Raising healthy and productive kids: A survey of dairy goat kid rearing practices on Canadian farms and their associations with farm performance

BY

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ABSTRACT

Dairy goat kid rearing is the foundation of the goat herd's productivity and profitability. The growth of goat kids in the preweaning and weaning periods is critical to maximize the does' future growth and lifetime profitability in the dairy herd, and this growth is largely determined by management practices in the kids' early life. The dairy goat industry in Canada is small but growing. However, few published research papers are available on dairy goat kid rearing, limiting the number of references available to guide producers in optimizing their productivity. The overall objective of this thesis was to draw a portrait of rearing practices in the dairy goat industry of Canada, and to identify rearing practices that improved farm performance, on which producers could focus to increase their farm performance and profitability. This objective was achieved with a literature review of dairy goat kid rearing practices in intensive production systems and a survey study investigating common kid rearing practices on Canadian dairy goat farms and their associations with overall herd performance.

The literature review identified and compared recommendations on dairy goat kid rearing practices in intensive production systems, between Canada, United States and France. The scientific literature was reviewed to compare scientific knowledge to current recommendations in the different sectors of kid rearing, including kidding management, colostrum, milk and solid feeding, health management, disbudding, housing, weaning, and growth monitoring of the kids. Gaps in the literature were identified in some areas such as the kidding management, milk and solid feeding, housing and weaning, where more knowledge would be beneficial to refine and validate current recommendations.

The survey study identified the common rearing practices on 25 % of the Canadian dairy goat farms and looked at associations between rearing practices and six performance indicators, including kid mortality, prevalence of diarrhea and respiratory diseases and growth prior to weaning, and herd milk production and replacement rate. Main findings from this study reveal that farm performance indicators were mostly affected by colostrum and milk feeding management practices. Other rearing practices were significantly associated with a different number of farm performance indicators, and those should all be taken into consideration when establishing best management practices for commercial dairy goat farms.

RÉSUMÉ

L'élevage des chevrettes est à la base de la productivité et de la rentabilité des troupeaux de chèvres laitières. La croissance des chevrettes pendant les périodes de pré-sevrage et de sevrage est essentielle pour maximiser la croissance future et la rentabilité à vie d'un troupeau laitier, et est largement déterminée par les pratiques de gestion des chevrettes en début de vie. L'industrie caprine laitière est relativement petite, mais en croissance au Canada. Cependant, peu de papiers scientifiques publiés sur l'élevage des chevrettes laitières sont disponibles, ce qui limite la quantité de références disponibles pour guider les producteurs dans l'optimisation de leur productivité. L'objectif global de cette thèse était de dresser un portrait des pratiques d'élevage dans l'industrie caprine laitière du Canada et d'identifier les pratiques d'élevage qui améliorent la performance des troupeaux, pratiques sur lesquelles les producteurs pourraient se concentrer pour accroître la performance et la rentabilité de leurs fermes. Cet objectif a été atteint grâce à une revue de littérature sur les pratiques d'élevage des chevreaux laitiers dans les systèmes de production intensive et à une étude par sondage sur les pratiques courantes d'élevage des chevrettes dans les fermes laitières canadiennes.

La revue de littérature a permis d'identifier et de comparer les pratiques d'élevage des chevrettes laitières recommandées pour les systèmes de production intensive au Canada, aux États-Unis et en France. La littérature scientifique a été examinée afin de comparer les connaissances scientifiques aux recommandations actuelles dans les différents secteurs de l'élevage des chevreaux, y compris la gestion des mises-bas et du colostrum, l'alimentation lactée, l'alimentation solide, la gestion des maladies, l'ébourgeonnage (ou l'écornage), le logement, le sevrage et le suivi de la croissance des chevrettes. Des lacunes ont été relevées dans la littérature pour certains aspects tels que la gestion des mises-bas, l'alimentation du lait et des aliments solides, le logement et le sevrage. Approfondir les connaissances quant à ces aspects permettrait de valider, voire raffiner les recommandations actuelles.

Le sondage a permis d'identifier les pratiques d'élevage courantes dans 25 % des fermes de chèvres laitières au Canada et d'examiner les associations entre ces pratiques d'élevage et six indicateurs de performance, notamment la mortalité, la prévalence des diarrhées et des maladies respiratoires avant le sevrage, la croissance des chevrettes avant le sevrage, la production laitière ainsi que le taux de remplacement du troupeau. Les principales conclusions de cette étude révèlent

que les indicateurs de performance des troupeaux ont été principalement influencés par les pratiques de gestion du colostrum et de l'alimentation du lait. D'autres pratiques d'élevage ont aussi été significativement associées avec certains des indicateurs de performance, ce qui nous indique qu'elles devraient aussi être prises en compte lors de l'établissement d'un guide des meilleures pratiques de gestion pour les fermes caprines laitières.

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CONTRIBUTION OF AUTHORS

Two coauthored manuscripts are presented as part of this thesis. The authors of both manuscripts (presented in Chapters 2 and 3) are:

Stéphanie Bélanger-Naud (primary author of both manuscripts), Elsa Vasseur (supervising author of both manuscripts)

Stéphanie Bélanger-Naud was the primary author of Chapter 2 and conducted the survey study presented in Chapter 3. Stéphanie designed the survey, distributed it and collected all the data from it. The data was cleaned out by Stéphanie and reviewed with Elsa Vasseur for decisions to be made before the statistical analyses were performed (Stéphanie). Elsa supervised the primary author and contributed to the design and statistical analysis of the study presented in Chapter 3. Elsa also reviewed and co-authored both manuscripts.

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CHAPTER 1 – GENERAL INTRODUCTION

The Canadian dairy goat industry has experienced considerable growth over the past 10-15 years, both in the number of animals and milk yield per goat (Lu and Miller, 2019). The total goat milk production has increased from 35.5 to 63.2 million litres between 2009 and 2017, which represents an increase of 78 % (Canadian Dairy Information Center, 2019). This increase was driven mainly by the increasing consumer demand for good quality and locally sourced goat cheese (Lu and Miller, 2019), towards which approximately 90 % of the goat milk is sent. Goat milk has also gained popularity for its lower lactose content, making it a good alternative for those allergic to cows' milk, and its higher digestibility compared with cow's milk (Park et al., 2007), as well as its beneficial nutritive values (Haenlein, 2004). The increase in goat milk production was largely driven by Ontario, where production increased by 105 % in the same period (Canadian Dairy Information Center, 2019). In fact, according to the latest statistics from 2017, Ontario was also the province with the highest number of producers (68 %) and that contributed the most to the total milk production (84 %) in Canada (Canadian Dairy Information Center, 2019). The second highest contributor to total milk production in Canada was Quebec, with a total production of 9.9 million litres (16 %) and 25 % of the producers in Canada, followed by the Western provinces (6 % of the producers) and the Maritimes (< 1 % of the producers; Canadian Dairy Information Center, 2019). The dairy goat industry remains a relatively small one in Canada, with only 424 registered producers in 2017 (Canadian Dairy Information Center, 2019), and resources are limited to help producers maximize their production and profitability.

Dairy goat producers face multiple challenges, including the availability and quality (i.e., slow genetic improvement, poor growth) of replacement does (or doelings, i.e., immature female goats), as well as the improvement of milk quality at the farm level (i.e., high bacteria and somatic cell counts; MAPAQ, 2018). The productivity of dairy goat farms is dependent on many factors associated with the genetics and management of the herd, which both influence the growth of replacement doelings. The weight at first breeding of the does was associated with lifetime profitability of the goat herd (Nadon et al., 2017). Hence, dairy goat kid rearing is the foundation of future milk production and productivity of dairy goats. Many factors of rearing practices can influence the growth of the kids and affect their ability to reach an optimal weight at breeding. However, although many studies have been carried out in the dairy cattle sector, there is a lack of

research in the Canadian dairy goat industry, especially regarding dairy goat kid rearing practices. Consequently, there are limited references and practical recommendations available to provide dairy goat producers with tools to raise their goat kids efficiently and help them optimize their future milk production. A recent survey of Ontario dairy goat farms (37 respondents) found that nutritional practices varied considerably between farms, and the two most common areas identified by producers as in need for research were nutrition and rearing of kids and doelings (Oudshoorn et al., 2016). Another study was undertaken in Quebec to investigate the feasibility of establishing a nursery for goat kids (53 respondents), and 35 % of the producers reported a goat kid preweaning mortality rate higher than 10 % (Services Conseils Bernard Belzile, 2010). This rate is the highest acceptable kid mortality rate in the first 30 days of life according to Valacta (2014), where it should fall below 5 % from the subsequent month to 7 months of age. This Quebec study also found that 23 % of the herds couldn't reach the optimal breeding weight of 32 kg at 7 months of age and 44 % had an age at first kidding greater than 15 months (Services Conseils Bernard Belzile, 2010), while the optimal age at first kidding should be 12 months (Nadon et al., 2017).

1.1 Hypothesis and Implications

The challenge Canadian producers face to raise their replacement doelings is important and has a direct impact on their herd productivity and farm profitability, therefore it should be addressed to improve the dairy goat industry in Canada. Producers don't have access to many resources, and we hypothesized that this was due to a lack of scientific literature to support recommendations in this domain. Our second hypothesis was that there was a large variability in rearing practices between dairy goat farms in Canada, which could be associated with a large variability in farm performance between farms. Therefore, we believe that there is a gap of knowledge to be filled to provide dairy goat producers with specific recommendations and reference material and improve farm performance. We also believe that the farms that follow recommendations also perform better than farms that don't have optimal kid rearing practices.

This thesis consists of a literature review and a survey study. The literature review identified current recommendations on dairy goat kid rearing practices in intensive production systems worldwide and investigated the extent to which these recommendations were backed up by scientific literature. The subsequent survey study identified the common kid rearing practices on

dairy goat farms in Canada and evaluated the associations between these practices and farm performance indicators.

1.2 Objectives

1.2.1 Overall objectives

The overall objectives of this thesis were to identify gaps in the literature on dairy goat kid rearing practices, from birth to weaning inclusively, and to evaluate current practices on Canadian farms to identify areas that could be improved to increase farm performance.

1.2.2 Specific objectives

More specifically, this thesis aimed to:

1. Identify the current dairy goat kid rearing practice recommendations in intensive production systems worldwide.
2. Assess whether these recommendations were based on scientific literature or not.
3. Evaluate the associations between six farm performance indicators and goat kid rearing practices on Canadian farms.
4. Determine if these six performance indicators could be used to divide farms in different management styles, and to identify which rearing practices differed between the different groups of farms

CHAPTER 2 – RAISING YOUR KIDS THE RIGHT WAY: A REVIEW OF THE CURRENT RECOMMENDATIONS AND SCIENTIFIC KNOWLEDGE ON DAIRY GOAT KID REARING IN INTENSIVE PRODUCTION SYSTEMS

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2.1 Abstract

Dairy goat kid rearing is the foundation of future milk production, yet little is known on this topic and references available to producers are limited, making it challenging for dairy goat farms to reach their full production potential. This review paper aimed to identify the dairy goat kid rearing practice recommendations available for intensive production systems, and to assess whether the different recommendations were based on scientific literature or not. Recommendations on dairy goat kid rearing practices, from birth to weaning inclusively, were presented and compared between countries under similar intensive production systems, including Canada, United States and France. The different areas of rearing investigated included kidding management, colostrum management, liquid and solid feeding, health management, disbudding, housing, weaning and growth monitoring. A review of the literature was undertaken to compare scientific knowledge to current recommendations in the different areas of kid rearing. Gaps in the literature were identified in some specific areas, including the kidding management, kid feeding, housing and weaning, where more research would be beneficial to refine and validate current recommendations on kid rearing practices.

2.2 Introduction

The global dairy goat population is growing, due to expanding demand for goat milk for its nutritional merits and other goat products (Lu and Miller, 2019). The top 3 goat milk producing countries in the world, in terms of quantities of milk produced, are India, Bangladesh and Sudan (Misachi, 2017). However, these countries mostly practice subsistence farming, where the milk produced is mainly directed to self-consumption, and the average herd size is less than 10 goats. This type of farming is very different from commercial farming, which usually involves external labour and capital resources to produce large quantities of milk for commercial purposes. Commercial farming can be divided into two different systems: intensive production and extensive, or pasture-based, production. Intensive production systems are more common in densely populated areas while extensive production systems are more common in areas with lower population density, and where the land is plentiful. Under intensive production systems, goats are usually confined in smaller areas, most often inside a barn, and milk production is maximized to increase the profitability of the farm with the high capital costs associated. This is the most common farming system in North American and European dairy goat farms. In fact, in terms of milk production per goat, Europe is by far the most important continent for production, with France, Spain and Greece

being the three largest producers, ranked 6th, 7th and 10th respectively in the world for total milk production (Misachi, 2017). France is the European benchmark, both in goat milk and cheese production (Ruiz Morales, 2017), and is often used as a resource for the North American dairy goat industry. The Netherlands is also taking more and more space in the European dairy goat industry and has become one of the most important resources for the French industry for their highly technological systems, good genetic quality and high capitalization of farms (Ruiz Morales, 2017). The dairy goat industry is similar in the United States and Canada as they are both relatively small (few farms), but increasing (Lu and Miller, 2019), and have similar intensive production systems. Their production systems and milk yield also compare to France as they have a similar level of intensification and climate. The other commercial farming system is extensive, or pasture-based production, which involves keeping goats in much larger areas, usually on pasture. This production system is often seen overseas, in Australia and New Zealand, where land is plentiful, and the climate is favorable to keep animals out on pasture. The number of farms overseas is relatively small (approximately 68 and 92 dairy goat producers, respectively; AgriFutures Australia, 2017; Scholtens et al., 2017) with an average herd size of around 250 dairy goats, which makes them comparable to other commercial systems in Europe and North America. However, because they are pasture-based systems, their productivity is not comparable to more intensive, confined production systems. Additionally, most of the milk produced in Australia and New Zealand is used to feed to the kids or sent for ultra-high-temperature (UHT) processing, therefore the production purpose is different.

The objective of this review paper was to identify the current dairy goat kid rearing practice recommendations in intensive production systems, and to assess whether the different recommendations were based on scientific literature or not. The hypothesis was that only a few peer-reviewed papers existed to support recommendations on goat kid rearing, and that a gap of knowledge would be found in literature. Recommendations from France, Canada and the United States were used as references for intensive production systems, and the kid rearing practices covered included kidding management, colostrum management, liquid and solid feeding, health management, disbudding, housing, weaning and growth monitoring.

2.3 Importance of goat kid rearing

Goat kid rearing is the foundation of the goat herd productivity. In fact, it was shown that does with an optimal weight at breeding had a higher probability of reaching first kidding and a lower age at first kidding (Nadon et al., 2017). Hence, maximizing the growth of doelings at an early age is important to reach this optimal weight at breeding, around the age of 7 months. It has been reported that the weight of the kids at 60 days of age (weaning) dominates over all other rearing parameters in a way that if sufficient, all other parameters will have a lesser effect on the growth of the goat (Doizé et al., 2013). In fact, a higher than average weight at 60 days of age increases the likelihood of attaining a higher than average weight at 120 days of age by a factor of 6.5 (Doizé et al., 2013). Therefore, it is crucial to maximize the growth and health of the kids in the preweaning period to maximize their future growth and production. Another important period in the kid's life is at weaning, when the kid transitions from a liquid to a solid diet, which is a stressful event and induces a decrease in growth rate (Greenwood, 1993; Gokdal et al., 2017). Therefore, it is critical to manage the weaning period in a way that will minimize stress as much as possible to diminish the effects on the kid's future growth.

This review paper will cover all rearing practices before weaning, including the management of the kidding period, as well as the weaning period, to include all events in the first 60 days of life of the kids, which was identified as the determining period for the kid's future growth (Doizé et al., 2013).

2.4 Recommendations on kid rearing practices

A review of the recommendations on kid rearing practices from Canada, the United States and France is presented in APPENDIX 1. These countries have been selected as international references since they all have similar intensive production systems. The references used for Canada's recommendations include the *Recommended code of practice for the care and handling of farm animals* (CARC, 2003), *Best Management Practices for Commercial Goat Production* (Ontario Goat, 2014), "*Guide: L'élevage de la chèvre"* (CRAAQ, 2016), and "*Guide d'élevage de la chevrette laitière"* (Valacta, 2014). As for France, references from the "Réseau d'élevage caprin" (INOSYS, 2016; Piedhault et al., 2014) and the "Institut de l'élevage" (2009) were used as they are some of the best resources for dairy goat production in France. Finally, for the United States, references from both the University of Wisconsin (Hedrich et al., 2008) and University of

California, Davis (Carlson, 2014) were used since California and Wisconsin are by far the two largest producing states, followed by Iowa, Texas and Pennsylvania (NASS, 2017; Lu and Miller, 2019). Recommendations on kid rearing practices are presented below, by rearing sector.

2.4.1 Kidding management

The number of kidding periods a herd should have per year is an important consideration for producers to optimize their kidding management. Because goats are seasonal breeders, only using natural breeding would make them all come in heat at around the same time in the year, when days get shorter, and there would only be one big kidding period per year. This can reduce the workload of producers since all the kids arrive at once, which facilitates kid management but also makes for a very busy time of year. This also means that all the goats would be dried off at approximately the same time, and milk production would not be stable throughout the year, causing income fluctuations and potential issues with not fulfilling the milk demand. An alternative is to divide the kidding season in more than one period, and that is to breed goats out of season. This can be done with the use of hormones or by playing with the lighting in the barn to trick goats into thinking it is fall again, when days get shorter. These techniques allow for a more consistent supply of kids and milk throughout the year, which leads to a more stable income. No recommendations are available on the optimal number of kidding periods per year to improve kid health and performance, however there is a possibility that more spread out kidding periods would decrease the kid crowding in the nursery, which in turn would decrease kid disease pressure.

The environment in which the kids are delivered play an important role in the kid's health. The kidding area should facilitate the kidding process and limit infection or disease transmission to the newborn kids. All recommendations agree that the area where the goats will give birth should be clean and dry with abundant bedding (APPENDIX 1) and should be disinfected before kidding to avoid any disease or infection transmission to the kid and goat at birth (Valacta, 2014). The area should also be well lit and spacious enough to minimize stress and overcrowding of the goats (Carlson, 2014).

Kidding monitoring is also very important as it can prevent an important number of complications around kidding. It is recommended to frequently observe goats that are close to kidding to be able to give them prompt attention when assistance is needed (APPENDIX 1). This includes day- and night-time monitoring as goats can deliver kids at any time in the day. The use

of baby monitors and barn-cams can facilitate the monitoring of births at all times (Carlson, 2014). Producers should organize their schedule and locate the kidding area in a frequently travelled area to be able to observe goats on a regular basis to decrease the amount of delivery complications when they are absent.

Frequent monitoring is also important to supervise the births and be able to remove kids from the dams as soon as possible to prevent them from nursing. This is a recommended practice across Canada and internationally to prevent the transmission of contagious diseases such as caprine arthritis encephalitis (CAE) and Johne's diseases from infected goats (APPENDIX 1). CAE is a multisystem viral disease caused by a lentivirus (type-C retrovirus), related to the visna virus of sheep, and is common on dairy goat farms around the world, especially in Canada (Simard, 2002), as it is contagious and persistent (de Lahunta and Glass, 2009). Some references even recommend preventing any licking of the kid by the dam to prevent transmission of CAE (INOSYS, 2016; Carlson, 2014) as it is not only transmitted through the colostrum and milk of infected does, but also by direct contact with saliva or mucous of infected does (de Lahunta and Glass, 2009). This virus raises important concerns for the productivity of goat herds and it was found to increase reproductive failure and decrease milk yield and lactation length of seropositive multiparous does (Greenwood, 1995). It was also shown to adversely affect the birth weight and growth rate before and during weaning of kids born from infected does (Greenwood, 1995). Finally, CAE virus was also shown to significantly increase the incidence of diseases in does, which suggests signs of immunodeficiency in does that were seropositive for CAE (Greenwood, 1995).

Finally, kids should be cleaned and dried as soon as possible after birth, especially if the dams did not get to lick them dry. This can be done with the use of a clean towel (Ontario Goat, 2014; CRAAQ, 2016) or a hair dryer to fluff the kid's hair, including the hair around the ears to prevent them from freezing (Hedrich, 2008). The kids should be kept in a warm location, and heat lamps can be used, if necessary, to keep the ambient temperature between 10 and 18^{o}C (Ontario Goat, 2014) or closer to 20^{o}C (INOSYS, 2016).

2.4.2 Colostrum management

Colostrum is one of the most important aspects of goat kid rearing as it acts as the early life insurance of the kid and has a direct influence on the kid's future growth and development. Just like in all ruminants, immunoglobulin (IgG) from the dam is not transferable to the fetus through the placenta, therefore the kid needs to consume colostrum to acquire antibodies as soon as possible after birth. This transfer of maternal antibodies through colostrum, also called passive transfer, is crucial to protect the kid against infectious diseases until it develops its own immune system.

The passive transfer of immunity to the kids can be assessed looking at the IgG level in the kid's blood serum at 24 h of age, when it was found to be at its peak (Rodríguez et al., 2009). The IgG blood serum concentration is an indicator of the amount of IgG intake by the kid (Castro et al., 2005). Mellado et al. (1998) suggested that a minimum of 800 mg/dL of serum IgG at one day old should be achieved to increase survival risk in extensively managed goat herds, while O'brien and Sherman (1993) suggested a minimum of 1200 mg/dL of serum IgG to help ensure a good health and survival to weaning in intensively managed goat herds.

Additional to the increase in health and survival of kids, the passive transfer of immunity also has a direct impact on the preweaning growth performance of dairy doe kids. Massimini et al. (2007) found that each 100 mg/dL increase in serum IgG at 24 h was associated with an increase in ADG of 0.005 kg/day and a higher weaning weight at 30 days of 0.185 kg.

In order to maximize the IgG absorption by the kid and avoid a failure of passive transfer, it is important to feed high quantities of colostrum, as early as possible after birth (Simoes et al., 2005) since the permeability of the kid's intestine to absorb IgG decreases fast. In fact, INOSYS (2016) stated that the absorption in the kids' intestine diminishes by 25 %, 6 hours after birth, and by 50 %, 20 hours after birth, while the CRAAQ (2016) reported that immunoglobulins could only be absorbed through the kids' intestine in their first 12 hours of life. However, no scientific literature was found on the exact time of intestinal gut closure for goat kids specifically. Recommendations on when to feed the first colostrum vary from immediately after birth to up to 6 hours after birth, but as a general rule, colostrum should be fed as early as possible after birth (APPENDIX 1). Additionally, the concentration of IgG in the goats' milk drops quickly after delivery (significantly lower in the 2nd hour after parturition, and further decreased at 4 and 10 hours after parturition; Moreno-Indias et al., 2012), therefore it is important to milk the goat as

soon as possible to ensure that the colostrum offered to the kids is of good quality. Another study reported a numerical (not significant) decrease in the IgG concentration in milk by 42 % between 3 and 12 hours after parturition, and a significant decrease at 24 hours compared to the concentrations at 3 and 12 hours (Yang et al., 2009).

In terms of duration for the colostrum feeding period, different recommendations exist, between 24 hours and 3 days (APPENDIX 1), but allowing kids to drink colostrum for 24 h was found to be sufficient to achieve an adequate serum IgG concentration and passive transfer. (Castro et al., 2005; Castro et al., 2009). Feeding colostrum for one day as opposed to two also reduced the handling time and gave better results when an equal quantity of IgG was used (Castro et al., 2005). However, feeding colostrum longer may have nutritional benefits due to its higher concentration in dry matter, fat, lactose and protein (Yang et al., 2009; Moreno-Indias et al., 2012).

The recommended quantity of colostrum to offer in the first 24 hours of life varies between 150 and 200 mL/kg of kid body weight, with a minimum of 50-100 mL/kg of body weight in the first meal (APPENDIX 1). A total of 2-4 meals should be offered in the first 24 hours of life of the kid. In the case of tube feeding (if the kid refuses to drink after 2 attempts 3-4 hours apart), it is not recommended to give more than 113 g at a time (APPENDIX 1).

The quality of the colostrum, in terms of concentration of IgG, is also very important to the success of passive transfer. In fact, the concentration of colostrum was shown to have a larger influence on IgG absorption than the amount of colostrum fed, when an equal amount of IgG was used (Table 2.1). In other words, the efficacy of IgG absorption was increased when a colostrum with higher IgG concentration was fed, no matter the quantity.

Different methods exist to evaluate the quality of colostrum, including visual observation, colostrometer, and Brix refractometer. The color method, validated by Argüello et al. (2005), uses a Chroma value to predict the IgG concentration in goat colostrum, and could easily be used by farmers using a plastic color fan with different colors for each Chroma value with their corresponding IgG concentration. The use of a Brix refractometer has been validated by Quigley et al. (2013) to evaluate the quality of bovine colostrum, where a cut point of 21 % Brix was most appropriate to estimate samples with an IgG concentration greater than 50 mg/mL. The Brix value has not yet been established for goat colostrum, however the use of a clinic refractometer has been validated as a tool to estimate the IgG content in goat colostrum by Castro et al. (2018). In this

study, a cut-off of 20 mg/mL or more was used to identify good quality colostrum. A refractometer could also be used to determine the passive transfer status of the kids with blood serum, where Brix measurements lower than 8.6 % for 1-day-old kids would indicate a failure of passive transfer (Batmaz et al., 2019).

Finally, the source of colostrum also has an important impact on the kid's health and growth. To prevent the transmission of caprine arthritis encephalitis (CAE) and Johne's diseases from the goat's colostrum, it is recommended to heat treat it at 56-60^{o}C for 1 hour (APPENDIX 1) to kill harmful bacteria before feeding it to the kids. However, it is important to not heat it too hot or too long to avoid destroying the colostrum's antibodies. Heat treating colostrum does not affect the growth and health of the kids, however it could impair some immunological functions of kids, such as serum IgG concentrations and delayed type hypersensitivity response, which suggests an alteration to cellular immune system (Fernández et al., 2006). Other recommended colostrum sources include cow colostrum or commercial colostrum replacer (lyophilized bovine colostrum). A study by Castro et al. (2005) found that lyophilized colostrum (prepared manually from a paste concentrate) was absorbed more efficiently than frozen colostrum, however the IgG concentration of the lyophilized colostrum was higher which could explain this difference. Pooling colostrum from different dams is not recommended (Ontario Goat, 2014).

2.4.3 Kid feeding

Milk

Different recommendations exist for the milk source artificially-raised kids should be fed, but they all have in common that it should be a substitute to goats' milk as it is not considered a "safe" option for the kids (i.e., high risk of CAE infection). Most references recommend using a milk replacer intended for goat kids as they have different nutritional needs than lambs or calves (APPENDIX 1). Milk replacers should contain between 16 and 24 % fat and 20 to 28 % protein, ideally whey- or milk-based as opposed to soybean-based (Hedrich, 2008; Carlson, 2014). It is crucial to follow mixing instructions when preparing a milk replacer, including an appropriate water to powder ratio, a precise dilution temperature (usually around 50-55 ^{o}C) and mixing time to make sure the milk is of good quality and the proteins are not denatured. Other milk options include pasteurized goats' or cows' milk to prevent transmission of CAE and Johne's diseases, in which case it is also important not to feed milk from treated animals. However, feeding milk replacer may

be more economical (CRAAQ, 2016). In fact, the use of commercial milk replacer was shown to be more economically viable than goats' milk to raise kids, but cows' milk was an even more economical option (Knupp et al., 2016). However, this study was done in Brazil, therefore results should be carefully interpreted before they are applied to Canadian farms as the rearing and milk feeding costs may differ between both countries and the outcome could be different. Comparing goats' milk to a lamb milk replacer fed to kids, both sources showed similar kid growths, however goat-milk-fed kids showed a higher nutrient digestibility, metabolizable energy and fattening than those fed with a lamb milk replacer (Sanz Sampelayo et al., 1990). This study states that goat kids made suitable use of the lamb milk replacer in terms of kid performance, therefore it could be used as a replacement to goat milk. It is also possible to enhance the nutritional quality of milk replacer by adding whey in the water used for the milk replacer preparation. Goat kids fed cow milk replacer mixed in water with 35 % whey showed a similar daily weight gain to kids that were fed whole goat or cow milk, and a higher daily weight gain than kids fed cow milk replacer with 0, 20 or 50 % whey (Galina et al., 1995). Feeding a higher percentage of whey caused severe diarrhea in kids, which resulted in a lower weight gain, therefore it is important to not overfeed it (Galina et al., 1995).

Milk can be either fed warm (38-44 ^{o}C) to increase consumption and speed of consumption or cold (4 ^{o}C) to decrease the quantity and speed of consumption (Hedrich, 2008). Fresh milk or milk replacers can be acidified to leave at ambient temperature for ad libitum consumption. Feeding of cold acidified milk replacer is considered a suitable option, especially during the cold season when the kids' water intake is lower (Andrighetto et al., 1994). Increasing the concentration of the acidified milk over the rearing period was not shown to influence kid performance and increased labour costs, therefore a fixed milk concentration should be maintained (Andrighetto et al., 1994).

In terms of quantity and frequency of milk offered, all recommendations agree on feeding milk at frequent intervals, ideally more than twice a day or ad libitum to allow the kids to feed at will, and smaller quantities at once (APPENDIX 1). Kids should be drinking 1.8 to 2.0 litres of milk per day from day 21 onward when fed ad libitum (Valacta, 2014). In restricted feeding systems, small, frequent feedings are recommended to increase digestibility and decrease digestive disturbances of the kids (Hedrich, 2008). Milk should be fed 3 to 5 times per day in the first few

days after birth (varies between 2 to 14 days), then at least two meals per day should be fed until weaning.

The recommended quantities of milk to feed are 0.5-1 L/day in the first 3 days, 1L/day until day 7, 1.5L/day from day 7 to 15, and 2L/day from day 15 to one week before weaning (CRAAQ, 2016). A study by Doizé et al. (2013) found that kids that were offered at least 2 litres of milk per day from 10 days of age up until weaning had a higher likelihood of reaching a higher than average weight at 60 days of age by a factor of 1.6. As milk quantity increases, it is however important to remember not to overfeed kids in one meal to avoid risks of bloating; the quantity to feed in one meal should not exceed 450 mL, or 280-340 mL in the first weeks after birth (Hedrich, 2008). Finally, it is also recommended to follow a constant feeding schedule not to disturb the kids' feeding routine (Institut de l'élevage, 2009).

Different milk feeding methods exist, however nipple feeding systems are strongly recommended over gutter systems as the kids must lift their head up to suckle, which closes their oesophageal groove and allows milk to bypass the rumen, and this is important to avoid gastric problems (Piedhault et al., 2014). Automatic milk feeders (AMF) can be used for a large number of kids when feeding ad libitum milk, otherwise multiple-nipple milk bars are good options for restricted milk feeding. In the case of AMF, at least 1 nipple should be available for every 15 to 20 kids in a pen, while at least one nipple should be provided per kid when milk is fed in restricted amounts using a multiple-nipple milk bar (APPENDIX 1). If a milk gutter is used, a minimum feeder space of 10-15 cm/kid should be provided (INOSYS, 2016).

When feeding ad libitum milk, it is important to replace the milk regularly to prevent bacteria multiplication in the milk, and automatic feeding equipment such as the mixing bowl and nipple supports should be cleaned daily, while tubes can be washed weekly (INOSYS, 2016). Milk preparation utensils should be well cleaned and sanitized after each use to ensure a good hygiene. Finally, all feeding material, including milk buckets used for restricted milk feeding, should be cleaned after each use. A poor hygiene of the feed distribution system was in fact found to be associated with a higher than average goat kid mortality in the first 30 days of age ($P = 0.05$), mainly due to feed contamination which is well known to increase the risks of kid respiratory disease and diarrhea (Buczinski, 2013). The use of a disinfectant to wash milk feeding equipment was associated with a higher kid growth before weaning, and increased the likelihood of the kids

to reach a higher than average growth at 60 days of age by a factor of 2.5 (Doizé et al., 2013), which shows the importance of thoroughly washing the milk feeding equipment.

Water

It is recommended that kids have access to clean, lukewarm water at all times, ideally between 1 and 2 weeks of age, according to Canadian and France references (APPENDIX 1), to facilitate the transition from a liquid to solid diet with water around weaning. No scientific literature is available on the effect of water intake on goat kids' performance.

Concentrates

Recommendations on concentrates availability to kids vary from 1 to 3 weeks of age, however the general rule is to offer it as early as possible to stimulate early consumption (APPENDIX 1). A good quality (18-20 % crude protein; Institut de l'élevage, 2009; CRAAQ, 2016) of highly palatable kid starter should be offered ad libitum (APPENDIX 1), or at least twice a day (INOSYS, 2016). The concentration of protein in concentrates was found to be correlated ($r = 0.65$, $P < 0.001$) with the average growth rate of kids in the first month after weaning when fed ad libitum concentrates from 1 to 2 weeks of age (Greenwood, 1993). In addition, feeding pelleted feed alone as opposed to pellets mixed with whole or rolled cereal grains were shown to increase the weight gain and feed conversion ratio of goat kids when fed ad libitum concentrates (Hadjipanayiotou, 1990). Multiple meals of fresh concentrates should be offered to stimulate consumption. The feeder space should be around 15-20 cm/head to limit competition when feeding multiple meals per day, or 3-5 cm/head when concentrates are fed free choice. Finally, kids should consume at least 200 g/day by weaning time to ensure a good transition to a solid diet (CRAAQ, 2016). It was shown that a concentrate consumption of 150 g or higher before weaning increased the likelihood of the kids to reach a higher than average weight at 60 days of age by a factor of 1.7 (Doizé et al., 2013).

Forages

Forage consumption is necessary to promote a good rumen development and ensure it is well-functioning at the time of weaning, when the kid transitions to a solid diet. According to most recommendations, a high quality forage should be introduced to the kid's ration around the same time as the concentrates (i.e., between 1 and 3 weeks old; APPENDIX 1). The hay should be leafy,

harvested in a young stage (early-bloom), and contain a maximum of 34 % acid detergent fibre (ADF) to increase digestibility and palatability (CRAAQ, 2016). Alfalfa hay should be avoided before the age of 4 months as important risks of bloating are associated. The hay should be fed free choice or 3 times a day to encourage consumption. In a study based on a questionnaire on kid rearing practices, the quantity and quality of hay offered before weaning was found to have no significant effect on the kids' growth (Doizé et al., 2013). However, a high consumption of forages (≥ 250 g/day) before weaning was found to be slightly unfavorable to the kids' growth, but this may have been due to the decreased consumption of concentrates more than the high consumption of forages (Doizé et al., 2013). No other scientific literature was found on the effect of feeding forages to kids before weaning.

2.4.4 Health management

Goat kids are sensitive animals to diseases, and there are many health issues to control to optimize the kid health management. Some of the common ones include neonatal losses, diarrhea, contagious ecthyma, CAE, and paratuberculosis (CRAAQ, 2016). It is also important to observe daily for signs of scours and respiratory disease (Ontario Goat, 2014). The maximum target kid mortality rate in the first month of the kid's life is 10 %, and 5 % between 1 and 7 months of age to minimize losses to the farm (Valacta, 2014). In a recent study on kid mortality on commercial dairy goat farms in New Zealand (1262 kids from 16 farms), a mortality rate of 10.4 % (range from 0 to 20.5 %) was reported between birth and first breeding, where 90 % of the deaths occurred before weaning (Todd et al., 2019). In comparison, a study carried out on Quebec commercial dairy goat farms (28 farms) found a similar mortality rate in the first month of age with a median of 10.2 %, however the variability was greater (0 to 51.3 %), and the mortality rate after one month of age was higher (median of 7.8 % with range of 0 to 25 %; Buczinski, 2013). Another study from Quebec had previously reported an average mortality rate of 14 % before weaning on a sample of 53 dairy goat farms (Services Conseils Bernard Belzile, 2010). Finally, in an Ontario study (37 farms), 82.4% of the producers reported to have a doeling mortality rate below 10 %, where 77.1 % reported a lower than 10 % mortality for kids under 7 days of age while 74.3 % said to be in that same mortality category for kids between 7 and 28 days of age (Oudshoorn et al., 2016). The main cause of death identified in the New Zealand study was gastrointestinal disorders (33.6 %), including bloat, ruptured abomasum, intestinal torsion and enteritis, followed by disbudding-related injury (15.9 %) and septicemia (12.1 %; Todd et al., 2019). In the first 14 days of age, the

main causes of death were septicemia and starvation or dehydration (18.6 and 14.0 %, respectively; Todd et al., 2019). Finally, deaths that occurred after 14 days of age were mainly attributed to gastrointestinal disorders and disbudding-related injuries (42.2 and 18.8 %, respectively; Todd et al., 2019). Main causes of mortality were not identified in the Quebec and Ontario studies. Being able to identify causes of death and adopting good health management practices on the farm are two critical steps to reduce kid mortality.

The first intervention that should be done to the kids is to dip or spray their umbilical cord with a disinfecting solution of 5 to 7 % tincture of iodine as soon as possible after birth to prevent navel infections (APPENDIX 1). If the navel cord is too long, it is recommended to cut it to 8-10 cm in length before disinfecting it to avoid it from dragging on the bedding and collecting bacteria (Hedrich, 2008). Infections should be monitored closely, and another application of iodine could be necessary after 24 hours if there are signs of redness (Ontario Goat, 2014). Disinfecting the umbilical cord in the minutes following birth was found to increase the kid's likelihood of attaining a higher than average weight at 60 days by a factor of 4.0 (Doizé et al., 2013).

Kids should also be provided with a selenium and vitamin E supplement at birth, either by injection (most common) or orally by complementing feeds with selenium (APPENDIX 1). A study by Ramirez-Bribiesca et al. (2005) reported that injecting kids born from selenium deficient goats with 0.3 mg of selenium and 4.2 IU of vitamin E per kg of body weight at birth was sufficient to decrease the mortality rate of kids in the first two months of age compared to the control treatment (60 % vs 24 % mortality, respectively; $P < 0.01$). Injecting double the dose of selenium and vitamin E showed similar results to the single dosage (24 % vs 20 % mortality, respectively; $P > 0.05$). In case of deficient areas where soils are low in selenium, pregnant goats can be supplemented with selenium as well (Hedrich, 2008). Supplementing goat kids with selenium and vitamin E was also shown to increase the likelihood of the kids to reach a higher than average weight at 60 days of age by a factor of 3.4 (Doizé et al., 2013).

Dam and kid vaccination are other important health management practices to prevent certain diseases that kids can contract early in life, including enterotoxaemia (*Clostridium perfringens* types C and D) and tetanus. It is recommended to vaccinate dams for these diseases in their last 3 to 4 weeks of gestation to transfer their immunity to the kids through colostrum at birth. Kids should then be vaccinated between 3 and 6 weeks of age, and another time 2 to 4 weeks later

(APPENDIX 1). If the dams were not vaccinated before kidding, kids should be vaccinated for the first time at 1 week of age (CRAAQ, 2016) to ensure that they acquire the necessary immunity. Some vaccines also exist for caseous lymphadenitis (Valacta, 2014), but don't seem to be commonly used.

Finally, coccidiosis and cryptosporidiosis are two important enteric diseases that should be controlled at the farm as they can cause diarrhea, decreased weight gains and occasionally death in goat kids (Foreyt, 1990). Coccidiosis (caused by *Eimeria spp.*) is the most common cause of diarrhea in goat kids and can be controlled with good nursery sanitation, and with the use of coccidiostats, such as decoquinate (e.g., Deccox®) or monensin (e.g., Rumensin®) in feed (Luginbuhl and Anderson, 2015). Kids should consume 1 mg of drug per kg of body weight per day for at least 30 consecutive days for the prevention treatment to be efficient (Foreyt, 1990). A good prevention and control of coccidiosis will significantly increase efficiencies in weight gains and production as opposed to treating (or not) the disease, which will result in economic loss to the producers (Foreyt, 1990). Valacta (2014) recommends adding coccidiostats (or anticoccidial drug) to the feed starting at 15 days of age, while INOSYS (2016) recommends planning for a prevention treatment at one month of age and another one at weaning. Interestingly, the use of 1 mg decoquinate/kg of body weight from 8 days before weaning to 75 days after weaning was shown to significantly increase the weight gain of kids and their first lactation milk yield at 100 and 200 days compared to untreated kids or kids treated for 30 days after weaning (Morand-Fehr et al., 2002). This study shows added benefits to using decoquinate in goat kids. Cryptosporidiosis (caused by *Cryptosporidium parvum*) is a milder disease than coccidiosis and usually affects kids under 30 days of age. It is transmitted by oral ingestion of infective oocysts found in feces of sheep, goats or carnivores (including humans), their three potential hosts (Foreyt, 1990). The primary symptom of this zoonotic disease is mild to severe diarrhea for 5 to 15 days, but can also show signs of depression, dehydration, anorexia, listlessness, unthriftiness and abdominal pain (Paul et al., 2014). There is no available effective treatment for this disease, however it is possible to control it with strict sanitation, such as disinfecting contaminated housing with ammonia or formalin and eliminating carnivore (including domestic and feral animals) feces from the goats' environment, and putting sick animals in quarantine (Foreyt, 1990). Decoquinate was however found to be an efficient treatment to decrease the severity of cryptosporidiosis in infected kids when orally medicated with 2.5 mg/kg/day for a 21-day period (Mancassola et al., 1997).

2.4.5 Disbudding

Disbudding kids is a common management practice performed on commercial dairy goat farms to avoid injuries to other goats in the herd and to handlers, and to minimize risks of goats getting stuck in fences or between pen partitions, which could potentially lead to deaths by hanging (Smith and Sherman, 2009). However, disbudding is both stressful and painful for the kids (Hempstead et al., 2017), therefore it should be controlled to minimize pain, accidents and complications (Liron et al., 2011).

Kids should be disbudded at a young age, before the horn buds are too big. This age is different for male and female goats as the males' horn buds are bigger than females' are at the same age (Smith and Sherman, 2009). Recommendations for the optimal time of disbudding vary between 3 and 15 days of age (APPENDIX 1), depending on the sex and growth of horn buds, but as a general guideline doe kids should be disbudded between 5 and 7 days of age and buck kids should be disbudded between 3 and 5 days of age (Smith and Sherman, 2009). Disbudding kids before 14 days of age was in fact shown to increase the likelihood of reaching a higher than average kid weight at 60 days of age by a factor of 2.6 (Doizé et al., 2013).

Heat cautery is the most widely used technique for disbudding kids (Alvarez and Gutiérrez, 2010; Hempstead et al., 2017; Valdmanis, 2007). It should be performed with an electric of gas hot iron tool with a tip diameter of 19-25 mm (Smith and Sherman, 2009), held on the horn buds for 2 to 3 seconds at a time until the horn buds can be removed. It is recommended to remove the buds to reduce the risk of infection (Matthews and Dustan, 2019) and increase the effectiveness at preventing horn regrowth (Hempstead et al., 2018c). This method was shown to induce an acute cortisol increase for 2 to 3 hours after disbudding (Alvarez and Gutiérrez, 2010) and significant stress- and pain-related behaviour responses (Alvarez et al., 2009; Hempstead et al., 2017). Additionally, cautery disbudding causes important tissue damage in goat kids, causing large, open wounds with evident scabs 6 weeks after disbudding (Hempstead et al., 2018b). Wounds usually take between 35 and 63 days to re-epithelialize and they remain painful until then (Alvarez et al., 2019). This method was also associated with a greater risk of skull or brain injuries than alternative methods (Hempstead et al., 2018e), however this risk could be decreased if the disbudding is performed correctly, by a competent person. These results raise important welfare concerns about

this procedure, and therefore alternative methods to disbudding have been evaluated, including caustic pastes, cryosurgery (liquid nitrogen) and clove oil (Hempstead et al., 2018b).

Caustic pastes are sodium, calcium or potassium hydroxide pastes that are applied around the horn buds to chemically burn them. This technique is not recommended for kids as it can potentially lead to blindness if it comes in contact with the kids' eyes or burn other body parts the paste comes in contact with (CARC, 2003). It was also found that kids disbudded with caustic paste had more persistent and acute pain sensitivity (Smith and Sherman, 2009; Hempstead et al., 2018a; Hempstead et al., 2018e) and showed a higher serum cortisol concentration than cautery disbudded kids 1 hour after disbudding (Hempstead et al., 2018b). Caustic pastes also cause red and open, raw wounds generating large eschars that remain apparent for up to 6 weeks after its use (Hempstead et al., 2018b).

Cryosurgical disbudding involves spraying liquid nitrogen on the horn buds for 10 seconds each to kill the cells. This method was also associated with a higher serum cortisol concentration than cautery disbudded kids 30 minutes after disbudding (Hempstead et al., 2018b), and more acute pain sensitivity than cautery disbudding (Hempstead et al., 2018e). Cryosurgical disbudding causes closed, dry wounds that eventually become open wounds with small scabs present 6 weeks after disbudding (Hempstead et al., 2018b).

Lastly, the newest technique investigated is the injection of clove oil, an essential oil of *Eugenia caryophyllata*, into the horn bud of the kids. Clove oil contains almost 72 to 90 % Eugenol, a natural phenolic compound which possesses many biological properties such as antiviral, antioxidant and anti-inflammatory (Molaei et al., 2015). However, at higher concentrations it can be cytotoxic to various species' cells, hence why its use has been investigated for goat kid (Molaei et al., 2015) and calf (Sutherland et al., 2019) disbudding. Clove oil injection in the kids' horn buds was shown to be efficient at stopping horn growth, due to complete necrosis of the bud tissues in dermal and epidermal layers, and there were signs of healing and re-epithelialization by days 8 to 10 already (Molaei et al., 2015; Farajli Abbasi et al., 2018). This method was tested against other alternatives and was shown to cause less pain than the caustic paste and cryosurgical methods, but had similar pain-related behavioural responses to cautery disbudding (Hempstead et al., 2018a). Mean cortisol concentration from clove oil disbudding was also similar to cautery disbudding and lower than the caustic paste and cryosurgical methods (Hempstead et al., 2018b). However, the

clove oil method showed higher haptoglobin concentrations than all other methods 24 hours after disbudding, which is indicator of an inflammatory response that is usually associated with pain (Hempstead et al., 2018b). Lastly, this method caused closed, dry wounds with blackened skin, with minimal scabs present 6 weeks after disbudding, which is sign of faster healing than the alternative methods (Hempstead et al., 2018b).

In conclusion, the caustic paste and cryosurgical methods seem to cause more pain than cautery and clove oil disbudding, but heat cautery has a higher risk of skull injuries. Therefore, clove oil disbudding appears to be an interesting alternative to cautery disbudding as it causes similar pain levels while not damaging the tissues as much and healing faster than cautery disbudding. More research needs to be carried out on the clove oil alternative as it is a relatively novel technique. Cautery disbudding remains a good option for now, as long as it is properly done.

Aside from the disbudding method itself, a most effective method to alleviate pain is using pain controls. It is in fact recommended to provide the kids with appropriate pain control, as prescribed by a veterinarian, to minimize pain associated with disbudding (APPENDIX 1). Different options exist, including the use of a local (e.g., lidocaine) or general (e.g., isoflurane gas) anesthetic, sedative (e.g., diazepam, xylazine), long-acting (e.g., meloxicam) or short-acting (e.g., ketoprofen, flunixin neglumine) anti-anflammatory. However, not all of them are efficient and safe to use for kids.

Local anesthesia consists of producing a nerve block by administering lidocaine hydrochloride (or an equivalent) subcutaneously around the nerves that supply the kids' horn buds to numb them, 15 to 20 minutes before disbudding. Each one of the goats' horn buds are supplied by two nerves: the cornual branch of the lacrimal nerve and the cornual branch of the infratrochlear nerve (see Figure 2.4.1), whereas calves' are only supplied by the cornual branch of the lacrimal nerve (Matthews and Dustan, 2019). Therefore, it may be more difficult to achieve an effective block with lidocaine in kids since a large number of local anaesthetics are necessary in a very small animal. The dosage has to be carefully adjusted to avoid toxicity as goat kids are very sensitive to lidocaine at a young age (Smith and Sherman, 2009; Matthews and Dustan, 2019). A total dose of 7 mg of lidocaine per kg of body weight was shown to be safe to use for cornual nerve block in goat kids, even if it is accidentally injected into veins (Venkatachalam et al., 2018). In practice, the subcutaneous administration of 0.5 mL of 1 % lidocaine hydrochloride around each of the two

cornual branches of the lacrimal and infratrochlear nerves of both the kid's horn buds was shown to be safe and effective to produce a cornual nerve block in goat kids (Venkatachalam et al., 2018). It is also possible to further dilute the lidocaine solution to a 0.5 % concentration by adding sterile water or saline, and administer 1 mL of this diluted solution around each nerve site to increase chance of reaching the nerves (Smith and Sherman, 2009). Unfortunately, lidocaine was not shown to prevent the short-term increase in cortisol concentration during and after disbudding and did not decrease the expression of behaviours (e.g., vocalizations) in kids, which indicates that pain and stress was not reduced with a lidocaine nerve block (Alvarez et al., 2009; Alvarez et al., 2015).

General anesthesia can be achieved with isoflurane gas slowly administered in oxygen through a face mask to render kids unconscious while disbudding is performed. This method is simple, quick and safe, however there are some health and safety concerns for the handlers (Matthews and Dustan, 2019). To control these, the mask should be close-fitted and used in a well-ventilated environment. Gas levels should always be monitored, and oxygen should be removed before disbudding to avoid combustion risk if a gas disbudder is used. The use of isoflurane gas as an anesthetic was proven to reduce pain associated with cautery disbudding in goat kids (Hempstead et al., 2018d).

Sedation by intramuscular injection before disbudding is another option to reduce pain associated with cautery disbudding. A study by Nfor et al. (2016) used dexmedetomidine hydrochloride, an alpha 2 agonist with both sedative and analgesic properties, 15 minutes before disbudding kids, and concluded that it significantly decreased the kids' cortisol level and pain-related behaviours after disbudding compared to disbudding with no pain control or with a nerve block and analgesic. Therefore, it was concluded that sedation could improve kid's welfare by reducing stress and pain related to disbudding.

Finally, analgesics can also be administered, orally or injected intramuscularly, after disbudding to reduce pain. A commonly used one is meloxicam, a nonsteroidal anti-inflammatory drug that can be administered by the producer without a veterinary on-site. The injection of meloxicam to kids once daily (0.5 mg/kg body weight) for 3 days after disbudding was shown to decrease signs of pain on the first day after disbudding compared with kids that did not receive the analgesic (Ingvast-Larsson et al., 2011).

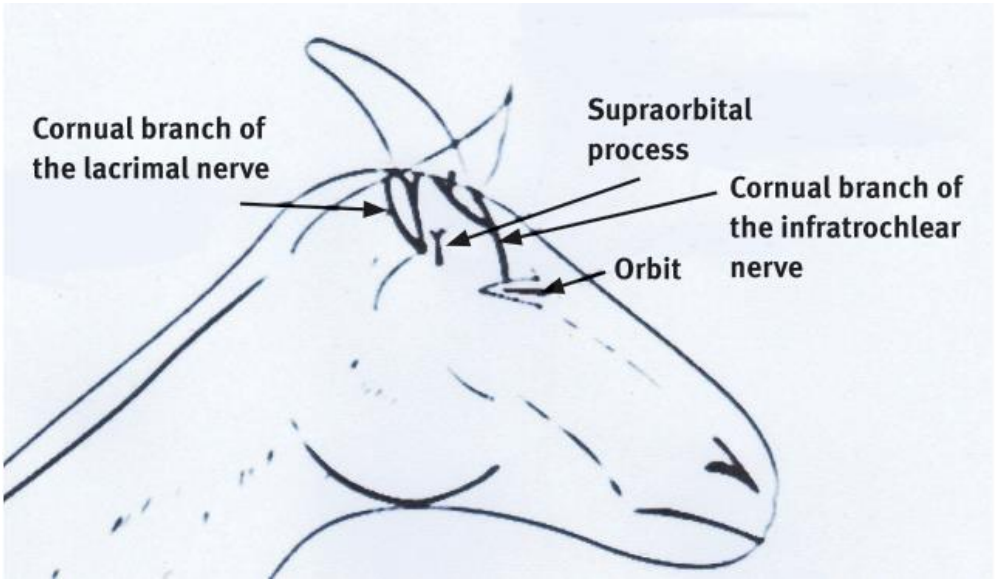

Figure 2.4.1 – Distribution of nerves to the horns of a goat (Matthews and Dustan, 2019)

2.4.6 Kid housing

Kids should be housed in a clean, dry and warm, draft-free environment to optimize their health and growth performance. The area where the kids are housed should be cleaned, washed with soap, disinfected and ideally left vacant between the kidding season(s) to minimize contamination between different groups of kids (APPENDIX 1). In a study of kid mortality factors on Quebec dairy goat farms, an adequate nursery hygiene was found to be associated with a lower than average goat kid mortality in the first 30 days of age ($P = 0.008$; Buczinski, 2013). Therefore, it is very important to keep the kids' environment clean to decrease mortality. Kids should be provided with a generous amount of clean and dry bedding (i.e., wood shavings, straw) to ensure a good kid comfort, and bedding should be monitored daily for moisture and depth (APPENDIX 1). The bedding should be changed frequently to reduce the risk of disease and limit ammonia build-up, which can lead to respiratory problems (Ontario Goat, 2014). The absence of ammonia in the kids' housing was also shown to increase the kids' likelihood of reaching a higher than average weight at 60 days of age by a factor of 1.6 (Doizé et al., 2013), which shows the importance of limiting the quantity of ammonia in the building. The room should be kept at a temperature between 12 and 18°C, depending on recommendations (Institut de l'élevage, 2009; CRAAQ, 2016).

Kids can be housed in groups of 15 to 25 kids of similar age to facilitate management, however they should be as homogeneous as possible to avoid competition at feeding, and should be reallocated based on weight as often as possible to keep them homogeneous (APPENDIX 1). Smaller groups are recommended in the first two weeks of life to limit competition and ensure proper observation of the kids (Carlson, 2014). A study by Goetsch et al. (2001) compared the effect of housing kids in individual pens, paired pens (experimental kid grouped with one trainer kid) or group pens (experimental kid grouped with at least 2 trainer kids) on pre- and post-weaning growth, and they found no effect of group size on average daily gain in the 8-week preweaning phase as well as up to 12 weeks of age (end of experiment). Kids were fed ad libitum milk up to 8 weeks of age, when they underwent a 6-day gradual weaning, and had access to ad libitum concentrates from 2 to 12 weeks of age. The results from this study suggest that kids should perform the same in group and individual pens, when provided enough resources (i.e., ad libitum feeding) to limit competition at feeding.

Doe kids can be housed with buck kids until 12 (CARC, 2003) to 16 (Ontario Goat, 2014) weeks of age before they should be removed to avoid unintentional breeding. The recommended floor space for unweaned kids varies between 0.25 and 0.5 m^2/head to avoid overcrowding, and the recommended kid feeder space is 15 cm/head to ensure that all kids are able to feed at the same time, without much competition (APPENDIX 1). A study by Doizé et al. (2013) reported that respecting the norms of 0.3 m^2/kid until 1 month of age, 0.5 m^2/kid from 1 to 2 months of age and 0.8 m^2/kid after 2 months of age increased the kids' likelihood of reaching a higher than average weight at 120 days of age by a factor of 4.2.

The nursery room should be separate and far from the adult goats to avoid any contact, including sharing the same air, with the goats to decrease risks of contracting slow-developing diseases like CAE (APPENDIX 1). In fact, a study on kid mortality factors found that herds where kids were housed in the same building as the adult goats (possible contact with adult goats) had a tendency ($P = 0.06$) to have a higher than average mortality rate after 30 days of age (Buczinski, 2013).

2.4.7 Weaning

Weaning is a very stressful period in the kid's life and often coincides with decreased growth and poor welfare as the kid transitions from a liquid to a solid diet. This change in the kid's diet involves changes in endocrine and metabolic functions. In fact, weaning was shown to decrease plasma glucose, amino acids and insulin levels (Atef Aufy et al., 2009; Magistrelli et al., 2010).

However, it is possible to minimize these negative effects with an appropriate weaning protocol. Kids are usually weaned at around 2 months of age, but their weight at this age will vary depending on their parity number, feed consumption and feed conversion ratio, therefore the kids' growth should be taken into consideration when deciding to wean them. It is recommended to wean kids at a minimum weight of 14 to 15 kg, or when they have reached 2 to 2.5 times their birth weight, to account for smaller animals (APPENDIX 1). In fact, it was found that kids that were weaned later (at 15 kg) as opposed to earlier (at 10 kg) grew faster and reached their optimal reproductive weight of 30 kg, 30 days before the kids that were weaned earlier (Palma and Galina, 1995). Another study on early weaning, where kids were completely weaned by day 36, showed that early weaned kids had significantly lower weight gains and higher mortality postweaning than kids that were traditionally weaned at 60 days of age (Luparia et al., 2009). Therefore, weaning kids early is an option that may be chosen by farmers to reduce milk replacer intake and costs, but may not be cost effective long term. However, it is important to note that weaning kids too late is costly and can be harmful to the development of the kid's reticulo-rumen (Lu, 1988). Kids weaned when they reached 3 times their birth weight showed similar growth performance up to breeding to kids that were weaned at 4 times their birth weight, which shows that kids can be successfully weaned when they reach 3 times their birth weight (Gokdal et al., 2017). As an alternative weaning criterion to growth, kids can be weaned based on their level of solid feed intake to ensure a smooth transition to their solid feed diet. Recommendations vary between a daily consumption of 115 to 200 g of concentrates, or 30 to 500 g of solid feed, including concentrates and hay (APPENDIX 1), but as a general recommendation kids must be consuming sufficient concentrates and forages before weaning to reduce stress at weaning.

The weaning method is also crucial to minimize weaning stress. Different methods exist to wean kids, including abrupt weaning, where the milk is removed completely from one day to the next, or progressive weaning, which can be achieved by decreasing the milk quantity over multiple days, skipping milk feedings, or different techniques. The most recommended practice is to do progressive weaning, with a transition period of 5 to 7 days, to allow the kids enough time to transition to solid feed while still have some access to milk (APPENDIX 1). Progressive weaning techniques recommended include decreasing the milk quantity and/or the number of meals per day over the transition period, but it is stated in the recommendations not to modify the milk concentration by diluting it in water (APPENDIX 1). A study by Magistrelli et al. (2013) evaluated the effects of a progressive weaning, achieved by reducing the milk quantity over 17 days, with 1 L/day fed in the last 10 days, with a weaning completed at 48 days, compared to unweaned kids of the same age. The results showed no difference between the two groups on growth performance, abnormal behaviours, or any other stress indicators, such as plasma haptoglobin, ceruloplasmin, albumin, antithrombin III or IgG A and G. This suggests that this method was suitable to wean kids with minimal stress.

2.4.8 Growth monitoring

The growth of dairy goat kids is an important indicator of the kid's health, welfare, and performance, but was found to be very variable between and within farms in a study on New Zealand dairy goat farms (Deeming et al., 2016). Therefore, it is important to closely monitor growth, starting at birth, to ensure that the kids' potential is maximized. In fact, most references recommend to weight kids at least at birth and weaning, and ideally during the growth process as well (APPENDIX 1). Monitoring the kids' growth takes time but allows for a better selection of replacement does when comparing their growth to the optimal growth chart. Furthermore, weighing replacement does at least 3 times from birth to breeding was shown to decrease the rearing duration and costs since the does reached the optimal breeding weight earlier than those that weren't weighed as often in the same period (Brunelle, 2014). Kids that were heavier at birth (higher than 3.5 kg) were found to have higher average daily gains than the kids that were born at less than 3.5 kg (Doizé et al., 2013). The birth weight of kids was also shown to affect the kids' survival rates ($P < 0.01$; Perez-Razo et al., 1998). Doizé et al. (2013) reported that kids with a birth weight between 3.5 ang 4.5 kg had a lower mortality rate than the lighter and heavier kids. Another study suggested that kids with low birth weights (< 2.8 kg) or from litters of 3 or more kids may need

special attention, as they showed consistently lower serum IgG concentrations than heavier kids from litters of 1 or 2 kids for 5 days after birth ($P < 0.05$; Castro et al., 2009). It is in fact not recommended to keep kids that weigh less than 2.8 kg (Piedhault et al., 2014) or 3 kg (INOSYS, 2016) at birth in the herd since their growth and development will be too uncertain. As a general reference, kids weighing less 2.5 kg at birth have a higher risk of hypothermia while kids weighing more than 5 kg have a higher risk of dystocia (or difficult birth), which both increase risks of early life mortality compared to normal-weight kids (Hart and Delaney, 2016).

Birth weight and kid growth can vary based on multiple factors, such as sex, litter size, breed and dam parity (Mavrogenis et al., 1984; Doizé et al., 2013). Male kids were shown to be heavier at birth and grow faster than female kids (Mavrogenis et al., 1984; Greenwood, 1993). Birth weight was also shown to be greater for male kids than female kids in another study by Martínez (2009). Single- and twin-born kids were found to be heavier at birth ($P < 0.001$) than kids born from litters of 3 or more kids (Doizé et al., 2013), whereas Martínez (2009) found that single-born kids were heavier than twin-born kids at birth. Finally, kids born from multiparous goats were also heavier ($P < 0.001$) at birth (Doizé et al., 2013) and grew faster before weaning (Mavrogenis et al., 1984) than those born from primiparous goats.

When monitoring the growth of doe kids, certain weight targets should be met to maximize the doe's future performance. In fact, poor growth was indicated as the 2nd reason for voluntary culling doelings (25.8 %), after reproduction (29 %), on Ontario dairy goat farms (Oudshoorn et al., 2016). This illustrates how important the doe's growth is to the productivity of the dairy goat herd. A typical growth curve chart was developed by Piedhault et al. (2014), where the optimal growth is presented for different levels of future milk production targets (Figure 2.4.2). The highest line represents the optimal growth curve to reach a milk production of 850 L/lactation/goat while the lowest line presents the minimum growth necessary to achieve a milk production of 650 L/lactation/goat, which is estimated to be the minimum production required to make a goat profitable under French standards (Piedhault et al., 2014). If the growth weight targets of this last curve are not met, the kids should be culled as they will have a hard time catching up to the other kids. The middle curve represents a situation where the kids' growth catches up after 4 months to achieve an intermediate milk production.

According to Piedhault et al. (2014), the "benchmark" birth weight for female kids should be of 4.5 kg for a single kid, 4 kg for twin kids, and 3.5 kg for triplets, and kids should weigh 10 kg with an average daily gain of 200 g/day at 30 days of age. At 60 days of age (weaning), kids should weigh 20 % of the herd adult weight (Piedhault et al., 2014), or 16 kg (INOSYS, 2016). It was found that does that had an average daily gain higher than 200 g/day before weaning also had a higher kidding rate, an earlier age at first kidding and a higher milk production at 100 days into their first lactation (Poupin et al., 2002). Setting growth objectives is therefore a good practice to maximize the does' future performance. The pre-weaning growth period is crucial to the kids' future development as it was shown that kids with a weight over the growth curve had 6.5 times more chance to have a weight over the curve at 120 days, and reaching a higher than average weight at this time increased their chance of achieving a higher than average weight at 210 days (7 months) of age by a factor of 5.78 (Doizé et al., 2013). Therefore, the weight at 60 days should be closely monitored to ensure that kids reach the weaning weight target. At 4 months of age, kids should weigh at least 24 kg to reach a weight higher than 30 kg, or 50 % of the adult weight, by the age of 7 months, the target breeding age (Piedhault et al., 2014). INOSYS (2016) recommends a weight of 33 kg at 7 months, or 55 % of the goat adult weight, with an average daily gain of 150 g/day. A study by Nadon et al. (2017) established that the optimal breeding weight of Alpine and Saanen goats at 7 months of age should be of 30 and 34 kg, respectively. It was also found that heavier goats at 210 days of age were associated with a significantly higher probability of first kidding and a lower age at first kidding (Nadon et al., 2017).

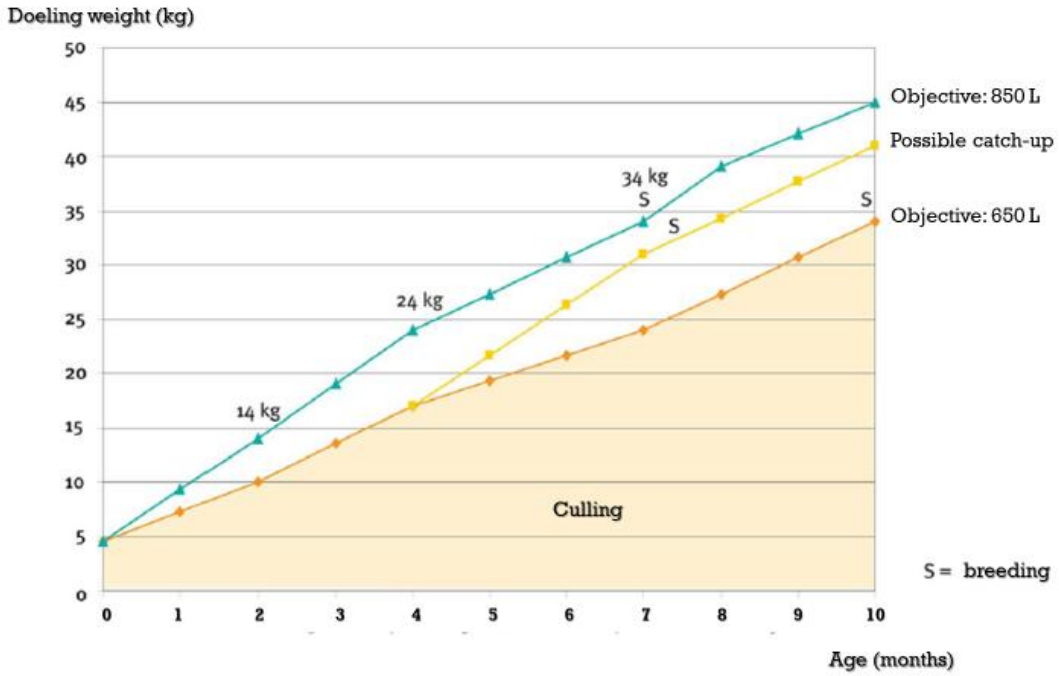

Figure 2.4.2 - Typical growth curves for dairy goat kids with different milk production objectives, adapted from Piedhault et al. (2014)

2.5 Conclusion

This review paper described the current recommendations and scientific literature available on kid rearing practices, from birth to weaning inclusively, for dairy goat farms under intensive production systems. The rearing sectors investigated included the kidding management, colostrum management, liquid and solid feeding, health management, disbudding, housing, weaning and growth monitoring. Recommendations from different references in Canada, United States and France were selected as they all have similar intensive production systems. This study identified some differences in recommendations between the selected references, and gaps in the literature to support some of the recommendations which are currently based on common knowledge. More research is necessary, especially in kidding management, kid feeding, kid housing and weaning, to refine and validate current recommendation in these mentioned rearing sectors.

2.6 Tables

Table 2.1 – Summary of scientific literature on colostrum management practices, including time of first feeding, source, quality, quantity, feeding method and duration of colostral period

Colostrum aspect explored[1]	**Number of kids**	**Breed (sex)**	**Treatments**	**IgG[2] results (mg/mL)**	**Significance**	**Reference**
Quality (IgG concentration)	56 kids	Majorera (male and female)	Trt[3]1: 100 mL atomized colostrum paste/kg BW[4] at 20 mg/mL Trt2: 50 mL atomized colostrum paste/kg BW at 40 mg/mL Trt3: 33.3 mL atomized colostrum paste/kg BW at 60 mg/mL Trt4: 25 mL atomized colostrum paste/kg BW at 80 mg/mL *All got 4g IgG/kg BW but at different concentrations.	Plasma IgG at day 1: Trt1: 12.41 Trt2: 13.62 Trt3: 15.18 Trt4: 21.02	IgG absorption peak reached at d 1 in all treatments ($P<0.05$) Trt4 ≠ Trt1 = Trt2 = Trt3 at all times ($P<0.05$)	(Rodríguez et al., 2009)
Quality (IgG concentration)	60 kids	Majorera (male and female)	Set quantity of lyophilized colostrum paste at different IgG concentrations: Trt1: 22.88 mg IgG/g. Trt2: 11.44 mg IgG/g. Trt3: 5.72 mg IgG/g.	Serum IgG at… <u>12 h:</u> Trt1: 9.02 Trt2: 4.03 Trt3: 1.55 <u>24 h:</u> Trt1: 9.53 Trt2: 4.69 Trt3: 3.26 <u>36 h:</u> Trt1: 10.28 Trt2: 5.63 Trt3: 4.54	At 12h: Trt1 ≠ Trt2 = Trt3 ($P<0.05$) At 24h: Trt1 = Trt2 = Trt3 ($P>0.05$) At 36h: Trt1 ≠ Trt2 = Trt3 ($P<0.05$)	(Castro et al., 2005)
Quality (IgG concentration) and duration of colostral period	80 kids	Majorera (male and female)	Trt1: 2 feedings/day for 1 day; 22.88 mg of IgG/g colostrum Trt2: 2 feedings/day for 2 days; 11.44 mg of IgG/g colostrum Trt3: 2 feedings/day for 1 day; 11.44 mg of IgG/g colostrum Trt4: 2 feedings/day for 2 days; 5.72 mg of IgG/g colostrum *All same amount of lyophilized colostrum paste.	Serum IgG at 24h: Trt1: 6.96 Trt2: 4.49 Trt3: 3.86 Trt4: 3.49 Serum IgG at 48h: Trt1: 9.43 Trt2: 4.43 Trt3: 3.37 Trt4: 3.17	Trt1 ≠ Trt2 at all sample times ($P=0.011$) Trt3 = Trt4 at all sample times ($P>0.05$)	(Castro et al., 2005)

Duration of colostral period	200 kids	Majorera (male and female)	Trt1: kids with dams for 24 h Trt2: kids with dams for 48 h Trt3: kids with dams for 120 h	Serum IgG at day 5: Trt1: 16.2 Trt2: 15.2 Trt3: 14.2	Trt1 = Trt2 = Trt3 (P>0.05)	(Castro et al., 2009)
Quantity, time of first feeding, and duration of colostral period	58 kids	Saanen (sex not specified)	Trt1: *ad libitum* colostrum on dam for 24h. Trt2: bottle-fed 200 mL colostrum in first hour of life. Trt3: bottle-fed 200 mL in first hour + 200 mL 8 h after birth. Trt4: bottle-fed 200 mL in first hour + 200 mL 14 h after birth. Trt5: bottle-fed 200 mL in first hour + 200 mL 12 h after birth + 200 mL 24 h after birth.	Serum IgG at 30h: Trt1: 24.7 Trt2: 16.5 Trt3: 26.0 Trt4: 18.6 Trt5: 23.0	Trt3 ≠ all other treatments (P<0.05) Trt1 = Trt4 = Trt5 (P>0.05) Trt2 ≠ all other treatments (P<0.05)	(Simoes et al., 2005)
Source and quality (IgG concentration)	25 kids	Saanen × Boer (female)	Trt1: goat colostrum with 45-55 mg/mL IgG Trt2: bovine colostrum with 45-55 mg/mL IgG Trt3: lyophilized bovine colostrum with 45-55 mg/mL IgG Trt4: goat colostrum with 15-25 mg/mL IgG Trt5: bovine colostrum with 15-25 mg/mL IgG	Serum IgG average (time not specified): Trt1: 6.2 ± 0.4 Trt2: 5.0 ± 0.4 Trt3: 6.7 ± 0.4 Trt4: 4.8 ± 0.4 Trt5: 5.0 ± 0.4	Trt1 = Trt2 = Trt3 (P>0.05) Trt3 ≠ Trt4 = Trt5 (P<0.05)	(Linhares Lima et al., 2013)
Source	40 kids	Majorera (male and female)	Trt1: lyophilized paste colostrum Trt2: frozen colostrum	Serum IgG at 24h: Trt1: 9.72 Trt2: 5.11	Trt1 ≠ Trt2 at all sample times (P=0.009)	(Castro et al., 2005)
Source	48 kids	Granadina and Nubian meat goats (sex not specified)	Trt1: natural suckling on dams for colostrum Trt2: kids separated from dam at birth and fed a colostrum supplement for calves (derived from cow lacteal secretions)	Serum IgG at 24h: Trt1: 10.11 ± 11.40 Trt2: 6.58 ± 7.03	Trt1 = Trt2 (P>0.05)	(Mellado et al., 2008)
Source	45 kids	Canary (sex not specified)	Trt1: kids fed goat refrigerated colostrum Trt2: kids fed goat frozen colostrum Trt3: kids fed commercial sheep colostrum	Serum IgG at 24h: Trt1: 12.8 ± 4.6 Trt2: 25.5 ± 19.9 Trt3: not detectable (< 0.2)	Trt1 = Trt2 (P>0.001)	(Argüello et al., 2004b)

Source (heat treatment)	26 kids	Murciano-Granadina (sex not specified)	Trt1: kids fed pooled goat colostrum Trt2: kids fed pooled, heat treated (56 °C for 30 min), colostrum	Serum IgG at day 2: Trt1: ~ 37* Trt2: ~ 27* *values taken from a line chart.	Trt1 ≠ Trt2 (P<0.01)	(Fernández et al., 2006)
Feeding method and quantity	60 kids	Canary (male and female)	Trt1: natural suckling on dams Trt2: hand-fed ad libitum colostrum twice daily for 3 d Trt3: restricted hand-fed; 100 mL/kg birth weight twice daily for 2 d.	Serum IgG at… 24h: Trt1: 21.86 ± 15.89 Trt2: 16.51 ± 7.91 Trt3: 14.15 ± 3.29 36h: Trt1: 22.06 ± 22.39 Trt2: 16.18 ± 7.09 Trt3: 17.79 ± 3.2	Trt1 ≠ Trt2 = Trt3 overall for all sample times (P<0.001)	(Argüello et al., 2004a)

[1]All studies were experimental studies
[2]Immunoglobulin G
[3]Treatment

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Connecting Text

The current recommendations and supporting scientific literature on dairy goat kid rearing practices in intensive production systems were reviewed in Chapter 2. It was found that recommendations varied slightly between references, but mostly in sectors that were not supported by scientific literature (e.g., the age at which concentrates and forages should be introduced in the kids' diet). Gaps in literature were identified in different rearing sectors, such as kidding management, kid feeding, housing and weaning, where more research should be carried out to refine current recommendations. The study outlined in Chapter 3 will present results from a survey that was sent out to all dairy goat producers in Canada to identify the common kid rearing practices in commercial dairy goat farms in Canada. Associations between rearing practices and farm performance indicators will be investigated to identify practices that affect performance indicators at the farm level. This study will complement the literature review presented in Chapter 2 with actual farm data, which will hopefully allow the identification of certain rearing practices that significantly affect farm performance in Canada.

CHAPTER 3 – A SURVEY OF DAIRY GOAT KID REARING PRACTICES ON CANADIAN FARMS AND THEIR ASSOCIATIONS WITH FARM PERFORMANCE

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3.1 Abstract

Kid rearing is the foundation of goat milk production, yet little is known about how to raise replacement does efficiently to make healthy and productive dairy animals. This survey study aimed to first identify the common rearing practices of Canadian commercial dairy goat farms (≥ 40 goats/farm), from birth to weaning inclusively, and to evaluate their associations with six farm performance indicators. The six farm performance indicators investigated included kid mortality, prevalence of diarrhea and respiratory diseases and growth prior to weaning, and herd milk production and replacement rate. In a second objective, this study evaluated the possibility to divide farms between different management styles based on these six performance indicators, and rearing practices were compared between the different groups of farms. A survey was sent to dairy goat producers across Canada by post or email, and 104 respondents were selected for analysis, representing 25 % of all Canadian producers. The 70-questions survey collected information regarding kidding management, colostrum management, milk and solid feeding in the preweaning period, health management, disbudding, housing, weaning, growth monitoring and farm performance indicators. Respondents included in the study were from Ontario (69 %), Quebec (22 %) and the Western provinces (9 %), and farm sizes ranged from 42 to 2,500 (median: 190) goats. A large amount of variation in rearing practices and farm performance was found between farms, which indicates potential for improvement. Colostrum and milk feeding management were the two main rearing sectors that were found to be associated with the highest number of farm performance indicators, which shows a close relationship between colostrum and milk feeding practices and overall farm performance. The six performance indicators allowed division of the farms in three distinct groups of producers, representing different management styles on a scale of intensification, between which rearing practices were compared. This survey study identified the kid rearing practices that separated the farms based on their performance and intensification scale. Rearing practices associated with higher farm performance should be implemented on farms to increase the productivity of the Canadian dairy goat farms.

3.2 Introduction

The preweaning period is a critical one in the dairy goat kids' life as the kids' performance during this period will dictate their future growth and performance in the productive herd (Doizé et al., 2013; Nadon et al., 2017). The weaning period also has a great impact on the kids' future growth and performance as it often coincides with a period of growth stasis and poor welfare

(Magistrelli et al., 2013). Hence, dairy goat kid rearing practices should be optimized to maximize the kids' performance before and during weaning and in turn maximize the herd productivity. However, references available to the dairy goat industry are limited and little is known on what the current kid rearing practices are on Canadian farms. Two provincial studies have reported information on dairy goat kid rearing practices and a large variation in practices was found between farms, both in Quebec and Ontario (Buczinski, 2013; Doizé et al., 2013; Oudshoorn et al., 2016). This illustrates the lack of consensus in the dairy goat kid industry in Canada which may explain why productivity is an issue on some farms (Services Conseils Bernard Belzile, 2010). Several management practices in the preweaning phase were found to be significantly associated with the growth (Doizé et al., 2013) and mortality (Buczinski, 2013) of dairy goat kids, however little is known on the relationship between kid rearing practices and overall farm performance. The first objective of this study was to evaluate the associations between six farm performance indicators and goat kid rearing practices on Canadian farms. The performance indicators investigated included kid mortality, prevalence of diarrhea and respiratory diseases and growth prior to weaning, and herd milk production and replacement rate. The second objective was to determine if these six performance indicators could be used to divide farms in different management styles, and to identify which rearing practices differed between the different groups of farms. It was hypothesized that more performant farms would follow recommended rearing practices and would have an overall better herd management than less performant farms.

3.3 Materials and Methods

A 70-question survey on dairy goat kid rearing practices, from birth to weaning inclusively, was sent out to all commercial dairy goat producers of Canada between June and October 2018 (APPENDIX 2). The online survey was distributed to all producers either by physical mail (Ontario producers) or electronic mail (producers from the rest of Canada) through the different dairy goat producers' organisations in Canada (OMAFRA, Ontario; Producteurs de Lait de Chèvre du Québec (PLCQ), Quebec; Western Canadian Dairy Goat Association, British Columbia) along with an explanatory letter and consent form. Email reminders were afterwards sent through the producers' respective dairy associations (PLCQ, Gay Lea Foods, Ontario Dairy Goat Cooperative) and the survey was shared on social media (i.e., Facebook) to reach a maximum number of producers.

3.3.1 Ethics statement

This study was reviewed and approved by McGill University's Faculty of Agricultural and Environmental Sciences (FAES) Research Ethics Board (REB) for research involving human participants (# 376-0118).

3.3.2 Survey design

The survey was designed following examples from previous studies on goat and calf management practices (Vasseur et al., 2010; Doizé et al., 2013; Stanek et al., 2014; Oudshoorn et al., 2016; Medrano-Galarza et al., 2017) and was reviewed by collaborators and a sample of industry and government stakeholders (e.g., nutritionists, veterinarians, welfare specialists, field advisors). It was then pilot tested with three producers, one from Ontario, one from Quebec, and one from Western Canada, who were contacted by the principal investigator by phone and invited to take the online survey, available both in French and English versions. The pilot producers were then contacted again by phone for feedback, and modifications to the survey were made accordingly. The approximate time taken to fill out the survey was 30 minutes. The questionnaire consisted of multiple choice and short answer questions and was divided in ten different sections to cover the entire goat kid rearing process, from birth to weaning inclusively, as well as some farm description information and performance data. The different kid rearing areas investigated included the kidding management (n = 4 questions), care of the newborn (n = 4), colostrum management (n = 10), milk and solid feeding (n = 18), weaning strategies (n = 3), housing conditions (n = 5), disbudding/dehorning (n = 3), health management (n = 4) and record keeping (n = 5). The data collected (answers to the questions) was categorical nominal (e.g., yes or no), categorical ordinal (e.g., frequencies from never to always) or continuous (e.g., quantity of milk produced annually).

3.3.3 Collection and management of data

Electronic surveys were collected directly on the SurveyMonkey® platform while paper surveys were entered manually in the same platform by the principal investigator before the data was exported to Microsoft Excel (Microsoft Corp., Redmond, WA).

A total of 175 surveys were returned either electronically (n = 122) or by mail (n = 53), from which those with an insufficient number of answers (n = 42; mostly surveys that were opened, but not completed), non-dairy breeds (n = 2) or duplicate surveys (n = 2) were eliminated to end up with 129 surveys. Furthermore, since the purpose of this study was to look at the dairy goat kid

rearing practices on commercial farms, the respondents with less than 40 goats (lactating and dry) were removed from the study in order to have a more representative image of the practices that commercial dairy goat producers follow in Canada. This cut-off number of 40 goats was based on the estimated number of goats necessary to produce the minimum requirement of milk to sell to both major processors in Ontario (Gay Lea, 2019; Ontario Dairy Goat Co-operative, 2019), and was also used as a cut-off in another goat study performed in Quebec (Services Conseils Bernard Belzile, 2010). With this, 104 respondents were kept for investigation. The herd sizes of participant farms (categorized based on Statistics Canada's size categories) are shown in Table 3.1.

The surveys were individually screened for errors and/or discordant answers. Aberrant answers and those due to misinterpretation of a question were excluded and marked as unanswered questions. Multiple choice and continuous response variables were transformed into pre-defined categorical or binary variables, based on current recommendations, if available (e.g., separate the kid from the dam at birth vs after first suckling), or based on the distribution of results (e.g., weaning age of < 8 weeks in 46 % of the cases, 8-10 weeks in 35 % of the cases, and > 10 weeks in 19 % of the cases), for ease of interpretation and further analysis on recommended practices.

Table 3.1 – Herd size of participants

	All participant farms (n = 129)	
Herd size (milking & dry goats)	N[1]	% (95 % CL)[2]
< 40 goats	25	19 (12-26)
40 - 200 goats	53	41 (32-50)
201 - 400 goats	41	32 (24-40)
> 400 goats	10	8 (3-12)

[1]Number of respondents [2]Percentage of respondents (95 % confidence limits)

3.3.4 Farm performance indicators

Information was collected on different farm performance indicators (presented in Table 3.2), including milk production, pre-weaning mortality, replacement rate, diarrhea and respiratory disease prevalence, and average daily gain from birth to weaning to evaluate the performance of the herds in different areas of production. Performance indicators were calculated based on data collected in the survey and therefore based on producer's recollection of performance data only. Indeed, the use of milk recording services is uncommon in the industry (24 herds across Canada in 2018; Brunelle, 2019) and performance data could not be collected through dairy herd improvement agency. The average daily gain from birth to weaning was calculated from the age

and weight of the kids at weaning, when both values were reported by the producer, and an average birth weight of 4 kg (Valacta, 2013) was used for the calculation since this information was not collected.

Table 3.2 – Performance indicators of participating farms

Performance indicators	N[1]	Min[2]	P25[3]	Med[4]	P75[5]	Max[6]
Milk production[7]	92	365	761	892	983	1400
Kid mortality from birth to weaning (%)	97	0	4	8	15	70
ADG[8] from birth to weaning (g/day)	40	85	155	193	214	295
Replacement rate (%)	85	0	10	24	30	100
Diarrhea prevalence (%)	97	0	3	10	25	100
Respiratory disease prevalence (%)	97	0	1	5	15	80

[1]Number of herds [2]Minimum [3]25th percentile [4]Median [5]75th percentile [6]Maximum
[7]Litres/goat/305 days
[8]Average daily gain

3.3.5 Statistical analysis

The survey data was exported to SAS version 9.4 (SAS Institute Inc., Cary, NC) to be analyzed. Descriptive statistics were used to estimate percentages and 95 % Wald confidence limits (categorical data) and medians, 25th and 75th percentile, and range (continuous data) for all the questions using the PROC SURVEYFREQ command for survey data analysis. Spearman correlations were performed to see if there were any associations between the different performance indicators (e.g., milk production and mortality) and with some farm characteristics (e.g., milk production and farm size). Univariate linear regression analyses were performed using PROC GLM to look at the relationships between the rearing practices and each performance indicator. Proportion variables (i.e., mortality rate, replacement rate, diarrhea and respiratory disease prevalence) were transformed using the arcsine of the square root of the variables to improve normality of the data (McDonald, 2014). The normality of all four variables was improved but still not met, however we assumed that ANOVA was reasonably robust to accept some skewness in the data distribution. The transformed values were back-transformed to present original units in the results using the squared sine of the transformed value.

A cluster analysis was performed with the farm performance indicators using the R Software (R Core Team, 2019) to look at how farms regrouped based on all 6 performance indicators and see if we could characterize different types of farms based on the resulting clusters. Missing observations on mortality (n = 7; 6.73 %), replacement rate (n = 19; 18.27 %), milk production (n = 12; 11.54 %), growth to weaning (n = 64; 61.54 %), diarrhea prevalence (n = 7; 6.73 %), and respiratory disease prevalence (n = 7; 6.73 %) were imputed using the multiple imputation technique with a random forest model, as implemented in the function *missForest* from the R package *missForest* (Stekhoven and Buehlmann, 2012). In addition to increasing accuracy and statistical power and accuracy (van Buuren, 2019), this methodology is satisfactory in conditions with large number of missing observations as well as complex and inter-correlated data (Tang and Ishwaran, 2017). Collinearity among variables was evaluated using a bivariate correlation matrix. The highest pairwise correlation was 0.49, not indicating the occurrence of multicollinearity between the variables. Therefore, all six performance variables were kept for cluster analysis. The clustering of the herds was conducted using the K-means algorithm. Prior to cluster analysis, the variables were scaled to have a mean = 0 and standard deviation = 1. Then the number of clusters was determined according to the Calinski criterion calculated for 2 to 10 potential clusters (Borcard et al., 2018) using the K-means algorithm as implemented in the R package *vegan* (Oksanen et al., 2019). The final K-means clusters were generated using the function *kmeans* from the R package *stats* (R Core Team, 2019). Principal components were calculated using the same scaled data set in order to visualize the cluster results (Supplemental Figure 3.1 and Supplemental Table 3.1).

The assumptions of a one-way ANOVA regarding residual normality and independency as well as homogeneity of variances were evaluated using the Shapiro, Bartlett, and Durbin-Watson tests, respectively. If met, the significance between clusters for each variable was determined using one-way ANOVA followed by Tukey test. If not met, we used the non-parametric test of Kruskal-Wallis followed by the Dunn test with Bonferroni correction for multiple comparison of means. Statistical significance was declared at an error level $\alpha < 0.05$ for all statistical tests.

Finally, rearing practices were compared between the clusters using pairwise Chi-squared (Fisher's Exact) tests with Bonferroni adjustments for multiple comparisons of categorical variables, and least square means with Tukey-Kramer adjustments for multiple comparisons of continuous variables to evaluate how practices differed between the different farm groups.

3.4 Results

3.4.1 General farm description

A total of 104 dairy goat farms were included in this study, representing approximately 25 % of the dairy goat farm population in Canada, which was estimated at 424 farms in 2017 (Canadian Dairy Information Center, 2019). Similar response rates were achieved in each province, even though surveys were sent by mail and electronically in Ontario and only electronically in the rest of Canada, which was expected based on Kaplowitz et al. (2004).The respondent characteristics are presented in Table 3.3. The distribution of respondents was representative of the distribution of dairy goat producers in Canada (Canadian Dairy Information Center, 2019). The main breeds were Saanen, Alpine and cross breeds (50 %, 28 % and 20 % of the respondents that had some, respectively). Descriptive statistics for the rearing practices prevalence are presented in APPENDIX 3.

Table 3.3 – General characteristics of participant farms

Farm characteristics	N[1]	% (95 % CL)[2]
Province	104	
Ontario	72	69 (60-78)
Quebec	23	22 (14-30)
Western[3]	9	9 (3-14)
Herd size, number of goats[4]	101	200 (114-300)[5]
Number of years in production	103	
1-5	39	38 (28-47)
6-10	27	26 (18-35)
11-15	17	17 (9-24)
16-20	14	14 (7-20)
> 20	6	6 (1-10)
Breeding age, months	87	9 (7.5-11)[5]
Breeding weight, kg	68	36 (34-39)[5]

[1]Number of respondents [2]Percentage of respondents (95 % confidence limits)
[3]British Colombia, Alberta, Saskatchewan, and Manitoba.
[4]Milking and dry goats
[5]Median (Q25-Q75)

3.4.2 Farm performance indicators and associated correlations

Looking at how the performance indicators are associated together, we saw a negative correlation between milk production and mortality ($r = -0.29$, $P = 0.007$), as well as positive correlations between mortality and both diarrhea prevalence ($r = 0.38$, $P < 0.001$) and respiratory

disease prevalence (r = 0.35, P = 0.001), and between the prevalence of diarrhea and respiratory disease (r = 0.26, P = 0.010). However, none of these correlations were strong enough (r > 0.70) to omit looking at the individual effect of each performance indicator. Correlation coefficients are presented in Supplemental Table 3.2.

Investigating correlations between performance indicators and some farm characteristics, we found that the more experienced farmers were associated with a higher replacement rate (r = 0.23, P = 0.033) as well as a lower diarrhea prevalence (r = -0.27, P = 0.009). The larger herds were associated with a higher mortality rate (r = 0.23, P = 0.026), a higher replacement rate (r = 0.35, P = 0.001) and a higher respiratory disease prevalence (r = 0.31, P = 0.003). Finally, the farms with a younger breeding age also had a higher milk production (r = -0.26, P = 0.023).

3.4.3 Associations between farm performance indicators and rearing practices

Results from the univariate linear regression analyses between kid rearing practices and performance indicators are presented in the following subsections, by performance indicator. Only practices that showed a significant ($P \leq 0.05$) association with a specific performance indicator were presented in the results. Descriptive statistics for each rearing practice, as they were used in the regression analyses, are presented in Supplemental Tables 3.3 and 3.4.

3.4.3.1 Milk production

The average milk production per goat was significantly associated with rearing practices in different management sectors, including colostrum, milk and solid feeding, health management, disbudding and record keeping (Table 3.4). More specifically, feeding colostrum within 2 hours after birth, and feeding concentrates higher in crude protein were practices associated with a significantly higher milk production. On the other hand, the producers who pooled colostrum, fed a milk replacer with a high crude protein concentration, used a gutter milk feeding system, and washed the milk buckets at each use (when used), were found to have a lower milk production. In terms of health management, the herds that added medication in milk either in prevention or when necessary to treat diseases, as well as those who fed concentrates treated with coccidiostats were found to have a significantly higher milk production. Disbudding kids at 2 weeks of age or younger and using pain control to do so was also associated with a higher milk production. Finally, the herds that kept more records, including record keeping for kid rearing, recording treatments administered

to kids, weighing kids at birth and using milk recording services were also found to have a significantly higher milk production.

Table 3.4 – Associations between rearing practices and milk production (litres/goat/305 days)

Rearing sector/practice	N[1]	Mean	SD[2]	Range	β [3]	95 % CI[4]	P-value
Colostrum feeding							
Time of first colostrum feeding							
> 2 hours after birth	17	793	211	684-902	Referent	--	--
≤ 2 hours after birth	55	915	185	865-965	122.02	16.284, 227.748	0.024
Pooled colostrum							
Yes	29	825	195	750-899	Referent	--	--
No	25	949	173	878-1020	124.38	23.093, 225.674	0.017
Milk feeding							
CP[5] content of milk replacer, %	56	--		--	-37.56	-75.721, 0.595	0.054
Use of a gutter to feed milk[6]							
No	80	888	193	846-931	Referent	--	--
Yes	7	724	95	635-812	-164.76	-311.542, -17.980	0.028
Washing frequency of milk bucket (or gutter)							
Not at each use	17	913	141	840-986	Referent	--	--
At each use	32	803	205	729-877	-110.21	-222.528, 2.102	0.054
Solid feeding							
CP[5] content of concentrates, %	65	--		--	17.61	1.370, 33.847	0.034
Health management							
Medication in milk							
Never	35	817	224	740-894	Referent	--	--
When necessary or in prevention	52	910	158	866-954	92.45	11.094, 173.812	0.026
Add coccidiostats in concentrates							
No, or when necessary	25	765	190	686-843	Referent	--	--
Yes, in prevention	59	909	165	866-952	144.12	62.216, 226.032	<0.001
Disbudding							
Time of disbudding							
≥ 3 weeks of age	22	788	188	705-872	Referent	--	--
≤ 2 weeks of age	49	906	189	852-960	117.45	21.015, 213.890	0.018
Use of pain control for disbudding							
No	51	823	193	769-877	Referent	--	--
Yes	31	943	168	881-1005	119.89	36.543, 203.232	0.005
Record keeping							
Milk recording							
No	78	838	182	797-879	Referent	--	--
Yes	13	1048	160	951-1144	209.49	103.008, 315.975	<0.001

Record keeping for kid rearing							
No	19	757	133	692-821	Referent	--	--
Yes	69	898	795	851-945	141.62	47.012, 236.235	0.004
Record treatments given to kids							
No	30	836	203	760-912	Referent	--	--
Yes	37	935	165	880-990	98.82	9.259, 188.380	0.031
Weigh kids at birth							
No	59	827	159	786-869	Referent	--	--
Yes	24	946	227	850-1042	118.94	31.777, 206.109	0.008

[1]Number of herds [2]Standard deviation [3]Regression coefficient [4]95 % confidence interval
[5]Crude protein
[6]Respondents could select more than one option

3.4.3.2 Mortality

The average mortality rate of the kids, from birth to weaning inclusively, was significantly associated with rearing practices during kidding management, colostrum and milk feeding, as well as health management (Table 3.5). Overall monitoring of the goat during the kidding period, including day- and night-time monitoring, as well as the use of video cameras to monitor in the barn, were found to be significantly associated with a lower kid mortality. Removing kids from the dams most of the time before first suckling was also associated with a lower mortality. In terms of colostrum and milk feeding, herds that fed a higher quantity of colostrum in the first 12 hours after birth and within 2 hours of birth, and provided at least one nipple per kid when feeding milk in a bucket were found to have a lower kid mortality. Finally, the herds that disinfected the umbilical cord within 2 hours after birth and administered Selenium and Vitamin E to adult goats during gestation also had a lower kid mortality rate than those who did not.

Table 3.5 - Associations between rearing practices and mortality rate of the herd (%)

Rearing sector/practice	N[1]	Mean[2]	Range[2]	β[3,4]	95 % CI[4,5]	P-value
Kidding management						
Kidding monitoring in the day						
≤ 2 times/day	26	15.3	9.4-22.3	Referent	--	--
Monitor > 2 times/day	60	8.6	6.1-11.5	-0.10	-0.198, -0.011	0.029
Kidding monitoring at night[6]						
Never	32	12.9	8.7-17.8	Referent	--	--
Monitor at least once	55	7.8	5.3-10.7	-0.09	-0.167, -0.003	0.042
Use video cameras for monitoring						
No	89	10.9	8.5-13.6	Referent	--	--
Yes	7	2.2	0.1-7.0	-0.19	-0.337, -0.039	0.014

Separation of kid from dam						
After first suckling > 50 % of the times	35	13.7	9.0-19.1	Referent	--	--
Before first suckling > 50 % of the times	60	8.3	6.0-11.0	-0.09	-0.167, -0.006	0.035
Colostrum feeding						
Time of first colostrum feeding						
> 2 hours after birth	17	20.0	12.7-28.4	Referent	--	--
≤ 2 hours after birth	55	7.6	5.1-10.5	-0.18	-0.289, -0.081	<0.001
Quantity of colostrum fed in first 12 hours, litres	65	--	--	-0.30	-0.518, -0.090	0.006
Milk feeding						
Number of kids per nipple on the bucket[7]						
> 1 kid/nipple	16	13.8	6.6-23.2	Referent	--	--
≤ 1	29	5.1	2.9-7.8	-0.15	-0.267, -0.040	0.009
Health management						
Time of umbilical cord disinfection[8]						
> 2 hours after birth	7	21.4	7.7-39.7	Referent	--	--
≤ 2 hours after birth	57	9.1	6.3-12.4	-0.17	-0.335, 0.014	0.033
Give Selenium + Vit.E to pregnant goats						
No	64	12.1	9.3-15.2	Referent	--	--
Yes	25	6.5	2.7-11.7	-0.10	-0.188, -0.007	0.036

[1]Number of herds
[2]Mean and range were back-transformed to facilitate interpretation of results. No standard deviation is presented since it is not appropriate to back-transform to the same scale.
[3]Regression coefficient
[4]Regression coefficient and 95 % CI are presented on the Arcsine scale since it is not appropriate to back-transform those values
[5]95 % confidence interval
[6]Monitoring after night chores
[7]Only those who feed milk in a milk bucket
[8]Only those who disinfect

3.4.3.3 Replacement rate

The average replacement rate in the herds was significantly associated with rearing practices around the colostrum and milk feeding, disbudding and housing of the kids (Table 3.6). The most impactful rearing practice was whether or not the kids were reared under the dams, where herds that reared kids under dams (drinking dam milk and housed with dams) had a significantly higher replacement rate than those that did not. Other rearing practices such as evaluating the quality of colostrum, using a gutter milk feeding system and feeding goat kid of calf milk replacer as opposed to other types of milk had a lesser effect on the herd replacement rate, but were still associated with a significantly higher replacement rate. Finally, the herds that disbudded kids in their first 2 weeks of age were found to have a significantly lower replacement rate.

Table 3.6 - Associations between rearing practices and replacement rate in the herd (%)

Rearing sector/practice	N[1]	Mean[2]	Range[2]	β[3,4]	95 % CI[4,5]	P-value
Colostrum feeding						
Evaluate colostrum quality						
No	24	15.6	11.1-20.6	Referent	--	--
Yes	24	23.3	17.4-29.8	0.10	0.003, 0.194	0.043
Milk feeding						
Kids fed under dams until weaning						
No	80	19.5	16.6-22.6	Referent	--	--
Yes	4	58.4	0.0-96.9	0.41	0.212, 0.613	<0.001
Use of a gutter to feed milk[6]						
No	73	18.6	15.6-21.7	Referent	--	--
Yes	7	30.4	22.0-39.6	0.14	0.009, 0.269	0.037
Milk type						
Fresh cow or pasteurized goat milk	7	9.7	2.0-22.4	Referent	--	--
Kid or calf milk replacer	60	21.0	14.5-24.8	0.16	0.021, 0.296	0.025
Fresh goat milk	4	14.3	5.9-25.7	0.07	-0.145, 0.287	0.514
Disbudding						
Time of disbudding						
≥ 3 weeks old	23	32.6	22.4-43.7	Referent	--	--
≤ 2 weeks old	48	17.2	13.5-21.2	-0.18	-0.286, -0.074	0.001
Housing						
Kids are housed with dams until weaning						
No	78	19.5	16.5-22.6	Referent	--	--
Yes	5	50.3	2.4-97.8	0.33	0.146, 0.517	<0.001

[1]Number of herds
[2]Mean and range were back-transformed to facilitate interpretation of results. No standard deviation is presented since it is not appropriate to back-transform to the same scale.
[3]Regression coefficient
[4]Regression coefficient and 95 % CI are presented on the Arcsine scale since it is not appropriate to back-transform those values
[5]95 % confidence interval
[6]Respondents could select more than one option

3.4.3.4 Diarrhea prevalence

The prevalence of diarrhea in kids between birth and weaning was significantly associated with practices around kidding management, colostrum and milk feeding, as well as record keeping (Table 3.7). Feeding a higher quantity of colostrum in the first 12 hours after birth, and within 2 hours of birth was associated with a significant decrease in diarrhea, along with allowing at least one nipple per kid in the pen when feeding milk in a multiple nipple bucket, as well as weighing kids at weaning. On the other hand, the herds with 3 or more kidding periods per year and those that use an automatic milk feeder have been shown to have a higher prevalence of kid diarrhea.

Table 3.7 - Associations between rearing practices and diarrhea prevalence of the herd (%)

Rearing sector/practice	N[1]	Mean[2]	Range[2]	β[3,4]	95 % CI[4,5]	P-value
Kidding management						
Number of kidding periods						
< 3 periods/year	32	6.3	3.3-10.2	Referent	--	--
≥ 3 periods/year	63	17.8	11.9-24.6	0.18	0.056, 0.308	0.005
Colostrum feeding						
Time of first colostrum feeding						
> 2 hours after birth	18	23.9	9.4-42.5	Referent	--	--
≤ 2 hours after birth	56	10.9	6.8-15.8	-0.17	-0.339, -0.008	0.040
Quantity of colostrum fed in first 12 hours, litres	66	--	--	-0.38	-0.718, -0.044	0.027
Milk feeding						
Gutter space, cm/head	6	--	--	-0.02	-0.040, -0.003	0.034
Use of an automatic milk feeder[6]						
No	52	9.8	6.3-13.9	Referent	--	--
Yes	40	19.4	10.9-29.6	0.14	0.012, 0.263	0.032
Number of kids per nipple on the bucket[7]						
> 1 kid/nipple	16	18.9	9.3-31.1	Referent	--	--
≤ 1	30	6.7	3.5-11.0	-0.19	-0.328, -0.048	0.010
Record keeping						
Weigh kids at weaning						
No	52	17.3	10.9-24.8	Referent	--	--
Yes	38	9.1	5.3-13.8	-0.12	-0.245, 0.001	0.051

[1]Number of herds
[2]Mean and range were back-transformed to facilitate interpretation of results. No standard deviation is presented since it is not appropriate to back-transform to the same scale.
[3]Regression coefficient
[4]Regression coefficient and 95 % CI are presented on the Arcsine scale since it is not appropriate to back-transform those values
[5]95 % confidence interval
[6]Respondents could select more than one option
[7]Only those who feed milk in a milk bucket

3.4.3.5 Respiratory disease prevalence

The prevalence of respiratory disease in kids between birth and weaning was significantly associated with rearing practices in kidding management, milk and solid feeding, and kid housing (Table 3.8). The farms that housed kids with adult goats until weaning to drink milk from their dams had a significantly lower prevalence of kid respiratory disease. Herds where kids had access to forages in the first two weeks of age also had a significantly lower respiratory disease prevalence, along with those who monitored kidding at night, and used video cameras to monitor in the barn. On the other hand, herds that had 3 or more kidding periods per year, and those that raised buck

(male) kids on the farm until they are at least 2 weeks old were shown to have a significantly higher respiratory disease prevalence.

Table 3.8 - Associations between rearing practices and respiratory disease prevalence of the herd (%)

Rearing sector/practice	N[1]	Mean[2]	Range[2]	β[3,4]	95 % CI[4,5]	P-value
Kidding management						
Number of kidding periods						
< 3 periods/year	32	4.6	2.3-7.7	Referent	--	--
≥ 3 periods/year	63	10.2	6.4-14.7	0.11	0.003, 0.214	0.043
Kidding monitoring at night[6]						
Never	29	12.7	6.2-21.0	Referent	--	--
Monitor at least once	58	5.8	3.6-8.4	-0.12	-0.228, -0.017	0.024
Use video cameras for monitoring						
No	90	8.6	5.9-11.8	Referent	--	--
Yes	7	1.0	0.1-4.8	-0.20	-0.390, -0.009	0.040
Milk feeding						
Kids fed under dams until weaning						
No	92	8.4	5.8-11.5	Referent	--	--
Yes	5	0.5	1.6-7.0	-0.22	-0.447, -0.001	0.049
Solid feeding						
Forages are made available…						
After 2 weeks of age	34	12.6	6.0-21.3	Referent	--	--
In first 2 weeks after birth	49	5.2	3.2-7.6	-0.13	-0.246, -0.022	0.019
Housing						
Kids are housed with dams until weaning						
No	91	8.6	5.9-11.7	Referent	--	--
Yes	6	0.6	0.5-5.0	-0.22	-0.426, -0.017	0.034
Buck kids raised on farm for 2 weeks or more						
No	49	5.3	3.0-8.1	Referent	--	--
Yes	47	11.4	6.7-17.1	0.11	0.014, 0.211	0.026

[1]Number of herds
[2]Mean and range were back-transformed to facilitate interpretation of results. No standard deviation is presented since it is not appropriate to back-transform to the same scale.
[3]Regression coefficient
[4]Regression coefficient and 95 % CI are presented on the Arcsine scale since it is not appropriate to back-transform those values
[5]95 % confidence interval
[6]Monitoring after night chores

3.4.3.6 Kid growth (average daily gain; ADG) from birth to weaning

The average daily gain (ADG) of the kids from birth to weaning was significantly associated with rearing practices around colostrum and milk feeding, weaning, kid housing and record keeping (Table 3.9). Herds that evaluated colostrum quality, grouped kids by age (as opposed to weight or sex), and kept a record of kids' diseases were associated with a significantly higher ADG from birth to weaning. By contrast, those that fed milk in buckets with tubes and nipples at the top had a significantly lower growth to weaning. Finally, herds with a higher average weaning weight and lower weaning age were found to have a higher ADG from birth to weaning, which was expected since ADG was calculated from those two variables.

Table 3.9 - Associations between rearing practices and average daily gain of kids from birth to weaning (g/day)

Rearing sector/practice	N[1]	Mean	SD[2]	Range	B[3]	95 % CI[4]	P-value
Colostrum feeding							
Evaluate colostrum quality	13	167.3	47.3	138.8-195.9	Referent	--	--
No	17	216.0	42.6	194.1-237.9	48.70	14.995, 82.397	0.006
Yes							
Milk feeding							
Use buckets with nipples at the top[5]							
No	29	202.9	45.4	185.7-220.2	Referent	--	--
Yes	10	164.8	43.6	133.6-196.0	-38.08	-71.475, -4.690	0.027
Housing							
Kids grouped by age[5]							
No	7	151.0	39.0	114.9-187.1	Referent	--	--
Yes	33	201.0	44.5	185.2-216.8	50.00	13.233, 86.758	0.009
Weaning							
Weaning age, weeks	40	--	--	--	-5.08	-9.629, -0.535	0.030
Weaning weight, kg	40	--	--	--	4.21	0.909, 7.501	0.014
Record keeping							
Record kids' diseases							
No	19	171.6	43.9	150.4-192.7	Referent	--	--
Yes	14	213.1	35.9	192.4-233.8	41.53	12.283, 70.770	0.007

[1]Number of herds [2]Standard deviation [3]Regression coefficient [4]95 % confidence interval
[5]Respondents could select more than one option

3.4.4 Cluster analysis

Respondents were separated into clusters based on the 6 performance indicators to see how farms resembled each other in different sectors, and we found 3 distinct groups (Table 3.10) which represent different management styles. Cluster 1 could be defined as more intensive production farms with high milk production and kid growth, but with a high replacement rate and disease prevalence. Cluster 3 could be defined as more extensive production farms with an average milk production and kid growth, but a low replacement rate, indicative of good longevity, as well as low mortality and disease prevalence. On the other hand, cluster 2 would represent the marginal producers with the lowest production numbers, an average replacement rate, and the highest mortality and disease prevalence. The clusters can be visualized on the principal component analysis graph (Supplemental Figure 3.1) as well as the table of contribution to variance (Supplemental Table 3.1).

Table 3.10 – Cluster analysis on performance indicators

Performance indicator	Cluster 1 (n^1 = 50)	Cluster 2 (n^1 = 14)	Cluster 3 (n^1 = 40)	SD^2	P-value
Mortality from birth to weaning, %	9,1 b	37,7 a	8,6 b	13,24	< 0.001
Replacement rate, %	30,1 a	23,1 ab	15,6 b	14,39	< 0.001
Milk production, L/goat/305 days	968,5 a	702,0 b	800,2 b	181,65	< 0.001
ADG^3 from birth to weaning, g/day	297,3 a	226,1 b	240,2 b	42,96	< 0.001
Diarrhea prevalence, %	13,7 b	56,8 a	8,5 b	21,39	< 0.001
Respiratory disease prevalence, %	16,5 a	15,9 ab	5,2 b	16,72	0.029

[1]Number of herds
[2]Standard deviation
[3]Average daily gain

Differences in rearing practices between the three clusters were analysed, and we found significantly different ($P < 0.05$) practices between the three different styles of producers (Table 3.11). Main differences were seen in the colostrum, milk and solid feeding sectors as well as kid housing. Herds in cluster 1, characterized as more intensive, fed cow colostrum, did not pool colostrum, used automatic milk feeders and added coccidiostats in the kids' concentrates more often than the herds in cluster 3, characterized as more extensive herds, but had similar practices

to cluster 2, characterized as the more marginal herds with non-optimal performance data. Cluster 1 also grouped kids by age more often and made larger groups of kids than the cluster 3 herds did. On the other hand, herds in cluster 2 were found to not feed colostrum in the first 2 hours after birth as often as the other two clusters. They also used automatic milk feeders more often than cluster 3 but did not allow at least 1 nipple per kid when fed with a multiple nipple milk bucket as opposed to cluster 3. Additionally, the quantity of colostrum offered in the first 12 hours of life of the kid (n = 69 herds) was significantly higher for clusters 1 and 3 as opposed to cluster 2 (686 ± 38 and 591 ± 42 vs 400 ± 65 mL; P = 0.001 and P = 0.045, respectively). The average weaning age of the herd (n = 68 herds) was also higher in cluster 3 as opposed to cluster 1 (10.0 ± 0.6 vs 7.6 ± 0.5 weeks, respectively; P = 0.008).

Table 3.11 – Difference in rearing practices between farm clusters (n = 3)

Rearing sector	Rearing practice	N[1]	Cluster 1 (%)	Cluster 2 (%)	Cluster 3 (%)
Colostrum	Feed colostrum in first 2 h after birth	78	86 a	36 b	80 a
	Don't pool colostrum	58	66 a	43 ab	23 b
	Feed cow colostrum	79	35 a	18 ab	6 b
Milk	Use automatic milk feeder(s)	95	51 a	71 a	22 b
	≤ 1 kid/nipple on bucket[2]	48	60 ab	0 b	83 a
Health	Add coccidiostats in concentrates	95	80 a	69 ab	49 b
Housing	< 15 kids/pen	89	46 b	54 ab	74 a
	Group by age[3]	98	84 a	86 ab	54 b

Different letters in a row indicate significant differences between clusters (P < 0.05)
[1]Number of herds
[2]Those that fed milk in a multiple nipple bucket
[3]Producers could select more than one option

3.5 Discussion

This study is the first to look at dairy goat kid rearing practices on all Canadian farms, with respondents from Ontario, Quebec and the Western provinces, and brings an important added value to the literature with information collected on 25 % of all commercial dairy goat farms in Canada. This response rate is high compared to other surveys conducted on dairy goat kid management in Ontario (Oudshoorn et al., 2016) and calf management in Canada (Medrano-Galarza et al., 2017). The distribution of our respondents between provinces was illustrative of the distribution of all dairy goat producers in Canada from 2017 (Canadian Dairy Information Center, 2019), which draws a representative picture of kid rearing practices across Canada.

The objectives of our study were to determine which rearing practices characterized the most performant farms and which ones differed between farms with different management styles. We were able to answer these questions with the use of six performance indicators (PI's), between which no strong associations were found, allowing us to look at all of them independently. Four PI's were chosen to evaluate performance during kid rearing, where a low mortality rate (previously used by Kristensen et al., 2008; Moran, 2009) and low prevalence of diarrhea (Svensson and Hultgren, 2008; Bach, 2011; Aghakeshmiri et al., 2017) and respiratory disease (Bach, 2011) were indicative of good kid health, and a high average daily gain (Vacek et al., 2015; Chester-Jones et al., 2017) was indicative of good growth performance between birth and weaning. Two PI's were chosen to evaluate overall performance of the herd, where a high milk production was indicative of good overall herd productivity (Gunnar Hansen et al., 2005), and a low replacement rate was indicative of good herd longevity, since the goats don't stay in the herd for a long time (Enevoldsen et al., 1996; Moran, 2009; Nor et al., 2014). A caveat for replacement rate is that our results showed associations between high replacement rates and large herds, which was also found by Enevoldsen et al. (1996) in a study on dairy cows, as well as with more experienced producers. This suggests that a high replacement rate is not necessarily a sign of poor longevity, but could also be associated with larger farms that are growing or have a different replacement policy in terms of doe selection (Enevoldsen et al., 1996). In fact, a study by Nor et al. (2014) identified associations between low average culling rates of dairy cows and herds that had a more than 5 % increase in herd size, as well as those that bought less than 1 % of animals per year. Therefore, associations between rearing practices and the replacement rate PI should be carefully interpreted. There was a high variability across farms for all six PI's, which allowed us to identify the better and less performant farms in order to answer our first research question. Those PI's also allowed us to answer our second research question by identifying different farm management styles, on an intensification scale (i.e., extensive vs intensive management). We were able to categorize farms in three different groups (clusters), based on whether they had a more intensive management style (higher milk production and kid growth but higher replacement rate and disease prevalence), a more extensive management style (low replacement rate, mortality and disease prevalence but average milk production and kid growth), or an overall marginal management (low production numbers, average replacement rate and high mortality and disease prevalence).

Effects of colostrum and milk feeding practices on farm performance

Of all the goat kid rearing sectors, from birth to weaning inclusively, the two that affected the most PI's were milk feeding and colostrum management, which had practices that significantly affected 6 and 5 out of the six farm PI's, respectively. As for milk feeding, this included the source (3 out of 6 PI's) and feeding method (all 6 PI's). More specifically, we found that the producers who let the kids drink milk from the dams had a higher replacement rate and a lower prevalence of kid respiratory disease, and those who fed milk replacer as opposed to other types of milk also had a higher replacement rate. Letting the kids drink milk from the dams is not a recommended practice, mainly to prevent Caprine Arthritis Encephalitis and Johne's diseases (recommendations for North America and France are presented in APPENDIX 1), and the higher replacement rate of the herds that leave kids under dams could reflect this higher incidence of diseases in the herd, decreasing the herd longevity. A study by Vacca et al. (2014) showed that artificially feeding kids with an acidified milk replacer showed similar growth performance to naturally fed kids (i.e., under the dams), while eradicating diseases transmitted through natural milk. Another study by Sanz Sampelayo et al. (1990) showed similar growth between kids fed goat milk and those fed milk replacer. However, natural goat milk was shown to have a positive effect on the kid's microbial colonisation and rumen fermentation compared to artificial feeding with milk replacer (Abecia et al., 2014), and increased nutrient digestibility and metabolizable energy (Sanz Sampelayo et al., 1990), which are all factors that should be considered when choosing a milk source. Feeding milk replacer remains the recommended practice (APPENDIX 1) to control diseases transmitted through goat milk, but it was also associated with a higher herd replacement rate. However, higher replacement rate is not necessarily indicative of poor performance as it could be influenced by a growing or larger herd. Those who fed milk replacers with a higher crude protein content had a lower milk production, but this data did not account for the quantity of milk given, which will change the total amount of proteins the kid gets. In terms of feeding methods, gutter systems (used by only 7 producers) showed a lower performance in milk production and a higher replacement rate, while using buckets with multiple nipples at the top decreased growth and automatic milk feeding systems showed higher diarrhea prevalence. Feeding milk in a gutter is in fact a practice that is not recommended as it forces the kid to drink with its head down, which does not close the oesophageal groove to prevent milk from falling into the rumen (Piedhault et al., 2014). Gutter systems were in fact previously shown to negatively impact the growth of dairy goat kids up to

weaning (Doizé et al., 2013). It is recommended to feed frequent, small milk feedings to kids (APPENDIX 1), and that is best done with the use of an automatic milk feeder as the kids can choose the quantity and time they want to drink milk. The lower growth from feeding milk in buckets with top nipples could be caused by less frequent feedings or a lower quantity of milk offered, while the increased diarrhea from feeding with automatic milk feeders could be caused by the larger quantities of milk fed. Therefore, it is important to not only select the right feeding system, but also adjust the quantity and frequency of milk feedings to improve performance if not using an automatic milk feeder. Finally, a higher competition at the milk bucket, defined by more than one per nipple at the feeder, was shown to increase kid mortality rate and diarrhea prevalence, which shows the importance to follow recommendations of one kid per nipple (APPENDIX 1) to decrease competition and increase kid health.

As for colostrum feeding, the time of first feeding had the largest impact on farm performance indicators (3 out of 6 PI's), followed by the quantity and quality of colostrum (with 2 out of 6 PI's each). When colostrum was fed within 2 hours after birth, a higher milk production, lower mortality rate and lower diarrhea prevalence was observed on the farm. This goes in line with current recommendations (APPENDIX 1). Findings from Simoes et al. (2005) also suggest feeing colostrum as soon as possible after birth to maximize IgG transfer to the kids in order to increase their survival rate. A higher quantity of colostrum fed in the first 12 hours of life were shown to decrease mortality and diarrhea rates. According to literature, the higher quantity of colostrum that is given early after birth will increase the amount of IgG transferred to the kids (Simoes et al., 2005), which in turn increases the survival rates of the kids (O'brien and Sherman, 1993; Mellado et al., 1998). Colostrum quality is also very important to increase this transfer of IgG's to the kids (Castro et al., 2005; Rodríguez et al., 2009; Linhares Lima et al., 2013), and we found that the herds that evaluated colostrum quality, which is the first step towards feeding high quality colostrum, were associated with a higher growth rate from birth to weaning, and a higher herd replacement rate. Finally, pooling colostrum was associated with a lower milk production, and this practice is in fact not recommended (APPENDIX 1).

Effects of kidding management practices on farm performance

Kidding management practices, including the number of kidding periods, kidding monitoring and kid-dam separation, affected three PI's which were all related to kid health (i.e., mortality, prevalence of diarrhea and respiratory disease). The herds that had three or more kidding periods per year had higher incidences of diarrhea and respiratory disease. No recommendations are available on the optimal number of kidding periods, but this could potentially be related to not properly cleaning and disinfecting the kidding area and nursery between groups of kids, as per recommendations (APPENDIX 1), which could increase disease transmission to kids. A previous study by Buczinski (2013) found a significant association between a higher than average kid mortality rate in the first month of life and a poor kid housing hygiene, which goes in line with this theory. Monitoring kids more often in the day, at night and using video cameras to do so were all associated with a lower kid mortality, and the two latter were also associated with a lower prevalence of respiratory diseases. These findings suggest that monitoring in general is crucial to reduce kid mortality and diseases, which goes in line with current recommendations (APPENDIX 1). It was also found that monitoring kiddings 10 or more times per day was associated with a higher kid weight at 60 days of age (Doizé et al., 2013), which could be the result of the lower disease prevalence and mortality rate found in this study. Finally, the herds that removed the kids from the dams in most cases before first suckling were found to have a lower kid mortality rate as well. This is also a recommended practice to avoid disease transmission from the dam to the kid at birth (APPENDIX 1).

Effects of kid housing management practices on farm performance

Kid housing management practices were also associated with 3 PI's, including replacement rate, prevalence of respiratory disease and average daily gain from birth to weaning. The herds that left the kids with the dams for more than 48 hours, or until weaning, had a higher replacement rate and a lower incidence of kid respiratory disease. The latter could be explained by the fact that the kids are housed in a well-ventilated area with all the goats as opposed to a closed nursery where all the kids are, and respiratory disease transmission is easier. However, this goes against previous findings which found that kids that were housed in an area where there was possible contact with adult goats tended to have a higher than average mortality rate after 30 days of age, which was explained by the greater risk of contracting respiratory diseases and diarrhea (Buczinski, 2013). Of

the herds that raised kids away from the dams, those that grouped kids by their age to have kids of similar age in a same group were associated with higher average daily gains between birth and weaning. This goes in line with current recommendations (APPENDIX 1) to make homogeneous groups to avoid competition at feeding as much as possible, and our study confirms that this increases kid growth from birth to weaning. Finally, the herds that raised their buck kids on the farm until they were at least 2 weeks of age were found to have a higher prevalence of kid respiratory disease. This could be due to a higher stocking density from keeping the male kids in the herd longer, which in turns could increase incidences of respiratory disease.

Effects of record keeping on farm performance

Taking and recording measures on the farm, whether it be on milk production or kid management, were found to be favorable to 3 out of 6 PI's, including an increased milk production and goat kid growth as well as a decreased diarrhea prevalence. More specifically, the herds that kept records during the kidding period as well as those that used milk recording services were found to have a higher milk production. The herds that recorded kids' diseases in their record keeping were found to have a higher kid growth between birth and weaning, and those that recorded treatments administered to kids in that same period had a higher milk production. Finally, the producers who weighed and recorded kids' weight at birth also had a higher milk production and those who weight kids at weaning were found to have a lower kid diarrhea prevalence. This goes in line with previous findings from Brunelle (2014) which showed that growth monitoring improved the selection of does and decreased the age at first breeding, which in turn could improve herd milk production and other performance. What these results suggest is that the farms that hold more records on their farm production numbers and performance data are also the ones that perform better. This is sign of better overall farm management than those that do not hold any records, making it more difficult to improve their production numbers.

Effects of health management on farm performance

Preventive health management practices were associated with lower kid mortality rates and higher future milk production. More specifically, adding coccidiostats in the kids' concentrates before weaning, and adding medications in the milk, either when necessary or in prevention, were both associated with a higher milk production. These practices are in fact recommended to control for coccidiosis and cryptosporidiosis in kids at a young age (APPENDIX 1). The relationship

between the use of coccidiostats and a higher milk production goes in line with findings from previous studies suggesting a relationship between the use of coccidiostats and an increase in kid weight gain efficiency before weaning (Foreyt, 1990), which could explain the higher milk production later on. Additionally, another study found positive associations between the use of coccidiostats before and after weaning and a higher weight gain again, but also a higher first lactation milk yield (Morand-Fehr et al., 2002), which shows that coccidiostats may have a long-term effect on the does' future milk production. Disinfecting the kids' umbilical cord within 2 hours after birth and administering selenium and vitamin E to the adult goats during gestation were both associated with a lower kid mortality rate.

Effects of disbudding practices on farm performance

The herds that disbudded kids in their first two weeks of age had a lower replacement rate and a higher milk production. This goes in line with current recommendations, which suggest disbudding kids between 3 and 15 days, or as soon as the buds appear, to reduce distress to the kids (APPENDIX 1). A previous study has also shown that disbudding kids within the first two weeks of age increased the kids' chances of reaching a higher than average weight at 60 days of age (Doizé et al., 2013), which could explain the higher consequent milk production seen in this current study.

Effects of solid feeding practices on farm performance

In terms of solid feeding, we saw that the herds that offered hay to the kids in their first two weeks of life had a lower incidence of kid respiratory disease. Recommendations on feeding hay at a kid's young age are contradictory and vary between providing it in the first week of age to right before weaning (APPENDIX 1). Doizé et al. (2013) reported that a high consumption of hay before weaning, which could be possible with an early availability of forages, had a slight adverse effect on kid growth, although the difference was not significant. This was not due to an over-consumption of hay itself, but more to the resulting under-consumption of concentrates, which are important to stimulate kid growth. However, it is still important to feed a reasonable amount of hay to kids before weaning to favor the kid's rumen development and ensure it reaches its full potential before weaning (Doizé et al., 2013). Therefore, it would be important to make hay available to the kids early enough before weaning, without encouraging an excessive consumption which could decrease the consumption of concentrates. As for concentrates, the herds that fed concentrates with a higher crude protein content also had a higher milk production. The consumption of high-quality

concentrates is important to stimulate early growth of kids, and the protein content plays an essential role to the kid development. In fact, a study by Greenwood (1993) reported a significant correlation between the protein concentration in the concentrates and growth rate after weaning, when fed ad libitum. This illustrates the important of the concentration of protein in a ration to favor kid growth, and goes in line with our results, which showed an increased milk production for herds that fed concentrates higher in protein. The higher milk production could be influenced by the bigger size of the milking does if their growth has been maximized early in life.

Differences in practices between different intensification farm clusters

On a scale of management intensification, we were able to identify practices that differed between more and less extensively management farms. The main differences in practices found between the more and less intensive farms were that the more intensive farms fed cow colostrum, used automatic milk feeding systems, added coccidiostats in the kid concentrates as a method to prevent coccidiosis, and grouped kids by age more often than the farms in the more extensively managed cluster. In turn, the more extensively managed farms pooled colostrum more often and made smaller groups of kids (i.e., less than 15 kids per pen) more often than the intensively managed farms. They also provided at least one nipple per kid when fed in a milk bucket more often than the third, marginal cluster while the more intensive group of producers lay in between the two. Finally, the marginal, or poorly managed farms, fed the first colostrum more than 2 hours after birth more often than the two other groups, used automatic milk feeding systems more often than the less intensively managed farms, and lay in between the two other clusters for all other practices. From those results, we can see that the more extensively managed farms were also those that provided the most space to their kids, which translated in a lower mortality and disease prevalence, while the more intensively management farms had bigger groups, but followed other recommended practices more closely which translated in a higher milk production. Interestingly, the higher crowding of more intensive farms could not be explained by larger herd size since there was no difference in herd size between the three clusters.

3.6 Conclusion

In conclusion, this study was the first to draw an exhaustive portrait of goat kid rearing practices, between birth and weaning, inclusively, on commercial dairy goat farms in Canada. Rearing practices were analyzed under the microscope of six performance indicators, to identify the practices that divided more and less performant farms. The main findings from this study reveal that good colostrum and milk feeding management practices increased the highest number of farm performance indicators. The six performance indicators also allowed to divide the farms between three groups of producers with different management styles on a scale of intensification. This study identified some kid rearing practices that were significantly associated with higher farm performance indicators, hence these practices should be implemented on farms to improve the productivity of dairy goat herds in Canada. This new information will support the knowledge transfer to help producers in the implementation of those practices on their farm. Follow-up research should also be dedicated to understanding the reasons why some producers are not following best recommended practices to better respond to the producers' needs in terms of extension efforts.

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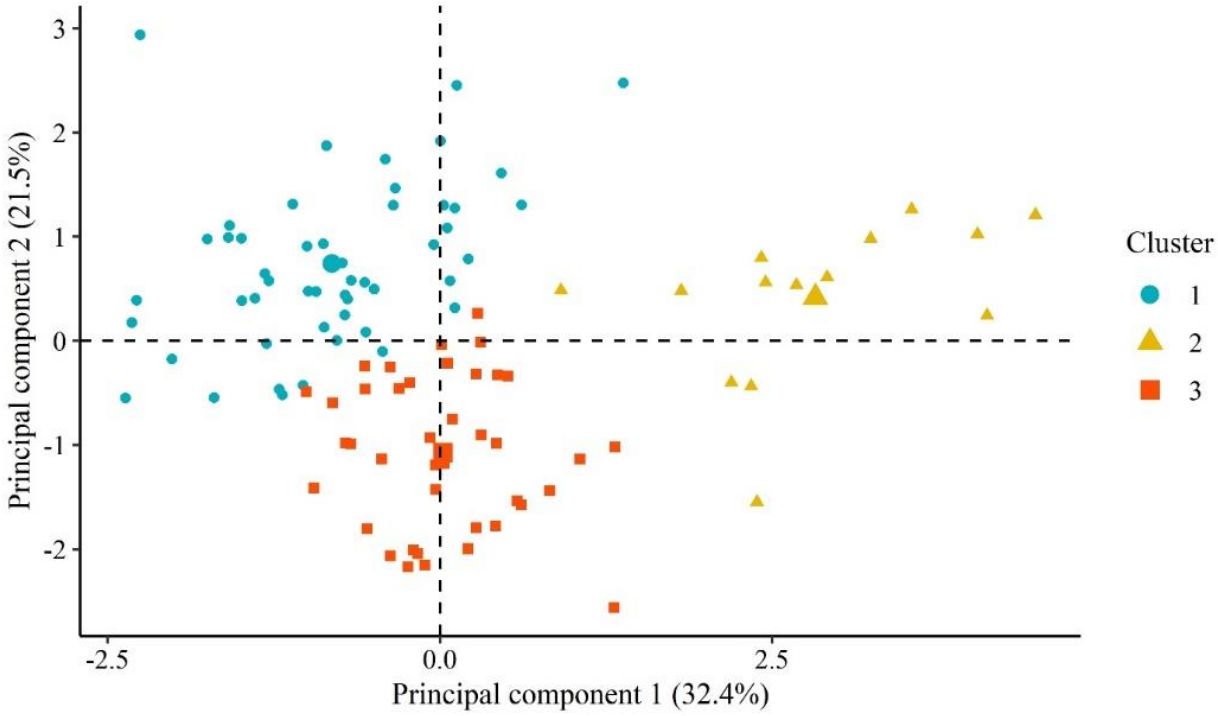
3.8 Supplemental material

Supplemental Figure 3.1 – Visualisation of the 3 farm clusters using principal component analysis, with principal component 1 and principal component 2. Cluster 1 = 50 farms, Cluster 2 = 14 farms, Cluster 3 = 40 farms



Supplemental Table 3.1 – Contribution to variance and coordinate of the variables to the principal components

Principal component	Variable	Partial contribution to variance (%)	Coordinate
PC1	Mortality rate	34.70	0.82
	Replacement rate	1.47	-0.17
	Milk production	15.97	-0.56
	Growth to weaning	21.58	-0.65
	% Diarrhea	21.71	0.65
	% Respiratory disease	4.57	0.30
PC2	Mortality rate	4.53	0.24
	Replacement rate	41.16	0.73
	Milk production	2.48	0.18
	Growth to weaning	20.90	0.52
	% Diarrhea	7.02	0.30
	% Respiratory disease	23.91	0.56

Supplemental Table 3.2 – Spearman correlation coefficients between farm performance indicators and farm characteristics on 104 dairy goat herds in Canada

Item	Milk prod.	Kid mortality	Replac. rate	Diarrhea[1]	Respiratory disease[1]	ADG[2] weaning	Herd size	Years in prod.	Breeding age
n	92	97	85	97	97	40	101	103	87
Milk production	1								
Kid mortality	-0.286**	1							
Replacement rate[1]	-0.073	0.119	1						
Diarrhea[1]	-0.112	0.375***	0.083	1					
Respiratory disease	-0.036	0.348***	0.175	0.260**	1				
ADG[2] to weaning	0.215	-0.131	0.226	-0.171	-0.259	1			
Herd size	0.033	0.229*	0.348**	0.033	0.308**	0.109	1		
Years in production	-0.018	-0.128	0.234*	-0.265**	-0.096	0.250	0.192	1	
Breeding age	-0.257*	-0.076	0.014	-0.043	-0.098	-0.016	-0.017	0.092	1

*indicates a $P \leq 0.05$; **indicates a $P \leq 0.01$; ***indicates a $P \leq 0.001$
[1]Prevalence
[2]Average daily gain

Supplemental Table 3.3 – Prevalence of kid rearing practices (categorical, binary data used for analyses)

Kidding management	N[1]	%[2]	95 % CL[3]
Number of kidding periods/year	101		
1 to 2 periods	35	35	25-44
> 2 periods	66	65	56-75
Kidding monitoring in the day	91		
≤ 2 times times/day	27	30	20-39
> 2 times times/day	64	70	61-80
Kidding monitoring at night	93		
Never	32	34	25-44
At least once	61	66	56-75
Use of video cameras for monitoring	102		
No	95	93	88-98
Yes	7	7	2-12
Separation of kid from dam	99		
After first suckling > 50 % of the times	35	35	26-45
Before first suckling > 50 % of the times	64	65	55-74
Kids left with dams to lick them dry[5]	102		
No	52	51	41-61
Yes	50	49	39-59
Kids dried manually (with use of heat lamp, towel, hair drier, heated foor, or other method)[5]	102		
No	36	35	26-45
Yes	66	65	55-74
Colostrum management (when hand-fed; n = 79; 77 % of respondents)	**N[1]**	**%[2]**	**95 % CL[3]**
Time of first colostrum feeding	78		
> 2 hours after birth	18	23	14-33
≤ 2 hours after birth	60	77	67-86
Length of the colostral period	79		
≤ 24 hours	28	35	25-46
> 24 hours	51	65	54-75
Use of oesophageal tube when necessary	79		
No	62	78	69-88
Yes	17	22	12-31

Colostrum source[4]	79		
Goat colostrum	44	56	44-67
Cow colostrum	17	22	12-31
Bovine colostrum replacer (lyophilized)	45	57	46-68
Use of frozen colostrum	79		
Never	42	53	42-64
Sometimes or always	37	47	36-58

The following apply to those who feed fresh colostrum (i.e., not lyophilized colostrum):

Thermize colostrum (heat treat at 56°C for 1 hour)	59		
No	35	59	46-72
Yes	24	41	28-54
Pool colostrum	58		
Yes	27	47	33-60
No	31	53	40-67
Evaluate colostrum quality	59		
No	29	49	36-62
Yes	30	51	38-64
Visually evaluate colostrum quality[5]	31		
No	10	32	15-50
Yes	21	68	50-85
Use refractometer to evaluate colostrum quality[5]	31		
No	22	71	54-88
Yes	9	29	12-46
Use colostrometer to evaluate colostrum quality[5]	31		
No	25	81	66-95
Yes	6	19	5-35

Milk feeding	N[1]	%[2]	95 % CL[3]
Kids fed under dams until weaning	103		
No	97	94	90-99
Yes	6	6	1-10
Milk type	87		
Fresh goat milk	4	5	0-9
Milk replacer (kid or calf)	75	86	79-94
Fresh cow or pasteurized goat or cow milk	8	9	3-15
Acidified milk	92		
No	68	74	65-83
Yes	24	26	17-35

Milk from goats with antibiotics	93		
Yes	10	11	4-17
No	83	89	83-96
Use of milk bucket(s) with nipples at the bottom[5]	95		
No	76	80	72-88
Yes	19	20	12-29
Use of milk bucket(s) with nipples at the top[5]	95		
No	67	71	61-80
Yes	28	29	20-39
Use of a gutter to feed milk[5]	95		
No	88	93	87-98
Yes	7	7	2-13
Use of single nipple bottle(s) to feed milk[5]	95		
No	71	75	66-84
Yes	24	25	16-34
Use of an automatic milk feeding system (AMF)[5]	95		
No	54	57	47-67
Yes	41	43	33-53
Number of kids per nipple (for bucket feeding)	48		
> 1 kid/nipple	16	33	20-47
≤ 1 kid/nipple	32	67	53-80
Number of kids per nipple (for AMF feeding)	41		
> 10 kids/nipple	8	20	7-32
≤ 10 kids/nipple	33	80	68-93
Number of milk meals/day (non-AMF systems)	53		
2 meals/day	30	57	43-70
3 or more meals/day	23	43	30-57
Washing frequency of milk bucket (or gutter)	54		
Not at each use	19	35	22-48
At each use	35	65	32-78
Washing frequency of AMF	41		
Every 2 or more days	24	59	43-74
At least every day	17	41	26-57
Solid and water feeding	**N[1]**	**%[2]**	**95 % CL[3]**
Time (age) of first concentrate availability	95		
≤ 2 weeks of age	51	54	43-64
> 2 weeks of age	44	46	36-57

Time (age) of first forage availability	85		
≤ 2 weeks of age	49	58	47-68
> 2 weeks of age	36	42	32-53
Time (age) of first water availability	87		
≤ 2 weeks of age	39	45	34-55
> 2 weeks of age	48	55	45-66
Health management	**N[1]**	**%[2]**	**95 % CL[3]**
Umbilical cord disinfection frequency	103		
< 50 % of the time	50	49	39-58
≥ 50 % of the time	53	51	42-61
Time of umbilical cord disinfection	68		
> 2 hours after birth	7	10	3-18
≤ 2 hours after birth	61	90	82-97
Selenium and vitamin E administered to dams during gestation	94		
	69	73	64-83
No	25	27	17-36
Yes			
Selenium and vitamin E administered to kids at birth	94		
	43	46	35-56
No	51	54	44-65
Yes			
Vaccination of dams during gestation	98		
No	52	53	43-63
Yes	46	47	37-57
Vaccination of kids before weaning	99		
No	66	67	57-76
Yes	33	33	24-43
Coccidiostats in concentrates	95		
No, or when necessary	32	34	24-43
Yes, in prevention	63	66	57-76
Medication in milk	94		
Never	40	43	32-53
When necessary or in prevention	54	57	47-68
Disbudding	**N[1]**	**%[2]**	**95 % CL[3]**
Time (age) of disbudding/dehorning	82		
In first 2 weeks of age	56	68	58-79
In the 3rd week or later	26	32	21-42

Use of pain control for disbudding	92		
No	59	64	54-74
Yes	33	36	26-46
Use of long-acting anti-inflammatory (> 24h) for disbudding[5]	92		
	70	76	67-85
No	22	24	15-33
Yes			
Use of short-acting anti-inflammatory (0-24h) for disbudding[5]	92		
	86	93	88-99
No	6	7	1-12
Yes			
Use of local anesthesia for disbudding[5]	92		
No	83	90	84-96
Yes	9	10	4-16
Use of a sedative for disbudding[5]	92		
No	88	96	91-100
Yes	4	4	0-9
Kid housing	N[1]	%[2]	95 % CL[3]
Possible contact with adult goats and/or sharing same air (same barn)	97		
Yes	34	35	25-45
No	63	65	55-45
Buck kid management	102		
Not kept on farm more than 2 weeks	52	51	41-61
Raised on farm for 2 weeks or more	50	49	39-59
Group kids by age[5]	98		
No	28	29	19-38
Yes	70	71	62-81
Group kids by weight[5]	98		
No	47	48	38-58
Yes	51	52	42-62
Group kids by sex[5]	98		
No	52	53	43-63
Yes	46	47	37-57
Kids are housed with dams until weaning	99		
No	93	94	89-99
Yes	6	6	1-11

Number of kids per pen	89		
< 15 kids	52	58	48-69
≥ 15 kids	37	42	31-52
Bedding addition frequency[4]	80		
At least every day	30	38	27-48
Between every day and every 2 days	24	30	20-40
< Every 2 days (3,5 times/week)	26	5	22-43
Pen cleaning frequency	96		
Less than once a week	63	66	56-75
At least once a week (4 x/month)	33	34	25-44

Weaning	N[1]	%[2]	95 % CL[3]
Weaning age	68		
< 8 weeks	31	46	33-58
≥ 8 weeks	37	54	42-67
Weaning weight	61		
< 15 kg	17	28	16-39
≥ 15 kg	44	72	61-84
Weaning criteria	92		
Age only	25	27	18-36
Weight only	20	22	13-30
Concentrate consumption only	3	3	0-7
Age & weight	33	36	26-46
Age & concentrate consumption	2	2	0-5
Weight & concentrate consumption	1	1	0-3
Age, weight & concentrate consumption	8	9	3-15
Weaning method	92		
Abrupt	36	39	29-49
Progressively (any progressive method)	56	61	51-71
Length of weaning period (if progressive)	60		
< 7 days	21	35	23-47
≥ 7 days	39	65	53-77

Record keeping	N[1]	%[2]	95 % CL[3]
Milk recording	103		
No	89	86	80-93
Yes	14	14	7-20
Record keeping for kid management	99		
No	25	25	17-34
Yes	74	75	66-83

Record kid vigour at birth[5]	72		
No	59	82	73-91
Yes	13	18	9-21
Record kid identification at birth[5]	72		
No	3	4	0-9
Yes	69	96	91-100
Record parent identification at birth[5]	72		
No	5	7	1-13
Yes	67	93	87-99
Record kid mortality from birth to weaning[5]	72		
No	9	26	16-37
Yes	53	74	63-84
Record kid diseases between birth and weaning[5]	72		
No	49	68	57-79
Yes	23	32	21-43
Record treatments administered to kids[5]	72		
No	32	44	33-56
Yes	40	56	44-67
Record kid vaccination[5]	72		
No	42	58	47-70
Yes	30	42	30-53
Weigh kids at birth[5]	92		
No	67	73	64-82
Yes	25	27	18-36
Weigh kids between birth and weaning[5]	92		
No	81	88	81-95
Yes	11	12	5-19
Weigh kids at weaning[5]	92		
No	53	58	47-68
Yes	39	42	32-53
Measure kid height at some point until weaning (inclusively)	92		
	88	96	91-100
No	4	4	0-9
Yes			

[1]Number of herds [2]Percentage of herds [3]95 % confidence limits

[4]Respondents could select more than one answer that applied to their situation, therefore the total prevalence (%) doesn't necessarily add up to 100 %.

[5]Those practices could be used in combination with another practice. Whether they used this practice or not does not mean they could not have used another one as well.

Supplemental Table 3.4 – Prevalence of kid rearing practices (continuous variables)

Rearing sector	N[1]	Min[2]	P25[3]	Med[4]	P75[5]	Max[6]
Colostrum feeding						
Quantity fed in first feeding, mL	72	44	175	250	300	500
Quantity fed in first 12 hours of life, mL	69	89	450	600	754	1000
Milk feeding						
Milk replacer crude protein content (%)	60	19	22	22	22	26
Milk replacer fat (%)	56	17	22	23	25	28
Solid feeding						
Concentrate crude protein content (%)	72	14	18	20	22	27
Weaning						
Weaning age (weeks)	68	5	6	8	10	20
Concentrate consumption at weaning (g/day)	13	50	100	250	250	500
Length of the weaning period	60	1	5	7	10	21

[1]Number of herds [2]Minimum [3]25th percentile [4]Median [5]75th percentile [6]Maximum

CHAPTER 4 - GENERAL DISCUSSION

Dairy goat kid rearing is an important topic in dairy goat production in Canada as it is a has long term repercussions on the adult productivity and herd performance. The overall productivity of the goat herd is in fact dependent on the growth of the kids in the preweaning period. However, there is little research to support the recommendations available on goat kid rearing practices under intensive production systems. The aim of the review paper presented in Chapter 2 was to compare the current recommendations available on dairy goat kid rearing between different countries under similar intensive production systems and to evaluate the extent to which those recommendations were based on scientific literature on goat kids. The most important gaps in literature identified were in the management of the kidding period, milk and solid feeding, housing and weaning sectors. The study presented in Chapter 3 allowed to identify the current rearing practices on dairy goat farms in Canada via the use of a survey. Relationships between rearing practices and six farm performance indicators were identified and allowed to divide the better from the less performant farms. The two rearing sectors identified as affecting the most performance indicators were the colostrum and milk feeding management sectors.

The findings from this thesis suggest that more research should be undertaken in several areas of goat kid rearing to refine and review the currently recommended practices. Gaps in the literature were identified and would benefit from research to improve the quality of recommendations to dairy goat producers. Those new findings will help to develop new reference material for farmers and support extension services efforts in implementing those recommended practices on the farms with less than optimal rearing practices to improve their farm profitability.

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APPENDIX 1 – International references on dairy goat kid rearing practices from birth the weaning, inclusively

Appendix Table A.1 – Review of recommendations on dairy goat kid rearing for Canada, Quebec and Ontario

References from Canada				
Rearing sector	L'élevage de la chèvre. **CRAAQ, Quebec, 2016**	Guide d'élevage de la chevrette laitière. **Valacta, Quebec, 2014**	Best Management Practices for Commercial Goat Production. **Ontario Goat, Ontario 2014**	Recommended code of practice for the care and handling of farm animals: Goats. **Canadian Agri-Food Research Council, CANADA, 2003**
Kidding Management				
Kidding area	--	Disinfect the pen before kidding.	Clean, draft-free, dry pens; fresh bedding and protocols for removal of placentas; and cleaning and disinfection as required.	Require a clean and dry area in which to give birth. Provide clean, dry bedding, regularly replaced.
Kidding monitoring	Monitor kiddings.	Monitor kiddings.	Do not disturb the doe but monitor her progress regularly.	Observe does frequently enough to ensure that any problems are given prompt attention.
Management and care of the newborn				
Separation from dam	Remove the kid immediately and move it to the nursery.	Remove kids from dams at birth.	Remove immediately from their dam.	Remove immediately after birth and don't allow to nurse.
Kid drying	Dry rapidly with a clean towel.	--	Dry with a clean towel. Use a heat lamp or radiant heater if required to maintain ambient temperature between 10-18^{o}C.	--
Colostrum Management				
Colostrum source	Thermized colostrum (56^{o}C for 1 hour).	Thermized colostrum (56^{o}C for 1 hour).	Ensure colostrum is from CAE-free does or heat-treat before feeding (56^{o}C for 1 hour). Do not pool colostrum from different dams.	Feed either heat-treated goat colostrum, cow colostrum, or commercial colostrum replacer.

Colostrum quality	--	--	Collect in as clean a manner as possible.	Adequate colostrum.
Timing of first meal	Within 2 to 6 hours after birth.	Within 6 hours after birth.	As soon as possible, within 1 to 6 hours after birth.	Immediately after birth.
Quantity of colostrum	100 mL/kg live weight in first meal.	50-75 mL/kg live weight per meal. 2-3 meals in 24 hours.	50 mL/kg of body weight, 4 times within the first 24 hours.	150 mL colostrum/kg of body weight over the first 24 hours.
Method of feeding	--	--	By bottle. If kids are too weak, force-feed using a flexible esophageal tube.	--
Duration of colostral period	--	24 h	24 h	3 days
Kid Feeding				
Milk source	Milk replacer for kids or lambs (more economical) or thermized or pasteurized goat milk.	Reconstituted milk.	Acidified milk (pH 4.1-4.5) or milk replacers.	Goat milk substitute (milk replacer or cow milk). Follow the manufacturer's instructions for feeding milk replacer.
Milk feeding program (quantity, frequency)	Ad libitum is recommended. If restricted, follow this program: 0.5-1 L/day in 3 meals minimum for the first 3 days, 1 L/day in 2 meals until day 7, 1.5 L/day in 2 meals from 7 to 15 days, and 2 L/day in 2 meals from 15 to 45 days.	Ad libitum or at least 3 meals/day. Feed 1.8 to 2.0 L/day from day 21 onward.	Follow manufacturer's instructions for recommended quantities. Bottle-fed kids will feed 4-5 x/day in weeks 1 & 2, and 2-3 x/day up to weaning.	Feed at frequent intervals, but not less than 2 x/day.
Milk feeding method (method and washing frequency)	Use automatic milk feeder (15-20 kids/nipple) or multiple-nipple milk bar for restricted kids (groups of 10-20 kids).	Prioritize a nipple feeding system over a gutter. Wash it every day.	Fed by nipple (bottle or kid bar), pail, or with self-feeder units (in larger operations).	Clean automatic feeding equipment at regular and frequent intervals. Clean and sanitize utensils after each use.

Concentrates (type, age, quantity, frequency, method)	Creep feed 30-50 g/day of fresh, highly palatable, 18-20 % protein kid starter from week 1. Offer in multiple meals to stimulate consumption. Aim for at least 200 g/day (ideally 300 to 400 g/day) consumption at weaning. Feeder space: 15 cm/head.	Introduce ad libitum concentrates at 14 days. Feeder space: 15 cm/head.	Provide a pelleted kid starter no later than at 3-4 weeks of age.	Introduce grain-based creep ration on a free choice basis by 1 week of age. Feeder space (free choice feeding): 3-5 cm/head.
Forages (type, age, quantity)	Give good quality hay (young and leafy, maximum 34 % ADF fibre), free choice, from day 8. Aim for a 200-250 g/day consumption at weaning.	Introduce a good quality forage at 21 days or older.	Provide clean hay prior to weaning.	Introduce high quality roughage on a free choice basis by 1 week of age.
Water access (age, method)	Provide access to clean and lukewarm water at all times.	Provide access to clean water before weaning.	Provide access to fresh water at all times before and through weaning.	Provide clean, fresh water free choice by 1 week of age.
Kid Health				
Navel disinfection	Drench or spray generously up to the basis of the belly at birth with a solution of 5-7 % tincture of iodine.	Drench or spray with a solution of 5-7 % tincture of iodine in the minutes following birth, and repeat.	Apply 7 % iodine to navels as soon as possible, dipping the full length in a single-use paper cup or using a quirt bottle. Clamp the navel off if bleeding persists. Monitor for infection; re-dip/reapply after 24 hours if needed.	Treat with a suitable navel disinfectant at birth.
Selenium & Vitamin E	Administer (inject) Vitamin E and Selenium at birth or complement feeds in selenium for oral administration.	Inject Vitamin E – Selenium to kids on day 1.	Inject kids with vitamins and minerals, following the protocols prepared in advance, or as directed by a veterinarian.	--

Vaccination (dam and kid)	Vaccinate kids for enterotoxaemia (*Clostridium perfringens* types C and D) and tetanus at 4-5 weeks of age if dams were vaccinated before kidding, otherwise vaccinate kids at 1 week old.	Vaccinate dams for clostridia (enterotoxaemia, tetanus), and some for caseous lymphadenitis before kidding, and kids at 4-6 weeks old and 2-4 weeks after.	--	--
Coccidiostats	--	Add coccidiostats in concentrates from 15 days of age.	--	--
Disbudding				
Timing	Between 3 and 14 days of age. Usually from day 4 for males and from day 8 for females or as soon as the buds appear.	Between 8 and 15 days of age.	Before 3 weeks of age.	Between 3 and 10 days of age.
Method, pain control	In a humane and hygienic way.	--	Provide appropriate pain control as advised by a vet and follow directions for the disbudding tool.	Use heated iron (10 seconds max) or electronic device; done by a competent person. Caustic pastes not recommended (danger of blindness if kid rubs it into its eyes).
Kid Housing				
Characteristics (size, bedding type and quantity)	Make homogeneous groups of 10-20 kids, to avoid competition at feeding. Floor space: 0.3 m^2/head.	Recommended pen density: 3.3 kids/$meter^2$. Add abundant straw bedding.	Floor space: 0.3 – 0.5 m^2/head. Provide plenty of clean, dry straw/bedding and change it frequently. Separate buck kids from doelings at 4 months to avoid unintentional breeding.	Group by age and size, in small enough groups to ensure accurate observation by the attendant(s). Floor space: 0.3-0.5 m^2/head. Add very clean and dry bedding. Separate bucks from doe kids at 12 weeks to avoid breeding.

Cleaning / disinfection, ventilation and temperature	Clean, dry and warm environment (18 °C).	Clean, wash with soap, disinfect and fallow pens before kidding season(s). Keep kids in clean and dry area, free from draft.	Keep kids in a warm, draft free, clean and dry pen.	Clean, sanitized housing. Keep all surfaces to which kids are exposed clean and free of excrement.
Type and place	Avoid any direct contact with adult goats until breeding to avoid contracting slow-developing diseases such as CAE.	--	Keep kids together for care and management in group pens and/or on pasture.	--
Weaning				
Criteria	Wean when kid weighs 15 kg maximum (usually 6-7 weeks old) and at the latest at 60 days of age. ADG should be of 170 g/d.	Wean when kid weighs at least 15 kg and eats at least 200 g of concentrates per day.	Consider both the weight and age. Wean when kid reaches 2.5 times its birth weight and eats at least 30 g of solid feed daily.	Wean when kid weighs at least 2.5 times its birth-weight, readily drinks water, and consumes a minimum of 160-225 g/day of solid feed.
Method	Progressive and smooth transition to feed. Decrease milk quantity to 1 L/day in 1 meal for the week before weaning.	Progressive (1 meal/day for 3-5 days) if fed with a gutter or bucket; drastic if fed with automatic milk feeder. Do not modify the milk concentration.	Gradual for early weaning, or either gradual or abrupt when weaning older, larger kids. Maintain access to solid feeds and fresh, clean water at all times.	--
Growth monitoring				
Growth measures and recording	Weigh and identify kids at birth. Avoid having goat kids too fat.	Weigh at birth and weaning.	Weigh at birth and record all information. Record weight and BCS at weaning in the kid records.	--
References	CRAAQ. 2016. L'élevage de la chèvre. Centre de référence en agriculture et agroalimentaire du Québec (CRAAQ), Québec, QC.	Valacta. 2014. Guide d'élevage de la chevrette laitière. Valacta, Sainte-Anne-de-Bellevue, QC.	Ontario Goat. 2014. Best Management Practices for Commercial Goat Production. Version 1.0, 168p. Ontario Goat, Guelph, ON.	CARC. 2003. Recommended code of practice for the care and handling of farm animals – Goats. Canadian Agri-Food Research Council (CARC), Ottawa, ON.

Appendix Table A.2 - Review of international recommendations on dairy goat kid rearing (France and USA)

References from France and the USA				
Rearing sector	**INOSYS – Réseaux d'élevage caprins, France, 2016[1] and 2014[2]**	**Institut de l'élevage, France, 2009**	**University of California, Davis, USA, 2014**	**Best Management Practices for Dairy Goat Farmers, Wisconsin, USA, 2008**
Kidding Management				
Kidding area	--	--	Provide clean, adequate space so that does are not stressed or crowded. Should be very well lit and in an area where people can easily observe the expectant mothers.	Provide clean environment, and stall bedded with straw or other absorbent material.
Kidding monitoring	--	--	Organize a schedule for the does to be observed on a regular basis. Baby monitors and barn-cams can be very useful. Observe every birth to see if they need assistance.	Locate the kidding stall near a well-traveled area to ensure that the doe will be frequently observed for kidding difficulties.
Management and care of the newborn				
Separation from dam	Prevent any licking of the kid by the dam to control CAE.	--	Remove kids from does immediately; do not allow kids to nurse the doe, or the doe to clean off the kids. If necessary, tape the teats of the doe to endure the kids cannot nurse.	Don't allow the kids to nurse directly, for disease prevention.
Kid drying	Dry soon after birth and maintain a temperature close to 20 °C. Use a heat lamp if necessary.	--	Assure kids are cleaned off and in a warm location.	Use hair dryer to fluff and dry the newborns and make sure the hair on the ears is absolutely dry. Hair dryers are better than heat lamps, which use a lot of energy, and don't contribute to the health of kids.

Colostrum Management				
Colostrum source	Thermized colostrum (1^2 to 2^1 hours at 56-60 °C). Only use first milking colostrum from goats that have been dry for 2 months. Favor colostrum from multiparous goats.	Thermized colostrum.	Frozen, heat-treated colostrum (heated to 56-57°C for one hour) from does in the resident herd is the most effective and safest colostrum to use. Commercial colostrum substitutes are not recommended as they do not provide the necessary antibodies. Use colostrum from only the first milking, and do not use colostrum from a doe that has been leaking milk or has been milked before kidding.	Heat-treated colostrum (heated to 57-62.7 °C and held at that temperature for 1 hour) to kill any harmful bacteria responsible for CAE and Johne's diseases.
Colostrum quality	Use a colostrum meter or a refractometer to evaluate colostrum quality. Should contain at least 50 g IgG/L of colostrum.	--	Determine that colostrum is of good quality; should be fairly thick and yellowish in color. For accurate measurement, use a "colostro-meter".	Test colostrum quality with a colostrum meter before it is pasteurized.
Timing of first meal	Within 2^2 to 6^1 hours after birth.	--	Within 8 to 12 hours after birth, but preferably within 2 to 3 hours.	As early as possible and prior to 18 hours after birth.
Quantity of colostrum	100 g/kg of live weight in 3^1 or 2 meals; first one within 2 hours after birth and second one 6 hours later[2].	--	Feed at least 227 g (10 % of body weight) in first meal. Smaller kids can be fed in two meals.	Feed 62.5 g/kg of body weight, three times during the first 24 hours (every 8 hours). If tube feeding, don't give more than 113g.
Method of feeding	--	--	Bottle feed, or tube very weak kids if necessary.	Bottle feed to insure adequate consumption. Tube feed if the kid refuses to drink after 2 attempts 3-4 hours apart Wash bottles and nipples thoroughly after each feeding.

Duration of colostral Period	2-3 days.	--	--	24 h
Kid Feeding				
Milk source	Skimmed milk powder or milk product concentrated (mainly whey). Follow mixing indications, dilution temperature (50-55 ^{o}C) and distribution temperature (38-44 ^{o}C).	Milk powder (160-180 g/L of reconstituted milk) or milk replacer based on whey (accelerates consumption of concentrates and forages). Choose a milk at 24 % fat. Follow mixing and feeding indications.	Pasteurized goat milk (preferably from clean, tested does), pasteurized cow milk or milk replacer (a formula intended for goat kids, with 20-28 % protein and 16-24 % fat) are "safe" option. Favor whey of milk-based protein rather than soy-based protein. Do not feed milk from treated animals.	Milk replacers with 16-24 % fat and 20-28 % protein with milk-based proteins. Can feed pasteurized milk (72 ^{o}C) before transitioning to milk replacer. Favor goat kid milk replacers over lamb and calf. Warm (39 ^{o}C) milk replacer will make the kids drink more, and cold (4 ^{o}C) will make them drink slower and/or less. Important to follow the exact directions of the manufacturer, including the water temperature for mixing.
Milk feeding program (quantity, frequency)	Feed 3 meals/day for the first days then 2 meals/day.	Follow a constant feeding schedule. Recommended ad libitum feeding.	--	Do not overfeed milk! Multiple-nipple milk bar: maximum 450 mL/kid in one meal (max 280-340 mL in the first weeks). Feed up to 4 times/day for the first 2-4 days, then 2 times/day. Small, frequent feedings increase digestibility and decrease digestive disturbances.

Milk feeding method (method and washing frequency)	Automatic milk feeder: 10-20 kids/nipple; multiple-nipple milk bar: 1 kid/nipple; gutter: 10-15 cm/kid.). Use a multiple-nipple milk bar over a gutter system to engage suckling with head up, which closes the oesophageal groove and prevents milk from falling into the rumen. Ensure good hygiene of mixing utensils. For automatic milk feeders, wash mixing bowl and nipple supports daily, and tubes weekly.	Automatic feeder: 15 kids/nipple; multiple-nipple milk bar: 1 kid/nipple. Clean all feeding material after each use, and the automatic milk feeder daily.	--	An automatic feeder may be an economical choice for large numbers of kids.
Concentrates (type, age, quantity, frequency, method)	Feed adapted concentrate 2 times/day, from 10 days of age[1] or from week 1[2]. Feeder space at weaning: 20 cm/kid.	Feed 18 % crude protein concentrate in the 2nd week of age. Feeder space: 12-15 cm/head.	--	--
Forages (type, age, quantity)	Distribute good quality (palatable and sufficiently fibrous) hay 3 times/day, from 10 days of age[1] or from week 1[2]. At weaning, hay should be of excellent quality and highly palatable to stimulate intake.	Feed quality hay in the 2nd week of age. Favor good grass hay, with soft and thin stems. Avoid alfalfa before 4 months of age; important risks of bloating.	--	Introduce a hand full when the kids are eating grain well.
Water access (age, method)	Provide access to clean water from day 10[1] or from week 1[2].	Provide access to clean water (free choice) in the 2nd week.	--	--

Kid Health				
Navel disinfection	Disinfect at birth. Drench the umbilical cord in an iodine solution.	Disinfect at birth.	Dip the navel with an iodine or chlorhexidine solution (Nolvasan®).	Dip the navel cord in a solution of 7 % tincture of iodine. Cut long navel cords to 3-4 inches long.
Selenium & Vitamin E	--	--	May be beneficial to give some vitamin and/or mineral supplementation to kids at birth.	In selenium deficient areas (soil level), supplement the goats with selenium (oral or injection) and inject kids with vitamin E + selenium preparations. Check with veterinarian to see if using a selenium-vitamin E supplementation (e.g., BOSE) is advisable.
Vaccination (dam and kid)	--	Vaccinate kids at 3 weeks of age + 3 weeks after for pasteurellosis enterotoxaemia.	Vaccinate does against *Clostridium perfringens C & D* (enterotoxemia) and tetanus in the last 30 days before kidding.	Vaccinate pregnant does with CDT and other vaccines, as needed, 3 weeks prior to kidding. Vaccinate kids for *Clostrdium perfringens* CD and tetanus at 3 weeks of age and 2 weeks later.
Coccidiostats	Plan a prevention treatment for coccidiosis at 1 month and another at weaning.	--	--	--
Disbudding				
Timing	From day 12 of age, depending on the growth of buds.	Between 8 and 12 days of age.	During the first 2 weeks of age; Swiss breeds and Lamanchas should be disbudded before 7 to 10 days of age, depending on birth weight and sex.	Between 3 and 14 days of age, while the horn bud is visible.
Method, pain control	Apply a spray antibiotic to avoid infection afterwards.	--	--	Electric disbudder.

Kid Housing				
Characteristics (size, bedding type and quantity)	Make homogeneous groups of 20-25 kids, and reallocate based on weight as often as possible, at each weighing. Keep females separate from males. Add straw daily to maintain a clean and dry bedding. Floor space: 0.5 m^2/kid[1] or 0.25-0.30 m^2/kid[2].	Make homogeneous groups of 15 kids, in pens of 2m x 2m. Add abundant and frequent bedding (straw). Floor space: 0.25 m^2/kid.	Keep kids isolated in small groups for 2 weeks. After two weeks, kids can be moved into older groupings.	Do not overcrowd.
Cleaning / disinfection, ventilation and temperature	Warm conditions for the first 20 days, and always well ventilated.	Keep environment as dry as possible. Temperature 12-15°C.	Keep kids in clean area not used to raise previous kids, at an appropriate temperature.	Clean the maternity and kid pens and leave them vacant for as long as practical. Keep the pens clean, dry and draft free. Ventilate so that there is never any smell of ammonia to prevent respiratory problems.
Type and place	The nursery should be in a room far and separate from the adult goats. Natural lighting: 10 % of surface[2].	--	Place in an area dedicated to kid rearing for 2 weeks.	Restrict contact of kids with adult goats, other goat raisers, and especially newly purchased kids.

Weaning				
Criteria	Animals should be ruminating, drinking water and making well-formed feces. The kid must consume 300 g/day of forages and 150-200 g/day of concentrates. The minimum weight must be of 14 kg. Aim for 20 % of adult weight at 60 days.	--	--	Based on the amount of grain (115 g/day) and water the kids are consuming. Fixed weaning ages are less desirable than weight goals such as 2.0 to 2.5 times birth weight.
Method	Progressive if the milk is fed in a multiple-nipple milk bar or a gutter; progressively reduce milk quantity from 6 weeks of age. Never change the concentration of the milk for weaning! Abrupt if fed with an automatic milk feeder (need close supervision since they have a harder time consuming solid feeds when fed ad libitum milk). May use a milk bar for a few days after the use of an automatic milk feeder.	Abrupt (automatic milk feeder).	--	--

Growth monitoring				
Growth measures and recording	Aim for 10 kg at 30 days of age (ADG of 200 g/day), and 16 kg at 60 days of age (ADG of 150 g/day).	Weigh at birth and at 2 months of age. Aim for 14 kg at 2 months of age.	--	--
References	[1] INOSYS. 2016. L'élevage des chevrettes: recommandations et conseils. INOSYS-Réseaux d'Élevage, Paris, France. [2] Piedhault, F., K. Lazard, M. Proust, B. Foisnon, V. Lictevout, J.-Y. Lhériau, and N. Bossis. 2014. Réussir l'élevage des chevrettes, de la naissance à la mise bas. Inosys, ed. Institut de l'Élevage, Paris, France.	Institut de l'élevage. 2009. Les fiches techniques caprines du Sud-Ouest: Place aux chevrettes. Fiche n°1. ISBN 978-2-84148-740-0 - Réf. IE : 00 09 57 105 - Novembre 2009. Institut de l'élevage, Paris, France.	Carlson, J. 2014. Kidding and Kid Rearing. Proc. of the 29th Annual Goat Field Day, Langston University. University of California, Davis, CA.	Hedrich, C., C. Duemler, D. Considine. 2008. Best management practices for dairy goat farmers. University of Wisconsin, Madison.

APPENDIX 2 – Survey on dairy goat kid rearing practices

This survey is addressed to all dairy goat producers of Canada who are currently in production.

Section 1: General Farm Description

1. How many years have you been a dairy goat milk producer?
   (a) 1-5 years (b) 6-10 years (c) 11-15 years (d) 16-20 years (e) more than 20 years

2. What are the three first characters of your zip code?

3. Over the past year, what was the average number of lactating goats compared to dry goats in your herd?

4. Over the past year, what would you estimate to be the proportion (%) of each breed in your herd?
   (% Alpine; % Saanen; % LaMancha; % Nubian; % Toggenburg; % Cross breeds; % Don't know)

5. Over the past year, how many live goat kids were born on the farm (excluding stillbirths)? (number of males and number of females)

6. Over the past year, what was your approximate female goat kid mortality, from birth to weaning, for those born on the farm (excluding stillbirths)?

7. What do you do with the buck kids (bucklings) born on the farm?
   (a) Eliminated at birth (b) Sold in the first 2 weeks of age (c) Sold between 2 and 4 weeks of age (d) Sold between 4 weeks of age and weaning (e) Sold after weaning (f) Other, please specify

8. Over the past year, what was the replacement rate of your herd (% of adult goats leaving the herd to be replaced by new does each year)?

9. Over the past year, what has been your herd's average milk production?
   (Liters/goat/year or total herd production/year according to milk production contract)

10. Over the past year, what was the average weight (kg) and/or age (months) at first breeding for does?

11. Do you use a milk recording service (for example Valacta, CanWest DHI or other)?
    (a) Yes (b) No

Section 2: Kidding Management

12. How many kidding periods do you have per year?
    (a) 1 (b) 2 (c) 3 (d) 4 (e) Kiddings are spread out throughout the year (f) Other, please specify

13. On average, how often (number of times) do you monitor kidding between the morning and the evening milking (physical or camera observations)?

14. On average, how often (number of times) do you monitor kidding between the evening and the morning milking (physical or camera observations)?

15. How do you monitor kiddings?
    (a) Video camera (b) In person (c) Other, please specify

Section 3: Management and Care of the Newborn

For the following questions, we are interested in your rearing practices for the female kids only.

16. Do you disinfect the umbilical cord of the kids at birth?
    (a) Never (b) Occasionally; less than 50 % of the time (c) Often, 50 % of the time or more (d) Always

17. If you disinfect the umbilical cord of the kids, when do you do it?

    (a) Less than 2 hours after birth (b) Less than 2 hours after birth and a second time between 12 and 24 hours after birth (c) 2 hours or more after birth (d) N/A; do not disinfect (e) Other, please specify

18. How long do the kids stay with their dam after birth? Please indicate the frequency at which the following situations occur on the farm:

    (% Removed immediately at birth; % Removed before the first suckling; % Removed in the first 24 hours; % Removed between 24 and 48 hours; % Left with their dam until weaning; % Other, please specify)

19. How are the kids dried at birth? Please check all that apply:

    Kids are not dried at birth – Kids are left with their dam to dry them – On abundant bedding in the first hours after birth – Under a heat lamp – Heating carpet/floor – With a clean towel – With a hair dryer – Other, please specify

Section 4: Colostrum Management

This section applies only if the kids are <u>not</u> left with their dam to drink the colostrum. If they are, select N/A for the following question and move to question 30.

20. When is the colostrum fed for the first time?

    (a) N / A; the kids are left with their moms to drink the colostrum (move to question 30) (b) Within 2 hours after birth (c) Between 2 and 6 hours after birth (d) Between 6 and 12 hours after birth (e) Between 12 and 24 hours after birth (f) More than 24 hours after birth (g) Other, please specify

21. Which method do you use to feed colostrum? Please check all that apply :

    Nipple bottle – Bucket with multiple nipples at the bottom – Bucket with multiple nipples at the top (with tubes) – Open bucket (no nipples) – Oesophageal tube – Other, please specify

22. What quantity of colostrum is fed at the first feeding?

23. What is the total quantity of colostrum fed to a kid during its first 12 hours of life?

24. How long do you feed colostrum to each newborn kid?

(a) For the first 24 hours of life (b) For the first 2 days of life (c) For the first 3 days of life (d) For the first 4 days of life (e) Other, please specify

25. What is your colostrum source? Please check all that apply :

Fresh goat colostrum – Frozen goat colostrum – Fresh cow colostrum – Frozen cow colostrum – Bovine colostrum replacer (dehydrated/lyophilized) – Other, please specify

26. Do you thermize your colostrum (heat treat at 56°C for 1 hour)?

(a) Yes (b) No

27. Do you pool (mix) colostrum from different goats?

(a) Yes (b) No

28. Do you evaluate the quality of your colostrum?

(a) Yes (b) Sometimes (c) No

29. If yes or sometimes, what do you use to evaluate the quality of colostrum? Please check all that apply:

Visual observation (colour, consistency) – Colostrometer – Refractometer – Other, please specify

Section 5: Feeding of Goat Kids Until Weaning

30. What is the principal source of milk fed to the kids?

    (a) N/A; the kids are left under their dam until weaning (move to question 41) (b) Fresh/whole goat milk (c) Fresh/whole cow milk (d) Pasteurized goat milk (heat-treated at 63°C for 30 minutes OR at 74°C for 15 sec) (e) Pasteurized cow milk (heat-treated at 63°C for 30 minutes OR at 74°C for 15 sec) (f) Dairy goat milk replacer (powdered) (g) Meat goat milk replacer (powdered) (h) Dairy calf milk replacer (powdered) (i) Goat whey (j) Cow whey

31. If you offer milk replacer, what is the composition of the milk powder?

    (% Crude protein; % Fat)

32. Do you acidify the milk or milk replacer before feeding it to the kids?

    (a) Yes (b) No

33. Do you offer milk from goats treated with antibiotics to the kids?

    (a) Yes (b) No

34. Do you add medication to the kids' milk?

    (a) Yes, in prevention (b) Only when necessary (c) No

35. If yes. What type of medication do you add to the kid's milk for prevention? Please check all that apply:

    Antibiotics – Coccidiostatic – N/A; no medication is added to the milk for prevention

36. How is the milk fed to the kids? Please check all that apply:

    Bucket with multiple nipples at the bottom – Bucket with multiple nipples at the top (with tubes) – Gutter (open trough for all kids in a same pen) – Single nipple bottles – Automatic milk feeder – Other, please specify

37. How often do you wash your milk feeding system?

(a) Every time it is used (b) Every day (c) 3 times a week (d) 2 times a week (e) Once a week (f) Other, please specify

38. What is your milk feeding space allowance?

(Number of kids/nipple or gutter space per kid)

39. What is your milk feeding program? Please check the total milk quantity offered per day per goat for each of the following periods (round to the closest quantity):

	0L	0.25L	0.5L	0.75L	1L	1.25L	1.5L	1.75L	2L	2.25L	2.5L	2.75L	3L	>3L
1 week of age	○	○	○	○	○	○	○	○	○	○	○	○	○	○
2 weeks of age	○	○	○	○	○	○	○	○	○	○	○	○	○	○
3 weeks of age	○	○	○	○	○	○	○	○	○	○	○	○	○	○
4 weeks of age	○	○	○	○	○	○	○	○	○	○	○	○	○	○
5 weeks of age	○	○	○	○	○	○	○	○	○	○	○	○	○	○
6 week of age	○	○	○	○	○	○	○	○	○	○	○	○	○	○
7 weeks of age	○	○	○	○	○	○	○	○	○	○	○	○	○	○
8 weeks of age	○	○	○	○	○	○	○	○	○	○	○	○	○	○
9 weeks of age	○	○	○	○	○	○	○	○	○	○	○	○	○	○
10 weeks of age	○	○	○	○	○	○	○	○	○	○	○	○	○	○
11 weeks of age	○	○	○	○	○	○	○	○	○	○	○	○	○	○
12 weeks of age	○	○	○	○	○	○	○	○	○	○	○	○	○	○
More than 12 weeks of age	○	○	○	○	○	○	○	○	○	○	○	○	○	○

40. In how many meals per day do you split the total amount of milk offered to the kids?

(a) 1 meal/day (b) 2 meals/day (c) 3 meals/day (d) 4 meals/day (e) Ad libitum (free choice) (f) Other, please specify

41. At what age (weeks) do you start offering a kid starter (concentrate) to the kids?

42. Is the feed starter (concentrates) offered ad libitum (free choice) or in a limited amount to the kids before weaning?

(a) Ad libitum (the kids can eat all they want) (b) Limited amount (c) N/A; no feed starter is offered before weaning (move to question 47) (d) Other, please specify

43. If you offer a limited amount of feed, what is your feeding program? Please check the total feed quantity offered per day per goat for each of the following periods (round to the closest quantity):

	0g	25g	50g	100g	150g	200g	250g	300g	>300g	Ad libitum
1 week of age	○	○	○	○	○	○	○	○	○	○
2 weeks of age	○	○	○	○	○	○	○	○	○	○
3 weeks of age	○	○	○	○	○	○	○	○	○	○
4 weeks of age	○	○	○	○	○	○	○	○	○	○
5 weeks of age	○	○	○	○	○	○	○	○	○	○
6 week of age	○	○	○	○	○	○	○	○	○	○
7 weeks of age	○	○	○	○	○	○	○	○	○	○
8 weeks of age	○	○	○	○	○	○	○	○	○	○
9 weeks of age	○	○	○	○	○	○	○	○	○	○
10 weeks of age	○	○	○	○	○	○	○	○	○	○
11 weeks of age	○	○	○	○	○	○	○	○	○	○
12 weeks of age	○	○	○	○	○	○	○	○	○	○
More than 12 weeks of age	○	○	○	○	○	○	○	○	○	○

44. What is the principal type of feed concentrate fed to the kids before weaning?

(a) Commercial pelleted feed (b) Commercial textured feed (c) House mix of grains and concentrates (d) Other, please specify

45. What is the composition of the kid starter offered?

(% Crude protein; % Crude fat)

46. Do you use anticoccidial products (such as Bovatec®, Rumensin® ou Deccox®) in your feed concentrates?

    (a) Yes (b) Only when needed (visible problems of diarrhea) (c) No

47. Which other feeds are offered to the kids and starting at what age (weeks) are they offered? Check all that apply, and specify from what age for each of the following:

    Dry hay – Fermented feeds (silage or TMR) – Straw – Water – Other, specify

Section 6: Weaning

48. On what criteria do you base your decision to wean a kid? Specify all that apply:

    Age (specify average age (weeks) at which kids are weaned) – Quantity of concentrates ingested (specify the average level of ingestion (g/day/kid) at the time of weaning) – Weight (specify the average weight (kg) of kids at weaning) – Other, please specify

49. How are the kids weaned?

    (a) Abruptly (the milk is removed completely in one day) (b) Progressively, by skipping milk feedings (c) Progressively, by reducing the milk quantity gradually (d) Progressively, by diluting the milk with water (e) Other, please specify

50. If the goats are weaned progressively, over how many days does the procedure usually happen?

Section 7: Goat Kids Health

51. Do you administer Selenium and Vitamin E (e.g., Dystosel, Selon-E, Muse) to the goat kids and/or pregnant goats? Please check all that apply:

    Yes, to the mothers during gestation – Yes, to the kids at birth – No Selenium or Vitamin E is administered to the goat kids or pregnant goats – Other Vitamins are given to the goat kids and/or pregnant goat (please specify which ones and when they are administered)

52. Over the past year, what do you estimate to be the number of cases of kids affected by the following health conditions between birth and weaning? (Indicate the prevalence; for example, 10 % diarrhea if 10 kids out of 100 were affected by diarrhea any time from birth to weaning)

    (% Diarrhea (for example coccidia, E. coli, Salmonella, etc.); % Respiratory problems (for example, pneumonia); % Contagious ecthyma (soremouth); % Nervous disorders; % Navel infections; % Arthritis; % Other, please specify)

53. Are the goats vaccinated during the gestation for immunity transfer to the kids (through colostrum)?

    (a) Yes (b) No

54. Are the kids vaccinated between birth and weaning?

    (a) Yes (b) No

Section 8: Housing

55. Where are the kids housed up to weaning? Please check all that apply:

    In an open area in the main barn (possible contact with adult goats; sharing the same air) – In a closed room in the main barn or in a separate building (no possible contact with adult goats) – Other, please specify

56. How are the kids allotted (divided) into different groups? Please check all that apply:

    By age – By weight – By sex – N/A; all kids are in one big group – N/A; the kids are in individual pens – Other, please specify

57. On average, how many kids are in one pen?

58. How often is bedding material added to the kids' pens?

    (Number of times per week; OR number of times per month; OR when necessary (specify the criteria used); OR never (no bedding material); OR other, please specify)

59. How often are the kids' pens cleaned (all bedding removed)?

(Number of times per week; OR number of times per month; OR number of times per year; OR when all the kids in the pen have been weaned; OR other, please specify)

Section 9: Disbudding/Dehorning

60. How long after birth are the kids disbudded/dehorned?

(a) In the first week (b) In the 2nd week (c) In the 3rd week (d) In the 4th week or more (e) Never (move to question 63)

61. Which method(s) do you use for disbudding/dehorning? Please check all that apply:

Chemical (caustic paste or stick, calcium chloride injections) – Hot metal (electric dehorning, hot iron dehorner, etc.) – Surgical (Gouge, Barnes type manual dehorning, dehorning spoon or tube) – Dehorning saw (steel wire) – Other, please specify

62. Which medication(s) do you use to control pain during disbudding/dehorning? Please check all that apply:

Long-acting anti-inflammatory (more than 24h; e.g., meloxicam) – Short-acting anti-inflammatory (0 – 24h; eg. ketoprofen, flunixin meglumine) – Local anesthetic (ex. Lidocaine) – Sedative (ex: Diazepam, Xylazine) – No medication is used – Other, please specify

Section 10: Record Keeping

63. Do you keep a written record of the kids' birth, health and/or growth?

(a) Yes, electronically (b) Yes, on paper (c) No (move to question 65)

64. What information is written in this record? Please check all that apply:

Kid vigour at birth – Kid's identification – Identification of the kid's parents – Mortality – Diseases – Treatments administered – Vaccination – Weight – Height – Body condition score – Other, please specify

65. When do you take weight measures? Please check all that apply:

    Never – At birth – At weaning – Between birth and weaning (specify the number of times)

66. When do you take height measures? Please check all that apply:

    Never – At birth – At weaning – Between birth and weaning (specify the number of times)

67. When do you take body condition score (BCS) measures? Please check all that apply:

    Never – At birth – At weaning – Between birth and weaning (specify the number of times)

Thank you so much for your participation in this project!

You have 1 in 5 chances to win one of our $10 Tim Hortons gift cards! Please enter your contact information below to be entered in the draw (optional). You can be assured that your contact will be dissociated from the information collected in your survey in order to keep your confidentiality. All contact information will be discarded after the gift cards have been sent.

Contact information:

Name (optional) – Email address – Phone number

Would you be interested in participating in the second part of this project, which consists in a visit at the farm for more detailed information and measures? If yes, please check the following box and make sure you have entered your contact information above. Please note that there is no obligation on your part by checking this box, and you may decide to withdraw from this project at any time.

- ☐ Yes, I would like to be contacted for the second part of this project

Feel free to add any comments/suggestions about the project here:

_____

Thank you again for your contribution and all the best in your future projects!

APPENDIX 3 – Tables of descriptive results on goat kid rearing practices

Appendix Table A.3 - Prevalence of kid rearing practices (categorical variables)

Kidding management	N[1]	%[2]	95 % CL[3]
Number of kidding periods/year	101		
1	12	12	5-18
2	23	23	14-31
3	14	14	7-21
4	14	14	7-21
Spread out throughout the year (or > 4)	38	38	28-47
Kidding monitoring during the day, times/day	91		
0	4	4	0-9
1-4	47	52	41-62
> 4	40	44	34-54
Kidding monitoring at night, times/night	93		
0	32	34	25-44
1-2	40	43	33-53
> 2	21	23	14-31
Kidding monitoring method	102		
In person only	95	93	88-98
Use of video cameras	7	7	2-12
Time of the kid-dam separation[4]	104		
≥ 50 % removed immediately at birth	52	50	40-60
≥ 50 % removed before first suckling	25	24	16-32
≥ 50 % removed in first 24 hours	20	19	12-27
≥ 50 % removed between 24 and 48 hours	14	13	7-20
≥ 50 % left with dam until weaning	16	15	8-22
Kid drying method[4]	102		
Not dried	11	11	5-17
Left with dam to dry them	50	49	39-59
Abundant bedding in first hours after birth	43	42	32-52
Heat lamp	38	37	28-47
Heating carpet/floor	5	5	1-9
Clean towel	46	45	35-55
Hair drier	7	7	2-12
Other	4	4	0-8

Colostrum feeding	N[1]	%[2]	95 % CL[3]
Timing of first colostrum feeding	102		
Within 2 hours after birth	60	59	49-69
2 to 6 hours after birth	16	16	9-23
> 6 hours after birth	2	2	0-5
N/A; kids are left with the dam to drink the colostrum	24	24	15-32
Method of colostrum feeding	79		
Nipple bottle only	61	77	68-87
Nipple bottle + oesophageal tube	14	18	9-26
Oesophageal tube only	3	4	0-8
Other	1	1	0-4
Length of the colostral period	79		
First 24 hours	51	65	54-75
First 48 hours	20	25	16-35
First 72 hours or more	8	10	3-17
Colostrum source[1]	79		
Goat colostrum	44	56	44-67
Cow colostrum	17	22	12-31
Bovine colostrum replacer (lyophilized)	45	57	46-68
Use of frozen colostrum	79		
No, feed only fresh colostrum	42	53	42-64
Some frozen colostrum	20	25	16-35
All frozen colostrum	17	22	12-31
Thermized colostrum (heat treated at 56°C for 1 hour)	79		
	24	30	20-41
Yes	35	44	33-56
No	20	25	16-35
N/A (lyophilized colostrum)			
Pooled colostrum	78		
Yes	31	40	29-51
No	27	35	24-45
N/A (lyophilized colostrum)	20	26	16-36
Colostrum quality evaluation	79		
No	29	37	26-48
Sometimes	11	14	6-22
Yes	19	24	14-34
N/A (lyophilized colostrum)	20	25	16-35

Colostrum quality evaluation method[4]	31			
Visual observation	21	68		50-85
Colostrometer	6	19		5-34
Refractometer	9	29		12-46
Milk feeding	N[1]		%[2]	95 % CL[3]
Milk type	94			
Fresh goat milk	4		5	0-9
Pasteurized goat milk	3		3	0-7
Fresh cow milk	5		5	1-10
Dairy goat milk replacer	67		71	62-81
Dairy calf milk replacer	8		9	3-14
N/A; kids are left with the dam until weaning	7		7	2-13
Acidified milk	92			
Yes	24	26		17-35
No	68	74		65-83
Milk from goats with antibiotics	93			
Yes	10	11		4-17
No	83	89		83-96
Milk feeding method[4]	95			
Bucket with multiple nipples at the bottom	19	20		12-28
Bucket with multiple nipples at the top	28	29		20-39
Gutter	7	7		2-13
Single nipple bottle	24	25		16-34
Automatic milk feeder (AMF)	41	43		33-53
Number of kids per nipple (for bucket feeding)	48			
0-1 kid/nipple	32	67		53-80
> 1 kid/nipple	16	33		20-47
Number of kids per nipple (for AMF feeding)	41			
0-10 kid/nipple	33	80		68-93
> 10 kids/nipple	8	20		7-32
Number of milk meals/day (non-AMF systems)	53			
2 meals/day	30	57		43-70
3 meals/day	10	19		8-30
4 meals/day	2	4		0-9
Ad libitum	11	21		9-32
Milk bucket (or gutter) washing frequency	54			
Every time it is used	35	65		52-78
Every day	13	24		12-36
3 times/week or less	6	11		2-20

Automatic milk feeder washing frequency	41		
Every day	17	41	26-57
3 times/week	17	41	26-57
2 times/week or less	7	17	5-29
Solid and water feeding	**N[1]**	**%[2]**	**95 % CL[3]**
Time (age) of first concentrate availability	95		
1st week of life	24	25	16-34
2nd week	27	28	19-38
3rd week	24	25	16-34
4th week or older	20	21	13-29
Concentrate quantity allowance	95		
No concentrates are offered before weaning	3	3	0-7
Restricted amount	8	8	3-14
Ad libitum	84	88	82-95
Type of concentrates	90		
Commercial pelleted feed	71	79	70-87
Commercial textured feed	12	13	6-20
House mix of grains	7	8	2-13
Time (age) of first forage availability	85		
1st week of life	23	27	17-37
2nd week	26	31	21-41
3rd week	10	12	5-19
4th week	12	14	7-22
5th week or older	14	17	8-25
Time (age) of first water availability	87		
1st week of life	27	31	21-41
2nd week	21	24	15-33
3rd week	10	11	5-18
4th week	13	15	7-23
5th week or older	16	18	10-27
Health management	**N[1]**	**%[2]**	**95 % CL[3]**
Umbilical cord disinfection frequency	103		
Never	34	33	24-42
Occasionally (< 50 % time)	16	16	8-23
Often (> 50 % time)	12	12	5-18
Always	41	40	30-49

Umbilical cord disinfection timing	68		
< 2 hours after birth	56	82	73-92
< 2 hours after birth + 2nd time between 12-24 hrs	5	7	1-14
> 2 hours after birth	7	10	3-18
Selenium and vitamin E administered to dams during gestation and/or to kids	94		
Yes, to dams during gestation	10	11	4-17
Yes, to kids at birth	36	38	28-48
Yes, to both dams and kids	15	16	8-23
No	33	35	25-45
Vaccination of dams during gestation	98		
Yes	46	47	37-57
No	52	53	43-63
Vaccination of kids before weaning	99		
Yes	33	33	24-43
No	66	67	57-76
Add coccidiostats in concentrates	95		
Yes, for prevention	63	66	57-76
Only when necessary	9	9	3-15
No	23	24	15-33
Added medication to the milk	94		
No	40	43	32-53
Only when necessary	36	38	28-48
Yes, for prevention	18	19	11-27
Type of medication added to the milk (if used)	18		
Coccidiostatics	12	67	43-91
Antibiotics	4	22	1-43
Both of the above	2	11	0-27

Disbudding	N[1]	%[2]	95 % CL[3]
Time (age) of disbudding/dehorning	85		
In 1st week	13	15	7-23
In 2nd week	43	51	40-61
In 3rd week	17	20	11-29
In 4th week or more	9	11	4-17
Never	3	4	0-8
Pain control	92		
Use pain control	33	36	26-46
No use of pain control	59	64	54-74

Type of pain control[4] (if used)	92		
Long-acting anti-inflammatory (> 24h)	22	24	15-33
Short-acting anti-inflammatory (0-24h)	6	7	1-12
Local anesthetic	9	10	4-16
Sedative	4	4	0-9
Kid housing	**N[1]**	**%[2]**	**95 % CL[3]**
Possible contact with adult goats and/or sharing same air (same barn)	97		
Yes	34	35	25-45
No	63	65	55-45
Buck kid management[4]	102		
Eliminated or sold at birth	5	5	1-9
Raised < 2 weeks of age	58	57	47-67
Raised between 2 and 4 weeks of age	6	6	1-11
Raised between 4 weeks of age and weaning	9	9	3-14
Raised until after weaning	41	40	31-50
Grouping strategy[4]	98		
By age	70	71	62-81
By weight	51	52	42-62
By sex	46	47	37-57
All in 1 group	1	1	0-3
N/A; with dams until weaning	6	6	1-11
Number of kids per pen	89		
< 10 kids	27	30	21-40
10-15 kids	31	35	25-45
> 15 kids	31	35	25-45
Bedding addition frequency	94		
At least every day	30	32	22-42
Between every day and every 2 days	24	26	17-35
< Every 2 days (3,5 times/week)	26	28	18-37
When necessary	11	12	5-18
N/A; slatted floor	3	3	0-7
Pen cleaning frequency	96		
At least once a week (4 x/month)	33	34	25-44
Between every week and every month (1-4 times/month)	35	36	27-46
< Once a month	8	8	3-14
When all kids have been weaned	20	21	13-29

Weaning	N[1]	%[2]	95 % CL[3]
Weaning criteria	92		
Age only	25	27	18-36
Weight only	20	22	13-30
Concentrate consumption only	3	3	0-7
Age & weight	33	36	26-46
Age & concentrate consumption	2	2	0-5
Weight & concentrate consumption	1	1	0-3
Age, weight & concentrate consumption	8	9	3-15
Weaning age	68		
< 8 weeks	31	46	33-58
8-10 weeks	24	35	24-47
> 10 weeks	13	19	10-29
Weaning weight	62		
< 15 kg	29	47	34-60
15-18 kg	24	39	26-51
> 18 kg	9	15	5-24
Weaning method	97		
Abrupt (milk removed in one day)	36	37	27-47
Progressively, by skipping milk feedings	19	20	12-28
Progressively, by gradually reducing the milk quantity	18	19	11-26
Progressively, by diluting the milk with water	10	10	4-16
Other	14	14	7-22

Record keeping	N[1]	%[2]	95 % CL[3]
Milk recording	103		
No	89	86	80-93
Yes	14	14	7-20
Record keeping for kidding management	99		
Yes	74	75	66-83
No	25	25	17-34
Type of record	71		
Paper	55	77	68-87
Electronic	13	18	9-28
Both paper and electronic	3	4	0-9

Information recorded[4]	72		
Kid vigour at birth	13	18	9-27
Kid's identification	69	96	91-100
Identification of the kid's parents	67	93	87-99
Mortality	53	74	63-84
Diseases	23	32	21-43
Treatments	40	56	44-67
Vaccination	30	42	30-53
Weight	22	31	20-41
Height	2	3	0-7
Body condition score (BCS)	1	1	0-4
Other	10	14	6-22
Growth monitoring – weight[4] (measures taken and recorded)	92		
	25	27	18-36
At birth	11	12	5-19
Between birth and weaning	39	42	32-53
At weaning			

[1]Number of herds [2]Percentage of herds [3]95 % confidence limits
[4]Respondents could select more than one answer that applied to their situation, therefore the total prevalence (%) doesn't necessarily add up to 100 %.

Appendix Table A.4 - Prevalence of kid rearing practices (continuous variables)

Rearing sector	N[1]	Min[2]	P25[3]	Med[4]	P75[5]	Max[6]
Colostrum feeding						
Quantity fed in first feeding, mL	72	44	175	250	300	500
Quantity fed in first 12 hours of life, mL	69	89	450	600	754	1000
Milk feeding						
Milk replacer crude protein content (%)	60	19	22	22	22	26
Milk replacer fat (%)	56	17	22	23	25	28
Solid feeding						
Concentrate crude protein content (%)	72	14	18	20	22	27
Weaning						
Weaning age (weeks)	68	5	6	8	10	20
Concentrate consumption at weaning (g/day)	13	50	100	250	250	500
Length of the weaning period	60	1	5	7	10	21

[1]Number of herds [2]Minimum [3]25th percentile [4]Median [5]75th percentile [6]Maximum