

THE NEED FOR STIMULATION IN VARIOUS BOVINE BREEDS AND OTHER SPECIES

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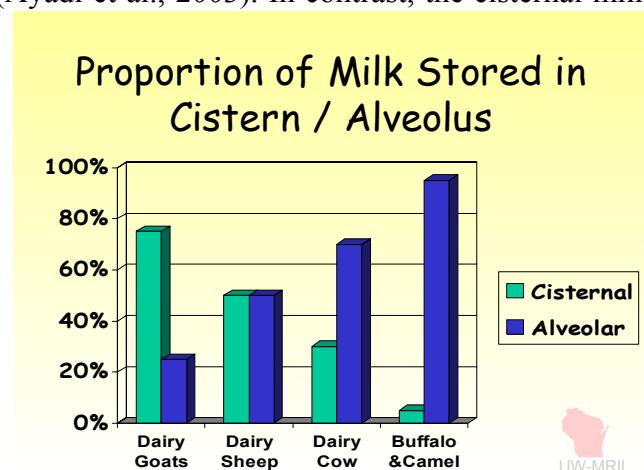
Abstract: A review of the scientific literature on the stimulation requirements for milk ejection in bovines and other species is presented. Differences in cisternal capacity, lactation number, and stage of lactation are known to influence stimulation requirements. The role of calf suckling compared to other types of tactile stimulation in the milk ejection process is discussed for Bovines, buffalo, camels, swine and other species. The results of a field study of the effect of calf suckling on peak milk flow rates are presented.

COMPARATIVE PHYSIOLOGY OF MILK REMOVAL

A common mechanism of milk ejection through the release of oxytocin followed by contraction of myoepithelial cells and removal of the alveolar milk seems to apply to the majority of species studied. However, there are species differences in the need or degree of oxytocin release at milking (Akers, 2002). For instance, two animal models are used to explain the different patterns of the milk ejection reflex. In the rabbit model, initial suckling by the litter induces the release of a single pulse of 20-50 μg oxytocin and milk removal is completed in 2-5 minutes. In the rat model, multiple pulses of 0.5 to 1.0 μg of oxytocin are released at intervals of 5-15 min throughout suckling periods of 30-60 min. The sow's milk ejection is similar to the rabbit model whereas human and ruminants' milk ejection pattern is more similar to the rat model (Cross, 1977).

There are large differences in the proportion of total milk stored within the cistern among ruminant dairy species. Specialized dairy cows store less than 30% of the total milk yield volume in the cistern after a normal milking interval (Ayadi et al., 2003). In contrast, the cisternal milk accounts for up to 75% in dairy goats (Marnet and McKusick, 2001), and in sheep it ranges from more than 50% for dairy breeds (McKusick et al., 2002) to less than 30% for meat breeds (Caja et al., 1999).

It has been argued that milk ejection may not be essential for adequate milk removal in animals that store most of the milk in the gland cisterns (Cross, 1977; and Akers, 2002). However, Marnet and McKusick (2001) state that oxytocin-mediated milk ejection is still of substantial importance in small ruminants for the



extraction of a milk with higher fat content. Although the cisternal compartment stores most of the milk produced in small ruminants, the alveoli retains the majority of the milk fat secreted, which can be only efficiently removed when milk ejection occurs (McKusick et al., 2002).

Buffalo cows have small udder cistern and almost 95% of the milk is stored in the alveolar compartment. As a result, pre-milking stimulation is of extreme importance for optimal milk ejection response in buffalos. Different from cows, the buffaloes' cisternal compartment is more prominent in the teats than in the gland (Thomas et al., 2003). The buffaloes' stimulation for milk letdown requires more time compared to cows, in average 2 minutes. For this purpose, the calf is used, in most cases, when milking is done by hand. However, the practice of using calves is not adopted in some herds where buffalo cows are machine milked in parlors (Svennersten-Sjaunja, 2000).

In camels, the presence of the calf is considered imperative for milk letdown and hand massaging is also used to enhance this response. The milk letdown in this specie is easily noticeable after a short period of suckling (1.5 min) when the teats suddenly swell becoming much larger than before. Because of this fact, some authors have assumed that camels do not have mammary cisterns. The milking needs to be performed soon after teats swelling, since duration of the milk letdown response is also very short, approximately 1.5 min (Yagil *et al.*, 1999).

The pig is one species that possesses 3-10 pairs of mammary glands without cisternae. A study performed to analyze the milk ejection reflex in the sow, found that the whole litter had to be suckling in order to elicit the milk ejection response, which occurred between 2 and 4 min from the onset of the period of initial massage of the udders. The nursing intervals occurred about every 45 min, and lasted only for 8-40 sec (Ellendorff and Poulain, 1984).

STIMULATION REQUIREMENTS FOR MILK REMOVAL IN DAIRY COWS

In dairy cows, suckling, hand and machine milking are known to cause sufficient mechanical stimulation to induce oxytocin response; although the literature reports contrary findings in the differences in intensity of stimulation caused by suckling and milking by machine in cows milked without the presence of the calf. Nevertheless, most authors have agreed that there is a higher oxytocin release in response to suckling as compared with milking in the presence of the calf. In comparison with hand milking, machine milking resulted in a smaller release of oxytocin (Gorewit *et al.* 1992). In a study, suckling and milking during the same period resulted in a poor ejection of milk (Krohn, 2001). Therefore, depending on the type of tactile stimulation of the mammary gland, different responses in oxytocin release will arise (Bruckmaier and Blum, 1998). A good pre-milking procedure is supposed to provide enough stimulation for milk letdown. The extents of hand stimulus effects are variable, possible arising from inter-breed variation in the response to stimuli (Walsh, 1974).

Interestingly, audio stimuli in the form of calf calls were not clearly shown to cause oxytocin release and affect the rate of milk ejection in Holstein cows (Pollock and Hurnik, 1978). Similarly, Mayer *et al.* (1991) did not find any evidence indicating that conditioned

oxytocin release is triggered by audio-visual stimuli. In contrast, Hurley (2002) argues that tactile stimulation of the teat is not essential for oxytocin release and subsequent milk ejection. According to him, approximately 38% of cows release oxytocin by conditioned visual and auditory cues, such as the sights and sounds of the milking parlor.

Mayer et al. (1991) showed no indications of a decrease in the secretion of oxytocin in response to pre-milking stimulation throughout the lactation to a level below the threshold required for milk ejection. However, Bruckmaier and Blum (1998) explain that, because of the reduced volume of milk stored in the udder at the end of lactation, there is an increasing stimulatory requirement to induce milk ejection response, which usually takes longer to occur. For this reason, pre-milking stimulation is even more important during this period.

When a pre-milking stimulation is not correctly done, an insufficient milk ejection response occurs and the milk is incompletely removed from the mammary gland. The larger the residual milk volume, the lower the milk secretory rate. Feedback inhibitor of lactation (FIL) is a milk-borne protein synthesized by secretory cells which has an inhibitory action on the same cells, limiting then further milk secretion (Wilde and Peaker, 1990). FIL is only active in the alveoli, in contact with the secretory cells, and its effect is concentration dependent. Therefore, the distribution of milk between cisternal and alveolar compartment will influence the degree of feedback inhibition in different species (Knight *et al.*, 1994). The excess of residual milk due to the inefficient milking prevents the relief of this FIL at that milking, thus, decreasing the milk secretion for the next milking.

STIMULATION REQUIREMENTS FOR MILK REMOVAL IN CROSSBRED COWS

Bos taurus cows have been intensively genetic selected for milk production for several years compared to *Bos indicus* cows. In genetic improved dairy breeds, suckling, a natural stimulation for milk letdown, was successfully replaced by hand or machine milking stimulation. Perhaps one of the consequences of genetic selection of *Bos taurus* cows was an alteration in the regulation of milk ejection (Tancin *et al.* 2001). Since these cows were also selected for rapid milking and ease of milking, it has been suggested that they probably acquired a reduced dependence of the milk ejection reflex (Akers, 2002).

In the case of cows with Zebu genetics, the successful milk removal may be dependent on higher levels of oxytocin in order to cause an adequate milk ejection response. This may be only achieved when the calf is used to stimulate the cow during the milking. It has been argued in the literature that the productivity of an animal is influenced by its



psychological state, which will be the result of the interaction between the genetic disposition and the environment stimuli (Pollock and Hurnik, 1978).

There is some evidence that the presence of the calf influences regulatory mechanisms related to the secretion and release of oxytocin and milk ejection during machine milking (Akers and Lefcourt, 1982; de Passilé *et al.*, 1997, Tancin *et al.*, 2000 a). From 10 to 20% of the milk in the udder at the start of milking normally remains in the mammary gland as residual milk (Heald, 1985). In two studies, machine milking was showed to leave more residual milk in the udder than hand milking and suckling (Hamann and Tolle, 1980 and Bar-Peled *et al.*, 1995). A comparison study between cows nursing or not their calves during the milking time (de Passilé *et al.*, 1997) showed that the presence of the calf increased significantly the residual milk volume. The authors suggested that the larger amount of residual milk might be a consequence of the significant lower levels of plasma oxytocin found in the nursed group, result that was also observed by another study (Tancin *et al.* 2000 a). A possible explanation is the maternal instinct of the nursed cow, withholding milk for the needs of the calf soon after milking (Bar-Peled *et al.*, 1995).

In cows with a normal lactation, the quantity of residual milk remains relatively constant as the milk yield increases in the first weeks of lactation. In contrast, cows that have a short lactation had a gradual increase in the amount of residual milk throughout their lactations. Some scientists believe that short lactation problems may be a consequence of a deficient milk ejection causing an inefficient milk removal. Poor milk ejection can be due to impaired oxytocin release, mammary insensitivity to oxytocin or to pituitary dysfunction (Murugaiyah *et al.*, 2001). Moreover, cow's temperament can contribute to the impaired milk ejection since stress was found to inhibit oxytocin release (Bruckmaier and Blum, 1998).

An experiment designed to study the effect of calf suckling on the stimulation of milk ejection and milk yield of Zebu type cattle concluded that suckling plus physical contact with the calf led to a higher milk yield than only physical contact with the calf. In turn, cows that had only physical contact with the calf also showed enhanced milk production compared to cows that were not suckled nor had physical contact with the calf (Orihuela, 1990).

In order to evaluate the effect of the calf absence during the milking of crossbred cows on the total lactation production, milk yield from 50 cows in two or three successive lactations were studied. In contrast with the specialized European dairy breeds, in which milk production in the second lactation is usually higher than the first, it was demonstrated that crossbred cows that participated in this study had a linear reduction in milk yield in successive lactations. Besides, the lactation length in the subsequent lactation was also gradually shortened. The authors suggested that this could be attributed to the "special behavior" of crossbred cows being milked without their calves (Alvarez *et al.*, 1980).

However, a study using Friesian x White Fulani cows (halfbreds, 3/4 and 7/8 Friesian genetics) milked without their calves, concluded that milk letdown problems due to the calf absence were not the cause of short lactations (Buvanendran *et al.*, 1981). Wellnitz *et al.* (1999) found that cows of European breeds at different production levels (> 45 kg/d and 25-30 kg/d) but similar stage of lactation (equivalent degree of udder filling) had comparable patterns of milk

ejection. It may not be possible to extrapolate these results to cows with *Bos indicus* genetics because their udder fill, at the same stage of lactation, but considering a different nutritional status, may not be comparable to *Bos taurus* cows.

STUDY OF BRAZILIAN CROSSBRED DAIRY COWS

Brazil has the second largest dairy herd in the world and is the sixth largest milk producing country in the world. While the dairy herds in Europe and the US are based almost entirely on Holstein/Friesian genetics, Indian breeds such as Gir, Guzera, and Nelore are important components of the genetic mix in Brazil. Most Brazilian dairy farms are made up of crossbred cows (mainly Holstein crossed with Zebu breeds). The predominance of crossbred cows in Brazil can be explained by their dual purpose for beef and milk as well as their ruggedness and better adaptability to a tropical environment when compared to purebred Holsteins.

An opinion survey was administered to 135 dairy producers in April 2001 at Agrishow, a major Brazilian agricultural exposition, in order to obtain information on milking, breeding and general management practices and the decision-making framework used by Brazilian dairy farmers. The results of these interviews showed that only 10% of the dairy farmers used pure Friesian-Holstein genetics in their herds and the remaining percentage had crossbred Friesian-Holstein genetics with breeds traditionally used in hot climates.

Approximately 3/4 of producers who had crossbred cows in their herd reported the use of calves for pre milking stimulation. According to these farmers, the presence of calves during milking is important, if not essential, to stimulate the milk letdown of crossbred cows. In addition, the presence of a calf is thought to reduce the aggressive behavior of these cows, thus ensuring easier handling during milking. Some producers indicated that milking crossbred cows without their calves may result in a shortened lactation period, mainly in 1H:1Z cows (50% Holstein and 50% Zebu).

A field survey was done in the months of May, June and July in 2001 and 2002 to quantify the milking characteristics of the crossbred cows typical of the Brazilian dairy herds. Data from 1419 crossbred cows, (426 1H:1Z, 545 3H:1Z and 448 7H:1Z) were collected on 12 farms in the Brazilian states Minas Gerais and São Paulo. Each sub-category (three types of cross, each with and without calf) was represented by at least 3 farms and each farm had at least 2 sub-categories represented. Milk meters were used to record the milk yield of individual cows in one-minute intervals during one morning milking. These data were used to calculate the total yield, total milking time, average flow rate (total yield/total time) and peak flow rate (maximum one minute yield). Statistical analyses of the data were performed using the SAS[®] Mixed Procedure to examine the effect of crossbreed, farm, presence of calf, lactation number, and stage of lactation on the peak milk flow rate and the time to reach peak flow (elapsed time from unit attachment to the peak flow time interval).

The main effect of calf (its presence for pre-milking stimulation) on peak milk flow rate was not significant, although the trend for milk peak flow rate was slightly higher for cows

milked without a calf (Figure 1). As expected, cows with higher percentage of Holstein showed a higher milk peak flow rate as well as higher milk production.

There did appear to be some interactive effects between breed, calf and lactation characteristics. The 7H:1Z cows with calf appeared to have a reduced peak milk flow. For 3H:1Z cows, the presence of the calf was associated with higher milk peak flow rate, but only in the beginning of the lactation. For the 1H:1Z cows, the presence of a calf was associated with a higher peak milk flow rate during the first two thirds of lactation (Costa 2002).

The association between calf and time to peak flow was significant for crossbred categories 3H:1Z and 7H:1Z, with cows with calf reaching peak flow rates sooner. However, this association may not be related to the presence of the calf by itself, since cows milked with calf are typically stimulated for a longer time before the attachment of the milking unit. This same trend appeared for 1H:1Z cows but the difference was not significant. This lack of significance may be a consequence of the small sample size of cows without calves (49), resulting in larger variability and therefore reducing the chances of reaching significance.

For 7H:1Z cows, our results show that the calves may be associated with reduced peak milk flow (inhibiting instead of stimulating the milk letdown) as well as reduced milk harvested by the milking machine (Costa 2003). For 3H:1Z cows, the benefit of using calves is questionable.

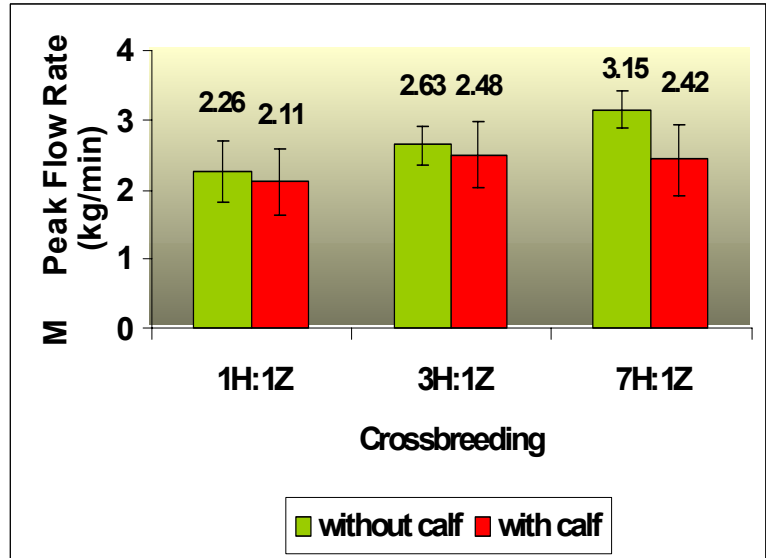


Figure 1. Milk peak flow rate for different crosses with and without calf used for pre-milking stimulation (error bars represent 95% confidence intervals).

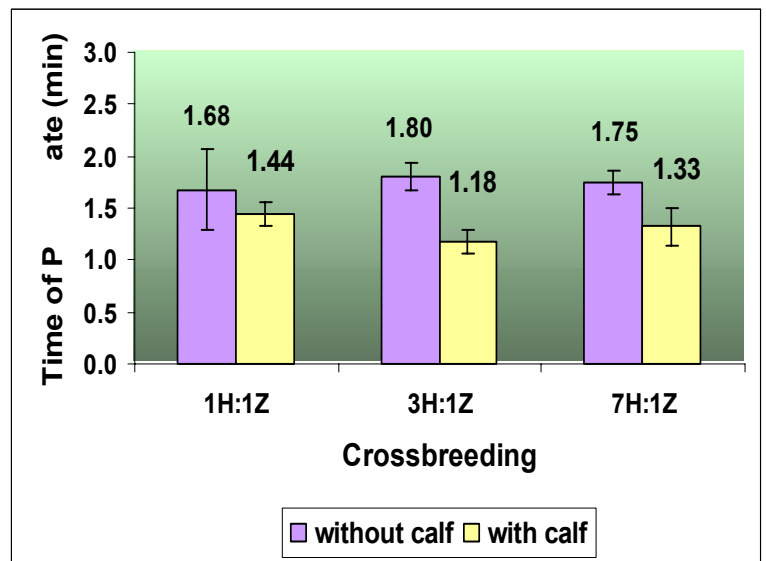


Figure 2. Time to reach milk peak flow in different crosses with and without calf used for pre-milking stimulation (error bars represent 95% confidence intervals)

According to our data, there was an association between the use of a calf and increased peak milk flow but only in the beginning of the lactation period.

Although the overall average of milk peak flow rate for 1H:1Z cows was not significantly different with or without calf, the group with calf had a slightly higher average in the first two thirds of lactation. This fact combined with the producers' opinion that some cows do not have milk letdown without calves could be a consequence of a more developed maternal instinct of Zebu cows. For cows that have this "emotional" blockage, the use of calves may be helpful. Genetic selection may be capable of reducing this effect. The use of a calf may still be desirable however, to keep 50% Holstein:50% Zebu cross cows calm during milking.

The differences observed in the time to reach peak flow are probably due more to differences in the 'prep/lag' time rather than stimulation. It is also difficult to determine how much milk the calf is able to harvest before unit attachment. The harvest of milk by the calf before the milking unit is attached would tend to shift the peak milk flow period earlier in the period of machine milking. Further details of this survey including milk quality and milk yield are presented by Costa (2003).

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