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A survey of dairy goat kid-rearing practices on Canadian farms and their associations with self-reported farm performance

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ABSTRACT

Although future production of dairy goats is influenced by kid-rearing practices, little is known regarding which practices maximize kid growth, welfare, and future production success. The objectives of this survey study were to (1) identify common rearing practices of Canadian commercial dairy goat farms and evaluate their associations with 6 farm performance indicators and (2) determine if farms could be grouped by management style on the basis of the 6 performance indicators and compare rearing practices common across the different groups. A survey was sent by post or electronic media to reach dairy goat producers across Canada. The questionnaire contained 70 questions on the following areas of kid rearing: kidding management, care of newborn, colostrum management, milk and solid feeding in the preweaning period, health management, disbudding, housing conditions, weaning strategies, record keeping and growth monitoring, and farm performance data. Performance indicators, calculated on self-reported data, were 305-d milk production, preweaning mortality rate, diarrhea and respiratory disease prevalence, average daily gain from birth to weaning, herd milk production, and replacement rate. A total of 175 questionnaires were returned. After applying inclusion criteria, including herd size (≥40 goats) and completeness of surveys, 104 respondents from Ontario (n = 72, 69%), Québec (n = 23, 22%), and the Western provinces (n = 9, 9%) were retained for analysis, representing 29% of all Canadian producers. 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. Colostrum and milk feeding management were found to be associated with all performance indicators except for kid respiratory disease prevalence, with timing of colostrum delivery and feeding method accounting for most the associations within each of the 2 areas. Replacement rate was mostly affected by whether or not kids were reared with their dam. Herds surveyed in the study could successfully be divided into 3 distinct groups (production-focused, longevity-focused, and low performance), representing different management styles on the basis of farm self-reported performance levels. Rearing practices found to be associated with higher farm performance could be targeted by advisory services to help improve management practices on Canadian dairy goat farms.

Key words: dairy goat kid, rearing practice, performance indicator, management

INTRODUCTION

The dairy goat industry has increased globally in the last half century, with a 22% increase between 2007 and 2017 alone, with most intensive commercial activity found in Europe and North America (Lu and Miller, 2019). In Canada alone, the dairy goat sector has increased in production by 78% in just over a decade, standing at 357 producers in 2018 and over 63 million liters of milk produced annually (Canadian Dairy Information Centre, 2019). As the industry grows, recommendations on best practices, particularly for crucial periods in the goat's life, becomes more important as a resource for dairy goat producers. For instance, the future growth of a dairy goat kid and its performance in the productive herd is influenced by the kid's performance during the preweaning period (Morand-Fehr et al., 2002), making the management of kids during this period critical for future success. Additionally, the preweaning and weaning periods are the periods where the

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risk of mortality is the highest in goat farms (Chauhan et al., 2019; Todd et al., 2019), resulting in an even greater importance placed on preweaning and weaning management to maximize the herd productivity. Hindering the optimization of dairy goat kid-rearing practices, however, are the limited references on dairy goat kid-rearing practices available for use in establishing recommendations for best practices for dairy goat producers. Indeed, a review of recommendations for intensive production systems in 3 comparable countries—Canada, the United States, and France—found several differences between country recommendations and general gaps in both information and scientific support in several management areas related to rearing, including kidding management, kid feeding and housing, and weaning (Bélanger-Naud, 2020; Bélanger-Naud and Vasseur, 2021). For example, a wide array of milk feeding management practices are included in American, French, and Canadian dairy kid-rearing recommendations, including method of feeding, quantity, and milk source, but scientific support behind these recommendations on the basis of kid growth, health, or other criteria could not be found.

Moreover, for those kid-rearing practices found to benefit kid health and growth, there is a lack of information on whether these beneficial practices carry over into adulthood and translate to improved herd performance. For example, colostrum management (e.g., prompt colostrum feeding after birth, Simoes et al., 2005; higher quality of colostrum fed, Linhares Lima et al., 2013) may boost passive immunity, decreasing preweaning health issues. Although it can be inferred that greater preweaning growth and health would advantage the kid performance (e.g., milk production, reproductive success) later in life, and lower mortality rates would improve culling decisions and replacement rates, the effect of these preweaning rearing practices on herd performance indicators remains to be demonstrated. The use of herd performance indicators covering a range of key management areas (i.e., health, production, young stock growth) to assess the farm economic or production success, as well as the efficacy of farm management practices, has been used in dairy cattle herds (Warner et al., 2020). This approach represents a promising avenue for targeting the most beneficial management practices for goat kid-rearing.

The first objective of this study was to evaluate the associations between 6 self-reported farm performance indicators and goat kid-rearing practices on Canadian farms using correlation and regression analyses. The 6 performance indicators used were selected based on the ease with which they could be collected and on their usefulness in predicting management efficiency. They consisted of preweaning mortality rate, prevalence of diarrhea and respiratory diseases, ADG from birth to weaning, herd milk production, and replacement rate. The second objective was to determine if these 6 performance indicators could be used to group farms in different management styles, and to identify which rearing practices differed between the different groups using a cluster analysis. It was hypothesized that farms more performant with regard to the 6 performance indicators would follow recommended rearing practices and would have an overall better herd management than less performant farms.

MATERIALS AND METHODS

Ethics Statement

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

Questionnaire Design

The questionnaire was designed following examples from previous studies on goat and calf management practices (Vasseur et al., 2010; Staněk et al., 2014; Oudshoorn et al., 2016; Medrano-Galarza et al., 2017) and was reviewed by collaborators and 2 external reviewers, covering a variety of fields of expertise (i.e., nutritionists, veterinarians, welfare specialists, field advisors). It was then pilot tested with 3 producers, 1 from Ontario, 1 from Québec, and 1 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 took approximately 30 min to complete the questionnaire and were contacted again by phone for feedback. Modifications to the questionnaire were made accordingly. The questionnaire consisted of 70 multiple choice and short answer questions and was divided in 10 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 following: 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 or dehorning (n = 3), health management (n = 4), and record keeping (n = 5). Performance data were also collected, including milk production (average over 305 d, in the past year), preweaning mortality rate (% over the previous year), replacement rate (% in the

past year), diarrhea and respiratory disease prevalence (% kids affected at least once before weaning, over the previous year), and ADG from birth to weaning (g/d; calculated from average age and weight at weaning in the previous year) to evaluate the performance of the herds in different areas of production. 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 in 305 d). They were based on producers' answers, which could be derived from farm registry, memory retrieval, or both (the source of data for each question was not collected).

Survey

The questionnaire (available online in Bélanger-Naud, 2020) was sent out to all commercial dairy goat producers of Canada (357 herds in 2018; Canadian Dairy Information Centre, 2019) between June and October 2018. It was distributed either by mail (hard copies; Ontario producers) or email (electronic link; producers from the rest of Canada) through different dairy goat producers' organizations in Canada [Ontario Ministry of Agriculture, Food and Rural Affairs, Ontario; Producteurs de Lait de Chèvre du Québec (PLCQ), Québec; Western Canadian Dairy Goat Association, British Columbia] along with an explanatory letter and consent form. Emails were afterward sent through different producers' dairy associations (PLCQ, Gay Lea Foods, Ontario Dairy Goat Co-operative), and the questionnaire was shared on different Facebook pages (i.e., Canadian Goats, Maritime Goats, Chèvre laitière Québec, Lactanet Caprin) to reach a maximum number of producers.

Data Collection and Management

Electronic questionnaires were collected directly on the SurveyMonkey platform (https://www.surveymonkey.com/), and paper questionnaires were entered manually in the same platform by the principal investigator before the data were exported to Microsoft Excel (Microsoft Corp.).

A total of 175 questionnaires were returned either electronically (n = 122) or by mail (n = 53); of these, surveys with an insufficient number of answers (i.e., < 5 answers; n = 42), herds comprising only nondairy breeds (n = 2), or duplicate surveys (n = 2) were eliminated to end up with 129 surveys. Furthermore, because 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 to have a more representative image of the practices that commercial dairy goat producers follow in Canada. The median herd size of this excluded group of producers (n = 25 herds) was 12, ranging from 2 to 35 goats (lactating and dry). 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 (i.e., 26,000 L annually calculated with a production of 650 L/goat over 305 d; Gay Lea, 2019; Ontario Dairy Goat Co-operative, 2019), and was also used as a cut-off in another goat study performed in Québec (Services Conseils Bernard Belzile, 2010).

The questionnaires were individually screened for errors and discordant answers. Multiple choice and continuous response variables were transformed into predefined categorical or binary variables based on current recommendations, if available (e.g., separate the kid from the dam at birth or not), or based on the distribution of results (e.g., wean kids at <8 wk of age in 46% of the cases vs. ≥8 wk in 54% of the cases), for ease of interpretation and further analysis on recommended practices.

Farm Performance Indicators

Six performance indicators (presented in Table 1) were calculated based on data collected in the survey; therefore, the indicators were based on producer's recollection of performance data only. The use of milk recording services is rare in the industry (24 herds across Canada in 2018; Valacta, 2019), and performance data could not be collected through dairy herd improvement agency. Therefore, the performance indicators were selected based on (1) relatively simple and key performance data that farmers may recollect more easily (e.g., mortality rate or morbidity prevalence), and (2) performance data covering a range of management areas (such as health, production, young stock growth, and profitability), previously associated with poor or good management practices, and used in the context of assessing herd management efficiency (Warner et al., 2020). The ADG from birth to weaning was calculated afterward from the age and weight of the kids at weaning, when both values were reported by the producer. An average birth weight of 4 kg (reference birth weight for twin dairy goat kids; Valacta, 2013) was used for the calculation because this information was not collected.

Statistical Analysis

Farm Performance Indicators and Associated Correlations. The survey data were imported in SAS version 9.4 (SAS Institute Inc.) to be analyzed. Descriptive statistics were used to estimate percentages of

Table 1. Performance indicators of participating farms from self-reported data[1] (n = 104)

Performance indicator	n	Min	P25	Med	P75	Max
Milk production, L/goat per 305 d	92	365	761	892	983	1,400
Preweaning mortality rate, %	97	0	4	8	15	70
ADG from birth to weaning, g/d	40	85	155	193	214	295
Replacement rate, %	85	0	10	24	30	100
Preweaning diarrhea prevalence, %	97	0	3	10	25	100
Preweaning respiratory disease prevalence, %	97	0	1	5	15	80

[1]Min = minimum; P25 = 25th percentile; Med = median; P75 = 75th percentile; Max = maximum.

categorical data using PROC SURVEYFREQ, and medians, 25th and 75th percentiles, and range of continuous data were estimated using PROC UNIVARIATE. Spearman correlations were performed to evaluate if there were any strong associations ($\rho > 0.70$) between the different performance indicators (e.g., between milk production and replacement rate) that would prevent their inclusion in the same model. Correlations were also assessed between farm performance indicators and selected farm characteristics (i.e., herd size, number of years in production, average herd breeding age) to investigate whether some performance indicators could be explained by farm characteristics.

Associations Between Farm-Reported Rearing Practices and Farm Performance Indicators. Univariable linear regression analyses were performed using PROC GLM to identify the relationships between rearing practices and performance indicator, with each performance indicator as model outcome. Proportion variables (i.e., preweaning 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 residuals (McDonald, 2014). The normality of the residuals for all 4 proportions variables was improved with the arcsine transformation but still not met; the ANOVA was assumed to be reasonably robust to accept some skewness in the distribution of residuals (Sahai et al., 2011). Values were back-transformed using the squared sine of the transformed value to present results using the original units (presented in Supplemental Tables S1–S6, https://escholarship.mcgill.ca/concern/articles/0z709243d?locale=en).

Cluster Analysis. A cluster analysis was performed using R Software, version 3.5.3 (https://www.r-project.org/), to group farms based on the 6 performance indicators and evaluate if the resulting clusters were associated with each performance indicator as well as specific rearing practices. Missing observations on preweaning mortality rate (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 statistical power and accuracy (van Buuren, 2019), this methodology is satisfactory in conditions with large number of missing observations as well as complex and intercorrelated 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 6 performance variables were kept for cluster analysis. The clustering of the herds was conducted using the K-means algorithm. Before cluster analysis, the variables were standardized 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*. Principal components were calculated using the same scaled data set to visualize the cluster results (presented in Figure 1 and Supplemental Table S7, https://escholarship.mcgill.ca/concern/articles/0z709243d?locale=en).

The difference between clusters for each performance indicator was determined using one-way ANOVA followed by Tukey test. 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 not met, the nonparametric test of Kruskal-Wallis was used, followed by the Dunn test with Bonferroni correction for multiple comparison of means.

Finally, rearing practices were compared between the clusters using Chi-squared tests, followed by pairwise Fisher's Exact tests with Bonferroni's multiple comparison adjustment for significant categorical variables, and least squares means with Tukey-Kramer's multiple comparison adjustment for continuous variables to

evaluate how practices differed between the different farm clusters. Statistical significance was declared at an error level $\alpha < 0.05$ for all statistical tests.

RESULTS AND DISCUSSION

General Farm and Data Description

A total of 104 commercial dairy goat farms were included in this study, representing approximately 29% of the dairy goat farm population in Canada, which was estimated at 357 farms in 2018 (Canadian Dairy Information Centre, 2019). Response rates were similar between provinces (Ontario: 27%, n = 23; Québec: 38%, n = 72; Western Canada: 27%, n = 9). The general characteristics of participant farms are presented in Table 2. All the results presented in the following results sections were computed using self-reported data by producers via the surveys.

Farm Performance Indicators and Associated Correlations

Looking at the associations between the targeted performance indicators (correlations presented in Supplemental Table S8, https://escholarship.mcgill.ca/concern/articles/0z709243d?locale=en), we found a negative correlation between milk production and preweaning mortality rate ($\rho = -0.29$, $P = 0.007$), as well as positive correlations between preweaning mortality and both diarrhea prevalence ($\rho = 0.38$, $P < 0.001$) and respiratory disease prevalence ($\rho = 0.35$, $P = 0.001$), and between the prevalence of diarrhea and respiratory disease ($\rho = 0.26$, $P = 0.010$). None of these correlations were strong enough (all $\rho < 0.70$) to omit looking at the individual effect of each performance indicator.

Although we found some significant correlations between performance indicators and farm characteristics (i.e., herd size, number of years in production, breeding age), no strong correlation coefficients were observed (all $\rho < 0.70$; Supplemental Table S8). The more experienced farmers were associated with a higher replacement rate ($\rho = 0.23$, $P = 0.033$) as well as a lower diarrhea prevalence ($\rho = -0.27$, $P = 0.009$). The larger herds were associated with a higher preweaning mortality rate ($\rho = 0.23$, $P = 0.026$), a higher replacement rate ($\rho = 0.35$, $P = 0.001$), and a higher respiratory disease prevalence ($\rho = 0.31$, $P = 0.003$). Finally, the farms with a younger breeding age also had a higher milk production ($\rho = -0.26$, $P = 0.023$).

Associations Between Farmer-Reported Rearing Practices and Farm Performance Indicators

With the use of 6 self-reported performance indicators, we were able to determine which individual rearing practices characterized the most performant farms in Canada according to each indicator. Four indicators were chosen to evaluate kid-rearing performance, where a low preweaning mortality rate (previously used by

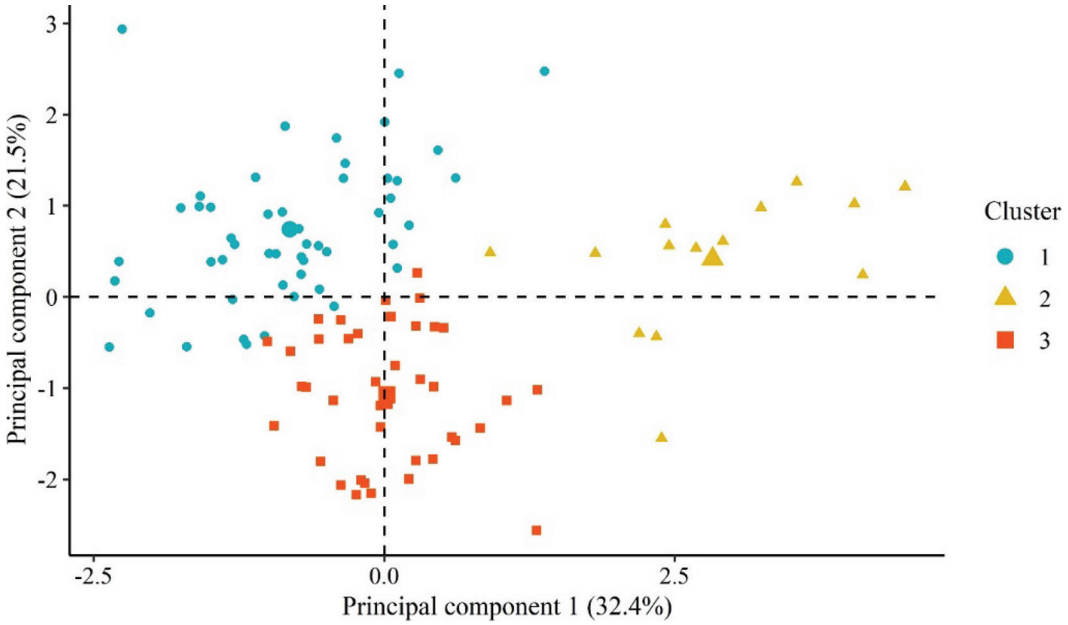

Figure 1. Visualization of the 3 farm clusters using principal component analysis, with principal component 1 and principal component 2. Cluster 1 (production-focused herds) = 50 farms, cluster 2 (low-performance herds) = 14 farms, cluster 3 (longevity-focused herds) = 40 farms.

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. A high ADG (Vacek et al., 2015; Chester-Jones et al., 2017) was indicative of good growth performance between birth and weaning. Two performance indicators were chosen to evaluate overall performance of the adult 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, because the goats stay in the herd for a longer time (Enevoldsen et al., 1996; Moran, 2009; Nor et al., 2014). Our results showed a positive association between high replacement rates and large herds, which must be interpreted with caution. Replacement rates can also be affected by other aspects of farm management that may differ between smaller and larger farms. For one, they could be associated with larger farms that are actively growing, or who, as a result of their expansion, have to engage in different replacement practices due to changes in herd genetic selection (Enevoldsen et al., 1996). Variability across farms for all 6 performance indicators was high, enabling us to identify the better and less performant farms to answer our first research question.

The results for each rearing practice and associated performance indicators are discussed and compared with currently available recommendations in Canada. One Canadian reference (CARC, 2003) and 3 provincial references from Ontario (Ontario Goat, 2014) and Québec (Valacta, 2014; CRAAQ, 2016) were used.

Effects of Colostrum and Milk Feeding Practices on Farm Performance. From birth to weaning, inclusively, the 2 goat kid-rearing sectors that were associated with the most performance indicators were the milk feeding and colostrum management sectors, which both had practices significantly associated ($P < 0.05$) with 5 out of the 6 farm performance indicators. For colostrum feeding, the time of first feeding had an effect on largest number of farm performance indicators (3 out of 6 performance indicators), followed by the quantity and quality of colostrum (with 2 out of 6 performance indicators each). When colostrum was fed within 2 h after birth, a higher milk production, lower preweaning mortality rate, and lower diarrhea prevalence were reported on the farm. This goes in line with current recommendations (Ontario Goat, 2014; CRAAQ, 2016). Studies reported that feeding high quantities of colostrum early after birth increased the amount of IgG transferred to the kids (Simoes et al., 2005), and in turn increased their survival rate (O'Brien and Sherman, 1993; Mellado et al., 1998). A higher quantity of colostrum fed in the first 12 h of life was shown to decrease preweaning mortality rate and diarrhea prevalence (Simoes et al., 2005). Colostrum

Table 2. General characteristics of participant farms

Farm characteristic	n[1]	%[2]	Med (P25, P75)[3]
Province	104		
Ontario	72	69	—
Québec	23	22	—
Western[4]	9	9	—
Number of years in production	103		
1–5	39	38	—
6–10	27	26	—
11–15	17	17	—
16–20	14	14	—
>20	6	6	—
Breed distribution, number of herds[5] with distribution	104		
≥50% Saanen	44	42	—
≥50% Alpine	20	19	—
≥50% Cross breeds	19	18	—
≥50% LaMancha	2	2	—
≥50% Nubian	5	5	—
≥50% Toggenburg	1	1	—
Herd size, number of milking and dry goats[4]	101	—	200 (114, 300)
Breeding age, mo	87	—	9 (7.5, 11)
Breeding weight, kg	68	—	36 (34, 39)

[1]Number of respondents.

[2]Percentage of respondents, for categorical response variables.

[3]Median (25th percentile, 75th percentile), for continuous response variables.

[4]British Colombia: n = 4; Alberta: n = 2; Saskatchewan: n = 1; Manitoba: n = 2.

[5]Respondents can fall in more than 1 category if they had 50% of 2 different breeds, and some others are not presented here if they had less than 50% of any breed.

quality is also very important to increase this transfer of IgG to the kids (Castro et al., 2005; Rodríguez et al., 2009; Linhares Lima et al., 2013), and we found that evaluating colostrum quality, which is the first step toward feeding high quality colostrum, was associated with a higher growth rate from birth to weaning, as well as a higher herd replacement rate. Finally, pooling colostrum, a practice which goes against recommendations (Ontario Goat, 2014), was associated with a lower milk production.

As for milk feeding, the source of milk was associated with 1 out of 6 performance indicators, and feeding methods were associated with 5 out of the 6 performance indicators. Producers who reported feeding milk replacer as opposed to fresh cow or pasteurized goat milk had a higher replacement rate. Feeding milk replacer is a recommended practice (Ontario Goat, 2014; Valacta, 2014) to control disease transmission; although the results we obtained could be interpreted as poor herd longevity, this association between feeding milk replacer and a high replacement rate could be explained by other elements such as a growing or larger herd, or very strict culling criteria. Regarding milk feeding methods, the use of trough feeders (used by only 7 producers) was associated with lower milk production and higher replacement rate. Our results support the current recommendation, which goes against feeding milk in a trough feeder. This method forces the kid to drink with its head down, which keeps the esophageal groove open, leading to milk ingestion in the rumen instead of the abomasum (Valacta, 2014). Although other practices were not associated with milk production and replacement rate, some associations with other performance indicators are worth noting: using buckets with multiple nipples at the top was linked to lower growth rates, and using automatic milk feeding systems was linked with higher diarrhea prevalence. We hypothesize that 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 in this type of feeding system. In fact, it is recommended to feed frequent, small milk feedings to kids (CARC, 2003; CRAAQ, 2016), something which may not have been implemented by farmers using buckets with multiple nipples. With regard to complying to this specific recommendation, automatic milk feeding systems appear as the best option as the kids can choose the frequency and quantity of their milk intake. Yet, our results still found some performance indicators to be negatively linked to the use of such systems, namely increased diarrhea. However, this association may be explained by the equipment cleaning routine, as this element was identified as a risk factor in previous literature (Medrano-Galarza et al., 2018). In fact, results from our survey showed that only 41% of the producers using automatic milk feeders washed their milk feeding system every day. Finally, a higher competition at the milk bucket, which could result from having more than 1 kid per nipple at the feeder, was shown to increase preweaning mortality rate and diarrhea prevalence, supporting a French recommendation to provide at least 1 nipple per kid at the feeder (INOSYS, 2016). Such an aspect is not specified in the Canadian guidelines.

Effects of Kidding Management Practices on Farm Performance. Kidding management practices, including the number of kidding periods, kidding monitoring, and kid-dam separation, were associated with 3 performance indicators that were all related to kid health (i.e., preweaning mortality rate, prevalence of diarrhea, and prevalence of respiratory diseases). Herds that reported having 3 or more kidding periods per year had higher incidences of diarrhea and respiratory disease. No recommendations are currently available on the optimal number of kidding periods, but this association could potentially be related to improper cleaning and disinfection of the kidding area and nursery between groups of kids, which could increase pathogen transmission. Proper cleaning and sanitation of such areas is part of the recommendations (Ontario Goat, 2014; Valacta, 2014). Monitoring kids more often in the day and at night, and video camera monitoring were all associated with lower kid mortality. Monitoring at night and with video cameras was also associated with a lower prevalence of respiratory diseases. These findings suggest that monitoring in general is crucial to reduce kid mortality and disease, which is in line with current recommendations (CARC, 2003). Finally, herds that reported removing the kids from the dams in most cases before first suckling were found to have a lower kid mortality rate as well. This practice is also recommended, as it helps avoiding pathogen transmission from the dam to the kid at birth (CARC, 2003).

Effects of Kid Housing Management Practices on Farm Performance. Kid housing management practices were also associated with 3 performance indicators, including replacement rate, prevalence of respiratory disease, and ADG from birth to weaning. Herds that reported leaving the kids with the dams for more than 48 h, or until weaning, had a higher replacement rate, but a lower incidence of kid respiratory disease. Our hypothesis on this matter is that under those conditions, the kids are housed in a well-ventilated area with the adult goats as opposed to a closed nursery where animal density is usually higher and where ventilation may be insufficient, making the transmission of respiratory pathogens easier. Of the herds that raised kids away from the dams, those that arranged groups to have kids of similar age in the same

group were associated with higher ADG between birth and weaning. This is in line with current recommendations (CARC, 2003) to make homogeneous groups to avoid competition at feeding as much as possible, and our study supports that this was associated with increased kid growth from birth to weaning. Finally, herds that raised their buck kids on the farm until they were at least 2 wk of age were found to have a higher prevalence of kid respiratory diseases. This could be explained by a higher animal density, due to keeping twice as many animals for a certain period of time, leading to poorer air quality, which is a risk factor for respiratory diseases.

Effects of Record Keeping on Farm Performance. Taking and recording measures on the farm, whether on milk production or kid management, was found to be positively associated with 3 out of 6 performance indicators, namely increased milk production, increased goat kid growth, and decreased diarrhea prevalence. More specifically, 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. Herds that recorded kids' diseases had higher kid growth between birth and weaning, and those that recorded treatments administered to kids during that same period had a higher milk production. Finally, farms where producers recorded kids' weight at birth also had a higher milk production. These results suggest that farms holding more records on their farm production numbers and performance data are also generally the ones that perform better. The keeping of records could be indicative of an overall better farm management system or could be directly linked to herd performance if such data are used as a tool for monitoring and improving production numbers.

Effects of Health Management on Farm Performance. Preventive health management practices were associated with lower preweaning 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 correspond to the recommendations, and aim to control coccidiosis in kids at a young age (Valacta, 2014). The relationship between the use of coccidiostats and higher milk production goes in line with findings from previous studies that suggest 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 higher weight gains, as well as higher first lactation milk yields (Morand-Fehr et al., 2002), which shows that the use of coccidiostats may have long-term effects on the does' future milk production. Disinfecting the kids' umbilical cords within 2 h after birth and administering selenium and vitamin E to the adult goats during gestation were both associated with a lower preweaning mortality rate. Although there are no published studies with which to compare our results related to those practices, the disinfection of the kids' umbilical cords right after birth is part of all the Canadian recommendations (Ontario Goat, 2014; Valacta, 2014; CRAAQ, 2016).

Effects of Disbudding Practices on Farm Performance. The herds that reported disbudding kids in the first 2 wk of age had a lower replacement rate and a higher milk production. This agrees with current recommendations, which suggest disbudding kids between 3 and 15 d, or as soon as the buds appear, to reduce distress to the kids (CRAAQ, 2016). No other published literature has looked into the effect of disbudding age in kids on any of the performance indicators we collected as part of our study.

Effects of Solid Feeding Practices on Farm Performance. In terms of solid feeding, herds that offered hay to the kids in their first 2 wk of life had a lower incidence of kid respiratory disease. This result is hard to explain, as no studies specific to goats have evaluated the effect of feeding hay at an early age versus a later age. Additionally, recommendations regarding the age at which hay should first be fed to kids are contradictory and vary between providing it in the first week of age to right before weaning (Ontario Goat, 2014; Valacta, 2014; CRAAQ, 2016). Herds that fed concentrates with a higher CP content also had a higher milk production. This agrees with a study by Greenwood (1993), which found a significant correlation between the protein concentration in the feed and growth rate after weaning when fed ad libitum, which could translate to a higher milk production.

Farm Cluster Descriptions and Associations with Performance Indicators and Rearing Practices

The cluster analysis allowed us to divide respondents in 3 distinct groups of farms (Table 3), based on the 6 performance indicators, that we were able to define on a scale of intensification (i.e., production-focused, longevity-focused, and low performance). The 3 groups differed on several rearing practices (Table 4). The production-focused farms reported feeding cow colostrum, using automatic milk feeding systems, adding coccidiostats in the kids' concentrates to prevent coccidiosis, and grouping kids by age more often than the longevity-focused farms. In turn, the longevity-focused farms reported pooling colostrum more often and mak-

Table 3. Division of farms in 3 clusters (production-focused, n = 50; low performance, n = 14; and longevity-focused, n = 40), based on performance indicators

Performance indicator	Production-focused	Low performance	Longevity-focused	SD	*P*-value
Preweaning mortality rate, %	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 per 305 d	968.5[a]	702.0[b]	800.2[b]	181.65	<0.001
ADG from birth to weaning, g/d	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

[a,b]Values with different superscript letters in the same row differ significantly ($P < 0.05$).

ing smaller groups of kids (i.e., less than 15 kids per pen) more often than the production-focused farms. They also reported providing at least 1 nipple per kid when feeding in a milk bucket more often than the low-performance cluster, and the production-focused group lay in between the 2. Finally, the low-performance farms reported feeding the first colostrum more than 2 h after birth more often than the 2 other groups, used automatic milk feeding systems more often than the longevity-focused farms, and lay in between the 2 other clusters for all other practices. From those results, we noticed that the longevity-focused farms limited competition between the kids the most by limiting the group sizes and allowing more access to milk feeding nipples, which translated to a lower preweaning mortality rate and disease prevalence; the production-focused farms had bigger groups of kids, but followed other recommended practices more closely, which translated in a higher milk production. Interestingly, the bigger groups of kids made in the production-focused farms could not be explained by larger herd size because there was no differences in herd size between the 3 clusters.

Study Limitations

The methodology used in the creation of the survey questions and in the conducting of the survey itself was designed to minimize biases; however, there were limitations that should be taken into consideration. Self-reported data may be subject to producer biases and errors. In addition, the use of direct questions with specific wording in a survey study may result in misestimation by producers, particularly regarding health issues (e.g., respiratory diseases, diarrhea) for which producers may have their own methods of classification of kid health that do not fit the description established by the survey. Moreover, producers that were indicated to have applied best-practice recommendations and also reported better outcome measures in dairy goats as kids and adults may apply other practices that benefit kid rearing or dairy goat production in adults that can lead to the overstating of correlations in this study. Likewise, a social desirability bias could be present; the most performant and well-informed producers could have overestimated their use of recommended best practices. Moreover, although our results reflect the responses of over a quarter of the Canadian dairy goat producers, the survey was voluntary in nature. As such, the presence of recruiting biases cannot be guaranteed against. Finally, the evaluation of associations between farm clusters or performance indicators and kid-rearing practices involved testing of many statistical hypotheses, thus increasing the risk of detecting associations

Table 4. Percentage of farms following different rearing practices within the 3 clusters (production-focused, n = 50; low performance, n = 14; longevity-focused, n = 40)

Rearing sector	Rearing practice	n[1]	Production-focused	Low performance	Longevity-focused
Colostrum	Feed colostrum in first 2 h after birth	78	86[a]	36[b]	80[a]
	Do not 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]

[a,b]Different superscript 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 1 option.

by chance only (type 1 error). Thus, further studies would be needed to confirm these associations.

CONCLUSIONS

Our study is the first to draw an exhaustive portrait of goat kid-rearing practices, from birth to weaning, inclusively, on commercial dairy goat farms in Canada. Self-reported rearing practices were analyzed under the scope of 6 performance indicators, to identify the practices that differed between more and less performant farms. Good colostrum and milk feeding management practices were positively associated with the highest number of farm performance indicators. The 6 performance indicators also allowed to divide the farms between 3 groups of producers with different management styles on a scale of intensification. Our study identified some kid-rearing practices that were positively associated with farm performance indicators, allowing us to target the most promising practices for future controlled studies by quantifying their effect in different goat production systems. This new information will also support the knowledge transfer to help producers implementing 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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