Cow-calf contact in dairy farming

– Norwegian cow-calf contact (CCC) farmers' practice and perceptions, and effects of CCC on behavior and performance on pasture

Juni Rosann E. Johanssen
09.02.24 at NMBU

NMBU

NORSØK
Norsk senter for økologisk landbruk

Agenda

- Background
- Interviews (Paper I)
  - M&M
  - Results
  - Summary of results
- Experiment (Paper II & III)
  - M&M
  - Paper II – Results behavior
  - Paper III – Results performance
  - Summary of results
- Future perspectives

Regulations in Norway

Conventional in Norway:

- No requirements for CCC
- No requirements for how much or how long milk feeding
- Allowed to keep calves in single pens for 8 weeks

Organic in Norway:

- Calf should suckle at least three days
- Drink from artificial teats at least one month
- Natural milk for at least three months
- Should be with other calves after one week

Calf rearing

Research shows positive effects of:

- Social rearing
- Increased milk allowance
- Drinking from artifical teats
- Increased space

- This may be fulfilled by practicing CCC?

How many practice CCC?

Master thesis in SUCCEED (2022):

- 1038 dairy farmers
- 3 % (31) CCC more than 2 weeks
- 15 % want to or plan to have CCC

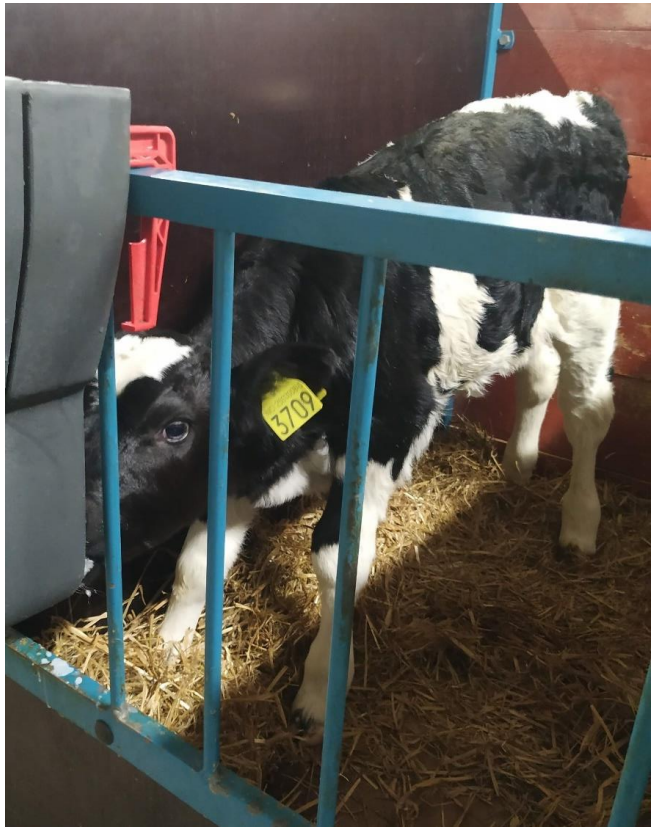
Ref: Berge & Langseth 2022

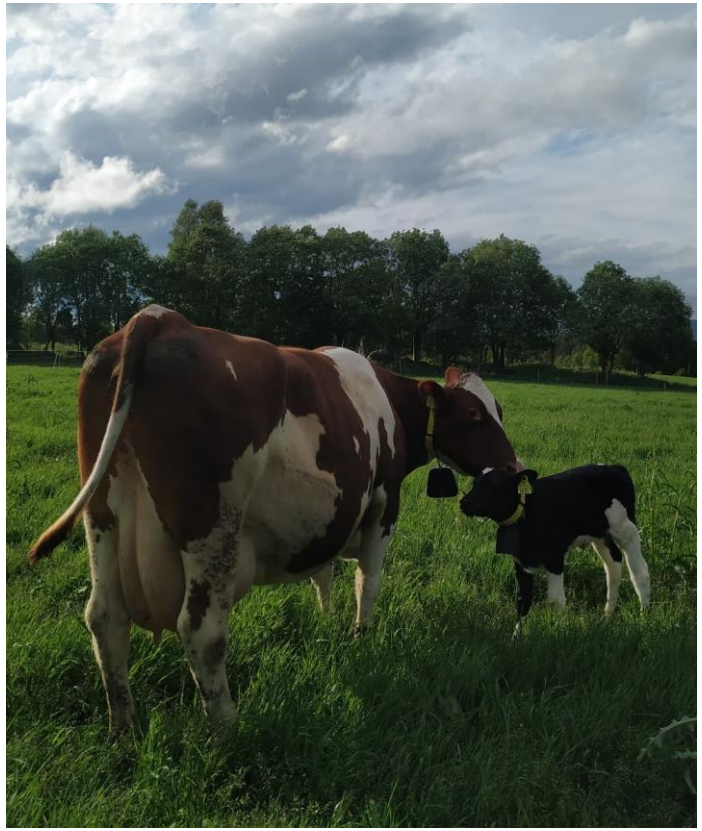
Consumers want CCC and pasture for cattle

- Animal welfare awareness
- What is natural for the animals
- Favor CCC
- Pastured cattle

Recent survey in Canada:

- Citizens ranked rearing of calves alone, in groups or with foster cows similarly – they don't want dams to be separated from their calves





Ref: Busch et al. 2017, Boyle et al. 2022, Placzek et al. 2021, Sirovica et al. 2022

Dyrevernalliansen
April 16, 2020 ·

Fantastiske nyheter! Et stort prosjekt om å ha ku og kalv sammen har fått tildelt forskningsmidler! Prosjektet handler om at melkekyr kan få være mor for kalven sin, og ledes av Veterinærinstituttet i samarbeid med bl.a. TINE. Vanlig praksis i dag er å skille dem fra hverandre like etter fødsel, noe som er stikk i strid med dyrenes behov. Forskerne skal undersøke flere aspekter ved å ha ku og kalv sammen, blant annet tekniske løsninger i moderne fjøs, ku og kalv sammen på beite og langtidseffekter av samværet. Dyrevernalliansen har sammen med våre givere arbeidet i flere år for at morkua og kalven skal få være sammen, og vi er svært glade for å se at dette temaet nå blir prioritert slik at flere kalver får være med mamma i fremtiden ❤️

Les mer om saken her: https://www.vetinst.no/.../tre-nye-forskningsprosjekter...

You, Tina Takło, Gitte Uldal and 3.6K others 232 Comments 257 Shares

Skilt fra mor

14 JANUARY, 2022

Visste du at ku og kalv skilles fra hverandre kort tid etter fødsel? I Norge tas kalver fra moren kort tid etter fødsel i konvensjonell melkeproduksjon, og 3 dager etter fødsel i økologisk produksjon. Den tidlige atskillelsen av ku og kalv er stressende og negativ for deres helse.

Ikke skill kalven fra mor - de hører sammen!

Navn *

Epost *

Telefon

Ja, jeg vil ha oppdateringer om kampanjer og muligheter for å redde dyr!

Start Complete

SKRIV UNDER

Båndet mellom ku og kalv

Det er viktig for mor og kalv å være sammen, ikke bare på grunn av dingen, men også fordi det gir kalven en trygghet å være sammen med mor. Båndet mellom mor og kalv er nemlig like viktig som det er for oss mennesker. Når de får være sammen, får de gjøre det som er naturlig for dem.

Ammepress i fjøset

Å ta kalven vekk fra kua er et verdivalg, men ikke først og fremst bondens verdivalg.

Camilla Mellemstrand
Publisert: 24.09.18, 09:16

I siste nummer av Norsk Landbruk kan du lese om melkeprodusent Ole Martin Bolstad, som lar kalvene die hele melkeperioden. Du jeg la ut en kortversjon av denne artikkelen på ulike landbruksgrupper på Facebook, var det stort sett hjerter og applaus å få. Mange skrev at de gjerne skulle gjort noe liknende og stilte faglig relevante spørsmål. Så lenge det var bønder som diskuterte med bønder var tonen god. Det så ut til å være en gjensidig forståelse om at kalvene i dette driftsopplegget har det veldig bra, uten at det må bety at kalver i helt andre driftsområder har det dårlig.

Her er årets mest leste saker

Ammepress i fjøset vant

Diskusjonen om kalver som dier hele melkeperioden tok av på nett i år

Bysten Heggdal
Publisert: 26.12.18, 08:00
Oppdatert: 02.01.19, 10:55

Det er med ganske god margin en kommentar som er årets mest leste sak på norsklandbruk.no sine nettsider. Vår journalist Camilla Mellemstrand skrev tyngen "Ammepress i fjøset" som er lest hele 7766 ganger om hvordan en sak om kalver som dier i hele melkeperioden kan føre til skyttergravskrig på sosiale

Båsfjøs og skille av ku og kalv

Det finnes ingen argumenter som rettferdiggjør skille av ku og kalv.

Elisabeth Gard
Forfatter av bøker om produksjonsdyrene i Norge
Publisert: 27.05.18, 11:02
Oppdatert: 27.05.18, 11:09

I et svarinnlegg til kronikken min "Forskjellig syn på dyrevelferd", skriver Cecilie Sørli at dyrevelferden i dagens konvensjonelle landbruk er god nok, også innen melkenæringen som i båsfjøs.

Jeg har selv et mellomfag i medisin og vil i dette innlegget vise til noen av de fysiologiske endringene som ku og kalv påføres, som følge av dagens driftsformer.

Her får kalvene gå med melkekyrne i to måneder

Arbeidssomt, men god dyrevelferd, sier Ole Martin Bolstad.

Går sammen: På gården til Ole Martin Bolstad får kalvene gå med kua i to måneder. Foto: Privat

Camilla Mellemstrand
Publisert: 08.08.17, 10:24
Oppdatert: 14.04.18, 15:35

Mens kalver i norsk melkeproduksjon stort sett tas fra kua straks etter fødselen, lar melkeprodusent Ole Martin Bolstad i Susendal i Hattfjelldal i Nordland, kalvene gå

Om ku og kalv nok en gang

Alle dyreunger skal få oppleve gleden ved å ha en mor.

Elisabeth Gard
Forfatter av bøker om produksjonsdyrene i Norge
Publisert: 07.06.18, 00:00
Oppdatert: 07.06.18, 00:00

Cecilie Sørlie har svart på innlegget mitt "Båsfjøs og skille av ku og kalv".Boken min "Melkekuenes liv" har undertittel "Lidelsene bak melkeglasset og meieriproduktene som ingen forteller om".

"Melkekuenes liv" er en vid tittel. Undertittelen ble valgt for å vise at av hovedtemaene i boken som er skille av ku og kalv. Sett fra kalvens side, som fratas både moren og det meste av morsmelken sin, er dette for meg et naturlig og

Håper flere får øynene opp for lengre dieperiode

– En utrolig god start for kalven, sier melkeprodusent Kathrine Sandvold Lundgren.

Enkelt i beiteseongen: Dirig fungerer veldig greit i beiteseongen, så Kathrine ønsker å styre mer mot vårkalvinger. Om vinteren kan det bli trangt i kalvingsbingen. Foto: Privat

Camilla Mellemstrand
Publisert: 21.06.17, 13:09
Oppdatert: 14.04.18, 17:27

Etter at vi skrev artikkelen om melkeprodusent Ole Martin Bolstad som lar kalvene gå sammen med mora i to måneder har debatten gått livlig i flere forum.

NOAH - for dyrs rettigheter
January 23 at 1:00 PM ·

I MELKEINDUSTRIEN SKILLES MOR OG KALV ETTER FØDSEL. DETTE MÅ FORBYS! ER DU ENIG?

I melkeindustrien blir kalven skilt fra moren raskt etter fødselen. Vi vet at dette er en stor følelsesmessig belastning, men hensynet til dyrene må vike... NOAH vil ha slutt på lidelsene til dyrene, vil du? Støtt oss ved å bli månedsgiver: www.dyrsrettigheter.no/medlem?f1=23r2

Også Mattilsynet har uttalt seg kritisk til hvordan kalvene behandles: "I mjølkeproduksjonen fratas fortsatt de fleste dyr muligheten til å utøve sterkt motivert atferd, som diing og morsomsorg. Kalvenes behov er et forsømt kapittel i mange nye fjøs. De utsettes ofte for ugunstig miljø, holdes sosialt isolert fra andre og er det eneste husdyret som føres restriktivt i speddyrperioden."

Les mer her: https://landbruksdyr.no/.../ku-og-kalv-i-industrien/...

2.9K 901 Comments 186 Shares

Anima - Stopp dyremishandling
19. november 2023 ·

Kommenter med et '💔' hvis du også synes at en kalv fortjener mer enn bare noen timer sammen med sin mor 😓

Les mer her 👉 https://stoppdyremishandling.no/skilt-fra-mor

Cow-calf natural behaviour

- Cow alone before calving
- Forms a bond within 5 min
- Calf hides, following dam
- Suckle 4-10 times a day
- 7-10 minutes per bout
- Weaning at 7-14 months

Ref: Hudson & Mullord 1977 , Vitale et al. 1986,, De Passille 2001, Reinhardt & Reinhardt 1982

Concerns about CCC

- Later separation → Increased stress
- Less delivered milk
- Less fat in delivered milk
- Inhibited milk ejection
- Lower income
- Colostrum intake

- Building constrains
- Not suitable mothers
- Aggression towards people
- Calves difficult to handle
- Word – Increased, stressful
- Pasture related challenges

Ref: Meagher et al. 2019, Weary & Chua 2000, Beaver et al. 2019, Vaarst et al. 2020, Neave et al. 2022, Berge & Langseth 2022

PhD aim

Acquire new knowledge about Norwegian dairy farming systems with cow-calf contact (CCC), through interviews with CCC farmers and an experiment with CCC on pasture

Interview study – Aim for paper I

Explore how Norwegian dairy farmers with CCC systems practice these systems and how they experience and perceive the interrelationships between cows and calves and humans within these systems

Photo: Farmer no.10

About the interviews

- Interview guide: Autumn 2020
- Criteria – calf with own dam for at least 4 weeks
- Interviews carried out: October 2020- March 2021
- 18 farmers, 13 farms, 1 excluded from paper 1
- 7 with farm visits and 5 online interviews
- 51-130 minutes
- 8 500 – 23 000 transcribed words per interview
- Analysed on NVIVO: Modified grounded theory

The farms

- 17 farmers from 12 farms
- Organic: 4, Conventional: 8
- Welfare label: 2
- Freestalls and AMS: 6, Freestalls and milking parlour: 2, Tiestalls: 4
- 14-60 dairy cows
- Milk quota: 75 – 420 tonnes (two with cheese production)
- Calving season: All year: 7, spring: 1, autumn: 2, other: 2

Photo: Farmer no.10

Cow-calf contact practice

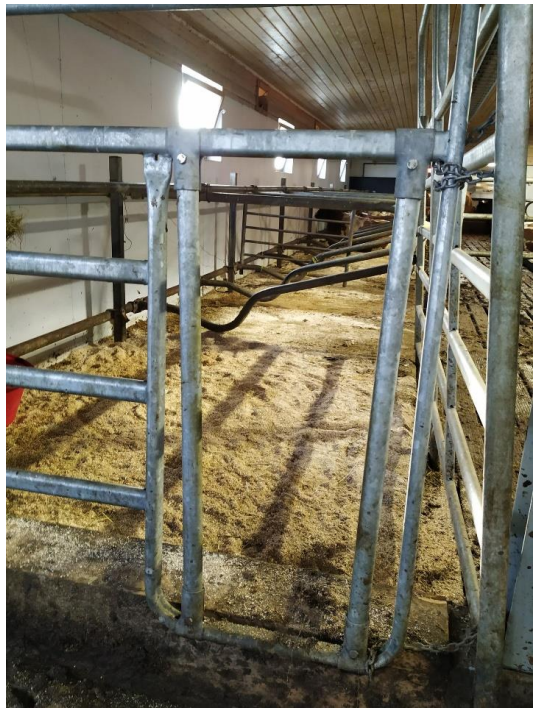
- 3 farms started in the 90s and 9 farms 2015-2019
- Duration of CCC: 6 weeks-4 months
- Most had cow-calf alone in calving pen for some days after calving (bonding)
- All farms with CCC in cow area
- 7 farms with CCC on pasture
- 10 farms had CCC whole milk feeding period
- 2 farms continued with milk feeding after full separation
- Separation and weaning: Abrupt, nose flap, gradually with fenceline and/or less time together

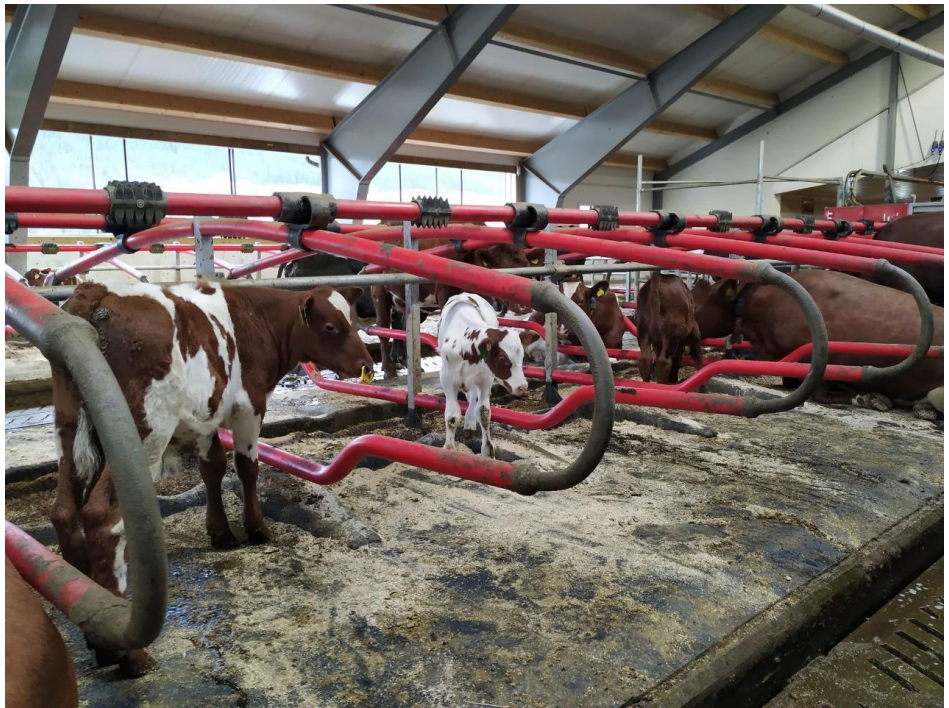
Photo: Farmer no.8

Farm 1

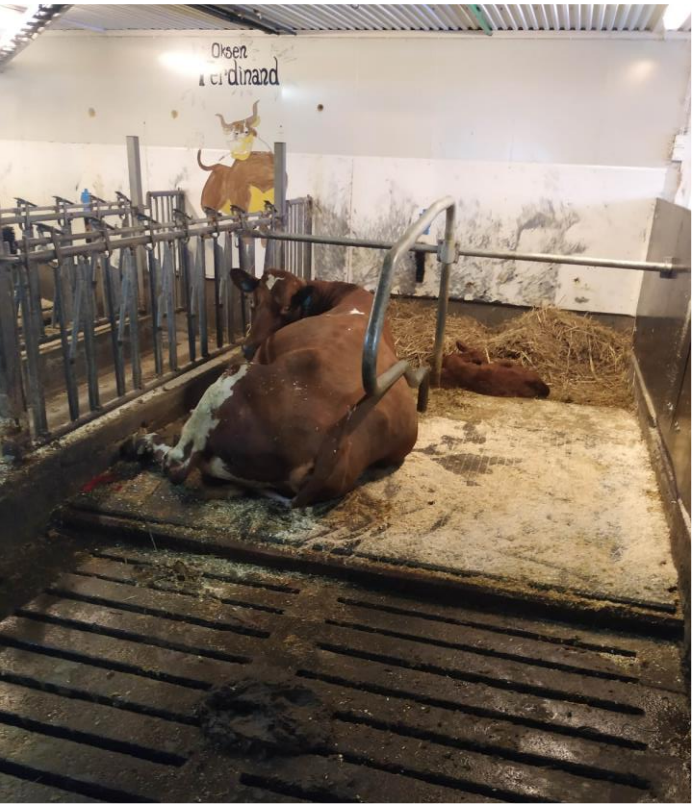
Farm 2

Farm 3

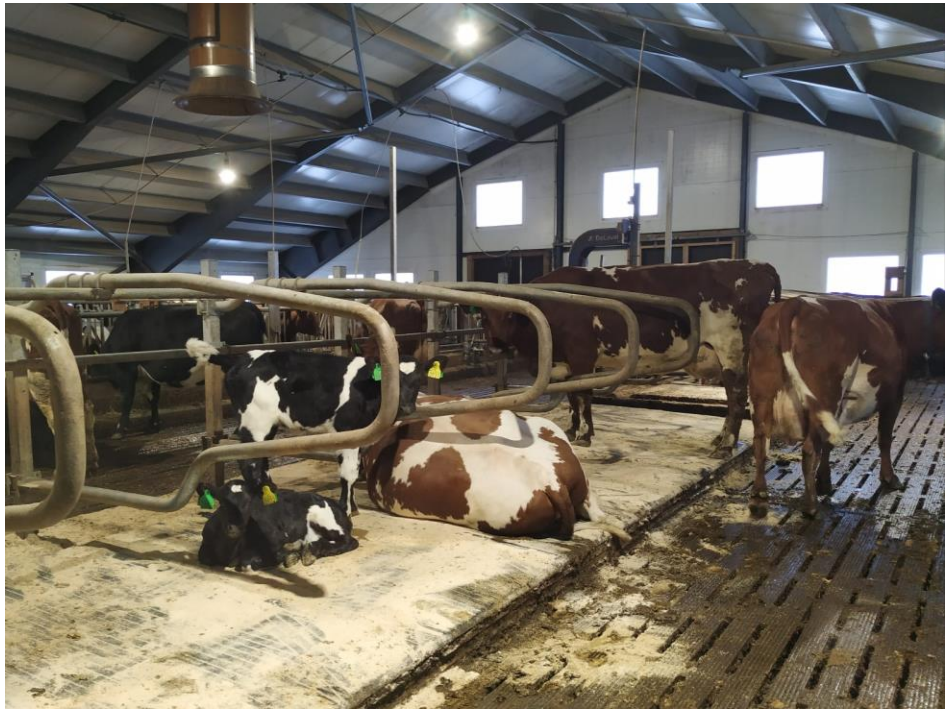


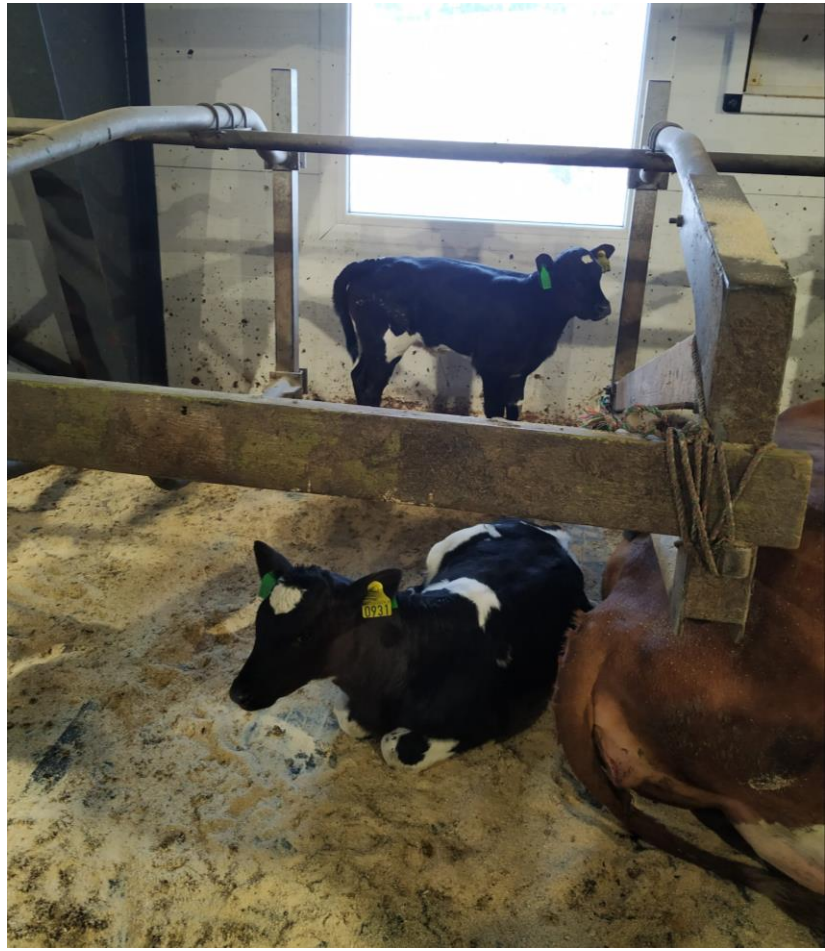


Farm 4



Farm 5





Farm 6

Summary of results

- Colostrum intake – not perceived a challenge, but practiced differently
- Good mothers taking care of their calves
- Some cows stressed or seem like their don't care – need time?
- Cows can show aggression to protect their calves – rarely – but increased risk with people they don't know
- Farmer and animals know each other – feel safe
- Calf handling – important but different practice and perceptions
- Calves learn from cows, but also from other calves

Photo: Farmer no.9

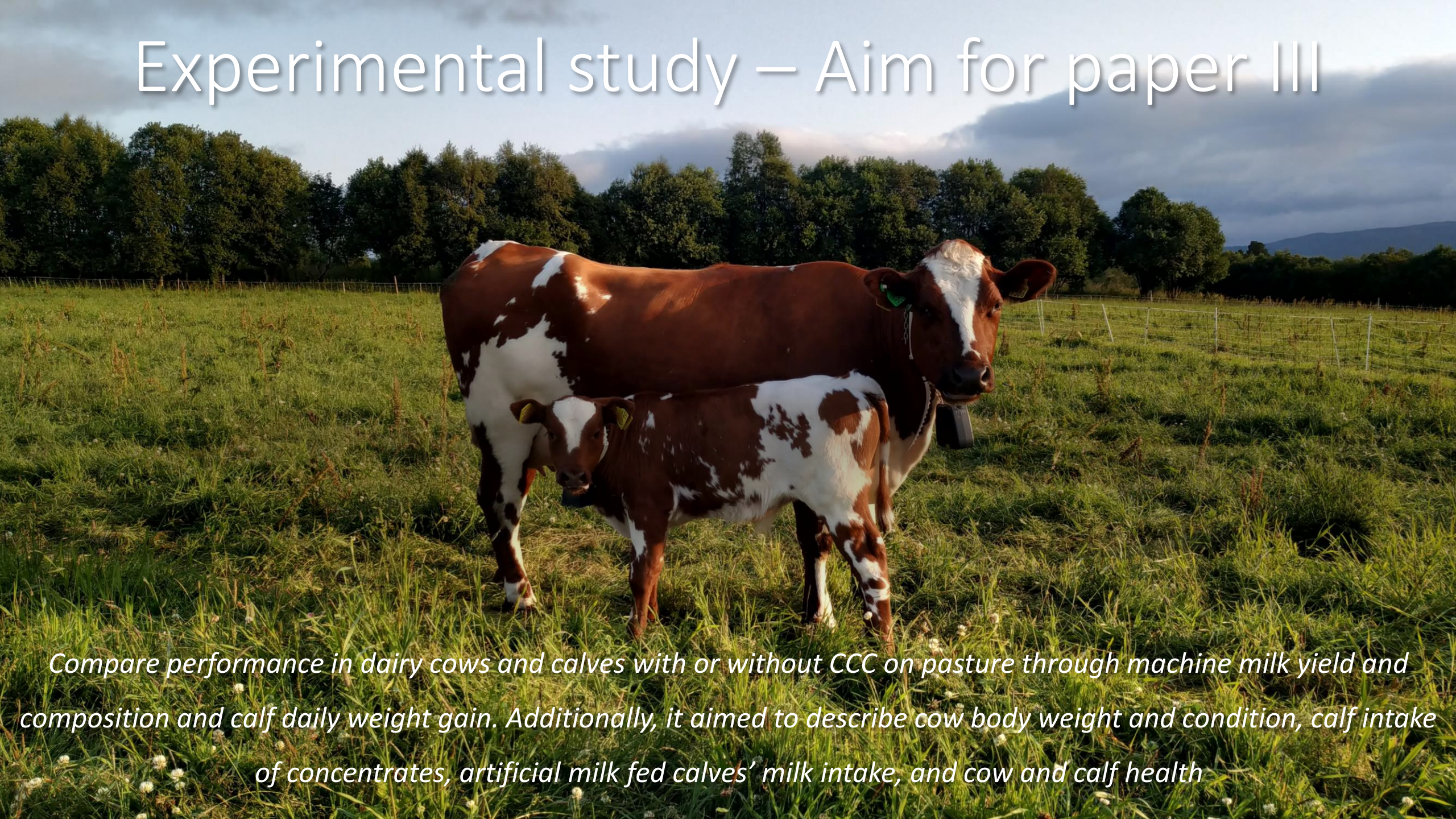
Summary of results

- Housing systems not adapted – space is important
- Most of them practice CCC after only small adjustments in the barn
- CCC requires different practice – more focus on observations, adaptations
- Different opinions about CCC on pasture – best and most natural according to some – others didn't want calves on pasture with the cows
- Challenge with separation stress – variations among animals, several found methods to minimize this
- Different opinions about workload – but less time on calf feeding
- Easier and more flexible system - specially for those with AMS
- The farmers are thriving with these systems
- Animal welfare and natural behaviour – important for these farmers

Experimental study – Aim for paper III

Compare behavior in dairy calves pastured with or without their dams by their use of calf hides, lying, grazing, playing, and allogrooming between calves. This also included describing their behavior in a food neophobia test, as well as describing their behavior of suckling or sucking milk, allogrooming between cow and calf, and the calves' vocalizations after weaning.

Experimental study – Aim for paper III



Compare performance in dairy cows and calves with or without CCC on pasture through machine milk yield and composition and calf daily weight gain. Additionally, it aimed to describe cow body weight and condition, calf intake of concentrates, artificial milk fed calves' milk intake, and cow and calf health

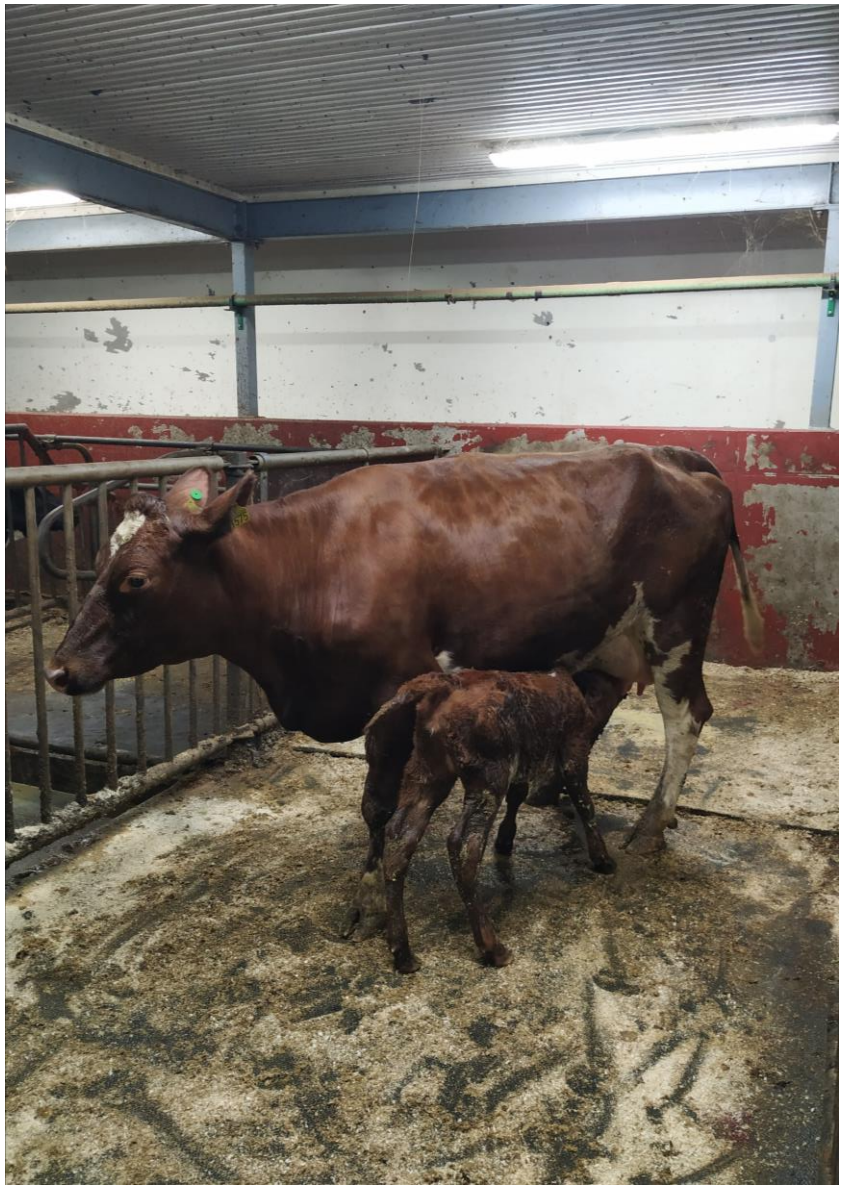
Animals

- Bergtun farm, 80 cows, free stall with AMS, summer pasture with milking parlor
- Cows had no previos experience with CCC

Group (pairs)	CC1 (n=5)	CC2 (n=5)	ES1 (n=4 pairs & 1 calf)	ES2 (n=5)
Calving dates	29. May - 6. June	8 - 14. June	7 - 15. May	17 - 25.May
Calf age variation	8 days	8 days	8 days	6 days
NRF	4 pairs	5 pairs	4 pairs	4 pairs
Holstein x NRF	1 pair	0 pairs	1 calf (1 dam excluded)	1 pair
Primiparous	2 cows	2 cows	1 cow	0 cows
Multiparous	3 cows	3 cows	3 cows	4 cows
Bull	1 calf	1 calf	4 calves	2 calves
Heifer	4 calves	4 calves	1 calf	3 calves
Pasture access on farm	None	None	18. May (only calves)	28. may (only calves)
Summer pasture access	10. June	17. June	7.June	7.June

Treatments

Treatment	CC (n=10 pairs in two groups)		ES (n=10 pairs in two groups)	
Weeks postpartum	Cow-contact	Suckling allowance	Cow-contact	Milk allowance
0-3	Whole day	Free, except during milking	1-3 hours on calving day, then none	12 L/calf/day (four meals)
4-6	Whole day	Free, except during milking	None	14 L/calf/day (four meals)
7	Partial (fence-line): 20 h/d, full contact: 4 h/d	After milking: 2 h morning, 2 h evening	None	8 L/calf/day (two meals)
8	Partial (fence-line): 22 h/d, full contact: 2 h/d	After milking: 1 h morning, 1 h evening	None	4 L/calf/day (two meals)
9	Total separation (audible and visible contact)	None (cows moved 120 m away)	None	None

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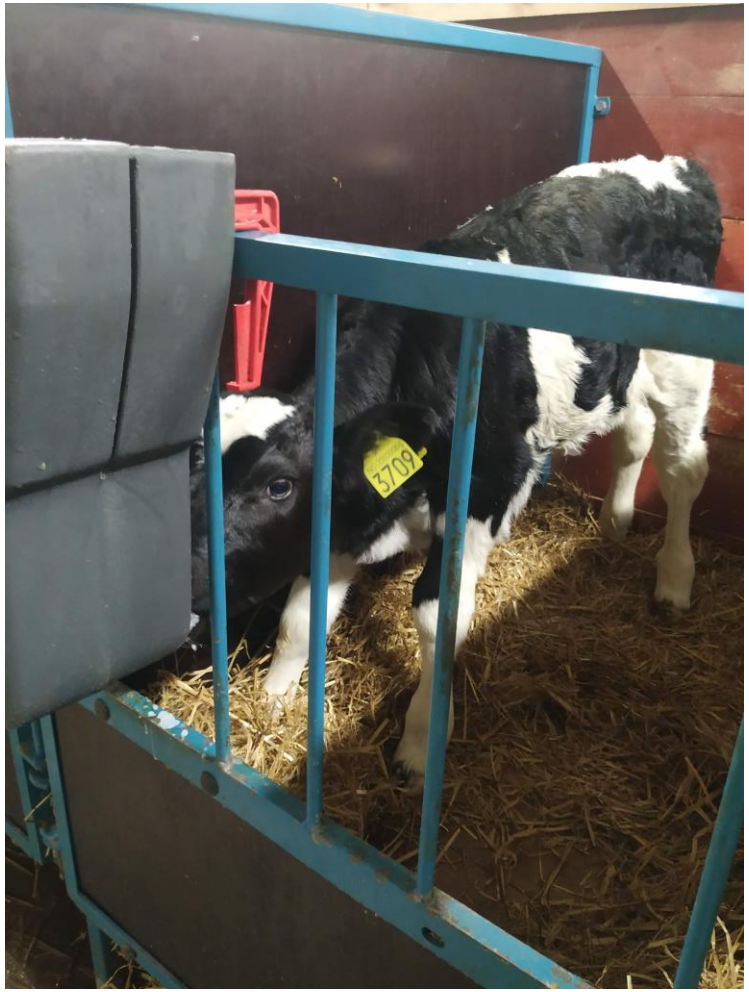
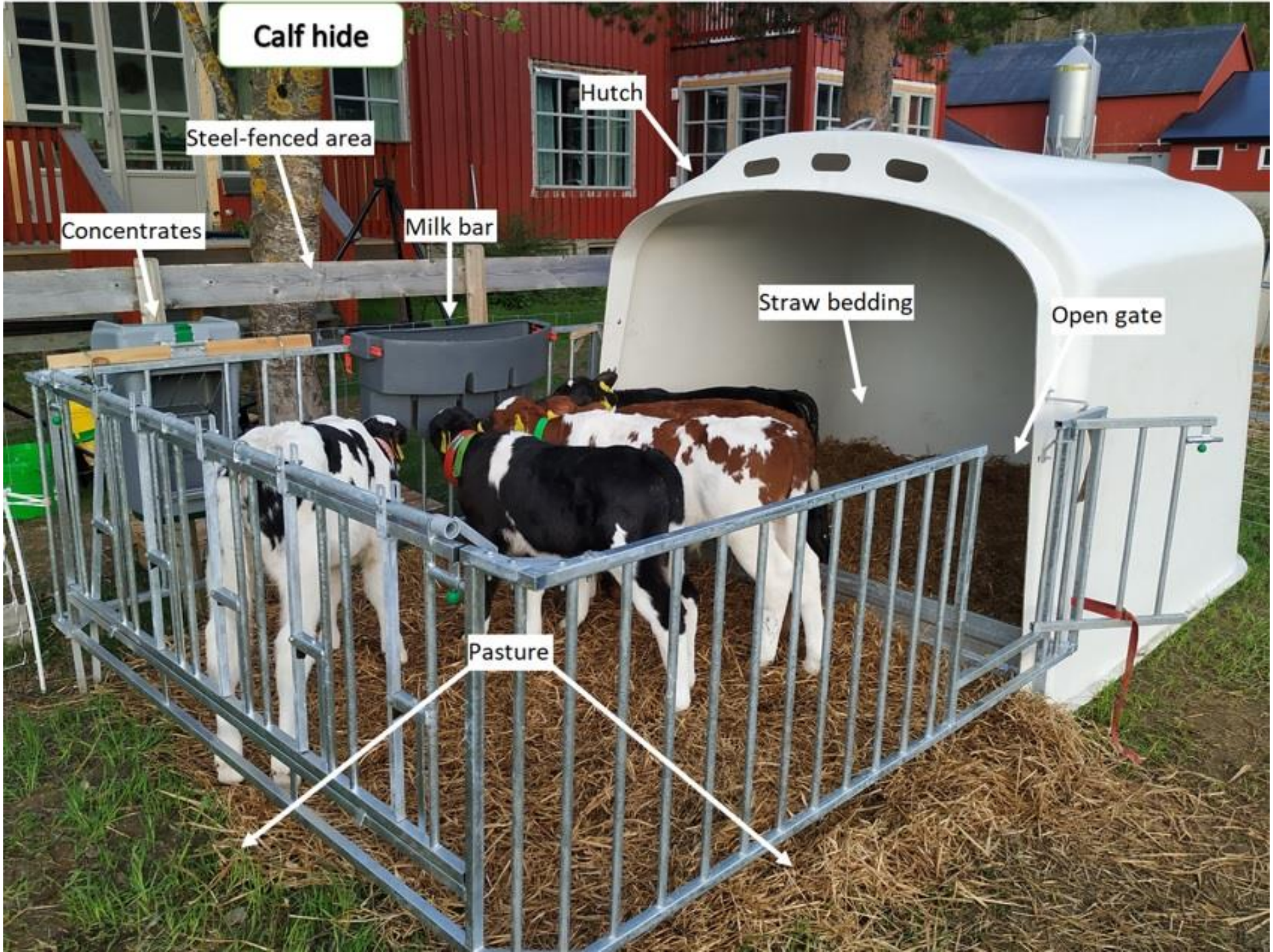

3709


1688


Summer farm pasture,
Nerskogen, 580 MASL
CC calves stayed here after separation
4.9 hectares
9.7 hectares
Milking parlor was here
CC pairs and ES cows were on pasture areas here
14.8 hectares
9.8 hectares
CC cows were moved here after separation
5.5 hectares
13.4 hectares
ES calves were on pasture areas here
11.0 hectares
Google Earth
Image © 2020 CNES / Airbus


Summer pasture 7. May


Calf hide
Hutch
Steel-fenced area
Concentrates
Milk bar
Straw bedding
Open gate
Pasture

Behaviour

Direct observations of calves – Day 1, week 3, 6 og 9:

- Grazing, lying, standing/moving, in calf hide
- Play, suckling/drinking milk, allogrooming, vocalisations (week 9)

Feeding test week 8:

- Concentrates, novel feed-hay, novel feed-carrots, empty bucket

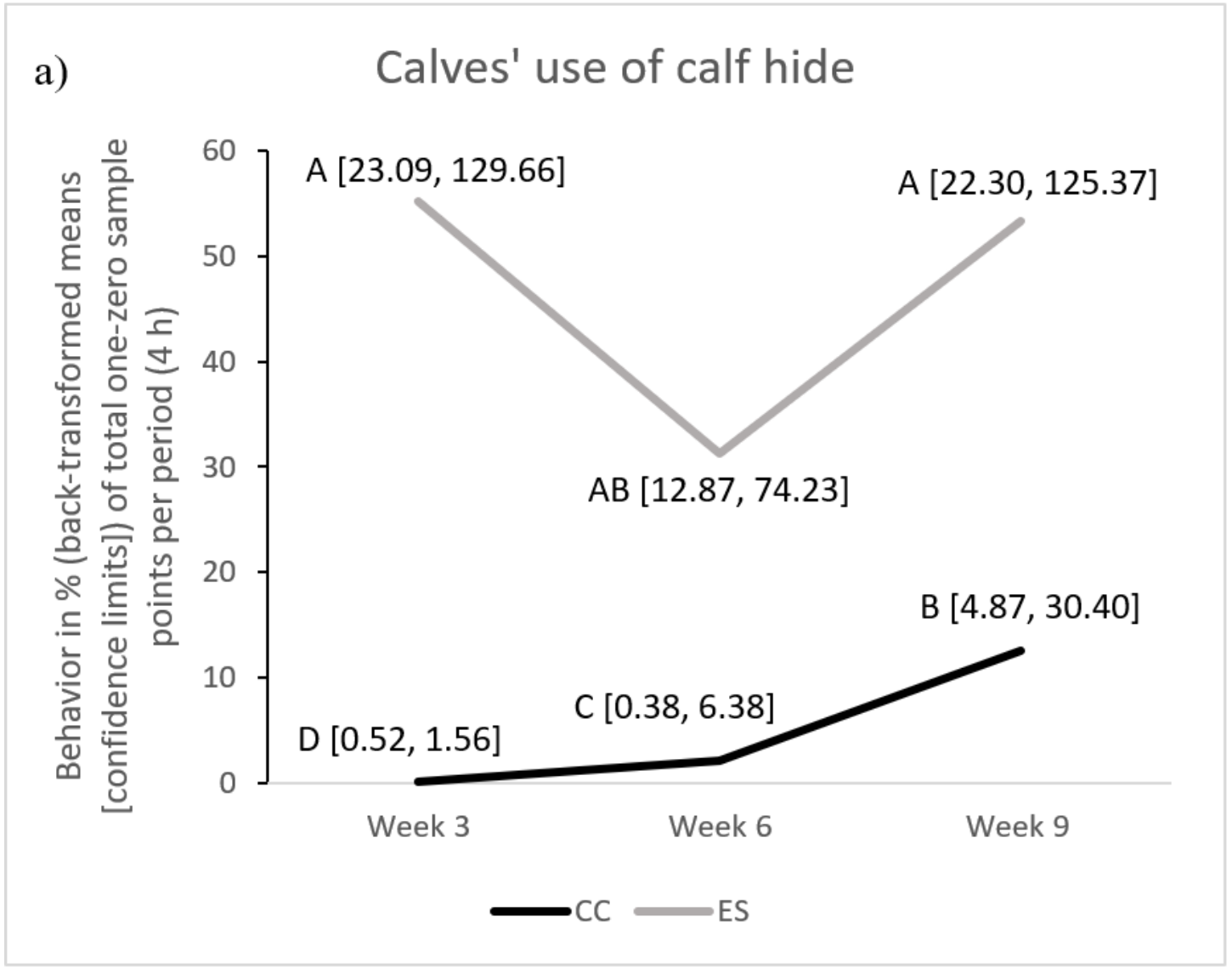
Nofence-collars (cows and calves):

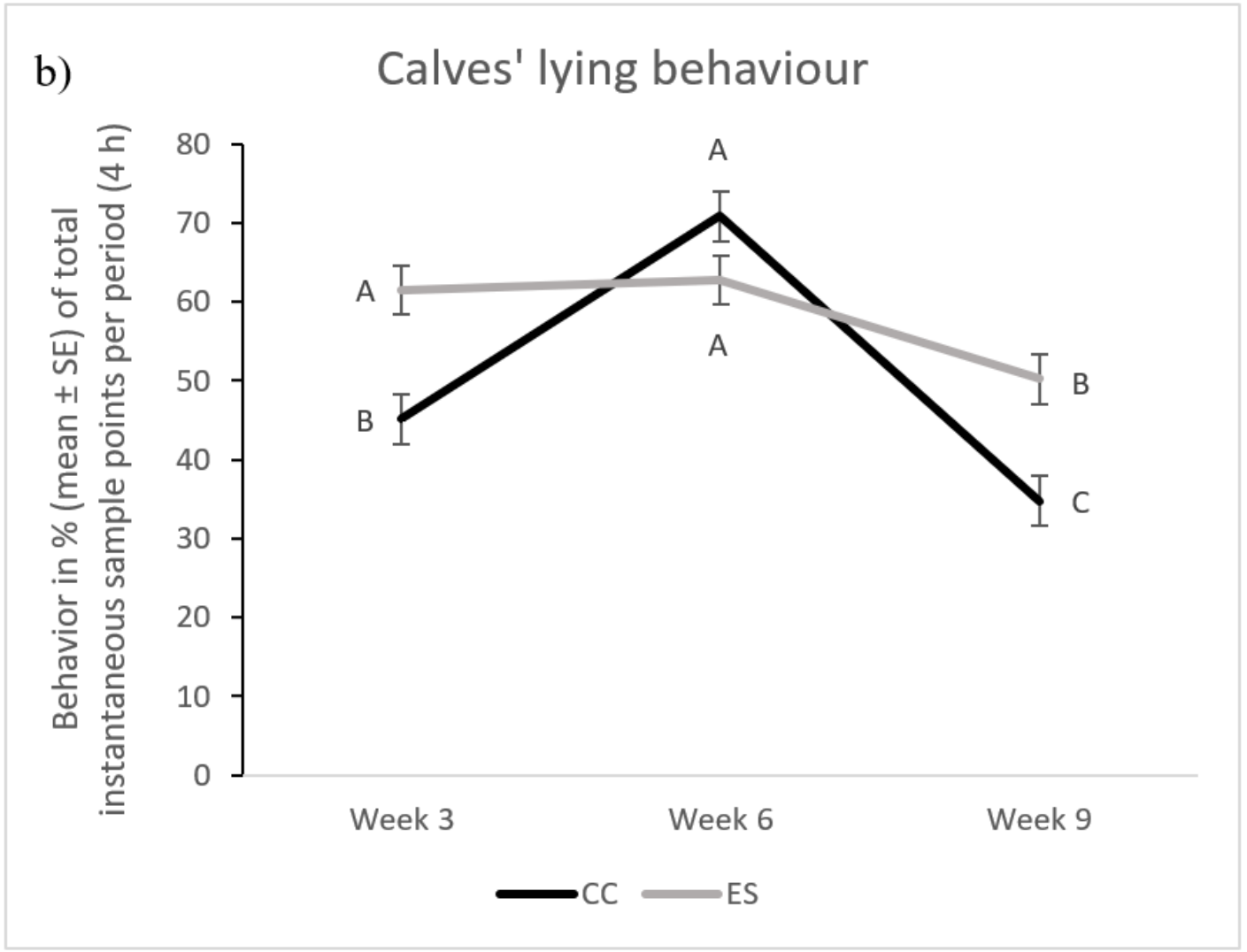
- GPS-positions
- Accelerometer-data activity
- Accelerometer-data suckling CC-calves

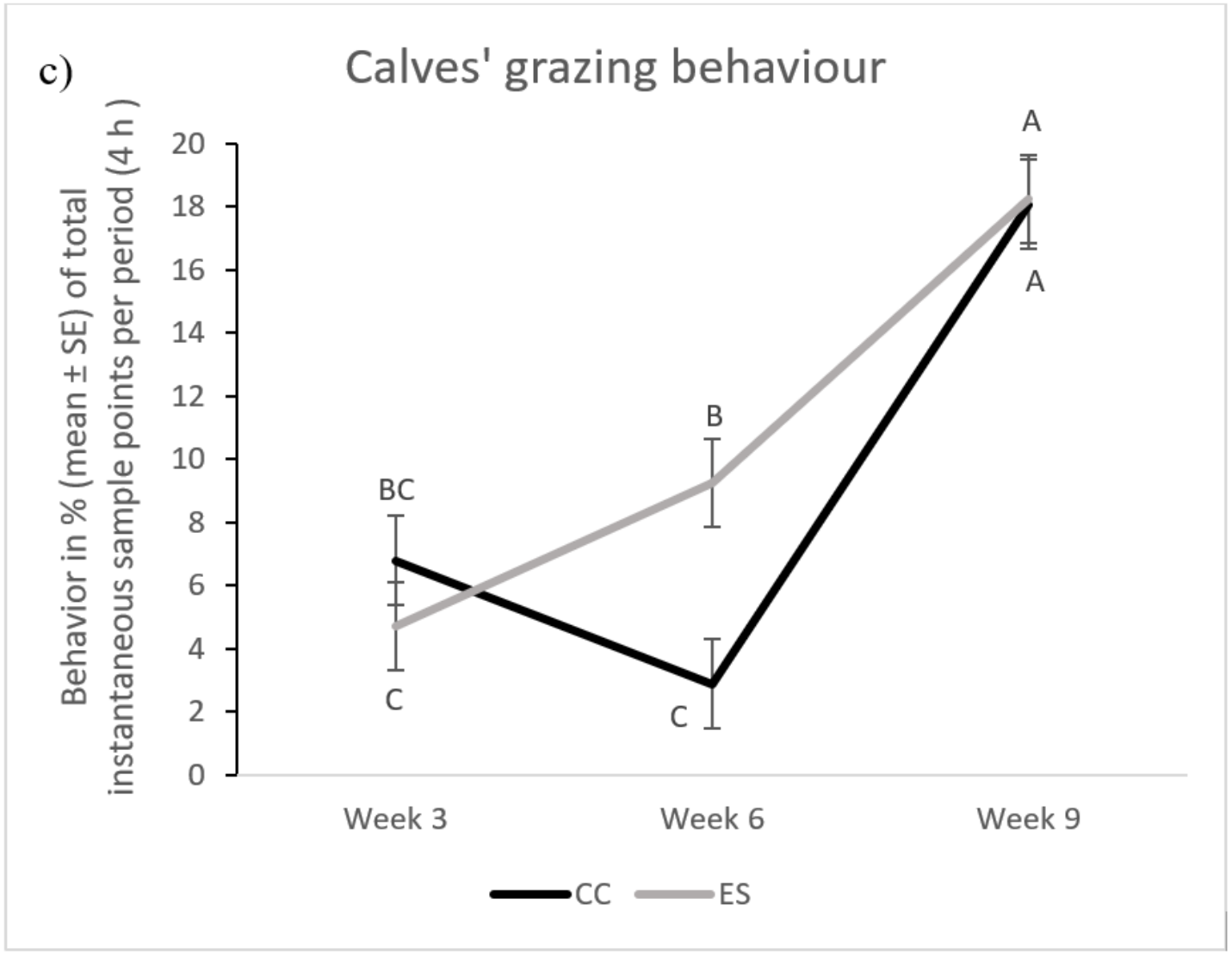
Performance and health

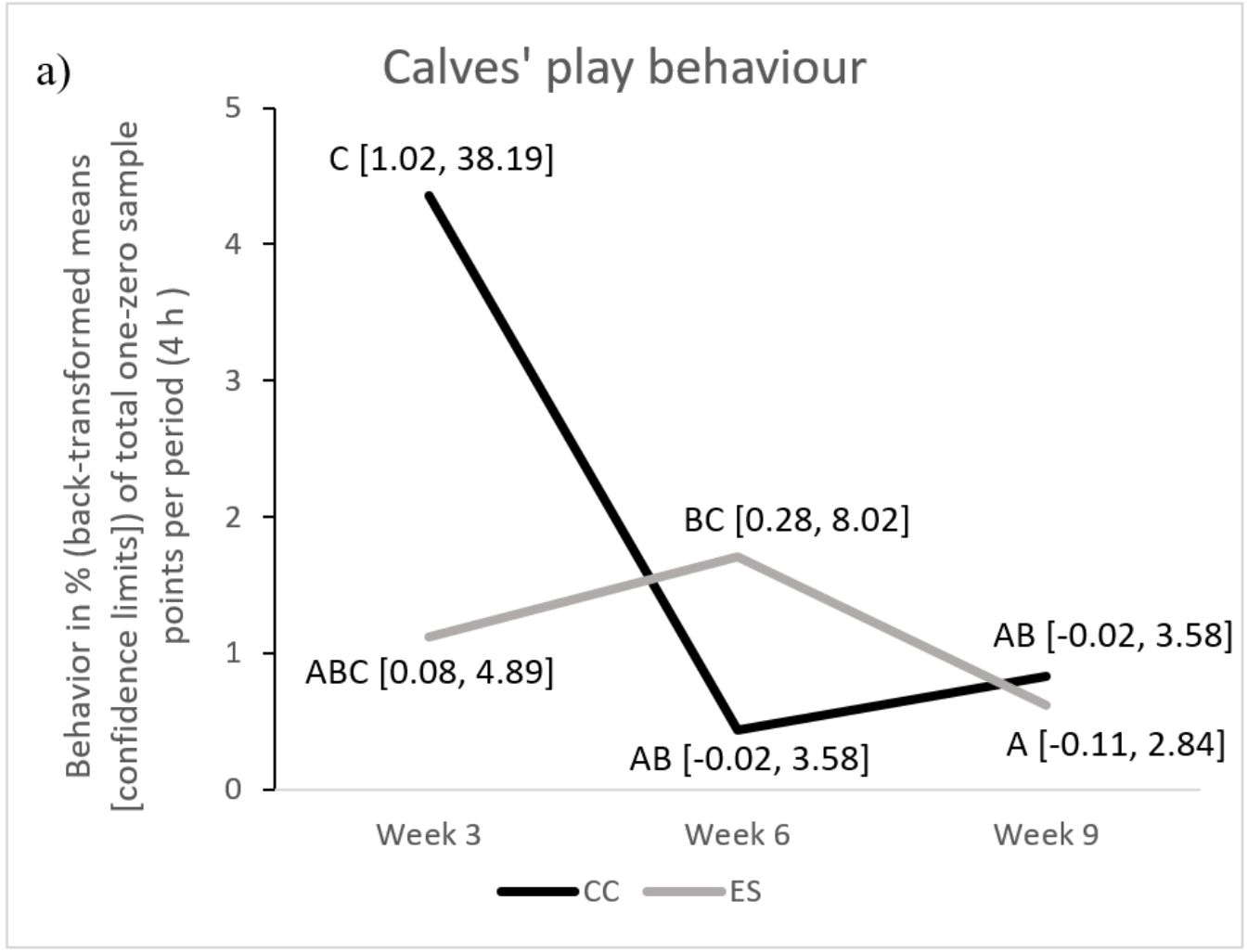
- Daily health checks
- Calves: Health assessments: After birth, pasture day 1, week 3, 6, 9
- Calves: Weighing: After birth, week 6, 9 + some weighings later until 6 months
- Cows: Health assesments, weighing, breast measure, body condition score: day 1 pasture, week 9 (+ breast measure after calving)
- Milk intake ES-calves, week 0-8
- Calves concentrate intake: Week 0-9
- Daily machine molk yield: week 0-11
- Milk samples: week 5 & 9
- Pasture registrations and samples

Calf performance
- Results


a)
Calves' use of calf hide
Behavior in % (back-transformed means [confidence limits]) of total one-zero sample points per period (4 h)
60
50
40
30
20
10
0
A [23.09, 129.66]
A [22.30, 125.37]
AB [12.87, 74.23]
B [4.87, 30.40]
C [0.38, 6.38]
D [0.52, 1.56]
Week 3
Week 6
Week 9
CC
ES

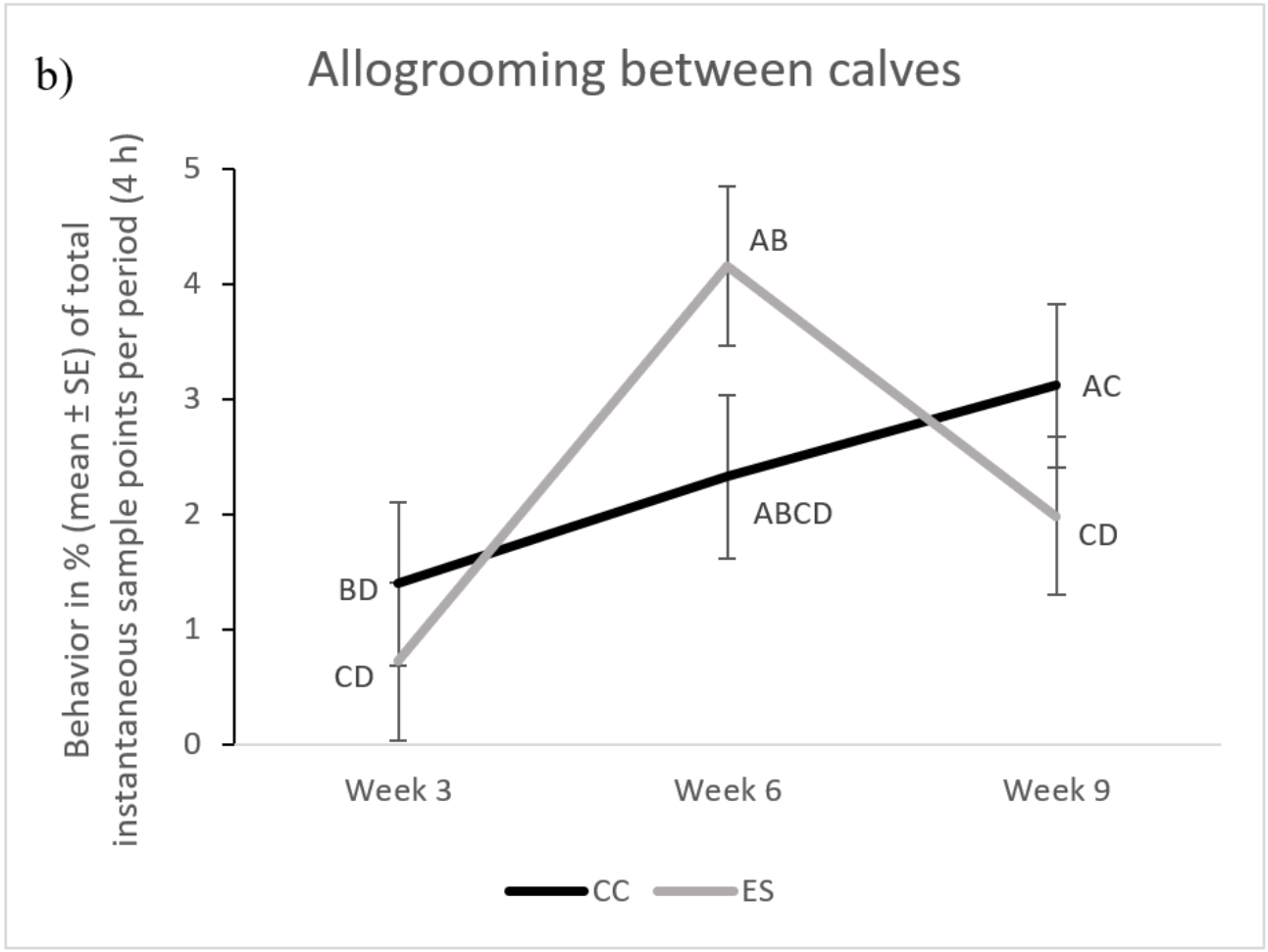

b)
Calves' lying behaviour
Behavior in % (mean ± SE) of total instantaneous sample points per period (4 h)
80
70
60
50
40
30
20
10
0
A
A
A
B
B
C
Week 3
Week 6
Week 9
CC
ES

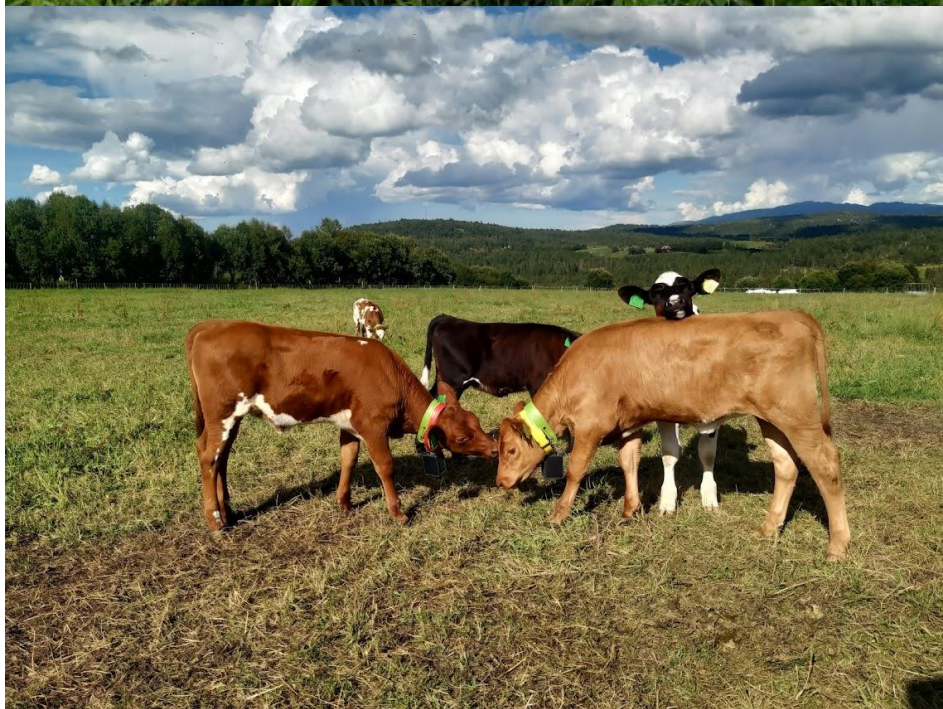

c)
Calves' grazing behaviour
Behavior in % (mean ± SE) of total instantaneous sample points per period (4 h)
20
18
16
14
12
10
8
6
4
2
0
A
A
B
BC
C
C
Week 3
Week 6
Week 9
CC
ES


a)
Calves' play behaviour
Behavior in % (back-transformed means [confidence limits]) of total one-zero sample points per period (4 h)
5
4
3
2
1
0
C [1.02, 38.19]
BC [0.28, 8.02]
AB [-0.02, 3.58]
ABC [0.08, 4.89]
AB [-0.02, 3.58]
A [-0.11, 2.84]
Week 3
Week 6
Week 9
CC
ES

Cow-calf allogrooming

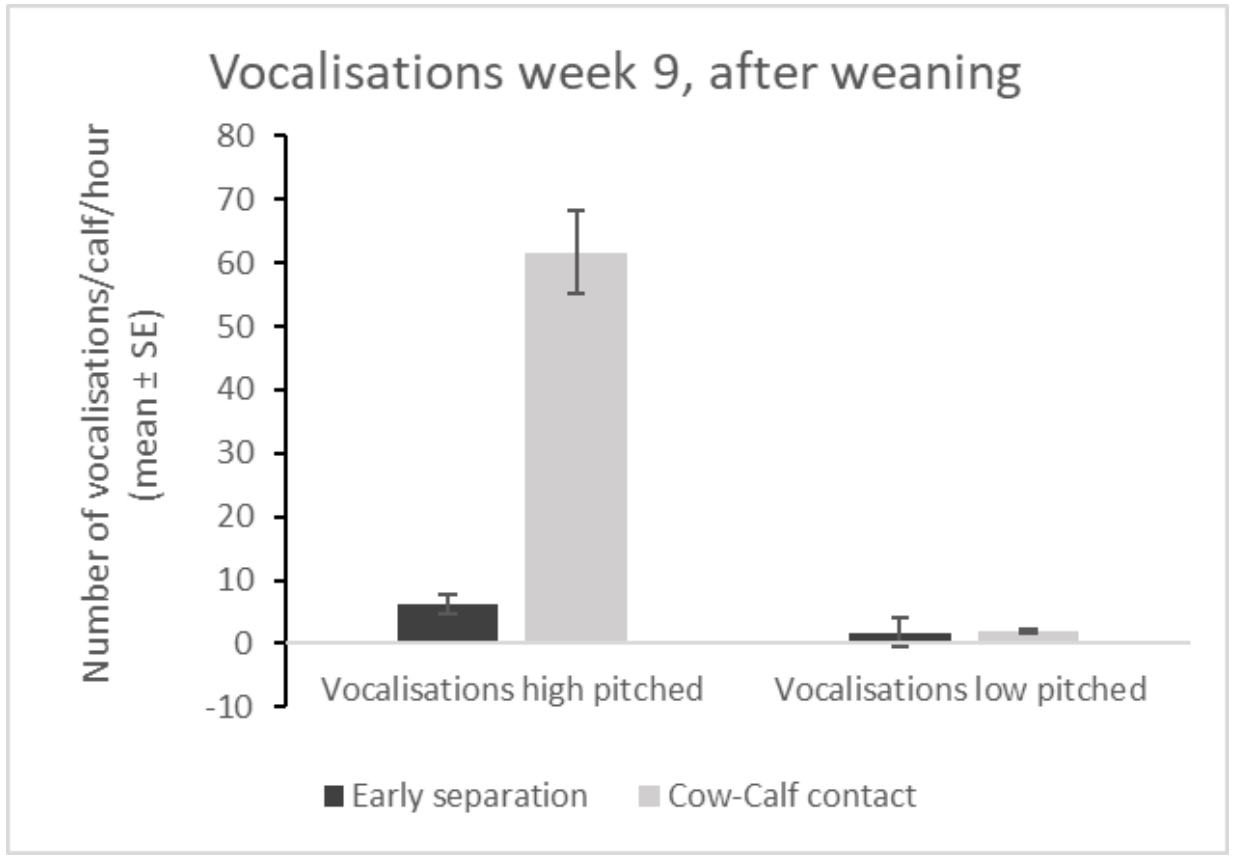
- Similar week 3 and 6: 2.8 vs 2.7 %



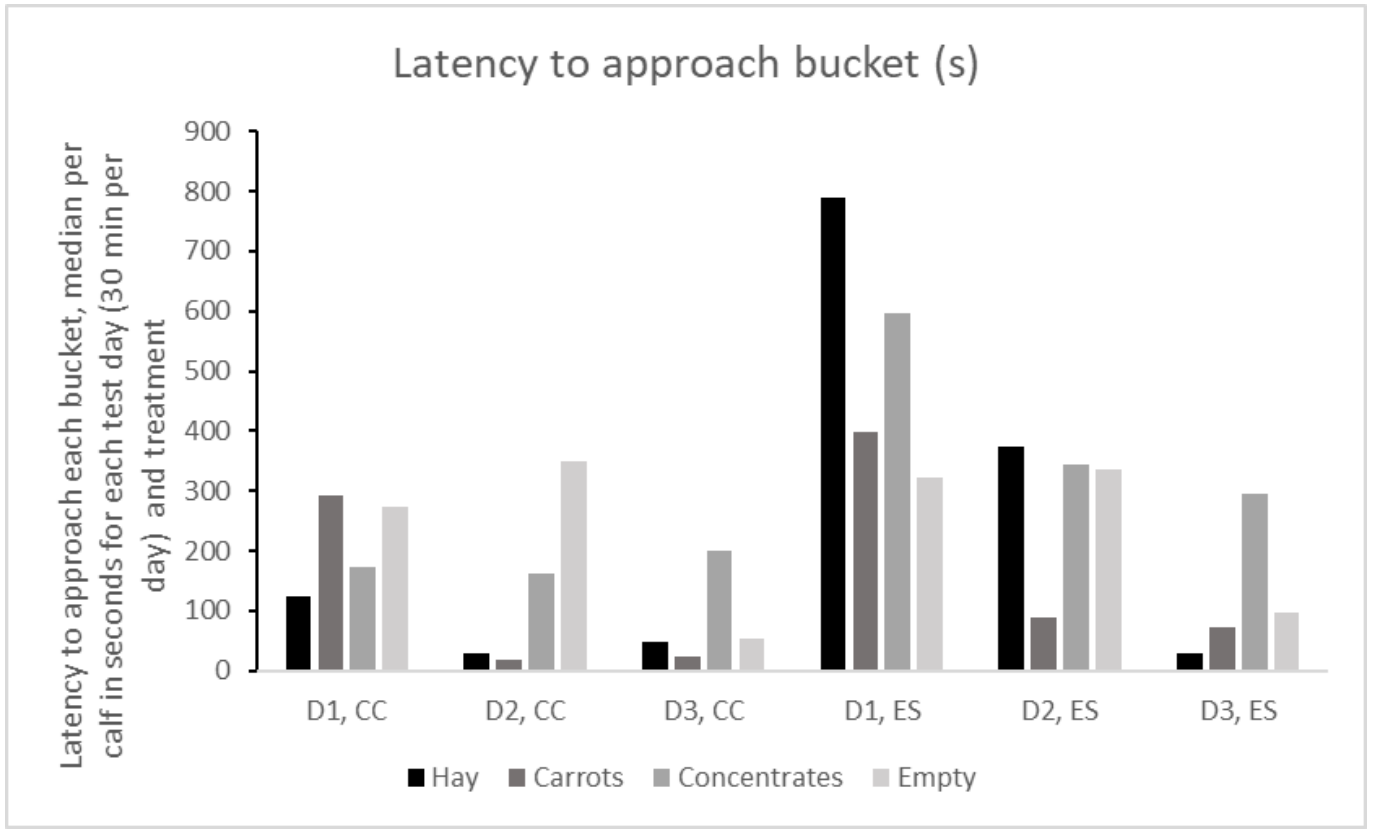


Suckling/sucking milk

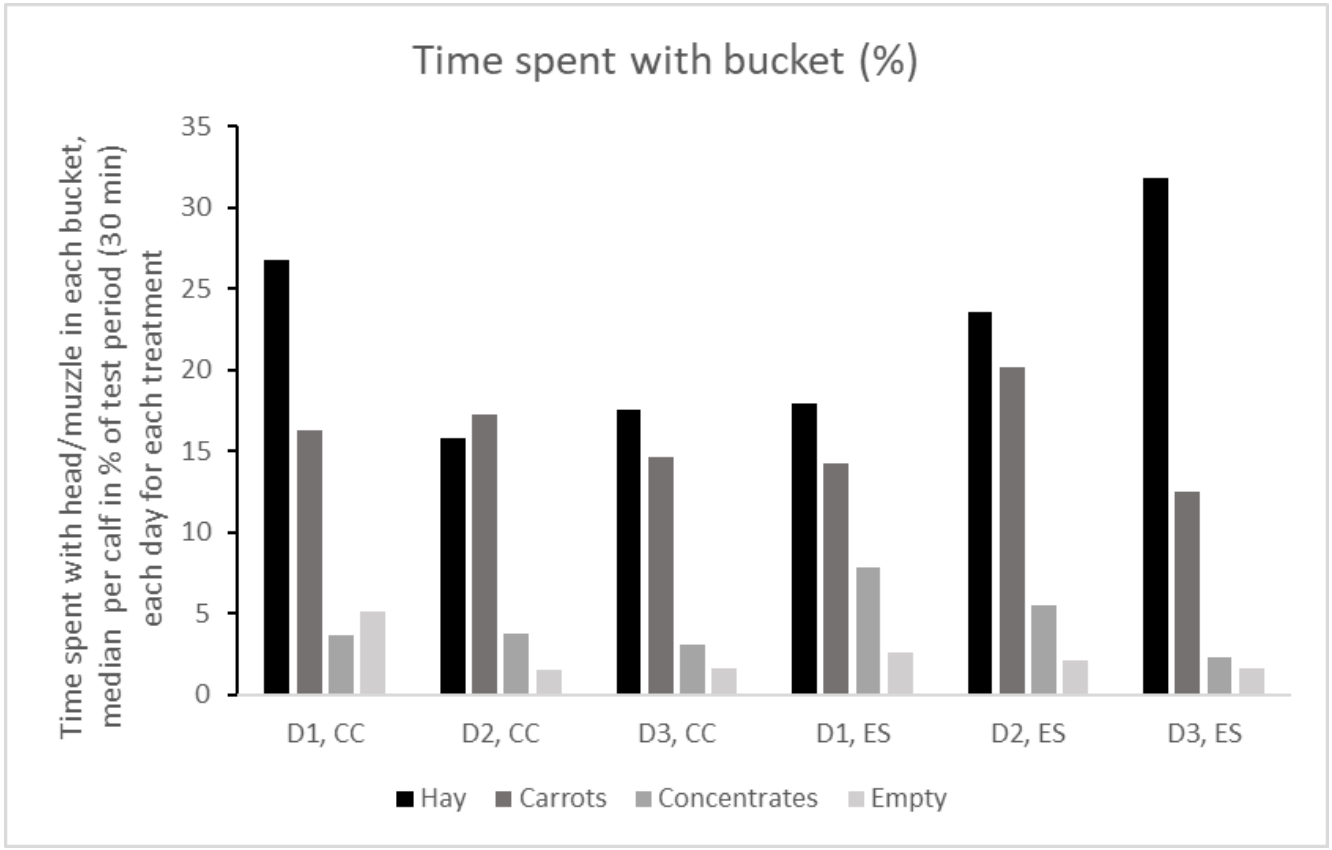
- CC and ES calves spent up to 13 min/period suckling og sucking milk
- CC calves suckling bouts week 3 vs 6: 3.1 vs 1.7 (8 h)
- CC calves time/bout week 4 vs 6: 4.2 vs 6.7 min



Food neophobia test



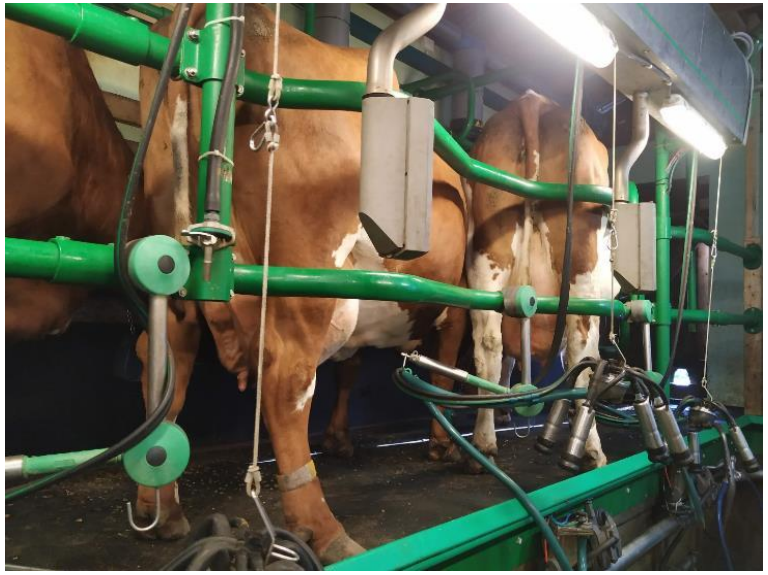
Food neophobia test

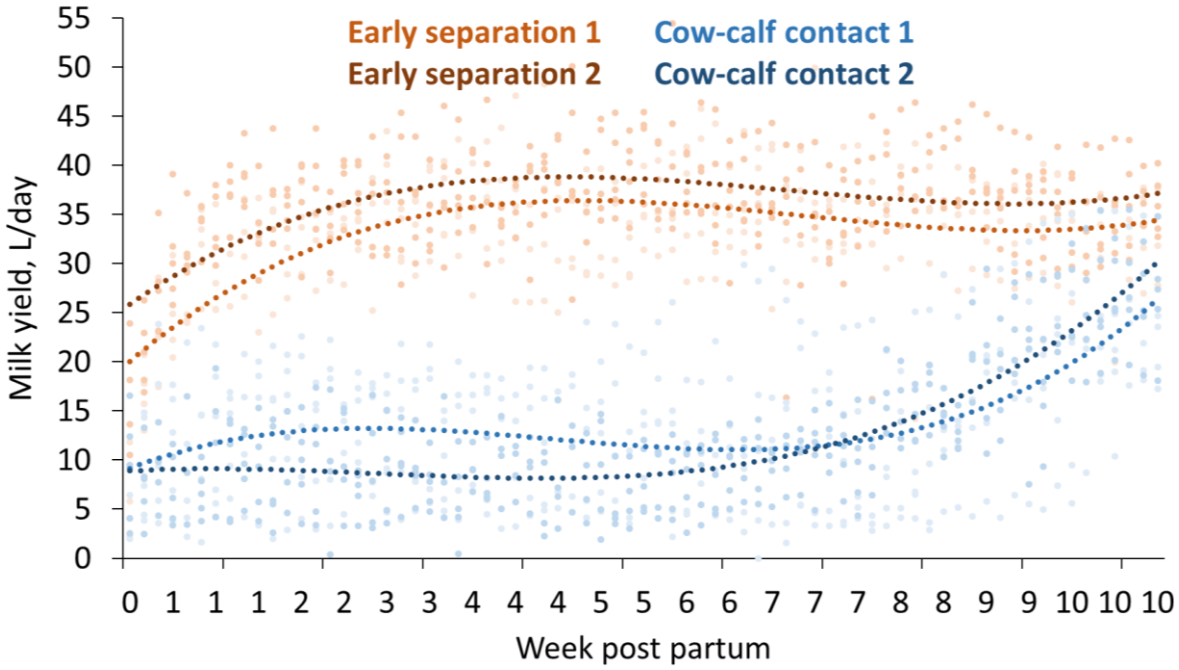


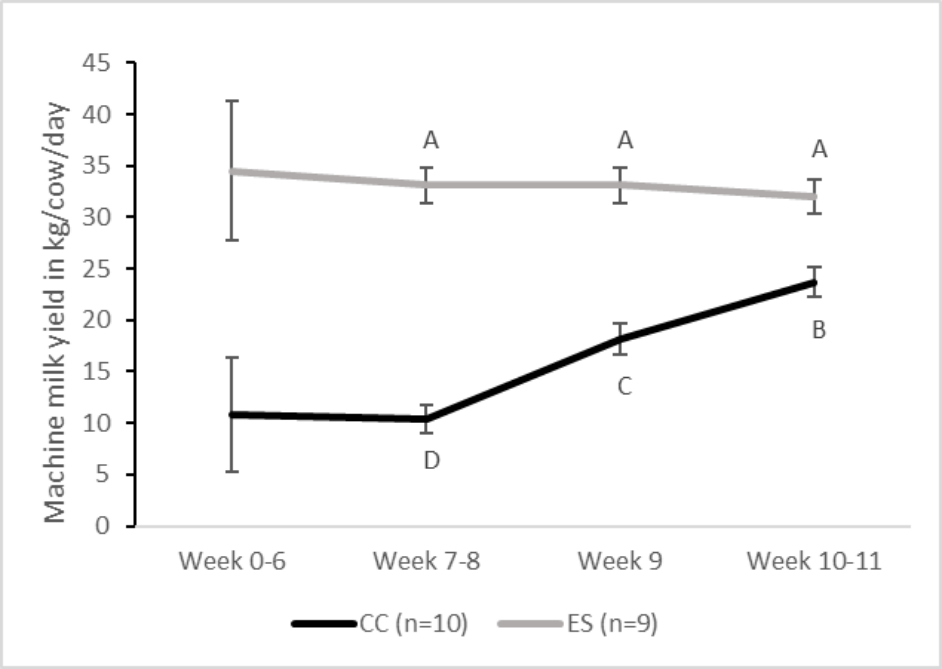
Cow performance - Results

Cows machine milk yield

- Week 0-6: 11 vs 35 kg/day







(68 days per cow)

Cows composition of machine milk

Week 5:

- No sign. difference in fat (but low)
- Difference in lactose and ECM

Post-experiment (week 14-18):

- No differences

	Treatment		Treatment
a. Item	CC (n=10)	ES (n=9)	P-value
Fat, %	**2.6 ± 0.2**	**3.3 ± 0.3**	**0.146**
Protein, %	3.2 ± 0.1	3.2 ± 0.1	0.647
Lactose, %	**4.5 ± 0.1**	**4.9 ± 0.1**	**0.005**
Total solids, %	10.3 ± 0.3	11.5 ± 0.3	0.111
ECM/day, kg	**7.8 ± 2.2**	**33.8 ± 2.4**	**0.010**
FFA, mEq/L	0.14 ± 0.06	0.12 ± 0.07	0.810
Urea, mmol/L	2.2	2.4	0.693
SCC, 10^3/mL	24.4	47.8	0.360
b. Item	CC (n=8)	ES (n=8)	
Fat, %	3.9 ± 0.4	4.0 ± 0.4	0.944
Protein, %	3.6 ± 0.1	3.6 ± 0.3	0.536
Lactose, %	4.9 ± 0.2	4.8 ± 0.2	0.675
Total solids, %	12.3 ± 0.5	12.4 ± 0.7	0.977
ECM/day, kg	**23.4 ± 4.4**	**28.4 ± 4.4**	**0.447**
FFA, mEq/L	0.5 ± 0.1	0.7 ± 0.4	0.222
Urea, mmol/L	5.3 ± 0.4	5.9 ± 0.8	0.535
SCC, 10^3/mL	47.5 ± 56.3	191.3 ± 315.8	0.313

Cows body weight and body condition

- Decrease in body weights
- Numerically higher in ES cows

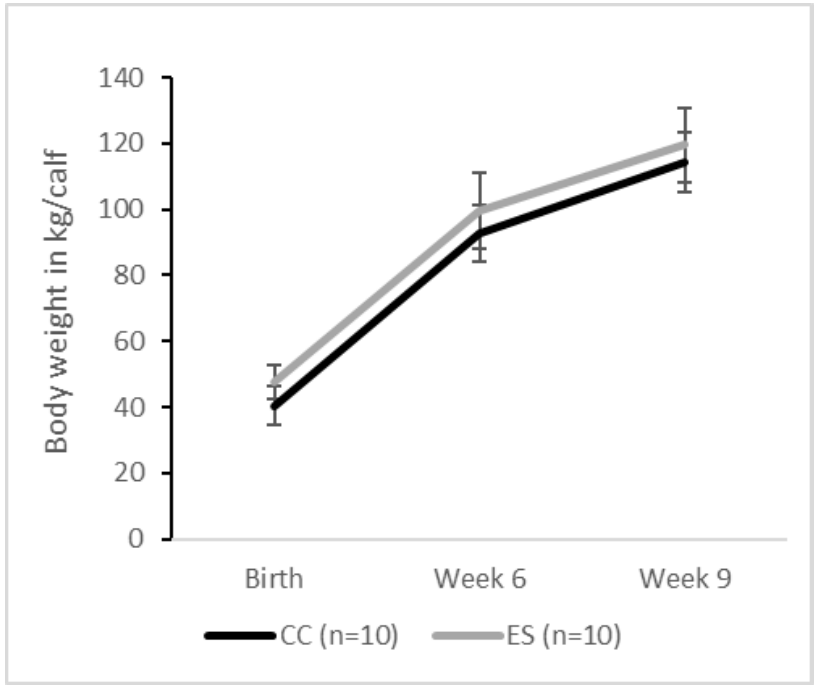
Item	Time	Treatment	
		CC (n=10)	ES (n=9)
BCS, 1–5-point scale	First pasture day	3.9 ± 0.6	3.7 ± 0.7
	Week 9	2.9 ± 0.4	2.5 ± 0.5
Body weight, kg	First pasture day	657 ± 98	691 ± 47
	Week 9	603 ± 82	622 ± 50
	Decrease in g/day	973 ± 462	1647 ± 552

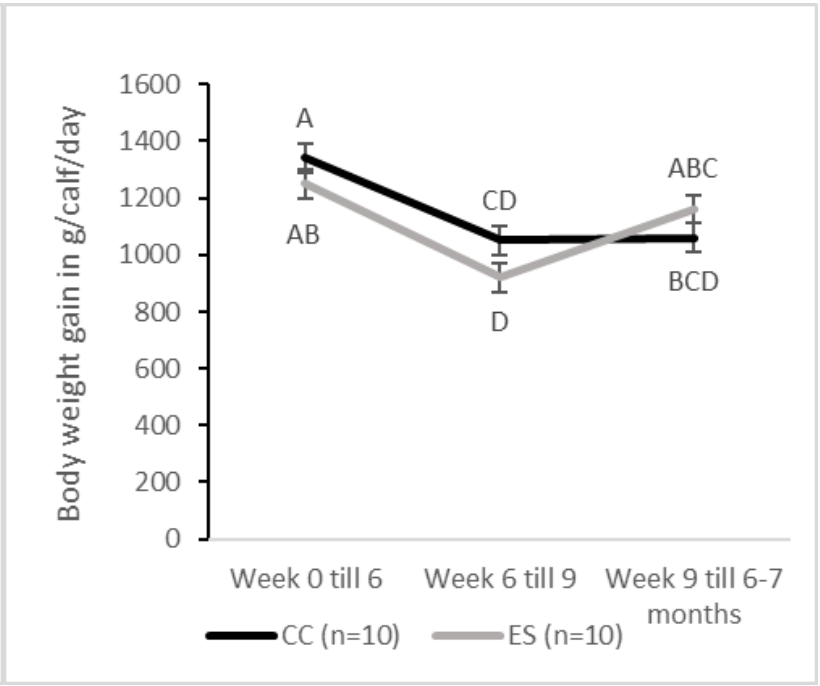
Calf performance - Results

Calf body weight and body weight gain

Weight gain:

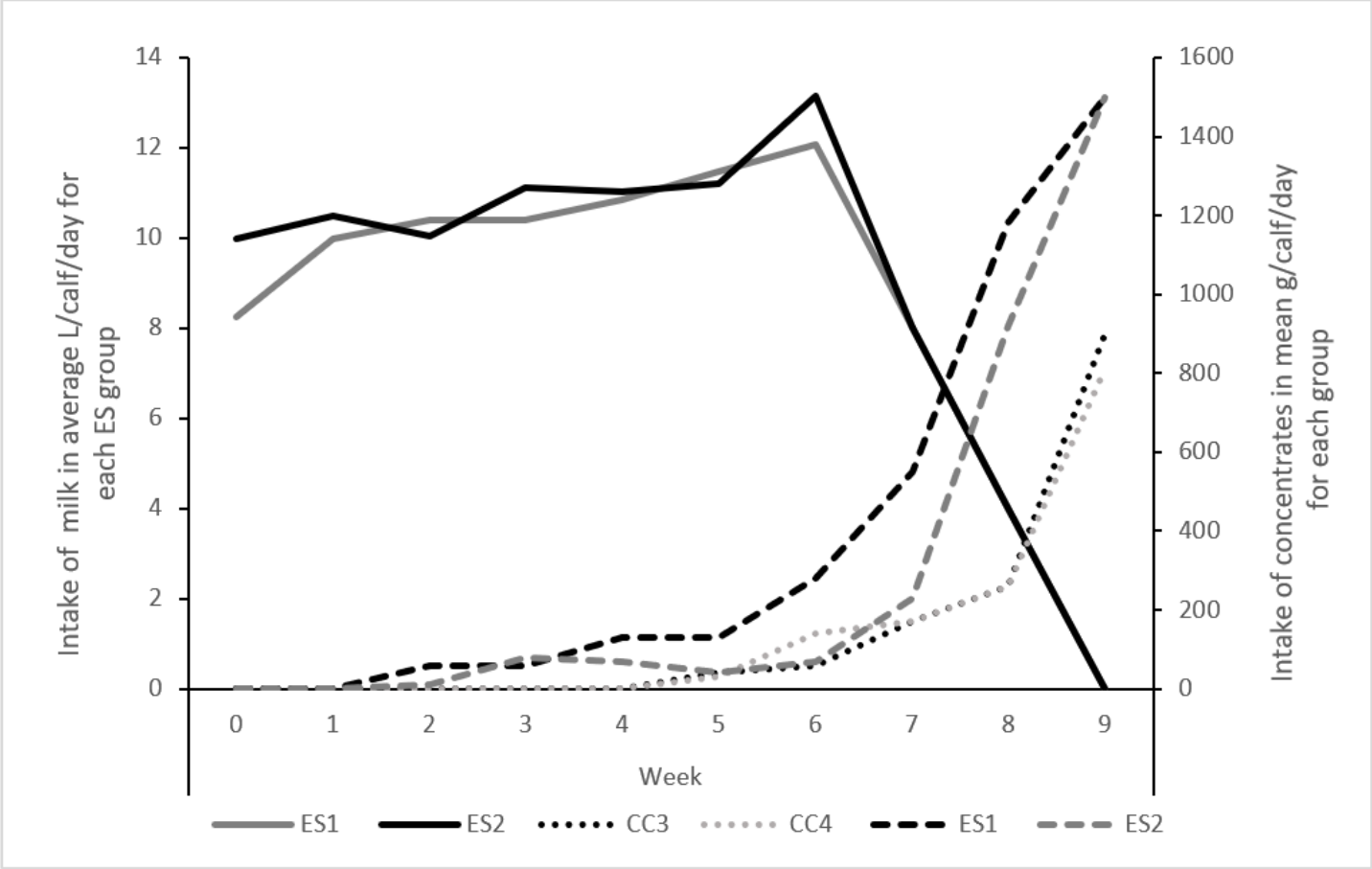
- 1.15 vs 1.11 kg/calf/day (CC vs ES)
- No differences within each period
- Decrease during weaning





Calves' intake of milk and concentrates

- ES: Milk intake 11 L/calf/day week 0-6 (allowance 12-14 L)
- ES: Earlier and more concentrates



Cow health

Inhibited milk ejection during milking in CC cows:

- Especially three primiparous cows
- Prominent during weaning-separation
- Concerns about mastitis and prolonged lower milk yield – Oxytocin injections
- Only the two oldest CC cows considered to have normal milk ejection

Health incident, cows	Item	CC1 (n=5)	CC2 (n=5)	ES1 (n=4)	ES2 (n=5)
Fecal consistency > 3	No. cows	0	1	4	2
Coughing score > 1	No. cows	0	0	0	0
Lameness	No. cows	0	0	0	0
Mastitis, clinical[1]	No. cows	1	2	1	1
Teat wounds/udder injuries	No. cows	1	2	0	2
Inhibited milk ejection	No. cows	3	5	0	0
Oxytocin in. week 0-6	No. of treatments	12	2	-	-
Oxytocin in. week 7-9	No. of treatments	26	26	-	-

Calf health

- Some diarrhea in CC and ES

  (ES around weaning)
- Some coughing in ES2
- CC: Hairless/small wounds on front knees
- General conditions not affected
- Generally good health

Health incident, calves		CC1 (n=5)	CC2 (n=5)	ES1 (n=5)	ES2 (n=5)
Fecal consistency > 3	No. calves	1	3	5	5
Coughing (scores 1-2)	No. calves	0	0	0	4
Lameness	No. calves	0	0	0	0

Summary of results

- Calf behavior influenced by CC - Dependent on age
- CC calves – Less cautions than ES day 1
- CC cows - Lower machine milk yield
- Challenge – Inhibited milk ejection
- CC cows - Lower fat in milk, not significant
- Milk composition – Similar post-experiment
- Calf weight gain, health – No differences

Future perspectives

- Calves receive learning, care, and protection from their dams – How important is this for their welfare?
- Methods to enhance milk ejection in CCC cows on pasture
- Mobile milking robot for CCC cows on pasture
- Methods for separation and weaning to reduce stress for cows and calves on pasture
- Survey among Norwegian consumers – will be done in 2024

Projects and financing

SUCCEED (2020-2023):

- *"Establish science based and practically feasible methods to allow increased contact between cow and calf in dairy production"*:

- The Norwegian Research Council, Research funding for the agriculture- and food industry (FFS-JA) (project no. 310728)

Kalvelykke (Calf Happiness) (2019-2022):

- Regional Research fund Mid-Norway

Dairy cow and calf together on pasture (2020-2021):

- The Norwegian Animal Protection Alliance's Research Fund

Supervisors and committee

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- Emma Matilda Ternman, Nord university

Committee coordinator:

- Inger Lise Andersen, NMBU

Extras

Term	Definition
CCC	Cow-calf contact: *"Any physical contact and behavioral interaction between a dam and her own calf or a foster cow and her foster calf"* (Sirovnik et al., 2020)
CCC system	"*Any housing or management where calves have contact to either the dam or a foster cow; cow-calf pairs either bond with or tolerate each other; they may or may not be able to suckle/nurse*" (Sirovnik et al., 2020)
Full CCC	*"Unrestricted CCC between a cow and her calf/foster calves is allowed; i.e. both suckling/nursing and affiliative interactions without any hindrance"* (Sirovnik et al., 2020)
Partial CCC	"*Limited CCC between a cow and her calf/foster calves, for instance, fence-line contact and/or prevention of suckling with a nose-flap or an udder net; in terms of daily duration of contact it can be whole-day or part-time*" (Sirovnik et al., 2020)
Whole-day CCC	*"The cow and the calf are managed together with CCC for almost 24 hours daily with a possible exception of being temporarily separated during milking and feeding and with a possibility to retreat"* (Sirovnik et al., 2020)
Part-time CCC	*"The cow and the calf are managed with CCC during specific periods of the day only, that is when temporary cow-calf separation exceeds milking and feeding times"* (Sirovnik et al., 2020)
AMS	Automatic milking system
NRF	Norwegian Red (cattle breed)
Artificial rearing	*"Calves are separated from the dam in the first days after calving and have no physical contact to the dam or foster cow"* (Sirovnik et al., 2020)
Machine milk yield	Milk delivered from the cow at milking
Calf hide	In this study a calf hide on pasture consisted of a hutch with straw bedding and an outdoor area surrounded by a steel fence.
Udder net	Net covering the cows' teats to prevent the calf from suckling
Fence-line contact	Limited amount of physical contact is allowed through a fence-line
CC	The cow-calf contact treatment in this thesis's pasture study
ES	The early separation treatment in this thesis's pasture study

Event	Week
Calvings	Week 0
CC pairs and ES calves let on pasture	Week 1
ES2 cows let on pasture	Week 3
ES1 cows let on pasture	Week 4
Full CCC/High milk allowance	Weeks 1-6
Gradual weaning	Weeks 7-8
Fully weaned and separated	Week 9
Calf behavior observations	Weeks 1, 3, 6 and 9
Calf food neophobia test	Week 8
Cow machine milk yield	Weeks 0-11
Cow machine milk composition	Weeks 5, 9, and weeks 14-16 (16 Sep)
Cow teat samples (mastitis bacteria)	Weeks 5 and 9
Cow breast girth	Week 0, pasture day 1 and week 9
Cow weighing	Pasture day 1 and week 9
Cow condition scoring	Pasture day 1 and week 9
Calf weighing	Weeks 0, 6, 9, and 6-7 months (3 Dec)
ES calf milk intake	Weeks 0-8
Calf concentrate intake	Weeks 0-9
Cow health assessment	Pasture day 1 and week 9
Cow and calf daily health checks	Weeks 0-9

Pasture info

Table 2. Feed value and chemical composition (NIRS) (average ± SD) of herbage samples derived from pastures before grazing in the pilot study with the two treatments: Cow-calf contact (CC) and early separation (ES).

Variable	CC pasture	ES-cows pasture	ES-calves pasture
n	13	8	8
NE_LMJ/kg of DM[1]	6.6 ± 0.6	7.0 ± 0.6	6.6 ± 0.4
Digestability, % of DM	76.6 ± 4.7	79.8 ± 4.3	77.1 ± 3.4
PBV, g/kg of DM[2]	25.1 ± 30.2	30.4 ± 35.4	10.0 ± 16.0
AAT, g/kg of DM[3]	86.7 ± 5.6	90.3 ± 5.9	86.4 ± 3.8
Crude protein, % of DM	17.5 ± 3.8	18.6 ± 4.6	15.9 ± 2.2
NDF, % of DM[4]	50.9 ± 4.6	51.5 ± 3.5	46.4 ± 4.8
Indigestible NDF, % of NDF	13.8 ± 6.8	9.4 ± 4.7	15.6 ± 3.1

Botanical comp	CC pairs	ES cows	ES calves
Timothy	63 %	56 %	
Smooth meadow-grass			42 %
Other grasses	18 %	29 %	2 %
Clover	6 %	5 %	4 %
Other herbs	14 %	10 %	52 %

Table 3. Clinical health parameters examined by a veterinarian for cows and calves in the two treatments: Cow-calf contact (n=10 cows and 10 calves), and early separation (n=9 cows and 10 calves). Mastitis, cell count, and udder or teat injuries were only examined in the cows.

Clinical parameter	Score					Reference
Fecal consistency	1= Normal consistency	2 = Pasty, semi-formed	3 = Pasty with large amounts of water, content adhered in the perineum and tail	4 = Liquid with fecal content adhered in the perineum and tail	5 = Liquid with blood	Hulsen, 2005
Coughing	1 = No cough	2 = Single cough	3 = Induced repeated coughs or occasional spontaneous coughs	4 = Repeated spontaneous coughs		Adapted from Renaud et al., 2018
Temperature	<38 = Low	38-39.5 = Normal	>39.5 = Fever			Løken, 2013
Temperature, calf > 2 weeks	<38.5 = Low	38.5-40 = Normal	> 40.0 Fever			Løken, 2013
Respiration	Low	Normal	High			Løken, 2013
Heart frequency	Low	Normal	High			Løken, 2013
Lameness	1 = Normal	2 = Mildly lame	3 = Moderately lame	4 = Lame	5 = Severely lame	Sprecher et al., 1997
Mastitis	Normal	Subclinical mastitis	Acute mastitis			Tine, 2017
Cell count by Schalm test	1 < 200 000	2 = 150 000 – 550 000	3 = 400 000 – 1.5 mill	4 = 800 000 – 5 mill	5 > 5 mill	Whyte et al., 2005
Teat or udder injuries	0 = No wound/damage (completely intact skin)	1 = Wound/damage (any hair loss or damaged skin				Clin. Observation, vet.

Statistical analysis

Calf behavior: The full model for each y: y = intercept + treatment + group(treatment) + calf(treatment; Group) + week + period + sex + treatment*week + treatment*period + week*period + treatment*week*period

Performance: The full models for the response variables (y) were:

1. Milk per day = intercept + treatment + group(treatment) + cow ID(group; treatment) + period + parity + treatment*period + period*parity + DIM + error

2. Fat, Protein, Lactose, Total dry solids, ECM, FFA, Urea* or SCC* (week 5) = intercept + treatment + group(treatment) + cow ID(group; treatment) + parity + DIM + error

3. Fat, Protein, Lactose, Total dry solids, ECM, FFA, Urea or SCC (week 14-18) = intercept + treatment + group(treatment) + parity + week + error

4. Weight gain = intercept + treatment + group(treatment) + calf ID(group; treatment) + sex + period + treatment*period + sex*period + birth weight + error

Fixed factors: Treatment, Parity, Sex, Period

Random factors: Calf, Cow, Group

Milk samples week 5: Two reg/cow/day, week 14-18: One reg/cow/day