Strategies for Keeping Cows and Calves Together on 104 European Dairy Farms – a Cross-Sectional Survey Study

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Simple Summary

Currently, dairy calves are most commonly separated from their dam within 24 hours after birth. The interest for prolonged contact between dairy calves and lactating cows during early life is increasing, but little is known about how farmers implement cow-calf contact. The aim of this study was to identify which practices are currently used on European farms with cow-calf contact (CCC), and which management challenges these farmers face. We found that cow-calf contact was practiced on a wide variety of farms, from small farms with outdoor housing to large farms with technology intensive systems. The calves were reared together with their dam, with foster cows, or using a combination of the two. It was also common to manually milk feed the calves during parts of the milk period. How much time cows and calves are kept together varied between farms, from 30 minutes per day to permanent contact except at milking. Building constraints were often mentioned as a barrier for implementing CCC. Many farmers reported stress-related behaviours when cows and calves were separated, and some alleviating strategies, e.g. different types of gradual separation and weaning, were identified. More research how to optimise weaning and separation practices, and to improve indoor housing on cow-calf contact farms would be beneficial for this growing sector.

Abstract

Although it is still most common to rear dairy calves separately from adult cattle, the interest in prolonged contact between dairy calves and lactating cows during early life is increasing. Previous research has documented positive effects of cow-calf contact (CCC) on e.g. early calf growth and udder health of suckled cows, but also negative effects such as increased separation distress and reduced weight gains after weaning. The aim of this study was to use information from European farms with prolonged cow-calf contact to identify innovative

solutions to common challenges for CCC farms. Commercial farms that kept dairy calves with adult lactating cows for seven days or more after birth were invited to participate, and interviews were performed with 104 farmers from six countries. During interviews, information about farm management, calf rearing, farmers´ perception of animal health on their farm, and their drivers and barriers for implementing CCC were collected. We found that CCC was practiced in a large variety of housing and management systems and of contact durations. Calves were either reared together with their dam, with foster cows, or using a combination of the two. About 25% of the farms also manually milk fed the calves during parts of the milk period. Daily contact time varied between farms, from 30 minutes per day to permanent contact except at milking. Behaviours indicative of separation distress, most commonly vocalisation of cows and calves, were reported by 87% of the farmers, while alleviating strategies, e.g. different types of gradual separation and weaning were reported by some farmers. Building constraints were most often mentioned as a barrier for implementing CCC.

Our findings show that the rearing of dairy calves together with lactating cows is practiced in a variety of commonly used husbandry systems. Reported challenges mainly relate to weaning and separation and building constraints which should be areas of future research.

Keywords: calf mortality; calf rearing; cow-calf contact; dairy cattle; farmer attitudes; health; management; suckling; survey

Introduction

Within the dairy sector, it is routine practice on many farms to separate cow and calf within 24 h after birth. However, there is an increasing interest among both consumers and dairy farmers in systems allowing prolonged contact between cow and calf during early life. These so-called cow-calf-contact (**CCC)** systems are defined as any type of housing or management system allowing calves contact with their dam or with foster cows [1]. Multiple surveys conducted in e.g. North America [2], the US and Germany [3], and Brazil [4] reported that a majority of participants with no involvement in the dairy industry do not favour early separation of cow and calf. Ventura et al. [2] also included results from participants working within the dairy sector and reported that >30% of the American farmers included in the survey disagreed with early separation. To meet consumer demands, products from CCC-farms are now marketed under labels specifying prolonged (≥12 weeks) cow-calf contact during early life in Germany [5].

Recent reviews [6,7] systematically evaluated scientific literature published until early 2018, in which early separation was compared to prolonged cow-calf contact. For calves, the results for many health outcomes (e.g., mortality, diarrhoea, and respiratory health) were inconsistent; however, the majority of reviewed articles reported a reduced risk of intramammary infections in suckled cows [6]. In addition, Meagher et al. [7] reported that most reviewed studies found that calves allowed to suckle had better daily weight gain during the milk-feeding period than artificially fed calves. Prolonged cow-calf contact was also related to a reduced risk of abnormal behaviours in the calves, including cross-sucking [7].

However, potential challenges have been reported with CCC-systems. Two of the most consistent findings are increased acute behavioural responses (e.g. vocalisation) when separation occurs 24 h postpartum or later, and reduced daily weight gain after weaning for

suckling calves [7]. Another review also highlighted control of transmissible diseases as a potential challenge when cattle are housed in mixed age groups [8].

Currently, the number of farms using CCC-systems is low in Europe, but the number of farms implementing cow-calf contact for a prolonged period after calving is likely increasing. However, farmers pioneering CCC-systems are hard to identify, as many European countries do not register this type of information in centralized databases. As such, we have an incomplete understanding of what type of farms are currently using CCC-systems in Europe, and whether farm demographics differ between regions. Detailed information about European farmers´ motives to implement CCC-systems are also largely lacking. More information on which type of practices are used on CCC-farms, and which factors the farmers perceive as challenging with these systems is crucial. The variability in management between pioneer farms may help to identify innovative solutions for common challenges in CCC-systems and could contribute by directing future research towards areas of importance for animals and farmers in this growing field.

Researchers from seven European countries (Austria, France, Germany, Italy, Poland, Sweden, and Switzerland) performed this interview survey as part of ProYoungStock, an EU-project funded by CORE organic. Interviews were conducted with dairy farmers using CCC-systems, with the aims of identifying and describing innovative calf rearing strategies that allow cow-calf contact after calving in the European dairy sector.

Material and Methods

For this study, we used a standardized questionnaire including both open questions to record continuous numerical data, and multiple-choice or checklist questions to record data related to factor variables and categorized numerical variables. Most multiple-choice questions were semi-open, providing an option “Other, please specify”, to allow identification

of important factors or themes not originally included in the questionnaire. Farmers could choose which questions to respond to; therefore, the number of answers differs between questions.

Questionnaire Development

The questionnaire (supplementary material Questionnaire S1) was developed in 2018 and consisted of 55 questions in seven subsections: administrative data, farm description, rearing system, suckling practices, performance testing, farmer perception of animal health, drivers and barriers for implementing CCC-systems. The development process included discussion and agreement between all project partners regarding linguistic clarity and interpretation of the included questions. A person with expertise in data collection from structured interviews facilitated the discussion, provided additional feedback on the written material and trained representatives from the different countries to ensure consistency in how the interviews were carried out. The questionnaire was then translated into the different national languages, and 1-6 persons per country performed the interviews. The interviews were carried out either by telephone or in person. Most interviews (79%) took place between August 28, 2018, and March 21, 2019; data collection was completed on June 25, 2019.

Participant Recruitment

As cow-calf rearing was believed to be an uncommon practice in all participating countries, our intention was not to collect a random or representative sample of farmers using CCC-systems, but rather to include a diverse range of farm types and management practices (e.g. geographical region, farm size, years of experience with cow-calf rearing, and rearing practices). Only dairy farms keeping calves together with adult lactating cows (either the dam or foster cows) for at least seven days were enrolled in the study. The goal was to identify at

least 20 organic or conventional farms meeting these criteria in each country. Depending on country, farms were identified through a combination of use of existing farm and advisor contacts, outreach to other research groups, advertisement in social media, and contact with farmer, dairy, and organic organizations. To further increase sample size, farmers taking the questionnaire were asked whether they knew other farmers using CCC-systems (described by Goodman [9] as snowball sampling).

Research groups from three countries (Germany, Italy and Switzerland) had active collaboration with CCC-farms, and could recruit farms through their existing networks, while three countries (Austria, Poland and Sweden) had not previously collaborated with CCC-farms and therefore partly relied on snowball referral for identification of potential farms. The French research group had recently (March 2018) performed a similar questionnaire on 102 farms that allowed at least two days cow-calf contact [10]. To avoid a low response rate from French farmers in the current study, data from the previous questionnaire were included for 26 farms meeting the enrolment criteria. Questions in the two questionnaires were largely, but not fully, overlapping, leading to missing data for some questions. A version of the French questionnaire translated to English is available as supplementary material Questionnaire S2.

Data Handling

Data were entered, verified and processed by representatives from each country, using the Netigate platform (Netigate AB, Stockholm, Sweden). When entering the data, responses were translated to English. Data entries were reviewed, erroneous entries were corrected, and farms that did not meet the inclusion criteria were removed from the data set. Finally, the complete data set was downloaded as a csv-file for further analyses in R version 4.0.0 [11–13] and as a xlsx-file for further analyses in Stata release 14 [14].

Data were then analysed descriptively regarding possible differences between 1) countries, 2) conventional and organic herds, and 3) small and large herds, as well as 4) different CCC durations. For comparisons related to herd size, the median herd size per country was calculated from the farms enrolled in the study. The farms were subsequently categorised as small (<median herd size), or large (≥median herd size). Regarding comparisons related to contact duration, the data set was split into short (7-28 days, moderate (29-90 days) and long contact (>90 days). The reported number of calves dying before three months of age per year (stillbirths not included) was divided by the reported number of calves born the last 12 months, to obtain an approximate mortality rate for young calves. Inconsistent answers (e.g. more calves weaned than born) to specific questions were removed when analysing the data, while responses to other questions were retained in the data set.

Results

Farms using CCC-systems were identified in all consortium countries except Poland. Of 121 identified farms fulfilling the enrolment criteria (≥7 days CCC after birth), data were obtained from 117 farms as four Swedish farms declined to participate in the study. Thirteen of these 117 farms were removed from the data set during data cleaning. Ten of the 13 removed farms either did not milk the cows or only milked for subsistence, two farms did not let the calves suckle but kept them with adult animals from three weeks of age, and one farm had only one dairy cow that was used as a foster cow.

Enrolled Farms

Farm characteristics of the 104 dairy farms included in the final analyses are presented in Table 1, while breeds used are presented in Table 2. In general, the number of adult dairy cows per farm was centred around the average herd size in each country, except for Italy and

194 Sweden (Figure 1). Most Italian herds were smaller than average, while in Sweden the herds
195 were either very small or average to large. Most farms, except in Italy, had implemented
196 CCC-systems after the year 2010. Of the 19 Italian farms, 15 started with CCC before the
197 year 1990 (Table 3), and many had used CCC-systems for generations. Most farms used open
198 pack or free-stall housing, while tie-stall housing was rare in all countries. Farms that kept
199 dairy cattle outside during all four seasons were only reported in Italy. Parlour milking was
200 the most common milking system in Austria, France, Germany and Switzerland, while this
201 system was uncommon in Italy and Sweden (Table 1). Of farmers responding to the question,
202 91 of 94 raised recruitment heifers on their own farm.

Table 1. Farm characteristics per country of 104 European farms with ≥7 days cow-calf contact after calving. Numerals indicate number of farms unless otherwise stated.

	Austria	France[1]	Germany	Italy[2]	Sweden	Switzerland
Number of farms	15	26	21	19	12	11
Median herd size[3]	25	50	55	40	85	30
Housing system						
Tie-stall	2	3	0	3	3	1
Cubicles	7	11	13	0	6	7
Open pack	5	12	8	9	2	2
Other	1[4]	0	0	7[5]	1[6]	1[7]
Milking system						
Pipeline	2	3	0	2	4	1
Parlour	11	21	19	2	1	7
AMS[8]	0	0	2	0	4	1
Bucket	2	0	0	10	2	1
Other	0	2[9]	0	5[10]	1[11]	1[12]
Income from milk[13]						
0-25%	1	-	1	3	2	1
26-50%	6	-	8	12	2	2
51-75%	4	-	5	2	4	6
76-100%	4	15	7	2	4	1
Calving practice						
Continuous	7	21	18	13	9	5
Seasonal	8	5	2	6	2	6
Other	0	0	1[14]	0	1[15]	0
Hectare crop land[16]	36±20	141±120	156±101	54±67	186±12	29±10
Hectare pasture[16]	16±14	110±91	56±41	33±32	115±143	27±11
Proportion of pasture in ration[17]						
0%	2	0	1	2	0	0
1-25%	0	0	0	1	2	0
26-50%	1	0	5	2	3	1
51-75%	1	0	8	7	0	1
76-100%	11	26	7	7	7	9
Certified organic	15	15	20	4	5	11

[1] All farms were located in two semi-mountainous regions (Grand-Est and Massif Central)
[2] All farms were located on Sicily
[3] Number of adult cows, including dry cows but excluding pregnant heifers
[4] One farm using both cubicle and open pack systems
[5] Seven farms that kept their dairy cattle outside during all seasons
[6] One farm that used both tie-stall and cubicle system
[7] One farm that used both cubicle and open pack housing
[8] Automatic Milking System
[9] One farm with pipeline milking in a free-stall system and one farm using a mobile milking parlour system
[10] Five farms that hand-milked for commercial purposes
[11] One farm with rotary milking system
[12] One farm using a mobile milking parlour system on pasture
[13] Lacking information from France (n=11) and Switzerland (n=1)
[14] Avoids calvings in February and March
[15] Avoids calving during winter
[16] Mean±SD; crop land=arable land with crops, pasture=both permanent pasture (land not ploughed for many years) and temporary pasture (leys occasionally ploughed)
[17] During pasture season

Table 2. Dairy breeds used on 104 European farms with ≥7 days cow-calf contact after calving per country.

Country	Dairy breeds[1]	
Austria	Fleckvieh (n=6) Tyrolian Grey[2] (n=3) Murbodner[2] (n=1)	Holstein (n=4) Dairy-type Brown Swiss (n=1) Dual-purpose Braunvieh[2] (n=1)
France	Montbéliarde (n=24) Abondance (n=3) Simmental (n=1) Vosgienne[2] (n=1)	Crossbreed (n=5) Holstein (n=2) Tarentaise (n=)
Germany	German Black Pied[2] (n=9) Fleckvieh (n=6) Dual-purpose Braunvieh[2] (n=3) Dairy-type Brown Swiss (n=1)	Holstein (n=9) Crossbreed (n=4) German Red Pied[2] (n=2) Angler Red[2] (n=1)
Italy	Modicana[2] (n=9) Pezzata Rossa[2] (n=2) Cinisara[2] (n=1) Siciliana[2] (n=1)	Crossbreed (n=5) Dairy-type Brown Swiss (n=) Holstein (n=1)
Sweden	Swedish Red (n=9) Swedish Polled[2] (n=5) Fleckvieh (n=1)	Holstein (n=8) Jersey (n=3)
Switzerland	Fleckvieh (n=7) Crossbreed (n=4) Holstein (n=2)	Dairy-type Brown Swiss (n=5) Dual-purpose Braunvieh[2] (n=2) Red Holstein (n=1)

[1] Multiple answers possible per farm
[2] Endangered breeds with state-supported breeding programs

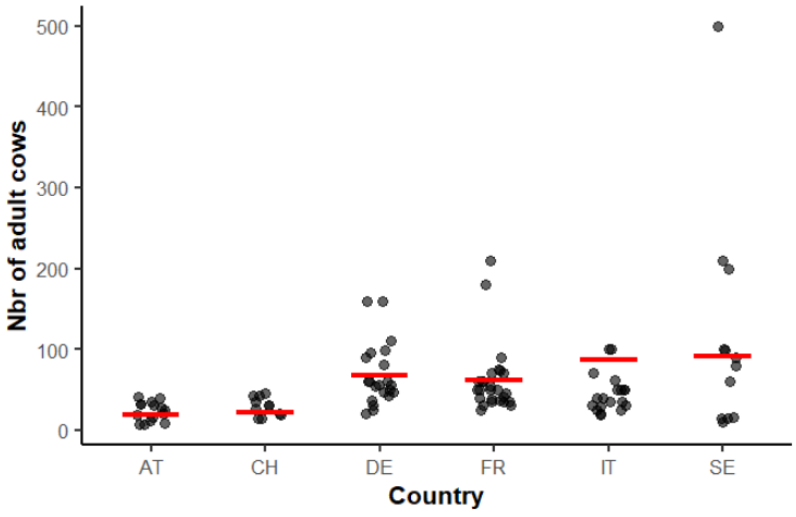


Figure 1. Number of adult dairy cows, including dry cows, on 104 European farms with ≥7 days cow-calf contact after calving per country. Red crossbars illustrate average number of adult cows per dairy farm in each country during the data collection period, based on information obtained from official sources (AT: ZAR Cattle breeding in Austria 2018, CH: Federal Statistical Office, DE: Milchindustrie-Verband e.V, FR: Centre national interprofessionnel de l'économie laitière, IT: Italian Animal Breeders Association, SE: Swedish Board of Agriculture).

Table 3. Description of cow-calf production systems used in 104 European farms with ≥7 days cow-calf contact after calving per country. Numerals indicate number of farms unless otherwise stated.

	Austria	France	Germany	Italy	Sweden	Switzerland
Number of farms	15	26	21	19	12	11
Started with CCC-systems						
<1990	1	1	0	15	0	0
1990-1999	2	1	4	0	2	0
2000-2009	2	5	3	2	5	2
≥2010	10	19	14	2	5	9
Rearing system						
Dam	8	6	4	11	5	3
Foster	1	0	5	2	2	1
Mix[1]	1	7	12	3	2	5
Dam + Manual[2]	5	13	0	3	0	2
Manual + Foster[3]	0	0	0	0	3	0
Contact allowance						
Permanent[4]	7	17	10	3	8	3
Half-day[5]	2	0	1	0	1	1
Around milking[6]	3	7	7	15	1	4
Multiple[7]	3	2	3	1	2	3
Median (IQR) number of calves per foster cow[8]	2.0 (2.0-2.0)	2.0 (2.0-2.8)	2.5 (2.5-3.0)	1.0 (1.0-3.0)	3.0 (3.0-3.5)	3.0 (2.8-3.4)
Median (IQR) age at weaning (weeks)[9]	15 (12-16)	19 (13-26)	16 (13-17)	25 (24-30)	12 (10-12)	20 (17-21)
Calf ration						
Forage access	15	26	21	19	12	11
Concentrate access	8	21	13	17	12	1
Age in weeks at first forage access[10,11]	1.3±0.8	0.8±0.4	1.0±0.0	2.9±1.8	1.1±0.3	1.0±0.0
Age in weeks at first concentrate access[10,12]	4.5±3.3	-	2.5±4.7	3.9±3.4	0.7±0.5	0

[1] Calves suckled both the dam and foster cows, either simultaneously when housed in a mixed group or first suckling the dam for at least one week and then transferred to foster cows

[2] Calves initially suckled the dams and were then manually milk fed

[3] Calves were first manually milk fed and then housed with foster cows

[4] Calves housed with the cows except during milking

[5] Calves housed with the cows either between morning and evening milking, or vice versa

[6] Calves could suckle either directly before, during or directly after milking, but were otherwise housed separately from the cows

[7] Two or more types of cow-calf contact were used depending on calf age, most often first permanent contact with dam, followed by restricted contact with the dam (n=4 farms) or foster cows (n=6)

[8] Calculated for all farms that used foster cows during any part of the milk period (i.e. Foster, Mix and Manual + Foster; n=44)

[9] Lacking information from Austria (n=1), Italy (n=4) and Switzerland (n=2)

[10] Mean±SD

[11] Lacking information from France (n=21) and Switzerland (n=1)

[12] Lacking information from France (n=21)

In Austria, Germany and Sweden large farms generally earned a larger proportion of household income from dairy production compared to small farms, while in Switzerland and Italy no clear relationship between herd size and income from milk production was discernible (Table 1). Fattening female calves (besides the male ones) for slaughter was relatively common in Switzerland (7 of 11 farms), Germany (12 of 21 farms), Italy (8 of 19 farms) and Austria (6 of 15 farms), but only occurred infrequently in Sweden (1 of 12 farms) and France (1 of 26 farms).

Rearing Systems

Various calf rearing strategies were used on the enrolled farms. Of the 104 farms, most either kept the calves with their dams until weaning (n=37) or used a mix of dams and foster cows (n=30). Mix of dam and foster rearing is here defined as either keeping the calves with their dams >7 days and then transferring them to foster cows, or alternatively housing dams and foster cows together and letting calves suckle all cows in the group until weaning. An additional 11 farms raised calves in foster cow systems (here defined as keeping the calves with their dams for ≤7 days after calving, followed by foster rearing). Farms using foster cows most commonly kept all female calves with the foster cows until weaning, except one farm that kept half of the calves in group boxes without contact with adult cows. The strategy to first manually feed the calves with milk followed by foster rearing was only used in Sweden (n=3). One of the farmers mentioned that this system was used to reduce the risk of diarrhoea among the calves. There were also 23 farms that initially kept calves together with the dam (23±13 days; mean±SD), and then manually fed the calves milk or used automatic milk feeding systems after separation. The relative frequencies of the different rearing systems per country are shown in Figure 2.

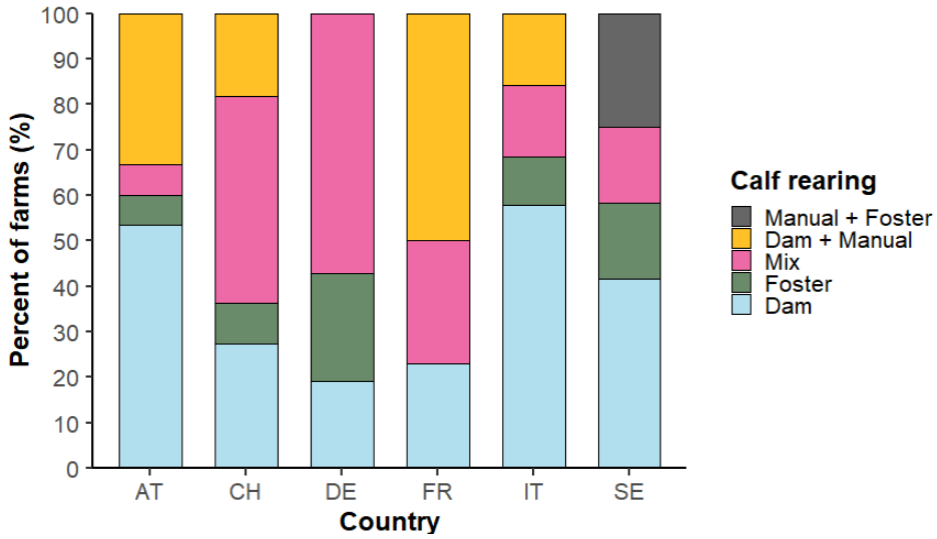


Figure 2. Rearing systems for female calves on 104 European farms with ≥7 days cow-calf contact after calving, depending on country (AT=15, CH=11, DE=21, FR=26, IT=19, SE=12 farms, respectively). Farms most often let calves suckle the dams (Dam) or foster cows (Foster) or used a combination of dams and foster cows (either chronologically or by group housing calves with both dams and foster cows; Mix) until weaning. Allowing the calves to suckle their dams for some weeks followed by separation and manual milk feeding (Dam + Manual) was practiced in several countries. In addition, some Swedish farms manually milk fed the calves for 1-4 weeks after birth, followed by foster cow rearing.

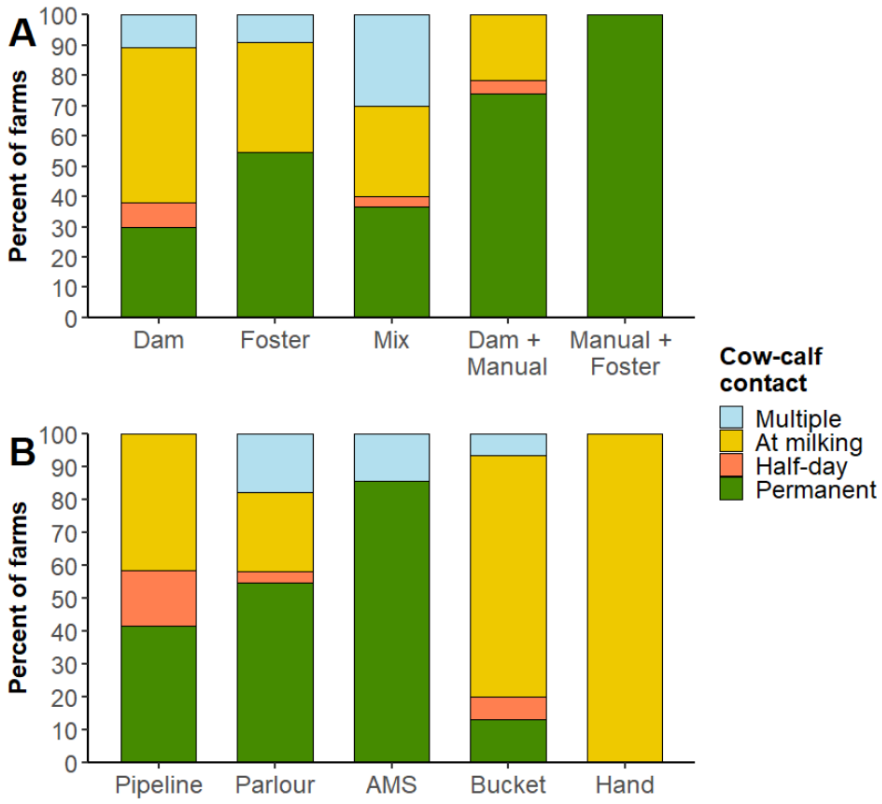
Median herd size for farms that used dam rearing was 30 adult cows [Interquartile range (IQR) 18-40], while it was 50 cows (IQR 43-99) for farms with foster rearing, and 50 cows (IQR 37-68) for farms using mixed rearing. Farms that transferred calves to manual milk feeding after the suckling period had a median herd size of 40 cows (IQR 33-60), while the median herd size for farms that transferred the calves from manual milk feeding to foster rearing was 210 cows (IQR 155-355).

Foster cows were used on 44 farms for at least part of the milk period. The number of calves per foster cow differed between countries (Table 3) but was similar in organic (2.6±0.7 calves; n=32) and conventional farms (2.6±1.1 calves; n=12). The age when calves were moved to foster cows differed between farms (range 0-90 days), although foster cow rearing began within three weeks after calving on 35 of the 42 farms responding to this question. Criteria for selecting early-lactation foster cows were reported by 39 farmers. The most

300 frequently stated criteria were high SCC (n=15), good maternal behaviour (n=13), and
301 difficulties to milk the cow (n=9). Four farmers specifically stated that they did not use cows
302 with high SCC as foster cows, and one farmer never used *S. aureus* positive cows for heifer
303 calves but occasionally for bull calves. Thirty farmers reported their criteria for selecting late-
304 lactation foster cows, which were similar to reasons for choosing early-lactation foster cows.
305 The most frequently stated criteria were high SCC (n=18), difficulties to milk the cow (n=9)
306 and that the cow had been selected for culling (n=7).
307

308 **Cow-Calf Contact Allowance**

309 Responses to open and semi-open questions were used to classify the daily amount of
310 cow-calf contact into either permanent contact (female calves had access to the cows except
311 during milking), half-day contact (female calves could access the cows either between
312 morning and evening milking or vice versa), restricted contact around milking (female calves
313 could suckle for a limited amount of time either before, during or after milking), or use of
314 more than one of these strategies (e.g. depending on the age of the female calves). It was most
315 common to allow permanent cow-calf contact (n=48 farms), followed by contact around
316 milking (n=37), using more than one strategy (n=14) and half-day contact (n=5; day-time
317 contact: two farms, night-time contact: three farms). The amount of CCC differed between
318 countries (Table 3), between calf rearing strategies (Figure 3A), and between types of milking
319 system (Figure 3B).



320

321 **Figure 3.** Type of cow-calf contact for female calves used on 104 European farms with ≥7
322 days cow-calf contact after calving, depending on calf rearing strategy and milking system.
323 Female calves were either continuously housed with the cows (Permanent), housed with cows
324 between the morning and evening milking (or vice versa; Half-day), could suckle the cows
325 around milking (At milking), or used more than one type of cow-calf contact depending on
326 e.g. calf age (Multiple). (A) Calf rearing strategies used at the farms included dam rearing
327 until weaning (n=36; Dam), foster rearing from ≤7 of age until weaning (n=11; Foster),
328 combination of dam and foster cow rearing (n=30; Mixed), initial suckling of the dam
329 followed by manual milk feeding (n=24; Dam + Manual), and manual milk feeding followed
330 by foster rearing (n=3, Manual + Foster). (B) Milking systems used at the farms included
331 pipeline (n=12), parlour (all types of indoor parlours; n=61), automatic (n=7), milking bucket
332 (n=15), and hand (n=5) milking systems. Four farms used unique milking systems; contact
333 allowance for these farms are not shown to facilitate interpretation.
334

335 On farms with parlour milking (n=62), permanent cow-calf contact was most common
336 (n=34). Sixteen of these 34 farms initially let the calves suckle their dams (median 21 days;
337 range 8-56 days) and then manually fed milk to the calves for the rest of the milk period
338 (median 16 weeks; range 9-26 weeks). Although six out of seven farms with automatic
339 milking systems (AMS) used permanent contact, no farm kept the calves in the milking herd.
340 For farms with bucket (n=15) and hand (n=5) milking system it was instead most common to

let the calves suckle around milking (n=16; Figure 3B). In these systems most farmers let the calves suckle during the full milk period (18 of 20 farms), most often from their own dam (14 of 20 farms).

All farms with half-day contact (n=5) kept cows and calves together once per day, the contact duration varied between 5.5-14 h per day. On farms with restricted contact that let the calves suckle before, after or at milking (n=37); it was uncommon that the calves had access to cows on other occasions (n=1). Contact duration per milking varied between 10-15 min and two hours per occasion.

Milk Period

On 96 of the 104 farms colostrum intake was achieved through suckling. On four of these 96 farms, the farmer mentioned that some of the calves additionally were manually fed to ensure colostrum intake, particularly lethargic calves. On the other eight farms all calves were manually fed colostrum, either by teat bucket (n=6), bottle (n=1) or drenching (n=1).

On 94 of the 104 farms, all calves of both genders had contact with lactating cows. On two farms either all female (n=1), or all male (n=1) calves were allowed to suckle, while a lower proportion of the other gender had contact with lactating cows (90% and 50%, respectively). On the remaining eight farms, the proportion of female and male calves allowed to suckle varied between 30-90% and 50-90%, respectively. For four farms, the proportion of suckling calves differed between genders; on two of these farms a larger proportion of female calves could suckle, while on two farms males more frequently were kept together with lactating cows.

The duration of the suckling period for female calves varied more within than between countries. In most countries, the suckling period varied between 20-200 days, with no major differences between conventional and organic farms (Figure 4A). It was uncommon to

provide supplemental milk to female calves during the suckling period. Only one farm supplied *ad lib* whole milk to all female calves during the full suckling period. An additional three farms either gave extra milk to some of the calves (n=1), to calves that were learning to suckle from foster cows (n=1), or to calves that were learning to drink from teat buckets (n=1; this farm sold all calves to a rearing farm). One additional farm provided supplemental milk feeding to calves with diarrhoea.

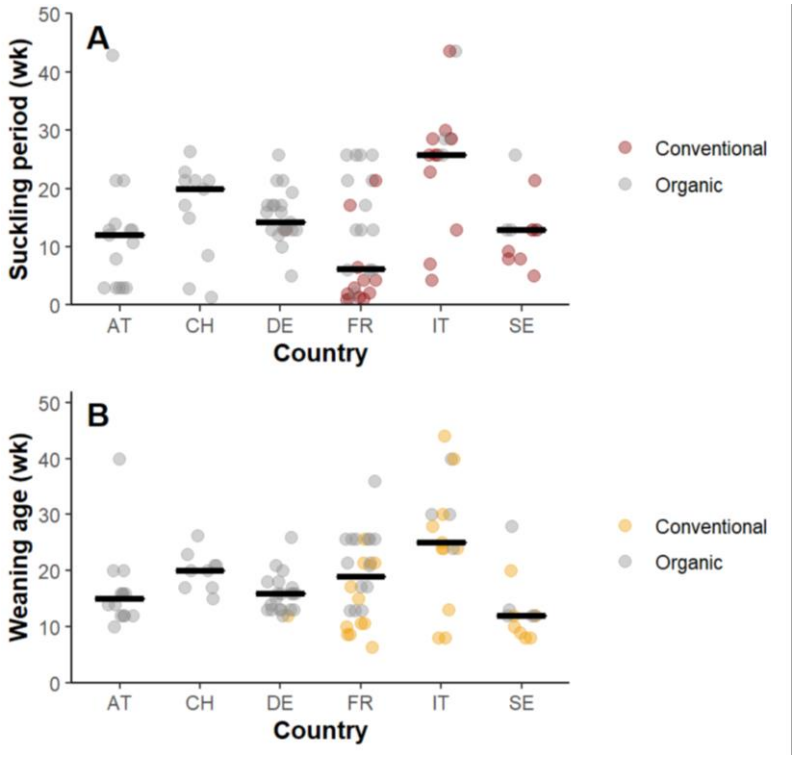


Figure 4. The milk period on European farms with ≥7 days cow-calf contact after calving, depending on country and farming method. The number of farms that responded differed between questions. (**A**) Duration of suckling period in weeks for female calves (n=102); (**B**) weaning age in weeks for female calves (n=97). Crossbars represent the median. The original questions asked about suckling duration in days and weaning age in weeks, which likely led to small systematic rounding errors for weaning age [i.e., calves weaned at 12 weeks (84 days) actually suckled until 90 days].

Weaning age was reported by 97 farmers, the other seven farms either mistook weaning age for age at separation or did not know when the calves were weaned (i.e., all calves were sold to a rearing farm during the milk period). Of the 97 farms, 70 let female calves suckle from birth until weaning. The age at weaning varied somewhat between countries (Figure 4B), and between conventional [median 12.5 (IQR 9.3-24.0) weeks] and organic farms [17.0

(IQR 13.0-21.4) weeks]. While many farms practiced abrupt weaning and separation, some farms used innovative strategies to achieve a gradual reduction of milk allowance, often combined with a gradual reduction in CCC. For calves that were group housed together with multiple lactating cows, gradual reduction of milk allowance could be achieved by reducing the number of cows kept in the pen over time (n=2), or by gradually reducing the daily duration calves were kept together with the cows (n=2). Strategies to gradually reduce milk allowance on farms with restricted CCC included reducing the number of times per day the calves could suckle (n=3), letting younger calves suckle the cows before older calves were given access (n=2), or starting to milk the cows as the calves got older (n=2). On some farms weaning was performed after separation, either by manually milk feeding the calves after separation (n=3), or by transferring the calves to cows already bonded with younger calves (n=3).

Weaning and Separation Distress

Most (87%) farmers reported animal responses to separation. The most common response was increased vocalization from cows (n=76), followed by increased vocalization from calves (n=56), difficulties to milk the cow after separation (n=17), and calves losing weight (n=9). None of the farmers experienced that the cows had reduced interest in feed after separation, and 14 farmers reported that they did not observe any problems when separating cows and calves. The most frequent strategies to manage distress at separation were stepwise separation of cows and calves (n=16), treatment with herbal remedies or homeopathy (n=11), keeping cows and calves so they could not hear each other (n=5), and using attractive feed to deviate cows' and calves' attention (n=4). Other farms used medical treatment of cows and calves (n=3), put nose flaps on the calves for some time before separation (n=3), or ensured visual contact between cows and calves for some days after separation (n=2). Separating small

groups of calves simultaneously, so they had company, was practiced on three farms, while this practice was avoided on one farm to reduce the risk that vocalisation from other calves in the group would elicit further stress responses.

Perception of Health

Cows

Of the 104 farms, 54 farmers perceived that the fertility of cows suckled by calves wasthe same as for cows that were only milked, while 20 and 10 thought that fertility was better and worse, respectively. Twenty farmers stated that they did not know whether there was any difference in fertility. The perceptions of CCC´s effect on fertility differed between countries (Figure 5A), but the length of the suckling period was similar for farms that thought fertility was better (104±74 days; mean±SD), the same (104±62 days) or worse (112±84 days). Udder health was perceived as the same in cows that were suckled and in cows that were only milked by 42 farmers, better by 40 farmers and worse by five farmers, while 17 farmers did not know (Figure 5B). Again, there was no obvious relation to the duration of the suckling period (better udder health: 124±74 days; same: 78±55 days; worse: 96±54 days).

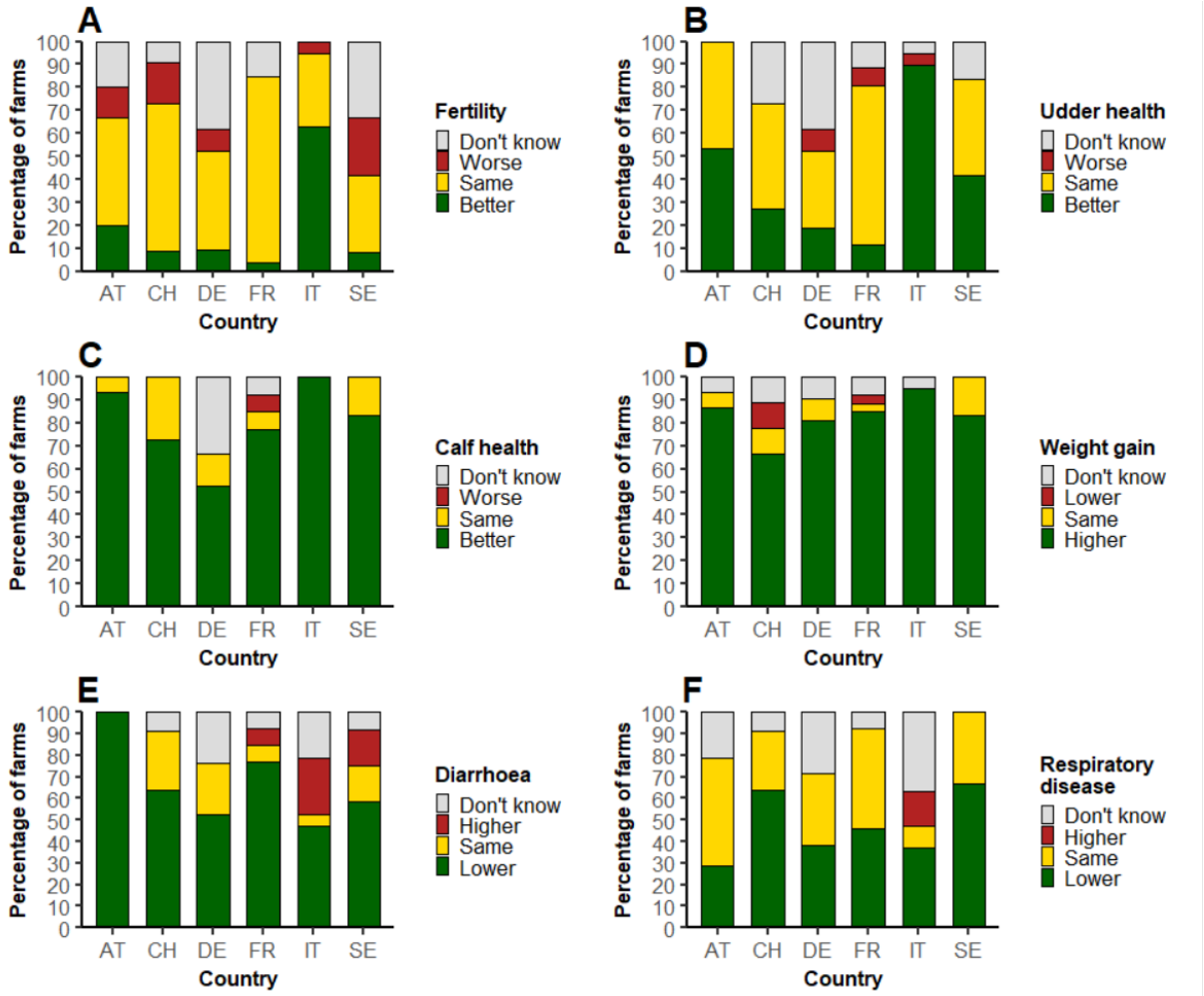


Figure 5. Perception of health on European farms with ≥7 days cow-calf contact after calving, depending on country. The number of farms that responded differed between questions: The perceived effect on (**A**) fertility of suckled cows, n=104; (**B**) udder health of suckled cows, n=104; (**C**) general calf health, n=104; (**D**) calf weight gain, n=102; (**E**) frequency of calf diarrhoea with impaired general condition, n=104; (**F**) frequency of respiratory disease in calves, n=103.

Calves

General calf health was perceived as better in suckling calves compared to manually milk fed calves by 82 of 104 farmers, while 11 farmers thought calf health was the same, two farmers thought it was worse, and nine farmers were uncertain (Figure 5C). Of 102 responding farms, 86 farmers found suckling calves to have higher weight gain compared to conventionally managed calves, seven farmers perceived no difference and two farmers thought weight gain was reduced, while seven farmers did not know (Figure 5D). When asked

about more specific health issues, a larger proportion of farmers was uncertain about the effect of CCC on calf diarrhoea (Figure 5E) and respiratory diseases (Figure 5F).

Sufficient information to calculate an approximate annual mortality rate for calves 0-3 months of age was reported for farms from Austria (n=14), Germany (n=21), Italy (n=18), and Switzerland (n=11). Although most farms stated that no or very few calves died annually, the approximate mortality rate was ≥10% for nine of the 64 farms included in this analysis (Figure 6).

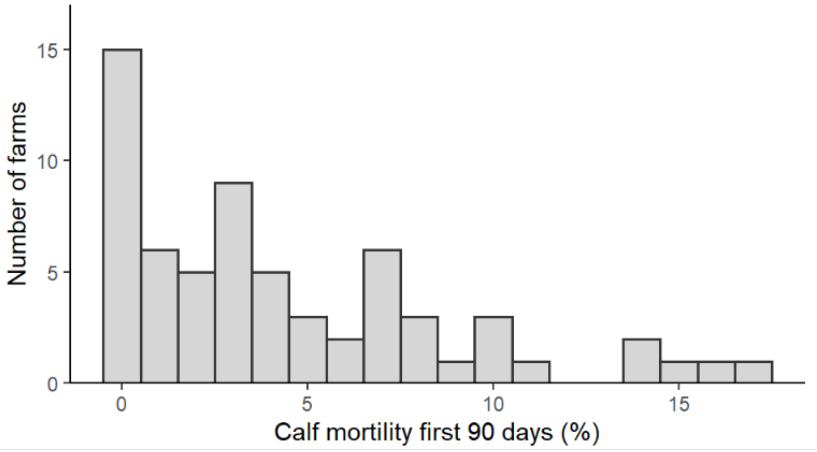


Figure 6. Estimated annual 0-3 months calf mortality rate on European farms with ≥7 days cow-calf contact after calving (n=64; AT=14, CH=11, DE=21, IT=18 farms, respectively).

Drivers and Barriers

Of 100 responding farms, 77 stated that their CCC-system was not more time consuming than an artificial rearing system where cows and calves are separated directly after birth, with 20 farmers commenting that CCC-systems are less time consuming. Conversely, 22 farmers thought CCC took more time. Thirteen of these 22 farmers did not comment on their answer. Of those who did, labour needed to move cows and calves (n=6) was the most frequently mentioned reason.

The main drivers mentioned for using CCC-systems were improved calf health (n=68), more natural calf rearing (n=52), and less time-consuming management (n=44; Figure 7).

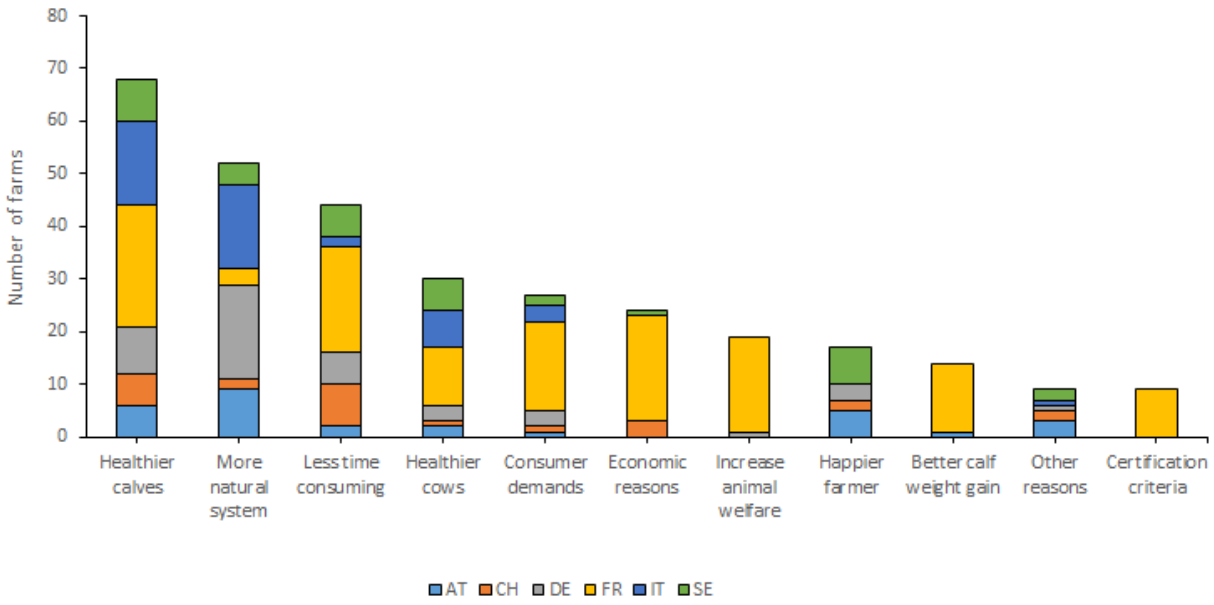


Figure 7. Drivers for implementing cow-calf contact on European farms (n=103). The category 'Other reasons' included "a place to put 'trouble cows' with e.g. poor legs", "dislike against plastic bottles", "cows that are difficult to milk usually work better in CCC-systems" and "wanted to give the system a try".

Common perceived barriers for implementing a CCC-system were improper barn construction (n=14), CCC-systems being too complicated (n=7) or too time consuming (n=5), lacking knowledge about CCC (n=3) and avoiding late separation (n=1). Forty-three of 104 farmers did not think of any barriers before starting with a CCC-system.

Open-ended answers on how the farmers wanted to modify their CCC-systems revealed that 46 of the 104 farmers were planning to alter some aspects of their production system. Rebuilding animal facilities was most often mentioned (n=17), primarily to improve indoor calf rearing (n=13), but also to enable CCC at pasture (n=1), reduce workload (n=1), increase farm size (n=1), and improve housing for adult cows (n=1). Some farmers also wanted to change some aspects of their management, and seven farmers specifically mentioned reducing stress at separation as important. Six of 46 farmers wanted to change CCC allowance, of which two planned to increase daily cow-calf contact, two planned to reduce daily cow-calf

contact and two planned to stop CCC and manually milk feed the calves in the future. An additional three farmers planned to stop with dairy farming in general.

Calf Rearing vs. Contact Allowance

Within the data set, there was a large variation in the duration that calves were kept with adult cows (range 7-305 days). To explore if the contact duration was associated with the type of CCC-system used at the farm, and with perceived health, separation distress, and drivers and barriers for CCC implementation, the data set was split into three categories. Farms using contact duration between 7-28 days were defined as short contact farms (n=16), farms with contact duration between 29-90 days as moderate contact farms (n=40), and farms with >90 days contact as long contact farms (n=48). Results for calf rearing strategies, perception of health and separation distress are presented in Table 4.

Table 4. Description of calf rearing and CCC allowance practiced on European farms, depending on how long the calves were kept with adult cows. Farmer observations of separation distress and their perceptions of health and fertility in relation to rearing without CCC are also reported. All outcomes are reported as proportion of responding farmers per contact duration category.

Contact duration	7-28 days	29-90 days	>90 days
Number of farms	16	40	48
Rearing system			
Dam	6%[1]	40%	42%
Foster cow	0%	13%	13%
Mix[2]	0%	20%	46%
Dam + Manual[3]	94%	20%	0%
Manual + Foster[4]	0%	8%	0%
Type of cow-calf contact			
Permanent[5]	69%	53%	33%
Half-day[6]	13%	5%	2%
Around milking[7]	19%	33%	44%
Multiple[8]	0%	10%	21%
Separation distress			
Vocalisation cow	94%	68%	71%
Vocalisation calf	50%	55%	54%
Milking difficulties	13%	13%	21%
Weight loss calf	6%	15%	4%
Cow health			
Mastitis			
Better	25%	35%	46%
Same	69%	45%	27%
Worse	0%	10%	2%
Uncertain	6%	10%	25%
Fertility			
Better	31%	10%	23%
Same	44%	58%	50%
Worse	6%	15%	6%
Uncertain	19%	18%	21%
Calf health			
Diarrhoea			
Better	75%	63%	67%
Same	6%	18%	10%
Worse	13%	10%	6%
Uncertain	6%	10%	17%
Respiratory disease			
Better	40%	43%	48%
Same	47%	40%	25%
Worse	7%	5%	0%
Uncertain	7%	13%	27%

[1] One farm that sold all calves to a rearing farm at 21 days of age

[2] Calves suckled both the dam and foster cows, either simultaneously when housed in a mixed group or first suckling the dam for at least one week and then transferred to foster cows

[3] Calves initially suckled the dams and were then manually milk fed

[4] Calves were first manually milk fed and then housed with foster cows

[5] Calves housed with the cows except during milking

[6] Calves housed with the cows either between morning and evening milking, or vice versa

[7] Calves could suckle either directly before, during or directly after milking, but were otherwise housed separately from the cows

[8] Two or more types of cow-calf contact were used depending on calf age, most often first permanent contact with dam followed by restricted contact with the dam (n=4 farms) or foster cows (n=6)

Natural rearing was considered an important driver in a somewhat higher number of farms with long contact (30 of 48 farms), compared to farms with short (6 of 16 farms) and moderate contact duration (16 of 40 farms). Within each group, calf health was more frequently mentioned as an important driver than was cow health (by a factor of 1.5-3.0). Reduced workload was important for around 40% of farmers in each group, while consumer demands and profit were mentioned by a higher proportion of farmers with short contact duration (short: 38% and 50%, moderate: 23% and 13%, long: 25% and 21%, respectively). Work satisfaction was considered important by a somewhat higher proportion of farmers with moderate contact duration (8 of 40 farms), compared to farms with short (2 of 16 farms) and long (4 of 48 farms) contact. Although few farmers reported barriers for CCC implementation, barn construction was most commonly mentioned as a challenge in all three groups (10-20% of responding farmers in each group).

Discussion

It is currently unknown how many farms use CCC-systems in Europe. Due to the difficulties in identifying farms that practice CCC, farms were recruited through outreach activities and farm collaboration networks. The enrolled farms should therefore not be considered a representative sample of all CCC-farms in the consortium countries, and inferences should be limited to our sample. However, the current research still constitutes the most comprehensive study evaluating calf rearing practices on European CCC-farms to date.

Cow-calf contact rearing was recently defined as “any system allowing physical contact between a dam and her own calf, or between a foster cow and her foster calf” by Sirovnik et al. (2020). In this study, CCC was defined as keeping calves with lactating cows for ≥7 days. This cut-off was chosen so that farms needed to keep cows and calves together for longer than the colostrum period to be eligible for inclusion. A higher cut-off would have limited the

number of farms we could include from some countries, as there were regional differences in the number of farms that transferred calves to manual milk feeding after an initial period with the dam.

Enrolled Farms

This study showed that CCC is practiced under variable conditions on European farms, from farms that house and hand milk their cows outdoors to farms with technology intensive systems such as AMS barns. Indoor loose-housing systems were most common, with 80% of farms using either open pack systems or cubicle barns. Even though parlour milking was the most common milking system (60% of the farms), a large variety of other milking systems were used on the farms. Bucket milking was the second most used milking method (14% of the farms), primarily because it was a common practice among the enrolled Italian farms.

Most farmers (57%) had started with CCC in the year 2010 or later, suggesting a rapid increase in farms with CCC in Europe over the last 10 years. Contrary, most Italian farmers had practiced CCC for several generations. This was likely due to all Italian farms being recruited on Sicily, with almost half of them keeping Modicana cattle for traditional cheese production. Modicana cattle is an indigenous Sicilian cattle breed that needs the presence of the calf for milk let-down, making CCC rearing a necessity. The use of the Modicana breed on Sicily also likely explains why letting calves suckle only during milking was more common, and the median suckling period was longer for the Italian farms, compared to the other countries. Cattle breeds used on the enrolled CCC farms differed between countries, and varied from dual-purpose breeds to specialised dairy breeds. Endangered breeds were used on some of the farms in all countries.

Rearing Systems

The enrolled farms used a variety of strategies for rearing calves together with adult cows, either together with the dams or with foster cows (or both). Although multiple types of CCC rearing were used in all countries, the systems used and their relative frequency differed. Reasons for these regional differences have not been explored in the current study, but it is possible that differences in certification requirements, public interest in animal welfare issues and regional customs could have influenced these results. For example, in Sweden foster cows have been used by a low number of farmers for decades [15], while the interest in dam rearing has increased during the last years. Initial manual milk feeding followed by foster rearing was only reported in three large (100+ adult animals) Swedish farms. As increased group size results in higher contact rate, it is possible that this rearing practice was used as a way to reduce disease spread to young calves in these herds.

Other types of CCC rearing were also related to herd size, with farms using dam rearing for the full suckling period generally being smaller compared to all other systems. Farms with dam rearing also had the highest proportion of farms earning ≤50% of household income from milk, and the highest proportion of farmers reporting natural rearing and work satisfaction as important drivers for using CCC. It is possible that, at least in the sample used in this study, dam rearing was perceived as more attractive for farmers interested in CCC from an ethical standpoint, while other systems allowed for a larger profit margin. It is important to note that the current study only provides indirect support for this notion; further qualitative research is needed to better understand CCC-farmers' perspectives on calf rearing practices.

Cow-Calf Contact Allowance

The most common practices for CCC were permanent cow-calf contact and contact around milking, which led to a large variability in daily contact duration (ranging from 30

minutes to >20 hours). Contact allowance (e.g. full-day contact, half-day or contact around milking) differed depending on what calf rearing practice and what milking system were used on the farms. This finding suggests that CCC is possible in a wide variety of dairy systems, but that factors such as barn construction and herd management influence which type of CCC is most feasible. For example, many farmers using foster rearing mentioned that the foster cows and calves were housed away from the milking herd, likely explaining why permanent contact was used on more than half of foster farms. Similarly, a number of farmers with permanent contact followed by manual milk feeding mentioned that the dam-calf pair was housed together in the calving box for an extended period until separation. Allowing suckling around milking was the second most common strategy for CCC among the enrolled farms, which may be because this practice is possible to implement without extensive reconstruction of the barn. Another possibility is that CCC allowance was restricted to increase the amount of saleable milk, although a recent study described that cows with a restricted suckling contact just before milking had lower machine milk yields than cows with half- and full-day contact [16].

Few farms used half-day CCC, despite previous research showing satisfactory calf growth both before [17] and after [18] separation. The system also allows for more social interactions between cows and calves compared to restricted contact around milking, and affiliative behaviours have been observed for dam-calf pairs even when suckling has been prevented with udder nets [19]. It is possible that the labour needed for separating cows and calves make this system less attractive for farmers, but this was not evaluated in this study. However, only one of the five farmers that used half-day contact considered CCC more time consuming than conventional calf rearing, compared to 14 of 37 farmers that allowed suckling only around milking.

Public Attitudes

Concerns from the public about separation at birth have been reported from a number of studies (e.g. Cardoso et al., 2017; Ventura et al., 2013). Although research on public views on different types of CCC rearing is largely lacking, it is possible that short daily CCC allowance would also be perceived less favourable compared to half- and full-day contact. In the current study, some farmers that let the calves suckle around milking kept them with adult cows for up to two hours per occasion. Such contact times would allow daily social interactions also between calves and cows on farms with restricted contact, and could be perceived as more attractive by the public. A recent study by Sirovica et al. [20] evaluated how the American public viewed four different calf rearing scenarios, comparing separation within 24 h after birth and single calf housing, separation within 24 h and group calf housing, foster rearing and dam rearing. Cows and calves in the dam rearing scenario were generally perceived as having good welfare. However, although the foster cow scenario described unrestricted suckling and full day contact, it was perceived as unfavourable like both systems with immediate separation. Likewise, willingness to pay more for milk if the calves were dam reared was more frequent compared to all other scenarios which did not differ in this regard. These findings suggest that early separation from the dam is a concern for the public, regardless of how the calves are reared afterwards.

However, Ritter et al. [21] reported that a large representative sample of US and Canadian citizens opposed early culling stronger than early separation when asked about the use of surplus dairy calves for beef production, with <3% of participants considering <1 month of age an appropriate age of slaughter. Similarly, few perceived transport of calves <1 month old appropriate. Although the management of male calves was not evaluated in the current study, some farmers mentioned that bull calves and unwanted heifer calves were sold from the farm before one month of age. The potential of discrepancies between calf rearing practices on

CCC-farms and expectations from the public is important, especially if the consumer is asked to pay a higher price for products from CCC-farms. To better inform farmers, and to maintain social acceptance for CCC, the European public's acceptance for calf rearing practices identified in the current study should be further evaluated.

Weaning and Separation Distress

Although behavioural responses after separation were commonly observed, abrupt separation was practiced on 85% of the farms. Reasons for choosing abrupt separation were not explored, but could have been due to e.g. farm management and building configuration. For the farms using gradual weaning and separation, the strategies could be grouped into weaning before separation, separation before weaning and gradual reduction both in CCC and milk allowance. However, the methods to achieve gradual weaning and separation varied considerably between farms. These discrepancies suggest that separation methods must be tailored to the situation on the individual farm, or alternatively that low-stress strategies for weaning and separation of suckling dairy calves have not yet been identified. Farmers that did not report problems at separation generally performed separation at a higher calf age [median 150 (IQR 59-180) days vs. 90 (IQR 55-150) days]. It is possible that the observed behavioural responses were less severe and therefore not perceived as a problem in farms that separated cows and calves at a later age. Johnsen et al. [23] reported that suckling dairy calves that knew how to drink milk from an automated milk feeder when they were separated at six weeks of age showed less separation distress, compared to dairy calves separated at the same age but with no previous experience with the feeder. Their results suggest that nutritional independence from the dam decreased behavioural responses to separation in calves, although this practice likely does not reduce separation distress in the cows.

Perception of Health

Most farmers self-reported good health and weight gains in the calves, suggesting that CCC can successfully be implemented in a variety of dairy systems. It is important to note that no independent assessment of these outcomes was performed, making the results susceptible to recall and social desirability bias. Similarly, farmers were asked to estimate early life mortality, with no requirement that they based this estimate on farm records. However, our results align with the findings of recent systematic reviews [6,7].

As only one farm used both CCC and artificial rearing of female calves, almost no farmers were able to directly compare the two rearing strategies. This may explain the relatively large proportion of farmers that were uncertain about the effects of CCC on health, particularly when asked about more specific disease symptoms such as diarrhoea. Roth et al. [24] observed diarrhoea more frequently in cow sucking dairy calves compared to artificially milk fed calves, but the cow sucking calves did not need to be treated against diarrhoea more often. The authors suggested that the loose faecal consistency was due the amount of consumed milk (osmotic diarrhoea). A higher number of days with loose stool but no concurrent increase in the number of calves needing medication has been reported for single housed calves on intensive milk feeding, compared to restrictive milk feeding [25,26], supporting this notion.

Self-reported mean 0-3 months cumulative mortality was relatively low (4.5%) compared to national numbers (e.g. for Germany: mean 3.7-7.4% 0-3 months mortality for female calves, depending on region; PraeRi [27]), which aligns with farmers' perceptions reported in another CCC study [28]. The nine farms with high (≥10%) annual mortality in the current study were somewhat smaller (both herd size and acreage), earned less money from milk, and used more traditional housing and milking systems compared to farms with <10% mortality (n=55). Although >75% of farmers from high mortality farms perceived general calf health and weight gain as better than in conventional calf rearing, relatively fewer thought diarrhoea

and respiratory disease were less common on CCC-farms compared to farmers from the low mortality farms. The relatively high proportion of farmers assessing frequency of diarrhoea- and respiratory diseases on CCC-farms compared to rearing systems without CCC as uncertain or higher or the same suggests that infectious diseases still play a key role for calf health and welfare on CCC-farms, and that CCC rearing is no substitute for other management practices aiming to reduce disease risks.

Drivers and Barriers

A large variability was seen in the drivers for the enrolled farmers, with reported drivers largely aligning with those reported by Vaarst et al. [28]. Drivers reported in the current study can be loosely grouped into drivers related to personal values (more natural husbandry, improved animal welfare and increased work satisfaction), improved animal health (improved health in cows and calves, and better weight gains in calves) and profitability (decreased workload, economic reasons, consumer demands and certification requirements). Drivers from these three groups were mentioned similarly often in the full data set, but there were regional differences in which drivers were considered important. Regional differences were most often due to a deviant response pattern for French farmers, possibly because of slight differences in how the questions were phrased in the two questionnaires.

Inappropriate barn design was mentioned as an important barrier for CCC twice as often as any other factor. Similar to what was reported by Vaarst et al. [28], the main concern for farmers in this study was to ensure proper calf housing when keeping cows and calves together. Specific building aspects that limited CCC rearing were not explored in this study, but e.g. slatted floors have been raised as a concern by farmers in an earlier study [28].

Calf Rearing vs. Contact Duration

Unsurprisingly, dam rearing followed by manual milk feeding was most common among farms with short contact duration, while dam and mixed rearing were more often practiced on farms with moderate to long CCC. Cow vocalisation after separation was observed by a higher proportion of farmers with short contact duration, suggesting that separation when the calves are young is very stressful for the cows. Pérez-Torres et al. [30] also reported that a higher proportion of Brahman cows was vocalising, and vocalised more frequently, when separated from their calves 25 days after calving, compared to when the calves were 45 days old. On the other hand, in the current survey, calf vocalisation was reported by approximately the same proportion of farmers regardless of contact duration, perhaps because calves' vocal responses to separation are more tied to hunger [23]. These findings conform to Stěhulová et al. [29], who reported higher frequency of vocalisation in beef cows with younger calves, while calves of all ages (age span 5-9 months) vocalised approximately the same after abrupt weaning and separation.,

Although uncommon, calf weight loss at separation was observed by a somewhat higher proportion of farmers with moderate (29-90 days) contact duration. It is possible that calves in this age group were still not nutritionally independent from the adult cows, while being more difficult to transfer to supplemental milk than calves <1 month of age.

With increasing contact duration, it was more common for farmers to perceive udder health as better, and less common to perceive it as the same as in animal husbandry without CCC. This result aligns with the findings of a recent systematic review [6], which reported that contact duration >60 days was more common in studies finding a positive effect of CCC on udder health compared to studies reporting no effect. On the contrary, most farms perceived fertility as being the same as in farms without CCC, regardless of contact duration.

Perceptions of calf health differed little depending on contact duration, with most farmers in each group considering CCC as beneficial for diarrhoea.

Study Limitations

Due to practical constraints, farms were enrolled through non-random sampling. However, even if snowball referral was used as a mean to recruit more farms, few farms were actually enrolled through other farmers. We included French farmers that had participated in a recent, largely overlapping survey in our data set to reduce the risk of non-response bias due to respondent fatigue. However, this choice resulted in missing data for questions that were not included in the French questionnaire. The questionnaire developed during the study was not piloted before data collection, but linguistic clarity and interpretation of the included questions were evaluated during joint training sessions. Despite these training sessions, issues distinguishing between e.g. weaning and separation were identified during data analyses. One possible explanation for these misconceptions is that the original English questions were translated to several different languages, potentially inducing slight differences in their meaning. Not all interviewers participated in the joint practice sessions, which could have compounded this issue.

Conclusions

The study showed that CCC is used in a large variety of housing systems in Europe today, suggesting that it is possible to rear dairy calves together with lactating cows in most commonly used housing systems as long as farm management is otherwise satisfactory. A large variation in calf rearing strategies and daily contact duration was observed. In general, CCC-farmers considered calf health and calf growth and natural behaviour of animals to be better on their farms, compared to farms without CCC. Weaning and separation distress was

commonly observed by farmers, and building constraints were most often mentioned as a barrier for implementing CCC.

Supplementary Materials

Questionnaire S1: ProYoungStock, Questionnaire S2: VetAgro Sup.

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Author Contributions

Conceptualization, H.E., N.F., B.FW., C.W., D.P., B.M., S.I., U.K., C.Si., A.P., M.C., T.S., A.SN., A.B. and K.A.; Methodology, H.E., N.F., B.FW., C.W., D.P., B.M., S.I., U.K., C.Si., A.P., M.C., T.S., A.SN., A.B. and K.A.; Data collection, N.F., B.FW., C.W., R.W., S.I., C.Si., A.M., D.P., B.M., M.C., M.S., A.SN., A.B., C.Sc., and K.A.; Formal Analysis, H.E. and

K.A.; Data Curation, H.E. and S.I.; Writing – Original Draft Preparation, H.E. and K.A.; Writing – Review & Editing, H.E., B.FW., R.W., C.W., D.P., B.M., S.I., U.K., M.C., A.SN., A.B. and K.A.; Visualization, H.E. and K.A.; Project Administration, K.A., A.SN. and A.B.; Funding Acquisition, N.F., B.FW., C.W., D.P., B.M., S.I., U.K., A.P., T.S., A.SN., A.B. and K.A.

Institutional Review Board Statement

The study was conducted in accordance with the Declaration of Helsinki and followed relevant international standards and guidelines for research. All respondents gave their informed consent before participating in the study and they were informed that all data would be treated confidentially and presented in such a way that their farm identities would not be revealed. No ethical approval was required for this study as no sensitive data was collected.

Data availability Statement

The data presented in this study are openly available in [repository name] at [doi], reference number [reference number], as is the scripts used to analyse the data.

Conflicts of Interest

The authors declare no known competing financial interest in the work reported. The funding bodies had no role in the design, execution, interpretation, or writing of the study.

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