pregnancy scanning and accelerated breeding programs.

In summary, the goat meat industry shows potential for improved reproductive outcomes from does and a cautious approach to promoting advanced breeding programs is encouraged.

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Acronyms and abbreviations

AI	Artificial insemination
ART	Assisted reproductive technologies
BCS	Body condition score
CAMAL	Cornell Alternate Month Accelerated Lambing
CIDR	Controlled internal drug release (device)
CL	Corpus luteum
DPI	Department of Primary Industries (NSW)
DSE	Dry sheep equivalent
EBV	Estimated breeding value
eCG	Equine chorionic gonadotropin
ET	Embryo transfer
FOO	Feed on offer
GICA	Goat Industry Council of Australia
GIG	Going into Goats
JIVET	Juvenile in vitro embryo technology / transfer
LOPU	Laparoscopic ovum pick-up
LTEM	Lifetime Ewe Management
ME	Metabolisable energy
MLA	Meat & Livestock Australia
MOET	Multiple ovulation embryo transfer
NKB	Number of kids born (EBV)
NKW	Number of kids weaned (EBV)
NRC	National Research Council (US)
PMSG	Pregnant mare serum gonadotropin
SG	Sheep Genetics

1 Background

There is significant interest within the goat meat industry in better understanding how much pressure can be applied to a breeding doe, taking into account factors such as the most appropriate time to join maidens and frequency of kidding. Producers want guidelines on best recommended practices to improve lifetime productivity of the doe. This includes maximising productive outcomes and profitability of the enterprise, through maximising kids weaned per doe over their lifetime.

The project was established to examine optimum breeding systems to improve lifetime productivity of the doe including comparisons between breeding systems with a single kidding annually vs more than one kidding every 12 months.

2 Project objectives

The objectives of the project were to have:

- Literature review completed on advanced reproductive systems for small stock, focusing on learnings for the goat industry
- Review of existing extension materials/programs for suitability to be adapted to goats
- Publication of 6-10 producer case studies focused on advanced reproductive systems
- Final report delivered to and approved by MLA.

3 Methodology

The methodology for the project is detailed below.

3.1 Literature review

A literature review of advanced breeding systems for both goat breeds and other small ruminant species was undertaken to: identify the range of reproductive management systems available to goat producers, the essential contributing factors and/ or constraints (including economic returns) that ensure the various systems succeed; identify information gaps; recommend topics for additional research if needed; and recommend interim services / decision aid tools / resources for producers should additional research be needed.

The consultants engaged the University of Melbourne Faculty of Veterinary and Agricultural Sciences Library to undertake the literature search. Below is a list of the main searches conducted, which were done without year of publication constraints.

- (("weaning") OR ("kid production" OR "kidding" OR "kidding interval" OR "kidding rate" OR "kidding season")) AND ("meat goat")
- (reproduction) AND ("meat goat")
- ("boer goats" or Rangeland or "kalahari reds") AND (reproduction)
- (("optimal breeding") OR ("best practice")) AND ("sheep" OR "ewe" OR "ewes")
- (("optimal breeding") OR ("best practice")) AND ("deer" OR "deer farming")
- 'accelerated kidding' and 'accelerated lambing'
- ("goat kid*") AND (care) AND (wean* or "post wean*").

Many of the articles could be freely obtained online, while the remainder were purchased, mostly through Science Direct. In all, more than 400 papers were reviewed.

There was a large number of articles about sheep reproduction specifically, many that were more generally about small ruminant reproduction and a modest number about goats specifically. There were very few relevant articles on deer reproduction. The goat literature included studies from all over the world including a diverse range of climates, production styles and breeds of goat. Caution has been applied when interpreting these studies for potential application to Australian breeds and conditions.

Similarly, although the two species have some reproductive similarities, and in some cases findings for sheep have been later substantiated for goats, it cannot be assumed that all findings would be true for both species.

The literature review provides detail on the female reproductive cycle. It then provides a review of the literature on all the different ways those features can be manipulated to optimise reproductive success. The strategies are divided into those that may be considered 'natural' and non-invasive, which includes maximising those characteristics and behaviours that occur naturally in breeding animals; and those that involve chemical or physical intervention, such as the use of hormones, artificial insemination or embryo transfer.

A considerable proportion of the literature reported data from academic studies which involved small numbers of animals in artificial experimental situations. It is difficult to directly extrapolate this information into 'real life' production systems. They do however provide a background of what is possible and identify ways in which new technologies and

management techniques could be further investigated for realistic implementation onto Australian farms.

3.2 Review of extension materials

The current meat goat extension material available on the MLA website 'Give Goats a Go' was reviewed in detail. This included the best practice videos, factsheets, 'Going into Goats' modules and goatmeat webinars.

The extension material for sheep was also reviewed to identify areas that could be adapted to provide new a relevant extension material for goat producers. This included 'Making More from Sheep', 'Lifetimewool' and 'WormBoss'.

Extension material for deer and cattle such as 'FutureBeef' were also reviewed. Relevant extension international material that was identified during the literature review was also reviewed.

All materials were reviewed to establish the feasibility of adapting them for the goat meat industry. A series of recommendations were developed based on this review and in consideration of the findings of the literature review. A listing of the materials reviewed is provided in Appendix 1.

3.3 Project communication and survey of industry practices

The project was extensively communicated, and invitations for producer input were extended, via direct emails to the MLA mailing list, industry Facebook pages, breed societies, processor contacts and live export contacts. The consultancy team was grateful for the assistance of Dr Sandra Baxendall, who publicised the project on the Facebook pages of several goat-related groups in which she is involved, as well as her own page.

The communication activities of the project are summarised in Table 1.

Table 1 : Project communication activities

Contact type	Number of individuals/ companies within group	Contact method	Number of contacts
Goat meat abattoirs	28	E-mail	Twice (31.2.18, 7.2.19)
Goat meat exporters	9	E-mail	Once (7.2.19)
Depots	14	E-mail	Twice (31.12.18, 7.2.19)
Goat groups	6	E-mail	Twice (31.12.18, 7.2.19)
Goat producers (from BGBAA* and BGA** websites	79	E-mail	Once (9.1.19)
Rangeland goats	1925 followers	Facebook page post	3 posts
Other	Unknown	Various	Unknown

*Boer Goat Breeders Association of Australia
** Boer Goats Australia

A database of goat meat producers from across Australia was progressively developed as contacts were made. The database will be provided to MLA separately to this report. It includes the details of those respondents who approved their inclusion in the database and those producer members of BGBAA and BGA whose data is publicly available on the respective web pages.

A minimum of 50 producers was to be selected randomly from the database and interviewed by telephone. These producers were intended to represent a cross-section of the goat meat industry by location, climate and management system. A brief overview of their enterprise was to be obtained. Despite best efforts, though, the response to the communication strategy was disappointing. The database of goat meat producers is thus less comprehensive than was anticipated.

As the producer response was not as strong as hoped, all producers who identified themselves were contacted by telephone. After discussion with the MLA Manager in January, a Survey Monkey® online survey was also set up to encourage more producers to supply their details without the need to speak to a consultant, and this also provided more responses.

The Survey Monkey® questionnaire mirrored the questions asked by telephone although on some occasions more details could be obtained from the telephone discussions. The telephone interviews covered the following main points:

Type of goat production systems	
Managed/partially managed or harvesting only	Age of joining of does/ age of culling (culling criteria)
Breeds of goats	Number of kiddings per year
Number of does/bucks	Doe nutrition during pregnancy
Time of joining/time of kidding	Pregnancy testing? (percentages)
Kidding percentage / weaning percentage	Income percentage of overall farm income
Age of weaning	Parasite and disease management
Post weaning care	Sources of information
Age of sale	Requirement for information
Main market	
Other businesses on farm	
Farm details	
Location	Pasture type
Climate	Rainfall

A copy of the Survey Monkey® questionnaire is provided in Appendix 2. Five respondents entered their postcode only and no further data. These entries were deleted.

3.4 Development of case studies

Six suitable case study participants were identified from the survey and through targeted engagement based on other information sources. The producers selected for the case studies had reproductive management programs that were advanced in one or more aspects, and adequate recorded data to allow for a detailed description of these programs through a case study format.

Originally, there was an intention to produce a small number of case studies on international goat producers as well as the Australian ones. Despite best efforts, the project team were unable to contact suitable candidates for these studies.

3.5 Preparation of final report

A draft of this report and of the literature review were reviewed by MLA and an external reviewer and revised before finalisation.

4 Results

4.1 **Literature review**

The literature review is provided as an attachment to this final report.

The original project brief sought coverage of the following topics in the literature review:

- Doe management
    - Examination of the best metric (ideal age or weight) for first joining.
    - Examination of recommended time of joining and optimal culling age for mature breeding does with the aim of maximising value at culling vs loss of productivity on farm.
    - Understanding of annual nutrition requirements for does with multiple vs single births.
- Frequency of reproduction (i.e. 3/24 months vs 1/12 months vs 2/12 months)
    - Cost comparison with traditional breeder systems.
        - Examination of the logistics and management changes required to make the system work (such as nutrition, joining times, parasite control, breed, geographic location etc.).
    - Impacts of this system (doe health, carrying capacity, markets and weaner management).
    - Documentation of the critical success factors.
- Weaning
    - Best management practices
        - Taking weaners through to production efficiently and cost effectively (replacement does to their first joining and males to slaughter)
        - Post weaning feeding, selection pressure, management recommendations
    - Maintenance of the doe during the weaning process
        - How to achieve maximum cyclicity post weaning (i.e. impact of doe weights, condition scoring, nutrition/stocking rates etc.)
        - Mitigating potential for poor performance in second kidding.

The literature review as presented divides the topics slightly differently. The review addresses all of the above topics, but also a number of others, and a three-tier organisational structure was developed to reflect a hierarchy of practices from ‘foundational’ to ‘advanced’ that developed during the course of the project. This is explained below.

As with all topics of scientific literature there are a number of conflicting opinions and opposing findings in research. The consultants have aimed to represent all views fairly and without prejudice in the literature review.

The findings of the literature review, and the survey / interviews, have been ‘mapped’ back to the above topic list in Appendix 3.

In summary, the literature review identified the following relevant points:

4.1.1 Foundational reproductive management practices

4.1.1.1 Health and Welfare

<u>Preventative measure for animal health</u>

- In does, beyond 6 years of age, there is a reduction in birth weight and weaning weight of kids

- Lambs born as multiples to ewes with udder lesions tend not to grow as well
- This was not a specific topic of the literature review

Biosecurity

- This was not a specific topic of the literature review

Managing stress

- The literature has extensive information about the potential for stress to impact on production. Most of the research has been reported in sheep. Some of the negative outcomes of stress include:
    - Interference with follicular development and ovulation;
    - Reduced sexual behaviour;
    - Reduced daily weight gains;
    - Shorter lactation;
    - Altered hormone production;
    - Reduced embryo survival;
    - Reduced embryo quality;
    - Delayed onset of oestrous;
    - Reduced foetal growth;
    - Ovulation occurring without oestrus; and
    - Longer oestrus.
- Research on cattle has shown that calmer cows have shorter calving intervals, faster milking speeds and increased fat and protein yields in milk

Preparing for extreme weather events and other unforeseen disasters

- McGregor 2005 'Nutrition and management of goats in drought'

4.1.1.2 Nutrition, body weight and body condition score

Nutrition

- Comprehensive reviews are found in Jolly 2013 and McGregor 2005 (drought)
- Most extension material from across the world quotes NRC (1981 or 2007) data, which is not based on Australian breeds and is mostly from experimental situations and small numbers of animals
- The impact of inadequate nutrition on reproductive outcomes in goats and sheep is well documented in the scientific literature and includes:
    - Reduced stress response in offspring;
    - Reduced production of progesterone and increased embryonic mortality in first-pregnancy ewes;
    - Slower onset of oestrus after synchronisation;
    - Reduced ovulation and pregnancy;
    - Higher embryonic mortality;
    - Delayed puberty;
    - Induced anoestrus;
    - Effects on the metabolic and physiological health of the adult and offspring;
    - Decrease in milk yield;
    - Reduced birthweight;
    - Reduced growth rate of kids;
    - Decreased perinatal lamb survival;
    - Permanent changes to the wool follicle population of lambs;
    - Decreased quality and quantity of sperm production;
    - Negative impact on embryonic development; and
    - Insufficient energy in colostrum to support twin lambs.

- Maintenance data in the literature varies considerably and is mostly derived from experimental situations:
    - Average of 22 sources estimates that maintenance for goats is 404.7 kJ ME/kg$^{0.75}$
    - From 140 days' gestation and through lactation does should be fed 2.5 times maintenance
- Some goats may be able to alter their energy requirements by 65% in times of poor pasture availability
- Response to increased nutrition differs between breeds
- More concentrated supplementary feed is recommended for heavily pregnant does
- In sheep, overfeeding after joining can affect embryo survival
- In sheep, poor nutrition of the ewe during pregnancy can affect lamb birth weight, wool follicle production, wool production, growth, carcase quality, reproductive potential
- Improved condition in sheep increases ovulation and reduces embryo mortality
- Improved nutrition in goats has led to longer breeding season (Payoga goats), increase in milk yield, birth weight, growth rate of kids (hairy goats)
- Overfeeding in ewes can cause dystocia
- In ewes, the foetal, placental weight and vascular development increases exponentially from 50-60 days gestation
- In Angora goats, maidens raised on better nutrition had greater joining weight, number of kids weaned (South Africa)

<u>Condition scoring</u>

- Kenyon et al 2014 provide a guide to key body condition scores (BCS) during the reproductive cycle in sheep:
    - Biggest gain is by ensuring all animal are above a target minimum
    - Relying on average BCS of flock means many will be below the minimum
- Gosh et al 2019 provide recommended BCS for various physiological states in does (the scientific background for the recommendations is unclear but BCS were similar to or slightly higher to those described in sheep)
- In sheep, higher BCS has been associated with increased length of breeding season, ovulation rate, pregnancy rate, embryo survival, lamb survival and lamb growth (but there is a curvilinear relationship between BCS and conception rate, and number of lambs born)
- Ewes in low BCS tend to have a better response to increased nutrition than those in higher BCS

<u>Body weight</u>

- As ewe weight increases there is a reduction in lamb deaths and an increase in lamb growth rate
- Larger does tended to have kids that were heavier at 10, 20, 30 weeks (Mebende goats, Uganda)

4.1.1.3 Management of joining, kidding and weaning

<u>Milk production</u>

- Improved nutrition in early lactation improved milk production in feral and Boer goats (by 11.5%)
- Cashmere does fed more in the last month of pregnancy had heavier kids at birth and they remained heavier through the testing period until 10 months of age

- In Boer goats, milk production increased with age, parity (until 5th lactation) of the doe and litter size
- The lactating ability of a doe is determined by its breed, nutritional status and a variety of other factors. Young Boer goats tend to respond better (in terms of lactation) to an increase in litter size than older goats

Birth to weaning

- In Nashville, Kiko had better birth to weaning performance than Boer and Spanish

Weaning

- Timing that is best for kids
    - Weaning may be based on age or weight
    - By weight
        - Weaning by weight produces less weaning shock in kids
        - Weaning weight may be considered 2.5 times that at birth
        - When dairy kids were weaned at 10kg (normal weight) or 30 days later, the later group grew quicker and reached the breeding age (60% of adult weight) one month earlier. But in both systems, they were ready to join by 8-9 months
    - By age
        - Under Australian Industry Standards and Guidelines for Goats, weaning should occur no earlier than 8 weeks
        - Dairy kids weaned at 4-6 weeks suffered more weaning shock than those weaned at 8-10 weeks
        - Goats that are weaned at 8-10 weeks tend to have a better growth rate at 16 weeks than those that are weaned earlier
    - Preparation for weaning success
        - Rumen development is vital to successful weaning and growth post-weaning. Feeding concentrates (in lambs and calves) stimulates development
        - Boer-cross kids receiving creep (with or without roughage) had better ruminal development
        - In Kentucky, kids born in autumn and spring had the same survival rates but the autumn-born kids grew quicker
- Timing that is best for the doe
    - Time of weaning should allow the doe time to recover and regain condition before the next joining season
    - Failure to wean kids can delay the return to oestrus for the doe and lead to a significant loss of body condition
- Failure to wean entire buck kids will result in:
    - Inbreeding (bucks servicing mothers and sisters)
    - Joining of doe kids before they reach a suitable body weight (generally regarded as 70% of adult weight)

Weaner care

- In weaner goats (French Alpine), those fed high and medium amounts of concentrate had higher average daily gain and prolificacy than those on low concentrate diet, but there was no impact on lactation
- In weaner Boer goats, there was no difference in daily gain between those on high and low ME diets

Joining

- Suitable body weight for first joining is generally regarded as 70% of adult weight

- Joining doe kids before they are of an appropriate weight can impact on their lifetime productivity, might result in an unsuccessful pregnancy or difficulties due to size at kidding time (dystocia) and a compromise in health and welfare

4.1.1.4 Measuring and recording

- Reporting and recording are mostly described in the literature in regard to genetic improvement by selection from within the herd
- Careful measurement allows the identification of subtle changes in reproductive performance due, for example, to the presence of a subclinical disease in the does or bucks
- Measurement and recording are essential to genetic selection programs. The unique identification of individuals is also required. Electronic ear tags are being used by some to improve their recording and for the use of automated drafting facilities

4.1.2 Tools to improve reproductive performance

4.1.2.1 Genetics

- KIDPLAN has three EBVs concerned directly with fertility:
    - Number of kids born (NKB);
    - Number of kids weaned (NKW); and
    - Scrotal circumference (yearling and hogget measurements)
- Producers are also selecting for positive traits (and against negative traits) within their own herds, for example in parasite resistance, growth rates, muscling for meat and mothering
- Reproductive traits generally have low heritability (in sheep, ovulation rate (0.15), litter size (0.13) and lambs weaned (0.05))
- Recording of reproductive EBV data is less common than for carcase and growth traits
- Aldridge (2017) recommends kid survival should be included among EBVs
- Genetics is important in optimising accelerated breeding programs (seasonality, ovulation rate)
- In sheep, selecting for lamb fertility might negatively impact growth
- Selection can improve out-of-season breeding and length of breeding season
- Crossbreeding can be used to increase litter size (must also monitor weaning rate)
- Crossbreeding with Boer goats has also been used extensively in Australia to improve the productivity of rangeland goats, improving cycling and ovulation earlier in the breeding season, prolificacy, litter size and growth rate at weaning
- However, rangeland goats have a greater flight zone and are less calm than Boers
- Calmer ewes have been shown to have lower mortality in their lambs and the same is probably true for does
- As with any intervention to improve reproductive performance, genetic approaches need to be applied carefully, requiring observation, monitoring and recording to detect the emergence of any negative changes

4.1.2.2 Hormone intervention

- In sheep, progesterone-impregnated sponges and controlled internal drug release (CIDR) devices produced similar results
- In sheep, progesterone-impregnated CIDR plus ram effect brought forward oestrous
- Boer goats have been synchronised with progesterone CIDR, prostaglandin and equine chorionic gonadotropin (eCG)
- Common hormone manipulation of oestrous involves progesterone by CIDR or sponge

- Prostaglandin causes luteolysis and induces ovulation, and is only really useful within the breeding season
- Two doses of prostaglandin are needed to ensure most animals respond
- In ewes, 2 doses of prostaglandin less effective than progesterone
- Melatonin with progesterone and eCG increased conception rate in ewes in NZ
- Melatonin with the buck effect was more effective than the buck effect alone at advancing kidding and improving fertility and prolificacy
- Inducing ewes to breed can have four outcomes:
    - Ovulate and conceive
    - Ovulate but not display oestrous
    - Display oestrous and mate but neither ovulate nor produce a corpus luteum (CL), which is rare
    - Display oestrous, ovulate but fail to conceive (most common)
- Hormones are costly and require skill in handling and use to ensure the welfare of the animals and human health is maintained
- The cost is unlikely to be justifiable in a commercial goat meat enterprise, except perhaps in a program to build up numbers of genetically superior animals for breeding stock

4.1.2.3 Light therapy

- In goats, photoperiod manipulation can allow out-of-season breeding in temperate and sub-temperate regions by initiating sexual activity in does and bucks
- It is not effective at synchronising goats
- Light (with progesterone or progesterone and eCG) did not increase reproductive performance in ewes in NZ

4.1.2.4 Targeted nutritional flushing

- In studies in sheep and goats targeted supplementary nutrition has been shown to:
    - Improve sperm production;
    - Increase ovulation rate;
    - Improve colostrum production; and/or
    - Improve kid survival
- Producers can positively impact fertility, birth weight and colostrum production by providing targeted supplementation at specific points in the reproductive cycle, for example before mating, in the last six weeks of pregnancy or in the last week before kidding
- Other studies have shown that feeding late pregnant ewes or does additional concentrate, even where the diet is already adequate, will improve colostrum production
- Improved colostrum production has been associated with better lamb / kid survival and a better ewe-lamb bond. This nutritional supplementation may only need to be provided for a week and will therefore not alter significantly the weight of the lamb / kid such that the risk of dystocia is increased
- In addition, supplementation is better provided as a concentrate in late-pregnant ruminants (especially those bearing large litters) because of the reduced abdominal space for the rumen to expand
- Ewes fed lupins, maize or barley in last week of pregnancy produce more colostrum
- In sheep, increased nutrition during last few days of oestrous cycle may increase ovulation rate and litter size
- Flushing, providing additional feed to does from 30 days prior to 30 days after joining, may improve fertility, pregnancy rates and lad to a higher number of multiple births
- Nutritional manipulation to optimise reproductive outcomes is clean, green and ethical

4.1.2.5 The buck effect

- The buck effect requires separation from does from one month at a distance no less than one kilometre
- It can induce puberty, synchronise females, stimulate cycling – in ewes, the first cycle can be advanced by 2 weeks
- It is regarded as 'clean green and ethical'
- In sheep, the response varies between breeds, time since last lambing, season, body condition, physiological state
- In goats, the response varies with breed and latitude, and sexual activity cannot be induced during anoestrous period in highly-seasonal goats
- The use of photoperiod manipulation of bucks and does prior to the buck effect improved the response, as did nutritional supplementation of does
- In the US, the buck effect can deliver almost year-round cycling and improved oestrous behaviours
- The buck effect can be used for artificial insemination (AI), focused feeding
- Synchronisation using (for example) the buck effect would facilitate shedding as kidding dates can be calculated more accurately
- The buck effect could also be used to optimise the chance of a successful mating period, for example by delaying joining where adverse weather is forecast
- As the buck effect is so powerful in some herds, producers need to be sure to provide a sufficient buck: doe ratio
- A variation of the buck effect is to introduce the buck to a portion of the mob initially and then add further small mobs of does to the main mob every 10-14 days, maximising the number of births that occur every couple of weeks, facilitating the use of limited shedding space and/or spreading the labour of tagging
- The buck effect may not be as useful in extensive rangeland enterprises with very large joining paddocks

4.1.2.6 Pregnancy testing

- In goats, a transabdominal ultrasound can detect pregnancy at 30-35 days, and at 40-70 days to count foetuses
- Accuracy to detect number of foetuses reduces beyond two – for three of more foetuses, scanning is best done at 7 weeks' gestation
- In sheep, scanning is either for wet / dry (to allow removal of dry animals from the flock, and saving in feed costs) or differentiating singles and multiples (through more specific targeted feeding)
- The value of scanning increase when perform during a poor season (feed is limiting)
- The value of scanning for multiples increases with number of foetuses / 100 females
- Cost can be a limit the use of ultrasonography especially for those properties that are geographically isolated. The cost of travel for a suitably qualified technician may be uneconomic unless the herd is large, and there are many does to be scanned
- The impact on the welfare of the female should be considered when choosing a method of pregnancy diagnosis – testing that involves tipping the animal over and/or insertion of a probe is more likely to cause distress than procedures that can be completed with the animal standing and the probe placed on the external skin surface
- Ultrasound pregnancy diagnosis is 'clean green and ethical', non-hormonal and non-invasive

4.1.2.7 Reducing kid mortality

- Lamb survival was increased in crossbred (10%) and merino (12%) ewes when shelter was provided
- Adequate colostrum distends the lamb's gut and increases the ewe-lamb bond

- The size of the mob at lambing can affect lamb survival (e.g. <200 – 93.3%, >200 – 79.8%)
- In cashmere goats, does that were supplemented had reduced kid mortality up to 16 days of age
- In ewes in NZ, the was a notable rise in lamb mortality for those less than 3kg and more than 9kgs, while lambs born less than 1.5kg did not survive

4.1.3 Advanced breeding programs

4.1.3.1 Accelerated breeding

- The vast majority of the research into accelerated breeding programs has been conducted in sheep, the most relevant being De Nicola's 2007 PhD on 'Accelerated lambing and out-of-season lamb production in New Zealand'
- Most of the studies do not include a control/annual breeding group, nor did they continue through the whole of the animals' reproductive lives, so the longer-term success and sustainability of the systems have not been well assessed
- The diversity of goat enterprises, in geography and management styles, makes it a challenge to devise a 'one size fits all' approach to accelerated breeding – for example, high temperatures can reduce sexual activity, slow foetal growth, reduce appetite, reduce milk production and increase stress
- Joining during lactation will provide some challenges with a decrease in pregnancy and kidding rates and an increase in prenatal wastage
- In sheep in one study, in comparison to a conventional program, the accelerated system resulted in:
    - Higher average breeding and pre-lambing ewe live weights;
    - Lower average pregnancy rate, due to the lower pregnancy rate out-of-season;
    - More lambs born and weaned per ewe;
    - Lower average lamb birth weights;
    - Similar average lamb mortality rates;
    - Lower weaning weights (but weaning occurred 10-36 days earlier than in the conventional system); and
    - Increased production costs (labour, feed, hormone treatment)
- Advantages of the accelerated system are:
    - Having a supply of marketable animals at different times of the year;
    - Achieving a premium price for stock market outside the 'typical' breeding system;
    - Some constancy of nutritional requirements throughout the year, with less dramatic variation in demand compared with a single-kidding system;
    - Reduced vulnerability of the herd to disease outbreaks or severe weather events (not all offspring are born at the same time);
    - More consistent use of staff and infrastructure throughout the year;
    - Potential for improved total production of goat meat annually; and
    - Potential for increased profit
- Disadvantages are:
    - Ongoing presence of disease-susceptible animals can mean disease persistence year-round – vaccination may be required to manage this issue;
    - Heavily-populated or frequently-used paddocks can become conducive to worm larvae survival, making it much harder to preserve a 'rested' paddock for young stock;
    - Identification and administration of appropriate nutrition for multiple births may be delayed, increasing the likelihood of pregnancy toxaemia;

    - Running poor ewes with lactating ewes might increase the spread of Johne's disease to other does and kids;
    - It is more difficult to enforce age separation which could facilitate the spread of disease;
    - Vigilance is required about the removal of bucks/rams after a defined joining time or management becomes chaotic; and
    - Kidding at different times of the year is a compromise
- Accelerated lambing systems require supplementary feeding, changes to the herd structure and stocking rate and other adjustments. Failure to manage nutrition properly increases the risk of metabolic diseases such as pregnancy toxaemia, especially in does bearing multiples, and poor condition in other classes of stock
- Main challenges are:
    - Overcoming seasonality, possibly requiring hormonal intervention to achieve out of season breeding;
    - Increased time spent in management (especially in extensive grazing systems);
    - Cannot match kidding to pasture curve, requiring constant attention to nutritional requirements, increased cost of supplementation; and
    - Cannot allow worm, health issues to limit production at all
- For an accelerated breeding program to be a success a number of important herd management and environmental factors need to be in place, namely:
    - Early weaning;
    - Ability of does to breed in all seasons and/or to breed while lactating, or shortly after lactation;
    - Sustained high-quality nutrition at all times of the year (which requires good productive land and/or irrigation);
    - A high level of management skill;
    - Rigorous monitoring of the body condition of does;
    - Optimal doe and buck health;
    - Protection / shedding for kids that will sometimes be born when the weather is adverse; and
    - Advanced doe health prevention and response programs.

<u>Two kiddings per year</u>

- There are only a few research articles on twice-a-year production systems and they were all on sheep and mostly from the 1960-70's
- There was no literature investigating and describing the impacts on the lifetime productivity of the does or ewes and profitability in the longer term
- Twice-a-year lambing in Awassi sheep (Turkey) showed 60% reduction in pregnancy rate in second joining
- 2-in-1 system in sheep in Canada produced 3.54 lambs per ewe per year
- In a 2-in-1 system in sheep in Finland, there was no decline in reproductive performance over the trial (4 years), 21.9% ewe wastage annually
- In a 2-in-1 system in sheep, 36% of lambs born were from ewes that lambed in the previous cycle ('bonus' lambs)

<u>Three kiddings in two years</u>

- There have been various studies in sheep and only very few purely goat-focused studies on 3-in-2 two breeding
- The main challenge was getting the does and ewes to cycle in the non-breeding season
- Most studies showed an increase in production with accelerated breeding, but again the majority of the studies were short and did not allow evaluation of long-term outcomes

- Those studies that included nutritional information found in sheep that energy requirements were more consistent across the year and that the overall increase in energy requirement for the doe was 11%, equating to an increase in efficiency of 17-47%
- Another study found that by extending the time from lambing for the first and second-lamb ewes from 75 to 90 days improved the lambing rate, number of lambs per ewe, litter weight at birth and the condition of ewes at mating
- Summary of research trials:
    - Crossbred ewes in Australia ; 41% more lambings than annual system;
    - Merino Rambouillet ewes, in Mexico 3-in-2, increase in production at birth 37% and weaning 28%;
    - Kivircik ewes in Pakistan, increase in production at birth 15% and weaning 19%;
    - Beetal goats, Pakistan, more kids per doe in 3-in-2 than annual; and
    - Crossbred ewes in Australia, over 1/3 more lambs born in 8-monthly joining than February joining alone. There was variation in performance between breeds.
- Economic analysis estimated return per ewe over the 7 years of the study was $755 compared to $357 (annual spring lambing) or $517 (annual winter lambing) in Canada

<u>STAR/CAMAL/5 kiddings in 3 years</u>

- STAR system (studied in NZ over 3 years)
    - 35% more labour input (13% higher per lamb weaned),
    - 6% higher energy requirement (because of the increase in lamb production, although on a per kilo of lamb basis the energy requirement is 6% lower)
    - Total weight of lambs weaned was 26,200kg and 24,300kg for the accelerated and conventional systems respectively
- Summary of research trials
    - CAMAL system in Awassi ewes in Turkey, with hormone stimulation had no increase in offspring born overall
    - Morlam ewes with continuous ram access compared to Dorset ewe joined every 2 months. 1.28 Morlam lambs and 1.21 lambs for Dorsets born annually
    - Dorset ewes in US under the STAR system averaged 0.98 lambings per year, delivered 1.5 and weaned 1.23 lambs

4.1.3.2 Assisted reproductive technologies

<u>Artificial insemination</u>

- Fresh semen can be used when all the does to be inseminated are within a short distance from the source, that is, at the same location or on properties within a short travel distance away
- Frozen semen maybe kept for many years, allowing bucks with preferred traits to be used for breeding for a period well beyond their natural life
- Acceptable pregnancy rates are achievable with:
    - Fresh semen, using pericervical or intracervical AI – intrauterine insemination via the cervix with fresh semen gives similar results to natural mating in does
    - Frozen semen, if deposited in the uterine lumen via laparoscopic or transcervical techniques
- Advantages:

    - Control of reproduction and, in conjunction with progeny testing, improvement in meat production of goats;
    - Precise kidding time (at particular season, and over a limited time);
    - Facilitation of supplementary feeding, to meet the increased requirements of does during lactation;
    - More efficient genetic selection and improvement;
    - Increasing the number of offspring per sire;
    - Vast and rapid diffusion of improved genetics;
    - Minimisation of the risk of disease associated with reproduction; and
    - In the case of frozen semen, 'spatial and temporal…dissociation between collection of spermatozoa and fertilisation'
- Progesterone-impregnated CIDRs or sponges are commonly used to synchronise does. Does are then given a dose of prostaglandin with or without pregnant mare serum gonadotropin (PMSG) at the time of removal of the CIDRs or sponges. One producer advised that PMSG has recently been taken off the market for use in goats and that alternatives are being trialled. Alternatively, two injections of prostaglandin given 9-10 days apart is effective at synchronising most does
- Bovine semen can be sorted into sexes with 90% accuracy (there are no reports of semen sexing in goats)

<u>Embryo transfer</u>

- Embryo transfer (ET) is much more complicated than AI, involving:
    - Oestrus synchronisation of donor and recipient;
    - Fertilisation of donor (natural or artificial insemination);
    - Embryo recovery from donor; and
    - Transfer of embryo into the recipient
- Advantages include:
    - Rapid introduction and multiplication of new breeds or desirable traits;
    - Increased genetic progress from more intensive selection on the female side and reduced generational interval by allowing both younger males and females to breed;
    - Reduced risk of disease spread (early developing embryos are protected against many infections); and
    - Support for other reproductive technologies such as sex determination and cloning
- Disadvantages include:
    - Cost;
    - Requirement for hormone treatment of both donor and recipient; and
    - Processes of collecting and implanting embryos are invasive and technically challenging, requiring expert skills
- Multiple ovulation and embryo transfer (MOET):
    - Involves the use of hormones to stimulate multiple ovulations, increasing the number of offspring that can be produced per female per cycle of treatment
    - Has had unpredictable success, and with its high cost the technique has had limited its use in goats
- *In vitro* fertilisation is lower cost
- Juvenile *in-vitro* embryo transfer (JIVET), using ova from pre-pubertal (3-4 months old) females, can be used to further reduce the generation gap and increase genetic gain
    - Laparoscopic ovum pickup (LOPU) – harvesting oocytes through laparoscopic aspiration of follicles under anaesthetic

    - Requires an experienced operator and general anaesthetic for the donor animal while the laparoscopy is performed, creating the potential for unreasonable compromise to welfare of the animals
    - Has no impact on onset of puberty, future fertility or growth
- Cost of cloning is likely to be prohibitive for use in goat production systems for now.

4.2 Extension material

A broad range of extension material was reviewed in detail to assess its direct relevance or possible adaptability to goat meat producers. Because reproductive performance is affected by almost all facets of the goat enterprise (such as health, welfare and nutrition), the review included most topics in goat meat production. Extension resources for sheep and some for cattle and deer were also reviewed.

The goat extension resources provided by MLA in particular are generally very comprehensive and of high quality. However, they could be presented in a more user-friendly way and there are a few specific gaps. For example, there is little content on accelerated breeding systems. Some of these gaps could be filled by adapting or linking to content from sheep extension or other resources (for example, WormBoss) while others will require new material to be written.

A summary of the extension material review follows. The abbreviations used are:

- M: module
- W: webinar
- F: factsheet (Going into Goats).

Appendix 4 also provides a detailed 'audit' of the extension materials against the key findings of the literature review and the industry survey and interviews undertaken for the project, in a table format.

4.2.1 Foundational reproductive management practices

4.2.1.1 Health and welfare

<u>Preventative measure for animal health: General</u>

- M3 – obligations in respect to livestock disease and health management and notifiable diseases
- M6.2, M6.11 – general diseases
- M6.5 – zoonotic disease information

<u>Preventative measure for animal health: Teeth</u>

- The MLA extension material does not have a teeth examination / ageing chart
- The NSW State Government has an AGFACT on ageing goats by teeth that provides a good series of photos, although in an old format
- F7 – information on four stages of the reproductive cycle and covers in detail condition and nutritional requirements of the doe, but it does not address disease specifically

<u>Preventative measure for animal health: Worm management</u>

- M9 – updated – much improved
- Internal and external parasites, monitoring, treatment and prevention
- W3 and 11, further information
- WormBoss goats – grazing management, resistance and resilience, worm testing

Biosecurity

- Farm Biosecurity web site – very comprehensive guide to biosecurity in livestock production systems. It includes:
    - Biosecurity toolkit for goat specifically
    - Information on how to avoid Johne's disease
    - National kid rearing plan
    - A template and supporting material to assist in developing a biosecurity plan
- M3 – biosecurity threats to an enterprise
- W7 and 9 – importance of biosecurity, how to create and manage a biosecurity plan

Managing stress

- F4 – goat behaviour and handling (to assist in handling)
- MLA webpage – animal handling, minimising stress – good tips to reduce stress
- M4 – goat behaviour and considerations for fencing and handling equipment
- M6 – goat handling – in the 'Tools' section, includes a number of strategies for reducing stress while handling goats
- M6.9 is about mustering stock and includes further information about ways to reduce stress when handling goats
- MLA document 'Requirements for handling goats to maximise eating quality', provides some general tips for reducing stress when preparing, dispatching and transporting goats for slaughter
- FutureBeef web page, 'Handling cattle', also provides some detailed information of low-stress handling of cattle and this type of detail (although goat-specific) would be very useful to include in the module, great pictures

Preparing for extreme weather events and other unforeseen disasters

- M1 – impact of weather patterns and extremes on animal performance
- M7 – nutritional requirements in severe weather events

Observing acceptable animal welfare standards

- Australian Industry Welfare Standards and Guidelines for Goats
- M3 – covers industry obligations and includes a list of the relevant models of codes of practice
- 'Fit to Load' – guidance for transport of livestock

4.2.1.2 Nutrition, body weight and body condition score

Nutrition

- M1 – calculating feed availability and dry sheep equivalent (DSE) ratings of the herd
- M2 – calculating the cost of production and budgeting
- F6 – calculating DSEs, stocking rate, carrying capacity and the effect of the reproductive cycle on these parameters
- F7 – nutritional requirements, BCS of does in the various stage of the reproductive cycle
- F8 – pasture growth curve, fundamental to planning of kidding time in many production systems
- M7 – **NB updated in last week of May 2019** – entirely on nutrition, includes the requirements for different types of goats in various metabolic states. It describes temperate and rangeland pastures and variation in feed quality throughout the year

- Best practice videos (x4) – calculation of feed demand and budgeting (for pasture and browse)
- W12 – total grazing pressure and goats
- EverGraze – regional pasture growth curves
- Tool 8.4 'Making More from Sheep' – feed budgeting template
- Feed on offer photo gallery 'Lifetime wool' and pictures to assist with the visual assessment of pasture availability in temperate climates

Condition scoring

- M6 – BCS guide no pictures of animal in various BCS
- BCS Guide by the American Institute for Goat Research is useful and includes pictures

4.2.1.3 Management of joining, kidding and weaning

- F7 – some management recommendations for doe care for the various stages in the reproductive cycle. It states; 'The preferred practice is to allow maiden does to grow out for another 6-12 months in controlled mating enterprises'.
- M1 – the suitability of a property for breeding in respect to climate, shelter and other factors
- M6 – some management information in a table for the various stages of reproduction for both and extensive and intensive systems (this table is in a difficult format to read and stay engaged with)

4.2.1.4 Measuring and recording

- M3 – industry record-keeping requirements
- M5 – recording of raw data from the herd such as bodyweights
- M11 – record-keeping for depots (for quality assurance purposes)
- F7 – monitoring performance – includes some of the parameters that can be measured and how those measurements can be used to improve productivity

4.2.1.5 Reproductive problem solving

- No problem solver was found in the extension material

4.2.2 Tools to improve reproductive performance

4.2.2.1 Genetics

- Sheep Genetics – resources on KIDPLAN
- MLA has expansive extension material on genetics over a number of media forms
- BP video – goat genetics
- M5 – goat selection and breeding, including information on breeding objectives, breeding and selection tools, introducing animals to a new environment and artificial breeding
- W2 –'Genetic improvement and parasite management – what you need to know'
- W8 – 'Genetic improvement within your herd – are you getting the most bang for your buck with your selection program?'
- FutureBeef – good section on cross breeding (simplified)
- M9 'Making More from Sheep' – 'Gain from genetics' module with particular focus on genetic gain in relation to sheepmeat and wool traits (some relevance to goats)

4.2.2.2 Hormone Intervention

- M5 – brief reference to its use in AI and ET in goats
- No detail available in sheep extension material

4.2.2.3 Light therapy

- Light therapy is not covered in the extension material

4.2.2.4 Targeted nutritional flushing

- The extension material covers nutrition very comprehensively but there is little reference to the use of targeted / adaptive / focussed nutrition

4.2.2.5 The buck effect

- M6 – brief description of the buck effect

4.2.2.6 Pregnancy testing

- F7 – productivity benefits of pregnancy testing
- 'Making More from Sheep' – M10, 'Wean more lambs' includes information on pregnancy testing
- 'Making More from Sheep' – Tool 10.7 outlines some of the advantages of pregnancy scanning and much of this information could be included in the goat material

4.2.2.7 Reducing kid mortality

- M6 – information on shelter, predation, nutrition and health in the period around birth in intensive and extensive systems

4.2.3 Advanced breeding programs

- There is essentially no extension material on advanced bereding programs, except for a section of M5 that discusses the main uses and the overall gains from using AI and ET. It does not include procedural details, specific costs or risks associated with the procedures including impacts on the health and welfare of the goats

4.3 **Survey and interviews**

In total, 63 questionnaires were completed online (excluding the postcode-only responses). This included those contacted by telephone, whose data was entered into the online questionnaire by the consultants, so that all data could be analysed together. The consultants spoke to 22 producers by telephone and several other relevant people. Table 2 shows the number of respondents from each state / territory and that number presented as a percentage of all of the respondents. Figure 1 shows the location of each of the producers who provided a response to the survey / questionnaire.

Table 2 : Numbers of producer respondents from each state/territory

State/Territory	**Number of respondents**	**Percentage of respondents**
Australia Capital Territory	0	-
New South Wales	19	30%
Northern Territory	0	-
Queensland	15	24%
South Australia	2	3%
Tasmania	2	3%
Victoria	18	29%
Western Australia	7	11%
Total	**63**	**100%**

Figure 1: Map showing the locations of producers who completed the survey

Unfortunately, the majority of the 63 responses were from enterprises with small numbers of goats, despite every reasonable attempt being made to engage producers with larger goat numbers. These smaller producers did however provide some insight into the appetite or otherwise to improve reproductive capability. In addition, some of these producers had engaged novel management tools that have provided ideas for future research with the potential for commercial use. All of the responses were for meat production enterprises, while one producer had previously run both dairy and meat goats. The consultants also engaged a large dairy producer but that data is not included in the here but presented, where relevant, in the discussion.

The most striking finding from the telephone interviews was the extent to which dry, tough conditions prevailed (some for several years), with all except one respondent making comments to this effect (the one exception had had recently received almost 600mm of rain in one week). It was clear that many producers were struggling with the lack of feed and the cost of supplementary feed and many reported that they had sold stock due to the conditions in recent months/years.

Details of the responses to the survey and consultations are presented in Appendix 5. In summary, the findings were as follows:

- Producers had trouble identifying a typical ‘annual rainfall average’ for their properties due to the enormous variation in recent years
- Annual rainfall varied from 2-300mm to more than 1000mm
- Only 6/63 producers used irrigation on their properties
- 22% of producers had goats that were only provided with grazing, 78% were provided with grazing and browse
- 59% of producers had purebred Boer goats, 89% Boer or Boer crosses
- 61% vaccinated their goats

- 11% of producers indicated they never drenched , 41% drenched regularly and 48% sometimes
- 51% of respondents said they condition scored their goats
- 18% of producers indicated that they sold goat meat for export and 69% goat meat in the local domestic market (this does not reflect the volume of sales, rather the number of producers who access those markets)
- 44% of producers also ran cattle or sheep
- The main limitations to productivity listed by producers were:
    - Kidding percentage and kid losses
    - Pasture/cost of feed
    - Drought/rainfall
    - Market
    - Genetics
- 37% of producers interviewed had been farming goats for 11-20 years, with 2, more than 30 years and 2, less than one year
- 27% of producers that completed the survey had fewer than 50 does, 74% had fewer than 500 does
- 59% of producers joined with one buck to 21-40 does
- 7 producers stated that their does kidded more than once every year, while 3 of the 7 also said they joined year-round
- A total of 10 producers indicated that they joined year-round or did not know how often their does were joined
- The average kidding percentage for those kidding twice a year was 155%, while the corresponding figure for those kidding once annually was 150%
- 42% of producers had their main joining in January and February
- The joining period varied considerably, the most common being:
    - 13% - less than 5 weeks
    - 35% - 6 weeks
    - 22% - 8 weeks
- The most common ages of first joining of maidens were:
    - 56% - 13-18 months
    - 23% - 7-12 months
    - 11% - 19-24 months
- Most producers used several criteria on which to cull does, the most common being:
    - 68% - physical characteristics
    - 63% - productivity
    - 59% - age
- 25% of respondents fed pregnant and lactating does browse and pasture only, while the majority offered supplements, mainly:
    - 66% - hay
    - 34% - grain
    - 29% - pellets
- 89% of producers said that they did not pregnancy test their does
- Only 16% of producers indicated that their production system was impacted by seasonal anoestrous
- 62% of producers indicated that they did not use the buck effect or hormones, melatonin or flushing in their enterprises
- 6 producers indicated in the survey that they were using accelerated breeding. Two of these actually had a year-round joining system, and two could not be verified as they chose not to be contacted.
- Of the 22 producers who were spoken to, 10 had tried accelerated breeding previously and all 10 said they would never try it again. The main reasons for this response included:

    - Fewer kids overall (fewer born, smaller size, predation)
    - Large and expensive nutrition requirements
    - Hard on animals, does without enough milk
    - ‘Disastrous’, ‘management porridge’
- The weaning percentages of those claiming to have accelerated breeding were: 98%, 180%, 135% and 160%
- 10 producers used AI and 6 of these also used ET
- Overall, 50% of producers had a weaning percentage of 100-200%
- 10 producers reported kid loss of 40% or more. Of that 10, 9 reported a kidding percentage of 150% or more (compared with 49% reporting a kidding percentage of 150% or more over the whole respondent group), while 6 had fewer than 50 does, (compared with 27%)
- 16 producers stated that they had a split weaning. 14 producers stated they weaned at 11-12 weeks and 15, 15-16 weeks.

These results are discussed in greater detail in Section 5.2 and in Appendix 5.

Other observations raised in the survey

A number of interesting observations were made by producers who responded to the survey or were interviewed. While not all are directly related to reproductive management, they are recorded here for completeness:

- One producer reported that introducing a Boer buck to a herd could generate a 33-50% increase in meat yield in three years, due to the low starting point in some herds. Another producer was able to reduce the age to marketable weight of 22kg from 11 months to 3 months, through genetic gain.
- Many commented that kid loss was a cause of significant loss of production for them, with at least six of the 22 spoken to reporting predation as a contributor to kid loss. The predators mentioned were dogs, pigs, foxes and eagles. One producer commented that it was not feasible to kid at certain times of the year because of predator activity. Other producers reported minimal losses of kids.
- Two producers have been shedding their does at kidding. Neither producer was keen to give precise details of the improvement in survivability of kids. They were both adamant, however, that the dramatic increase in survival justified the additional costs of infrastructure and wages for labour to oversee kidding. One of these producers ran 100 does and the other 2-3,000 does (only 70 could be shedded at a time). In both enterprises, does that were close to kidding were identified and brought into the shed (within a week of kidding) and fed on a concentrate diet. They were kept in the shed until about a week after kidding or as soon as the kids were doing well. One of the producers said this was particularly useful for does that had been synchronised and artificially inseminated as they had an accurate due date for them.
- One producer advised that he used electronic ear tags in his goats and one of the main reasons he used them was to allow him to use an automatic drafter to help reduce the person power required, as he was essentially running the enterprise alone and casual help was difficult to find.
- There was variation in health concerns, as seen by the answers in respect to drenching, and from phone discussions. Some enterprises have major worm problems, and without timely treatment losses can be significant, while others never drench. A couple of producers noted that their goats had far fewer worm issues with the drier weather as ‘one of the best cures for worms is drought’. Two producers were selecting for worm resistance in their goat herds. Nutrient deficiencies had a significant impact on the enterprises of two respondents at different times in recent years.

- Four of the producers interviewed reported a significant event/s from which they had incurred large stock losses. Three of these events involved dramatically wet and cold weather. Does were reportedly kidding and walking away leaving their kids on the ground. One producer reported having 60 poddy kids following that event, out of approximately 100 does, and many other losses. Another was a cold winter that resulted in only eight of 40 kids surviving. In another case, very wet conditions in a high rainfall area caused significant kid losses: 'it was too wet for the goats'. Finally, one producer experienced two extreme events in two years, the first being a wild storm in which 30% of the weaners died from exposure and stress, the second an extreme heatwave with several consecutive days of above 46 degrees and the majority of kids perished.
- Some of the producers identified issues they thought were significant in the success of goat meat farming (separate to reproductive management). These included:
  - The decrease in the number of suitable abattoirs;
  - The remoteness of some properties making it not financially viable to engage services such as pregnancy testing, AI and ET;
  - Highly variable seasons; and
  - Excessive heat.
- One producer highlighted a lack of specific information on designing and building suitable yards for goats. He said dealing with rangeland goats that were not handled regularly posed challenges and that well planned and designed yards could make this process much easier. Building a set of yards is a significant capital cost, and that is amplified to cater for the high stock numbers on some properties in the northern states. A well-planned and well-built set of yards will minimise stress, injuries and management time. The availability of designs that have been shown to be effective would be of great benefit. [NSW DPI has an AGFACT on yard design for goats including considerations for rangeland goats. Incorporating some of this information into the 'Going into Goats' material could be beneficial.]

4.4 Case studies

Six case studies were prepared from among the interviewees for the project. The cases were selected firstly among those who were using an advanced breeding program, preferably involving more than 200 goats. Further case studies came from producers with smaller numbers of goats who were using an interesting reproductive management model that might create ideas for future research and/or potential adoption on larger properties.

The case studies provide more in-depth information on particular production systems compared to the survey. In some cases during the initial telephone conversation it was determined that the production system was in fact not suitable as a case study and was therefore not included. It was a challenge to engage all the producers selected as they were all very busy, mostly dealing with significant drought. Each of the producers engaged took the consultative process and the development of the case study very seriously and was keen to ensure their business was represented accurately. All of the information that was provided in the interviews has been included in the reports. There were questions asked to which the producers did not have, or were not willing to provide, answers. Clear reasons for management decisions, where provided, were included in the studies.

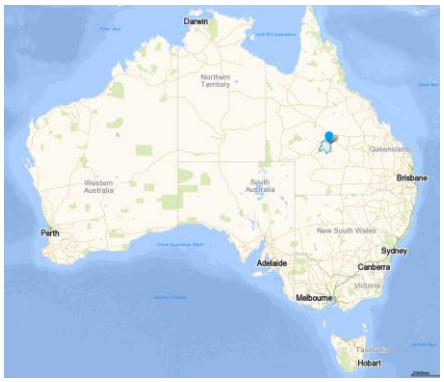
In all cases, the producers were provided with drafts of their study and all of the feedback provided by them was incorporated into the final versions presented here.

It was clearly a very challenging time for the majority of the producers, and some were facing harsh decisions as to whether to even join their does again next season, whether to send

them away on agistment or to sell stock. All of the case study producers were very helpful and did their best to provide meaningful and useful assistance to this project.

They are provided below.

4.4.1 Isisford, Queensland



Dick Cribb manages Gydia Park in Isisford, Queensland and has been farming goats for seven years. The property covers 10,500 hectares and comprises around one-quarter mulga country, one-quarter old (original) gydgee and one-half pulled gydgee. The property has an annual rainfall of 200-300mm. Gydia Park has both cattle and goat enterprises. Dick's main market is meat goats for export, but he also sells a few bucks for breeding.

The goat enterprise comprises 200-500 Boer and Boer cross does in a typical year, depending on the season, with fewer goats run during the very dry years. The goats are not vaccinated or drenched. They have access to native pasture and mostly mulga and gidgee browse. If needed, the does are supplemented with cotton seed duing late pregnancy and during lactation.

Typically, there is one buck to 30 does. Maiden does are usually first joined at 7-12 months of age. The doe kids stay with their mothers and are not weaned. Dick has seen losses in the past from stress at weaning and avoids weaning the doe kids where possible. Dick has found that the majority of maidens do not get pregnant until they are 12 months old. He finds maidens to be very poor mothers and generally not successful in raising their first kid, probably due to a combination of predation, mismothering and leaving kids behind to follow the mob. However, they do well the second time. Dick has found that joining at 7-12 months does not significantly impact on the growth of the maiden does.

Part of the decision to run goats was to use them to control the browse. Dick has found, though, that they have not significantly impacted on the browse, and while they do eat the regowth it has not been affective enough to kill the plants. Goats do however take away a lot of the good available feed from the cattle. He has found that young cattle do not do as well when they co-graze with goats, but breeding cows perform better.

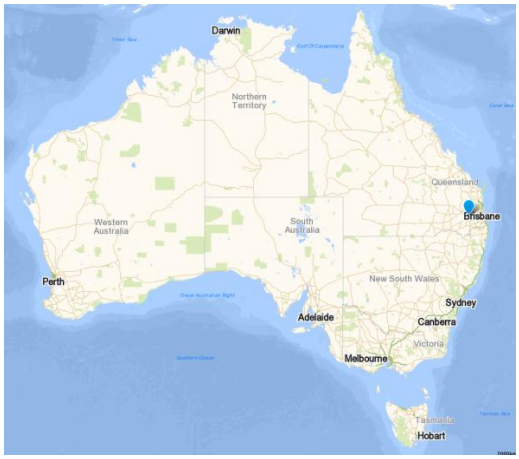
Dick has had a challenging start to goat farming with impacts from extreme weather events and predation. In 2012 he began joining twice a year and achieved a kidding percentage of 65% in the first year. In November that year, wild storms led to the loss of 30% of the weaners. A heat wave in the following January, with temperatures of more than 46 degrees for several days, caused the deaths of a large numbers of the kids. The kidding percentage dropped to 28% that year and Dick stopped controlled joining.

In 2014, the number for does was reduced due to drought. There was also a significant impact from a large number of wild pigs, dogs and kangaroos. The property had electric fences but because of the kangaroos it proved impossible to keep them working long enough to be effective. Over 2015 and 2016, Dick sold more does and the kidding percentage dopped further. Wild pigs and wild dogs caused the main predation problems. A large boar can catch and take whole kids.

In August 2016 an exclusion fence was built on one third of the property. This provided a proetected area of 3,800 Hectares for the goats. Immediately the kidding rates started to rise and continued to improve rapidly over the next three years: 2016 – 34%, 2017 – 80% and 2018 – 160%. Dick says that the exclusion fence has been a worthwhile economic investment. It has benefted the goats and the cattle as well as reducing the grazing pressure from the kangaroos. Dick hopes to be able to extend the exclusion fencing in the future. Dick has decided not to wean his doe kids any longer but to let them remain with their mothers. After suffering severe losses from two freak weather events he thinks the long term surviability of the kids will be improved this way. The buck kids have been weaned however to prevent unplanned matings.

In 2019, Dick plans to return to controlled breeding. He intends to join the does for 6-8 weeks. He thinks this will make management of the goats much easier. He has found that if does and kids are disrupted, especially early after birth, the does will walk away and leave the kids behind and they do not return for them. A set joining will make it easier to time mustering to reduce the risk of disruptions to the doe-kid relationship. It will also make it easier to get a ‘marketable line for stock’ to sell.

4.4.2 Goombungee, Queensland



Yarrabee Boer goat stud is located at Goombungee in Queensland and is managed by Helen Darlington.

Yarrabee’s Boer goat and Dorper sheep enterprises occupy around half each of 242 hectares. Cattle are also run on an adjacent area of the property. The average annual rainfall was 700mm and now varies considerably, and is usually less than 500m. In 2018 the farm only received 375 mm, while in 2011, 1,125mm fell.

The pasture is mostly native, comprising bluegrass and kangaroo grasses. Improved pastures have been difficult to establish because of the dry climate in recent years. Some paddocks grow good clover in the winter (when the rainfall allows) and some forage crops

are grown after suitable rain. Little browse remains for the goats, with only occasional access to some wattle and eucalypt trees.

The Yarrabee herd includes both standard and red Boers. Since 2011, doe numbers have been gradually reduced from 150 to the current 50. When the stud had a larger number of goats a buck to doe ratio of 1:40 was used for mating. A higher ratio is used now. Does are joined from the end of March for six weeks, so kidding runs from the end of August into September. Maiden does are first joined at approximately 18 months of age. The does are not scanned for pregnancy but Helen monitors male activity in the mob especially around the time of the second cycle to identify those does that are cycling again and thus not yet pregnant. Does are culled for physical defects of the udder or feet or for declining teeth. Does only ever kid once a year and all does are joined to kid at the same time.

Helen manages her does to minimise the number of triplets and quads, as she has found that litters of more than twin kids are undesirable. When there are more than twins, the kids are smaller and the does are unable to successfully raise them in their environment. To assist with managing doe fertility, prior to joining, the does are kept on a maintenance ration only. A paddock is chosen is ensure that the does do not receive any ‘flushing’, that is, an increase in ovulatory rate due to improved nutrition.

The bucks are housed about three kilometres from the breeding does during the non-mating period. When they are introduced to the does for the joining period the buck effect, which induces cycling of does, is very pronounced. This makes it a real challenge to tag and record kids in the first few days of kidding. In one season, 50 does kidded in two days out of a mob of 150. To moderate the buck effect, Helen puts part of the doe mob with the bucks for about 10 days and then adds some more does. This allows for a more staggered and manageable kidding period.

Helen prefers that her does are mated successfully during their first cycle as she has found that they are less likely to have more than two kids. Historically, she has found that successful matings during the second cycle are much more likely to result in pregnancies of three or four kids.

During pregnancy the condition of the does is maintained mostly on pasture alone, although this is dependent on the season and does are provided with supplementation if required. During the last six weeks of pregnancy does are put on an increasing ration (100-500g) of grain or pellets per day with cereal hay. This supplementation continues through into lactation (until six weeks post kidding). If the season allows, the does might be provided with daily but limited access to an oaten crop instead of the grain/pellets.

For kidding, does are brought into a smaller and more sheltered paddock near the house. The does stay in this paddock until after they kid and the kids are established, at about two weeks of age, and then they are moved out to another paddock. Yarrabee repeatedly records 200% kidding with only a 1 % loss of kids from birth to weaning. Predators are no longer a problem (due to the careful management and presence of Maremma guardian dogs at all times) in this enterprise and most losses occur in the first few days after birth. From a couple of weeks of age, the kids have access to pellets away from the does. Helen said that this has caused some problems with rodents in the past and when conditions are dry some kids have over-eaten on the supplementation causing them to be a little unwell for a short time. Helen weans both buck and doe kids at 12 weeks but again this may vary with the season. If the season is good and the does are producing plenty of milk, weaning might occur a little later, while in dry conditions when feed is limited, she finds it more economically viable to wean earlier. It is more cost-effective to wean early and feed the kids than to feed the does to produce enough milk to feed the kids adequately.

After weaning the kids are put into a good paddock (if there is one available) and they are fed pellets and hay. The amount of supplementation varies depending on the pasture available.

The dry seasons have reduced the incidence of worm issues, but the does are strategically drenched before kidding and vaccinated with Glanvac®. All young animals are vaccinated twice, one month apart, and older animals are vaccinated annually.

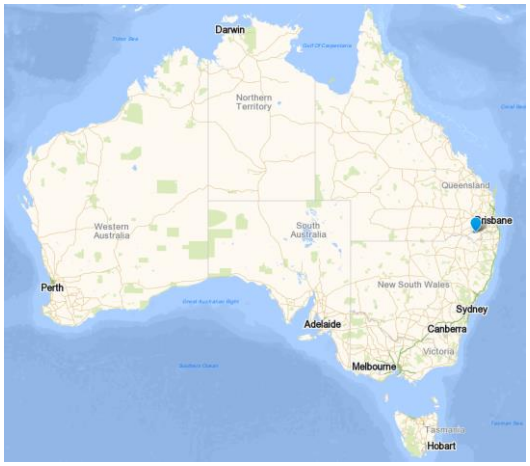
Yarrabee's main market is breeding animals although culls are sold for meat. The demand for Red Boers is very positive and Helen struggles to meet this demand.

Helen says the dry seasons have significantly impacted her business with limited pasture and increasing costs of feed. Despite recent adverse conditions, the Standard and Red Boer goats thrive in this environment with their high fertility posing some challenges. The severe dry has brought some benefits in terms of parasite control but continues to challenge livestock producers like Helen who are under constant pressure to adapt their businesses and management models to be viable.

Helen has used embryo transfer in the past to build up her fullblood Boer numbers although she says this is no longer necessary as there are sufficient numbers to breed from naturally, and such expense could not be justified in the current dry conditions.

Yarrabee provides a good example of adapting management to suit a changing climate. Helen is moderating the fertility of her does to ensure it remains at a sustainable level. This improves the survivability of the kids that are born, avoids the need for increased management intervention and considers the health, welfare and productivity of the livestock in the longer term. The buck effect is clearly very powerful at synchronising does. While this profound response poses a challenge for tagging and keeping track of kids at birth, it can be a cost-effective way of facilitating targeted nutritional supplementation for late pregnant does and for ease of management for kidding supervision, weaning and marketing of goats.

4.4.3 Gore, Queensland



Sunset Hill Boer Goats is located in Gore in Queensland and comprises 100-200 Boer does, running alongside a beef cattle enterprise. The goats do not compete with the cattle for pasture and work well as a dual enterpise. Pieter van Jaarsveld is the manager of the property and has been farming goats for four years. Sunset Hill produces mainly breeding stock, sold both domestically and internationally, and meat is also sold on the domestic market.

The goats graze on native pastures and browse on broad leaf regrowth and eucalyptus on just over 1,000 hectares. The property receives 500-600mm of rainfall annually.

The goats are vaccinated and are drenched as needed. The does are joined every eight months for six weeks. Maiden does are joined for the first time at 13-18 months. In late pregancy and into lactation the does are supplemented with hay, grain and pellets.

Does are pregnancy tested. The average kidding rate is approximately 95%.

Proegesterone-impregnated CIDRs are used to synchronise the does for artificial insemination (AI). Sunset Hill uses a combination of AI and natural mating. The AI is used to breed specific genetics into their herd. It is a cost-effective alternative to buying genetically high-quality animals that need to be fed and maintained. In addition, Pieter believes that genetic diversity is limited in Australia, and finds he can optimise breeding and genetic diversity faster and avoid the risk of inbreeding by using AI.

The main driver for the accelerated joining is to grow the herd size quickly while also improving herd genetics. For Pieter, the main advantage of an accelerated breeding program is growing the herd size while minimising upfront costs. The program also allows him to get to know his herd better and to learn to adapt and change management as the herd is exposed to a variety of different situations. In addition, it means that there are goats to sell thoughout the year, which helps to manage the risk for market access. Ultimately, Pieter believes that this is the optimum way to breed goats.

The main challenge in running an effective accelerated breeding program is the seasons. Although the goats are hardy, young goats are susceptible to the cold winters. The winter kidding is therefore very labour intensive to ensure maximum survivability of the kids. Goat survivability is drought conditons is very good. Precision in the timing of joining is important, and the animals need to be healthy and fed on the right diet, with timely medical treatments and time to recover and rest. Good infrastructure and careful organisation are essential for the program to be successful.

4.4.4 Mount Hope, New South Wales

Big Ampi Rangeland Goats is run over three properties in the New South Wales Western Division. The owners live off-farm and travel extensively for their other business interests. This provides them with access to new and innovative farm management practices from all over the world, which they think has been very beneficial to the development of the Big Ampi goat enterprise.

Big Ampi produces goat meat for the domestic and international markets and weaner does for live export. Other categories of livestock include cattle and sheep.

The annual rainfall on the properties ranges from 240mm near Menindee to 380mm near Mount Hope. The Boer composite goats graze on native pasture and some forage crops and browse on brush and woody plants. A program to sow some improved pasture species on the higher rainfall block is underway. The goat enterprise comprises large mobs of does that are joined every eight months. The joining time is staggered so that does are kidding year-round and there is a continuity of supply of sale stock, although there is a trade-off in the kidding percentage per joining.

The buck: doe ratio used is 4-5% for four weeks and then 6-7% for a further two weeks. Big Ampi has found that some paddocks are better for joining than others, and whilst the reasons for this are not clear, the pregnancy rates are definitely higher in the better paddocks. The managers feel they need to investigate further the availability of trace elements (e.g. selenium) in those paddocks. In the interim, and driven by the dry conditions and extensive use of supplemental feed, lick blocks are being used. All does are scanned for pregnancy and those that are not pregnant are re-joined as a separate group.

Maidens are joined for the first time at about 13-18 months. This time has been selected as the head stockman has learnt from experience that if does are joined at seven months they fail to grow out well and fail to produce good heavy kids. Maidens are not weighed but are selected on individual assessment by experienced stockmen. Culling criteria for does include productivity, physical characteristics and health. Big Ampi has been selecting for goats that have good fertility and fecundity. This selection emphasis is ongoing but good progress has been made.

Depending on the season, does are provided with an increasing amount of supplementation from six weeks prior to kidding, and this continues through into lactation. Kids are introduced to feed while they are still on their mothers, which means that once they are weaned they are well conditioned to feeders and concentrated feed and this helps them cope during the immediate post-weaning phase. Kids are weaned at 8-12 weeks of age at 15-25kg. They are fed on a familiar feed ration for a few weeks immediately following weaning which assists them to maintain a good growth rate and adapt to a diet without milk.

Predation is a major issue and, as the goats are mostly white, and more visible, it makes them more susceptible to predation. Paddocks are selected for kidding that offer some shelter for the does but also minimal risk of predation. The main predators include pigs and wedge tailed eagles. Active involvement in in a local wild dog management plan is working well to manage predation from dogs. Areas of scrub near productive paddocks that can/do harbour pigs have been cleared under a property vegetation plan (PVP). The weather is not cold enough during winter to impact on kid survivability at kidding during that time. The weaners are six-way vaccinated and all goats are drenched as needed.

The climate in the western division suits the accelerated kidding program as there is very little evidence of seasonal anoestrus and the property is able to grow both winter and summer species of grasses, shrubs and chenopods. This provides nutrition for the goats throughout the year, which is essential in this type of program as the peak demand for nutrition varies every year depending on joining times. The rangeland environment does pose some challenges. The extensive nature of the property and the sheer size of paddocks mean that mustering and the droving animals to yards for husbandry procedures are major and costly undertakings. Any additional management steps that require the goats to be mustered need to be considered through a cost/ benefit analysis.

A high buck: doe ratio is used to ensure good coverage of the does at joining. A paddock for joining might be over 2,000 hectares. This reduces the effectiveness of the buck effect, which has been shown to be very effective in many intensely managed goat herds and could

be valuable for Big Ampi in its accelerated breeding program if a rangeland application could be found. The aim is always to have as many does as possible kid close together and to avoid stragglers (kids born late in the cycle). Late kids tend to be smaller at weaning and can struggle with the early weaning regime. The system aims to avoid late, small and weak kids.

Maintaining the does in good condition and being able to provide them with good quality and well-timed nutritional support is essential to the successful management of an accelerated breeding program. They have found that nutrition during the last four weeks of gestation is particularly critical. Big Ampi has been impacted by the drought. The last three joinings and two kiddings have occurred in drought conditions. Does require significant nutritional support to maintain their reproductive capacity during these conditions. The balance of energy and protein in the feed ration changes from late pregnancy to lactation. In normal environmental conditions the varying nutritional requirements of the does do not require as much careful management and intervention.

Additional information:
Local Land services have recently completed a review of several goat enterprises in Western NSW in a report called 'Rangeland goat production in western NSW: Where are they now?'. Big Ampi was one of the enterprises reviewed. It provides additional information about the enterprise and can be viewed at:
https://western.lls.nsw.gov.au/__data/assets/pdf_file/0004/853411/Rangeland-goat-production-in-Western-NSW.pdf

4.4.5 Condobolin, New South Wales

'Malleevale' is a 22,250 hectare property located near Condobolin in New South Wales. The average rainfall is 400mm and the property has cattle, sheep, cropping as well as goats. The property is owned by a family partnership and Ian and Alison Manwaring. Ian and Alison are part of the partnership and have been farming goats for 20 years but have increased their management intensity over the last five years. Malleevale has 1,200-1,800 does and runs the bucks at 3-5% (1:30-1:20). The herd was started with a rangeland base and introduced Boer genetics. Over time the herd has become more 'Boer like' in appearance with improved traits for meat production and quality. Ian estimates that the herd is 80-90% Boer goat now. Some of the goats are sold to Malaysia as breeding stock while the majority of the females and young wethers go into the meat trade.

The goats eat pasture only. The pasture base includes a mixture of native and improved pasture, lucerne and clover. Does are supplemented with hay, grain and pellets if required, depending on the season. Maiden does may be joined at seven months but this depends on

the season and whether they are considered to be big enough. Joining in October has been a problem due to seasonal anoestrous.

The maiden does to be joined at seven months are selected based on a close inspection in the yards. Only does that are deemed big enough will be joined at seven months, others will wait until the next joining and does that are not doing suitably well will be culled and reared with the male kids to be sold for meat. Approximately 20% of maiden does will be culled. The does are not weighed. Maiden does are run as a separate mob and a higher number of bucks is used at joining at seven months and generally this occurs in a smaller area to improve conception rates. The pregnancy rate in maidens is generally 80-86%, with a weaning rate of approximately 160%

Predation is such a significant issue at certain times of the year that it makes kidding at those times not feasible. Artificial insemination is used regularly, using introduced semen to improve genetic diversity, while at other times semen is from Malleevale's own bucks. Ian believes that twinning is the optimal kidding rate although he and Alison do not select against does that produce more kids or singles, rather, selection is based on overall performance. The buck effect is not generally used as the bucks are not housed far enough away. Does are boxed for joining and generally 70% will conceive on their first cycle. Pregnancy testing is used most years.

Ian places great emphasis on the importance of measuring and recording productivity so that superior animals can be selected over time. How an animal looks does not necessarily correlate with how it performs. Ian reports a pregnancy rate of 90-94% and a kidding rate of 250-280% with a weaning percentage of 100-150% in mature does.

In recent years some does have been shedded for kidding. The dramatic increase in kid survival has easily justified the increase in cost in infrastructure and management. The first 5-7 days of life are crucial for kid survival and shedding for approximately one week after kidding has helped survival significantly. Does are brought into the shed when they are about one week from kidding. Does that have conceived via AI are the obvious first choice here because their due dates can be accurately predicted – for other goats, the ability to predict imminent kidding is 70-80%.

Currently Malleevale only has shedding capacity for 70-100 does at any one time. In the shed the does are kept in individual pens on dirt as straw bedding was found to get too wet. In order to maximise the use of the shed Ian is looking to join the does in smaller groups to create a staggered kidding, so that more animals can kid in the shed. This will increase the time spent managing the goats but Ian thinks this is justifiable given the improvements in survivability seen so far. With improved survivability in kids Ian believes that he can run 600 does and achieve the same production outcomes as 1,000 does.

Last year, only maiden does were shedded and they had a kidding percentage of 190% and a weaning percentage of 160-170%. This is 10% above what would normally be expected under paddock rearing conditions for maiden does. Ian anticipates that shedding could increase kid survival by 100% in mature does. As mature does have more twins and triplets (therefore kids are smaller) the impact of shedding is likely to be more significant. Ian believes that it is not just the shedding, but also the increased labour to watch the does at kidding and ensure kids get a drink soon after they are born, that makes the difference.

Goats are vaccinated for pulpy kidney and worm burdens are monitored through faecal egg testing and a strategic drench before kidding. There has been no increase in disease amongst the shedded goats. The herd as a whole has shown some evidence of deficiencies in recent years including thiamine. Ian thinks that this occurs when the goats are on a diet of

pure lucerne. They have found that the goats respond well if a lick is provided at times when they have increased access to pure lucerne.

4.4.6 Key points

The case studies identified a number of strategies that producers have found to be successful in their enterprise, including the following:

- Building exclusion fences can be very effective at reducing kid losses from wild pigs and wild dogs, as well as reducing the grazing pressure caused by kangaroos. Maremma dogs can also be very successful at reducing kid losses due to predation.
- Monitoring male (buck) activity in the herd around the second cycle can be an effective way or identifying those does that are cycling again and are therefore not pregnant.
- The buck effect can be useful to bring does into cycle after introduction to the herd. This can assist in creating a tight kidding and makes it much easier to provide targeted supplementation in late pregnancy and lactation.
- In tough seasons where pasture is limiting it can be more cost-effective to wean kids at a younger age than to supplement does enough to ensure adequate milk supply for kid growth.
- Creep feeding kids can help kids transition form milk fed to weaned.
- Supplementation during the last 6 weeks of pregnancy and then continuing into lactation for 6 weeks is an economically-sound feeding method.
- Accelerated joining can be an effective way to grow the number of goats in a herd quickly.
- Kidding in winter in an accelerated breeding program can be problematic in cold climates. It can significantly impact on kid survivability.
- Some report that joining a maiden doe at seven months can limit her lifetime productivity by inhibiting her growth and her ability to produce heavy kids.
- Predation at certain times of the year may make kidding untenable, and this is an important consideration for accelerated breeding program where there is less flexibility in the kidding time. Shedding can be used however to overcome this risk.
- The provision of proper and sufficient supplementation is essential when using accelerated breeding.
- Inadequate nutrition in late gestation can result in significant kid loss. Supplementation is most beneficial if provided before the does are allowed to slip in condition significantly.

5 Discussion

5.1 **Project objectives**

5.1.1 Literature review completed on advanced reproductive systems for small stock, focusing on learnings for the goat industry

The literature review has been completed and is included as an attachment to this report. A summary of the findings have been included in Section 4.1. There is extensive literature in regard to advanced sheep reproductive programs as well as a number of papers that cover small ruminants (sheep and goats) and others that cover goats alone. There is very little literature on deer reproductive programs.

The challenge of interpreting the literature review is considering what is possible and what is realistic and economically viable and appropriate for the health and welfare of the livestock.

In addition, there is marked variation within the Australian goat meat industry with the use of different goat breeds as well as climate/environment and the way individual businesses are managed. Much of the goat-specific research has been carried out on a single breed of goat in a unique environment in a single overseas country, and care must be taken extrapolating that information to Australian conditions with breeds such as Rangeland and Boer and their crosses that are largely used here.

5.1.2 Review of existing extension materials/programs for suitability to be adapted to goats

All of the current goat extension material has been reviewed including modules, fact sheets, webinars and best practice videos. The key extension programs for 'Making More from Sheep' and 'Lifetime Ewe Management' were also reviewed. A summary of the findings from the review of the extension material is included in Section 4.2.

There is a large amount of specific information available on goat reproduction. It could be improved by combining all the materials into a single extension package and presenting it in a more contemporary format. Tables, pictures and key point highlights could be used to break up the text and make it more engaging.

There is also considerable generic pasture information elsewhere on the MLA website that is relevant to most livestock producers especially those in the southern states.

5.1.3 Publication of 6-10 producer case studies focused on advanced reproductive systems

Six case studies were produced (see below). Case study subjects were selected from among those who responded to the online survey or were otherwise referred to the project. The subjects of the case studies were contacted several times to gather the information and were asked to review a draft of the case study for accuracy before it was finalised. Some of the cases are about advanced breeding programs while others include the successful use of reproductive tools.

5.1.4 Final report delivered to and approved by MLA.

This final report has been delivered to MLA.

5.2 **Findings from the consultations**

5.2.1 General findings

Although the response from producers to the survey was less enthusiastic than hoped, respondents did provide good coverage of production systems across a variety of locations (as shown in Figure 1 above). Some producers were primarily involved in the production of goat meat breeding stock while the majority interviewed produced goats for meat domestically and for export.

The relatively poor response to the survey and call for participation did not compromise the final outcome of the project. Whilst additional responses would have been welcome, the team was confident that all of the important issues in respect to reproductive management were raised during the interviews and in the survey.

The challenging environmental conditions create a significant resistance to risk-taking and a reluctance to consider any sort of expansion to current business models and reproductive

plans. Nutrition is one of the largest limitations for many goat farmers. While a significant number of producers have relied upon goats eating browse and grazing alone without supplementation, current conditions have made this a challenge if normal stocking rate are to be maintained. From those that were spoken to, some had decreased stocking numbers. The cost of supplementary feed is difficult to manage economically for some producers.

A valuable reference point for the current study is the survey of Nogueira et al (2016) of 31 goat meat production systems in New South Wales and Queensland, covering the period 2012-13. The properties were specifically selected, not randomly chosen. The mean property size was 18,296 hectares and the average herd size was 5,161 head. Seventeen producers were from the pastoral zone and 14 from the high rainfall zone. The pastoral properties tended to be larger and mostly involved commercial goat producers and opportunistic harvesting. The properties in the pastoral zone accounted for 99% of the total land in the survey and 97% of the goat herd. The goats in the high rainfall area made up only 3% of the herd in this survey, and these producers mostly specialised in seed stock breeding.

In the current study, respondents were drawn from six states. The geographic distribution of respondents is somewhat different to that of Nogueira et al (2016) and this is likely to account for some differences in the findings between the two reports. In addition, care is needed to compare the findings from the two projects because the specific questioning details may have differed. However, overall the data is useful to include here to strengthen the findings of this review.

The main reasons for running goats identified in Nogueira's study were to target international markets (81%) or domestic markets (58%), and weed control (29%). In this current study, there was greater focus on domestic markets (69%), with 5% targeting live export and 18% meat export. The most important market sectors for producers in Nogueira's study were domestic (81%), live export (68%) and carcase export (61%).

Forty-eight percent of producers in the Nogueira study reported that they kept some reproductive performance records. This practice was not specifically evaluated in the current study but the majority of producers provided kidding percentages and details of joining time and joining age of maidens, which would suggest that at least 88% of producers in this study kept records of some sort.

Eighty-nine percent of producers reported that they drenched their goats at least some of the time in this study compared to 52% in Nogueira's. Interestingly, though, in the Nogueira study only 19% considered worms not to be a problem, leaving 29% that considered worms to be an issue but did not drench. As expected, 100% of producers in the high rainfall zone, but only 29% in the pastoral zone, reported worms to be a problem.

Vaccination was used by 52% of producers in Nogueira's study and 61% of producers in this study. Eighty-eight percent of those using vaccines in Nogueira's study were from the high rainfall zone. Thirty-five percent of producers reported body condition scoring their goats – usually just as 'good' or 'bad' – compared with 51% of producers in this study.

Nogueira et al found only 2/31 producers used KIDPLAN as part of their selection criteria for choosing bucks.

5.2.2 Reproductive management

A review of the 63 producer responses for this study shows a clear trend for reproductive management to involve seasonal (autumn) joining, for a set period, then weaning 3-6 months after kidding. The majority of producers did not join maiden does until their second

year of production. Those that did join maidens earlier tended to have non-weaning enterprises and thus the matings were opportunistic. There was a mixed appetite to improve reproductive capacity in goat meat enterprises, mostly due to either a lack of time (not the primary enterprise) or lack of feed (drought).

Nogueira et al (2016) found that most producers (87%) identified a natural breeding season from December to May with a non-breeding season from June until December. Only the stud breeders 45% (14/31) had a controlled breeding season. In this study approximately 87% of producers had controlled breeding enterprises.

The mean age of first joining for maidens was 8.5 months in the pastoral zone and 15.5 months in the high rainfall zone, although only 8/17 producers from the pastoral area provided an answer to this question. In this study 56% of producers joined maiden does at 13-18 months and only two at seven months.

Sixty-one percent of producers in Nogueira's study weaned their goats, compared to 86% in this study, plus another 5% that weaned but not until after 31 weeks. Nogueira et al found an average weaning age in pastoral areas of 4.5 months and for high rainfall areas 3.2 months, with both groups targeting the same weaning weight of 25 kilograms. The average weaning age for respondents in this study (where details were provided) was 3.5 months.

Ten percent of producers in Nogueira's study had ultrasound pregnancy testing performed. This study found a similar proportion (11%, but method not specified).

In the pastoral zone, kidding percentage was available for only one of Nogueira's properties (60%), while in the high rainfall zone the average over the 14 properties was 94% (and up to 190% in a good season).

Culling criteria for does were similar between the two studies and are shown in Table 3.

Table 3: Comparison of culling criteria between Nogueira et al (2016) and the current study (NB: 59 respondents answered this question)

Variable	Nogueira et al 2016 (2)	Current study
Age	58%	59% (35/59)
Productivity	65% failure to deliver kid 39% failure to rear kid	62% (37/59)
Physical characteristics	90% for seed stock producers	68% (40/59)
Health	Mastitis 48%	47% (28/59)
Seasonal variation	N/A	15% (9/59)

Overall, in Nogueira's study, 68% of all producers provided supplementary feeding, including all producers in the high rainfall zone and 7/17 (41%) in the pastoral zone. Supplements were provided to does, kids and bucks by 68%, 61%, and 55% of producers respectively. In this study, 75% of producers provided some supplementation to their does, and hay (64%), grain (34%) and pellets (29%) were the most common supplement types. In Nogueira's study the most common were formulated rations (48%) and grain (26%) (it seems a little unusual that hay was not listed as a supplement in this list).

Only three of the 17 properties in the pastoral area of Nogueira's study provided details on mortalities, and for those enterprises the average kid loss (1-3 months) was 33.3 %. All 14 properties in the high rainfall zone had kid mortality data, which averaged 11%. The reported reasons for mortalities included starvation, dehydration, predators and old age.

The kid mortality rate varied considerably among the 63% of respondents who provided data to this study. Kid loss was a significant issue for many producers, while others had almost no losses between kidding and weaning. The average kid mortality rate from birth to weaning was 27%.

On the properties that had low kid mortality some management features were:

- Shedding for kidding;
- Maremma dogs and close surveillance to manage the predator risk;
- Exclusion fences;
- The ability/ willingness to supplementary feed kids form multiple births where the doe is unable to supply sufficient milk; and
- Some irrigated country, to allow feed such as lucerne to be grown year-round.

Nogueira et al (2016) do not report the use of advanced breeding programs such as artificial insemination or embryo transfer, nor any hormone treatments. In the current study, a number of Boer goat stud breeders as well as commercial goat meat producers in temperate and pastoral locations were interviewed. The stud breeders were much more likely to have used one of these technologies, as the relatively high costs associated with these techniques could be more economically justified due to the high value of the stock. These techniques would be difficult to justify economically on a purely commercial goat meat production enterprise or a harvest-only system.

Eighty-four percent of producers in Nogueira's study were willing to consider management change to improve profitability. Focusing on target markets and improving target management were considered the best ways to achieve this (48% and 45% respectively). Thirty-five percent were interested in improving profitability by using better bucks, and 16% in reducing death rate, improving marking percentage and increasing weight at turn-off.

Mixed messages were received from industry experts interviewed for this study. Those directly involved with goat meat production believed that, while the price for goat meat is at its current level, it would be uneconomical to consider high input breeding programs on most commercial enterprises. Others, however, suggested that the goat meat industry needs to look more closely at its dairy counterparts and to utilise some of the reproductive programs that they have implemented. It would be unwise however to extrapolate reproductive management from dairy to meat enterprises without due consideration of the differences between the two industries. The breeds used are different and the nutritional and reproductive requirements differ considerably as do the production and economic outcomes. Practically, as dairy goats are milked twice daily, there are substantially increased opportunities to observe and perform reproductive procedures (such as AI) compared with meat enterprises.

As the majority of producers are under considerable pressure from the dry conditions, it seems unlikely and not feasible financially for most meat producers to radically expand their breeding programs in the short term. Others have no interest in advanced breeding programs because their goat enterprise is only part of a business portfolio and they have no more resources to dedicate to this area.

Only two enterprises using accelerated breeding were both identified and agreeable to be contacted as part of this project. Big Ampi, (Section 4.4.4) has a large number of does (more than 2,000) and has been kidding three times in two years for two years, while Sunset Hill Boer Goats runs 1-200 does and has been kidding three times in two years for five years. These two case studies provide a good introduction into what can be done with this approach and the challenges it presents. In summary, the advantages, challenges and key success factors that they have encountered include:

Advantages:

- Continuity of meat supply
- Ability to sell stock throughout the year (more regular income)
- Ability to increase herd size quickly

Challenges:

- High cost and labour requirements of hormones, and some potential for market access limitations
- Photoperiod effect
- Impact of predators
- Cost of mustering in extensive systems
- Reduced buck effect in extensive enterprises
- Variation in feed availability, drought
- Impact on the productive life of the doe
- Cost effective supplementary feeding during times of insufficient pasture, drought

Key success factors:

- Good nutrition all year round
- Right breed of animal – which breeds are more suited to 'all year' joining?
- Good pregnancy rates across all seasons
- Tight kidding period, with a majority of does joined on their first cycle
    - Avoids small kids that often struggle to thrive
    - Allows for timely weaning and recuperation of does before re-joining
- Protection of kids from the cold when kidding in the winter months
- Precision of timing with nutrition and health management
- Good infrastructure and careful organisation.

5.3 Proposed approach to extension and research for improved reproductive performance

5.3.1 Overview

Variation in climate, enterprise size, management styles and producer knowledge make it impossible to identify a 'one size fits all' advanced breeding program for Australia goat meat producers. In addition, the industry experience of producers varies considerably, from those who have been goat farming for 20 years and are actively involved in industry development and improved production systems, to those who have little previous goat experience and are learning as they go along. A significant proportion of producers grow goats as just one of a number of enterprises and are not prepared to spend more management time to improve the reproductive performance of their goats.

The diversity of climate within Australia alone poses a significant obstacle to developing a single strategy to improve reproductive capacity and capability of does. The variation in climate and more specifically rainfall drives the variation in property size, stocking rate, pasture availability, fencing and the capability to perform management procedures necessary to improve reproductive capacity of does. While some goat meat is produced in systems that rely mostly on opportunistic harvest, with minimal managerial intervention, others are much more intensive, including shedding of does at kidding. Furthermore, livestock producers are facing increasing challenges with climate change and extreme variation in seasonal rainfall (McKeon 2009). Responses to this present study were certainly affected by extreme weather conditions.

The literature review and consultation process have been effective in identifying the current status of the goat meat industry as well as potential strategies for improving production quality and consistency for the future. It is clear that there are opportunities for improvement in doe reproductive management within the Australian goat meat industry. For many enterprises this would simply mean 'doing the basic things better': for example, joining for and weaning at defined times, monitoring doe weight and providing supplementation as required, health management (vaccinating and drenching), systematic measurement and recording of reproductive parameters and selection / culling based on solid criteria. Development of extension material and/or an online course would be beneficial to assist the uptake of these practices.

Other, more advanced reproductive practices and technologies may also have a place. However, these are not without risk. These risks include:

- Animal health and welfare risks. Programs that could significantly advance breeding have the potential to negatively impact on the welfare of the animals – for example, by increasing the number of kids born beyond the capacity of the does (and the owner) to keep them alive (the issue of kid loss is no doubt a significant issue for the goat meat industry and is currently the subject of another project funded by MLA).
- Financial risks. Improving breeding outcomes for livestock often requires additional financial outlay, especially advanced breeding programs such as AI or ET. These outlays may be lost in a poor season, or protected only through further investment in nutritional supplementation.
- Environmental and biosecurity risks. Increasing the number of animals carried may place significant pressure on the property with increased potential for over grazing, erosion, and the introduction of weeds through supplementary feeding.
- Market and industry reputational risks. Intensive approaches to reproduction may not be consistent with consumer ideas of 'clean, green and ethical' production and specifically, 'hormones' are not popular with consumers. International importing country requirements of goat meat and live goats must also be considered.

The current study indicated that a significant proportion of goat meat producers are not able or are unwilling to alter their current approach to implement new programs. This was attributable to a variety of reasons but the most immediate concern was dealing with the drought. Producers were unsure how they were going to survive the season, without considering anything new. Those who were interested in trying to advance their breeding programs need to understand the risks and how they can manage them. Interviews completed as part of this project revealed that there are some producers who have adopted production systems where unreasonable mortalities occur repeatedly. Often, it seems, this is more a product of 'not knowing' than deliberately 'not doing'.

It is important therefore that the development of reproductive improvement programs is supported by extension material that includes the relevant health, welfare and other implications of more intensive systems. An additional component to strengthening the goat industry is to improve the resilience, flexibility and adaptability of production systems. Extension in these areas will assist producers to manage their enterprises to better cope with the variation in climate, feed costs, meat prices and the balance of competing interests.

As Jolly (2013) noted, '*The current gross margins for goat enterprises may preclude cost-effective supplementation to improve Boer goat progeny survival and it may be that introduction and/or selection of more environmentally resilient genetics are required to underpin the growth of Australian intensive goat meat production'*.

5.3.2 Extension material generally

MLA has a substantial body of extension material, in a number of different formats, on the 'Give Goats a Go' web page. The information is currently divided up according to the format: videos, webinars, factsheets and modules. As some concepts are covered in one form but not others, information could easily be missed by a visitor to the website. For example, factsheet 7 has some excellent information on measuring and recording in an goatmeat enterprise, but this information is not included in any of the other material.

'Give Goats a Go' could be streamlined and made more user-friendly by organising information by topic – for example, nutrition, health, reproduction and so on. Each of these topics would include all relevant resources in the various formats. It would incorporate the most current and relevant information from the various goat resources as well as from sheep and cattle where relevant. The reader should be able to navigate around extension material online more simply, using simple (click) links rather than needing to open new modules and other extension media forms. There is a danger with this expansive network of information that the vital fundamental principles will be missed.

The 'Going into Goats' (GIG) material includes extensive information on different diseases (M6.2 and 6.11). However, it is organised in a way that presumes prior understanding (i.e. by disease). While the information is a handy reference, it would be more valuable if it were organised in a way that facilitated problem-solving – for example, by answering questions such as: 'Is there something wrong with my goats? When should I seek help? What should I do to minimise health problems? Goat selection and breeding (M5) could similarly be written from a problem-solving perspective.

The extension material from reputable sources for goats, sheep and deer (within Australia) has been reviewed, and is summarised in Appendix 1. International extension material that was identified during the literature review is included in the relevant sections of this report.

A summary of the key reproductive features (as outlined by MLA in the Project outline) is included in a table below (Appendix 3). This includes literature review findings, current extension material, the consultation findings and proposed extension material and research.

There are some specific gaps in the material on reproduction, and these are detailed in the table in Appendix 4.

5.3.3 Extension material and new research on reproduction

It is recommended that the goat meat industry take a three-tiered approach to meat goat reproductive management extension and research. The three tiers are:

1. Foundational reproductive management practices;
2. Tools to improve reproductive performance; and
3. Advanced breeding programs.

These three tiers represent a progression from foundational, minimum requirements for good reproductive performance through to interventions of greater complexity and risk. They are further described in general terms below, while specific recommendations for changes to extension material and possible new areas of research are detailed in Appendix 4 and Section 6.

5.3.3.1 Foundational reproductive management practices

Foundational reproductive management practices are elements of management that must be in place before considering more advanced approaches. For example, there is high risk in

attempting an accelerated breeding program when basics of good doe nutrition have not been implemented.

There is much productive gain to be made by improving the following areas across the goat meat industry:

- Health and welfare;
- Nutrition;
- Management of joining, kidding and weaning;
- Measuring and recording; and
- Reproductive problem solving.

There is already much information available in the extension material about recommended joining age for maidens, age of weaning etc and this could be incorporated into a 'foundational practices' framework.

Health and welfare

It is the producer's responsibility to ensure the good health and welfare of the animals in their care. Ill-health can very rapidly affect the welfare of livestock as well having a significant impact on productivity, so it is essential to maintain good doe health to optimise reproductive outcomes. Doe health and welfare include both preventative and response management. They require careful selection of animals based on their suitability for that climate and appropriateness to be joined and re-joined.

The areas of doe health and welfare that need to be considered include:

Preventative measures for animal health: Prevention of ill-health begins with the selection of animal suited to the purpose and location in which they are to be farmed. There have been various reports in the literature and from consultations suggesting that some breeds have failed to thrive when their environment has been changed. This includes introducing animals to a new area with a different climate (from hot to cold, or vice-versa).

It is important, when the reproductive demands on a doe are increased (for example, by increasing breeding frequency or litter size), to ensure that the doe has the capacity to cope with this change. This includes assessing does prior to joining for their udder health, condition of feet, number of teeth and any other physical and health traits. Does should be culled rather than joined if they are unlikely to be able to breed successfully or if doing so is likely to compromise their health.

Producers should adopt the vaccination program most appropriate to their herd and environment, identified through consultation with a local goat specialist. Producers need to be aware of the diseases most likely to affect their goats so they can perform informed surveillance to detect abnormalities early and then respond quickly to limit spread and further impacts on herd health and welfare.

Biosecurity: Livestock enterprises benefit from a biosecurity plan (which also forms part of the Livestock Production Assurance (LPA) program) to minimise the likelihood of introducing disease onto the property and providing containment for any disease that does enter a herd. Animals should be monitored sufficiently so that any compromise to health and welfare is identified without delay and an appropriate response initiated in a timely manner. This includes having adequate facilities to remove sick or injured animals from the herd so their condition can be properly assessed and the appropriate treatment provided. A veterinary practitioner may need to be engaged to assist with this process.

Managing stress: Producers have an interest in reducing the incidence of stress in their stock, as stress is associated with compromised health, welfare and productivity. Stress can be brought about by transport, sudden change of diet or insufficient nutrition or water, close proximity of predators, extreme weather events, mustering, handling and husbandry activities. These stressors can be minimised by good planning, the adoption of low-stress handling techniques and careful monitoring of food, water, health and welfare.

The impact of stress on productivity of livestock can be profound. The reaction of an animal to stress is in part a survival reaction to delay the transfer of genetic material (failing to breed) until it is a more favourable time.

Preparing for extreme weather events and other unforeseen disasters: Producers need to plan for events that may impact on the health and welfare of their stock, including extreme weather events, fire, floods?, drought and disease outbreaks. Farmed animals rely totally on their carers to protect them from adversity. With forward planning, producers can develop strategies and response plans to minimise the impact on the health and welfare of their stock of an extreme weather event or other disaster.

Observing acceptable animal welfare standards: The Australian Industry Welfare Standards and Guidelines for Goats (S&G) was developed by Animal Health Australia (AHA) and the Goat Industry Council of Australia (GICA). The document is intended to ensure consistency in managing goat welfare across Australia, including extensive and intensively-managed goats. To date, the S&G remain voluntary. This is unfortunate, as they provide a consistent and defensible framework for welfare regulation. It would be desirable for the S&G to be formally adopted. Regardless, goat producers should be aware of the S&G, as they are industry-set, minimum standards of care for farmed goats within Australia.

<u>Nutrition, body weight and body condition score</u>

There is extensive information and scientific research demonstrating the negative impact of undernutrition on various aspect of the reproductive cycle, as well as the lifetime productivity of offspring, although mainly in sheep. In the northern states of Australia, in particular, nutrition is thought to be the main driver for sexual activity. High standards of nutrition of does should be a priority for all enterprises.

Several producers consulted for this project highlighted nutrition as a topic that they could learn more about, and many acknowledged that nutrition had a major impact on their profitability.

One industry professional advised that the key time to feed does is in late pregnancy as this is when the best return for investment is achieved. They advised that rangeland goats in late pregnancy on inadequate nutrition will abort. There have been various studies in sheep and goats showing the benefits of supplementing in late pregnancy. With quality nutrition and management practices does should successfully complete gestation resulting in the birth of a viable kid/s, with potential milk production maximised and the incidence of health disorders (including mastitis) minimised.

Appropriate quality and quantity of nutrition is essential to ensure that the health and welfare of goats is maintained and that productivity is maximised. The key to nutritional success is being able to link herd requirements to pasture growth, to optimise the use of the pasture and minimise the amount of supplementation required. This requires producers to be aware of how the nutritional requirements of their goats change through the reproductive cycle. Producers also need to be able to assess the amount of pasture and browse available. Linking doe nutritional needs with available pasture is more challenging in an accelerated breeding program of three kiddings in two years or five in three years because of the

necessity to kid at eight-month intervals. In effect, kidding will occur at three different times of the year over two years, and then that cycle repeats.

The relationship between body condition score and body weight of the doe/ewe has been shown to directly impact several events in the reproductive cycle. Measuring the condition score of livestock is a good way to measure how they are managing with their nutritional supply and productive demands. There has been extensive research into the effect of the condition score and body weight of females on their reproductive success.

Managing joining, kidding and weaning

Joining for a limited time is a very good way of managing reproduction. The ideal joining period will vary depending on the enterprise (extensive or intensive). Generally, a shorter joining is preferred – for example, 5-8 weeks. This joining period dictates the rest of the productive cycle on that property for the year.

There are benefits for productivity, health and welfare by managing the joining period to the shortest time feasible. A more spread-out joining naturally results in a more drawn-out kidding, which means does and newborn kids need to be monitored for longer, increasing the requirement for management input. Marking and weaning is also more difficult when the age of the kids varies widely. Some will be older or bigger than is ideal for marking or weaning, while others will be too small. It also makes it difficult to provide targeted supplementary feeding either prior to ovulation or in the last few weeks of pregnancy as not all does will be at the same stage of pregnancy or at the same point in oestrus at the same time. In terms of marketing, it is also much easier to have kids of a similar age (and weight) to draft out as a saleable group.

Producers must also select a time for kidding when the weather is most favourable for doe and kid survival. Several producers advised that kidding outdoors is not an option in some areas at certain times of the year, because kids will not survive as conditions are too cold and/or wet. This limitation can be overcome by providing shedding for kidding.

A controlled joining period is most likely to be successful when the other contributing factors to reproductive success are also managed, that is, good buck and doe health. Does should be in good body condition and an appropriate buck: doe ratio used (based on the age of bucks and size of paddock). If the buck effect is used then the buck number may need to be increased to allow for the large number of does that will cycle in the first few days.
As seen from results of the producer consultations for this project, there is wide variation in the age of weaning across the industry, and a significant proportion of producers join year-round and do not wean.

Measuring and recording

A vital step in improving reproductive capability of any livestock production systems is measuring and recording key reproductive parameters. In the absence of measurements, it is not possible to know what is being achieved and whether outcomes are appropriate, improving or declining.

Reproductive problem solving

Detailed measurement and recording allow a producer to identify when their enterprise is underperforming. Generally speaking, goats are very fertile and an annual kidding rate of more than 100% is a reasonable expectation in most systems, while a kidding rate less than this may suggest that there is a problem with the fertility of the does and/or bucks.

5.3.3.2 Tools to improve reproductive performance

The second tier in the reproductive management structure comprises a series of tools that can be relatively easily incorporated into the reproductive program once the 'essentials' (good health, welfare, nutrition and so on) are in place. These tools include:

- Genetics;
- Hormonal intervention;
- Light therapy;
- Targeted nutritional flushing;
- The buck effect;
- Pregnancy testing (Plus singles + multiples) ; and
- Steps to reduce kid mortality.

Genetics

Genetic approaches are a powerful means of improving livestock productivity. They include:

- Crossbreeding / hybrid vigour (i.e. between-breed mating);
- Within-breed mating, using sires from outside the herd, which may involve selection of sires with favourable reproductive estimated breeding values (EBVs) using KIDPLAN; and
- Selection within the herd.

A number of producers who contributed to this project believe that there is insufficient genetic diversity available within meat goat breeds in Australia and that this is limiting their productivity growth.

KIDPLAN has three EBVs concerned directly with fertility:

- Number of kids born (NKB);
- Number of kids weaned (NKW); and
- Scrotal circumference (yearling and hogget measurements).

Bucks with a higher positive EBV for NKB or NKW can be expected to sire daughters that will give birth to or wean (respectively) a higher percentage of kids. Bucks with a higher positive EBV for scrotal circumference can be expected to produce sons with higher scrotal circumference and therefore fertility.

In addition to these EBVs are several concerned with live weight traits, including maternal weaning weight (an estimate of the doe's potential for milk production and ability to provide a better maternal environment), birth weight and weaning weight.

An industry expert advised that, currently, there are insufficient producers contributing to the genetic information in KIDPLAN and this significantly limits its effectiveness as a tool for genetic gain. Producer consultations indicated mixed views on the value of KIDPLAN and significant variation in participation (although this is an observation from the telephone interviews, not the online survey, which did not include a specific question on KIDPLAN). In the study of Nogueira et al study (2016) of NSW and Queensland producers, only 2 of 31 respondents were using KIDPLAN. Those who used KIDPLAN were keen to see its use progress while some other producers were unfamiliar with its function.

Discussions with producers for this project indicated, not surprisingly, that some are actively using genetic selection while others have little focus on this area. A small number were selecting for certain characteristics or a 'new breed type' without appearing to fully understand the importance of genetic diversity and the possibility of negative implications from selection within a closed group. Some others relied on 'natural selection' or 'survival of the fittest' and this is not an acceptable way to select for improvement in any farmed

livestock population. Discussion of these points should be included in any extension materials.

Hormonal intervention

Hormonal intervention can be used to synchronise oestrus in does as well as inducing does that are in seasonal or lactation anoestrus to cycle. Synchronisation is most commonly used in production systems that are using AI and/or ET. Numerous protocols are described in the literature, varying in the type of hormone used, the dose and duration of use. The most commonly used hormones are progesterone and prostaglandin. These drugs are either only available on prescription from a veterinarian or require special handling.

There is some debate about the use of hormones in livestock production systems. The industry also needs to consider the use of chemicals in terms of its continued market access. It is likely that the use of these products in livestock production will be under increasing scrutiny over time and their use may limit the access of those products into certain markets. It is important to consider this before developing complex and expensive programs based on the use of products that may in the future be banned or restrict market access.

Light therapy

Although light therapy is unlikely to be economically justifiable in a commercial herd, it is an option to consider for goat herds that are significantly impacted by seasonal anoestrus. The effectiveness of light therapy will vary depending on the breed of goat, the season and their location relative to the equator. This manipulation of photoperiod is sometimes used in the dairy sector along with the use of melatonin. The use of melatonin can increase the reproductive function of both males and females, and lengthen the breeding season. The cost of melatonin is limiting even in a dairy enterprise.

Targeted nutritional flushing

Targeted nutritional flushing (‘adaptive nutrition’ or ‘focus feeding’) involves providing extra nutrition to goats at particular times in their reproductive cycle to effect particular outcomes. It can be costly, especially when supplementary feed costs are high, and so should be used with careful consideration of the benefit/cost.

It is not desirable, though, to improve ovulation rate in all enterprises. Where producers are recording kidding rates of 200% or more there may be no economic advantage in increasing litter size to 3, 4 or 5 kids. Many of the producers interviewed for this project believed that any kids additional to twins represented were in fact a disadvantage to successful reproduction. As the litter gets larger the kids become smaller and potentially less viable. Does are anatomically designed to feed no more than two kids and some find that does cannot manage raising more than two effectively. Without the ability to provide special care to extra kids beyond twins, improving fertility is not desirable in these herds.

In addition, if a producer is suffering large kid losses in their herd, then there is a welfare imperative not to consider producing more kids without first working to improve kid survivability (as covered in Section 1).

The buck effect

The buck effect is an effective tool at synchronising oestrus in does and fits into the ‘clean green and ethical’ model of livestock production. It is effective in most, but not all, breeds of goats. The bucks need to have been sited more than 1km away from the does for at least one month before introduction to be effective. Synchronising offers the management

advantages of better targeted supplementation in late pregnancy and lactation, planning for kidding supervision, and tight weaning where the majority of the animals are a similar age.

Pregnancy testing

There are various ways to diagnose pregnancy in goats. Ultrasonography is the most commonly used and is a reliable tool for diagnosing pregnancy and determining the number of foetuses in a pregnancy. Pregnancy testing allows the identification of empty does so they can be culled or re-joined according to the reproductive plan. Pregnant does can be drafted into a separate mob so they can be provided with the appropriate care. Quantifying the number of foetuses also allows for improved precision in nutritional supplementation in late pregnancy.

Without the ability to identify animals that are pregnant, it is possible that many empty animals will be carried for a whole season. The costs of keeping a pregnant and non-pregnant animal are much the same including the provision of proper and sufficient feed, health programs (vaccination and drenching) and management time. It is particularly important not to have ‘passengers’ in times of drought where there is limited feed and the increased cost of supplementation. Profitability can be significantly impacted by running dry stock in intensively or semi-managed goat meat enterprises.

In situations where the testing accuracy is poor it can have a significantly negative impact on the welfare of the goats and on the overall enterprise productivity. When producers use pregnancy diagnosis to make significant management decisions based on the pregnancy status and number of foetuses, accuracy is integral. Animals falsely described and treated as ‘empty’ may be culled or provided inadequate nutrition and other care, resulting in poor supervision at kidding and low body condition score making them susceptible to metabolic disease, poor milk production and poor kid survivability. Some producers also draft and manage does according to the number of foetuses. A doe with a single foetus that is fed as if she was carrying two or three kids is more likely to suffer dystocia. Alternatively, does carrying triplets fed nutrition suitable for a single foetus may lose weight and have reduced survivability of kids at birth.

Reducing kid mortality

Kid mortality is recognised as an important and significant factor limiting production on some properties, while for others it is of no particular consequence. Improving survivability of kids post-birth is a good first step to improving reproductive outcomes. Enterprises that suffer significant kid losses after birth are not recommended to adopt programs to improve kidding percentage until the mortality issues are rectified.

As kid mortality is the specific topic of another project currently being competed on behalf of MLA, the details off this issue have been left to be explored by that project. However, the benefit of shedding does around kidding was raised by several respondents to this review.

5.3.3.3 Advanced breeding programs

The third tier of reproductive management comprises advanced breeding programs. These are only suitable for producers who have the fundamental (tier 1) practices in place and have also made appropriate use of the tools in tier 2. It is neither economically sensible nor ethically appropriate to implement an advanced breeding program in a herd that does not have the necessary managerial, financial and animal health and welfare support. In addition, enterprises need to be informed, resilient and adaptable to deal with significant seasonal variation and a changing climate in the longer term.

Introducing any new reproductive management strategy requires detailed and comprehensive planning to ensure that the health and welfare of the animals is maintained and not compromised by the changes. All of the advanced breeding programs require does to be pushed to their reproductive limits and therefore the potential for compromise to their health and welfare is increased. Meticulous attention to detail in monitoring and recording is required to ensure subtle changes in wellbeing are detected. Producers also require the flexibility and capacity to respond to any adverse developments in a timely manner, to ensure the welfare of the goats is maintained.

The two main advanced breeding technologies are:

- Accelerated breeding; and
- Assisted reproductive technologies (ART).

Accelerated breeding

The main forms of accelerated breeding system are joining twice in one year, joining three times in two years and joining five times in three years.

In general, accelerated breeding systems require:

- Does to breed at all times of the year;
- The ability to meet peak nutritional requirements at different times of the year; and
- Increased management input to provide sufficient feed, monitoring the body condition of does, and appropriate management of joining, kidding and weaning.

There are many challenges and risks facing producers embarking on accelerated breeding programs. In order to consider accelerated breeding, producers need to be performing at a high standard with the capacity and capability to handle the intensity of such a system. Very tight joining periods must be maintained for success of the program. There is no margin for compromise in nutrition, parasite control, or health management in an accelerated program. The does are performing at their peak and cannot be impacted by other avoidable limitations.

Kidding twice per year is the least complex form of accelerated breeding. At least one of the kiddings can be selected to avoid kidding at times of adverse weather and to optimise feed availability against doe metabolic requirements. Of the 63 producers who completed the survey for this project, none had a sustained and successful system of breeding twice every year.

In systems involving three kiddings in two years, mating occurs every eight months and in five-in-three systems there may be five mating periods across the 12 months of a year for the herd. This means that the time of kidding will vary from year to year. It is very difficult, therefore, to avoid kidding in times of extreme heat, cold or wet. These seasonal extremes could significantly impact on kid mortality. Several producers during discussions commented that weather extremes had contributed to kid mortality in their production systems in the past. These weather extremes can also impact on pregnancy rates. Some producers also reported that predators are such a problem at certain times of the year it is not viable to kid during those periods as the losses will be too great.

Accelerated breeding programs require a more rigid breeding program with less flexibility to vary joining and kidding times to minimise environmental stress and pressures and to optimise the matching of pasture availability and metabolic demand. Breeding successfully

every eight months or five different times over three years is likely to be a challenge on properties where seasons have marked extremes of hot, cold or wet.

Assisted reproductive technologies

Assisted reproductive technologies (ART) include artificial insemination and embryo transfer (*in vitro* and *in vivo*). These technologies allow for improved genetic gain and an ability to overcome the seasonality of breeding in some goats. The use of semen can also reduce the likelihood of introducing disease into a herd compared with introducing live bucks.

Of the 63 producers who completed the survey for this project, six were using AI and ET while four were using AI alone. Some had used these techniques in the past, usually to establish their herds, but no longer saw a need for ART or found it financially justifiable. The main producers that are likely to be interested in these types of procedures are those involved in producing breeding stock for the domestic and international market. This is probably the only situation where this expense could be justified and recouped. The success of these techniques seems to be determined by the preparation of the does as well as the skill of the technician.

Some producers are able to perform their own AI while others rely on technicians and this can be limiting in terms of the cost, especially those remotely located. Does are generally synchronised to make it easier to AI many animals at the same time. This is especially important if a technician is engaged for this function or where fresh semen is used. The effectiveness of any synchronisation program varies with the breed of the does, the time of the year (breeding or non-breeding season), the timing, type and dose of hormone used.

While these techniques provide a unique opportunity to improve the genetics in a herd quite quickly it would be difficult to financially justify in a purely commercial enterprise. An industry expert advised that with the current value of goat meat it would be very difficult to justify such expensive procedures in most enterprises.

6 Conclusions/recommendations

This project has found that, unsurprisingly, there is a wide range of reproductive management systems in use in the Australian goat meat industry. These vary in complexity. There are opportunities to increase productivity through the adoption of more intensive reproductive systems. However, there are limits to the appetite and capacity for these systems, often for sound reasons of benefit/cost balance and because ongoing poor seasonal conditions in many parts of Australia have heightened the understanding of risks associated with high-input systems.

6.1 Extension: general recommendations

MLA makes available a good range of extension material on reproductive management in goats. There are some gaps, however, and there is an opportunity to reorganise the material to provide better guidance to producers and ensure that all vital information is readily available and that moving between resources is easy.

The following general additions or modifications to current extension material are recommended for consideration:

- Make ‘Give Goats a Go’ more user-friendly by organising information by topic – for example, nutrition, health, reproduction and so on. Each of these topics would include all relevant resources in the various modes (videos, webinars, factsheets and

modules) and would be extensively cross-referenced. ‘Making More from Sheep’ would be a good model
- Collate all of the material on a particular topic into a central resource, rather than (in particular) splitting it between ‘modules’ and ‘fact sheets’ (and within modules, between the body of the module and the ‘tools’). The reason why material should be in one place and not another is sometimes not clear, making valuable information sometimes difficult to find. Modules could still be organised in such a way that they can be subdivided into smaller units
- Upgrade the various ‘Going into Goats’ modules and especially 6, ‘Husbandry’, to the format of module 9 (‘Parasite control’), as the format of module 9 is easier to follow than the table-heavy format of module 6
- Develop material that assists producers to understand:
    - How the various reproductive management practices relate to each other and to the overall management of the enterprise
    - The logic of progressing from foundational reproductive management practices to more advanced breeding programs
    - How to evaluate the benefits, costs and risks of decision-making in goat farming including more intensive approaches such as accelerated breeding

6.2 Specific extension and research recommendations

It is suggested that the following three-tier structure could be used as an organising principle for extension, research and progression in reproductive management. A priority (High, Medium or Low) has been assigned to each recommendation based on the consultants’ view on its likely benefit and uptake by goat meat producers.

6.2.1 Foundational reproductive management practices

These are elements of management that must be in place before considering more advanced approaches, namely high standards of health and welfare; nutrition; management of joining, kidding and weaning; measurement and recording; and reproductive problem solving.

6.2.1.1 Health and welfare

<u>Preventative measures for animal health</u>

- Disease prevention information could be divided up as follows:
    - Pre-joining and general doe health: udder health, feet, body condition, nutrition, teeth, parasite control;
    - Pregnancy health: timely doe vaccination to help protect both doe and kid health, abortions, metabolic diseases; and
    - Lactation health: metabolic diseases, mastitis, metritis (uterine infections) **(Medium)**
- Develop a disease incursion decision-making tool:
    - How do I know if I have a problem?
    - What are the signs of disease?
    - When should I get help?
    - Who should I call?
    - What should I do while I am waiting for help? **(Medium)**
- Include a dental ageing chart with photos of teeth at various ages **(Medium)**
- Incorporate all the parasite management material into a single unit and/or link to WormBoss goats, including a problem-solving approach to preventing, treating and managing worms **(High)**

<u>Biosecurity</u>

- Include a link to the Farm Biosecurity website in current material **(Medium)**
- Emphasise the importance of biosecurity across all aspects of livestock production **(Medium)**

Managing stress

- Develop material on impacts of stress and methods to avoid it, as part of the animal health and welfare areas of extension, including:
    - Impacts of stress on reproduction (list from literature review);
    - Causes of stress (transport, sudden change of diet or insufficient nutrition or water, close proximity of predators, extreme weather events, mustering, handling and husbandry activities);
    - Minimising stress; and
    - Greater risk from stress in more intensive systems such as accelerated kidding **(High)**
- Develop more detailed material about low-stress handling (as in FutureBeef), including fear, temperament, moving animals including behaviour, good movement, approach, pressure, mustering into small groups, starting, controlling and the speed of movement (include pictures) **(High)**

Preparing for extreme weather events and other unforeseen disasters

- Highlight the importance of planning and responding to extreme weather events and other unforeseen disasters from a welfare perspective (see next section) **(High)**
- Develop extension material about farming in a changing climate – 'resilient' farming – recommended here because decision-making regarding drought is very much concerned with reproductive management. This material would include:
    - How much supplementation would be needed in times of drought;
    - Making decisions about feeding versus selling stock;
    - Strategies such as electing not to join, joining to minimise multiples and early weaning **(High)**

Observing acceptable animal welfare standards

- Ensure welfare considerations for all management tools, breeding programs and procedures are included in the extension material (for example, selecting kidding time when weather is favourable to kid survival or providing alternative shelter) **(High)**
- Develop a welfare-specific module/unit in future extension material. This might include:
    - Importance of welfare;
    - Producer responsibilities and obligations;
    - Legislation, codes, standards;
    - Signs of poor welfare;
    - Consequence of compromised welfare;
    - Production cost of losses and poor welfare;
    - Potential cost to industry (market access) of poor welfare management **(High)**

6.2.1.2 Nutrition, body weight and body condition score

- Combine all the nutritional material into one comprehensive guide **(High)**
- Enhance extension material on nutrition by including a feed on offer (FOO) pasture +/- browse guide with pictures that assist with the visual assessment of pasture availability in temperate climates, from Lifetime Ewe Management **(Medium)**
- Develop a body condition guide for goats that includes pictures and is also available as an app or ute guide **(High)**

- Emphasise the importance of measuring the condition score of livestock**,** including the reproductive parameters shown to be influenced by body condition score (see literature review) **(High)**
- Develop a reproduction planner for goat meat production systems, including variables such as:
    - Season;
    - Pasture availability;
    - Other key on-farm activities; and
    - Likelihood of extreme weather events such as extreme and prolonged heat and cold (which can dramatically affect kid survival and joining success) **(Medium)**

Research opportunities:

- Validate the maintenance requirements for some key goat breeds and crosses in a variety of climatic conditions, using the recommendations of McGregor (2005) and Jolly (2013) as a basis **(Medium)**
- Validate the proposed feeding curve for pregnant/lactating does of McGregor (2005) **(Medium)**
- Validate the recommended condition scores of does at various steps in reproductive cycle, for different breeds at different locations **(Medium)**
- Evaluate the cost-effectiveness of supplementing does in late in pregnancy in order to boost colostrum production (this could be done in conjunction with a study of shedding to improve kid survival – see below) **(High)**
- Develop or adapt a module/unit on goat farming in a drought, including among other things:
    - Guidance on feeding vs culling
    - Principles of adaptable and resilient farming **(High)**

6.2.1.3 Management of joining, kidding and weaning

- Develop an interactive reproduction planning tool that allows producers to consider different options for:
    - Age of first joining;
    - Age of weaning; and
    - Accelerated breeding programs (see below), based on considering the risk, financial return, nutrition and disease management at their location with their breed of goats **(High)**
- Highlight and emphasise the importance of controlled joining and weaning, including:
    - Better goat health and welfare;
    - Ease of targeted nutritional supplementation;
    - Saving of management time (shorter period of supervision at kidding);
    - Increased opportunity for does to recuperate before re-joining;
    - Better timing of kidding and weaning to match nutrition and weather;
    - Avoidance of unwanted matings, siblings and small maidens;
    - Reduced variation in kid age and size, allowing
        - More successful weaning (fewer small kids);
        - Easier establishment of a line of goats for sale; and
        - Greater ease of mob movement without dealing with newly born kids **(High)**
- Merge and refine the extension material on the management of joining, kidding and weaning. Use a contemporary and interactive format that allows the reader to link to relevant information located in different sections, such as nutritional needs and condition scoring charts. Upgrade content to make clear the foundational practices. **(High)**

- Include more detailed information including the advantages, risks, costs and techniques of:
    - Creep feeding;
    - Shedding;
    - Different weaning times; and
    - Different ages of joining maidens **(High)**

Research opportunities:

- Conduct a study to further clarify the production and financial effects of supplementary feeding does for a week before kidding to boost colostrum production (possibly in conjunction with shedding study – see below) **(Medium)**
- Conduct a study to compare the outcomes of creep feeding / trail feeding kids before weaning, including changes in:
    - Growth rate;
    - Weight at weaning;
    - Post weaning growth; and
    - Post-weaning survival **(High)**

6.2.1.4 Measuring and recording

- Emphasise the value in measuring and recording for:
    - Determining enterprise profitability;
    - Measuring production gain;
    - Identifying poor performers;
    - Early detection of disease;
    - Calculating improvements or otherwise from changes to management such as target feeding; and
    - Easier ongoing assessment of profitability given season changes to aid decision making **(High)**

6.2.1.5 Reproductive problem solving

- Develop a reproductive problem-solving tool for extension purposes, possibly presented as a flowchart, to allow a producer to investigate why their enterprise is not achieving expected reproductive outcomes such as target kidding percentages **(Medium)**

6.2.2 Tools to improve reproductive performance

This tier comprises a series of practices that can be relatively easily incorporated into the reproductive program once the foundational elements are in place, including genetics; hormone / chemical intervention; light therapy; targeted nutritional flushing; the buck effect; pregnancy testing; and steps to reduce kid mortality.

6.2.2.1 Genetics

- Combine extension material on genetics of reproduction into a single reference source, crosslinked to M5, possibly organised into:
    - Crossbreeding;
    - Within-breed selection; and
    - Within-herd selection **(High)**
- Material should include, unless otherwise covered in M5:
    - Consideration of benefits and risks of manipulating genetics in a goat herd;

    - Emphasis that natural selection' or 'survival of the fittest' are not acceptable ways to select for improvement in any farmed livestock population (e.g. allowing animals to die from worm burdens to identify resistant phenotypes);
    - Favourable and unfavourable correlations between traits and the need to plan to deal with them (e.g. increased litter size can be associated with reduced kid survival, necessitating pregnancy testing, increased nutrition of does and possibly shedding or other steps to improve kid survival);
    - Ensuring sufficient genetic variation to protect the herd from becoming inbred – selection solely from within a closed herd is not sustainable; and
    - The value and application of KIDPLAN **(High)**
- Consider, through Sheep Genetics (SG), opportunities to increase the involvement of producers in KIDPLAN to expand the database and enable it to be a more effective genetic selection tool, e.g. by targeted programs that reward producers for contributing data to the KIDPLAN database (similar to the SG initiative to increase the collection of data on worm egg counts in sheep several years ago) **(Medium)**

6.2.2.2 Hormonal intervention

- Develop a section in the extension material on the use of hormones to manage oestrous in goats, including:
    - Indications and contraindications, restrictions and risks associated with use (including workplace health and safety, market access constraints);
    - Brief description of the three main hormones: progesterone, prostaglandin and melatonin;
    - Broad description of how they are used generally: means of administration, management required, regime (in broad terms), workplace health and safety considerations; and
    - Emphasis that hormone treatments are prescription-only in Australia and should only be used under the supervision of a veterinarian **(High)**

Research opportunities:

- Undertake a desktop benefit/cost analysis of using hormones to synchronise does or induce does in anoestrus to cycle **(Low)**

6.2.2.3 Light therapy

- Develop some brief material on the application and risks of light therapy **(Low)**

Research opportunities:

- Investigate the response, cost and practicality of using artificial light and melatonin to manage photoperiod **(Low)**

6.2.2.4 Targeted nutritional flushing

- Expand the extension material to include targeted nutritional supplementation of does at critical points in the reproductive cycle, and the
    - Benefits;
    - Costs; and any
    - Risks associated with such supplementation **(High)**
- Advise caution in increasing fertility, as advantages are quickly restricted by the doe's ability to feed more than one kid, decreasing size and survivability of kids born and overall loss **(High)**

Research opportunities:

- Undertake a desktop benefit/cost analysis of providing increased nutrition at key times in the reproductive cycle **(High)**

6.2.2.5 The buck effect

- Expand the section of the buck effect to provide further information on indications for use (e.g. synchronising does for targeted feeding, shedding etc) and the risks or possible challenges associated with its application **(High)**

Research opportunities:

- Undertake a desktop benefit/cost analysis of using the buck effect considering possible production gains, shorter kidding period, fewer straggler kids, shorter and more targeted feeding period **(Medium)**
- Conduct research to identify ways to more effectively exploit the buck effect, especially in extensive pastoral regions, assessing the limits of the buck effect in terms of paddock and mob size and percentage of bucks **(Medium)**

6.2.2.6 Pregnancy testing

- Expand the information on pregnancy testing in the extension material, ideally including the results of financial modelling of the benefit/cost of pregnancy testing, and/or a calculator with which goat breeders can estimate the benefit/cost ratio for their own enterprise **(High)**

Research opportunities:

- Undertake a desktop benefit/cost analysis of scanning in various goat meat production enterprises, in various locations in various conditions (e.g. dry conditions when feed is limiting) **(High)**

6.2.2.7 Reducing kid mortality

The current project on kid mortality should assist to provide further extension material for this section. Kid mortality is an area of **high priority.**

Research opportunities:

- Perform a detailed production and financial study of one or more enterprises in which does are shedded around kidding time, to provide guidance to others considering this approach. Include:
  - Infrastructure costs; and
  - Implications of splitting the kidding time to make best use of the infrastructure **(Medium)**

6.2.3 Advanced breeding programs

This tier comprises the most complex and risky reproductive management approaches: accelerated breeding programs and use of assisted reproductive technologies (artificial insemination and embryo transfer).

6.2.3.1 Accelerated breeding

- Develop extension material on accelerated breeding programs, including the various approaches, the systemic considerations associated with each program (matching physiological demands with feed availability, seasonal anoestrus and so on) and the advantages, disadvantages and risks associated with each. The importance of having the foundational reproductive management practices in place prior to trialling an accelerated breeding program should be emphasised **(Medium)**

Research opportunities:

- Develop a desktop model to evaluate the benefit/cost of accelerated breeding program for a goatmeat enterprise **(Medium)**
- Based on outcomes from modelling, prospectively establish a long-term evaluation of a 'best-bet' accelerated breeding program under commercial conditions, designed to identify the benefits, costs and risks associated with the program **(Medium)**
- Alternatively, evaluate accelerated breeding systems in existing enterprises over the lifetime of goats to assess impact / profitability over a generation, in particular:
    - Effect on the breeding life of the does;
    - Cost of nutrition and any interventions to induce cycling; and
    - Ideally, a comparison to an annual breeding mob run at the same time under the same conditions **(High)**

6.2.3.2 Assisted reproductive technologies

- Expand the extension material on assisted reproductive technologies, to include an overview of the various techniques and the advantages, disadvantages and risks of each and principles of decision-making about whether to use them, but there is no requirement for technical details, rather a referral to sources of further information or the appropriate experts **(Low)**

7 Key messages

- Findings of reproductive research in sheep should be interpreted cautiously. They provide useful clues to the reproductive possibilities for goats, but the specifics of application to goats may differ significantly.
- The literature contains volumes of papers on the various aspects of reproduction in goats and sheep, but no novel ideas were identified. It is also clear that there is no 'silver bullet' to optimise reproductive success in Australian meat goat production systems.
- There are many goat production research papers evaluating the various stages of the reproductive cycle. The information comes from various goat breeds in various climates, and from the three main goat enterprises: dairy, fibre and meat. By reviewing a large number of these paper and averaging the data, a general guide to production requirements can be established. Future research may look at validating such estimates for Australian breeds in Australian climates rather than retesting from scratch in experimental conditions.
- The diversity in Australia's goat meat production in terms of breed, location and management systems make it impossible to devise a 'one size fits all' approach to improved reproductive management.
- There is scope to improve profitability and productivity in many goat meat enterprises by improving the standard of basic doe care and husbandry. This includes controlled joining and weaning, improved nutrition and better ability to monitor the health and welfare of stock.
- Establishing these foundations are essential before a producer considers implementing any advanced breeding program.
- A three-tiered approach to improving reproductive performance of goats will ensure the gradual development of appropriate skills and knowledge of producers, and that a minimum standard of care is maintained.
- Advanced breeding programs require complex and continuous management and attention to detail. While they can be more profitable, they are also much more risky both financially and for the health and welfare of the does.

- Most of the research on accelerated breeding programs concerns sheep and includes only a few years of information. There is little known about the long-term implications of accelerated breeding on doe lifetime productivity and the potential impacts of extended periods of drought on the success of the approach.
- Developing extension material on animal welfare and adaptable and resilient farming is warranted. These two areas have been identified as being essential given the findings of this report and the changing climate.
- Revamping the MLA extension material into a more contemporary and electronically interactive format with all the resources are centralised is recommended. This will provide a simple but comprehensive ‘extension’ experience and ensure the vital messages are not lost.

8 Bibliography

The bibliography is included at the end of the literature review, which is provided as a separate document.

Appendix 1: Extension materials reviewed

1. Meat goat extension material

1.1 Give Goats a Go (MLA)

MLA already have several different information sources available to goat producers. Some of these are available just as e-documents and others are available in hard copy. The MLA website provides easy access to this material. The main web page for goat information provided by MLA is ‘Give Goats a Go’. This page provides access to:

1.1.1 Best practice videos

- Getting into goats introduction
- Goat fencing
- Goat genetics
- Goat nutrition – Part 1: Nutrition introduction and determining forage supply
- Goat nutrition – Part 2: Determining forage demand
- Goat nutrition – Part 3: Calculating a forage budget
- Goat nutrition – Part 4: Supplementation of goats
- Live weight scales
- Markets and profits
- Fit to load guide

1.1.2 Factsheets

Factsheet 1: Profitability in goat production

- Profitability underpins good business
- Calculating profit
- Profitability
- Profitability and wealth creation
- Cost of production
- MLA cost of production calculator
- Analysing and enterprise
- Using cost of production to make better decisions
- How increased productivity will affect cost of production and profit margin

Factsheet 2: Marketing goats

- Understand market requirements
- Factors in choosing a market
- Production environment
- Marketing options
- Supply capability
- Product consistency
- Supply consistency
- Cost of production

Factsheet 3: Understanding dressing percentage when marketing goats

- Dressing percentage
- On farm weighing
- Factors affecting dressing percentage
- Gut fill

- Hydration
- Condition
- Skin weight
- Breed and muscularity
- Carcase trim, dressing and weighing procedure

Factsheet 4: Understanding goat behaviour and handling

- Goat handling principles
    - Vision
    - Point of balance
    - Flight zone
- Goat behaviour
    - Fencing
    - Yards
    - Transport
    - Social behaviour
    - Maternal behaviour
- Moving goats
- Grazing behaviour
    - Selectivity
    - Graze and browse
    - Goat camps
    - Watering points

Factsheet 5: Infrastructure for goats

- Yards and handling facilities
- Water supply
- Fencing for goat control

Factsheet 6: Managing livestock numbers

- Understanding the numbers
    - Dry sheep equivalents
    - The effect of the reproductive cycle on DSE
    - Stocking rate
    - Carrying capacity
    - Adult equivalents
- Farmed grazing systems
- Rangeland Grazing systems
- Calculating stocking rate in a rangeland production system
- Calculating the area of land required to support an enterprise in a farmed goat production system

Factsheet 7: Production from a breeding doe

- Monitoring performance
- Managing goats to maximise reproductive performance
    - Stage 1: Pre-joining management of breeding does, breeding bucks and maiden does
        - Seasonality

        - Body weight and conditions scoring at joining
        - Managing maiden does -age of joining
        - Managing bucks for joining
    - Stage 2: Post joining
    - Stage 3: Pre-kidding -foetal development and kid survival
    - Stage 4: Kidding to weaning

Factsheet 8: Grow out options to meet market specifications

- Maximising return
- Understanding market specifications
- Relating market specification to your production environment
- Understanding growth rates (including a comparison of growth rates for rangeland goats compared to other breeds, and a review of a number of factors that can affect the growth rate of kids)
- Cost of production
- Bringing it together – showing the various options to deal with kids that are not of commercial weight (on-selling kids to grow out, release and re-muster, retain pasture specifically to grow kids out, grow out to reach feedlot entry weight then lot feed)

1.1.3 Going into Goats guide

The 'Going into Goats' (GIG) program was developed in 2006 and includes a GIG guide with 12 modules. The guide provides information on the major production aspects of farming meat goats. The information in the modules is extensive. There are aspects of all the modules that are relevant to reproduction, however the main modules containing reproduction information are 5, 6, 7 and 12. The information in the modules is divided into facts in one section followed by relevant tools in the second half of the module.

Upgrading the presentation to suit a more electronic-based platform would allow easy integration of all of the various information sources already available. It would also allow the user to move freely between production information freely.

Module 1: Property planning

- Goal setting
- Enterprise choices
- Customers and processors
- Suitability of land for goats
    - Shelter
    - Soil type
    - Climate
    - Feed availability
    - Access to water
    - Topography
    - Threat from predators
    - Established infrastructure
- Scale of operation
- Financial implications
- Fitting in with existing enterprises
- Planning considerations
- Toolkit 1
    - Finding further information
    - Dry sheep equivalents

    - How to conduct an effective web search

Module 2: Financial analysis

- Buying a goat-farming business
- Changing the operation of an existing farm business to include a goat enterprise
    - Enterprise gross margins
    - Return on capital
- Existing goat producer, seeking to improve performance of his/her business
    - Cost of production
    - Benchmarking
    - Valuing secondary benefits
    - Risk management
- Toolkit 2:
    - Finding further information
    - Checklist of financial data and physical figures required for a business analysis
    - Example of gross-margin calculator
    - Example of partial budget
    - A partial budget investigating the use of goats for week control
    - Fallback marketing options
    - BizCheck® benchmarks for meat enterprises-intensive enterprises
    - Profitability of an extensive goatmeat enterprise

Module 3: Industry obligations

- Animal welfare
- Livestock health and disease management
- Sale and movement of goats
- Farming goats – WA and SA
- Quality assurance
    - Food safety
- Biosecurity biological threats to your enterprise
    - Diseases and parasites of animals
    - Pests and diseases of plants
    - Animal pests
    - Weeds
    - Algal blooms
- Toolkit 3:
    - Finding further information
    - Rules pertaining to the movement of goats
    - List of notifiable animal diseases for Australia
    - National vendor declaration (goats) and waybill
    - NSW statement
    - Transaction levies

Module 4: Infrastructure

- Goat behaviours
- Fencing
    - Electric fencing
    - Conventional fencing

- Water
    - Waterways
    - Dams
    - Reticulated water systems
- Yards
- Handling equipment
- Toolkit 4:
    - Finding further information
    - Fence designs-producer experiences
    - Hints for siting troughs
    - Yard designs
    - Training goats to respect fences and yards

Module 5: Goat selection and breeding

- Goat breeds
- Setting a breeding objective
- Breeding and selection tools
    - Visual selection
    - Raw data
    - Estimated breeding values
    - Artificial breeding
- Induction of goats into your environment
- Toolkit 5:
    - KIDPLAN-estimated breeding values definitions
    - How to use KIDPLAN results

Module 6: Husbandry

- Extensive system – birth, lactating does, young kids, weaning, growing kids, joining, pregnancy
- Intensive system – birth, lactating does, young kids, weaning, growing kids, dry does, joining, pregnancy
- Physiological facts
- Toolkit 6:
    - Goat handling
    - Finding further information
    - Common health problems
    - Distribution map showing areas prone to trace-element and mineral deficiencies in Australia
    - Vaccinating against diseases
    - Zoonotic diseases of goats
    - Growth rate and mature weight tables
    - Is marking of male kids a necessity for your enterprise?
    - Live body condition scoring – an assessment of fat reserves
    - Mustering stock
        - Reducing stress
    - Joining options
        - Maidens at 7 months old
        - Maidens at 19 months
        - Autumn joining
        - Out of season joining

        - Remove bucks after joining
        - All year breeding
        - Other health issues

For each of the phases in the reproductive cycle, the key issues of concern are identified, with their relevance explained, in this module. A number of management tasks are listed that, if implemented, could mitigate these issues/risks to successful production. Some of the issues identified include shelter, predation, nutrition, condition, growth rates, health, seasonal influence and culling. The information is presented separately for the two different types of production system which allows the system-specific issues to be identified clearly.

There is a section on handling goats which includes considerations to reduce stress. Behavioural characteristics of goats and accompanying management tips for both intensive and extensive enterprises are also included.

There are also a number of tools to assist with care of goats including gastrointestinal parasites. There is information on the clinical signs, diagnosis and treatment including various product options. There is a list of diseases/conditions that can commonly affect goats including how they might present (clinical signs), diagnosis and preventative management strategies. There is a tool that includes a map showing locations in Australia where trace element deficiencies are likely to occur. Another tool provides the information producers will need in order to decide if the marking of male kids is necessary in their enterprise. There are also tools on vaccinating goats, zoonotic diseases of goats, growth rates and mature weight figures, condition scoring, mustering stock and joining options.

The information on joining includes the decisions producers need to make in respect to joining, the options available to them, the factors they should consider in making each decision and the various management requirements to facilitate reproductive success

<u>Module 7: Nutrition</u>

- Know the nutrient requirements of your stock
    - Water
    - Energy and protein
- Requirements
    - Maintenance
    - Activity (type of grazing)
    - Pregnancy
    - Milk production
    - Growth
    - Severe weather
    - Fibre/roughage
    - Vitamins and minerals
- Changing diets
- Buying supplements (comparing of costs)
- Know your resource and how it grows
    - Quality and quantity
    - Maintaining your feed base
    - Grazing temperate pastures
    - Managing rangelands
- Toolkit 7:
    - Finding further information
    - Nutritive value of common goat feeds
    - Palatability of plants commonly eaten by goats

    - Nutritional disorders
    - Toxic plants
    - Feedlotting goats

This module provides a comprehensive guide to the importance of nutrition in goat meat production as well as some detailed information and tools to assist producers to calculate the needs of their stock and to measure the quality and quantity of the feed on offer. Consideration of all of these factors will allow producers to develop their own annual feeding programs.

The module provides a series of tables that allow producers to calculate the feed requirements for their stock. There are tables of data on maintenance requirements based on live weight. Additional tables provide the necessary data to allow for pregnancy, lactation, growth and activity level of goats which will alter their net requirements. The impact of severe weather conditions on nutritional requirements is also discussed here.

There is also detail about the importance of the various components of diet including fibre, energy, protein and vitamins and minerals.

The module also provides information on sourcing and feeding supplements including the best way to change a goat's diet while causing the least disruption to production.

The module also provides details on grazing in temperate pastures and rangelands. The information is specific for the different regions and considers peculiarities of those grazing systems including the best time for grazing, the dry sheep equivalent for goats, stocking rates, monitoring and identifying signs of overgrazing.

There are various tools such as those on the nutritional value of common goat feeds including pasture, concentrates, trees and shrubs and weeds. There are also tools showing the palatability of plants to goats, nutritional disorders, toxic plants and feedlotting goats.

<u>Module 8: Marketing</u>

- Market specifications
- Market strategy
    - Knowledge of markets
    - Selling options- how, when,
    - Product promotion
- Toolkit 8:
    - Finding further information
    - List of processors and buyers
    - Preparing goats for market and relocation
    - The skin-on product
    - The relationship between liveweight and carcase weight

<u>Module 9: Parasite control-updated version</u>

- Guidelines for controlling internal parasites of goats
- Detecting infections
    - Faecal worm egg counting
    - Drench resistance testing
- Controlling worms
    - Preventing new infections
    - Immunity and worms

    - Treating worms
    - Worming and drench resistance
    - Quarantine drenching
    - Managing drench resistance
    - Hints for effective drenching
- Guidelines for controlling lice and other external parasites of goats
    - Lice
        - Detecting, controlling and treatment for lice
        - Rules for effective and safe use of lice control products
    - Ticks, mites, fleas, nasal bots
- Toolkit 9:
    - Finding further information
    - Glossary of terms
    - Information on commercially available chemicals registered for parasite control in Australian goats

Module 10: Mohair production

Module 11: Goat depots

- Depot planning, design and construction
    - Location
    - Site
    - Design
    - Construction
- Handling and husbandry
    - Goat behaviours
    - Unloading and loading
    - Drafting
    - Stress
    - Quarantine requirements
    - Record keeping and documentation
    - Market specifications
    - Handling equipment
- Goat health, nutrition and depot hygiene
    - Stress
    - Food and feeding
    - Water
    - Weather
    - Disease management
    - Treatment and vaccination
    - Parasites
    - Predation
    - Housekeeping
- Toolkit 11:
    - Finding further information
    - Hints for managing goats in depots
    - Tips on feeding and health
    - Humane treatment of animal needing to be destroyed
    - Hints to help your business and avoid pitfalls
    - National Livestock Identification System
    - Depot designs – depot operators experience
    - An example of documentation

Module 12: Rangeland management

- Business management (includes record keeping)
- Infrastructure
- Animal husbandry and welfare
    - Mustering
    - Trapping
    - Holding goats in paddocks and yards
    - Drafting and culling
    - Breeding and selection
    - Managing predation
    - Ear tagging
    - Transportation of goats
    - Water
    - Nutrition and feed
    - Shelter and shade
    - Disease
- Grazing management of rangeland goats
- Marketing

This module includes information on the different types of rangeland goat enterprises as well as the customers that suit each of the enterprises. Each section is supported by real case studies. This module is a good general introduction to goat farming in the rangelands but lacks the details that a producer would need to start from scratch, or for those that are established, looking to improve their reproductive productivity.

There is business management information including planning, managing finance and risk, requirements for record keeping and tips on managing people.

There is practical farm based information on infrastructure such as fencing and yards and handling equipment and watering facilities. Animal husbandry and welfare is covered quite comprehensively although there are few 'best practice' figures. There is information on trapping, mustering drafting and culling. The culling information is general only. Breeding and selection are also covered in little detail.

Predation (wild dogs, foxes, wild pigs) and guard animals are all discussed here and there is a tool on wild dog control. The legislative requirements for ear tagging and stock movements are included.

The section on nutrition covers both feed and water requirements and there is a brief section on diseases.

1.1.4 Goatmeat webinars

- Webinar 1: Goatmeat market requirements, prices & trends
- Webinar 2: Goatmeat markets – opportunities, development and promotion
- Webinar 3: Genetic improvement and parasite management – what you need to know
- Webinar 4: Grazing pressure and dog control case study
- Webinar 5: The goat live-export industry – an overview
- Webinar 6: FAMACHA and goats –a practical on-farm technique for barber's pole
- Webinar 7: On-farm biosecurity – what you need to know to protect your livelihood

- Webinar 8: Genetic improvement within your goat herd – are you getting the most bang for buck with your selection program?
- Webinar 9: Biosecurity plans – how to set one up for your business and reap the rewards
- Webinar 10: Goatmeat market update
- Webinar 11: Internal parasite control for goats and how WormBoss can help
- Webinar 12: Total grazing pressure and goats
- Webinar 13: Rangeland goat growth rate trials
- Webinar 14: Opportunities for positioning goatmeat in the domestic market

1.1.5 Other

- Goats on the Move eNewsletter – quarterly email that provides tips, tools, updates, market news and case studies for subscribers
- Events and activities
- A guide to visual assessment of goats (2018). This guide has been designed to help goat producers assess does and bucks visually when making production decisions. It has been developed by MLA and provides a description of traits and photographs for easy reference. Visual assessment refers to identifying traits that may be considered as favourable and thus maybe selected for or unfavourable trait that may be selected against. An individual business enterprise needs to decide on what trait are important to them and then they can develop their own selection program. For each trait defined by the guide there is information on when the trait is best assessed (age), a description of the trait and a scoring systems for that trait. The traits covered in the guide are:
    - Jaw and teeth
    - Head and horns
    - Shoulders and back
    - Legs and feet
    - Hocks
    - Udder and teats
    - Testicles

1.2 Other MLA materials relevant to goats

1.2.1 Is it Fit to Load?

This is a national guide to the selection of animals that are fit for transport, applicable to all livestock. It provides a simple description supported by photographs and certain conditions. It has been developed to make it easier to make decisions about the fitness of animals before they are transported.

1.2.2 KIDPLAN

KIDPLAN is hosted by Sheep Genetics. The KIDPLAN section of the Sheep Genetics website provides fact sheets on:

- An introduction to KIDPLAN
- Understanding KIDPLAN EBVs
- KIDPLAN EBV definitions

There are also links to other pages on Sheep Genetics site with general (non-goat-specific) information on:

- Key steps (general information on subscribing to Sheep Genetics)
- ASBVs and indexes explained (general information)
- How to use the databases (although referring to LAMBPLAN and MERINOSELECT)

- Quality assurance guidelines

1.2.3 Profitable Grazing Systems

Profitable Grazing Systems is an MLA group-based delivery program designed to assist red meat producers to improve business performance. The program considers the following:

- Whole farm approach
- Key profit drivers
- Best practice
- New research findings
- Financial implications of decision making

1.2.4 Tools and calculators

The MLA website provides a number of tools and calculators for red meat producers.

- Cost of production calculators
    - Cost of production beef, lamb and goat
    - Cost of production sheep and wool
- Animal health and nutrition calculators
    - Health cost benefit calculator (cattle)
    - Calving histogram calculator (cattle)
    - Breeder mortality calculator (cattle)
    - BeefSpecs calculator (cattle)
    - ParaBoss (see WormBoss below)
- Feed calculators
    - Stocking rate calculator (cattle and sheep)
    - Feed demand calculator (cattle and sheep)
- Pasture tools and calculators
    - Rainfall to pasture growth outlook tool
    - Feed budget and rotation planner
    - Pasture improvement calculator
    - Phosphorus tool
    - Pasture trial network
- Climatic impact tools
    - FarmGAS calculator
- Predictive tools
    - RI (refrigeration index) calculator
- MSA Index calculator (cattle)

1.2.5 Bred Well Fed Well workshops

Bred Well Fed Well is one-day workshop highlighting the key production benefits of superior genetics, plus feed management for improved reproductive performance and livestock productivity. The material delivered is not available on the MLA website, but it is likely that it could be used in other extension material.

1.2.6 EverGraze: More livestock from perennials

The EverGraze program was a national research, development and extension project to develop and test farming systems to improve profitability of livestock, by using perennial plants. It also aimed to reduce ground water recharge and soil loss in high rainfall areas. EverGraze is now managed by MLA, AWI and Agriculture Victoria.

Like Lifetimewool, EverGraze has delivered various information packages and tools, and its outcomes continue to be delivered through training. The EverGraze Regional Packages provide detailed information on:

- Overview of the land use in that area
- Soils, and what this means for pastures
- Livestock systems and industry benchmarks
    - Whole farm analysis
    - Sheep-meat and wool and beef cattle , Goats not included specifically
    - Stocking rate potential
- Climate
    - Rainfall
    - Temperature
    - Seasonal variation
- Pastures
- Environmental issues

There are also links to further material mostly based around pasture improvement and management.

1.2.7 WormBoss Goats

WormBoss is part of the ParaBoss suite of resources on the control of parasites in sheep and goats.

This site provides recommended worm control programs for goats by region. For each region, detail is provided on:

- Grazing management (most susceptible animals, preparing low-risk weaner paddocks)
- Breed and feed for resistance and resilience
- When to worm test and when to drench (how to test, drench decision guide)
- Managing drench resistance
- Appendices: liver fluke control, parasite life cycles, factors contributing to paddock contamination, ‘smart grazing’ to control scour worms in weaner sheep, drench groups

The WormBoss material is very comprehensive and regularly updated by experts. It could be linked to by any other extension package without the need for duplication.

1.3 New South Wales Department of Primary Industries extension material

The NSW DPI website on goats includes a number of Agfacts and other products, organised as follows:

- Goat breeds: origin, breed characteristics
    - Anglo-Nubian
    - Angora
    - British Alpine
    - Saanen
    - Toggenburg
- Management and production
    - Artificial methods of rearing goats
    - Gross margin budgets for meat goat enterprises
    - Guard animals for livestock protection

    - How to tell the age of a goat – Agfact (dated but with good pictures of teeth of animals at various ages (2003))
    - NSW goat industry summary
    - Rangeland goat production in western NSW – detailed report on seven case studies on rangeland goats enterprises from western NSW (2012)
    - Shearing cashmere goats
    - Yard design for goats – Agfact (dated but some good general information (2007))
    - Movements
        - Moving goats into and within NSW
        - National Goat Health Statement
        - NLIS sheep and goats
        - Stock movements including transport and export
- Health and disease
    - Primefacts on various common goats diseases
    - Managing internal parasites in organic livestock production systems
    - Managing worms in goats in NSW
    - Notifiable diseases in NSW
    - Biosecurity duty of goat producers
- Welfare

1.4 Australian Industry Welfare Standards and Guidelines for Goats 2016

The Australian Industry Welfare Standards and Guidelines for Goats were developed by experienced goat professionals in conjunction with Animal Health Australia and the Goat Industry Council of Australia (GICA).

The standards are what industry has deemed to be a minimum requirement for acceptable care of goats. The guidelines are practices that are recommended to achieve suitable welfare outcomes for the animals.

2. Sheep extension material

2.1 Making More from Sheep

Making More from Sheep comprises 12 modules and some ‘hot topics’. Each of the modules includes information on the benefits of the material in the module, and then a number of procedures and tools. The 12 modules are:

1. Plan for success
2. Market focused wool production
3. Market focused lamb and sheepmeat production
4. Capable and confident producers
5. Protect your farm’s natural assets
6. Healthy soils
7. Grow more pasture
8. Turn pasture into product
9. Gain from genetics
10. Wean more lambs
11. Healthy and contented sheep
12. Efficient pastoral production

Relevant modules are discussed below.

Module 1: Plan for success

This module includes business planning information that could be easily transferred into a module for goat meat producers. It includes procedures for establishing business objectives and plans, calculating cost of production, quantifying risk and developing a risk management plan and assessing enterprise changes and new technologies. There are various tools associated with this module and the majority of these could also be easily adaptable to suit goatmeat production enterprises.

Tools such as the SWOT analysis, a process for setting goals and objectives, preparing a business plan and preparing for the future of the farm could all be used within the goat industry with minimal or no change. The MLA cost of production calculator already has the option to select goats as the production species. The farm risk assessment template and drought example and the partial budget template could be used without change by goatmeat producers. The Sustainable Grazing Systems one-page planning process could be applied to goat farming systems located in southern Australian high rainfall enterprises that are looking to improve their productivity while improving the environment.

Module 3: Market focused lamb and sheepmeat production

A goat meat equivalent to this module would be essential in any extension package. The principles applied in this module are fully transferrable, but the details would need to be modified to suit the goat meat market. This module is designed to assist producers to deliver quality-assured products that meet market specifications. The anticipated outcomes include an improved ability to manage the price risk and production system, meet market and consumer expectations and improve business profitability. The procedures are:

- Deciding on the most profitable product
- Managing the system to meet market expectations
- Deciding on the most profitable selling method
- Responding to short and long term price and market signals

There are ten tools which would all need to be rewritten to be appropriate for goat meat. The same scope of tools would be beneficial to goat producers.

Module 4: Capable and confident people

This module provides practical ways to boost capacity, capability and confidence of people involved in your business, from family members of those you employ, contractor or advisors. It explores ways to communicate more effectively, define more clearly responsibilities within the business, establish an appropriate balance between work and leisure time and improving relevant skills and knowledge. All of the six tools that are part of this module could be used for goat production systems and would require only very minor edits where ‘sheep’ have been referred to specifically. The information included in this module is equally applicable to goat enterprises.

Module 5: Protect your farm’s natural assets

The purpose of this module is to assist producers to plan their business to improve profit while better managing the natural resources. Management principles might include the storage of carbon in grasses, trees and soil to offset the methane produced by ruminants such as goats. These types of changes can assist in building the capital value and profitability of the business while building on long term sustainability. The 12 tools of this module could be used within goat production systems and include dealing with weeds and salt, control of pest species and establishing a photo record over time. The only tool that

would require some significant editing for goat production concerns stock water requirements which is specifically prepared for sheep.

Module 6: Healthy soils

Soil health is vital in all farming production systems and this module provides a generic guide to good soil health through testing and preservation, which should ultimately lead to optimal pasture growth.

Module 7: Grow more pasture

Pasture in this module includes annual and perennial pastures, forage crops, stubbles, dual purpose cereals and browse shrubs. The three procedures in this module cover improving and maintaining soil fertility, managing and monitoring grazing patterns to ensure desirable plant species are productive and dominant, and establishing new pastures.

The information in this module would require little modification to be used in the goat industry. The main difference would be the inclusion of browse where relevant.

Module 8: Turn pasture into product

Matching feed supply to need without negative impact on natural resources and the feedbase is the main theme of this module. The procedures include understanding your feed supply and animal demand and how to match these with minimal risk, whilst considering seasonal variation that occurs within the year and between years.

The ‘MLA rainfall to pasture growth outlook’ and the ‘Daily pasture growth estimates’ tools are based on data collected from southern Australia and therefore could not be applied to goat farming enterprises in Queensland. The ‘MLA feed demand calculator’ has been developed to calculate the total monthly feed demand of all livestock on a property, but currently there is no capacity to record goats in this tool, and a page to include all goats would be required for this tool to be useful for goat meat producers. It would give producers the ability then to consider sheep, cattle and goats demands on the property.

The feed budgeting template requires editing to include grazing requirements of the various goat production types. The ‘feed year plan template’ and the practical pasture measuring tools could be used for any livestock grazing production system. The guide to rotational grazing is general and could be immediately used for goat production systems.

Module 9: Gain from genetics

The specific details of this module and the tools are intended for use by sheep producers. The principles of genetic selection however are the same for all livestock production systems. Editing to include goat breeding values and traits relevant to goats production would provide a valuable module for goatmeat producers.

Module 10: Wean more lambs

This module is another vital one for goat meat production but would need to be rewritten to provide goat-specific information. The module has procedures that include the following general concepts:

- Ensuring most females become pregnant
- Managing mothers for best offspring survival
- Maximising number of offspring that are weaned
- Managing weaners for maximal survival and productivity

- Preparing females for next joining

The eight tools adapted with goat-specific material would be highly relevant and useful to goat meat producers. These tools cover:

- Condition scoring
- Management planning for breeding animals
- The male affect
- Target condition scores and fat scores for females
- Bodyweight targets for weaners and maiden females
- Male check list
- Pregnancy scanning
- Checklist for new born deaths

Module 11: Sheep health

This module is clearly written for sheep, but the outline could support the equivalent information for goats. Some of the disease information would be relevant for both sheep and goats.

Module 12: Efficient pastoral production

This module would be an important inclusion into goat extension material as there are a number of goat producers located in the pastoral zone. It defines a pastoral zone as an area with native pastures that are grazed by domestic, feral and native herbivores which includes goats.

The seven procedures in this module are all relevant to goats and most could be directly replicated into a goatmeat extension program. The procedures are as follows:

- Know your property
- Establish a vision
- Efficient pastoral production (this procedure includes some sheep specific production and equipment information that would need to be altered to be goat-relevant, but these changes would be relatively minor, and this information is readily available)
- Determine a grazing management approach
- Match grazing pressure to feed supply
- Manage pest animal species
- Obtain best production from rainfall received

The majority of the information included in these procedures is general for grazing enterprises in the pastoral zone includes the management challenges and considerations and would require little if any alteration to be included into goat extension material.

There are 21 tools included in this module and they are mostly about planning, setting goals and measuring and monitoring the feed available. There are additional tools on controlling pest animals, managing the native scrub and monitoring. There is a specific tool for condition scoring of sheep and this could easily be replaced by information on condition scoring goats.

2.2 Lifetimewool project

The Lifetimewool project was a national project supported by Australian Wool Innovation, CSIRO, several state agencies and a number of farm businesses. It created a significant bank of knowledge on the nutrition and management of ewes to optimise reproductive performance, lamb survival and the wool production of the ewe and her progeny. The findings of the project have been packaged in the Lifetime Ewe Management (LTEM)

training course and various products and tools. These include a series of region-specific recommendations for nutritional management.

LTEM is a nationally-accredited course that involves six hands-on sessions over 12 months for 6-7 producers at a time. The training is coordinated by Rural Industry Skills Training (RIST). The program has been designed to improve the understanding of the importance of nutrition and management on the performance of the ewe and lamb in sheep production systems. It has trained an estimated 4000 producers.

The LTEM program is designed to run over the breeding cycles of the ewe with each training session coinciding with a significant stage in female reproductive cycle. There is a significant focus on condition scoring, assessing feed on offer and feed budgeting. These skills are supported by information on the impact of ewe nutrition on her performance and that of her progeny. Producers that have participated in LTEM program have increased the stocking rate of their ewes, reduced ewe mortality and increased weaning rates, the net gain being an increase in the number of lambs weaned per hectare.

The topics covered are:

- Weaning and preparing ewes for next year's joining
- Setting up for joining — manipulating ewe condition
- Linking ewe condition at joining with lambing potential
- Mid-pregnancy – looking forward and planning for lambing
- Late pregnancy – optimising lamb survival and future productivity
- Economic analysis of different feeding strategies.

The Lifetimewool project website has information on a number of topics, including:

- How whole farm profit is affected by the condition of ewes
- Ewes in better condition at joining conceive more lambs
- Improving lamb survival
- More productive lambs through better ewe management
- Managing twinning ewes for higher production
- Managing ewe mortality
- Improving ewe fleece weight and wool quality
- Impact of pregnancy scanning on farm profit
- Regional guidelines

The site also contains a number of tools, including:

- Condition scoring
- Fat scoring
- Pasture quality and quantity (including variability of digestibility of pasture, food on offer pasture photo gallery, assessing pasture for herbage mass)
- Estimating reproductive rate
- Feed budgets
    - In the dry or drought
    - Break of season
    - In green
    - Pastures in NSW

For development of goatmeat production information the consideration of regional differences would be essential to ensure the information is relevant to all goat meat farming enterprises. There would be vast differences in the recommendations for production systems that are based largely on purely harvest compared to those intensively managed systems.

3. Deer extension material

The Deer Industry Association of Victoria website makes available the book ‘Deer farming’ by Chris Tuckwell (2003). The book is a useful resource of information for newcomers to deer breeding. It includes some best practice measures, an overview of the reproductive cycle of deer and information on nutrition.

Appendix 2: Online survey questions

Q1 Please provide your postcode (we need this as a minimum, in order to analyse the data)

Q2 OPTIONAL. Please provide us with some further contact details. These details will be added to a database to be held by MLA and will be used to keep in touch with you about the project and future extension activities.

Q3 What is your average annual rainfall?

Q4 Do you use irrigation water for pastures?

Q5 Do your goats browse or graze?

Q6 What type of pasture do you have?

Q7 If relevant to you, what type of browse do the goats have access to?

Q8 How would you describe your goat management?

Q9 What is the main breed/s of goat farmed on your property?

Q10 Do you vaccinate your goats?

Q11 Do you drench your goats?

Q12 Do you condition score your does?

Q13 What are the main markets you aim to access from your goat meat enterprise?

Q14 What other farm enterprises do you have?

Q15 What do you see as the major limitations to the productivity of your goat meat / stud stock production system?

Q16 How long have you been farming meat goats? (years)

Q17 In a typical year, how many breeding does do you run on your property?

Q18 On average, how many does do you mate per buck?

Q19 In a typical year how many times does each doe kid?

Q20 How many times do you join / kid in a year?

Q21 In what month does joining start? (if more than one joining, first joining)

Q22 If relevant, when does second joining occur?

Q23 How long does joining go for?

Q24 What age are maiden does when they are first joined?

Q25 What criteria do you use to cull does? (please mark all that are relevant)

Q26 What are pregnant and lactating does fed? (please mark all that are relevant)

Q27 Do you pregnancy test does?

Q28 Does seasonal anoestrus impact on your production system? (seasonal anoestrus is a period of time when animals are not sexually active. It generally occurs during the same season/months every year.)

Q29 Which of the following treatments and procedures have you used on your goats? (please mark all that are relevant)

Q30 Do you currently use accelerated kidding? (for example, 3 kiddings in 2 years or 5 kiddings in 3 years)

Q31 Do you use artificial insemination in your production system?

Q32 Do you use embryo transfer in your production system?

Q33 What is your average annual kidding percentage?

Q34 What is your average annual weaning percentage?

Q35 At what age are kids weaned? (if buck and doe kids are weaned at different times please specify)

Q36 Is there anything else you would like to tell us about your reproductive management?

Q37 We would like to prepare a small number of case studies of interesting goat reproductive management programs for extension purposes. Would you be interested in having your program written up as a case study, if appropriate?

Appendix 3: Summary of findings against key reproduction variables

The following is a summary of the findings of the project in relation to a series of key reproductive measures identified in the original project brief. The table includes the findings from the literature review and producer consultations and the content of current extension material.

Reproductive management variable	Producer consultations	Literature review	Extension material current	Comment
Doe management				
Best measure of first joining (age/weight)	• 56% of producers joined their maidens for the first time at 13-18 months, 23% at 7-12 months • One producer who joins maidens at 7 months had kidding percentages of 4-43% • Some producers commented that joining was not based on age alone but that does needed to be sufficiently 'grown out' – mostly this was based on the producer's judgment rather than weighing	• Does should be 60-70% of their mature body weight at first joining • This would generally be at an age no less than 7 months	• M6 – puberty at 40% of mature weight, from 3.5-12 months (normally 7 months), no ref to 6.1 • M6.10 tool – joining options 7 months compared to 19 months (pros and cons) • F3 – seasonality, age, weight	• A producer's ability to get maiden does to the recommended joining weight by 7 months will vary between enterprises • When crossbreeding is being used the mature age might not be as clear
Optimal time of joining (this is interpreted to mean the season of joining)	• 10/63 producers joined year-round • 42% of producers started their joining in March or April, while January and February were also common months for joining • 68% of producers said that seasonal anoestrous did not impact on their business	• Goats are short day breeders – best reproductive outcomes are generally achieved with joining as days get shorter (autumn and winter) • The variation in breeding season is also influenced by breed, latitude, rainfall, temperature, humidity, doe body condition score and feed available	• M6 – general information about seasonality • F3 – seasonality, age, weight	• Optimal time of joining will vary with location; latitude, rainfall and time of maximal pasture growth, breed of goat (seasonality) • In accelerated systems, determining optimal joining times is much more complex and there is much less flexibility to maximise pasture availability at kidding
Optimal time of culling (to maximise value at culling vs loss of production on farms)	• In the survey, producers could select more than one criterion for culling • The main criteria nominated were physical characteristics (68%),	• There is quite a bit of information available concerning reasons to cull • No information was identified for sheep, goats or deer about the comparative cost of culling and loss of farm production	• MLA web page on culling stock lists some key criteria by which to assess the need to cull animals	• Optimal time of culling for a particular enterprise would vary depending on the season in current and recent years, market prices etc.

Reproductive management variable	Producer consultations	Literature review	Extension material current	Comment
	productivity (63%) and age (59%) • Almost 50% chose health as a reason for culling and 15% seasonal variation • Other criteria for culling included poor mothering and 'breed flaws' for stud animals • In discussion with producers they emphasised that the degree of culling varied from year to year, with a changing herd structure and the amount of feed available and prices of feed and stock	compared to keeping does/ewes for another season	• M6 – culling information, including the physical and production issues that would indicate a need to cull	• In years that are drier, or if prices for older does are better, more does may be culled than in a year when there is plenty of feed
Animal nutritional requirements for multiple versus single births	• The main comment made was that all goats were assumed to be carrying at least twins and were fed accordingly • The small number of producers who pregnancy tested (11%) showed that most did not know the pregnancy status of their does	• There is good information on the nutritional requirements for pregnant ewes, but the data for goats is less definitive, with wide variation between studies and between breeds in the recommendations • Most of the quoted data for goats is from the NRC, and there is some concern about using these figures as they are based on small numbers of non-Australian breed goats in experimental conditions • Some estimations have been created by averaging data from several sources • There is plenty of research showing the link between ewe body condition score and body weight and lamb survivability • As a general rule of thumb, pregnant does/ewes require 2.5 times maintenance from 140 days gestation and into lactation • There is adequate information available on the nutritional value of various feeds,	• M9 – nutritional information • F7 – recommended body condition scores, energy requirements during pregnancy	

Reproductive management variable	Producer consultations	Literature review	Extension material current	Comment
		allowing for feed budgeting and cost analysis • Some goats may be able to alter their energy requirements by up to 65% in times of poor pasture availability • BCS Guide by the American Institute for Goat Research is based on a relatively small numbers of animals in experimental conditions, and was not based on breeds used in Australia • 60kg non-dairy doe pregnancy with twins 11.42 MJ/kg/d in early pregnancy and 15.27 MJ/kg/d in late pregnancy		
Frequency of reproduction				
Cost-comparison with traditional breeder systems	• Only two producers who agreed to be contacted were performing a 3-in-2 breeding program, one for 5 years, the other 2 • Ten of the producers who were spoken to had tried accelerated breeding and had found it to be completely unsuccessful for them, citing reasons such as impact on the animals, requirements for a huge amount of feed and time and kids being born in bad weather and small	• There is only one paper that compares the cost of accelerated versus annual breeding and it is in sheep – there is no information in the literature for goat accelerated breeding programs • An economic analysis of a 3-in-2 system in sheep in Canada, over 7 years, resulted in a total contribution margin of $755 compared to annual $357 (spring lambing) or $517 (winter lambing)	• Extension material contains a brief mention of the possibility to breed more than once a year but little detail is provided • The consultants were unable to find any extension material on accelerated breeding that covered economics or any of the issues listed here	• A valid cost comparison for goats under Australian conditions would require the development of a detailed simulation model +/- field validation, although the comparison would depend very much on specific circumstances (location, season, breed, cost of feed, goat prices and so on)
Examination of the logistics / management changes • Nutrition • Joining times • Parasite control • Breed	• One producer had experienced challenges due to drought over the last few joinings – they were able to provide a large amount of high quality nutrition but despite that fertility	• In sheep in New Zealand in a 5-in-3 system (STAR), the ME requirements of the ewes were 11% higher than in an annual breeding program, which was 17-47% more efficient than an annual program. There was 35% more labour required overall (13.5% more per lamb)		• There is very little detail available in sheep or goats looking into these aspects of management / logistics of accelerated joining systems • This aspect of production could be evaluated using a

Reproductive management variable	Producer consultations	Literature review	Extension material current	Comment
• Geographic locations	appeared to be impeded by the extended dry	• The literature is clear that, to manage a successful accelerated breeding program, females need to be provided with good quality nutrition • The literature suggests that the production pressure on does in accelerated breeding systems makes it vital that worm control and doe health are well managed		simulation model as per one of the recommendations
Impacts of these systems on: • Doe health • Carrying capacity • Markets • Weaner management	• One of the producers chose accelerated breeding for continuity of supply for market, the other identified increasing herd size as a key driver	• Most of the studies into accelerated breeding only lasted a few years • There are no longer-term (ewe/doe lifetime) studies on the longer-term effects on doe health • One of the advantages of an accelerated breeding program is continuity of supply and possibly price premiums for out-of-season product. The consultants were unable to identify any studies quantifying these benefits in the Australia goat meat market • In order to manage breeding every 8 months, kids would ideally be weaned by 10 weeks of age to allow the doe two weeks' rest before re-joining • Strategies to improve weaning success include the provision of creep feed while kids are still on the does • Having a short joining period means there are fewer stragglers, and this can make weaning easier as the size range of kids is tighter		• There is little published about these criteria in sheep or goats. It is anticipated by the nature of the system that carrying capacity will decrease, as annual nutritional requirements of does increase and there are more kids to feed • It is anticipated that the continuity of supply will improve access to some markets but this still might be limited by the volume of product • Doe health is likely to susceptible to the negative impacts of worms and disease due to the more highly stressed nature of this production system. It would be reasonable to expect that the productive life of the doe would be negatively impacted by such a system but there is no available data in sheep or does to substantiate this
Documentation of the critical success factors	• The ability to provide good quality nutrition throughout the year	• The critical success factors for accelerated breeding are likely to include: ○ Early weaning;		• Critical success factors for accelerated breeding have been identified by those who have attempted such systems,

Reproductive management variable	Producer consultations	Literature review	Extension material current	Comment
	• Maintaining the condition score of does • Short kidding time to avoid small stragglers (that struggle at weaning) • Well-timed nutritional support to boost fertility and lactation • Kidding in winter is problematic in cold climates. It is very labour intensive to achieve suitable kid survival rates in those conditions. • Seasonal anoestrous does not impact on production in some areas	○ Ability of does to breed in all seasons and/or to breed while lactating, or shortly after lactation; ○ Sustained high-quality nutrition at all times of the year (which requires good productive land and/or irrigation); ○ A high level of management skill; ○ Rigorous monitoring of the body condition of does; ○ Optimal doe and buck health; ○ Protection / shedding for kids that will sometimes be born when the weather is adverse; and ○ Advanced doe health prevention and response programs		and they should be presented in extension material to ensure that any new adopters understand the risks
Weaning				
Best management factors • Taking weaners to production efficiently and cost effectively • Post weaning feeding, selection pressure, management recommendations	• 16/60 respondents to this question had a split weaning where bucks are weaned earlier than does • Some producers commented that when the season was good and there was a surplus of feed they may wean later. During drought conditions some reported to wean earlier as it was cheaper to feed the weaner than to feed the doe enough to make adequate milk for the weaners • Some producers provided kids with access to creep feed while still on their mothers and they	<u>Weaning</u> • Timing best for kids ○ Australian Industry Standards and Guidelines for Goats, weaning should occur no earlier than 8 weeks ○ Weaning weight may be considered 2.5 times that at birth ○ Weaning by weight results in less weaning shock in kids ▪ Weaning may be based on age or weight ○ Dairy kids weaned at 4-6 weeks suffered more weaning shock than those weaned at 8-10 weeks ○ Dairy kids were either weaned at 10kg (normal weight) or 30 days later. The latter group grew quicker and reached the breeding age (60% of adult weight) one month earlier. But in both	F3 – weaning information	• These management factors would be best evaluated using a desktop modelling program where the variable can be changed easily and the outcomes reviewed

Reproductive management variable	Producer consultations	Literature review	Extension material current	Comment
	thought this assisted the kids to do well after weaning	systems, they were ready to join by 8-9 months ○ Goats that are weaned at 8-10 weeks tend to have a better growth rate at 16 weeks than those that are weaned earlier • Preparation for weaning success ○ Rumen development is vital to successful weaning and growth post weaning. Feeding concentrates in (lambs and calves) stimulate development ○ In Boer cross kids receiving creep (with or without roughage) had better ruminal development ○ In Kentucky kids born in autumn and Spring had the same survival but the autumn born kids grew quicker • Timing best for the doe ○ Weaning to allow the doe time to recover and regain condition before the next joining season. ○ Failure to wean the kids can delay the return to oestrus for the doe and lead to a significant loss of body condition • Failure to wean entire buck kids will result in: ○ Inbreeding (bucks servicing mothers and sisters) ○ Joining of doe kids before they reach a suitable body weight (generally regarded as 70% of adult weight) <u>Weaner care</u> • In weaner goats (French Alpine), those fed high and medium amounts of concentrate, had higher average daily gain and prolificacy than those on low		

Reproductive management variable	Producer consultations	Literature review	Extension material current	Comment
		concentrate diet, but did not impact fort lactation production • In weaner Boer goats, there was no difference in daily gain between those on high and low ME diets		
Maintenance of the does during weaning • Maximum cyclicity post weaning (doe bodyweight, condition score, nutrition/stocking rate) • Mitigating potential for poor performance in 2nd kidding	• The majority of the interviewed producers did not think does had grown out enough by 7 months for joining no matter what the season. This was based on experienced observations for the most part • Stocking rate was not a consideration raised by any producer but they spoke more about providing the right amount of nutrition	• 'Body weight and condition are probably more important than age in determining initial juvenile oestrus, or post-partum oestrus' (Nye 2004) • The connection between BCS and body weight and lamb/kid survival is clear • In McGregor 2005, estimates the maintenance energy requirements for goats by averaging figures from about 22 sources. The estimated energy maintenance for goats is 404.7 KJ ME/kg^0.75. • From 140 days gestation and through lactation does should be fed 2.5 times maintenance • In sheep, Kenyon et al 2014 provide a guide to key condition scores during the reproductive cycle		• Managing all of the production-limiting risks such as weight loss from inadequate or improper nutrition, worms, compromises to health, timely weaning to allow a doe a rest before re-joining • Consideration of the likely impact of photoperiod given and the location and breed of goats

Appendix 4: Audit of extension materials against literature review findings

Foundational reproductive management practices

Extension	Literature review	Extension and research needs / opportunities (priority)
Health and welfare		
Preventative measures for animal health		
General • M3 – obligations in respect to livestock disease and health management and notifiable diseases • M6.2, M6.11 – general diseases • M6.5 – zoonotic disease information Teeth • The MLA extension material does not have a teeth examination/aging chart • The NSW State Government has an AGFACT on aging goats by teeth that provides a good series of photos, although in an old format • F7 – information on four stages of the reproductive cycle and covers in detail condition and nutritional requirements of the doe, but it does not address disease specifically Worm management • M9 – updated – much improved • Internal and external parasites, monitoring, treatment and prevention • W3 and 11, further information • WormBoss goats – grazing management, resistance and resilience, worm testing	• In does, beyond 6 years of age, there is a reduction in birth weight and weaning weight of kids • Lambs born as multiples to ewes with udder lesions tend not to grow as well • This was not a specific topic of the literature review	Extension • Disease prevention information could be divided up as follows: ○ Pre-joining and general doe health: udder health, feet, body condition, nutrition, teeth, parasite control; ○ Pregnancy health: timely doe vaccination to help protect both doe and kid health, abortions, metabolic diseases; and ○ Lactation health: metabolic diseases, mastitis, metritis (uterine infections) **(Medium)** • Develop a disease incursion decision-making tool: ○ How do I know if I have a problem? ○ What are the signs of disease? ○ When should I get help? ○ Who should I call? ○ What should I do while I am waiting for help? **(Medium)** • Include a dental ageing chart with photos of teeth at various ages **(Medium)** • Incorporate all the material into a single unit and/or link to WormBoss goats, including a problem-solving approach to preventing, treating and managing worms **(High)**
Biosecurity		
• Farm Biosecurity web site – very comprehensive guide to biosecurity in livestock production systems. It includes: ○ Biosecurity toolkit for goat specifically ○ Information on how to avoid Johne's disease ○ National kid rearing plan	NA	Extension • Include a link to the Farm Biosecurity website in current material **(Medium)** • Emphasise the importance of biosecurity across all aspects of livestock production **(Medium)**

Extension	Literature review	Extension and research needs / opportunities (priority)
○ A template and supporting material to assist in developing a biosecurity plan • M3 – biosecurity threats to an enterprise • W7 and 9 – importance of biosecurity, how to create and manage a biosecurity plan		
Managing stress		
• F4 – goat behaviour and handling (to assist in handling) • MLA webpage – animal handling, minimising stress – good tips to reduce stress • M4 – goat behaviour and considerations for fencing and handling equipment • M6 – goat handling – in the 'Tools' section, includes a number of strategies for reducing stress while handling goats • M6.9 is about mustering stock and includes further information about ways to reduce stress when handling goats • MLA document 'Requirements for handling goats to maximise eating quality', provides some general tips for reducing stress when preparing, dispatching and transporting goats for slaughter • FutureBeef web page, 'Handling cattle', also provides some detailed information of low-stress handling of cattle and this type of detail (although goat-specific) would be very useful to include in the module, great pictures	• The literature has extensive information about the potential for stress to impact on production. Most of the research has been reported in sheep. Some of the negative outcomes of stress include: ○ Interference with follicular development and ovulation; ○ Reduced sexual behaviour; ○ Reduced daily weight gains; ○ Shorter lactation; ○ Altered hormone production; ○ Reduced embryo survival; ○ Reduced embryo quality; ○ Delayed onset of oestrous; ○ Reduced foetal growth; ○ Ovulation occurring without oestrus; and ○ Longer oestrus. ○ Research on cattle has shown that calmer cows have shorter calving intervals, faster milking speeds and increased fat and protein yields in milk	<u>Extension</u> • Develop material on impacts of stress and methods to avoid it, as part of the animal health and welfare areas of extension, including: ○ Impacts of stress on reproduction (list from lit review, left); ○ Causes of stress (transport, sudden change of diet or insufficient nutrition or water, close proximity of predators, extreme weather events, mustering, handling and husbandry activities); ○ Minimising stress; and ○ Greater risk from stress in more intensive systems such as accelerated kidding **(High)** • Develop more detailed material about low-stress handling (as in FutureBeef), including fear, temperament, moving animals including behaviour, good movement, approach, pressure, mustering into small groups, starting, controlling and the speed of movement (include pictures) **(High)**
Preparing for extreme weather events and other unforeseen disasters		
• M1 – impact of weather patterns and extremes on animal performance • M7 – nutritional requirements in severe weather events	McGregor 2005 'Nutrition and management of goats in drought'	<u>Extension</u> • Highlight the importance of planning and responding to extreme weather events and other unforeseen disasters from a welfare perspective (see next section) **(High)** • Develop extension material about farming in a changing climate – 'resilient' farming – recommended here because there decision-making regarding drought is very much concerned with reproductive management. This material would include: ○ How much supplementation would be needed in times of drought;

Extension	Literature review	Extension and research needs / opportunities (priority)
		○ Making decisions about feeding versus selling stock; ○ Strategies such as electing not to join, joining to minimise multiples and early weaning **(High)**
Observing acceptable animal welfare standards		
• Australian Industry Welfare Standards and Guidelines for Goats • M3 – covers industry obligations and includes a list of the relevant models of codes of practice • 'Fit to Load' – guidance for transport of livestock	N/A	<u>Extension</u> • Ensure welfare considerations for all management tools, breeding programs and procedures are included in the extension material (for example, selecting kidding time when weather is favourable to kid survival or providing alternative shelter) **(High)** • Develop a welfare-specific module/unit in future extension material. This might include: ○ Importance of welfare; ○ Producer responsibilities and obligations; ○ Legislation, codes, standards; ○ Signs of poor welfare; ○ Consequence of compromised welfare; ○ Production cost of losses and poor welfare; ○ Potential cost to industry (market access) of poor welfare management **(High)**
Nutrition, body weight and body condition score		
Nutrition		
• M1 – calculating feed availability and dry sheep equivalent (DSE) ratings of the herd • M2 – calculating the cost of production and budgeting • F6 – calculating DSEs, stocking rate, carrying capacity and the effect of the reproductive cycle on these parameters • F7 – nutritional requirements, BCS of does in the various stage of the reproductive cycle • F8 – pasture growth curve, fundamental to planning of kidding time in many production systems • M7 – **NB updated in last week of May 2019** – entirely on nutrition, includes the requirements for different	• Comprehensive reviews are found in Jolly 2013 and McGregor 2005 (drought) • Most extension material from across the world quotes NRC (1981 or 2007) data, which is not based on Australian breeds and is mostly from experimental situations and small number of animals • The impact of inadequate nutrition on reproductive outcomes in goats and sheep is well documented in the scientific literature and include: ○ Reduced stress response in offspring: ○ Reduced production of progesterone and increased embryonic mortality in first-pregnancy ewes; ○ Slower onset of oestrus after synchronisation; ○ Reduced ovulation and pregnancy; ○ Higher embryonic mortality;	<u>Extension</u> ○ Combine all the nutritional material into one comprehensive guide **(High)** ○ Enhance extension material on nutrition by including a feed on offer (FOO) pasture +/- browse guide with pictures that assist with the visual assessment of pasture availability in temperate climates, from Lifetime Ewe Management **(Medium)** ○ Develop a body condition guide for goats that includes pictures and is also available as an app or ute guide **(High)** ○ Emphasise the importance of measuring the condition score of livestock, including the reproductive parameters shown to be influenced by body condition score (see literature review) **(High)** ○ Develop a reproduction planner for goat meat production systems, including variables such as: ○ Season;

Extension	Literature review	Extension and research needs / opportunities (priority)
types of goats in various metabolic states. It describes temperate and rangeland pastures and variation in feed quality throughout the year • Best practice videos (x4) – calculation of feed demand and budgeting (for pasture and browse) • W12 – total grazing pressure and goats • EverGraze – regional pasture growth curves • Tool 8.4 'Making More from Sheep' – feed budgeting template • Feed on offer photo gallery 'Lifetime wool' and pictures to assist with the visual assessment of pasture availability in temperate climates	○ Delayed puberty; ○ Induced anoestrus; ○ Effects on the metabolic and physiological health of the adult and offspring; ○ Decrease in milk yield; ○ Reduced birthweight; ○ Reduced growth rate of kids; ○ Decreased perinatal lamb survival; ○ Permanent changes to the wool follicle population of lambs; ○ Decreased quality and quantity of sperm production; ○ Negative impact on embryonic development; and ○ Insufficient energy in colostrum to support twin lambs. • Maintenance data in the literature varies considerably and is mostly derived from experimental situations ○ Average of 22 sources estimates that maintenance for goats is 404.7 kJ ME/kg$^{0.75}$ ○ From 140 days' gestation and through lactation does should be fed 2.5 times • Some goats may be able to alter their energy requirements by 65% in times of poor pasture availability • Response to increased nutrition differs between breeds • More concentrated supplementary fed is recommended for heavily pregnant does • In sheep, overfeeding after joining can affect embryo survival. • In sheep, poor nutrition of the ewe during pregnancy can affect lamb birth weight, wool follicle production, wool production, growth, carcass quality, reproductive potential • Improved condition in sheep increases ovulation, reduces embryo mortality • Improved nutrition goats has led to longer breeding season (Payoga goats), increase in milk	○ Pasture availability; ○ Other key on-farm activities; and ○ Likelihood of extreme weather events such as extreme and prolonged heat and cold (which can dramatically affect kid survivability and joining success) **(Medium)** <u>Research</u> • Validate the maintenance requirements for some key goat breeds and crosses in a variety of climatic conditions, using the recommendations of McGregor (2005) and Jolly (2013) as a basis **(Medium)** • Validate the proposed feeding curve for pregnant/lactating does of McGregor (2005) **(Medium)** • Validate the recommended condition scores of does at various steps in reproductive cycle, for different breeds at different locations **(Medium)** • Evaluate the cost-effectiveness of supplementing does in late in pregnancy in order to boost colostrum production (this could be done in conjunction with a study of shedding to improve kid survival – see below) **(High)** • Develop or adapt a module/unit on goat farming in a drought, including among other things: ○ Guidance on feeding vs culling ○ Principles of adaptable and resilient farming **(High)**

Extension	Literature review	Extension and research needs / opportunities (priority)
	yield, birth weight, growth rate of kids (hairy goats) • Over feeding in ewes can cause dystocia • In ewes, the foetal, placental weight and vascular development increases exponentially from 50-60 days gestation • In Angora goats, maidens raised on better nutrition had greater joining weight, number of kids weaned (Sth Africa)	
Condition scoring		
• M6 – BCS guide no pictures of animal in various BCS • BCS Guide by the American Institute for Goat Research is useful and includes pictures	• Kenyon et al 2014 provide a guide to key condition scores during the reproductive cycle in sheep ○ Biggest gain by ensuring all animal are above a target minimum ○ Relying on average BCS of flock means many will be below the minimum • Gosh et al 2019 provided recommended BCS for various physiological states. (The scientific background for this was unclear but BCS were similar to slightly higher to those described in sheep). • In sheep, higher BCS has been associated with increased length of breeding season, ovulation rate, pregnancy rate, embryo survival, lamb survival and lamb growth (but there is a curvilinear relationship between BCS and conception rate, and number of lambs born) • Ewes in low BCS tend to have a better response to increased nutrition than those in higher BCS	
Body weight		
	• As ewe weight increases there is a reduction in lamb deaths and an increase in lamb growth rate • Larger does tended to have kids that were heavier at 10, 20, 30 weeks (Mebende goats, Uganda)	

Extension	Literature review	Extension and research needs / opportunities (priority)
Management of joining, kidding and weaning		
• F7 – some management recommendations for doe care for the various stages in the reproductive cycle. It states; 'The preferred practice is to allow maiden does to grow out for another 6-12 months in controlled mating enterprises'. • M1 – the suitability of a property for breeding in respect to climate, shelter and other factors • M6 – some management information in a table for the various stages of reproduction for both and extensive and intensive systems (this table is in a difficult format to read and stay engaged with)	<u>Milk production</u> • Improved nutrition in early lactation improved milk production in feral and Boer goats (11.5% more) • Cashmere does fed more in the last month of pregnancy had heavier kids at birth and they remained heavier through the testing period until 10 months of age • In Boer goats, milk production increased with age, parity (until 5th lactation) of the doe and litter size • The lactating ability of a doe is determined by its breed, nutritional status and a variety of other factors. Young Boer goats tend to respond (in terms of lactation) better to an increase in litter size than older goats. <u>Birth to weaning</u> • In Nashville, Kiko had better birth to weaning performance than Boer and Spanish <u>Weaning</u> • Timing that's best for kids ○ Australian Industry Standards and Guidelines for Goats, weaning should occur no earlier than 8 weeks ○ Weaning weight maybe considered 2.5 times that at birth ○ Weaning by weight has less weaning shock in kids ○ Weaning may be based on age or weight ○ Dairy kids weaned at 4-6 weeks suffered more weaning shock than those weaned at 8-10weeks ○ Dairy kids were either weaned at 10kg (normal weight) or 30 days later. The latter group grew quicker and reached the breeding age (60% of adult weight) one month earlier.	<u>Extension</u> • Develop an interactive reproduction planning tool that allows producers to consider different options for: ○ Age of first joining; ○ Age of weaning; and ○ Accelerated breeding programs (see below), based on considering the risk, financial return, nutrition and disease management at their location with their breed of goats **(High)** • Highlight and emphasise the importance of controlled joining and weaning, including: ○ Better goat health and welfare; ○ Ease of targeted nutritional supplementation ○ Saving of management time (shorter period of supervision at kidding); ○ Increased opportunity for does to recuperate before re-joining; ○ Better timing of kidding and weaning to match nutrition and weather; ○ Avoidance of unwanted matings, siblings and small maidens; ○ Reduced variation in kid age and size, allowing ▪ More successful weaning (fewer small kids); ▪ Easier establishment of a line of goats for sale; and ▪ Greater ease of mob movement without dealing with newly born kids **(High)** • Merge and refine the extension material on the management of joining, kidding and weaning. Use a contemporary and interactive format that allows the reader to link to relevant information located in different sections, such as nutritional needs and condition scoring charts. Upgrade content to make clear the foundational practices **(High)** • Include more detailed information on the advantages, risks, costs and techniques of: ○ Creep feeding; ○ Shedding; ○ Different weaning times; and

Extension	Literature review	Extension and research needs / opportunities (priority)
	But in both systems, they were ready to join by 8-9 months ○ Goats that are weaned at 8-10 weeks tend to have a better growth rate at 16 weeks than those that are weaned earlier • Preparation for weaning success ○ Rumen development is vital to successful weaning and growth post weaning. Feeding concentrates in (lambs and calves) stimulate development ○ In Boer cross kids receiving creep (with or without roughage) had better ruminal development ○ In Kentucky kids born in autumn and Spring had the same survival but the autumn born kids grew quicker • Timing that's best for doe ○ Weaning to allow the doe time to recover and regain condition before the next joining season. ○ Failure to wean the kids can delay the return to oestrus for the doe and lead to a significant loss of body condition • Failure to wean entire buck kids will results in: ○ Inbreeding (bucks servicing mothers and sisters) ○ Joining of doe kids before they reach a suitable body weight (generally regarded as 70% of adult weight <u>Weaner care</u> • In weaner goats (French Alpine), those fed high and medium amounts of concentrate, had higher average daily gain and prolificacy than those on low concentrate diet, but did not impact fort lactation production • In weaner Boer goats, there was no difference in daily gain between those on high and low ME diets	○ Different ages of joining maidens **(High)** <u>Research</u> • Conduct a study to further clarify the production and financial effects of supplementary feeding does for a week before kidding to boost colostrum production (possibly in conjunction with shedding study – see below) **(Medium)** • Compare the outcomes of creep feeding / trail feeding kids before weaning, including changes in: ○ Growth rate; ○ Weight at weaning; ○ Post weaning growth; and ○ Post-weaning survival **(High)**

Extension	Literature review	Extension and research needs / opportunities (priority)
	Joining • Suitable body weight for first joining generally regarded as 70% of adult weight • Joining doe kids before they are of an appropriate weight can impact on their lifetime productivity. It might also result in an unsuccessful pregnancy or difficulties due to size at kidding time (dystocia) and a compromise in health and welfare	
Measuring and recording		
• M3 – industry record-keeping requirements • M5 – recording of raw data from the herd such as bodyweights • M11 – record-keeping for depots (for quality assurance purposes) • F7 – monitoring performance – includes some of the parameters that can be measured and how those measurements can be used to improve productivity	• Reporting and recording were in the literature particular in response genetic improvement by selection from within the herd • Careful measurement allows the identification of subtle changes in reproductive performance due, for example, to the presence of a subclinical disease in the does or bucks • Measurement and recording are essential to genetic selection programs. The unique identification of individuals is also required. Electronic ear tags are being used by some to improve their recording and for the use of automated drafting facilities	Extension • Emphasise the value in measuring and recording for: ○ Determining enterprise profitability; ○ Measuring production gain; ○ Identifying poor performers; ○ Early detection of disease; ○ Calculating improvements or otherwise from changes to management such as target feeding; and ○ Easier ongoing assessment of profitability given season changes to aid decision making **(High)**
Reproductive problem solving		
• No problem solver was found in the extension material		Extension • Develop a reproductive problem-solving tool for extension purposes, possibly presented as a flowchart, to allow a producer to investigate why their enterprise is not achieving expected reproductive outcomes such as target kidding percentages **(Medium)**

Tools to improve reproductive performance

Extension	Literature review	Extension and research needs / opportunities
Genetics		
• Sheep Genetics – resources on KIDPLAN	• KIDPLAN has three EBVs concerned directly with fertility: ○ Number of kids born (NKB);	Extension

Extension	Literature review	Extension and research needs / opportunities
• MLA has expansive extension material on genetics over a number of media forms • BP video – goat genetics • M5 – goat selection and breeding, including information on breeding objectives, breeding and selection tools, introducing animals to a new environment and artificial breeding • W2 –'Genetic improvement and parasite management – what you need to know' • W8 – 'Genetic improvement within your herd – are you getting the most bang for your buck with your selection program?' • FutureBeef – good section on cross breeding (simplified) • M9 'Making More from Sheep' – 'Gain from genetics' module with particular focus on genetic gain in relation to sheepmeat and wool traits (some relevance to goats)	○ Number of kids weaned (NKW); and ○ Scrotal circumference (yearling and hogget measurements) • Producers are also selecting for positive traits (and against negative traits) within their own herds, for example in parasite resistance, growth rates, muscling for meat and mothering • Reproductive traits generally have low heritability (in sheep; ovulation rate (0.15), litter size (0.13) and lambs weaned (0.05)) • Recording of reproductive EBV data is less common than for carcase and growth traits • Aldridge (2017) recommends kid survival should be included among EBVs • Genetics is important in optimising accelerated breeding programs (seasonality, ovulation rate) • In ewes, selection for improved reproductive performance over 11 years resulted in an increase in lambing rate of 87% compared to the control group 70% • In sheep, selecting for lamb fertility might negatively impact growth • Selection can improve out-of-season breeding and length of breeding season • Crossbreeding can be used to increase litter size (must also monitor weaning rate) • Crossbreeding with Boer goats has also been used extensively in Australia to improve the productivity of rangeland goats, improving cycling and ovulation earlier in the breeding season, prolificacy, litter size and growth rate at weaning • However, rangeland goats have a greater flight zone and are less calm than Boers • Calmer ewes have been shown to have lower mortality in their lambs and the same is probably true for does • As with any intervention to improve reproductive performance, genetic approaches need to be applied carefully, requiring observation, monitoring and recording to detect the emergence of any negative changes	• Combine extension material on genetics of reproduction into a single reference source, crosslinked to M5, possibly organised into: ○ Crossbreeding; ○ Within-breed selection; and ○ Within-herd selection **(High)** • Material should include, unless otherwise covered in M5: ○ Consideration of benefits and risks of manipulating genetics in a goat herd; ○ Emphasis that 'natural selection' or 'survival of the fittest' are not acceptable ways to select for improvement in any farmed livestock population (e.g. allowing animals to die from worm burdens to identify resistant phenotypes); ○ Favourable and unfavourable correlations between traits and the need to plan to deal with them (e.g. increased litter size can be associated with reduced kid survival, necessitating pregnancy testing, increased nutrition of does and possibly shedding or other steps to improve kid survival); ○ Ensuring sufficient genetic variation to protect the herd from becoming inbred – selection solely from within a closed herd is not sustainable; and ○ The value and application of KIDPLAN **(High)** • Consider, through Sheep Genetics, opportunities to increase the involvement of producers in KIDPLAN to expand the database and enable it to be a more effective genetic selection tool, e.g. by targeted programs that reward producers for contributing data to the KIDPLAN database (similar to the SG initiative to increase the collection of data on worm egg counts in sheep several years ago) **(Medium)**

Extension	Literature review	Extension and research needs / opportunities
Hormonal intervention		
• M 5 Brief reference to its use in AI and ET in goats • No detail available in sheep extension material	• In sheep sponge and CIDR produced similar results • In sheep, progesterone-impregnated CIDR plus ram effect brought forward oestrous • Boer goats have been synchronised with progesterone CIDR, prostaglandin and eCG • Common hormone manipulation of oestrous involves progesterone by CIDR or sponge • Prostaglandin causes luteolysis and induces ovulation, and is only really useful within the breeding season • Two doses of prostaglandin needed to ensure most animals respond • In ewes, 2 doses of prostaglandin less effective than progesterone • Melatonin with progesterone and eCG increased conception rate in ewes in NZ • Melatonin with the buck effect was more effective than the buck effect alone at advancing kidding and improving fertility and prolificacy • Inducing ewes to breed can have four outcomes: ○ Ovulate and conceive ○ Ovulate but not display oestrous ○ Display oestrous and mate but neither ovulate nor produce a CL (rare) ○ Display oestrous, ovulate but fail to conceive (most common) • Hormones are costly and require skill in handling and use to ensure the welfare of the animals and human health is maintained • The cost is unlikely to be justifiable in a commercial goat meat enterprise, except perhaps in a program to build up numbers of genetically superior animals for breeding stock	<u>Extension</u> • Develop a section in the extension material on the use of hormones to manage oestrous in goats, including: ○ Indications and contraindications, restrictions and risks associated with use (including workplace health and safety, market access constraints) ○ Brief description of the three main hormones: progesterone, prostaglandin and melatonin; ○ Broad description of how they are used generally: means of administration, management required, regime (in broad terms), workplace health and safety considerations; and ○ Emphasis that hormone treatments are prescription-only in Australia and should only be only used under the supervision of a veterinarian **(High)** <u>Research</u> • Undertake a desktop benefit/cost analysis of using hormones to synchronise does or induce does in anoestrus to cycle **(Low)**
Light therapy		
• Light therapy is not covered in the extension material	• In goats, photoperiod manipulation can allow out-of-season breeding in temperate and sub-temperate regions by initiating sexual activity in does and bucks • It is not effective at synchronising goats • Light (with progesterone or progesterone and eCG) did not increase reproductive performance in ewes in NZ	<u>Extension</u> • Develop some brief material on the application and risks of light therapy **(Low)** <u>Research</u> • Investigate the response, cost and practicality of using light and melatonin to manage photoperiod **Low**

Extension	Literature review	Extension and research needs / opportunities
Targeted nutritional flushing		

• The extension material covers nutrition very comprehensively but there is little reference to the use of targeted / adaptive / focussed nutrition	• In studies in sheep and goats targeted supplementary nutrition has been shown to:
	  ○ Improve sperm production;
	  ○ Increase ovulation rate;
	  ○ Improve colostrum production; and/or
	  ○ Improve kid survival.
	• Producers can positively impact fertility, birth weight and colostrum production by providing targeted supplementation at specific points in the reproductive cycle, for example before mating, in the last six weeks of pregnancy or in the last week before kidding
	• Other studies have shown that feeding late pregnant ewes or does additional concentrate, even where the diet is already adequate, will improve colostrum production.
	• Improved colostrum production has been associated with better lamb / kid survival and a better ewe-lamb bond. This nutritional supplementation may only need to be provided for a week and will therefore not alter significantly the weight of the lamb / kid such that the risk of dystocia is increased
	• In addition, supplementation is better provided as a concentrate in late-pregnant ruminants (especially those bearing large litters) because of the reduced abdominal space for the rumen to expand
	• In sheep increase nutrition during last few days of oestrous cycle may increase ovulation rate and litter size
	• Flushing is providing addition food to does from 30 days prior to 30 days after joining, may improve fertility, pregnancy rates, higher number of multiple births
	• In ewes in India those fed 200-300g supplementation (unknown quality) for 2 weeks prior to joining had increased; twinning, total number of lambs born, lambing percentage
	• Nutritional manipulation to optimise reproductive outcomes is clean, green and ethical
	• Ewes fed lupins, maize or barley in last week of pregnancy produce more colostrum
		<u>Extension</u>
		• Expand the extension material to include targeted nutritional supplementation of does at critical points in the reproductive cycle, and the
		  ○ Benefits;
		  ○ Costs; and any
		  ○ Risks associated with such supplementation **(High)**
		• Advise caution in increasing fertility, as advantages are quickly restricted by the doe's ability to feed more than one kid, decreasing size and survivability of kids born and overall loss **(High)**
		<u>Research</u>
		• Undertake a desktop benefit/cost analysis of providing increased nutrition at key times in the reproductive cycle **(High)**

The buck effect		

Extension	Literature review	Extension and research needs / opportunities
• M6 – brief description of the buck effect	• The buck effect requires separation from does from one month at a distance no less than one kilometre • It can induce puberty, synchronise females, stimulate cycling – in ewes, the first cycle can be advanced by 2 weeks • It is regarded as 'clean green and ethical' • In sheep, response varies between breeds, time since last lambing, season, body condition, physiological state • In goat, response varies with breed and latitude, and sexual activity cannot be induced during anoestrous period in highly-seasonal goats • The use of photoperiod manipulation of bucks and does prior to the buck effect improved the response, as did nutritional supplementation of does • In US, the buck effect can deliver almost year-round cycling and improved oestrous behaviours • The buck effect can be used for AI, focused feeding • Synchronisation using (for example) the buck effect would facilitate shedding as kidding dates can be calculated more accurately • The buck effect could also be used to optimise the chance of a successful mating period, for example by delaying joining where adverse weather is forecast • As the buck effect is so powerful in some herds, producers need to be sure to provide a sufficient buck: doe ratio • A variation of the buck effect is to introduce the buck to a portion of the mob initially and then add further small mobs of does to the main mob every 10-14 days, maximising the number of births that occur every couple of weeks, facilitating the use of limited shedding space and/or spreading the labour of tagging • The buck effect may not be as useful in extensive rangeland enterprises with very large joining paddocks	<u>Extension</u> • Expand the section of the buck effect to provide further information on indications for use (e.g. synchronising does for targeted feeding, shedding etc) and the risks or possible challenges associated with its application **(High)** <u>Research</u> • Undertake a desktop benefit/cost analysis of using the buck effect considering possible production gains, shorter kidding period, fewer straggler kids, shorter and more targeted feeding period **(Medium)** • Conduct research to identify ways to more effectively exploit the buck effect, especially in extensive pastoral regions, assessing the limits of the buck effect in terms of paddock and mob size and percentage of bucks **(Medium)**
Pregnancy testing		
• F7 – productivity benefits of pregnancy testing • 'Making More from Sheep' – M10, 'Wean more lambs' includes information on pregnancy testing	• In goats, transabdominal ultrasound can detect pregnancy at 30-35 days, and at 40-70 days to count foetuses	<u>Extension</u> • Expand the information on pregnancy testing in the extension material, ideally including the results of financial modelling of the benefit/cost of pregnancy testing, and/or a calculator with

Extension	Literature review	Extension and research needs / opportunities
• 'Making More from Sheep' – Tool 10.7 outlines some of the advantages of pregnancy scanning and much of this information could be included in the goat material	• Accuracy to detect number of foetuses reduces beyond two – for three of more foetuses, scanning is best done at 7 weeks' gestation • In sheep, scanning is either for wet / dry (can remove dry animal from flock, save feed cost) or differentiating singles and multiples (through more specific targeted feeding) • The value of scanning increase when perform during a poor season (feed is limiting) • The value of scanning for multiples increases with foetuses/100 females • Cost can be a limit the use of ultrasonography especially for those properties that are geographically isolated. The cost of travel for a suitably qualified technician may be uneconomic unless the herd is large, and there are many does to be scanned • The impact on the welfare of the female should be considered when choosing a method of pregnancy diagnosis – testing that involves tipping the animal over and/or insertion of a probe is more likely to cause distress than procedures than can be completed with the animal standing and the probe placed on the external skin surface • Ultrasound pregnancy diagnosis is 'clean green and ethical', non-hormonal and non-invasive	which goat breeders can estimate the benefit/cost ratio for their own enterprise **(High)** <u>Research</u> • Undertake a desktop benefit/cost analysis of scanning in various goat meat production enterprises, in various locations in various conditions (e.g. dry conditions when feed is limiting) **(High)**
Reducing kid mortality		

M6 – information on shelter, predation, nutrition and health in the period around birth in intensive and extensive systems	• Lamb survival was increased in crossbred (10%) and merino (12%) ewes when shelter was provided
	• Adequate colostrum distends the lamb's gut and increases the ewe-lamb bond
	• The size of the mob at lambing can affect lamb survival (e.g. <200 – 93.3%, >200 – 79.8%)
	• In cashmere goats, does that were supplemented had reduced kid mortality up to 16 days of age post birth
	• In ewes in NZ, the was a notable rise in lamb mortaility for those less than 3kg and more than 9kgs, while lambs born less than 1.5kg did not survive
		<u>Extension</u>
		• The current project on kid mortality should assist to provide further extension material for this section. Kid mortality is an area of **high priority**.
		<u>Research</u>
		• Perform a detailed production and financial study of one or more enterprises in which does are shedded around kidding time, to provide guidance to others considering this approach. Include:
		  ○ Infrastructure costs; and
		  ○ Implications of splitting the kidding time to make best use of the infrastructure **(Medium)**

Advanced breeding programs

(As there is very little if any extension material already available on advanced breeding programs that column has been deleted)

Literature review	Extension and research needs / opportunities
Accelerated breeding	
General • The vast majority of the research into accelerated breeding programs has been conducted in sheep, the most relevant being De Nicola's 2007 PhD on 'Accelerated lambing and out-of-season lamb production in New Zealand' • Most of the studies do not include a control/annual breeding group, nor did they continue through the whole of the animals' reproductive lives, so the longer-term success and sustainability of the systems have not been well assessed • The diversity of goat enterprises, in geography and management styles, makes it a challenge to devise a 'one size fits all' approach to accelerated breeding – for example, high temperatures can reduce sexual activity, slow foetal growth, reduce appetite, reduce milk production and increase stress • Trying to mate during lactation will provide some challenges with a decrease in pregnancy and kidding rates and an increase in prenatal wastage • In sheep in one study, in comparison to a conventional program, the accelerated system resulted in: ○ Higher average breeding and pre-lambing ewe live weights; ○ Lower average pregnancy rate, due to the lower pregnancy rate out-of-season; ○ More lambs born and weaned per ewe; ○ Lower average lamb birth weights; ○ Similar average lamb mortality rates; ○ Lower weaning weights (but weaning occurred 10-36 days earlier than in the conventional system); and ○ Increased production costs (labour, feed, hormone treatment) • Advantages of the accelerated system are: ○ Having a supply of marketable animals at different times of the year; ○ Achieving a premium price for stock market outside the 'typical' breeding system; ○ Some constancy of nutritional requirements throughout the year, with less dramatic variation in demand compared with a single-kidding system; ○ Reduced vulnerability of the herd to disease outbreaks or severe weather events (not all offspring are born at the same time); ○ More consistent use of staff and infrastructure throughout the year; ○ Potential for improved total production of goat meat annually; and ○ Potential for increased profit • Disadvantages are: ○ Ongoing presence of disease-susceptible animals (e.g. orf) can mean disease persistence year-round – vaccine may be required to manage this issue; ○ Heavily-populated or frequently-used paddocks can become conducive to worm larvae survival, making it much harder to preserve a 'rested' paddock for young stock;	<u>Extension</u> • Develop extension material on accelerated breeding programs, including the various approaches, the systemic considerations associated with each program (matching physiological demands with feed availability, seasonal anoestrus and so on) and the advantages, disadvantages and risks associated with each. The importance of having the foundational reproductive management practices in place prior to trialling an accelerated breeding program should be emphasised **(Medium)** <u>Research</u> • Develop a desktop model to evaluate the benefit/cost of accelerated breeding program for a goatmeat enterprise **(Medium)** • Based on outcomes from modelling, prospectively establish a long-term evaluation of a 'best-bet' accelerated breeding program under commercial conditions, designed to identify the benefits, costs and risks associated with the program **(Medium)** • Alternatively, evaluate accelerated breeding systems in existing enterprises over the lifetime of goats to assess impact / profitability over a generation, in particular: ○ Effect on the breeding life of the does; ○ Cost of nutrition and any interventions to induce cycling; and ○ Ideally, a comparison to an annual breeding mob run at the same time under the same conditions **(High)**

Literature review	Extension and research needs / opportunities
○ Identification and administration of appropriate nutrition for multiple births may be delayed, increasing the likelihood of pregnancy toxaemia; ○ Running poor ewes with lactating ewes might increase the spread of Johne's disease to other does and kids; ○ It is more difficult to enforce age separation which could facilitate the spread of disease; ○ Vigilance is required about the removal of rams after a defined joining time or management becomes chaotic; and ○ Kidding at different times of the year is a compromise • Accelerated lambing systems require supplementary feeding, changes to the herd structure and stocking rate and other adjustments. Failure to manage nutrition properly increases the risk of metabolic diseases such as pregnancy toxaemia, especially in does bearing multiples, and poor condition in other classes of stock • Main challenges are: ○ Overcoming seasonality, possibly requiring hormonal intervention to achieve out of season breeding; ○ Increased time spent in management (especially in extensive grazing systems); ○ Cannot match kidding to pasture curve, requiring constant attention to nutritional requirements, increased cost of supplementation; and ○ Cannot allow worm, health issues to limit production at all • For an accelerated breeding program to be a success a number of important herd management and environmental factors need to be in place, namely: ○ Early weaning; ○ Ability of does to breed in all seasons and/or to breed while lactating, or shortly after lactation; ○ Sustained high-quality nutrition at all times of the year (which requires good productive land and/or irrigation); ○ A high level of management skill; ○ Rigorous monitoring of the body condition of does; ○ Optimal doe and buck health; ○ Protection / shedding for kids that will sometimes be born when the weather is adverse; and ○ Advanced doe health prevention and response programs.	
Two kiddings per year	
• There are only a few research articles on twice-a-year production systems and they were all on sheep and mostly from the 1960-70's • There was no literature investigating and describing the impacts on the lifetime productivity of the does or ewes and profitability in the longer term • Twice a year lambing in Awassi sheep (Turkey) showed 60% reduction in pregnancy rate in second joining • 2-in-1 system in sheep in Canada produced 3.54 lambs per ewe per year • In a 2-in-1 system in sheep in Finland, there was no decline in reproductive performance over the trial (4 years), 21.9% ewe wastage annually • In a 2-in-1 system in sheep, 36% of lambs born were from ewes that lambed in the previous cycle ('bonus' lambs)	

Literature review	Extension and research needs / opportunities

Three kiddings in two years
• There have been various studies in sheep and only very few purely goat-focused studies, on 3-in-2 two breeding
• The main challenge was getting the does and sheep to cycle in the non-breeding season
• Most studies showed an increase in production with accelerated breeding, but again the majority of the studies were short and did not allow evaluation of long-term outcomes
• Those studies that included nutritional information found in sheep that energy requirements were more consistent across the year and that the overall increase in energy requirement for the doe was 11%, equating to an increase in efficiency of 17-47%
• Another study found that by extending the time from lambing for the first and second-lamb ewes from 75 to 90 days improved the lambing rate, number of lambs per ewe, litter weight at birth and the condition of ewes at mating
• Summary of research trials:
  ○ Crossbred ewes in Australia ; 41% more lambings than annual system
  ○ Merino Rambouillet ewes, in Mexico 3 in 2, increase in production at birth 37% and weaning 28%.
  ○ Kivircik ewes in Pakistan, increase in production at birth 15% and weaning 19%.
  ○ Beetal goats, Pakistan, more kids per doe in 3 in 2 than annual.
  ○ Crossbred ewes in Australia, Over 1/3 more lambs born in 8 monthly joining than February joining alone. There was variation in performance between breeds.
• Economic analysis estimated a return per ewe over the 7 years of the study was $755 compared to $357 (annual spring lambing) or $517 (annual winter lambing) in Canada
STAR/CAMAL/5 kiddings in 3 years
• STAR system (studied in NZ over 3 years)
  • 35% more labour input (13% higher per lamb weaned),
  • 6% higher energy requirement (because of the increase in lamb production, on a per kilo of lamb basis the energy requirements is 6% lower)
  • Total weight of lambs weaned was 26,200 kg and 24,300 kg for the accelerated and conventional systems respectively
• Summary of research trials
  ○ CAMAL system in Awassi ewes in Turkey, with hormone stimulation had no increase in lambs born overall
  ○ Morlam ewes with continuous ram access compared to Dorset ewe joined every 2 months. 1.28 Morlam lambs and 1.21 lambs for Dorset's born annually.
  ○ Dorset ewes in US, STAR system, average 0.98 lambings per year, delivered 1.5 and weaned 1.23 lambs	

Assisted reproductive technologies	
Artificial insemination (NB: M5 includes the main uses and the overall gains from using AI and ET. It does not include procedural details, specific costs or risks associated with the procedures including impacts on the health and welfare of the goats) • Fresh semen can be used when all the does to be inseminated are within a short distance from the source, that is, at the same location or on properties within a short travel distance away	<u>Extension</u> • Expand the extension material on assisted reproductive technologies, to include an overview of the various techniques and the advantages, disadvantages and risks of each and principles of decision-making about whether to use them, but

Literature review	Extension and research needs / opportunities

• Frozen semen maybe kept for many years, allowing bucks with preferred traits to be used for breeding for a period well beyond their natural life
• Acceptable pregnancy rates are achievable with:
  ○ Fresh semen, using pericervical or intracervical AI – intrauterine insemination via the cervix with fresh semen gives similar results to natural mating in does
  ○ Frozen semen, if deposited in the uterine lumen via laparoscopic or transcervical techniques
• Advantages:
  ○ Controlling reproduction and, in conjunction with progeny testing,
  ○ Improve meat production of goats Precise kidding time (at particular season, and over a limited time);
  ○ Facilitation of supplementary feeding, to meet the increased requirements of does during lactation;
  ○ More efficient genetic selection and improvement;
  ○ Increasing the number of offspring per sire;
  ○ Vast and rapid diffusion of improved genetics;
  ○ Minimisation of the risk of disease associated with reproduction; and
  ○ In the case of frozen semen, 'spatial and temporal…dissociation between collection of spermatozoa and fertilisation'
• Advantages of AI:
  ○ Efficient genetic gain
  ○ Precision of kidding
  ○ Targeted feeding,
  ○ Shedding of does at kidding (if desired), and
  ○ Ease of management for kidding, weaning and marketing.
• Progesterone-impregnated CIDRs or sponges are commonly used to synchronise does. Does are then given a dose of prostaglandin with or without pregnant mare serum gonadotropin (PMSG) at the time of removal of the CIDRs or sponges. One producer advised that PMSG has recently been taken off for use in goats and that alternatives are being trialled. Alternatively, two injections of prostaglandin given 9-10 days apart is effective at synchronising most does
• Bovine semen can be sorted into sexes with 90% accuracy (no report in goats)
	there is no requirement for technical details, rather a referral to sources of further information or the appropriate experts **(Low)**

Embryo transfer	

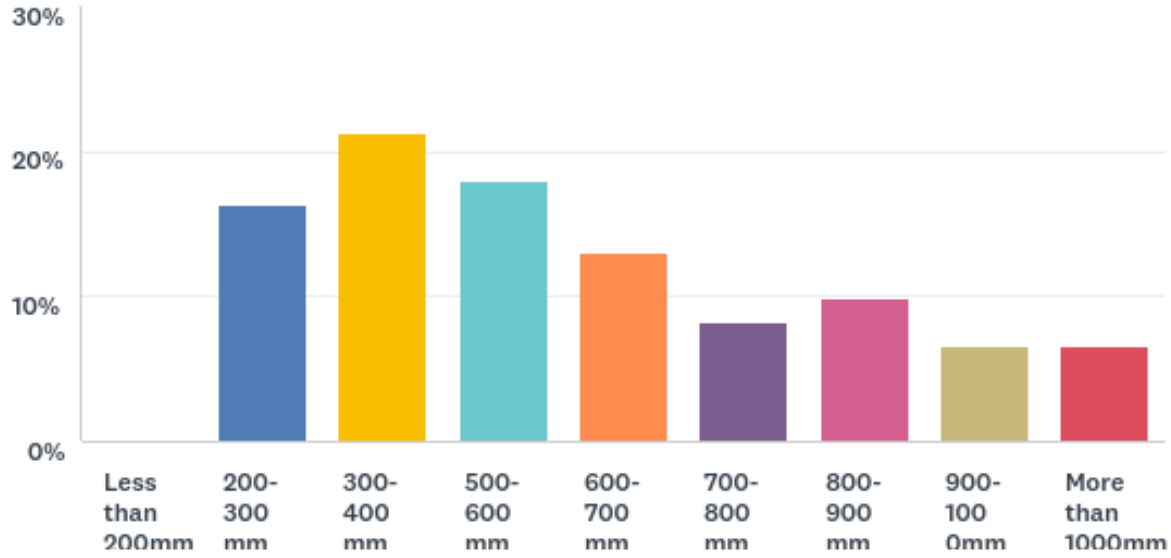
• ET is much more complicated than AI, involving:
  ○ Oestrus synchronisation of donor and recipient;
  ○ Fertilisation of donor (natural or artificial insemination);
  ○ Embryo recovery from donor; and
  ○ Transfer of embryo into the recipient.
• Advantages include:
  ○ Rapid introduction and multiplication of new breeds or desirable traits;
  ○ Increased genetic progress from more intensive selection on the female side and reduced generational interval by allowing both younger males and females to breed;
  ○ Reduced risk of disease spread (early developing embryos are protected against many infections); and
  ○ Support for other reproductive technologies such as sex determination and cloning;	

Literature review	Extension and research needs / opportunities

• Disadvantages include:
  ○ Cost;
  ○ Requirement for hormone treatment of both donor and recipient; and
  ○ Processes of collecting and implanting embryos are invasive and technically challenging, requiring expert skills
• Multiple ovulation and embryo transfer (MOET):
  ○ Involves the use of hormones to stimulate multiple ovulations, increasing the number of offspring that can be produced per female per cycle of treatment
  ○ Has had unpredictable success, and with its high cost the technique has had limited its use in goats
• In vitro fertilisation is lower cost
• Juvenile in-vitro embryo transfer (JIVET), using ova from pre-pubertal (3-4 months old) females, can be used to further reduce the generation gap and increase genetic gain
  ○ Laparoscopic ovum pickup (LOPU) – harvesting oocytes through laparoscopic aspiration of follicles under anaesthetic:
  ○ Requires an experienced operator and general anaesthetic for the donor animal while the laparoscopy is performed, creating the potential for unreasonable compromise to welfare of the animals
  ○ Has no impact on onset of puberty, future fertility or growth
• Cost of cloning is likely to be prohibitive for use in goat production systems for now	

Appendix 5: Detailed results from producer survey and consultations

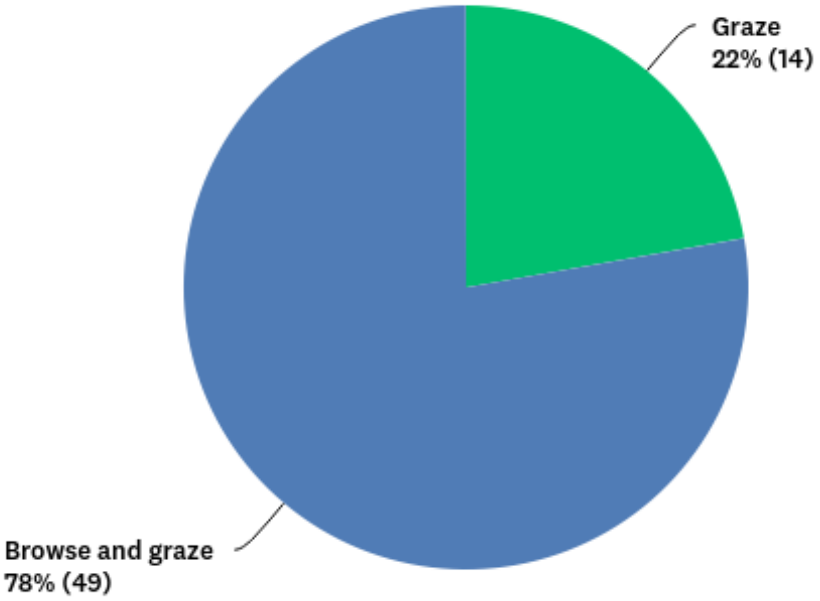
Q3. What is your average annual rainfall?



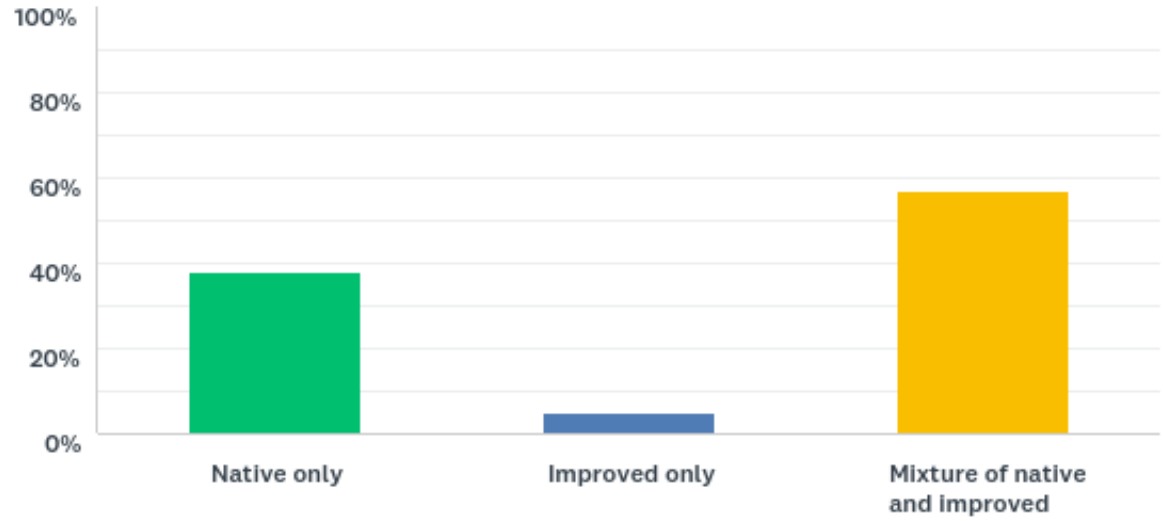
Respondents' average rainfall varied between 200-300mm to more than 1000mm. During the telephone consultations, and almost without exception, interviewees said that they had trouble nominating a 'normal' or 'typical' rainfall for their location. All but one interviewee described the conditions as drier than normal or drought-affected.

Q4. Do you use irrigation water for pastures?
Only six of the 63 producers who completed the survey used irrigation water on their pastures. One of these, who was interviewed by phone, did not have goats as a primary source income. The goats in this case benefited from access to irrigated pastures on occasion along with grazing irrigation channels and banks.

Q5. Do your goats browse or graze?

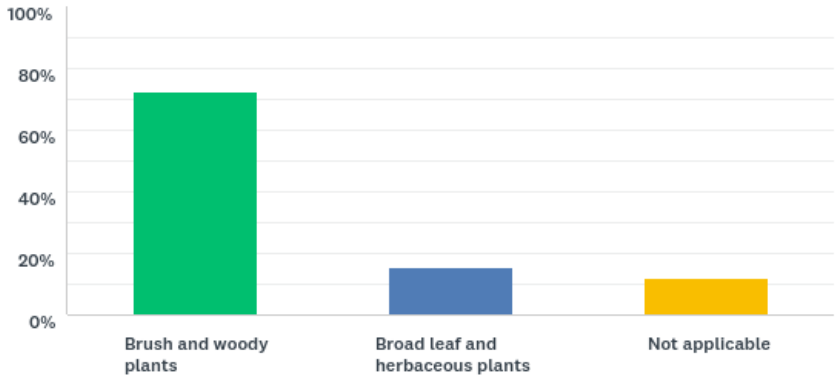


Q6. What type of pastures do you have??



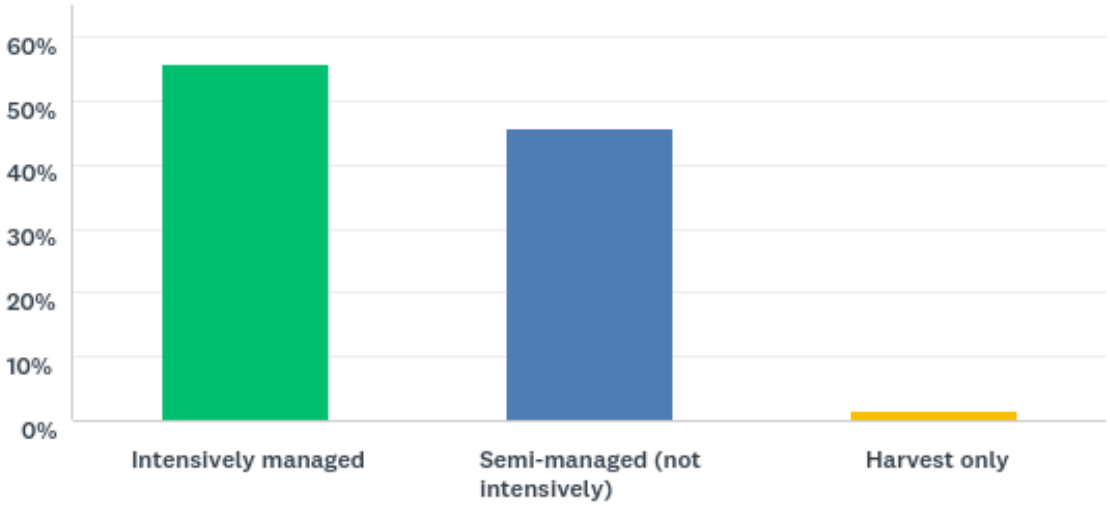
Fourteen of the respondents (22%) reported that their goats only had access to grazing. Fifty-seven percent of producers said that their goats had access to a combination of native and improved pastures. Three enterprises (5%) had just improved pasture and 38% native only. One third each of the properties with native-only pasture were in Victoria and Queensland with three or fewer in each of the other states except Tasmania in which there were no native-pasture-only enterprises. This finding might reflect a management decision to run goats where pasture is of poorer quality (native). Some believe that goats are better able to produce more successfully than other livestock such as cattle and sheep on poorer-quality pasture. Some properties had both improved and native pasture, but some producers reported that the goats were preferentially grazed on the native pasture and the improved pasture was for cattle and sheep.

Q7. If relevant to you, what type of browse do the goats have access to?



Seventy-eight percent (49) of survey respondents reported that their goats had access to browse and grazing. Of the 49, 37 reported their browse to consist of brush and woody plants, while another eight said their browse comprised broad leaf and herbaceous plants. Four producers did not provide information about the nature of their browse. Some of the producers reported on the telephone that their goats had eaten all the browse and therefore no longer had access to it.

Q8. How would you describe your goat management?



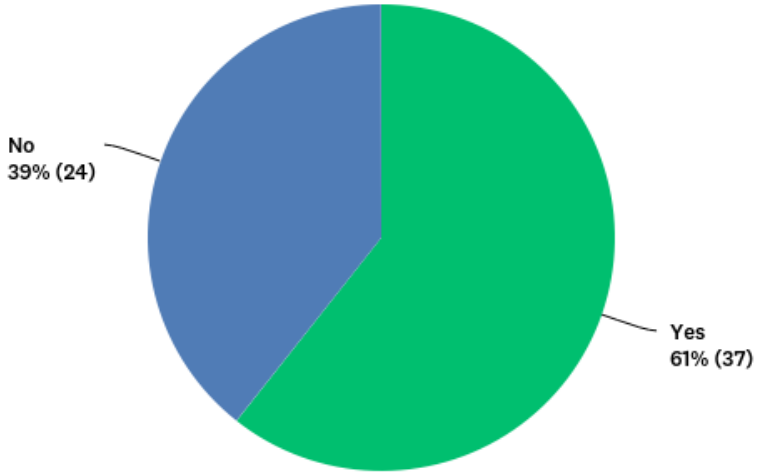
This question was designed to gauge how the producer categorised their management system. The different systems were not defined in the survey, in order not to complicate the question. It was also possible to tick more than one answer to this question. Two producers skipped this question. Two producers reported two management systems: one, both semi- and intensively managed, with the comment that they didn't know which they were; the other semi-managed and harvest only. This producer had two different enterprises on the property, a semi-intensively managed farmed system and the other a harvest-only business from the local rangeland population.

Q9. What is the main breed/s of goat farmed on your property?
This question did not provide a set list of responses – respondents nominated their breed by free text. Responses to this questions are summarised in the table.

Breed	Number of producers
Boer only (red or standard)	37
Boer and Boer cross	18
Rangeland and rangeland cross	8 (6 of which are duplicated in row above)
Kalahari red	1
Angora	3
Other	1
Did not answer	1
Total	**63**

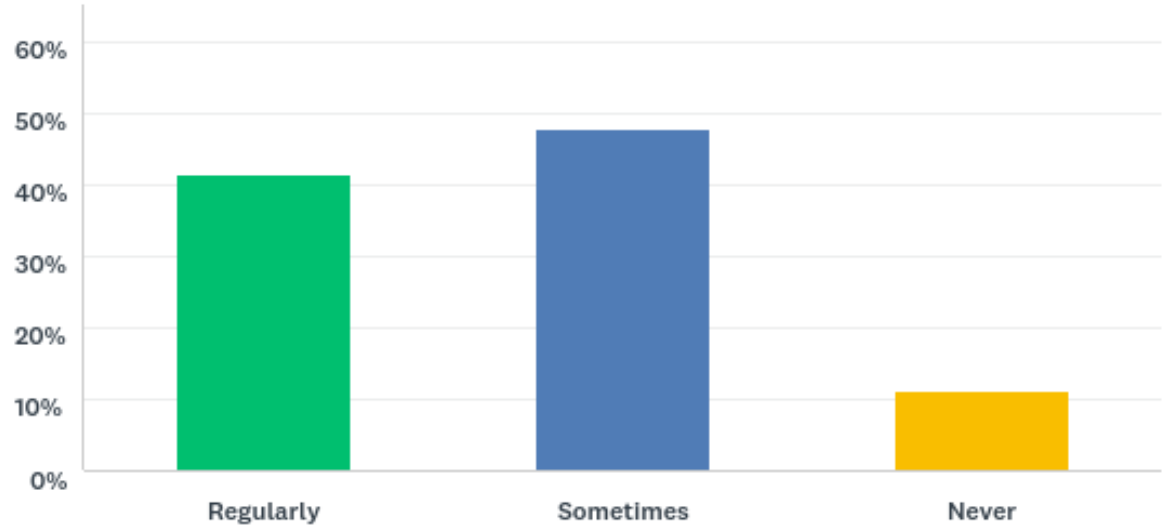
Thirty seven (59%) of respondents had purebred Boer goats. A total of fifty-five had Boer goat or Boer goat crosses. Eight producers had rangeland or rangeland crosses (only one reported that they ran 'straight' rangelands goats). There were three producers with Angoras, one with Kalahari reds and another described his goats using a breed name that is not a registered so it has been included as 'other' here. Overall, 89% of producers had Boer or Boer cross goats.

Q10. Do you vaccinate your goats?



The majority of producers (61%) said they vaccinated their goats. Some of the producers stated that they used to vaccinate but no longer did so, and another couple mentioned this was something that they would look at in the future. This question does not explore the appropriateness of vaccine regimes (number of doses given, boosters etc) nor the number of different diseases vaccinated against. Some of the producers spoken to directly followed a consistent vaccination protocol, while others were more ad hoc in their vaccination program.

Q11. Do you drench your goats?



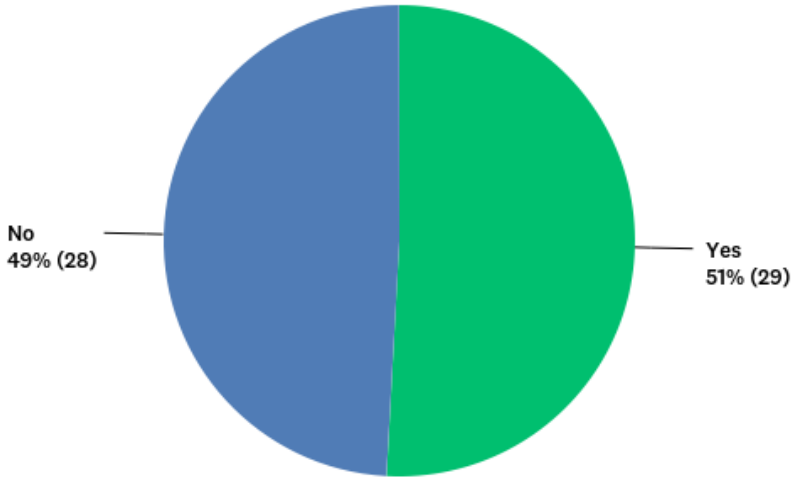
Eleven percent of producers indicated that they never drench their goats, while 41% reported regular drenching and 48% drenched 'sometimes'. The table below compares the location of the properties that reported drenching 'regularly' and 'never'. It also shows the percentage of producers from within each state that reported these drenching patterns. It is clear that the percentage of producers who drench regularly is greater than the percentage that do not drench at all.

Associations between rainfall and drenching were not examined. Worm problems are well established as being a greater problem in high rainfall areas. Furthermore, findings from this survey in relation to drenching are likely to be confounded because of the extended drought experienced in many areas. Several producers reported that they had drenched less or not at all during the recent months / years of drought.

State/Territory	Number of producers that never drench	% of producers that never drench	Number of producers that regularly drench	% of producers that regularly drench
New South Wales	1	5%	5	26%
Queensland	3	20%	4	26%
South Australia	-	-	2	100%
Tasmania	-	-	2	100%
Victoria	2	11%	9	50%
Western Australia	1	14%	4	57%
Total	**7**		**26**	

Some producers reported that losses could be significant without regular drenching and that this was one of the biggest challenges they faced. Others, however, do not drench at all and believe they have no worm problems. One producer said that the drought had been a very good cure for their worm problem. Some producers reported that they monitored worm burdens by faecal egg testing. A number also reported that finding suitable drench was a challenge because of the lack of registered products available for use in goats.

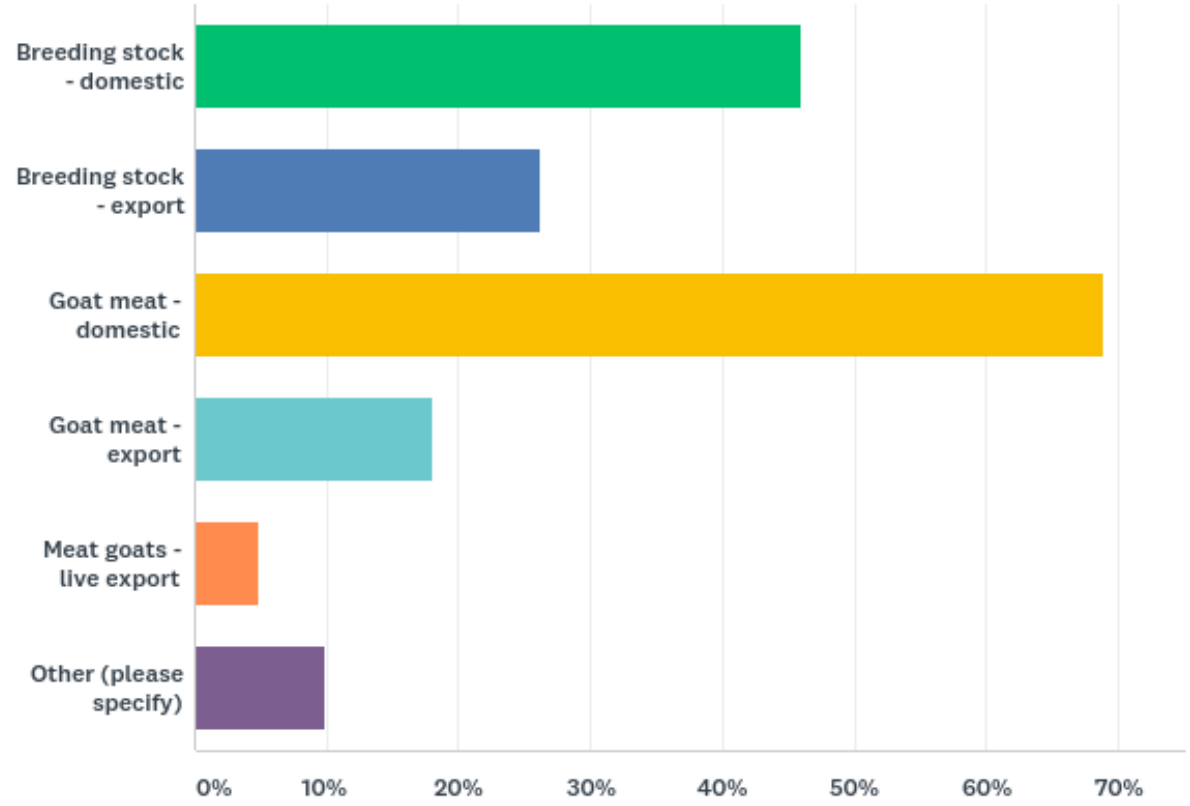
Q12. Do you condition score your does?



Only 57 respondents answered this question, which suggests that the proportion of respondents who condition score does is lower than the 51% indicated by the result. Most of the producers interviewed by phone said they performed at least a visual assessment of condition. Those that physically handled the goats to condition score them were generally doing it to assess the readiness of their stock for market.

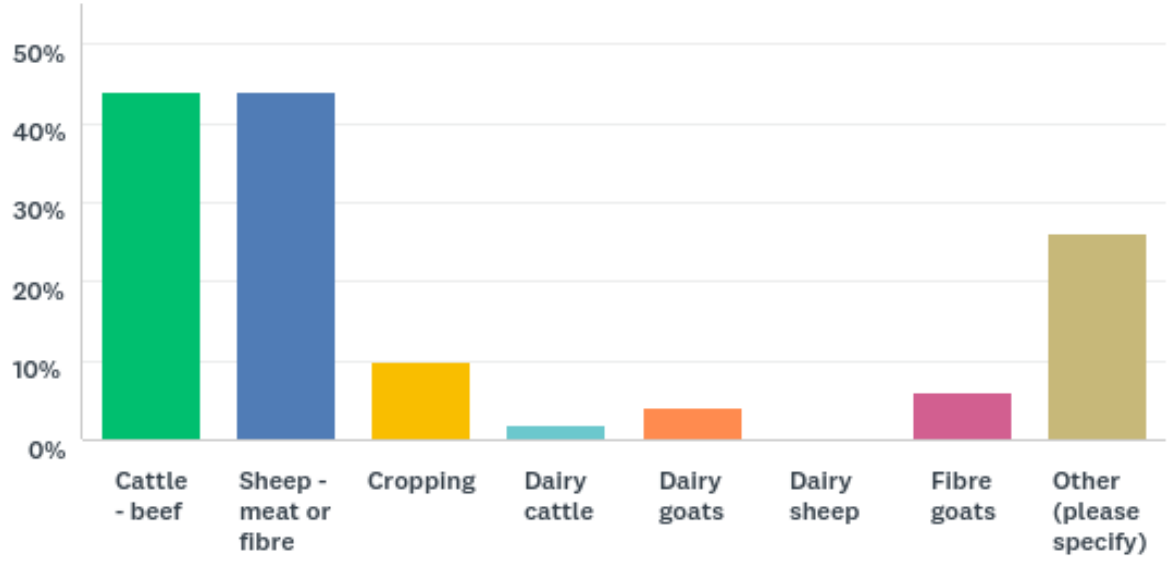
Those producers who did condition score their does reported an average kidding rate of 159% and weaning rate of 125%, while for those who did not, the corresponding figures were 126% and 101%. These differences may reflect that those producers who condition score their does also provide improved nutrition or management that will improve conception rates, embryo survival and kid survival.

Q13. What are the main markets you aim to access from your goat meat enterprise?



The findings from this question show that the respondents had a diverse range of target markets between them. Some producers were in the primary business of producing breeding stock while others primary market was goats for meat. Most businesses sold at least some goats into the meat market for use domestically or internationally. These may have been cull animals or animal superfluous to needs for breeding.

Q14. What other farm enterprises do you have?



An unusually large number of respondents (13) did not answer this question. Respondents could select more than one answer. There was a diverse range of other farm enterprises

identified. Forty-four percent of producers also ran beef cattle, or sheep for meat or fibre, and 10% also had cropping. The remainder of other farm enterprises were selected by fewer than three producers and included dairy goats, dairy cattle, fibre goats, poultry, pigs, sugar cane, hay and off-farm income.

Q15. What do you see as the major limitations to the productivity of your goat meat/stud stock production system?

The most common limitations to productivity, as nominated by respondents, are shown in the table.

Limitation	Number of responses
Kidding % and kid losses	13
Pasture/cost of feed	10
Drought / rainfall	8
Market	6
Genetics	6
Land size	4
Animal health (worms, feet)	3
Lack of finances	2

Other reasons for limited productivity, each nominated only once, were:

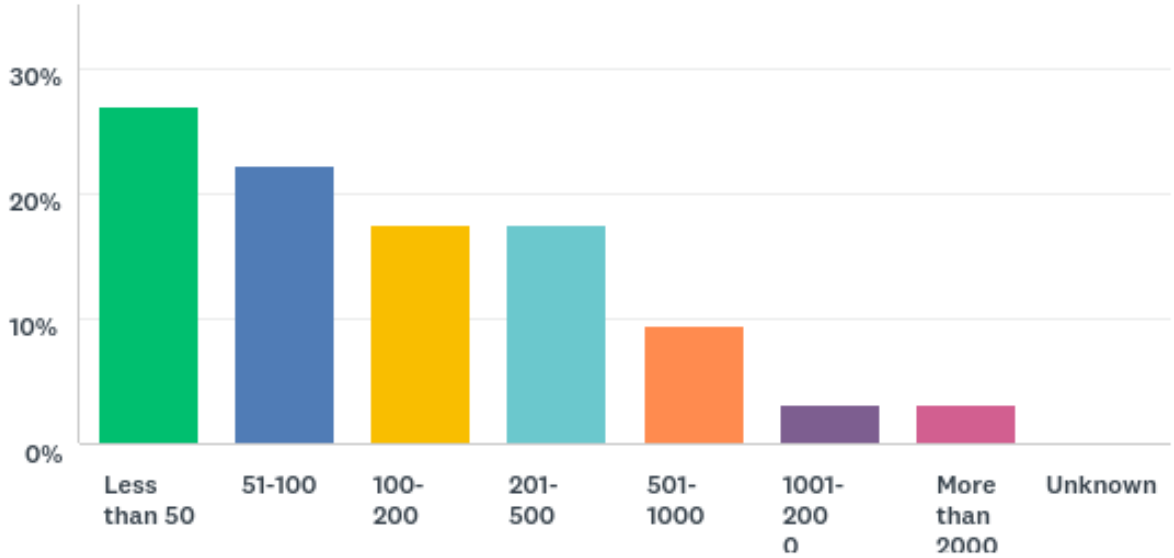
- Lack of an exclusion fence
- Goats is one of several businesses
- The industry as a whole
- Theft, feral hunters
- Growth rate
- Knowledge
- Average age of producers
- Excess rain
- Escaping animals
- Lack of abattoir and butcher facilities.

Q16 How long have you been farming meat goats (years)?
Responses to this question are shown in the table.

Number of years in goats farming	Number of producers
Less than 1 year	2
1-5 years	15
6-10 years	13
11-20 years	22
21-30 years	6
More than 30 years	2

As the table shows, there was a good variety of experience amongst those who participated in the survey.

Q.17. In a typical year, how many breeding does do you run on your property?



The largest grouping of producers was in the band with fewer than 50 does (27%). Seventy-four per cent of producers had less than fewer than 500 does.

The table below shows the distribution of doe herd sizes by state. There did not appear to be any pattern within any state. All states were represented by producers that varied significantly in the number of goats on their properties.

Number of does	New South Wales	Queensland	South Australia	Tasmania	Victoria	Western Australia
Less than 50	4 (21%)	3 (20%)	1 (50%)	1 (50%)	7 (39%)	1 (14%)
51-100	4 (21%)	5 (33%)	-	1 (50%)	3 (17%)	1 (14%)
101-200	3 (16%)	2 (13%)	-	-	5 (28%)	1 (14%)
201-500	4 (21%)	1 (7%)	1 (50%)	-	2 (11%)	3 (43%)
501-1000	2 (11%)	3 (20%)	-	-	-	1 (14%)
1001-2000	2 (11%)	-	-	-	-	-
More than 2000	-	1 (7%)	-	-	1 (6%)	-
Total	**19**	**15**	**2**	**2**	**18**	**7**

Five of the producers interviewed by phone said that they had recently sold a large number of their does because of the poor season/s.

Q18. On average, how many does do you mate per buck?
The table shows the distribution of responses to this question.

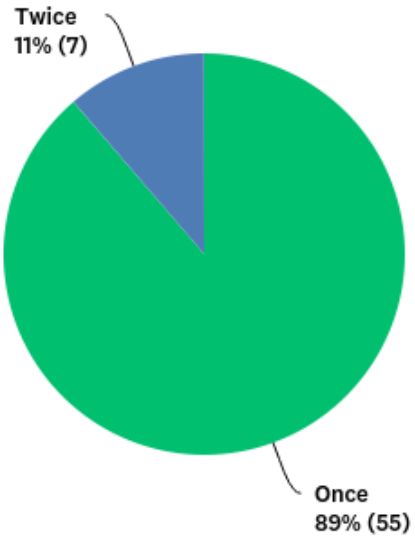
Number of does per buck	Number (%) of respondents
15 or less	4 (6.6)
16-20	9 (14.8)
21-30	22 (36.1)
31-40	14 (23.0)
41-50	11 (18.0)
More than 50	1 (1.6)
Total	**61 (100%)**

The modal band was 21-30 does per buck (36%).

Table shows the number of does used per buck compared to the property size, for producers that provided this information in phone interviews (total 18 responses). There does not seem to be any clear correlation between the two parameters, but the sample size is very small so this is not surprising.

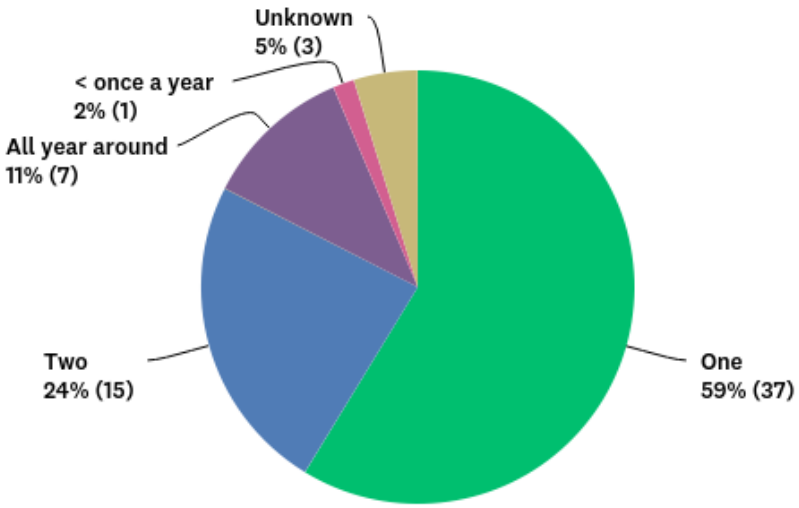
Size of property	Number of does to each buck at joining					
	15 or less	16-20	21-30	31-40	41-50	More than 50
50 Ha or less		xxx	x	xx		
51-100 Ha			x		x	
101-500 Ha	x		xxx		x	
501-1000 Ha			x	x		
1001-2000 Ha						
More than 2001 Ha			xx		x	
Total	**1**	**3**	**8**	**3**	**3**	**0**

Q19. In a typical year, how many times does each doe kid?



Eighty-nine percent of respondents indicated that their does only kid once in every year. This leaves seven producers (11%) who said they kidded twice a year, while three did not answer the question. Of the seven who indicated twice-per-year kidding, three also identified themselves as kidding all year around.

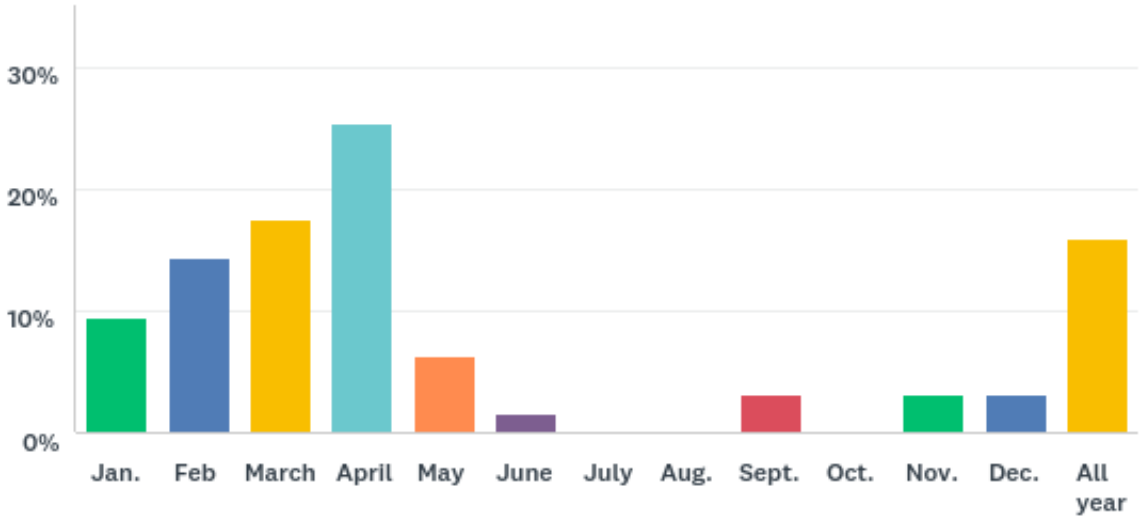
Q20. How many times do you join / kid in a year?



The majority of producers (59%) joined / kidded once a year, 24% twice a year. Eleven percent of producers (total number of 7) indicated that they kid all year-round. One respondent said they kid less than once per year and 5% said they did not know how often their does were joined/kidded.

The average kidding percentage for the producers who reported that they kid twice a year was 155%, while for those with one kidding the average percentage was 150%. Interestingly, these figures are very similar. As some of this data was collected by online survey, however, it was not possible to verify that these figures were in fact annual percentages and not per kidding percentages.

Q21. In what month does joining start? (if more than one joining, first joining)



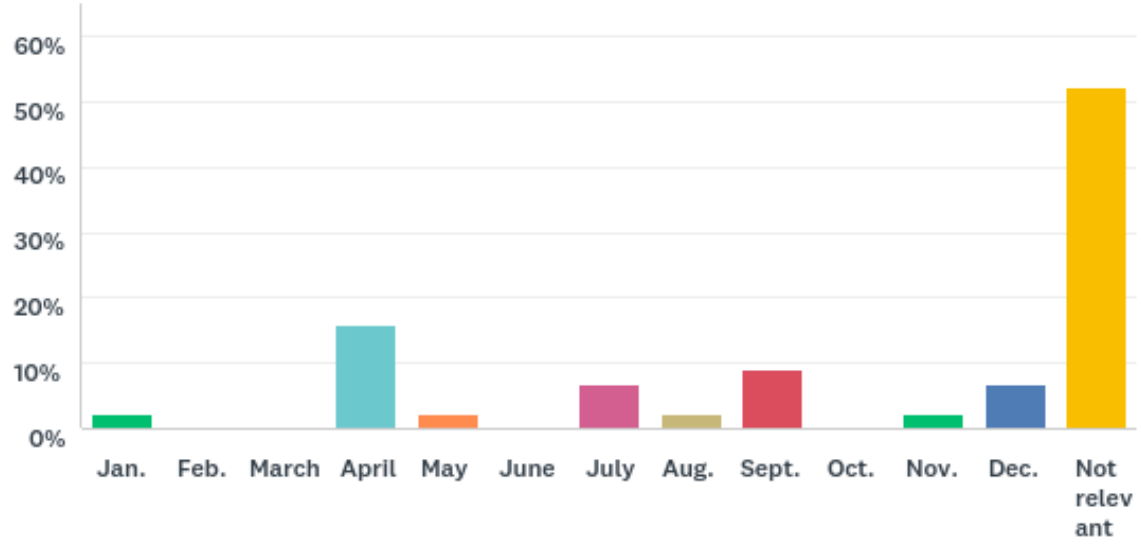
The majority of producers joined their does in autumn. Forty-two per cent of all producers started their main (or only) joining in March or April. Other popular months for joining were

January and February. Only 11 per cent of respondents had their main joining between June and December with no set joinings in July or August. Sixteen per cent of producers (10) joined all year-round. This is in contrast to the previous question (Q20) in which 7/63 producers said they kidded year-round.

All the states has respondents who joined year-round except Tasmania, as shown in the table below.

State/Territory	No. of respondents kidding year-round	Total number of respondents	% of respondents kidding year-round
New South Wales	2	19	11%
Queensland	3	15	20%
South Australia	1	2	50%
Tasmania	0	2	0%
Victoria	3	18	17%
Western Australia	1	7	14%
Total	**10**	**63**	

Q22. If relevant, when does second joining occur?

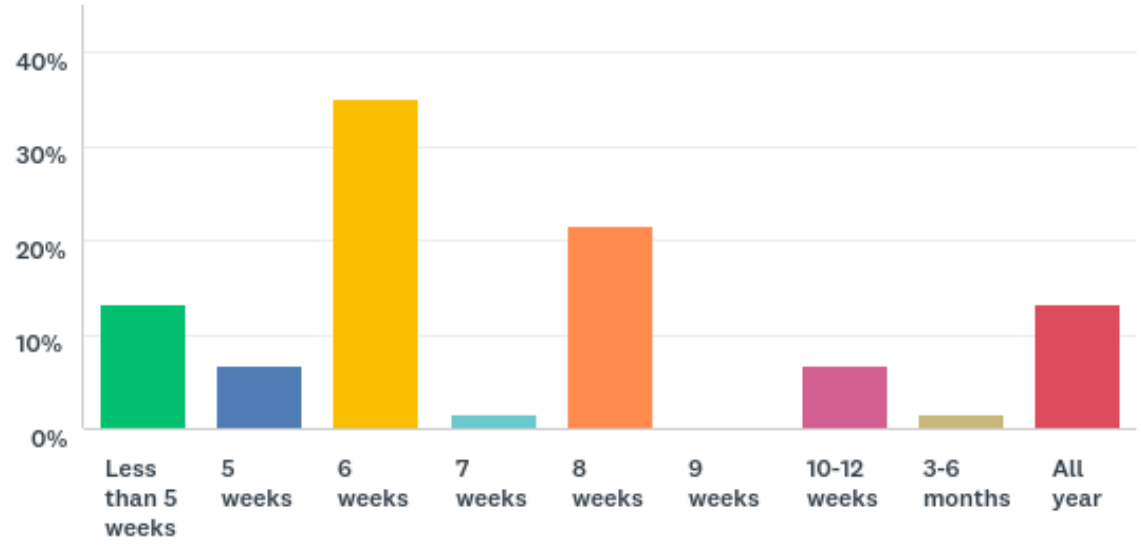


Only 16 respondents supplied a interpretable answer to this question. Many did not answer at all or answered ‘not relevant’, while others marked the same month as the first joining. The table below shows, for the 16 respondents who did report a second joining, the joining periods, location of the property and breed of goats farmed. All states except South Australia has producers that joined twice a year. Herd sizes ranged from fewer than 50 goats to over 200 goats.

Of the 16 respondents who nominated two joining periods, only five reported that their does kidded twice a year. Of these five only two agreed to be involved in follow-up discussions about their enterprises. The other 11 producers who nominated their enterprises as having two joinings also nominated that each doe only kidded once. In other words, they split the mob and some of the does were mated at different times, but each doe only had one kidding opportunity.

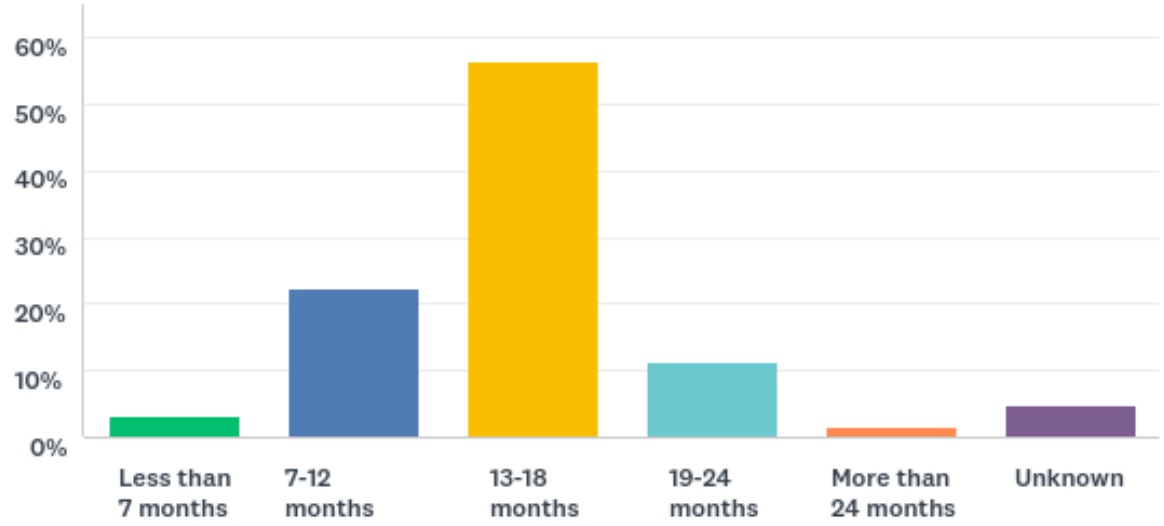
State/Territory	Goat Breed	First joining month	Second joining month
Queensland	Boer	February	September
Victoria	Boer	May	January
Victoria	Boer	June	December
Victoria	Boer	February	May
Tasmania	Boer and Boer cross	February	April
New South Wales	Boer	December	April
New South Wales	Boer cross	January	April
New South Wales	Boer	January	September
Western Australia	Boer Aussie red and crosses	November	April
Victoria	Boer	May	December
Victoria	Boer	March	July
Victoria	Boer	March	September
Tasmania	Angora	September	April
Queensland	Boer and Boer cross	January	July
Queensland	Boer	April	November
Queensland	Rangeland, red Boer/ Kalahari	December	August

Q23. How long does joining go for?



Interestingly, in response to this question, only eight producers nominated that they kid year-round, in contrast to the findings in Q21 above in which 10, and Q20 in which seven, respondents nominated themselves as kidding year-round. However, three respondents skipped this question, so this might explain the discrepancy. There was an array of joining periods recorded but the majority of producers joined for six weeks (35%), eight weeks (22%) and less than 5 weeks (13%). Fifty-two producers had a defined breeding period and 47/60 (78%) joined for eight weeks or less.

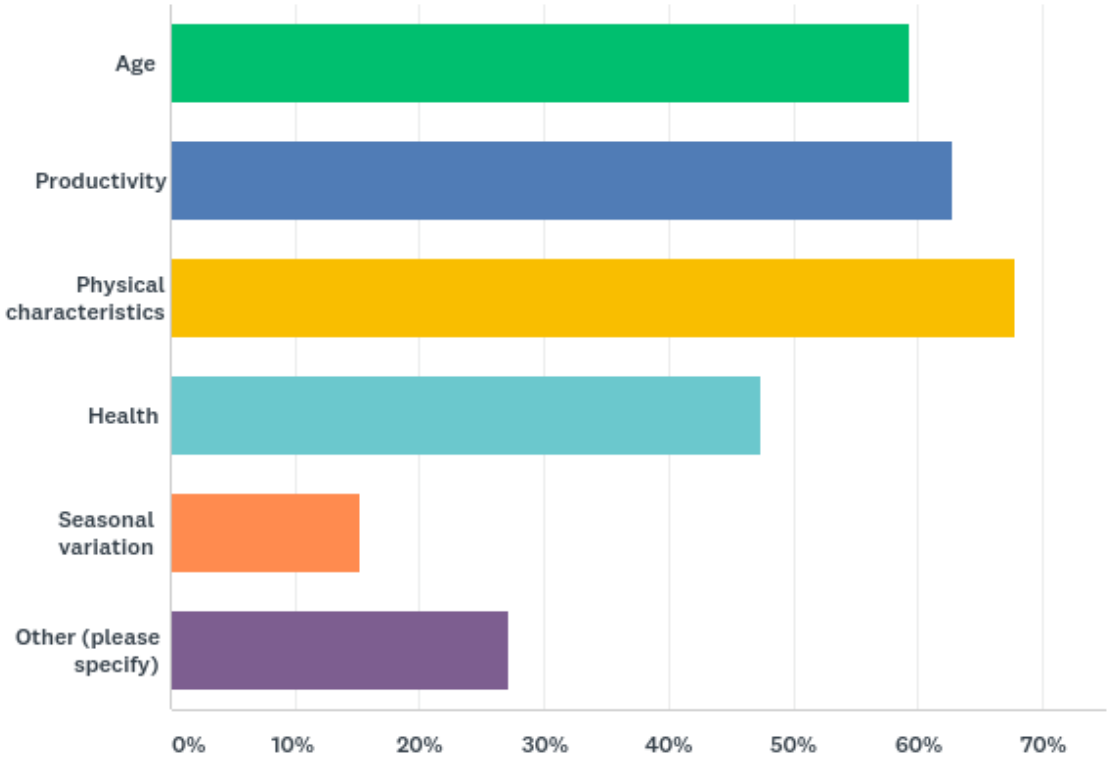
Q24. What age are maiden does when they are first joined?



The majority (56%) of maiden does are joined for the first time between 13-18 months of age, followed by 23% at 7-12 months and 11% at 19-24 months. Only one producer joined maidens older than 24 months and two less than seven months. Of these, one joins year-round and in the other case the does are exposed to the bucks by seven months for an opportunistic mating. If they fail to become pregnant they are given another chance. In this enterprise the success of this first mating with maidens (at less than seven months) is extremely variable with kidding percentages varying from 43% to 4%.

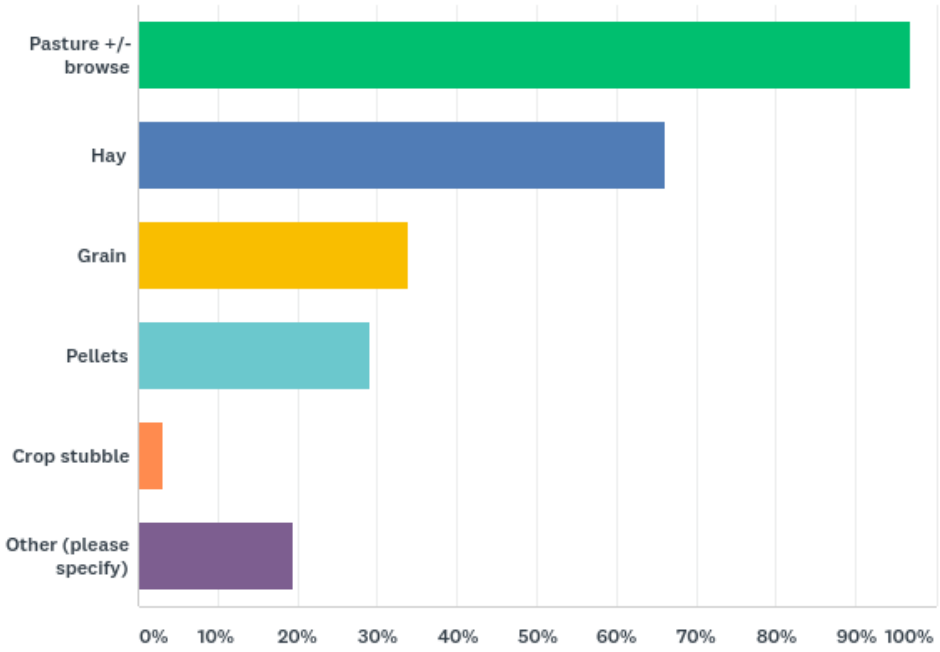
During the phone consultations a couple of producers advised that the age of the maidens was not the only selection criterion for first joining. Some would also use the animal's weight.

Q25. What criteria do you use to cull does? (please mark all that are relevant)



In this question, respondents were able to select more than one option. Thirty- one producers selected more than one culling criterion for their does. Age, productivity and physical characteristics were the most commonly selected, all with similar popularity (59%, 63% and 68% of respondents respectively). Producers who were interviewed indicated that the lack of 'productivity' mostly referred to failure to conceive, failure to raise a kid or poor mothering. Almost half of respondents also picked 'health' as a culling criterion, while only 15% picked seasonal variation. Some of the producers culled heavily for 'breed flaws' as they were producing purebred breeding stock. Others nominated poor mothering ability as another reason for culling does.

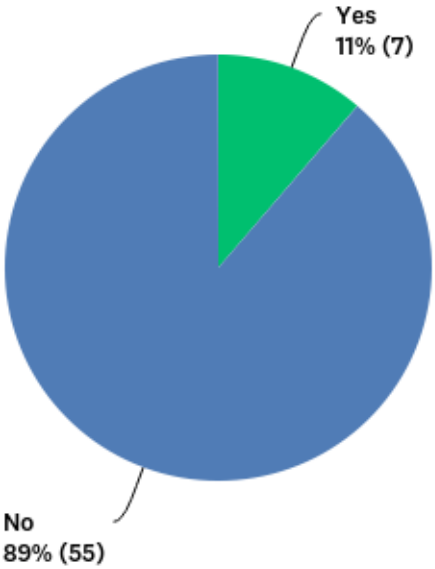
Q26. What are pregnant and lactating does fed? (please mark all that are relevant)



Again, respondents could choose more than one response to this question. Sixteen producers said that their pregnant and lactating does were fed by grazing and browse alone. Hay was the most common supplement and was used by 66% of producers followed by grain (34%) and pellets (29%). Several producers advised that the goats also had access to mineral blocks, but it is not possible to record the exact number that use them as this was not asked specifically.

During the telephone consultations one producer indicated that does that are either pregnant or lactating were allocated the best paddock available on the property at the time.

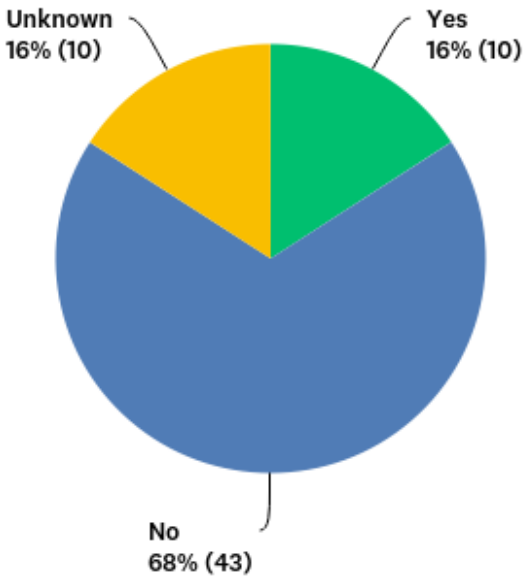
Q27. Do you pregnancy test does?



The vast majority of respondents (89%) did not pregnancy test their does.

One respondent commented that pregnancy testing was essential to have any idea as to what is going on in the herd. Empties were identified and culled and the remaining goats were run as a single mob. He said that as Boer goats have such good fertility it was assumed that all does were pregnant with multiples and the whole herd was fed accordingly.

Q28. Does seasonal anoestrus impact on your production system? (seasonal anoestrus is a period of time when animals are not sexually active. It generally occurs during the same season/months every year.)



Most respondents (68%) believed that seasonal anoestrus did not impact on their production system. Sixteen per cent were unsure if it impacted and 16% thought it did impact on their production.

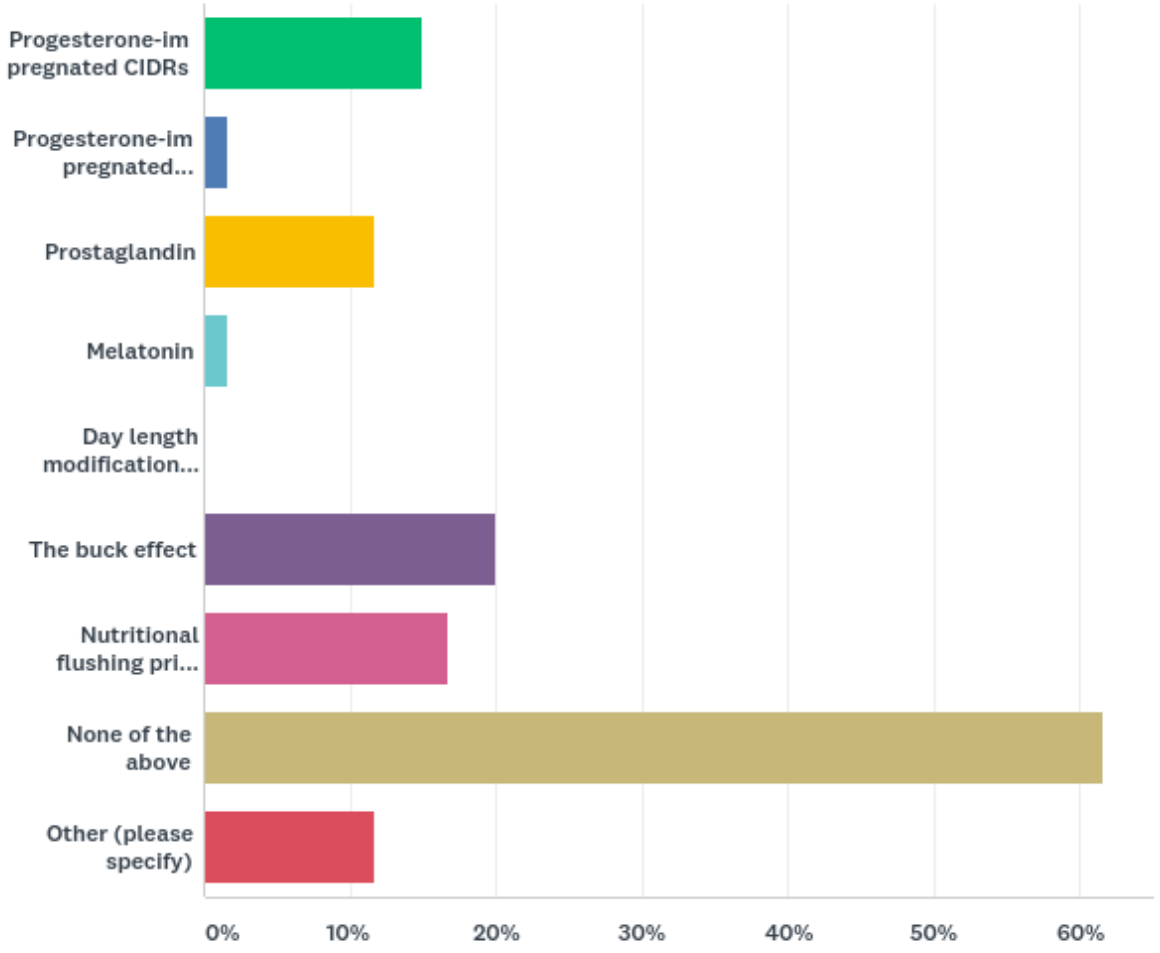
The table below compares various parameters of those producers who reported to be impacted by seasonal anoestrus. It shows that a variety of different types of production systems were impacted. Of the ten producers who believed that it was a problem for them, two kidded year-round, four had two kiddings per year and four had one kidding per year. Five of the ten producers had a kidding percentage of less than 100% annually and four had a kidding percentage more than 100% including values of 150 and 180%. (One of the producers did not record their kidding percentage.) It is difficult to know whether or not the seasonality of breeding impacted on the lower kidding percentage in the five producers with less than 100% kidding. Further investigation with pregnancy testing would help determine if the pregnancy rate is high and the kids are lost in utero or if the does are failing to become pregnant during the mating period.

The kidding percentages seem to bear no correlation to the buck: doe ratio. For example, in this group three producers used a buck: doe ratio of 1:50 and reported kidding percentages of 80, 120 and 150%. In the section on question 21 the impact of buck: doe ratio across all the respondents is explored further.

Number of kiddings per year	Kidding percentage for doe per year	Joining start month/s	Buck: doe ratio
All year	100%	All year	1:25
Once	80%	April	1:25
Once	80%	February	1:40
Twice	150%	December and April	1:50

Number of kiddings per year	Kidding percentage for doe per year	Joining start month/s	Buck: doe ratio
All year	130%	All year	1:20
Twice	180%	November/ April	1:30
Twice	Not provided	March/ July	1:40
Twice	100%	September/ April	1:30
Once	120%	February	1:50
Once	80%	April	1:50

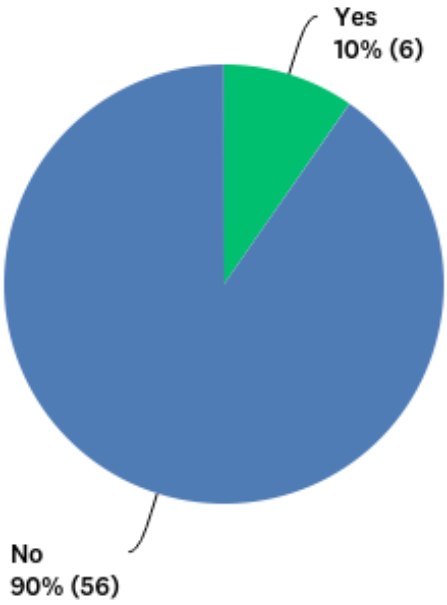
Q29. Which of the following treatments and procedures have you used on your goats? (please mark all that are relevant)



Sixty-two percent of respondents to this question said that they use none of the above-listed hormone or other treatments. Ten producers indicated that they used progesterone implants (sponges or controlled internal drug release (CIDR) devices). On further consultation one producer had used progesterone sponges in the past but was no longer using them. Eight of the other nine indicated that they used artificial insemination (AI) and/or embryo transfer (ET).

Twenty percent of producers used the buck effect and 17% reported the use of flushing before joining. Some of the producers interviewed said that that the buck effect is very effective and that most of the does will cycle within three days of the buck going in.

Q30. Do you currently use accelerated kidding? (for example, 3 kiddings in 2 years or 5 kiddings in 3 years)



Only six producers indicated that they were currently using accelerated kidding in their enterprises. Of those six, two actually had year-round joining. The other four did join twice a year, two had a three-in-two program, and in the other two cases the consultants were unable to confirm the details of the production systems because the producers did not want to be contacted for further consultation.

Of the 22 producers interviewed, 10 had tried accelerated kidding. All of the ten that had tried it said they would never try it again. The comments included:

- *It was 'management porridge'.*
- *Less kids born in in winter, lower number of kids overall*
- *Don't waste your time unless you have a lot of feed*
- *Some times of the year you cannot kid, does don't have enough milk*
- *Disaster, it's a lot of work, maybe in a smaller enterprise*
- *Predators are extra bad at some times of the year make kidding untenable. Tried it once not again*
- *Too hard on animals*
- *Not really a lot more gained, requires lots of supplementary feeding, increased cost, less kids per kidding*
- *Requires too much feed to keep them in condition and to provide for kids*
- *Kids were little, it was not successful*
- *Disastrous*

Some comments from those who had not tried it were:

- *Not worth the increase in management required*
- *No, not now*
- *Might try in the future, but it will require good nutrition*
- *Decided not to because it takes a lot out of the doe, need to wean early*
- *Country not good enough*

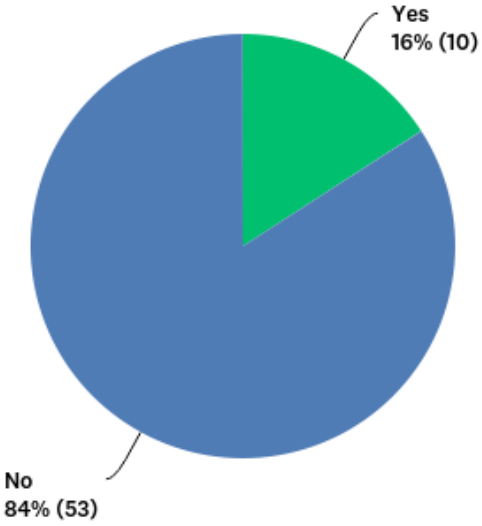
The table below compares various production parameters for the four enterprises identified as kidding twice in a year.

	Property 1	Property 2	Property 3	Property 4
Rainfall	500-600mm	300-400mm	300-400mm	500-600mm
Breed	Boer	Boer	Boer	Rangeland-red Boer/Kalahari
No of does	100-200	Less than 50	51-100	More than 2000
Number of does per buck	30	50	40	40
Joining period	6 weeks	8 weeks	8 weeks	10-12 weeks
Age of first joining maiden does	13-18 months	7-12 months	7-12 months	7-12 months
Location of property by state	QLD	VIC	WA	QLD
Vaccination	Yes	No	Yes	No
Worming	Sometimes	Never	Sometimes	Never
Time in goat farming	4 years	9 years	15 years	10 years
Do you pregnancy test?	Yes	No	No	No
Interventions	Progesterone The buck effect	Nil	Progesterone	Nil
Kidding percentage %	95	200	135	180
Weaning percentage%	98	180	135	160
Weaning age	12 weeks	Determined by mother	4 months	3 months
Graze +/- browse	Graze and browse	Graze and browse	Graze and browse	Graze and browse
Pasture type	Native only	Native and improved pasture	Native and improved pasture	Native and improved pasture
Supplementary feed for pregnant and lactating does	G/B* hay, grain and pellets	G/B hay an crop stubble	G/B, hay	G/B
AI or ET	AI	nil	nil	nil

*Graze and browse

While it is interesting to compare these four enterprises, no common features stand out from the table.

Q31. Do you use artificial insemination in your production system?



Ten of the 63 producers use artificial insemination (AI) and six use embryo transfer (ET). As expected, all producers that use ET also use AI.

From the phone consultations, some comments about AI were:

- *AI is useful for establishing new crosses and introducing new bloodlines*
- *Nutrition and preparation of the does is crucial to success*
- *With the ability to store semen well, AI can be used to produce animals from the past that had proven to be very good*
- *AI is cheaper to perform than ET, and therefore involves less risk for the producer.*

Some reported variable success with AI. One producer had a pregnancy rate of 22/54 treated. One producer reported only 22 successful pregnancies in 74 does. They felt that the lack of success was due to poor preparation of the does prior to the procedure.

The table below provides further details about the producers who currently use AI or ET. Of the ten producers who used AI, all but two did not have pure Boer goats and eight sold breeding stock either domestically or overseas. All four of the properties that performed AI and ET had pure Boers and sold breeding stock domestically and /or internationally. The range in number of goats on the properties that performed AI and ET was very broad, ranging from less than 50 to 1-2000. It could be expected that the major reason for preforming AI and ET would be to accelerate genetic gain and this is more likely to be an objective in those production systems that sell breeding stock.

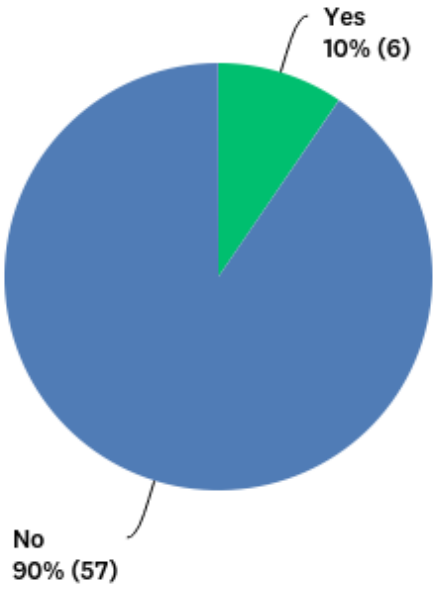
On one of the properties using ET, goats would be synchronised on farm before being sent to a special ET centre for completion of the process. The embryos had been implanted using the cervical and laparoscopic technique previously.

Artificial insemination	Embryo transfer	Number of goats	Breed	Target market
X	X	201-500	Boer	BS – export and domestic
X	-	100-200	Boer	BS – export and domestic, GM – domestic
X	X	100-200	Boer	BS – export and domestic
X	X	201-500	Boer	BS – domestic
X	-	51-100	Boer	-
X	X	100-200	Boer	BS – export

Artificial insemination	Embryo transfer	Number of goats	Breed	Target market
X	-	Less than 50	Boer	BS – domestic
X	-	1001-2000	Feral/Boer cross	BS – export and domestic, live export
X	X	201-500	Boer and rangeland	GM – export
X	X	501-1000	Boer	BS – export and domestic, GM – domestic

BS-breeding stock, GM-goat meat

Q32. Do you use embryo transfer in your production system?



Of the six producers performing ET, five agreed to be contacted and were spoken to in person by the consultants. Most of these producers said that they did not use ET routinely every year but every second or third year depending on market demand and on farm performance. One producer who has used ET on several occasions said it was very expensive. As great care is needed for the donor and recipient, there is a large cost in feed and preparation of the animals. Some producers saw ET as being quite hit and miss and that, given the cost, this was a significant risk.

Producers used ET to increase the number of a specific genetic type – generally it was not used to improve genetic diversity. On one property ET was used to increase the number of superior animals, using the best sires and dams they could to produce more seed stock to sell. One producer had experience using the multiple ovulation procedure and noted that recovery rate varied and yield could be low. He said the best return came from using does that were 2-3 years old from whom 16 embryos could be harvested in one procedure, but that younger animals were not as productive for normal ET.

Q33. What is your average annual kidding percentage?

Reported kidding percentages are shown in the table.

Kidding percentage	Number of producers	Percentage of producers
Not recorded	5	8%
Unknown	2	3%
100 or less	19	30%
101-150	13	21%
151-200	19	30%
201-250	3	5%
251-300	2	3%
Total	**63**	**100%**

The table shows that there was quite a variation in kidding percentages amongst the producers who completed the survey. Sixty -two percent (39) of all the 63 producers had a kidding percentage between 100-200%. Almost one third of participants had a kidding percentage of 100% or less.

Q34. What is your average annual weaning percentage?

The average weaning percentage for the producers is shown in the table below. Fifty percent of respondents had a weaning percentage between 100-200%. Two producers recorded a weaning rate higher than their kidding rate, and these values were counted as invalid. There were slightly more respondents who did not answer this question compared to the previous question, possibly because they did not know their weaning rate.

Weaning percentage	Number of producers	Percentage of producers
Not recorded	7	11
Unknown	3	5
Invalid	2	3
50 or less	2	3
51-100	21	33
101-150	16	25
151-200	10	16
201-250	-	-
251-300	2	3
Total	**63**	**99% plus rounding error**

The following table shows the average percentage of kid loss between kidding and weaning.

Average % loss between kidding and weaning	Number of producers		Kidding percentage of 100% or less	Kidding percentage of 101% to 200%	Kidding percentage of 201-300%
Invalid recording	23		-	-	-
10% or less	11		5	6	
11-20%	16		3	12	1
21-30%	4		2	1	1
31-40%	2		1		1
41-50%	1				1
51-60%	3			3	
61-70%	1				1
71-80%	1			1	
81-90%					
91-100%	1			1	
Total	**63**				

In order to interpret the table above correctly, it needs to be recalled that many of the kidding percentages were more than 100% and so producers may lose 20% of their kids and still

have a weaning percentage of more than 200%. So the percentage loss here is not the percentage overall of kids died but the reduction in percentage from the kidding percentage.

The following table shows the kid loss by state.

Average %loss between kidding and weaning	Number of producers		NSW	QLD	SA	TAS	VIC	WA
Not valid recording	23							
10% or less	11		2	3		1	1	4
11-20%	16		6	5		1	3	1
21-30%	4		1	1	1			
31-40%	2			1			1	
41-50%	1		1					
51-60%	3		1				1	1
61-70%	1						1	
71-80%	1						1	
81-90%								
91-100%	1		1					
Total	**63**							

There is quite a wide distribution of kid losses within each state. There is no obvious pattern here that would suggest more losses were seen in one state more than another – but with the usual caveat that numbers of respondents are small.

The table below shows the ten producers who had a kid loss of 40% or more and compares their production and environmental details parameters. The two major findings that stand out are that 9/10 (90%) of these producers had a kidding percentage of 150% of more, while over the 63 producers 49% had a kidding percentage in that range. In addition, 60% of the producers here had fewer than 50 does despite this size category representing only 27% of the 63 total respondents. As discussed earlier, there is not enough data to draw any particular conclusions but this could point to an area for investigation in further studies.

	Property 1	Property 2	Property 3	Property 4	Property 5	Property 6	Property 7	Property 8	Property 9	Property 10
% kid loss from kidding to weaning	40	40	40	50	53	55	55	70	80	100
Rainfall	500-600mm	600-700mm	900-1000mm	500-600mm	700-800mm	600-700mm	200-300mm	300-400mm	300-400mm	800-900mm
Diet	Browse and graze	Graze	Browse and graze	Browse and graze	Graze	Graze	Browse and graze	Graze	Browse and graze	Browse and graze
Pasture type	Mixture native / improved	Native only	Native only	Mixture of native and improved	Native only	Native only	Native only	Mixture of native and improved	Mixture of native and improved	Mixture of native and improved
Brewed	Boer	Boer	Boer	Boer	Boer x Angora	R'land	Boer / Aussie red	Boer	Boer	Boer X
Vacc?	No	Yes	Yes		Yes	No	No	Yes	No	Yes
Drench?	Sometimes	Sometimes	Regularly	Sometimes	Regularly	Sometimes	Sometimes	Sometimes	Sometimes	Regularly
Condition score?	Yes	Yes	Yes		Yes	No	No	Yes	No	No
Years goat farming	1	22	10		8	14	5	13	15	4
No. does	<50	<50	<50	201-500	<50	<50	201-500	<50	100-200	201-500
Kiddings/yr	20	15	20		30	9	80	35	40	45
Length of joining	One	One	One	One	One	One	One	One	All year around	All year around
Supp'tion for late pregnant and lactating does	5 wks	6 wks		6 wks	<5 wks	< 5 wks	8 wks	8 wks	All year	6 wks
Kidding %	Hay	Hay/grain	Hay/ pellets		Hay/ pellets	Hay/grain		Hay/pellets	Hay/ crop stubble	Hay

Q35. At what age are kids weaned? (if buck and doe kids are weaned at different time please specify)

Of the 60 producers who responded to this question, 16 recorded that they had a split weaning for doe and buck kids. Eleven of those 16 provided details of the time of both weanings and these are shown in the table below.

Buck weaning age (weeks)	Doeling weaning age (weeks)
16	24
12	20
12	14
12	16
12-16	16-20
16	20-24
12	16
16	20-32
12	24
8-10	12
12-14	16

The following table shows the weaning age of kids compared to property size and kidding percentage.

Weaning age (weeks)	Number of producers
8 or less	1
9-10 weeks	0
11-12 weeks	14
13-14	5
15-16	15
17-18	-
19-20	7
21-22	
23-24	9
25-30	2
More than 31	3
Unknown/not weaned	7
Total	**63**