Graduate Student Literature Review: Current recommendations and scientific knowledge on dairy goat kid rearing practices in intensive production systems in Canada, the United States, and France*

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ABSTRACT

Dairy goat kid rearing is the foundation of future milk production, yet little is known on this topic. References available to producers are limited, making it more difficult for dairy goat farms to reach their full production potential. This review paper aimed to identify the current recommendations on dairy goat kid rearing practices for intensive production systems and to assess whether the different recommendations were based on scientific literature. 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, the 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. Gaps in the literature were identified in all areas except for disbudding. More research on the topic of goat kid raising practices would be beneficial to refine and validate current recommendations.

Key words: dairy goat kid, rearing practice, management, recommendation

INTRODUCTION

Goat milk has been produced around the world since the domestication of goats around 11,000 yr ago (Hirst, 2019) for both self-consumption and commercial production in intensive and extensive systems. This industry has been growing worldwide since the 1960s and has experienced drastic increases in the past few decades (i.e., 22% increase in global dairy goat population between 2007 and 2017, and 62% increase in goat milk production between 1993 and 2013; Miller and Lu, 2019). This recent growth is due to the expanding demand for goat milk due to its nutritional merits (e.g., lower lactose content, higher digestibility with smaller fat globule size, higher vitamin A content; Turkmen, 2017) and other goat products (Lu and Miller, 2019). Although the largest proportion of the dairy goat population is found in Asia and Africa, most commercial intensive dairy goat producers are found in Europe and North America (Miller and Lu, 2019).

In intensive production systems, dairy goat kid rearing is the foundation of future herd productivity. Maximizing the growth and health of doelings in the preweaning period is important to maximize their future growth and performance. Another important period in the kid’s early life is weaning (i.e., when the kid transitions from a liquid to a solid diet), which can have negative effects such as a decrease in growth rate (Gökdal et al., 2017). Therefore, it is critical to manage the weaning period in a way that will minimize stress to diminish the negative effects on the kid’s future growth.

The objective of this review paper was to identify the current dairy goat kid rearing practice recommendations in Canadian intensive production systems and to assess whether the different recommendations were based on or validated by goat-specific scientific literature. Although our primary focus was to assess recommendations from Canada, we chose to include those from France and the United States as well due to their similarities with the Canadian dairy goat production systems. Recommendations from Canada, France, and the United States were collected, including Canadian national and provincial guidelines from the 2 main producing provinces (Quebec and Ontario), French national guidelines, and guidelines from the 2 main producing US states (California and Wisconsin; see selected references in Supplemental Tables S1 and S2, https://escholarship.mcgill.ca/concern/articles/vt150p60w?locale=en). The kid rearing practices in-
cluded were kidding management, colostrum management, liquid and solid feeding, health management, disbudding, housing, weaning, and growth monitoring. Following this, we conducted an independent search of scientific papers published between 1984 and 2020 on the different aspects of kid rearing using WorldCat (worldcat.org) to determine which aspects of kid rearing required additional research. Specific keywords used in the search included “dairy,” “goat,” “kid,” “rearing,” “management,” “separation from dam,” “kidding area,” “kidding monitoring,” “navel disinfection,” “umbilical cord,” “drying,” “colostrum,” “milk,” “feed,” “concentrates,” “hay,” “forages,” “water,” “feeding method,” “weaning,” “housing,” “kid environment,” “vaccination,” “selenium,” “vitamin E,” “coccidiosis,” “disbudding,” “pain control,” “pain management,” “growth,” “growth curve,” “monitoring,” and “record keeping.”

We hypothesized that the recommendations would be general and variable across sources due to a limited amount of accessible goat-specific published scientific knowledge. A lack of available scientific publications does not mean that recommendations are unsuitable or incorrect; however, identifying knowledge gaps on key areas of dairy goat kid rearing practices will support the direction of future research endeavors.

Each section of this review follows the same structure: the current recommendations are introduced and then discussed based on available goat-specific scientific literature. Supplemental Tables S1 and S2 summarize the current recommendations from the selected regions.

### KIDDING MANAGEMENT

The environment in which kids are delivered and the early care of kids play an important role in their survival and health. The kidding area should facilitate the kidding process and prevent infection or disease transmission to newborn kids. Recommendations agree that the kidding area should be clean and dry with abundant bedding and should be disinfected before kidding to prevent any disease or infection transmission to the kid and goat at birth. It is also recommended that the area be well lit and spacious enough to minimize stress and overcrowding of the goats. No goat-specific scientific literature was available on the effect of the kidding area on kidding management performance to support these recommendations.

Frequent kidding monitoring is recommended to increase attention on the goats in case of delivery complications and to remove kids from the dams soon after birth for disease prevention, if necessary. The use of baby monitors and barn-cams can facilitate the monitoring of births at all times. No goat-specific scientific literature was available on this topic.

Removing kids from the dams as soon as possible after birth is recommended to prevent the transmission of contagious diseases, such as caprine arthritis encephalitis (CAE) and Johne’s diseases from infected goats. Caprine arthritis encephalitis is highly prevalent on dairy goat farms around the world, especially in more developed countries such as Canada (77%), France (77%), and the United States (81%; Adams et al., 1984). The prevalence of CAE likely remains high, but no recent figures are available to our knowledge. This multisystemic viral disease has significant economic repercussions, such as decreased growth rate for seropositive kids and decreased milk yield for seropositive does (Greenwood, 1995). Caprine arthritis encephalitis is contagious and persistent, and it can be transmitted to kids through either thecolostrum and milk of infected does (the most important transmission route) or direct contact with saliva or mucus of infected does (Reina et al., 2009). This evidence appears to support the recommendation of immediate removal of kids from does and kidding area. However, the effect of kid removal on CAE prevention has not yet been investigated. Furthermore, the success of kid removal before colostrum intake was found to be overestimated by dairy goat farmers in New Zealand compared with the actual kid removal success rate (Zobel et al., 2020). It is also important to note that the recommendation of kid–dam separation does not apply to CAE-free herds. In fact, some herds are beginning to promote the young staying with the dam, given negative consumer perception on kid–dam separation and the potential benefits of keeping them together. Johne’s disease, also known as paratuberculosis, is an infectious chronic inflammatory bowel disease caused by Mycobacterium avium ssp. paratuberculosis (MAP). This disease is highly prevalent in goat herds in Canada (83% of dairy goat herds in Ontario; Bauman et al., 2016), France (63% of dairy goat herds in France; Mercier et al., 2010), and the United States (55% of Missouri Boer goat herds; Pithua and Kollias, 2012) and was found to reduce weight gain in dairy goat kids (Malone et al., 2013). Young kids can be infected either across the placenta of infected does (Manning et al., 2003) or by consuming MAP-contaminated colostrum, milk, or other feed. In fact, MAP is most commonly shed in the manure of infected goats (Windsor, 2015) and can be easily transmitted to goat kids, hence why it is recommended to remove kids from the dams as soon as possible after birth. To our knowledge, no published study evaluated the efficacy of the recommended practice of early removal on reducing CAE and MAP prevalence and supporting kid management performance.

Last, it is recommended to clean and dry kids as soon as possible after birth with a clean towel or hair dryer to
thoroughly fluff the kid’s hair and prevent it from freezing. Afterward, the recommendation states that kids should be kept in a warm location (ambient temperature between 10 and 20°C, depending on references). With support from the literature, it is also recommended, in most instances, to provide ample amounts of clean, dry bedding. The provision of bedding, which can improve the thermal insulation provided to kids, tends to improve lying times and weight gain compared with barren floor surfaces (i.e., metal mesh flooring; Sutherland et al., 2019). Recommendations state that heat lamps can also be added if necessary, and although they were not found to improve kid growth performances, kids preferred lying in the warm area created by such lamps (Sutherland et al., 2019). No published goat-specific scientific literature looked at the effect of drying kids (Sutherland et al., 2019). Recommendations state that heat lamps can also be added if necessary, and although they were not found to improve kid growth performances, kids preferred lying in the warm area created by such lamps (Sutherland et al., 2019). No published goat-specific scientific literature looked at the effect of drying kids and keeping warm temperatures in the nursery on kidding management performance.

**COLOSTRUM MANAGEMENT**

The transfer of maternal antibodies through colostrum, also called passive transfer of immunity, is crucial to protect the kids against infectious diseases until they develop their own antibodies. Recommendations on when to feed the first colostrum vary from immediately after birth to up to 6 h after birth, but as a general rule, it is recommended to feed colostrum as early as possible after birth. The time of first colostrum feeding after birth is critical to maximize the IgG absorption by the kid and avoid a failure of passive transfer (the scientific literature on colostrum management practices is summarized in Supplemental Table S3, https://escholarship.mcgill.ca/concern/articles/vt150p60w?locale=en) because the permeability of the intestines to absorb IgG declines quickly after birth. However, no scientific literature was found on the exact time of intestinal gut closure for goat kids specifically.

The source of colostrum also has an important effect on the kid’s health and growth. Different sources of colostrum can be fed to kids, including commercial colostrum replacer (lyophilized bovine colostrum), cow colostrum, or heat-treated goat colostrum. Colostrum taken from the herd does can be a source of protective antibodies against diseases that the kids could contract in early life (and against which does can be vaccinated); however, it can also harbor pathogens such as the CAE virus and MAP if the does are infected. Thus, before feeding colostrum from the herd does, it is recommended to heat treat goat colostrum following specific protocols (56°C for 1 h) to kill pathogens without decreasing the colostrum IgG and protein quality. Three studies evaluating the effect of feeding different sources of colostrum did not find differences in the IgG transfer measured in the kids’ blood serum as long as the same quantity of IgG was provided (Supplemental Table S3). However, 2 other studies have found an effect of the colostrum source: one study found that lyophilized colostrum (prepared manually from a paste concentrate) was absorbed more efficiently than frozen colostrum, though the IgG concentration of the lyophilized colostrum was higher and could explain this difference in absorption efficiency (Castro et al., 2005; Supplemental Table S3). Another study found that serum IgG was higher in kids fed colostrum compared with kids fed a colostrum substitute, even when fed the same quantity per kilogram of BW (Constant et al., 1994; Supplemental Table S3). Heat treating colostrum was not found to affect the growth and health of kids; however, it impaired some of their immunological functions, such as serum IgG concentrations, and delayed type hypersensitivity response, thus suggesting an alteration to the cellular immune system (Fernández et al., 2006; Supplemental Table S3).

The quality of the colostrum, in terms of concentration of IgG, is also very important to the success of passive transfer of immunity. It is strongly recommended to evaluate colostrum quality before feeding colostrum to a kid, either by visual observation or with the use of a colostrometer or a Brix refractometer. The recommended minimum concentration for a good-quality colostrum is 50 g of IgG/L. The concentration of IgG in 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 (Supplemental Table S3). In other words, the efficacy of IgG absorption was increased when colostrum with the higher IgG concentration was fed regardless of the quantity. Different colostrum quality evaluation methods have been tested for goat colostrum. The color method, validated by Argüello et al. (2005), uses a chroma value to predict the IgG concentration in goat colostrum. Farmers can use plastic color fans to match different colostrum colors to a specific Chroma value with a corresponding IgG concentration. However, its use has not yet been validated on the farm, and careful consideration should be given when comparing results from a colorimeter and those determined by the human eye. The use of a Brix refractometer has been validated by Quigley et al. (2013) to evaluate the quality of bovine colostrum. The refractometer indirectly indicates the concentration of IgG in colostrum from a refractive index measurement, wherein 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. This study established its cut-off value using ELISA, whereas Quigley et al. (2013) used the radial immunodiffusion method; therefore, the 2 values may not be comparable. Limited literature is available on the threshold IgG concentration used to define good-quality goat colostrum. To feed a good-quality goat colostrum, the dams should be milked as soon as possible after delivery because the concentration of IgG in colostrum drops quickly after delivery (significantly lower in the second hour after parturition, and further decreased at 4 and 10 h after parturition; Moreno-Indias et al., 2012). Another study reported a decrease in the IgG concentration in milk at 24 h compared with the concentrations at 3 and 12 h after parturition (Yang et al., 2009).

The recommended quantity of colostrum to offer in the first 24 h of life varies between 150 and 200 mL/kg of kid BW, in 2 to 4 meals, with a minimum of 50 to 100 mL/kg of BW in the first meal. In the case of tube feeding (if the kid refuses to drink after repeated attempts 3–4 h apart), it is not recommended to give more than 113 g (110 mL) at a time. Although a few studies investigated the effect of different quantities of colostrum provided to kids on passive transfer, quantities were always studied in combination with other colostrum aspects (e.g., feeding method, time of first feeding; Supplemental Table S3), likely in an attempt to account for aspects such as abomasal capacity in newborn kids. No study looked at the independent effect of colostrum quantity to be able to support the current recommendations.

In terms of duration for the colostrum feeding period, different recommendations exist, varying between 24 h and 3 d, but research showed that allowing kids to drink colostrum for 24 h was sufficient to achieve an adequate serum IgG concentration and passive transfer (Supplemental Table S3). Feeding colostrum for 1 d as opposed to 2 d also reduced the handling time and resulted in higher blood serum concentration when an equal quantity of IgG was used (Castro et al., 2005). However, it is important to note that colostrum provides kids not only with antibodies but also with growth hormones, fat, and other nutrients, which may justify feeding it for more than 24 h in some cases.

Finally, no recommendation states the importance of measuring passive transfer to the kids or gives any guideline on the minimum quantity of IgG to avoid failure of passive transfer. Instead, passive transfer is the main outcome of good colostrum management practices. Studies showed it is possible to assess the quality of passive transfer to the kids by measuring the IgG level in their blood serum at 24 h of age, when it was found to be at its peak (Rodriguez et al., 2009). The IgG blood serum concentration is a good indicator of the amount of IgG intake by the kid and is used in most studies evaluating colostrum management practices (Supplemental Table S3). Mellado et al. (1998) suggested that a minimum of 800 mg/dL serum IgG at 1 d of age should be achieved to increase survival risk in extensively managed goat herds, whereas O’Brien and Sherman (1993) suggested a minimum of 1,200 mg/dL serum IgG between 2 and 4 d of age to help ensure good health and survival to weaning in intensively managed goat herds. However, these studies measured the blood serum concentration at different ages and used different methodologies, with the second study using a very small sample size and no survival analysis. As such, the results should be interpreted carefully, and more research should be conducted on goat kid serum IgG. It is also possible to determine the passive transfer status of a kid using a refractometer to measure the Brix level in the kid’s blood serum, where Brix measurements lower than 8.6% for 1-d-old kids would indicate a failure of passive transfer (Batmaz et al., 2019). In addition to improving the health and survival of kids, passive transfer of immunity has been shown to have a direct effect 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/d and a 0.185-kg higher weaning weight at 30 d. However, the number of animals used in this study and the inclusion of outliers may have affected the results and conclusions of this study. Moreover, the increase in weaning weight could be considered negligible for a commercial dairy goat operation.

**KID FEEDING**

**Milk**

It is recommended to feed milk at frequent and constant intervals, ideally more than twice a day, or ad libitum to allow the kids to feed at will and in smaller quantities at once. Small, frequent feedings are recommended to increase digestibility and decrease digestive disturbances of kids. No published literature is available to support these recommendations. Recommended milk quantities vary between 0.5 and 1 L in the first week of age, followed by 1.5 L in the second week of age, and 1.8 to 2 L in the following weeks up until weaning. No goat-specific scientific literature was available on this topic.
Different milk feeding methods exist; however, nipple feeding systems are recommended over trough feeding systems as kids must lift their head up to suckle, which closes their esophageal groove, allowing milk to bypass the rumen, and avoids gastric problems. Automatic milk feeders are recommended for large numbers of kids when feeding ad libitum milk; otherwise, multiple-nipple milk bars are an alternative for restricted milk feeding. In terms of competition at the milk feeder, it is recommended to allow at least 1 nipple for every 15 to 20 kids when feeding with automatic milk feeders, or at least 1 nipple per kid when milk is fed in restricted amounts using a multiple-nipple milk bar. A minimum feeder space of 10 to 15 cm/kid should be provided when feeding milk in a trough. No published literature evaluated the effect of different feeding methods, milk feeding space, or number of nipples per kid on the kids’ performance to support these recommendations.

Good milk feeding hygiene is critical to maintaining good kid health. It is recommended to clean and sanitize all milk feeding material (e.g., milk preparation utensils, milk buckets) after each use. In the case of ad libitum feeding, it is recommended to renew the milk regularly to prevent bacterial propagation in the milk, and to clean the automatic feeding equipment (i.e., mixing bowl and nipple supports) daily, whereas tubes can be washed weekly. To our knowledge, no goat-specific papers have been published on this topic.

Lastly, to safely provide kids with all the nutrients they need, the milk source is also important to consider. Different recommendations exist for artificially raised kids, including goat milk replacer, pasteurized goat milk, or cow’s milk. All options represent substitutes for raw goat milk, as it is not considered a safe option for kids (i.e., high risk of CAE infection). If feeding a milk replacer, recommendations state a content of 16 to 24% fat and 20 to 28% protein, ideally whey or milk based as opposed to soybean based. Milk replacers should be carefully prepared following the mixing instructions. Compared with kids fed lamb milk replacer, kids fed goat milk showed higher nutrient digestibility, metabolizable energy, and fattening, whereas both groups showed similar growth (Sanz Sampelayo et al., 1990). These results suggest that goat kids made suitable use of the lamb milk replacer and that it could be used as a replacement for goat milk. Another study evaluated the effect of adding whey to the water used for milk replacer preparation to enhance the nutritional quality of milk replacer. Goat kids fed cow milk replacer mixed in water with 35% whey had a daily weight gain similar to that of 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. The latter whey concentration caused severe diarrhea and resulted in lower weight gains (Galina et al., 1995). Finally, acidifying fresh milk or milk replacer to leave at ambient temperature for ad libitum consumption is possible and was considered a suitable option, but mostly during the cold season when kids’ water intake was lower (Andrighetto et al., 1994). However, kids in this study were not provided with water, likely affecting their intake of milk in the warm and cold seasons and affecting the results and conclusions of the study.

**Water**

To facilitate the transition from a liquid diet to a solid diet at weaning, it is recommended that kids have access to clean, lukewarm water at all times, ideally as early as 1 to 2 wk of age. Although this corresponds to what can be considered a most basic need for all species, no scientific literature is available on the effect of water intake on goat kids’ performance.

**Concentrates**

Concentrate consumption before weaning is important to facilitate the transition from milk at weaning. Recommendations on concentrate availability to kids vary between 1 and 3 wk of age; however, the general rule is to offer it as early as possible to stimulate early consumption. It is recommended to offer a good-quality (18–20% CP) and highly palatable kid starter ad libitum or at least twice a day. The starter should be changed frequently to stimulate consumption. 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 kids were fed ad libitum concentrates from 1 to 2 wk of age (Greenwood, 1993). In addition, feeding pelleted feed alone, as opposed to pellets mixed with whole or rolled cereal grains, was shown to increase the weight gain and feed conversion ratio of goat kids fed ad libitum concentrates (Hadjipanayiotou, 1990). The recommended minimum quantity that kids should consume before weaning is 200 g/d to ensure a good transition to a solid diet. However, one recent study investigated the effect of weaning strategies on concentrate intake and found that kids start eating significant amounts (100 g/d or more) of concentrates only once the milk weaning process starts (Zobel et al., 2020). Last, the recommended feeder space when feeding multiple meals per day (restricted feeding system) is 15 to 20 cm/ head, or 3 to 5 cm/ head when concentrates are fed ad libitum. However, no published literature is available to justify this recommendation.
Forages

Forage consumption is necessary to promote rumen development and ensure it is functioning well at the time of weaning. 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 wk of age) and fed ad libitum or 3 times a day to encourage consumption. The hay should be leafy, harvested at a young stage (early bloom), and contain a maximum of 34% ADF to increase digestibility and palatability. However, it is recommended to avoid alfalfa hay before the age of 4 mo to reduce risks of bloating. No scientific literature was found on the effects of feeding forages to kids before weaning.

HEALTH MANAGEMENT

The first intervention recommended is to dip or spray the umbilical cord of kids with a 5 to 7% iodine tincture disinf ecting solution as soon as possible after birth to prevent navel infections. The application can be repeated at 24 h if signs of redness are present. If the navel cord is too long, it is recommended to cut it to 8 to 10 cm in length before disinf ecting it to prevent it from dragging on the bedding and collecting bacteria. No goat-specific scientific literature was available on this topic.

It is also recommended to supplement kids with selenium and vitamin E at birth, either by injection (most common) or orally by complementing feeds for the prevention of white muscle disease. 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/kg of BW at birth was sufficient to decrease the mortality rate of kids in the first 2 mo of age compared with the control treatment (60% vs. 24% mortality, respectively; \( P < 0.01 \)). Injecting double the dose of selenium and vitamin E showed results similar to the single dosage (24% vs. 20% mortality, respectively; \( P > 0.05 \)).

Vaccination of dams and kids is another important health management practice 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 wk of gestation so that immunity is transferred to the kids through the colostrum at birth. Kids should then be vaccinated between 3 and 6 wk of age and again 2 to 4 wk later. If the dams were not vaccinated before kidding, it is recommended to vaccinate the kids for the first time at 1 wk of age to ensure that they acquire the necessary immunity.

To our knowledge, no study evaluated type or age at vaccination on kid’s health management performance.

Finally, specific recommendations are available to manage coccidiosis, which is the most common cause of diarrhea in goat kids (Luginbuhl and Anderson, 2015). Coccidiosis can lead to decreased weight gains and occasionally death in kids, thus posing important economic concerns (Foreyt, 1990; Ruiz et al., 2012). To control for coccidiosis in goat kids, it is recommended to add an anticoccidial drug (coccidiostat; e.g., decoquinate) to the kids’ feed starting at 15 to 30 d of age, depending on the recommendation source. Feeding 1 mg of decoquinate/kg of kid BW per day for 30 d was found to be efficient at preventing coccidiosis in dairy goat kids around weaning (Mage et al., 1995).

DISBuddING

Disbudding kids, although not performed on every farm, is a common management practice done on commercial dairy goat farms to avoid injuries to other goats in the herd and handlers and to minimize risks of goats getting stuck in fences or between pen partitions. However, disbudding is both stressful and painful for the kids (Hempstead et al., 2017) and should be controlled to minimize pain, accidents, and complications. Disbudding-related injuries were found to be the second highest cause of mortality on New Zealand dairy goat farms, representing 17% of mortality cases from birth to weaning (Todd et al., 2019). It is recommended to disbud kids at a young age, between 3 and 15 d of age, before the horn buds grow too large. No published literature examined the effect of disbudding age on goat kid performance.

The recommended and most widely used technique for disbudding is heat cautery (Hempstead et al., 2017). Cautery disbudding can be performed with an electric or gas hot iron tool with a tip diameter of 19 to 25 mm (Smith and Sherman, 2009). The hot iron tool is held on the horn buds for cycles of 2 to 3 s each until a copper ring of cauterized tissue is formed, and the horn buds can be removed (Alvarez et al., 2019). Removal of the horn buds was found to reduce the risk of infection (Matthews and Dustan, 2019) and prevent horn regrowth (Hempstead et al., 2018c). This method was shown to induce an acute cortisol increase for 2 to 3 h after disbudding (Alvarez and Gutiérrez, 2010) as well as significant stress- and pain-related behavior responses (Alvarez et al., 2009; Hempstead et al., 2017). Additionally, cautery disbudding causes tissue damage in goat kids, creating large, open wounds with scabs evident 6 wk after the procedure (Hempstead et al., 2018a). Wounds usually take between 35 and...
63 d to re-epithelialize and remain painful until then (Alvarez et al., 2019). Cautery disbudding was also associated with a greater risk of skull or brain injuries than alternative methods if not performed correctly by a trained person (Hempstead et al., 2018e). In light of these welfare concerns, alternative methods to disbudding have been evaluated, including caustic pastes, cryosurgery (liquid nitrogen), and clove oil (Hempstead et al., 2018a). Among alternative methods of disbudding, caustic pastes (i.e., sodium, calcium, or potassium hydroxide pastes) can be applied around the horn buds to chemically burn them. However, this technique is not recommended for kids as it can potentially burn other body parts due to contact with the paste and can lead to blindness if contact occurs with the eyes. It was also found that kids disbudded with caustic paste had more persistent and acute pain sensitivity (Hempstead et al., 2018b,e) and showed a higher serum cortisol concentration 1 h after disbudding compared with cautery-disbudded kids (Hempstead et al., 2018a). Caustic pastes also cause red, open, and raw wounds that generate large eschars that remain apparent for up to 6 wk after its use (Hempstead et al., 2018a).

Although different disbudding methods have varying implications on pain, it is possible to alleviate pain with effective management. Recommendations suggest providing kids with appropriate pain control, as prescribed by a veterinarian, to minimize pain associated with disbudding. Different options have been shown to effectively alleviate pain, including the use of a local (e.g., lidocaine) or general (e.g., isoflurane gas) anesthetic, sedatives (e.g., dexametomidine) to manage intraoperative pain, or long-acting anti-inflammatory drugs (e.g., meloxicam) for postoperative pain management. The recommendation does not specify which option or combination to use as best management practice. Goat kids are very sensitive to local anesthesia and toxicity can occur. One study investigated the effect of local administration of 0.5 mL of 1% lidocaine hydrochloride around each of the 2 cornual branches of the lacrimal and infratrochlear nerves of both horn buds and found it to be safe and effective to produce a cornual nerve block in goat kids (Venkatachalam et al., 2018). However, in 2 other studies, the injection of 1 and 2 mL of 2% lidocaine at the cornual branches of the lacrimal and infratrochlear nerves of each horn bud was not sufficient to prevent a short-term increase in cortisol concentration during and after disbudding and did not decrease the expression of stress-related behaviors (e.g., vocalizations) in kids. This indicated that the lidocaine nerve block did not reduce pain or stress (Alvarez et al., 2009, 2015). Because the efficacy of local anesthesia is uncertain, a better option could be to perform general anesthesia with the use of isoflurane gas, which was proven to reduce pain during cautery disbudding in goat kids (Hempstead et al., 2018d). Alternatively, sedation by intramuscular injection of dexametomidine hydrochloride 15 min before disbudding is another pain control method that was shown to decrease kids’ cortisol levels and pain-related behaviors after disbudding (Nfor et al., 2016). Finally, the injection of meloxicam to kids once daily (0.5 mg/kg of BW) for 3 d 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), and thus can serve as an efficient postoperative pain control method.

**KID HOUSING**

It is recommended to house kids in a dry, warm (12–18°C), and draft-free environment to maximize their health and comfort. In addition, it is recommended to clean, disinfect, and leave the nursery vacant between the kidding seasons to minimize contamination between different groups. No goat-specific literature backs this recommendation.

It is also recommended to provide kids with generous amounts of clean and dry bedding (e.g., wood shavings, straw) to promote comfort and to monitor bedding moisture and depth daily. Infrequently changed bedding can increase the risk of disease and ammonia buildup, which can lead to respiratory problems. No published literature has investigated the effect of bedding provision and management on goat kid performance.

Kids can be housed in groups of 15 to 25 kids of similar age and weight to facilitate management. The recommendation specifies that groups should be as homogeneous as possible to avoid competition at feeding and recommends reallocation based on weight as often as possible to keep the homogeneity. Interestingly, the potential risks of disease spreading, which may be increased with frequent regrouping, are not mentioned in any of the recommendations or literature. Smaller groups are recommended in the first 2 wk of life to limit competition and ensure proper observation of the kids. Goetsch et al. (2001) compared the effect of housing kids in individual pens, paired pens, or group pens on pre- and postweaning growth. This study found no effect of group size on ADG in the 8-wk preweaning phase or up to 12 wk of age (end of experiment). Kids were fed ad libitum milk and had access to ad libitum concentrates from 2 to 12 wk of age. The results from this study suggest that kids should perform the same in group and individual pens when provided with sufficient resources (i.e., ad libitum feeding) to limit
competition at feeding. The recommended floor space for unweaned kids varies between 0.25 and 0.5 m²/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 with limited competition. No published literature examined the link between floor space and goat kid performance.

Finally, it is recommended to keep the nursery room separate and far from the adult goats to avoid contact and air exchanges that could contribute to the transmission of diseases (e.g., CAE). No goat-specific literature supports this recommendation.

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. Weaning also involves concurrent changes in endocrine and metabolic functions, such as decreases in plasma glucose, AA, and insulin levels (Magistrelli et al., 2007; Atef Aufy et al., 2009). However, these negative effects can be minimized with appropriate weaning protocols. Recommended kid weaning criteria are variable and based on weight (i.e., 14–15 kg, or when kids have reached 2–2.5 times their birth weight), age (i.e., 6–8 wk of age), or solid feed consumption (i.e., daily consumption of 115–200 g of concentrates or 30–500 g of solid feed, including concentrates and hay). Kids weaned later (at 15 kg) as opposed to earlier (at 10 kg) were found to grow faster and reached their optimal reproductive weight (30 kg) 30 d before kids weaned earlier (Palma and Galina, 1995). Another study found lower weight gains and higher mortality postweaning in kids weaned early (completely weaned by d 36) compared with kids weaned at 60 d of age (Luparia et al., 2009). Kid growth performance up to breeding was similar in kids weaned at 3 times their birth weight compared with kids weaned at 4 times their birth weight (Gökdağ et al., 2017). No literature was available on the optimal solid feed consumption for a successful weaning.

Regarding weaning methods, it is most often recommended to wean kids progressively, over a 5- to 7-d period, to provide kids with sufficient time to transition to solid feed while still retaining limited access to milk. Recommendations state that this can be done by decreasing the milk quantity or the number of meals per day over the transition period but not by modifying the milk concentration through water dilution. However, in the case of automatic milk feeding systems, recommendations favor abrupt weaning as the preferred method. Magistrelli et al. (2013) evaluated the effects of progressive weaning (achieved by reducing the milk quantity over 17 d, with 1 L/d fed in the last 10 d and weaning completed by 48 d of age) compared with unweaned kids of the same age. The authors found no difference between the 2 groups in growth performance, abnormal behaviors, or other physiological stress indicators (e.g., plasma haptoglobin, ceruloplasmin), suggesting that the weaning method was suitable to minimize stress. However, the study used only a small number of male Saanen kids. Very recent data from Zobel et al. (2020) showed no difference between weaning 3-mo-old kids either abruptly or gradually by diluting milk or reducing the milk quantity over 6 d, on feed intake and behavior of kids. However, an important factor was likely the weaning age of the kids (12 wk old), which may indicate that kids were ready to be weaned by that time and the weaning method had a lesser effect on their performance.

GROWTH MONITORING

The weight and growth of dairy goat kids are good indicators of the kids’ overall performance and were found to be variable between and within farms (Deeming et al., 2016). It is recommended to closely monitor the kids’ growth by weighing them at least at birth and weaning and ideally sometime in between as well. Monitoring the growth of doe kids at specific times (e.g., birth, 30 d of age, 60 d of age) should help to better select replacement does and maximize their future performance. In a survey study on Ontario dairy goat farms (Oudshoorn et al., 2016), poor growth was indicated as the second most common reason for doeling voluntary culling (25.8%) after reproduction (29%), illustrating farmers’ perception of how important doe growth is to the productivity of the dairy goat herd. Recommendations state that the optimal birth weight of kids should lie somewhere between 3 and 5 kg and that kids lighter than 2.8 or 3 kg at birth should not be kept in the herd because their growth will be too uncertain. Kid birth weight was found to affect survival rates (Perez-Razo et al., 1998; Chauhan et al., 2019). Kids with low birth weight (<2.8 kg) or kids from litters of 3 or more exhibited lower serum IgG levels during the first 5 d of life than heavier kids or kids from litters of 1 to 2, demonstrating a greater susceptibility to infection ($P < 0.05$; Castro et al., 2009).

The recommended target weight for goat kids at 30 d of age is around 10 kg, with an ADG of 200 g/d, and the target weight at 60 d of age is around 16 kg, or the equivalent of 20% of the goat’s adult BW. This recommendation is not confirmed by any published goat-specific literature.
CONCLUSIONS

This review paper describes the current recommendations on kid rearing practices, from birth to weaning inclusively, in Canada, France, and the United States and the scientific literature available for dairy goat farms under intensive production systems. This study identified some differences in recommendations between the selected references despite the similarities between the countries’ intensive production systems. The current recommendations in those regions are mostly tailored to suit the main breeds their production systems use (i.e., Alpine, Saanen); hence, there is a need for research to determine whether recommended practices should vary across breeds. This study also identified multiple areas of goat rearing where gaps in the literature exist. Even in areas for which published references are available, these papers are generally few in number such that with the exception of disbudding, all areas can be considered as lacking robust data to support current recommendations. This lack of scientific literature does not mean those recommendations are unsuitable, but it does highlight a need for more research to be conducted with the goal of refining and validating current recommendations using data sourced from goat kid-specific literature.

ACKNOWLEDGMENTS

The authors acknowledge the funding support of the Natural Sciences and Engineering Research Council of Canada through the Canada Graduate Scholarship–Master’s program. The authors also thank Roger Cue for the revision of early versions of the manuscript and Véronique Boyer for editing the manuscript (McGill University, Sainte-Anne-de-Bellevue, QC, Canada). The authors have not stated any conflicts of interest.

REFERENCES


Bélanger-Naud and Vasseur: LITERATURE REVIEW: RAISING YOUR KIDS THE RIGHT WAY


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