Management considerations to prevent respiratory disease in group-housed preweaned dairy calves

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Abstract
Group housing systems for preweaned dairy calves offer certain benefits including increased flexibility of labor and earlier calf socialization. However, the comingling of preweaned dairy calves will increase the opportunity for pathogen transmission. As a consequence, increased morbidity, and particularly bovine respiratory disease, is frequently a challenge in these systems. Producers committed to adopting group housing should carefully consider how to best design and manage facilities, and how best to manage calves within the system, with a view to minimizing infectious disease challenge and maximizing immunity. In a preceding companion article, Dr. Theresa Ollivett (University of Wisconsin – Madison) discusses a number of important facility design and management principles, the importance of sanitation, and pair housing. The current article will discuss other (non-facility related) best management practices for group-housed preweaned dairy calves, including colostrum management, group composition and dynamics, nutritional management, and disease detection.

Key words: respiratory disease, preweaned dairy calf, group housing

Introduction
In recent years, we have observed an increase in the adoption of group housing systems for preweaned dairy calves. Options for milk delivery systems for group-housed calves include automated (computerized) feeders, mob feeding, or free-choice acidified milk or milk replacer. Group housing systems for preweaned dairy calves offer certain benefits including increased flexibility of labor (though not necessarily labor savings) and earlier socialization. However, the comingling of preweaned dairy calves will increase the opportunity for pathogen transmission through nose-to-nose contact, aerosol transmission and a shared contaminated environment (e.g. contaminated bedding, waterers, nipples). As a consequence, increased morbidity and mortality, and particularly bovine respiratory disease (BRD), can be challenging in these systems.17 Producers curious about adopting group housing systems should consider their goals and priorities for the calf rearing program (e.g. goals for growth, goals for health, etc.) and carefully weigh the potential advantages and disadvantages before making a decision. Producers already committed to group housing should consider how to best design and manage these facilities, and how best to manage calves within the system, in order to mitigate disease risk.

From the veterinarian's viewpoint, providing more services and consulting in the area of youngstock management, including the increased use of large animal veterinary technicians, represents a tremendous opportunity to improve animal welfare and performance, to increase value to clients, and to generate more practice revenue. When consulting in group-housed calf systems, as with anything else, the basic principles of disease prevention are to minimize infectious disease challenge and maximize immunity. In a preceding companion article, Dr. Theresa Ollivett (University of Wisconsin – Madison) discussed a number of important facility design and management principles, the importance of sanitation, and pair housing. The current article will discuss other (non-facility-related) best management practices for group-housed calves, including colostrum management, group composition and dynamics, nutritional management, and disease detection. Many of the principles discussed here are universal, meaning that they apply to any kind of preweaned calf housing system, be it single or group, while others are specific to group-housing situations.

Colostrum management
Good colostrum management is the cornerstone of any successful youngstock program. Basic principles are to feed a sufficient volume of clean, high-quality maternal colostrum or colostrum replacer as soon as possible after birth, ideally delivering an average of 300 g of immunoglobulin G (IgG) to the average calf within 1 to 2 hours of birth.[14] If practical to implement, there are also growth and health benefits from providing additional colostrum feedings and/or supplementing the milk diet with colostrum or transition milk for the first 2 to 3 weeks.[2,5,20,31] Transfer of passive immunity (TPI) can be monitored through periodic evaluation of serum total protein (STP) concentrations or serum Brix readings in 1 to 9-day-old calves.[39] A group of calf management experts recently published new consensus recommendations for monitoring TPI in dairy calves (Table 1).[23] While significant advances in colostrum management have been achieved by the dairy industry over the past 20 years, opportunities for further improvement remain in a majority of herds, creating an opportunity for the herd veterinarian to get involved in program design, training and ongoing monitoring activities. A comprehensive review of colostrum management principles can be found at Godden et al. (2014).[14]

Group composition and dynamics
This section considers age at introduction to the group, group size, stocking density, variation in calf ages within the group, and flow of calves into and out of the group, and is a critical determinant of risk for BRD and other diseases within the group.

Age at introduction. There is tremendous farm-to-farm variation in the age at which calves are introduced to the group pen. While not all studies agree, most observational and controlled studies report behavioral and health benefits to delaying introduction by backgrounding and hand feeding the calf in an individual pen for up to 12 to 14 days prior to introduction to the group. If introduced at an older age, the calf is quicker to learn how to drink from the new feeding system (e.g. computer feeder).[12,26,32] In a randomized trial of 892 calves in 9 Swedish herds, designed to evaluate the impact of group size on health, Svensson et al. (2006) reported a 50% increase in risk for BRD if calves were moved into the group at 12 or fewer days of age.[38] In a more recent randomized trial that assembled calves into groups of six, the authors reported a significantly lower preweaning disease incidence if calves were grouped at 21 days of age (scours=40%; BRD=18%) versus grouping at one day of age (scours=72%; BRD=56%).[8]

Group size. Manufacturers and distributors of automated calf feeding systems will frequently communicate that calves may be assembled into groups as large as 25-30 calves per group (or per nipple). However, multiple studies have reported increased disease incidence when calves are housed in larger groups (greater than 7 to 8 calves per group) as compared to calves housed in smaller groups or housed individually. In a controlled trial of 892 calves in 9 Swedish herds that randomized calves to small groups (6-9 calves) or large groups (12-18 calves), Svensson et al. (2006) reported a 40% increase in risk for BRD and reduced rate of gain for calves in large groups.[38] In a different observational study of 3,081 calves in 122 Swedish herds, Svensson et al., (2003) reported the odds of BRD were more than double for calves in large groups of 8 or more calves (7.4% of calves with BRD; OR = 2.2 (1.2-3.8)), as compared to individually housed calves (3.5%) or calves housed in smaller groups (3.3%).[37] An observational study of 47,057 calves in 1,685 U.S. herds reported that preweaning mortality risk was 40-52% higher in herds that housed calves in large groups (≥ 7/group) as compared to herds housing preweaned calves individually or in small groups.[24] Finally, in an 18-month study of 10,179 calves on 38 Midwest farms using computer feeder systems, larger group sizes were associated with increased odds of higher nasal scores.[18]

Another potential drawback is that larger group sizes may negatively impact calves' ability to access the computer feeder, resulting from competition and disturbances from other calves while in the feeder.[16] At the very least, this social constraint may negatively impact animal wellbeing, though in more extreme cases it could also negatively impact milk intake, thereby resulting in reduced health and performance of individual calves. If producers want to capture the benefits of socialization while minimizing disease risk, pair housing (2 calves per pen), or at least keeping groups small as possible, is strongly recommended.

Stocking density. Stocking density refers to the area of bedded resting space (ft^2 or m^2) afforded to each calf, and should be considered independent of group size. In an 18-month study of 10,179 calves on 38 Midwest farms using computer feeder systems, Jorgensen et al., (2017b) reported that for every additional square meter of space allowed per calf there was a 10.4% decrease in the odds of receiving a higher ear score (P = 0.006) and a 7.7% decrease in the odds of a higher eye score (P = 0.008) when using a standardized health scoring system to score all calves on bimonthly visits.[18] These results are consistent with previous work demonstrating that increased space per calf was associated with fewer adverse health events in calves.[1] Experts recommend a minimum of 45-50 ft^2 of bedded resting space per calf when calves are housed in large groups.[15]

Group dynamics. Group dynamics considers the flow of animals into and out of the pen as well as the range of calf ages within a single group. Producers should strive for an all-in-all-out approach to managing pens, and to keep the age distribution as narrow as possible within any one pen. Some of the biggest health catastrophes we have personally observed have been in continuous flow systems where, after introducing a particular infectious agent into the pen (e.g. *Salmonella* spp. or *Mycoplasma* spp.), that pathogen now becomes endemic within the pen, transmitted from older animals to all new arrivals thereafter. Even if it takes a producer one or two weeks to fill a pen, they should still manage it as an all-out program by weaning all calves, followed by completely emptying and then sanitizing the pen before refilling.

Keeping the age range as narrow as possible within a pen makes sense from the point of view of preventing older/larger calves from outcompeting younger/smaller calves at the feeder, as well as to prevent older calves from exposing the younger and more susceptible calves to pathogens. While published studies are limited, Jorgensen et al. (2017b) reported that increased age range in calf groups was positively associated with mortality rate.[18] Medrano-Galzara et al. (2018b) also reported increased within-pen prevalence of BRD was associated with sharing air with weaned cattle up to 8 months of age.[27] While evidence-based guidelines are lacking, a practical and achievable goal would be to limit the range in ages within a pen to a maximum of 1 week (preferred) or 2 weeks (the absolute limit).

Nutritional management

This section considers the daily milk allowance and meal allowance program from birth to weaning, grain and water management to promote rumen development, weaning strategies, and the importance of providing a clean and consistent high quality milk or milk replacer diet to calves.

Feed a full potential milk feeding program. It is critical that the pre-ruminant calf receive a high plane of nutrition from the milk diet in order to support an adequate rate of gain (goal of 1.6-1.8 lbs/day (0.73-0.82 kg/day) for Holsteins), as well as a stronger and more resilient immune system and improved health (Godden et al., 2005; Ollivett et al., 2012). Producers are strongly encouraged to adopt a full potential milk feeding program – providing a daily milk allowance of at least 20% of the birth weight of the calf (e.g. ≥ 8.5 qts or ≥8 L per day; ≥ 2.2 lbs or ≥1kg DM per day for a Holstein calf) of clean, high quality milk replacer or whole milk. Adjustments to nutrient intake from milk (total DM consumed) should also be made, as necessary, to support continued weight gain and immune competency in the face of periods of cold stress. Feeding pasteurized whole milk (instead of milk replacer) was associated with reduced scours and BRD incidence (Godden et al., 2005; clinical trial in individually housed calves) or reduced BRD prevalence (Medrano-Galarza et. al. 2018b; observational study of group-housed calves).[13,27] This may be attributed to higher levels of nutrients or immune factors in whole milk compared with milk replacer in these two studies. Beyond the short-term growth and health benefits, a meta-analysis of 12 controlled studies showed a significant improvement in first lactation milk production in the adult when feeding a full potential (vs conventional) milk feeding program in the preweaning period.[35] In one commercial New York herd, Soberon et al., (2012) estimated that every 2.2 lb (1 kg) per day increase in average daily gain was associated with an estimated 2,449 lb (1,113 kg) increase in milk yield in first lactation.[34]

Offer a sufficiently large meal allowance. In addition to ensuring a high daily milk allowance, it is important to ensure that the autofeeder program (or other milk delivery system) provides a sufficiently large meal allowance (≥ 2.1 qt or ≥ 2 L per meal). Larger meal allowances ensure that calves leave the feeding station feeling satiated, and so should lay down and sleep, rather than hang around the feeder competing for their next meal. One randomized trial demonstrated that if calves were only allowed small but frequent meal allowances (6.4 L/day offered as 8 meals of 0.8 L/meal) they spent significantly more time standing in the feeding station each day, and a significantly greater proportion of that time was 'unrewarded', as compared to calves that were offered fewer but larger meals (6.4 L/day offered as 4 meals of 1.6 L/meal).[16] On commercial farms, restricting the daily milk allowance or forcing small meal allowances presents as increased aggression and displacements at the feeder. Cross-sucking behavior, which can be a concern in group-housed calves, may also be motivated by hunger and influenced by limiting milk allowance.[16]

Ensure the consistency and cleanliness of the whole milk or milk replacer diet. The level and consistency of total solids (TS) of the milk or milk replacer fed is important to gut health, with a reasonable goal for milk TS between 12.5 and 13.5% (not exceeding 15%), and with no more than a 1% fluctuation in TS occurring from meal to meal (S. McGuirk. University of Wisconsin-Madison. Personnel communication). Excessively high (> 15%) and/or excessively variable TS, which can contribute to hyperosmolality, risks creating osmotic diarrhea and abomasal emptying disturbances.[4] Conversely, if TS are too low, then calf performance will suffer due to restricted nutrient intake. In a cross-sectional study of 17 autofeeder herds in Ontario, Canada, milk TS < 10% was associated with increased within-pen prevalence of BRD.[27] Just as for hand-mixing milk replacer, autofeeder systems must be monitored regularly to verify that the equipment is accurately mixing and delivering a consistent milk diet to the calves. The TS in whole milk can be estimated by taking the milk Brix % reading then adding 2%.[28] However, for milk replacers, the correction factor to estimate TS from Brix refractometer readings is unique to each commercial product, necessitating the creation of a standard curve for each product in order to estimate TS from Brix readings.[11]

The cleanliness of milk or milk replacer, whether delivered via mob feeders, ad libitum feeding systems, or autofeeders, is also critical to calf health. This can be monitored by doing periodic milk cultures (goal: total bacteria count < 20,000 cfu/mL; total coliform count < 10 cfu/mL). In an 18-month study of 10,179 calves on 38 Midwest farms using computer feeder systems, Jorgensen et al., (2017b,c) reported that bacterial contamination of milk was common, and that high bacterial counts measured in the milk or milk replacer were associated with increased odds for higher attitude and ear scores, and higher odds for calves having a detected fever.[18,19] Similarly, Medrano-Galarza et al. (2018b) reported that increased within-pen prevalence of diarrhea was observed when total bacteria counts in milk taken from the autofeeder mixing jar exceeded 100,000 cfu/mL.[27] James et al., (2017) recommended automatic cleaning of autofeeders four times per day, once daily circuit cleaning, once daily cleaning of nipples, and frequent (e.g. weekly) replacement of the feeding hoses. [15]

Do not delay allowing calves access to the full daily milk allowance. Another important nutritional consideration that may play into calf growth and health is the long-held practice of slowly increasing the daily milk allowance over a period of a couple weeks or longer, before finally reaching the target peak daily milk allowance (L/day). In a recent survey of 38 upper Midwest dairies using automatic feeding systems, Jorgensen et al. (2017c) reported that the average calf started at an average allowance of 5.4 L/d and increased to a peak feeding level of approximately 8 L/d over a period of 3 weeks.[19] The explanation offered by producers for this "slow ramp-up" practice is to avoid what is perceived to be "milk scours". However, and while feeding higher volumes of milk will result in softer, pastier formed stools, it will not cause scours or sick calves. We firmly believe that this practice of intentionally restricting nutrient intake, by slowly ramping up the daily milk allowance, will impair growth as well as potentially impair the calf's ability to successfully respond to infectious disease challenge.

There is great variation between calves in their ability to consume milk, and while not all calves will drink the full peak allowance in the days after birth, we don't want to limit higher intakes for those calves that want it. When offered ad libitum access to milk in the first days of life, dairy calves will drink an average of 8 L/day by 4 days of age, and individual calves will drink up to 12 L/d, without causing scours.[9] Recent studies have reported a positive association between milk consumption very early in life and both health and growth.[9,18,21,30] de Passillé et al. (2014) reported that when calves were offered ad libitum milk during the first 5 days of life, those calves that remained healthy up to 28 days of age were more likely to have consumed more milk during the first 5 days as compared with calves that experienced a morbidity event.[9] In a recent randomized controlled trial of 1,264 calves on five Midwest dairy farms, Knauer et al., (2018) reported that offering the full (peak) milk allowance from day one of life improved calf growth during the first 3 weeks as compared with a program that gradually increased the milk allowance, with no detrimental effect on calf health, including scours.[21] In summary, producers should be encouraged not to use an excessively long delay in the ramp-up

Table 1: Consensus recommendations for monitoring transfer of passive immunity in dairy calves in the United States (With permission, modified from Lombard et al., 2020)[22]

Transfer of passive immunity category	Serum IgG category (g/L)	% of calves in herd in each category	Equivalent serum total protein (g/dL)	Equivalent serum Brix (%)
Excellent	≥ 25.0 g/L	> 40%	≥ 6.2 g/dL	≥ 9.4%
Good	18.0 – 24.9 g/L	~ 30%	5.8 – 6.1 g/dL	8.9 – 9.3%
Fair	10.0 – 17.9 g/L	~ 20%	5.1 – 5.7 g/dL	8.1 – 8.8%
Poor	< 10.0 g/L	< 10%	< 5.1 g/dL	< 8.1%

period to reach the peak daily milk allowance. If producers are nervous about offering the full allowance in the first day or two, then a reasonable goal is to aim to reach the full/peak daily allowance by 5 to 7 days of age. If very young calves are truly scouring and sick, then differentials to investigate include infectious agents, osmotic diarrhea (e.g. due to excessive osmolality or excessive variation in osmolality of milk diet), high bacteria counts in milk or milk replacer, or poor quality (indigestible) milk replacer ingredients.

Rumen Development and Weaning. It is critical to promote rumen development by ensuring that calves have easy access to palatable, high-quality, free-choice water and starter pellet by 3 days of age. In large group pens, it is recommended that starter pellet be placed in low, easy to access troughs within the pen so that calves can more quickly discover it (vs access outside a fence line feeding system). Some producers are reluctant to offer a full potential milk feeding program because increased access to milk can slow how quickly calves come onto dry feed. It is certainly true that if starter intake and associated rumen development is insufficient by the time of weaning, this can result in post weaning "slumps" including a negative energy balance, weight loss, and associated increased susceptibility to infectious disease. However, multiple studies have demonstrated that calves can be successfully weaned off of full potential milk feeding programs through the adoption of two simple strategies:

- **Delay weaning to 8 or 9 weeks** or later to allow the calf more time to increase dry feed intake and adequately develop the rumen.[10]
- **Use a step-down (not abrupt) approach to wean the calf over a 14-day period**, allowing the calf more time to increase grain consumption and further rumen development.[33,36] Gradual weaning of calves can also help to reduce cross-sucking.[29]

Disease detection

One of the purported benefits of automated feeding systems is that they may assist producers in identifying suspected sick calves by using software algorithms that detect changes in feeding behaviors which are associated with disease, such as reduced daily milk intake (L/day) or drinking speed (mL/min). However, research has demonstrated that there is tremendous calf-to-calf variation in feeding behaviors, and to what degree, if at all, sick calves may alter their feeding behaviors. Furthermore, factors such as calf age and milk allowance can greatly impact the suitability of using automated feeding behaviors as early disease indicators.[3,22,25] As one example, Borderas et al. (2009) reported that calves on a high milk allowance that became ill were inclined to modify feeding behaviors such as reduced milk intake (L/day), reduced frequency of visits to the feeder, and reduced duration of visits, while calves on a low milk allowance that became ill only reduced the visit duration to feeders, as compared to healthy calves on a similar milk allowance.[3] As such, the computer missed identifying many sick calves and, of those calves that were detected, the change in feeding behavior was not flagged by the computer any sooner than an experienced human observer. Theorizing that the tremendous variation in feeding behaviors between different calves was part of the explanation for why fixed algorithms had poor disease detection ability, Knauer et al. (2018) applied statistical process control techniques to individual calf feeding behaviors in an attempt to improve disease detection in computer-fed group-housed calves.[22] Unfortunately, the results of this study showed that, for the feeding behaviors monitored, the use of CUSUM control charts did not provide sufficient sensitivity or predictive values to detect a sick calf in a timely manner as compared with trained, experienced personnel. Finally, in a recent study of BRD in computer-fed group-housed dairy calves, Cramer et al., (2020) reported that calves with subclinical BRD did not alter their feeding behavior.[7] Furthermore, for calves with clinical BRD, the changes in feeding behavior that were noted by the computer (reduced drinking speed) still was not useful to detect sick calves before clinical signs were apparent to a trained observer. The take home message from these and other studies is that, while feeding behaviors collected by autofeeder systems may serve as an aid in the detection of calfhood disease, this approach will not be a reliable nor timely strategy, nor should it be used as the sole strategy, for the detection of calves with clinical BRD or other diseases.[3,6,7,21] Therefore, it is important that trained personnel continue to visually observe calves on a daily basis for signs of illness.

Summary

While group housing systems for preweaned dairy calves offer certain benefits such as flexibility of labor and early socialization, increased morbidity, and particularly an increased incidence of BRD, is frequently a challenge in these systems. A summary of recommended management practices to mitigate BRD risk in group-housed preweaned calves is as follows:

1. Have an excellent colostrum management program in place
2. Provide extended feedings of colostrum or transition milk for the first 2 to 3 weeks if it can be practically implemented on the farm
3. Delay introduction to the group (ideally > 12-14 days of age)
4. Keep group sizes as small as possible (ideally < 7 calves)
5. Provide a minimum of 45-50 ft^2 of bedded resting space per calf
6. Manage groups as all-in-all-out systems
7. Keep a narrow age range within each group (ideally < 1 week; 2 weeks maximum)
8. Offer a full potential milk feeding program, ensuring a high daily milk allowance (≥ 8.5 qts or 8 L/day; or ≥ 2.2 lbs or 1 kg DM/day), and offer a sufficiently large meal allowance (≥ 2.1 qt or 2 L/meal)
9. Monitor to ensure the consistency and cleanliness of milk or milk replacer
10. Do not delay allowing calves access to the peak daily milk allowance
11. Delay weaning until 8 or 9 weeks or later, and use a 14-day step-down weaning strategy
12. Do not rely on a computer algorithm to detect sick calves based on changes in feeding behaviors. Daily observation of calves by trained personnel is a must to detect sick calves

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