Report: Deliverable 2.1 Keeping cow and calf together – impacts on animal performances, behaviour, welfare and farm economy (INRAE, SLU)

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1. Research question

The most promising practices allowing cow-calf contact (CCC) identified in the surveys made at an EU scale in WP1 were implemented in on-farm trials in FR and SE. The goals were to quantify the consequences of CCC practices on cows' milk production and composition, reproductive performance, changes in body weight and condition, health and stress at weaning as well as calves' weight gains, health and stress at weaning. In all trials the CCC practices were compared against a control method (where cows and calves are separated within 24 h after birth) in the same herd. Finally, the ultimate goal was to estimate the labour demand for the different CCC practices as well as their economic consequences.

This deliverable reports the main results obtained in the experiments made in France and in Sweden.

2. Experiments made in France

In FR, according to the most promising cow-calf-contact (CCC) methods identified in WP1, 3 trials were implemented at an INRAE experimental farm. We tested reuniting calves and dams for short durations (20 min before or 2.5 h after morning milking) in Trial 1 and for long durations: 9 h between the morning and evening milkings in Trial 2 and 6 h between the morning and evening milkings until 3 weeks of age or until weaning in Trial 3. In all trials, each CCC practice was applied on a group of 14 dam-calf pairs (7 Holstein [Ho] and 7 Montbéliarde [Mo]). Control-calves were separated from their dam at birth and feed with tank milk provided by an automatic milk feeder at 13-14% of their body weight. All calves were weaned at the age of 11-12 weeks, at a weight of at least 100 kg. In trials 1 and 2, all male and female calves were reared with the dams until weaning whereas in trial 3, 5 male calves (out of 14) were sold after 3 weeks.

2.1 Trials 1 and 2

Results obtained in Trials 1 and 2 were included into a manuscript submitted to the journal "Animal" on the 17 of December 2021. The summary is reported in italics hereafter and the full text is available at https://orgprints.org/id/eprint/42896/.

Calves in most European dairy farms are separated from their dams either immediately or within a few hours after birth, prompting increasing society concern on animal welfare reasons. The aim of this study was to identify practices to maintain cow-calf contact (CCC) that balance the benefits for calf growth and *health against the negative impacts on sellable milk and stress at weaning. We tested reuniting cows and calves for 20 min before (Before-group) or 2.5 h after (After-group) morning milking (Trial 1) or for a 9 h period between the morning and evening milkings (Dam-group, Trial 2). Control-calves were separated from their dam at birth and artificially suckled with tank milk provided daily at 13% (Trial 1) and 14% (Trial 2) of their body weight. In both trials, each practice was applied on a group of 14 dam-calf pairs (7 Holstein [Ho] and 7 Montbéliarde [Mo]). All calves were weaned from the age of 11 weeks at a weight of at least 100 kg. In Trial 1, the After-group was prematurely stopped when the calves were 8 weeks of age as calf growth became limited (318 g/d) due to low milk intakes (3 kg/d). During the first 8 weeks of lactation, milk yield at the parlour was 29%, 51% and 42% lower in After-, Before and Dam-cows respectively. From Week 14 to 16 when all calves were separated from their dam, before-cows still produced 25% less milk than Control-cows while Dam-cows reached the milk yield of Control-cows within a week. Milk protein content was 2.1 g/kg higher in Before-cows and 1.3 g/kg higher in Dam-cows while milk fat content was 3.2 g/kg higher in Before-cows but 5.2 g/kg lower in Dam-cows compared to Control-cows. There were no significant differences in milk Somatic Cells Counts (SCC) and in frequency of cow and calf health events between suckling and control groups. Compared to Control-calves, calf growth until weaning was higher in the suckling calves in Trial 1 (873 vs. 702 g/d) and similar in Trial 2 (935 vs. 928 g/d). At weaning, Before- and Dam-calves started to vocalize earlier and continued to vocalize longer than controls. In conclusion, the best compromise between cow milk yield and calf growth is a long period of CCC (9 h) between the morning and evening milkings. Still abrupt weaning stresses both cows and calves even if CCC has been restricted before separation.*

2.2 Trial 3

2.2.1. Animal performances

Results related to animal performances obtained in Trial 3 were summed up into a 4-pages conference paper presented at the Video Pre-Conference on Animal Husbandry on the 21-22 September 2020. The summary is reported hereafter in italics and the full text is available at https://orgprints.org/id/eprint/40425/.

In organic dairy farms, cow-calf contact is encouraged until weaning and requested by society. However, farmers question this practice, especially because of the loss of marketable milk. At INRAE experimental farm 'Herbipole', we tested two different suckling strategies on animal performance and behaviour. A 14-cow 'Classic' rearing system (C group) was compared during 14 weeks to two suckling systems. In the C group, calves were separated from dams immediately after birth and fed with an automatic milk feeder until weaning. In the 'Dam' group (D), dam-calf contact was allowed from birth to weaning, between morning and evening milking. In the 'Mixed' group (M), calves were kept with dams until three weeks (as in D group) before being separated and reared as in C group. All calves were weaned at about 11 weeks. On average, over 14 weeks, D and M cows produced 25.1% less milk at parlour than C cows; milk fat content was 3.6 g/kg lower in D group compared to C and M, and milk protein content was intermediate between C and M. After 11 weeks, D-calves weighed 20.5 kg more than C and M calves. Cows and calves both vocalised for one week after separation or after weaning. All calf vocalisations were at a maximum during the first four days. Cows' vocalisations were less notable when calves were removed after three weeks compared to 11. In conclusion, a three-week suckling period seems better for farmers' income and cows' distress, but it induces stress for calves at both separation and weaning, without benefit on growth.

During the 16 weeks of the trial, the frequency of health disorders was not significantly different between groups of cows and calves. The number cows with at least one reproductive disorder was 5, 3 and 2 in Control, Dam and Mixed cows respectively and the number of non-reproductive disorders (including mastitis and lameness) was 4, 3, 4 in Control, Dam and Mixed cows respectively. The number of calves with at least one respiratory disorder was 1, 3, 2 in Control, Dam and Mixed calves respectively and the number of calves with at least one non-respiratory disorder (including diarrhoea) was 4, 1, 3 in Control, Dam and Mixed calves respectively.

2.2.2. Blood metabolites

Research Question:

In Trial 3, additional measurements on cow blood metabolites (not reported into the previous publication), were made in order to try to answer the question: "does the energy balance of the suckled cows explains their higher milk protein content?". Our hypothesis was that, because suckling cows produced less total milk (suckled + milked) (see the full paper on Trials 1 and 2) and presumably had similar feed intake, their energy balance was probably higher than that of Control-cows. This could explain the higher milk protein content of suckling cows as energy balance is one of the main drivers of milk protein content. In addition, this hypothesis was supported by the higher BCS of Dam-cows found in Trials 2 and 3 but this hypothesis has never been tested. We focused on blood variables (glucose, NEFA, BHB) that reflect the rate and extent of tissue mobilization and therefore that can be used to predict the energy status of the animal (Larsen et al., 2016).

Material and Methods:

In order to go one step further, we took blood samples from the tail vein after the morning milking with EDTA containing tubes (Terumo France, Guyancourt, France) at weeks -1 (before calving), 3 (all calves suckling), 10 (before weaning) and 13 (after weaning) after calving. Samples were centrifuged at 1,200 × g for 20 min at 4°C and the obtained plasma immediately stored at −20°C. After thawing, the plasma concentrations of non-esterified fatty acids (NEFA; Kit NEFA-HR2, Fujifilm WAKO), glucose (Kit 981379, ThermoScientific), urea (Kit 981818, ThermoScientific) and BHB (Kit 984325, ThermoScientific) were analyzed on a chemistry analyzer (Arena 20 XT Chemistry System, ThermoScientific, Walthan).

The data were analyzed using the MIXED procedure of the SAS 9.4 software package (SAS Institute Inc., Cary, NC). Cows were considered as statistical unit and used in the models as random factors. The model took into account the effects of CCC practice (Control group and two suckling groups), breed (Ho or Mo) and interactions group × week of lactation as fixed factors, week of lactation (3, 10, 13) as repeated factor and results obtained one week before calving as covariate. For all data, normality of residuals was checked using the Shapiro-Wilk test.

Results and discussion:

Significant Week effects were observed for plasma NEFA, BHB and Glucose concentrations while CCC practice had no significant effect on plasma metabolites (Table 1). Plasma NEFA and BHB significantly decreased from Week 3 to Week 10 and 13 (Figure 1) while plasma glucose decreased from week 3 to 10 and increased from week 10 to 13 (result not shown).

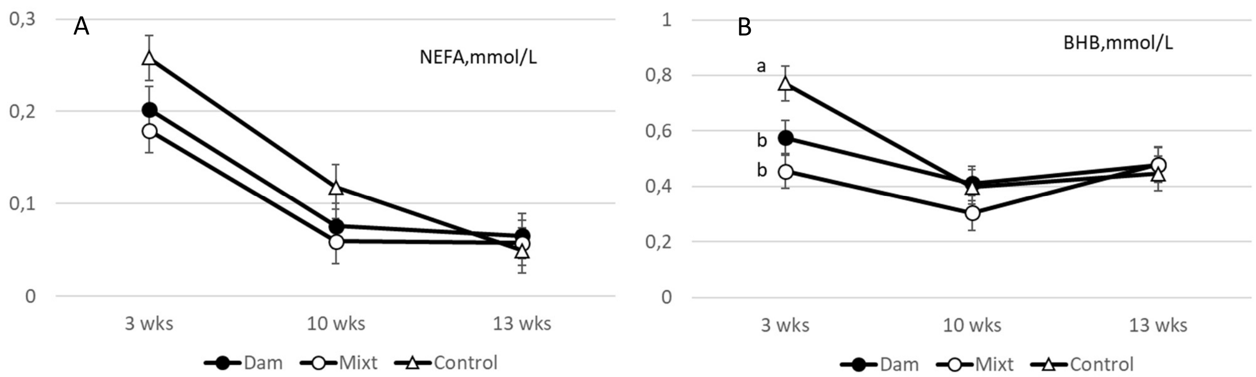
The higher plasma concentrations of NEFA and BHB observed in Week 3 were expected because cows were at lactation peak, when the energy balance is the most negative. Indeed, the higher plasma NEFA concentration observed in Week 3 reflects directly lipomobilisation (Chilliard et al., 2000) that remained relatively low in comparison to other studies where severe undernutrition was applied (Billa et al., 2020). As plasma BHB originates in part from rumen butyrate, (Miettinen and Huhtanen, 1996), its higher concentration observed in Week 3 probably reflects concomitant modifications of intake, possibly lower in week 3, and ruminal butyrate synthesis as well as incomplete β-oxidation of mobilized NEFA. The plasma BHB concentrations remain nevertheless below the 1.2 mmol/L threshold of subclinical ketosis (LeBlanc et al., 2005) except for one cow from the Control group in week 3 (2.16 mmol/L).

Table 1. Effect of CCC practice (Dam, Mixt, Control - P), animal breed (Holstein, Montbéliarde - B) and week post calving (3, 10, 13 - W) on blood plasma metabolites of cows.

	CCC Practice (P)				Significance			
	Dam	Mixt	Control	SEM	P	B	W	PxW
Blood plasma metabolites								
NEFA (mmol/L)	0.11	0.10	0.14	0.015	0.16	0.07	<0.001	0.36
BHB (mmol/L)	0.49	0.51	0.54	0.058	0.10	0.60	<0.001	0.048
Glucose (g/L)	0.45	0.42	0.46	0.016	0.14	0.05	<0.001	0.57
Urea (g/L)	0.19	0.20	0.23	0.011	0.11	0.03	0.27	0.77

None of the CCC practices affected significantly plasma metabolites but plasma BHB concentration was higher in Week 3 in the control group in comparison to the two CCC groups (significant interaction, Figure 1b). As animal feeding was similar in the 3 groups of cows, this higher plasma BHB concentration could reflect an incomplete β-oxidation of higher amount of NEFA mobilized by Control cows. However, our hypothesis of a lower energetic balance of Control cows is not validated by plasma NEFA that were not significantly higher in Control cows during week 3 despite the numeric differences observed (Figure 1a).

Figure 1. Evolution from week 3 to week 13 of concentration in NEFA (A) and BHB (B) in cows plasma according to CCC practice (Dam, Mixt, Control - P).



In conclusion, the analyses of the blood plasma metabolites made in this study do not confirm our hypothesis that CCC cows have a higher energetic balance at lactation peak that could explain their higher milk protein content. The latter could be the consequence of a dilution effect as the total milk production of CCC cows is lower from week 1 to week 8 (see results from Trial 1 where total milk production was estimated thanks to the measurement of milk drunk by calves).

2.2.3. Hair cortisol

Research Question:

Cortisol, also sometimes called the stress hormone, has been increasingly used as a biomarker of stress in animal blood (Romero, 2004). In contrast to cortisol concentration in blood, saliva, faeces, urine and milk, hair cortisol concentration is a marker of chronic stress that reflects a period of weeks or months (Comin et al., 2011; Meyer and Novak, 2012). As hair cortisol concentration is not likely to be affected by manipulation during sampling and daily physiological or acute changes, hair cortisol seems to be an interesting non-invasive biomarker of chronic stress and has already been associated with housing, management and handling of animals (Heimbürge et al., 2019). However, hair cortisol varies in bovine hair according to a number of fixed factors including age, parity, breed, environment, season, body region and hair colour (Vesel et al., 2020) which make difficult the definition of thresholds for the qualification of chronic stress. Nevertheless, hair cortisol was successfully related to different stressful conditions including late pregnancy, beginning of lactation, diseases, high stoking density or changes of environment (Vesel et al., 2020).

In order to compare the chronic stress level of calves reared or not with their dam until weaning, cortisol measurements in the hair of the calves were performed just before weaning (60.3 ±4.3 days) and about 4 weeks after weaning (29.9 ±0.3 days) in Trial 3 (Volame 3). See details paragraph 2.2.

Material and Methods:

For each sample, a few grams of clean hair was collected from the animal's shoulder using an electric clipper. The individual samples were stored at room temperature in envelopes, protected from light, until the cortisol analysis. The analysis was carried out at Swedish University of Agricultural Sciences (Department of Clinical Sciences, 750 07 Uppsala, Sweden) using Salimetrics ELISA kit https://salimetrics.com/wp-content/uploads/2018/03/salivary-cortisol-elisa-kit.pdf. After log10 transformation and removal of two outliers, the data were analysed by analysis of variance (SAS GLM procedure). The model took into account the rearing practice (Group of calves: Control, Dam, Mixt), the sex (male, female) and the breed of calves (Holstein, Montbéliarde), and for the pre-weaning measurement the age at sampling as a covariate.

Results and conclusions:

Hair cortisol content measured just before weaning was significantly lower in calves reared with their dam until weaning (Dam group) than in calves separated at birth or after 3-4 weeks (-26.1% at 19.9 pg/mg; Table 2). Four weeks after weaning, this difference tended to persist (-27.8% at 11.2 pg/mg). These results confirm that during the pre- and post-weaning period, the level of stress of calves reared with their dam until weaning seems to be lower than the level of stress of calves reared without their dam. This result was obtained even thaw calves reared with their dam had a stressful abrupt weaning that was confirmed by their earlier and longer vocalizing period, in comparison to controls calves at weaning. Dam calves had presumably also a higher level of activity as they were grazing with their dam during the pre-weaning period, contrary to Mixt and Control-calves that stayed inside the barn in their collective pen until weaning. Change from winter indoor to summer pasture was shown to increase hair cortisol level (Comin et al., 2011; Peric et al., 2017) which reinforce the conclusion that the level of stress of calves reared with their dam until weaning is lower than the level of stress of calves reared without their dam. In addition, female calves had a lower hair cortisol level than male calves after weaning (11.0 vs 17.4 pg/mg).

Table 2. Effect of CCC practice (Dam, Mixt and Control), Breed (Holstein and Montbéliarde) and Calves' sex (Male, female) on claves' hair cortisol. Hair samples were taken on 9 calves per CCC practice before weaning (60.3 ±4.3 days) and 4 weeks after weaning (29.9 ±0.3 days)

	CCC Practice (P)				Significance		
	Dam	Mixt	Control	SEM	Practice	Breed	Sex
Hair cortisol (log10 pg/mg)							
Before weaning	1.44b	1.42a	1.30a	0.036	0.02	0.28	0.28
After weaning	1.05	1.17	1.20	0.051	0.08	0.37	0.01

2.2.4. Cow reproductive performances

Research Question:

The aim of this work was to check if the reproduction performances of cows were affected or not by calves sucking. Previous studies, reviewed by Krohn (2001), showed that suckling postpone normal follicle activity and heat behaviour until after weaning, which results in a significant lengthening of the post-partum anoestrus interval. Nevertheless, Krohn (2001) concluded that suckling does not affect the number of empty days nor the calving interval because of a relatively higher fertility of the cows when the calves are removed. Considering that within trials the number of cows was too limited to draw any conclusion, we merged all the data from the different trials organised within ProYoung Stock in order to confirm or not the previous conclusions on a high number of animals.

Material and Methods:

We have collected reproduction data from five dairy farms in three countries (FR, CH, SE) where some of the female calves (that will become the future heifers of the farm) are suckled by their dam for several weeks. On each farm, we collected data on approximately equivalent numbers of cows that suckled their calves and those that did not: FR = 98 vs 69; CH = 26 vs 27; SE = 18 vs 21.

After checking, eliminating and correcting some data, we performed Chi-square tests on binary data (yes/no) of "pregnancy" and "new calving" [total data, by type of suckling (short duration/day) and by parity (primiparous/multiparous]) as well as analysis of variance (SAS GLM) for the different intervals, considering type of suckling and parity in the model.

Results and discussion:

We found no significant difference between the cows that suckle their calves and those that did not. The proportion of pregnant cows and the new calvings were similar in Control and Dam cows (Figure 2 A) as well as the intervals between calving and 1st insemination, calving and fertilizing insemination and calving and next calving. The interval between calving and 1st insemination was longer in primiparous than in multiparous cows (Table 3 and Figure 2B) and interestingly we found significant interactions between groups and parity for the intervals between calving and fertilizing insemination and calving interval (Table 3 and Figure 2C and 2D).

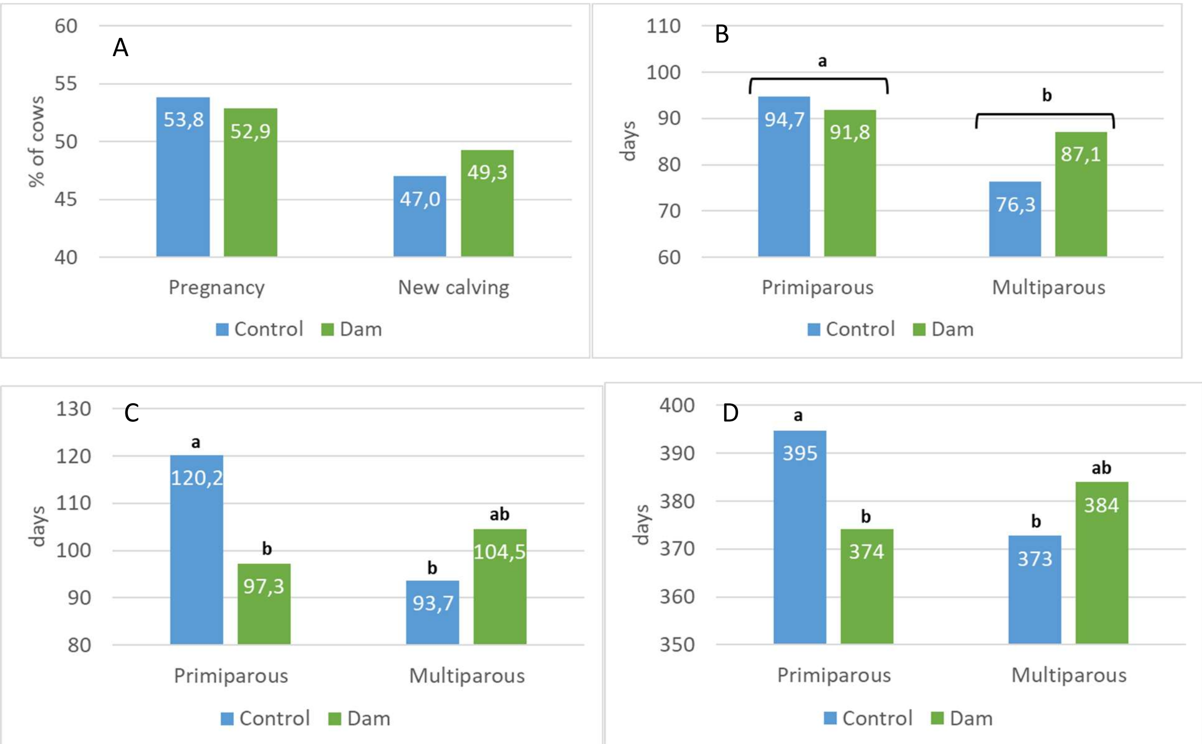
Table 3. Effect of CCC practice and parity on cow reproductive performances.

	Group (G)			*P-Value*		
Intervals (day)	Control	Dam	SEM	group	Parity (P)	G x P
calving - 1st insemination	85	89	3.48	0.421	0.021	0.169
calving - fertilizing insemination	107	101	4.05	0.294	0.098	0.004
calving interval	384	379	4.21	0.437	0.308	0.009

The presence of calves seems to improve the reproductive performance of primiparous cows. In particular, the intervals from calving to fertilizing insemination (Figure 2 C) and calving interval (Figure 2 D) were reduced by 23 and 21 days respectively in Dam cows in comparison to Control-cows while they were not modified for multiparous cows.

An equivalent work has to be completed on the health data collected in the same farms.

Figure 2. Performances of reproduction (proportion of pregnant cows and new calvings - A) in control (n= 117) and dam cows (n=140) and intervals from calving to first insemination (B), calving to fertilizing insemination (C) and calving interval (D) from of Control and Dam cows according to parity .



With data on 124 to 257 cows according to the criteria, we confirm the previous conclusions of Krohn (2001) that suckling does not impair calving interval. We could as well show that, on the contrary, suckling seems to improve the reproduction of primiparous cows, which is the most challenging in dairy farms. This result is therefore particularly interesting and seems quite robust considering the high number and variety of cows and conditions considered in this work. It represents an original result that was never reported previously to our knowledge.

2.2.5. Calves' grazing behavior at pasture

Results related to grazing behaviour obtained in Trial 3 were summed up into a 4-pages conference paper presented at the Video Pre-Conference on Animal Husbandry on the 21-22 September 2020. There results were presented as well into a full paper published in Frontiers in 2020. The full text is available at https://www.frontiersin.org/articles/10.3389/fvets.2020.600949/full. The summary is reported hereafter in italics.

Rearing dairy calves with their mothers could teach them how to graze, optimizing grass use, and improving their welfare and performance. We tested the short-term effects of dam-calf contact experience on grazing and social behavior of weaned calves, monitored over seven days for their first post-weaning grazing experience. "Dam" (D) calves were reared and grazed with their mothers until weaning. "Mixed" calves (M) were separated from their mothers after 4 ± 0.5 weeks, they experienced dam-calf contact, but not grazing. "Standard" (S) calves had never experienced either dam-calf contact (separated at birth) or grazing. Each group grazed an equivalent pasture plot offering heterogeneous herbage. Scan sampling of calves' activities was performed every 5 min, 6 h per day, on Days 0, 1, 2, 3, and 7. Daily, the time when calves started grazing after introduction to pasture, and the number and duration of their grazing cycles were measured. Daily activities were differentiated into ingestion, rumination, and idling. The proportion of time that calves spent grouped with other individuals or isolated, and standing or lying were recorded. When grazing, their bites were characterized by botanical family group, height of the selected bite and vegetation status. Individual average daily gains from the 2-week periods before and after grazing were calculated, and were equivalent between groups (313 ± 71 g/d). On Day 0, D-calves started grazing immediately (1 ± 4.1 min), unlike Mand S-calves (39 ± 4.1 and 23 ± 4.1 min), and D-calves grazed patches of dry grass 21.7 times less than M-calves and 16.9 times less than S-calves. Dry herbage patch preference and grazing start time differences disappeared on Day 1. Calves spent the same time ingesting and idling, but M-calves spent on average 1.6 times less ruminating than D- or S-calves. The D-calves showed grazing behavior similar to that of adult cows, selecting grasses throughout pasture utilization, although legumes and forbs were present in the grazed layer. On the contrary, M- and S-calves did not express any specific preference. The S-calves spent more time isolated but had more positive reciprocal interactions than the calves in the other groups.

2.2.6. Synthesis of results from Trials 1, 2 and 3

Among the different CCC practices implemented in the INRAE experimental farm, those allowing a short daily contact with the dams (2.5 h after or 20 min before morning milking) were discarded. A short contact with dams (2.5h) immediately after morning milking strongly limits calf growth due to low milk intakes and is responsible for heath sensibility of calves. On the contrary, a short contact with dams before morning milking allows calves to drink a high quantity of milk and consequently to have a high growth rate until weaning but milk losses at parlour are the highest over the first 16 weeks of lactation (-45%). In this case, the distress at weaning for cows and calves was limited due to a weak bond established between calves and cows.

Table 4. Consequences of the suckling practices tested in France in Trials 1, 2, 3 ("Volame 1, 2, 3 respectively) on cows and calves performances during the 16 first weeks of lactation. In each trial, experimental groups were compared to a control group of animals.

Consequences of suckling systems on animal performance compared to non-suckling system		VOLAME 1	VOLAME 2	VOLAME 3	
		Before 20 min/d, **weaning**	Dam 9 h/d, **weaning**	Dam 6 h/d, **weaning**	Mixed 6 h/d, **4 wk**
COW PERFORMANCE *Milk yield and composition at parlour during 16 weeks after calving*	**Milk yield** (kg/d - [%])	**-10.6** [-45%]	**-8.3** [-31%]	**-7.8** [-30%]	**-5.4** [-21%]
	Milk fat content (g/kg)	**+3.2**	**-5.8**	**-4.0**	-0.8
	Milk protein content (g/kg)	**+3.0**	**+1.3**	**+1.0**	**+1.6**
CALF PERFORMANCE	**Weight at weaning** (kg)	**+12.5**	-2.5	**+19.0**	-2.7

The most promising CCC practices seem to be the ones allowing a long daily contact with the dams. Compared to control cows, during the first 16 weeks of lactation, milk yield at parlour was 31 % (-8.3 kg/d) and 30 % (-7.8 kg/d) lower in Dam-cows in Trial 2 and 3 respectively. Interestingly milk yield at parlour was equivalent whatever the number of calves kept with dams (all calves in Trial 2 and female calves [65%] in Trial 3). Milk losses at parlour were the lowest when calves are separated from their dam at 3 weeks of age (Mixed-cows, -21%) but in this case, tank milk must be provided to calves after separation and until weaning. In addition, this CCC practice has no beneficial effect on calves' growth and calves experience a first distress at separation from the dams and a second one at weaning (Table 5).

In all scenarios, milk composition is affected; milk protein content was systematically higher in CCC cows (+1.0 to +3.0 g/kg) compared to control cows and milk fat content was lower in CCC cows (-0.8 to -5.8 g/kg) except when calves drink the low fat milk of the beginning of milking. There were no significant differences in milk SCC and in frequency of cow and calf health events between CCC and control animals. Compared to control-calves, calf growth until weaning was higher in Dam1b and Dam3-calves (+12.5 and +19.0 kg) and was similar in Dam2- and Mixed-calves.

In conclusion, the best compromise between cow milk yield and calf growth and welfare is a long period of CCC (6 to 9 h) between the morning and evening milkings applied to all calves until weaning. Still abrupt weaning stresses both cows and calves even if CCC has been restricted before separation.

Table 5: Synthesis of the main results related to cow and calf distress at weaning in the 3 experiments made in INRAE (Trials 1, 2, 3 are "Volame 1, 2, 3 respectively). In each trial, experimental groups are compared to a control group of animals. This qualitative evaluation is based on the proportion of animals vocalizing during the week after separation or weaning and the duration (number of days) of vocalization.

Proportion x duration of animals that vocalized during the week after separation/weaning	VOLAME 1	VOLAME 2	VOLAME 3			3 years
	Before	**Dam**	**Dam**	**Mixed** (6 h/d, 4 wk)		**Control**
	20 min/d, weaning	9 h/d, weaning	6 h/d, weaning	At separation (4 wk)	At weaning	At weaning
COWS	+	+++	+++	++		
CALVES	++	+++	+++	+++	++	++

2.2.7. Economic consequences of CCC practices

Results related to the simulations of the economic consequences of CCC practices implemented in different types of farming systems were presented at the 24th Congress of Animal Science and Production Association held in Padova (Italy) on the 21st-24th of September 2021. A full text is currently under preparation and will be submitted for publication in 2022. The summary is reported hereafter in italics.

In dairy production, one of the relevant common welfare concern is the early separation of calves from their dams. Therefore, research interest in cow-calf contact (CCC) rearing systems during the milk-feeding period is increasing. This practice was studied mainly from the animal welfare and performance point of view but the economic consequences are still poorly documented. At INRAE experimental farm 'Herbipole', two different CCC strategies were compared to calves separated from dams immediately after birth and fed with an automatic milk feeder until weaning. The CCC strategies consisted in: 1/ dam-calf contact allowed for short dairy periods (20 min before morning milking) until weaning at 13 weeks (2017); 2/ dam-calf contact allowed for day-time contact between morning and evening milkings until weaning at 12 weeks (2018 and 2019). Regardless of the duration of the contact period, the daily milk ingestion of suckling calves is about 11% of their weight until weaning, and it takes five weeks to suckled cows to reach the milk production of Control cows after separation from the calves. The simulations started from the hypotheses reported in table 6. We did n0t took into account possible changes in vet costs due CCC. Starting from these technical results, we used Diapason, a database created by the « INOSYS Réseaux d'élevage », to simulate the impact of these innovative practices on the economic viability of typical intensive, extensive and organic farming systems in France.

Table 6. Summary of the correction factors calculated for each criterion selected for the economic simulation (the data are in comparison to the data of the Control)

	Milk sold[a]	*Milk fat content[b]*	*Milk protein content[b]*	*Calves weight at weaning[c]*	*Concentrate for heifers[d]*	*Workload[e]*
Day-time contact	*-985 kg*	*-7,7 g/L*	*+1,4 g/L*	*+12 kg*	*-60 kg*	*-13 h*
Short-time contact	*-1 360 kg*	*+3,2 g/L*	*+2,4 g/L*	*+15 kg*	*-75 kg*	*+41 h*

[a] *per year, for each cow that suckle her calf until weaning (12 weeks)*
[b] *on average, per L of milk milked at parlour (i.e. sold) for a cow that suckle her calf until weaning (12 weeks)*
[c] *for a female calf suckled by its dam for 12 weeks*
[d] *quantity of concentrate saved from weaning to first insemination for a female calf suckled by its dam*
[e] *per year for each dam-calf pair*

We concluded from these simulations that the short-time daily contact system is associated to a reduction of net farm income per worker varying from – 6 k€/year in the extensive system to - 11 k€/ year for the intensive and organic systems. On the opposite, a day-time contact system for 12 weeks can be economically viable (+0.5 k€ per worker) both in an intensive and in an organic farming system, since, despite the loss of milk due to suckling, there is also a reduction and an improvement of working conditions, associated with a better growth of calves. Moreover, the reduction in the price of milk is marginal, so this practice would be economically viable if we assume the application of a label on milk of this kind of system.

3. On-farm cow-calf contact experiments in Sweden

In SE, the trial was carried out on two organic (KRAV-certified) dairy farms with loose-housing systems, hereafter referred to as farm A and farm B. In the experimental groups, cow and calf were kept together during daytime for the whole milk feeding period of 90 days. In the control group, calves were separated from the mother after 1-3 days and were manually fed whole milk from the milk tank. The results from this study will be published and defended on the 12th of January, 2022, by veterinary student Karin Jannerman as part of her master thesis project.

3.1 Farms in the experiment

Farm A had an average of 115 milking cows of the breeds Swedish Red and White Cattle (SRB), Swedish Holstein (SH), ProCROSS, Swedish Polled and Jersey. Cows of the Jersey and Polled breeds were not included in the study. The cows were milked in a Lely Astronaut milking robot. During the experiment, the cow-calf pairs were kept separately from the rest of the cows, with the cows being let in to the calves in the morning after milking. Cow and calves were separated in the afternoon and then kept apart during the night.

Farm B had about 40 milking cows of the SRB breed. The cows were milked in a Volontary milking system by DeLaval. Cows and calves in the experimental group were kept together daytime. On farm B, cows and calves were together in the loose-housing area with all lactating cows. They were then separated in the evening and the calves spent the night in the calf creep.

3.2. Animals and selection

The experiment was conducted in 2019 with batches of three trial calves (allowed to suckle their dam) and 3-4 control calves (separated from their dam) in each round and on each farm. In total, 18 experimental calves and 21 control calves and the same numbers of experimental and control cows, were included.

Round 1: calves born between 2019-03-17 and 2019-05-17.

Round 2: calves born between 2019-05-18 and 2019-07-11.

Round 3: calves born between 2019-07-23 and 2019-10-29

Heifer calves were primarily included to allow follow-up during the first lactation. In cases where not enough heifer calves were born within the period, bull calves were used instead. On farm A, one bull calf was included in the experimental group and on farm B one bull calf was used in the cow-calf group and six bull calves in the control group. Calves were randomly allocated to either the experimental or control group.

3.3 Data collection

Farmers were responsible for recording the weight of calves on a weekly basis from birth to weaning. They also recorded disease events and treatments for cows and calves in the trial. For the cows, inseminations and pregnancy test results were also recorded. The milk yield of the cows, the number of milkings and the somatic cell count were obtained from their automatic milking systems. The data were compiled in Microsoft Excel. We also performed face-to-face interviews with the farmers to capture their perceptions and experiences of the trial.

3.4 Experimental design

3.4.1. The experimental group

The experimental calves were kept together with their mothers during the day for the whole milking period. On farm A the calves were kept out to pasture 24 hours a day during the summer. They had wind and rain protection in the form of a large calf hutch (i.e. only the calves could enter). After the cows were milked in the morning, they were released into the calf pen and the calves could suckle and be with their mothers. In the afternoon, the cows were herded back into the barn. On farm B, the calves were kept in a pen (calf hutch) inside the barn and could get out to the loose grazing area of the cows through a gate. In the evening, the gate was locked so that only the calves could return to the calf hutch, they could no longer go out to the cow pasture. In this way, cows and calves were kept separate at night. The calves had free access to concentrates and roughage.

3.4.2. The control group

On farm A, the calves were kept inside the barn in the same building as the cows. The calves were separated from the cow after the first day and then housed in single stalls for approximately one week, where the calves were fed with a dummy bucket. The calves were then moved to group stalls with automatic calf feeding and fed 10 litres of milk per day. On farm B, the calves were kept in group stalls in the same building as the cows for the whole period. They spent the first 3 days with their mother in the calving pen before the cow was moved out to the loose-housing system. The control calves were then manually fed milk in a bucket before being moved to a group pen with an automatic calf feeder. The calves were fed 9 litres of milk per day. The calves had free access to concentrates and roughage throughout the experiment on both farms.

3.5 Statistical analyses

Statistical analyses were performed using SPSS® software (IBM 2020). The data from the binders in which the farmers recorded data were entered into an Excel spreadsheet (Microsoft 2020). Data were then imported into SPSS for further analysis. Somatic cell counts in the milk were logarithmized to make the variable normally distributed. Univariate analyses were performed to examine differences between the experimental and control groups. Continuous outcome variables were analysed using two-sided t-test and categorical variables using Chi2-test. A P-value of <0.05 was considered to indicate that an association was statistically significant.

3.6 Results

3.6.1 Weight gain in calves

Descriptive results from weighing and measuring the calves, carried out once a week with some variation, are given in Table 7.

Table 7. Weight gain per week during the milk feeding period reported as mean (± SD)

Farm and group	Weight gain, kg per week	Weiht at birth, kg
Farm A, Cow-calf (n=9)	9.59 ± 1.19	40.9 ± 6.9
Farm A, Control (n=10)	7.30 ± 2.01	39.6 ± 8.0
Farm B, Cow-calf (n=9)	9.38 ± 0.99	36.7 ± 7.3
Farm B, Control (n=11)	6.76 ± 0.89	44.1 ± 9.8
Farm A + B, Cow-calf (n=18)	9.49 ± 1.06	38.9 ± 7.1
Farm A + B, Control (n=21)	7.04 ± 1.52	41.5 ± 8.7

The experimental calves gained on average 35% more per week compared with control calves. The higher weight gain in calves that suckled their dam was statistically significant on both farms.

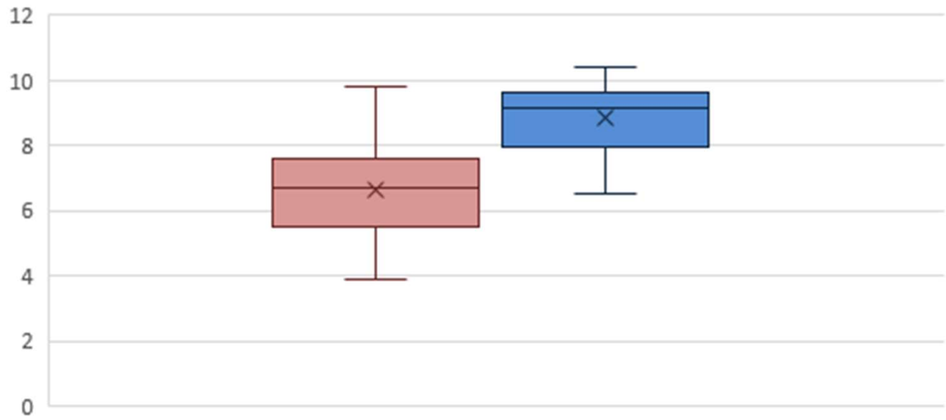


Figure 3. Box plot showing the distribution of the average weight gain of calves in kg per week. (Blue: calves suckling their mother; Red: Control calves that have been artificially fed).

3.6.2 Milk production

The suckled cows gave on average 42% less milk per day during the first 90 days of the lactation, 9% less milk per day after weaning (days 100-120). The average milk production (± SD) during the first 130 days of lactation were 34.1 ± 11,3 kg and 25.3 ± 9.2 kg for control and suckled cows, respectively, on farm A and 34.4 ± 8.8 and 21.4 ± 10.6 for control and suckled cows, respectively, on farm B. In figure 3 average lactation curves for each group are presented. During the study period, the suckled cows produced on average 10.8 kg less milk to the tank than the control group.

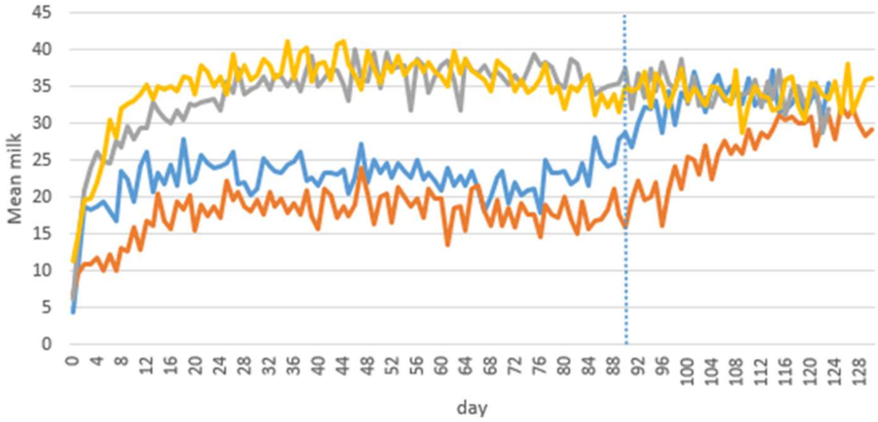


Figure 3. Average milk yield in kilograms on y-axis and lactation day on x-axis. Day 90 is marked with a dashed vertical blue line. Yellow = Farm B control; Grey = Farm A control; Blue = Farm A suckled cows; Orange = Farm B suckled cows.

3.6.3 Somatic cell count (SCC)

On farm A, one of the nine control cows had an average SCC above 200 000 cells/ml compared to the suckled cows where six out of nine had an average SCC above 200 000 cells/ml. On farm B, the corresponding distribution was all control cows and seven of nine suckled cows. When comparing the median instead, we found that one of nine control cows and one of nine suckled cows on farm A, and eight of eleven control cows and two of nine suckled cows on farm B had median values above 200 000 cells/ml. On farm A, SCC values have been recorded in 2057 out of 7241 milkings, i.e. 28% of milkings and for farm B in 6190 out of 8684 milkings, i.e. 71% of milkings. One farm B there was a problem with bacteria in the drinking water which caused the elevated SCC.

3.6.4 Interviews with farmers on the experimental farms

In the interviews, farmers reported that they generally had a positive view of keeping cows and calves together. The calves allowed to suckle their dams had grown well and were generally perceived as healthy, although it was more difficult to tell if the calves had diarrhoea because the faeces were mixed with the cows' faeces. The calves allowed to suckle their dam were percieved as more shy and afraid of people. Both farmers stated that more time is needed to be spent socialising with the calves to overcome this. However, the overall time spent on calf care was similar or somewhat shorter for the calves that suckled their dam as these calves did not need to be manually fed and could be monitored at the same time as watching the lactating cows in the barn.

Both farmers reported that they had a significant drop in saleable milk, and a lower fat content from suckled cows compared to control cows. On farm B, extra time had to be spent scraping cubicles because the calves were defectating and urinating there. One farmer had some difficulties with the milking robot emptying the remaining udder parts if one udder part was already emptied by the calf before milking. Some cows allowed more calves than just their own calf suckle. Both farmers felt that keeping cows and calves together added value, but also believed that a cow-calf contact system is not suitable for all dairy farmers and that it is important that the farmer has an interest in this type of system for it to work well. Farm B has, since the end of the study, chosen to keep all recruitment heifers together with their dams during the milk feeding period. Farm A could consider introducing the system provided that some adaptations is made in the barn so that the cows have the possibility to choose when they want to spend time with the calf. The farmer on Farm A also stated that another important aspect, before introducing this system, is a higher milk price to compensate the reduced amount of salable milk.

4. Conclusions:

Trials in FR and SE investigating the effects of dairy calf rearing allowing mother suckling before morning milking or with daytime cow contact showed that suckled cows gave 5 to 13 kg/d (21% to 45%) less milk at parlour than control cows during the first 4 months of lactation. This loss of saleable milk is due to more milk drunk by calves and to a removal of a lactation peak estimated at -275 kg in the first French trial. In FR, milk protein content was higher in suckled cows compared to control cows, but fat content was lower except in cows feeding calves before milking. There were no differences in SCC in the FR trials but a tendendency for higher SCC in suckled cows in SE. Cows and calves in the trials in both groups were healthy and we found no difference in health events. Growth until weaning was higher in cow-calf contact calves than in control calves. These trials have demonstrated that it is manageble to keep cow and calf together but there are still challenges with cow-calf contact systems regarding in particular cow and calf distress at weaning.

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Animal welfare statement: The French animal experiment took place in 2019 at the INRAE Herbipôle experimental farm (DOI:https://doi.org/10.15454/1.5572318050509348E12), located in Marcenat (F-15114, 45.30°N, 2.84°E, 1080 m a.s.l.). All procedures were approved by the local animal ethic committee and followed the guidelines for animal research of the French Ministry of Agriculture and all other applicable national and European regulations.