

# Intensified Pre-Weaning Calf Feeding Programs: Impacts on Growth and Behavior

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## Introduction

There are a range of viewpoints on how best to feed and manage dairy calves early in life. Traditional approaches to rearing dairy calves have focused on stimulating early solid feed intake through restricting intake of milk or milk replacer. A conventional milk feeding rate is approximately 10% of a calf's birth weight, an amount that translates to between 4 and 5 L/day, supporting under 0.5 kg/d of weight gain (Appleby, 2001; Jasper and Weary, 2002). This conventional approach to feeding calves facilitates early weaning and has been viewed as economically appealing due to reduced feed costs. However, there is increasing on-farm adoption of alternative feeding programs which provide a higher plane of nutrition. Feeding programs which provide greater milk allowances support greater growth relative to outcomes of conventional restricted feeding, and thus are typically referred to as "intensified feeding," or "feeding for accelerated growth." These feeding programs provide quantities of milk that more closely resemble intake levels of a suckling calf, and allow "biologically appropriate" growth rates (Drackley, 2008), which fall between 0.75 and 1 kg/d (Tedeschi and Fox, 2009; Appleby, 2001).

In supporting increased intake, intensified feeding programs provide a number of immediate benefits, including greater growth prior to weaning, performance of natural feeding patterns, and improved welfare. Further, recent interest has turned to longer-term impacts of greater rates of weight gain early in life, such as improved performance in lactation. The increasing adoption of intensified feeding for dairy calves poses opportunities and challenges for other aspects of calf management, such as different approaches to housing, weaning methods, and provision of solid feed.

## Early Impacts of Intensified Feeding

### ***Plane of nutrition and growth***

In contrast to the restricted amounts of milk provided in conventional feeding programs (10% of BW, or 4 to 5 L/d), calves provided more milk are able to double their nutrient intake (Khan et al., 2011a), consuming between 8 and 16 L/d when milk is provided *ad libitum* (Appleby, 2001; Jasper and Weary, 2002; Miller-Cushon et al., 2013a). In terms of milk replacer, conventional feeding programs typically provide 1 to

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1.5% of BW on a dry matter (**DM**) basis whereas intensified programs provide milk at 2 to 3% of BW on a DM basis. Some intensified feeding programs also alter the DM content of the milk replacer in addition to the feeding amounts; for example, providing milk replacer prepared with 18% compared to 12% DM (Terré et al., 2009).

Improved growth in intensified feeding programs can be accomplished by providing higher amounts of milk replacer (Diaz et al., 2001; Brown et al., 2005) as well as whole milk (Jasper and Weary, 2002). However, a calf's protein requirement increases with rate of body weight gain; thus, feeding a conventional milk replacer (containing 20 to 22% CP and 20 to 21% fat) at a greater rate will not supply sufficient protein for lean tissue growth and surplus energy will be converted to fat (Drackley, 2008; Brown et al., 2005). When energy is not limiting, calves have increased lean tissue growth when milk replacer contains 26 to 28% CP, and 15 to 20% fat (Diaz et al., 2001). In comparison, whole milk contains approximately 27% protein and 26 to 28% fat (Appleby, 2001; Shamay et al., 2005).

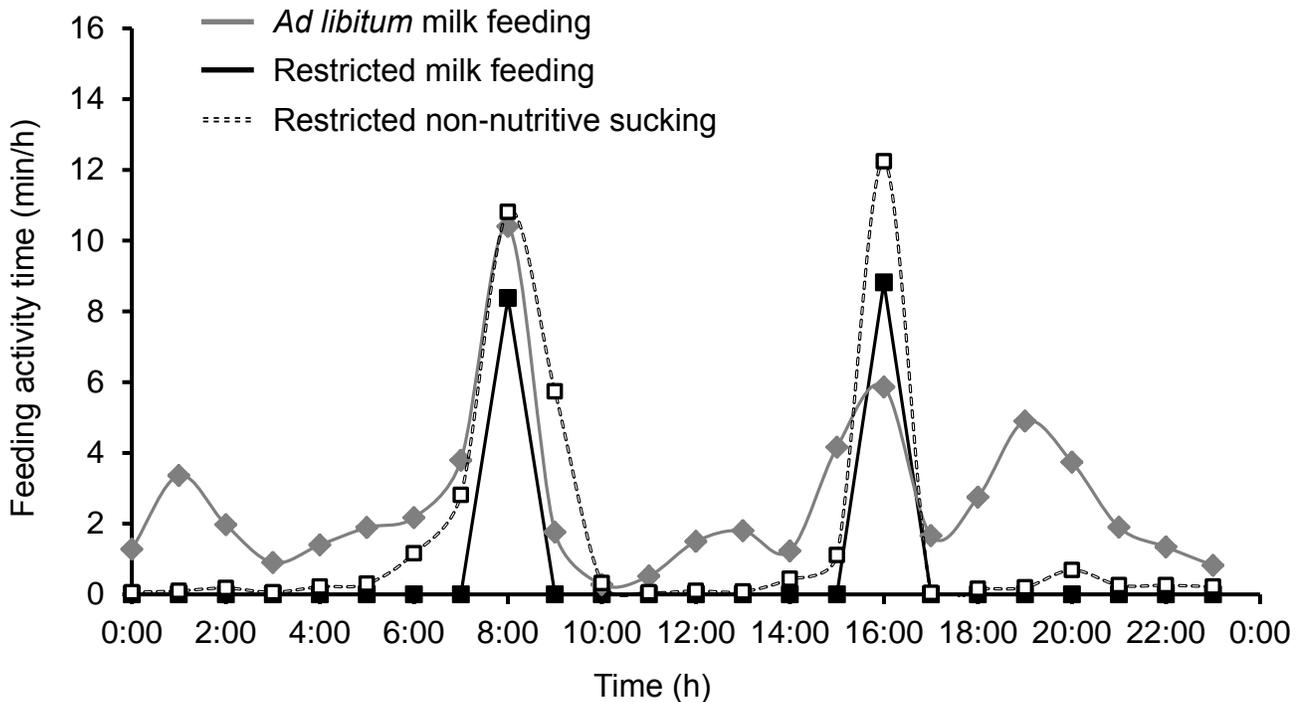
Intensified feeding programs have marked impacts on performance of the calf early in life, including improved rate of weight gain, structural growth, and efficiency of feed conversion (Diaz et al., 2001; Khan et al., 2007). Whereas conventional feeding programs typically support 0.3 to 0.6 kg/d in growth, intensified feeding programs allow weight gain ranging from 0.6 to over 1 kg/d. For calves provided milk *ad libitum*, average daily weight gain is typically between 0.8 and 1.2 kg/d (Appleby, 2001; Miller-Cushon et al., 2013a; Jasper and Weary, 2002). Advantages in structural growth (girth and height) in calves managed in an intensified feeding program have been noted both preweaning and postweaning (Khan et al., 2007).

### ***Feeding behavior patterns and welfare***

In addition to impacting growth, the milk feeding program greatly influences feeding behavior patterns of the calf. Intensified feeding systems, especially those that provide *ad libitum* access to milk or milk replacer, allow calves to exhibit a diurnal pattern of milk intake (Figure 1). Calves provided milk *ad libitum* have peaks of feeding activity at sunrise and sunset, and consume milk in 8 to 10 meals/d (Appleby, 2001; Miller-Cushon et al., 2013a). This pattern of milk intake and resembles the natural behavior of a calf nursing the dam (Lidfors et al., 1994; de Passillé, 2001). In contrast, calves fed according to conventional practice typically receive their milk allotment in two feedings per day (Figure 1), such that total time spent feeding during the day is greatly reduced. For example, calves provided milk at a rate of 5L/d spent about 10 min/d feeding, whereas calves provided milk *ad libitum* spent 45 to 60 min feeding (Appleby et al., 2001; Miller-Cushon et al., 2013a).

Calves fed restricted quantities of milk have frequent unrewarded visits to the feeder (De Paula Vieira et al., 2008; Borderas et al., 2009), suggesting that they are hungry (De Paula Vieira et al., 2008). Further, calves are highly motivated to suck and will spend considerable amounts of time engaged in non-nutritive sucking (Figure 1) when provided restricted amounts of milk. In addition to differences in feeding behavior,

calves provided restricted amounts of milk spent less time lying (Borderas et al., 2009; De Paula Vieira et al., 2008), vocalized more frequently (Thomas et al., 2001), and performed less play behavior (Krachun et al., 2010). Thus, intensified feeding systems have clear welfare implications for the calf, allowing performance of natural feeding behavior patterns and reducing hunger.



**Figure 1.** Diurnal feeding activity of calves provided milk *ad libitum*, and feeding and non-nutritive sucking activity for calves provided restricted amounts of milk (5 L/d). Adapted from Miller-Cushon et al. (2013b).

### Longer-Term Effects of Intensified Feeding

From an economic perspective, motivation for feeding greater amounts of milk to calves depends in part on the potential long-term impacts of this feeding practice on performance of the calf. In controlled studies, early plane of nutrition has been found to have a number of impacts on longer-term production potential. In comparison to providing calves with restricted access to a low-energy milk replacer (23% crude protein, 15% fat), provision of whole milk to calves in *ad libitum* amounts was reported to have a range of long-term positive effects across different studies, including reduced age at conception and calving (Bar-Peled et al., 1997), increased BW at calving (Bar-Peled et al., 1997; Moallem et al., 2010), and improved milk production (Bar-Peled et al., 1997) or milk fat yield (Shamay et al., 2005; Moallem et al., 2010).

Similarly, results of studies comparing different amounts and qualities of milk replacer suggest that an intensified milk replacer feeding program reduces age at first calving (Raeth-Knight et al., 2009; Davis Rincker et al., 2011). Regression analysis of several published data sets suggests a positive impact of preweaning growth on later

milk production, with an improvement in milk production of 225 kg for an increase in pre-weaning average daily gain (**ADG**) of 100 g/d (Bach, 2011). Soberon et al. (2012) also reported a positive correlation between preweaning ADG with first lactation milk yield, suggesting an improvement in milk yield of 850 to 1,113 kg for every 1 kg of preweaning ADG. Davis Rincker et al. (2011) reported an economic analysis suggesting that, although cost of intensified feeding was greater than conventional, total costs by time of first lactation were not different.

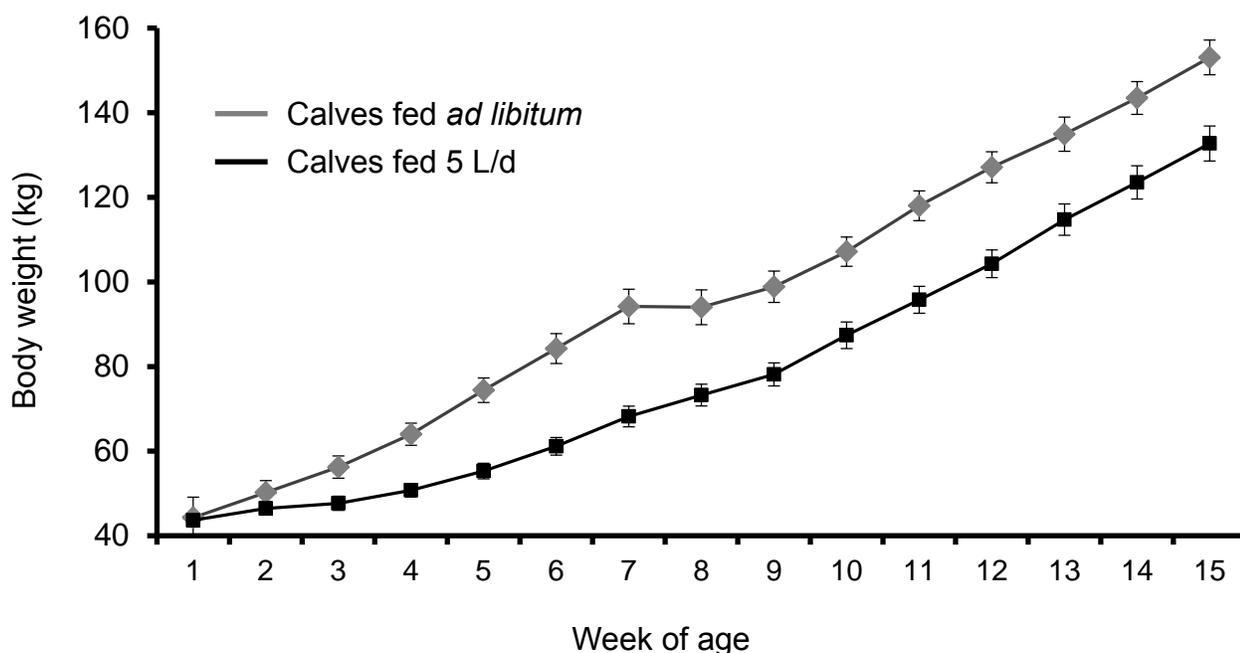
Despite significant effects of intensified feeding programs on feeding behavior of the calf prior to weaning, there is little evidence to suggest that preweaning milk feeding level has a persistent effect on feeding patterns (Miller-Cushon, 2013a). However, Miller-Cushon (2013a) reported that, in the week after weaning, calves previously provided restricted amounts of milk consumed their solid feed more quickly and had larger meals, compared to calves provided milk *ad libitum*. Although differences in meal characteristics did not persist, differences in rates of intake after weaning suggest that previous experience with a restricted feeding scenario may have some impact on feeding motivation.

## **Challenges and Opportunities**

### ***Weaning strategies***

Although intensified feeding programs hold much potential to improve short and long-term performance and welfare of dairy calves, there remain challenges with their implementation. The long-standing popularity of conventional restricted milk feeding programs was based on encouraging solid feed intake early in life and facilitating a smooth transition at weaning. Solid feed intake early in life is critical for rumen development, and consistent weight gain through weaning requires that the calf be consuming sufficient amounts of solid feed prior to removal of milk (Khan et al., 2011a). When provided greater quantities of milk, calves have less frequent and smaller meals of concentrate (Miller-Cushon et al., 2013a). Consequently, rumen development is delayed, such that post-weaning nutrient digestibility is lower in calves provided more milk (Terré et al., 2007; Hill et al., 2010). Thus, a challenge with an intensified feeding program is to support consistent growth through weaning.

Although greater weaning weights as a result of increased pre-weaning nutrition can be maintained into the post-weaning period (e.g. 8 kg weight advantage at 20 d post-weaning (Jasper and Weary, 2002) and 20 kg weight advantage at 56 d post-weaning; Figure 2), these results are not consistent. A number of studies indicate that weight gain of calves provided great quantities of milk may suffer at time of weaning if intake prior to weaning was low. For example, weight gain of calves provided milk replacer *ad libitum* may plateau during weaning whereas restricted-fed calves maintain consistent growth (ADG of -0.03 vs 0.6 kg/d; Figure 2). In some cases, differences in weight gain through weaning negated any body weight advantage arising from the pre-weaning feeding program (Borderas et al., 2009; DePassillé et al., 2011). This suggests that maintenance of greater body weights is extremely sensitive to weaning method.



**Figure 2.** Growth of calves provided milk *ad libitum* or at a restricted level (5 L/d). Adapted from Miller-Cushon et al. (2013b). Weaning occurred during week 7.

The most important aspect of a weaning program is encouraging sufficient intake of solid feed intake prior to removal of milk. A gradual weaning process that encourages greater solid feed intake appears to maintain weight advantages for calves managed in intensified feeding systems. Khan et al. (2007) employed a step-down weaning method, reducing milk quantity 20 d prior to weaning at 7 weeks, and found that calves previously fed milk *ad libitum* maintained a weight advantage 40 d post-weaning. Age of weaning also influences post-weaning performance. de Passillé et al. (2011) reported that calves provided greater quantities of milk had no weight advantage over conventionally-fed calves after abrupt weaning at 7 weeks, but when weaned later (at 13 weeks), calves had begun consuming more solid feed and maintained a weight advantage over calves provided less milk. When considering potential for early growth to improve later production performance, maintaining improved growth through weaning is critical.

### **Solid feed intake and selection**

In addition to the milk feeding program, solid feed provision is an important component of early management. When managed in conventional feeding systems, calves are typically provided *ad libitum* access to a high energy grain concentrate alongside restricted quantities of milk. Early intake of concentrate is critical for rumen development, as rumen papillae development occurs in response to butyrate produced through fermentation of carbohydrates (Warner et al., 1956; Sander et al., 1959). Provision of forage has long been discouraged, out of concern that it will displace

concentrate intake and, consequently, impair rumen development (Hill et al. 2008; Kertz et al. 1979). However, there is evidence to suggest that forage provision does not need to reduce concentrate intake (Khan et al. 2011b; Castells et al. 2012) and, further, may positively impact ruminal environment, reducing acidity of ruminal fluid (Suárez et al. 2007; Khan et al. 2011b) and improving feed efficiency (Coverdale et al. 2004). When offered a choice of hay and concentrate, calves selected a proportion of hay ranging between 5 and 30% of total DM intake (Castells et al., 2012; Miller-Cushon et al., 2013b; Khan et al., 2011b), depending on the type of hay provided and, potentially, other nutritional factors such as milk intake. Selection in favor of hay has been found to decrease after weaning, suggesting that calves may alter dietary selection patterns in response to energy requirements (Miller-Cushon et al., 2013b).

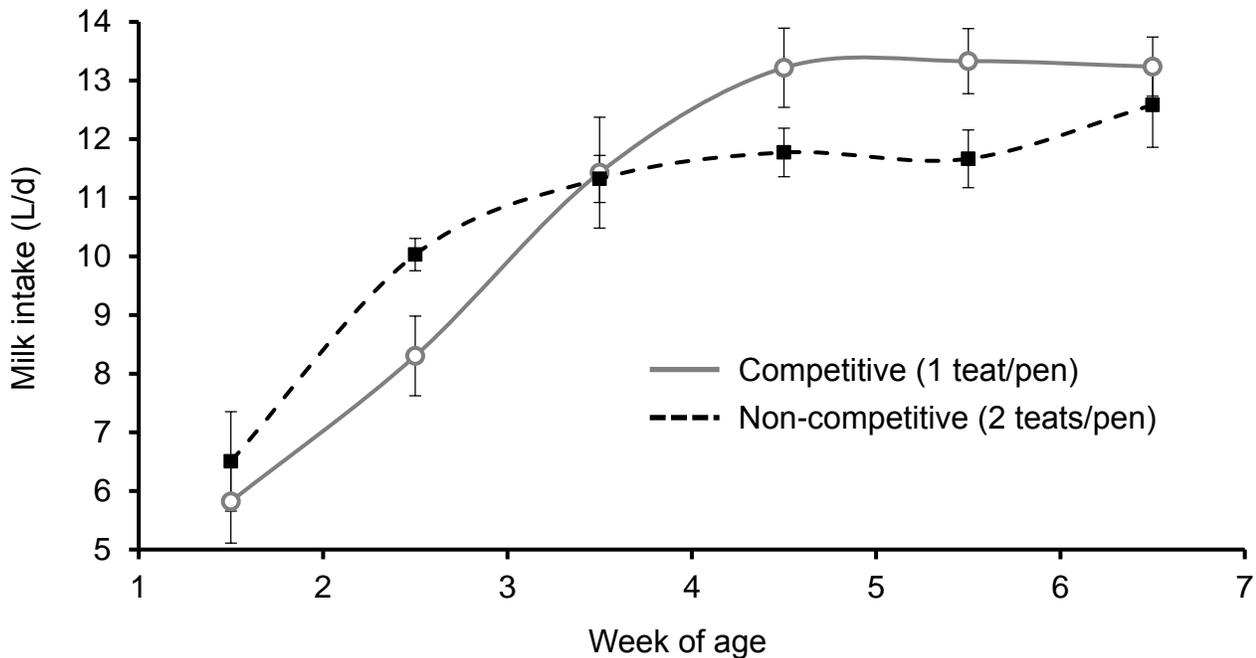
### ***Housing and feeding management***

Implementation of intensified feeding programs can also impact feeding management on a larger scale. Whereas conventionally-raised calves are typically housed individually, intensified feeding systems are often being adopted hand-in-hand with group-housing systems. Group housing of calves allows for the social facilitation of feeding behavior, resulting in calves beginning to consume solid feed earlier in life and consuming more solid feed prior to weaning (Hepola et al. 2006; De Paula Vieira et al. 2010). Group-housed calves also vocalized less during weaning (De Paula Vieira et al., 2010), suggesting that social contact is beneficial during this stressful transition. Calves housed with social contact gain weight more consistently through weaning (Chua et al., 2002), likely due in part to both greater intakes of solid feed prior to removal of milk and reduced stress. Thus, social contact may contribute to a successful weaning transition of calves managed in an intensified feeding program.

A major factor helping the implementation of intensified feeding programs is the growing adoption of computerized calf-feeding systems. These systems reduce the manual labor associated with increasing milk allotments, facilitate group-housing for calves while allowing for monitoring of individual intake, and provide control over feeding patterns and weaning programs. Calves fed by a computerized feeder are typically managed in larger groups, with 10 to 15 calves per feeder (Weber and Wechsler, 2001; Jensen and Holm, 2003). While social contact is valuable in supporting intake early in life, competition for access to artificial teats may be an issue. Even minimal competition for access to artificial teats (1:2 ratio of teat to calf) resulted in reduced milk intake in the early weeks of life for calves fed ad libitum (Figure 3). Further, calves chose to stand and feed at the same time, even when provided a single feeding space (Miller-Cushon et al., 2014), suggesting that calves may be motivated to feed in synchrony rather than adopting different feeding schedules.

Exposure to a competitive feeding environment also has potential to have longer-term impacts on feeding and social behavior. Compared to calves reared in a non-competitive feeding environment, calves reared with restricted teat access were found to persistently displace each other more frequently and consume their feed more quickly after weaning, despite having unrestricted access to feed buckets during the post-

weaning stage (Miller-Cushon et al., 2014). Persistent competitive behavior has potential to pose problems later in life, as competition for access to feed in adult cattle encourages large and infrequent meals (Hosseinkhani et al., 2008; DeVries and von Keyserlingk, 2009), which can negatively affect ruminal pH (Krause and Oetzel, 2006). Thus, as intensified feeding systems are increasingly adopted, further work is encouraged to assess longer-term effects of different management strategies on both performance and behavioral development of dairy calves.



**Figure 3.** Milk intake of calves fed competitively (1 teat/pair of calves) or non-competitively (2 teats/pair of calves). Milk was provided *ad libitum*.

### Conclusions

When managed in intensified feeding systems, calves will consume at least twice the amount of nutrients typically supplied according to conventional feeding strategies. Intensified feeding programs provide a higher plane of nutrition and support greater rates of growth. Feeding behavior is greatly influenced by feeding program, with access to greater quantities of milk allowing the expression of more natural feeding behavior patterns, such as those exhibited by a calf suckling the dam, and reducing behavioral indicators of hunger. Further, greater rates of gain prior to weaning are associated with earlier calving ages and improved milk production, suggesting that there may be a longer-term economic advantage to providing calves with more milk.

In successfully implementing intensified feeding programs, management and housing issues must also be considered. Successful weaning of calves providing greater quantities of milk requires a gradual process of reducing milk intake to encourage sufficient solid feed intake prior to removal of milk. There is also growing

evidence that provision of hay may be beneficial in encouraging greater total intake prior to weaning. Approaches to housing calves can impact outcomes of intensified feeding programs. Social housing for calves encourages greater solid feed intake and reduces stress through weaning. However, competition in group-housed calves may reduce milk intake when access to teats is restricted.

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# **SESSION NOTES**