

## **Early weaning: new insights on an ever-persistent problem in the dairy industry**

Tomislav Mikuš, Rok Marzel, Ornella Mikuš

### **SUPPLEMENTARY FILE**

#### **Literature Search methodology**

The authors collected 147 scientific research and review papers from online international scientific databases (Web of Science, Scopus, Google Scholar). Keywords were preselected focusing on the criterium to review novel practices in addressing early weaning issues, but also taking into account a possible broader list of keywords. Therefore, keywords for data collection were selected individually or combined as follows:

1. Early weaning/weaning
2. dam-calf/cow-calf
3. pair housing/dual housing
4. weaning system/rearing system
5. novel practice/approach
6. dairy calf enrichment
7. policy/dairy sector/animal welfare/animal ethics
8. economic effects/cow-calf separation/weaning
9. consumers/animal welfare/animal ethics/cow-calf separation

The literature search focused on all dairy farm systems, excluding no methods of keeping. The initially generated list of all papers is available upon request from the authors. Further paper selection was based on the examination of the papers' contents and evaluation of whether papers were actually usable for the purposes of this review. Selected papers were grouped into the three major categories *Calves-only Systems*, *Policy and Economics* and *Cow-Calf Rearing Systems*. The first two categories are directly related to early weaning and are discussed in the main article. The third category together with its references is covered here and is also the focus of the papers contained in the second section of this Special Issue, which is dedicated to the issue of cow-calf contact.

## **Calf-cow rearing systems**

In the course of the last couple of years, a number of studies examined possible solutions, benefits and deficiencies of keeping calves and cows together. By eluding early weaning in the first hours after parturition, these rearing systems allow, for both cow and calf, the expression of positive behaviour and their normal psychological and social development. Following a careful review, the authors divided these systems into two major groups – *free access cow-calf systems* which allow cow and calf full-time contact, and systems that allow cow-calf contact only a few times per day – *limited access cow-calf systems*.

### *Free access cow-calf rearing systems*

Keeping a calf and cow together is the most natural way of rearing, largely similar to traditional farming. In general, these systems imply that cow and calf will be kept together in close proximity throughout the day, for a period of 6 to 12 weeks after birth. By further division within this group we can discern two systems: dam-calf system and foster cow system. Both of them are feasible in different farm management systems as reviewed by Johnsen *et al.* (2016).

### Dam-calf system

Regarding the behavioural benefits, in this management system the cow is free to express her maternal behaviours (i.e. licking, rubbing, nursing) which are of the utmost importance for further development of the dam-calf bond. Licking starts in the first moments of a calf's life

(Houwing *et al.* 1990.; Vandenheede *et al.* 2001) and becomes the dominant maternal behaviour in the first couple of hours post-partum, continuing to be one of the most important positive social behaviours throughout the animal's life (von Keyserlingk & Weary, 2007; Wagenaar & Langhout, 2007). As nursing frequency is regulated by the calf and the cow themselves, it allows for the calf to receive a higher amount of milk which is beneficial for the calf's growth rate (Grøndahl *et al.*, 2007; Meagher *et al.* 2019), and potentially better milk yield in the first lactation of future heifers (Shamay *et al.* 2005; Brouček *et al.* 2006). This system also has a positive health effect on the dam and the calf (Asheim *et al.* 2016), and it has been proven to reduce stereotypic behaviours such as cross- and nonnutritive suckling and tongue rolling among calves (Roth *et al.* 2009; Veissier *et al.* 2013).

However, the dairy industry's focus is milk production and for now there is no feasible management option that would allow joint holding of dams and calves until natural weaning. In this presented system the calf is weaned from the dam at around 6-12 weeks of age, but even that has a negative economic impact for high-yielding dairy cows (Kišac *et al.* 2011). Kišac *et al.* (2011) further recommends that for highly productive dairy cows, keeping the calf with the dam should not last longer than 21 days after birth. According to literature, weaning at that economically appropriate age has negative behavioural effects as well, such as frequent, high pitched vocalizations and poor weight gain (Hepola *et al.* 2007; Johnsen *et al.* 2015a).

### Foster cow systems

The main difference between the foster cow system and the dam-calf system is the number of suckling calves. The foster cow system implies that one cow will nurse 2-4 calves out of which none needs to be her own. The system can be a continuation of the dam-calf system when calves are kept with the dam for the first week(s) after birth and then transferred to a foster cow. Several studies show that there are beneficial effects on the calf due to group housing and social interactions between the cow and other calves (Wagenaar & Langhout, 2007; Buchli *et al.* 2017), but challenges such as non-acceptance of the alien calves and weak bonding with some calves still persist (Loberg, 2007). Per Johnsen *et al.* (2016) data regarding the weight gain of calves are not very consistent, especially when the foster cow has lower milk yield. Additionally, the same author stated that studies on solid feed intake and post-weaning performance of fostered dairy calves are scarce.

As well as in the single calf system, calves and cows in the foster cow system show signs of post-weaning stress. In order to avoid the aforementioned stress, several studies by Loberg *et al.* (2007a; 2008) suggest a two-step weaning system using nose-flaps.

#### *Limited cow-calf systems*

The second group of cow-calf management systems are limited cow-calf systems, wherein it is implied that the time which the cow and the calf spend together is restricted to several hours, or as short as 30 minutes per day. These systems are applied in different management systems worldwide, from the tropical areas (Fröberg *et al.* 2008) to the Mediterranean (Mikuš, 2018), Central and Northern Europe (Johnsen *et al.* 2015a; 2016). Although traditionally these systems were demanding for the farmer, given the need to repeatedly bring and separate the calves to and from the cows, several research papers show that such management can be implemented in automated systems, which certainly can make them more attractive to the dairy industry (Roth *et al.* 2009; Johnsen *et al.* 2016).

Behavioural benefits and strong bonding between cow and calf can be acknowledged in all limited systems, from those where cow and calf are kept together for two short (15-30 minutes) suckling sessions per day (Fröberg *et al.* 2008; Roth *et al.* 2009), to the systems where cow and calf spend 12h per day together (Veissier *et al.* 2013; Johnsen *et al.* 2015). These systems somewhat imitate natural maternal behaviour in which a cow after calving leaves the calf and rejoins the herd while the calf waits on her return (Langbein & Raasch, 2000). We can therefore assume that the strong bonding behaviour described by the literature reviewed in this section after a period of separation restores the mother-calf bond. This relationship develops even if there is no suckling, but only in social interactions between dam and calf (Johnsen *et al.* 2015) and can lead to a reduction in stereotypical behaviours such as cross suckling (as reviewed by Johnsen *et al.* 2016).

Studies regarding growth rates and other physiological benefits suggest that even in short suckling periods calves are able to ingest large amounts of milk (de Passillé *et al.* 2008). More in-depth research is needed to determine the exact benefits and disadvantages during the pre- and post-weaning periods in this rearing system as studies are still inconclusive (as reviewed by Johnson *et al.* 2016).

## References

- Asheim LJ, Føske Johnsen J, Havrevoll Ø, Mejdell CM & Grøndahl AM 2016 The economic effects of suckling and milk feeding to calves in dual purpose dairy and beef farming. *Review of Agricultural, Food and Environmental Studies* **97** 225-236
- Brouček J, Arave CW, Kisac P, Mihina S, Flak P, Uhrincat M & Hanus A 2006 Effects of Some Management Factors on Milk Production in First-calf Heifers. *Asian-Australasian Journal of Animal Sciences* **19** 672-678
- Buchli C, Raselli A, Bruckmaier R & Hillmann E 2017 Contact with cows during the young age increases social competence and lowers the cardiac stress reaction in dairy calves. *Applied Animal Behavior Science* **187** 1-7
- de Passillé AM, Marnet P-G, Lapierre H & Rushen J 2008 Effects of twice-daily nursing on milk ejection and milk yield during nursing and milking in dairy cows. *Journal of Dairy Science* **91** 1416-1422
- Fröberg S, Gratte E, Svennersten-Sjaunja K, Olsson I, Berg C, Orihuela A, Galina CS, García B & Lidfors L 2008 Effect of suckling ('restricted suckling') on dairy cows' udder health and milk let-down and their calves' weight gain, feed intake and behaviour. *Applied Animal Behavior Science* **113** 1-14
- Grøndahl AM, Skancke EM, Mejdell CM & J.H. Jansen JH 2007 Growth rate, health and welfare in a dairy herd with natural suckling until 6–8 weeks of age: a case report. *Acta Veterinaria Scandinavica* **49** 16
- Hepola H, Raussi S, Veissier I, Pursiainen P, Ikkeläjäarvi K, Saloniemi H & Syrjälä-Qvist L 2007 Five or eight weeks of re-restricted suckling: Influence on dairy calves' feed intake, growth and suckling behaviour. *Acta Agriculturae Scandinavica - Section A: Animal Science* **57** 121-128
- Houwing H, Hurnikn JF & Lewis J 1990 Behavior of periparturient dairy-cows and their calves. *Canadian Journal of Animal Science* **70** 355-362
- Johnsen JF, de Passillé AM, Mejdell CM, Bøe KE, Grøndahl AM, Beaver A, Rushen J & Weary DM 2015 The effect of nursing on the cow-calf bond *Applied Animal Behavior Science* **163** 50-57

- Johnsen J.F., Ellingsen K., Grøndahl A.M., Bøe K.E., Lidfors L & Mejdell CM 2015a The effect of physical contact between dairy cows and calves during separation on their post-separation behavioural response. *Applied Animal Behavior Science* **166** 11-19
- Johnsen JF, Zipp KA, Kälber T, de Passillé AM, Knierim U, Barth K & Mejdell CM 2016 Is rearing calves with the dam a feasible option for dairy farms? - Current and future research. *Applied Animal Behavior Science* **181** 1-11
- Kišac P, Brouček J, Uhrinčat' M & Hanus A 2011 Effect of weaning calves from mother at different ages on their growth and milk yield of mothers. *Czech Journal of Animal Science* **56** 261-268
- Langbein J & Raasch M L 2000 Investigations on the hiding behaviour of calves at pasture. *Archives Animal Breeding* **43** 203-210
- Loberg JM 2007 Behaviour of Foster Cows and Calves in Dairy Production. *Doctoral thesis*. Faculty of Veterinary Medicine and Animal Science, Swedish University of Agricultural Sciences, Skara, Sweden
- Loberg JM, Hernandez CE, Thierfelder T, Jensen MB, Berg C & Lidfors L 2007a Reaction of foster cows to prevention of suckling from and separation from four calves simultaneously or in two steps. *Journal of Animal Science* **85** 1522-1529
- Loberg JM, Hernandez CE, Thierfelder T, Jensen MB, Berg C & Lidfors L 2008 Weaning and separation in two steps—a way to decrease stress in dairy calves suckled by foster cows *Applied Animal Behavior Science* **111** 222-234
- Meagher RK, Beaver A, Weary DM, von Keyserlingk MAG 2019 Invited review: A systematic review of the effects of prolonged cow-calf contact on behavior, welfare, and productivity. *Journal of Dairy Science* **102** 5765-5783
- Mikuš, T 2018 The effect of dairy cow age and calf sex on the level of stress during early weaning. *Doctoral thesis*. Faculty of Veterinary Medicine, University of Zagreb, Zagreb, Croatia
- Roth BA, Barth K, Gygax L, Hillmann E 2009 Influence of artificial vs. mother-bonded rearing on sucking behaviour, health and weight gain in calves. *Applied Animal Behavior Science* **119** 143-150
- Shamay A, Werner D, Moallem U, Barash H & Bruckental I 2005 Effect of nursing management and skeletal size at weaning on puberty, skeletal growth rate, and milk production during first lactation of dairy heifers. *Journal of Dairy Science* **88** 1460-1469

- Vandenheede M, Nicks B, Desiron A, Canart B 2001 Mother–young relationships in Belgian Blue cattle after a Caesarean section: characterisation and effects of parity. *Applied Animal Behavior Science* **72** 281-292
- Veissier I, Care S & Pomies D 2013 Suckling, weaning, and the development of oral behaviours in dairy calves. *Applied Animal Behavior Science* **147** 11-18
- von Keyserlingk MAG & Weary DM 2007 Maternal behavior in cattle. *Hormones and Behavior* **52** 106-113
- Wagenaar JP & Langhout J 2007 Practical implications of increasing ‘natural’ living’ through suckling systems in organic dairy calf rearing. *Netherlands Journal of Agricultural Science* **54** 375-386