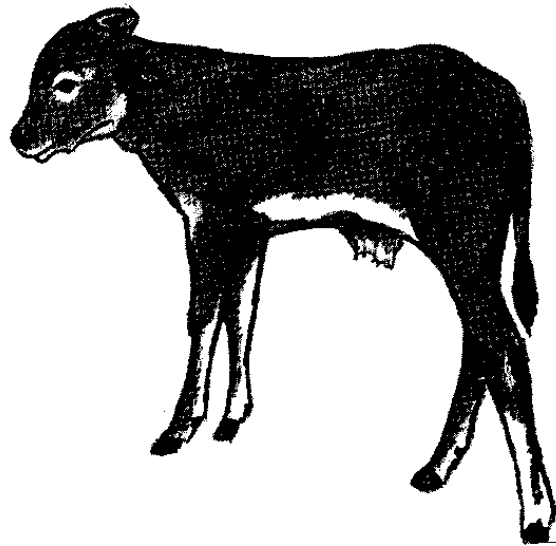


# **Do calves in tropical areas behave differently when artificially milk-fed than when nursed restrictively?**

*Beter sig kalvar i tropiska områden annorlunda vid artificiell mjölkutfodring än vid restriktiv digivning?*

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**Degree project in Ethology, 20 credits (30 ECTS credits)  
Biology program**

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## 1. SUMMARY

In tropical areas Zebu cattle (*Bos indicus*) and crossbreeds between Zebu and humpless cattle (*Bos taurus*) are most common due to their better capability to produce milk in hot and humid climate. It is generally believed, that these cows need to have their calves next to them during milking in order to stimulate milk let-down. After milking, the calf is usually allowed to suck the residual milk from its mother. The dairy breeds used in Europe and North America let the milk down during milking without having the calf by their side. The European and North American calves are often artificially milk-fed with whole milk or milk substitute from buckets or bottles. The artificially milk-fed calves do not have the possibility to perform non-nutritive sucking on a teat. There is a risk that internal factors (underlying motivation) stimulate the calves to perform some substitute (vacuum) behaviour.

The aim of this study was to find out if artificially milk-fed crossbred calves performed more abnormal behaviours, had a lower weight gain or reduced health, compared to restrictively suckling calves.

The study was performed on the research institute “El Clarin” outside Martinez de la Torre in the state of Veracruz, which is located in the tropical region of eastern Mexico.

The animals used were calves of mixed breed of 25% Holstein, 25% Zebu and 50% Simmental. The dairy cows were F1-crossings, 50% Holstein and 50% Zebu.

At five days of age the calves were randomly assigned to one of two treatments: R) restrictively suckling calves (n = 11) or A) artificially milk-fed calves (n = 11).

The behavioural observations of the calves started at the age of seven days and were repeated once a week (day 7, 14, 21, 28, 35, 42, 49, 56), to an age of two months. The behavioural observations were performed twice a day. In the morning (7-13 h), the observations were performed during the milking and suckling/drinking milk, 30 minutes for each calf. In the afternoon (17-19 h), the observations were performed on the pasture during one hour for each calf. All behaviours were recorded with 0-1 sampling at one minute intervals. Statistical analyses were made with Wilcoxon Rank Sum test and Chi<sup>2</sup>-test (SAS 8.2).

The results from the observations during milking revealed that the A-calves showed significantly more of the behaviours “sniff and lick interior” (p<0.01) and “cross-suck” (p<0.05), and a tendency for more “lick other calves” (p<0.1) than the R-calves. The relationship between the R-cows and their calves during milking included more “cow sniffing calf” (p< 0.05) and “cow licking calf” (p<0.1) compared to the A-cows.

After milking the A-calves showed significantly more of the behaviours “sniff and lick interior” (p<0.01), “calf sniff other calf” (p<0.01), “calf lick other calf” (p<0.05) and “cross-suck” (p<0.0001) than the R-calves. The R-calves were sniffed, licked and rubbed by their dams, but also sniffed, licked and rubbed their dams during the restrictively suckling.

During the afternoon observations the A-calves showed significantly more of the behaviours “eat concentrate” (p<0.05) and “cross-sucking” (p<0.01) than the R-calves. The

R-calves showed significantly more “walk” ( $p<0.01$ ) and “sniff ground” ( $p<0.05$ ), and a tendency of more “play” ( $p<0.01$ ) than the A-calves. There were no significant differences between the treatments regarding the following behaviours; “lie”, “stand”, “graze”, “ruminate”, “drink water”, “lick self”, “lick other calves” and “social interactions”.

The R-calves tended to have a higher weight gain than the A-calves ( $p<0.1$ ), but the lowest weight gain was found in those A-calves that got milk substitute during more than half of the observation time. The A-calves were more often diagnosed with diarrhoea than the R-calves ( $p<0.05$ ). The coat condition of the A-calves was more often recorded to have unlicked and not so shiny coat compared to the R-calves.

The conclusion is that the artificially milk fed calves had more abnormal behaviours and reduced health, compared to the restrictively suckling calves. Therefore, I suggest that the welfare of the restrictively suckling calves was better.

## 1. SAMMANFATTNING

I tropiska länder är Zebu-boskap (*Bos indicus*) och korsningar mellan Zebu (t ex Brahman) och boskap utan puckel (*Bos taurus*) vanligast. Genom denna korsning får man boskap som producerar mer mjölk i länder med varmt och fuktigt klimat. Det anses allmänt att dessa kor behöver kalven vid sin sida när de ska mjölkas för att kunna släppa ner mjölken. Efter mjölkningen får kalven vanligtvis tillfälle att dia residualmjölken från modern. Mjölkkor som används i Europa och Nordamerika släpper ned mjölken utan att ha kalven vid sin sida. De europeiska och nordamerikanska kalvarna är oftast artificiellt mjölkuppfödda med helmjolk eller mjölkersättning från hink eller flaska. När dessa kalvar inte har möjlighet att utföra exempelvis icke-näringsgivande sugbeteende är risken att inre faktorer (underliggande motivation) stimulerar kalven att utföra ersättningsbeteenden (vakumbeteenden).

Målet med denna studie var att utforska om artificiellt mjölkuppfödda kalvar utför mer onormala beteenden, har lägre viktökning eller sämre hälsa jämfört med restriktivt diande kalvar.

Studien utfördes på försöksstationen "El Clarin" som ligger strax utanför staden Martinez de la Torre i den tropiska delen av staten Veracruz i östra Mexiko.

Djuren som användes var korsningskalvar med 25 % Holstein, 25 % Zebu och 50 % Simmental. Mjölkkorna var av F1-korsning 50 % Zebu och 50 % Holstein.

När kalvarna var fem dagar gamla delades de slumpmässigt in i följande behandlingar: R) restriktivt diande kalvar (n=11) eller A) artificiellt mjölkuppfödda kalvar (n=11).

Beteendeobservationerna av kalvarna utfördes en gång i veckan från 7 till 56 dagars ålder. Observationerna utfördes två gånger om dagen. På morgonen (kl. 7-13) utfördes observationerna under mjölkningen och efter mjölkningen när kalvarna fick mjölk, 30 minuter per kalv. På eftermiddagen (kl. 17-19) utfördes en timmas observation per kalv när de befann sig i inhägnaden. Alla beteenden registrerades som 0-1 variabler med en minuts intervall. Statistisk analys gjordes med Wilcoxon Rank Sum test och Chi<sup>2</sup>-test (SAS 8.2).

Vid mjölkningen visade A-kalvarna signifikant mer av beteendena "nosa och slicka på inredningen" ( $p<0,01$ ) och "onormalt sugande" ( $p<0,05$ ), och en tendens av mer "slicka andra kalvar" ( $p<0,1$ ) än vad R-kalvarna gjorde. Förhållandet mellan ko och kalv vid mjölkningen visar att beteendena "ko nosar på kalv" ( $p<0,05$ ) och "ko slickar kalv" ( $p<0,1$ ) utfördes oftare av R-kor än av A-kor.

Efter mjölkningen visade A-kalvarna signifikant mer av beteendena "nosa och slicka på inredningen" ( $p<0,01$ ), "nosa på annan kalv" ( $p<0,01$ ), "slicka annan kalv" ( $p<0,05$ ) och "onormalt sugande" ( $p<0,0001$ ) än R-kalvarna. De senare fick motta nosade, slickade och strykande mot kroppen utav sina mödrar, och nosade, slickade och strök sig mot kroppen på sina mödrar under den restriktiva digivningen.

Under eftermiddagsobservationerna visade A-kalvarna signifikant mer av beteendena "äta kraftfoder" ( $p<0,05$ ) och "onormalt sugande" ( $p<0,01$ ) än R-kalvarna. Istället visade R-kalvarna signifikant mer av beteendet "gå" ( $p<0,01$ ) och "nosa på marken" ( $p<0,05$ ), samt

en tendens av mer "lek" ( $p < 0,01$ ) än A-kalvarna. Det var ingen signifikant skillnad mellan behandlingarna i följande beteenden; "ligga", "stå", "beta", "idissla", "dricka vatten", "slicka sig själv", "slicka annan kalv" och "sociala interaktioner".

R-kalvarna hade en tendens till högre viktsökning än A-kalvarna ( $p < 0,1$ ), men den lägsta viktökningen hade de A-kalvar som fick mjölkersättning under mer än halva observationstiden. A-kalvarna diagnosticerades signifikant oftare för diarré än R-kalvarna ( $p < 0,05$ ). Hårremmens skick hos A-kalvarna registrerades oftare för att vara oslickad och inte så skinande jämfört med R-kalvarnas hårrem.

Slutsatsen av studien är att artificiellt mjölkuppfödda kalvar hade fler onormala beteenden och sämre hälsa, jämfört med restriktivt diande kalvar. Därför föreslår jag att välfärden hos restriktivt diande kalvar var bättre.



## 2. INTRODUCTION

The welfare of domesticated animals is an important issue to study. If the animals in human care have a good life it means less suffering for the animals and in the end more money to the owners. Sweden has one of the strictest legislations in the world concerning housing and keeping of animals. The aim of the law is to give the animals status. Animals shall be handled well and be protected from unnecessary suffering (2 § in the law of prevention against cruelty to animals). In 4 § it is stated that animals shall have the possibilities to perform natural behaviours. One organisation for inspection and certification of organic production is KRAV. This organisation provides regulations on ecological farming for example, how to make animals healthier and to give them more possibilities to perform natural behaviours.

My studies were carried out in cooperation with the so-called “cow-calf group”, which is a part of FOOD 21. This is a research program that started 1997 and the aim is to get a sustainable food production “from soil to table”. MISTRA, the environment strategic research foundation, is funding this project.

Artificial rearing of calves is common in Europe and North America, where humpless cattle are the main type. In the tropical areas humped cattle are more common, and they are often thought to need to have their calves next to them during milking in order to let the milk down. It is also more common to have restrictively suckling calves when having humped cattle. The behaviour of calves during milking of the cow, when the calves are fed milk and when the calves are together in the green pasture, has not been thoroughly studied in tropical areas before.

This study has focused on the welfare of calves in a tropical environment. We were interested to observe if different management of Zebu-Holstein cows and calves in Mexico would result in different behaviours.

### 2.1 History

About 12 000 years ago the domestication of cattle started (Loftus et al., 1994). The two different species, humpless cattle (*Bos taurus*) and humped cattle (*Bos indicus*), have diverged for about 600 000 to more than 1 million years and have lived in places independently from each other in several locations from different lines of aurochs (Loftus et al., 1994; Machugh et al., 1997). These different species of cattle are different genetically and are usually kept in different environments (Jung, 2001). Between these two types of cattle the main phenotypic differences are that Zebu has larger ears to increase the surface for heat regulation and in most of the breeds they have a hump. The *Bos indicus*

breeds are more heat-tolerant than the *Bos taurus* breeds. On the other hand the *Bos taurus* cattle have higher potential to produce milk or beef under optimal feeding and housing conditions (Jung, 2001).

## 2.2 Cow and calf contact

Soon after parturition a selective mother-young bond is established, where mother and offspring are able to recognize each other. For the cow to recognize its calf, sniffing and licking the calf is most important. The function of licking is thought to be removing the foetal membranes, drying the coat, stimulating activity, breathing, circulation, urination and defecation of the calf (Flower & Weary, 2001). Another reason for the licking is that it may strengthen the attachment between mother and young (Lidfors, 1994). Olfaction helps the cow to find her calf (Lidfors, 1994). Lidfors (1994) has also showed that vocalization of the cow was most frequent the first hours after calving. The explanation for why the cow vocalizes is that the calf could learn to recognize its mothers call.

Only five minutes of contact with the calf is sufficient for the formation of a strong, specific maternal attachment to the calf (Hudson & Mullord, 1977). If the calf is kept together with the dam for at least 24 hours after parturition the new-born has the possibility to stand up, suckle and defecate, and this facilitates the intake of colostrum which gives the calf the important immunoglobulin (IgG) (Hopster et al., 1995; Lidfors, 1994).

Calves kept together with the mother are more active, and they lick themselves and vocalize less than calves separated from the mother at birth (Lidfors, 1994). If the calf is allowed to spend more time with the cow it can improve health, weight gain and future productivity (Flower & Weary, 2001). Bonding between cow and calf in the beginning of the calf's life is important, so that they can find each other and prevent that the cow gives the important and valuable milk to a calf which is not hers.

Fewer cases of diarrhoea have been observed in dairy calves which have been kept with the mother until 10 days after birth (Flower & Weary, 2001). It is necessary for the newborn calf to get colostrum quickly after birth. Skrivan et al. (1984) showed that the Ig-level of colostrum decline rapidly after calving. Calves with low concentrations of absorbed Ig are more susceptible to diarrhoea (Flower & Weary, 2001).

## 2.3 Suckling

The duration of suckling for the calves with free access to the dams udder is about one hour daily, distributed over 5-8 meals (Hafez & Bouissou, 1975). The age at weaning in Zebu calves under natural conditions is around 8-11 months (Reinhardt & Reinhardt, 1981).

A calf performs suckling in a certain pattern. First it stimulates the udder by tactile, vocal and/or visual behaviours, called pre-stimulation. This stimulation help to stimulate milk let-down. When the calf sucks a teat rhythmically, it gets milk and this part of the suckling is

called nutritive sucking. Thereafter, follows the post-stimulation or non-nutritive sucking, which includes more butting and teat-change than during milk intake (Lidfors et al., 1994; Mayntz & Costa, 1998; Jung, 2001).

A calf from a low yielding cow continues to suck when access to milk has declined and this is like post-stimulation suckling (Lidfors et al., 1994; Mayntz & Costa, 1998).

Post-stimulation, which is suggested to be the same as non-nutritive sucking, can increase the future milk yield (de Passillé et al., 1992; Jung, 2001; Lupoli et al., 2001). The function of pre-stimulation is believed to induce milk flow or let-down (Hafez & Schein, 1962).

Hall (1988) has defined some of these behaviours in the following way:

*Suckling* – the behaviour of the young contributing to the procurement of milk from nipple or teat.

*Sucking* – the mouth movement.

*Nursing* – the physiological and behavioural activity of lactating mammal promoting the transfer of milk to the young.

## 2.4 Abnormal behaviours

When a calf is sucking on another calf's body part (e.g. ear, navel, penis or scrotum) this is called cross-sucking. Cross-sucking can lead to health and welfare problems for the exposed calf (de Passillé et al., 1992; Unshelm et al., 1982), or to hair less spots of the body (Dybkjaer, 1988). An inner motivation to suck and the taste of milk are suggested to be the reasons for why artificially reared calves start to suck on objects and other calves (de Passillé et al., 1992; de Passillé et al., 1996; Lidfors, 1994).

Most of the studies on cross-sucking have been done on calves in industrialized countries and on *Bos Taurus* calves. It is important to do studies also on calves from developing countries, if they consider changing their way of rearing calves.

Earlier studies have shown that cross-sucking is most frequently displayed within six minutes after the milk intake has finished (Lidfors, 1993). De Passillé & Rushen (1994) observed that calves on a low-feed level increased cross-sucking after a subsequent meal. This sucking motivation is reduced more by sucking behaviour than by milk intake, although it is not completely independent of hunger.

Abnormal sucking behaviour has also been observed in adult cows, where some cows intersuck and drink many litres of milk from other cows (Lidfors & Isberg, 2004).

## 2.5 Importance of movements, exploration and social behaviour with other calves

The calf starts to graze at one week of age and is more selective than the adult animals. When it becomes older the calf starts to examine the environment more. Calves graze selectively in order to learn what is tasting good or not (Lidfors, 1991). This is also an example of why it is important for the calves to have access to a green pasture. Jensen (1996) has studied play behaviour in calves (*Bos taurus*) and found that locomotion play tended to increase in large pens. The quality of locomotion play was also affected so that it involved more movements in large pens. The study also showed that a bigger space is more important for calves older than two weeks (Jensen, 1996).

The social behaviours are also important natural behaviours of the calf, for example they rest and play together. The function of play behaviour is to exercise the muscles, learn to know the environment and the other animals (Lidfors, 1991). The movements during playing look similar to the movements that are performed during behaviours as disturbance, defence, fight and mating (Lidfors, 1991).

## 2.6 Milking

The Zebu cow is generally believed to need the calf next to her during milking in order to let the milk down. The calf helps inducing milk let down by tactile, vocal or visual stimulation (Unshelm et al., 1982; Wiepkema et al., 1983). In some cases, if the calf is not there, an injection of oxytocin is needed (Orihuela, 1990) but usually the calf is tied next to the head of the cow during milking.

In the tropics of Veracruz, Mexico, approximately 85 % of the ranches are used for both milk and meat production (dual purpose systems) (Pulido, 2001). Over 90 % of these ranches apply hand milking (Bernando Marin, 2002 pers. comm.).

The calves are usually reared by applying restrictive suckling. This method is more animal friendly and often a more economical system of raising calves than artificial milk feeding, especially in the tropics and in other countries where access to clean water (for the milk substitute) is limited or milk substitutes are not available.

### 3. AIM

The aim of this study was to investigate the effect of restricted suckling versus artificial milk feeding on abnormal, foraging, play and explorative behaviour and weight gain and health in calves with mothers of *Bos indicus* and *Bos Taurus* F1-crosses and fathers of *Bos Taurus* breed. The questions to be answered were:

- Do suckling calves perform less abnormal behaviour than milk-fed calves?
- Do suckling calves perform less foraging behaviour than milk-fed calves?
- Do suckling calves perform more play and explorative behaviour than milk-fed calves?
- Do suckling calves have a higher weight than milk-fed calves?
- Is the calf health better in suckling calves than milk-fed calves?
- Does the relationship between cow-calf develop better in suckling calves than milk-fed calves?

My hypotheses were that the artificially milk-fed calves would have more abnormal behaviours, more foraging behaviours, lower weight gain and poorer health compared to restrictively suckling calves. They were also expected to show less play and explorative behaviour and to have bond to the mother in a less developed way compared to the restrictively suckling calves.



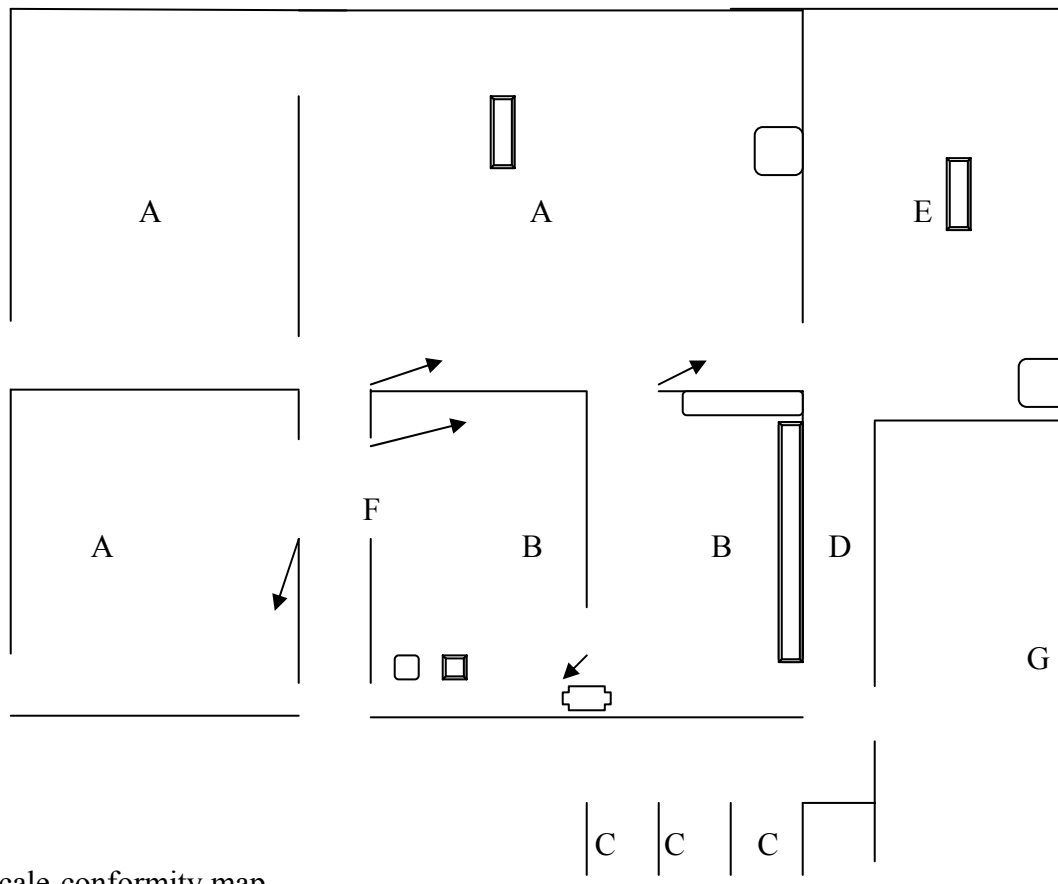
Figure 1. A calf cross-sucking on the ear of another calf at the research farm “El Clarin”. (Photo: Anette Aspegren-Güldorff).



## 4. MATERIAL & METHODS

### 4.1 Housing

The study was carried out at the research station “El Clarin” at “CEIEGT” (Center of Teaching, Research and Extension in Tropical Animal Husbandry) of the Faculty of Veterinary Medicine of the National University of Mexico. The centre is located near the Federal Highway of Martinez de la Torre in the North-Central region of Veracruz.



No scale-conformity map.

*Figure 2. The housing and milking place. A = green pasture pen, B = a pen with concrete floor and roof, C = milking parlour, D = cow and calf chute, E = pen where cows and calves where gathered after milking, F = a path from the pens to the milking place, G = pen for collecting the cows before milking. When the milking had finished the A- and B-pens were closed with gates (→).*

□ = Water, ■ = Concentrate feed, + = Calf-scale.

All calves were housed in the same enclosure, which included a pen (6 m x 8 m) with a floor made of concrete and a tin roof and the green pasture pen (50 m x 13 m) (Fig.2). The calf pen was divided in two parts, and between those the calf weighing scale was placed (Fig 2).

Next to the enclosure with calves was the milking parlour (C, Fig.2). There was also a pen where the cows and their calves (R-calves) were gathered together during 30 to 60 minutes after milking, to let the calves suckle (E, Fig.2).

The artificially milk-fed calves (A-calves) were separated from their mothers directly after milking had finished and were given milk from bottles in the included pen (B, Fig.2).

## 4.2 Animals

At the farm there were about 80 dairy cows of F1-crossing (50% Holstein (*Bos taurus*) and 50% Brahman (*Bos indicus*)). The father of the calves was from the breed Simmental (*Bos taurus*). Thus, the calves were a mixed breed consisting of 75% *Bos taurus* (50% Simmental and 25% Holstein) and 25 % *Bos indicus* (Brahman). In our study we used 24 cow-calf pairs (Table 1).

From the beginning, the number of suckling calves was 12, five females and seven males. The number of artificially reared calves was 12, six females and six males (Table 1). The treatment of the artificially reared calves was changed by the ranch after the 14<sup>th</sup> of June. Before this date, the artificial calves were fed with whole-milk twice a day. After the 14<sup>th</sup> of June, the calves were fed with milk substitute (milk powder mixed with water from the cheese manufacture) only once a day. This abrupt change made the calves ill and one calf in our observation group died. We excluded this calf from our study, as well as a cow that developed acute mastitis (Table 1).



Table 1. Information about cow identity, year of birth and the number of lactations and the calf identity, sex and treatment (R=restrictive suckling and A=artificial milk-feeding)

Cow number	Birth year of cow	Lactation number	Calf number	Calf sex	Treatment
517-0	2000	1	29	male	R
545-9*	1999	2	32	male	A
513-0*	2000	1	23	male	A
657-0	2000	1	33	male	R
512-0*	2000	1	34	male	A
583-5	1995	3	35	female	R
58-1*	1991	7	37	male	A
778-7****	1997	3	38	female	R
651-9**	1999	2	39	female	A
765-9	1999	1	40	male	R
693-6	1996	4	41	male	R
521-0	2000	1	42	male	R
544-0**	2000	1	43	male	A
17-8**	1998	2	47	female	A
523-0	2000	1	48	female	R
602-8**	1998	3	49	female	A
531-9	1999	1	50	female	R
658-9	1999	2	51	female	R
541-0**	2000	1	58	female	A
586-3	1994	4	57	male	R
791-4	1994	5	56	male	R
707-4**	1994	6	54	male	A
653-0**	2000	1	53	female	A
52-2***	1992	7	59	female	A

\*) = Calves fed whole-milk more than half of the observation time.

\*\*) = Calves fed with milk-substitute more than half of the observations time.

\*\*\*) = Calf died before 56 days of age, and was excluded.

\*\*\*\*) = Calf excluded because the cow developed severe mastitis.

#### 4.3 Feed

Both cows and calves were kept on pasture with native grasses (*Paspalum spp* and *Axonopus spp*), the introduced species Santo Domingo star grass (*Cynodon nlemfuensis*), water and mineral salt *ad libitum*.

During the milking, the cows had access to molasses *ad libitum* in a feed trough. Directly after the milking the cows got access to concentrate feed and silage, before they were moved to the green pasture.

All calves were kept with their dams during the first five days in life, and could then suckle colostrums as long as it was produced by the individual cow.

The calves in the artificially milk-fed group got two bottles each of whole milk in the morning (~8.00) and two bottles in the afternoon (~14.00). Each time the total amount of milk for both bottles was around 3.6 litres. From the 14th of June, in the middle of the study, the artificially milk-fed calves were fed with milk substitute instead of whole milk. The milk substitute was made of 1.1 kg of milk substitute powder mixed with 10 litres of warm cheese serum (Carlos E Hernandez, 2002 pers. comm.).

The restrictively suckling calves were fed from one teat, which had been left un-milked during the milking and the residual milk from the other three teats. One teat was always left un-milked to save milk for the calf. It should always have been the right hind teat, but this was not always the case. These calves were suckling twice a day, 08.00 in the morning and 14.00 in the afternoon, until four months of age.

The calves had access to a green pasture, concentrate and water. The type of concentrate was locally grown for this farm (Bernardo Marin, 2002 pers. comm.).

The average intake time for the artificial calves which got milk from two bottles, before the 14<sup>th</sup> of June, was about 5 minutes and the R-calves feeding time was about 30 minutes.

However, they could perform other behaviours than suckling during this time.

The average milk quantity per feeding time for the A-calves was 3.15 litres and for the R-calves it was 3.44 litres (established by weigh-sucking-weigh).

#### 4.4 Management

Cows and calves were separated in different pastures all the time except during milking and suckling. In the morning, before the milking, the calves were gathered in a pen (Fig. 2).

The cows were fetched by cowboys to the milking stall and by a person, who led the animals to the milking and fetched the calf that belonged to the cow. The calf was tied close to the head of the cow and stayed there during the whole milking. The cow was fed molasses and her hind legs were tied together during the milking. The station used three milking machines (Maquina ordeñadora) with milk tubes, taking the milk to the tank inside a building.

#### 4.5 Methods

From 5 days of age the calves were randomly allocated to one of the following treatments:

- \* R-calves: Restricted suckling, twice per day, 30 minutes after the morning milking from one teat left un-milked and the residual milk from the other three teats, and in the afternoon from all four teats. The cows were not machine milked in the afternoon.

- \* A-calves: Artificial milk feeding, the calves were fed with whole milk from a bottle with a nipple twice daily from the 5th of March to the 13th of June. This treatment was changed the 14th of June from when the artificial calves were fed with two and a half

bottle of milk substitute in the morning only. The cows all four teats were milked once a day during the morning milking. In the afternoon these cows were not milked.

#### 4.6 Behavioural observations

The behavioural observations of the calves started at the age of seven days and were repeated once a week (day 7, 14, 21, 28, 35, 42, 49, 56) to an age of two months. Observations were made in May, June and July 2002. The behavioural studies were performed two times a day. In the morning the studies were made during and after the milking and suckling/drinking milk, and in the afternoon on the pasture.

##### 4.6.1 Behavioural observations in the morning

The behavioural observation in the morning was divided into two parts:

- Cow and calf behaviour for both treatments during the milking. Recordings of the behaviour was done from the moment both cow and calf were tied at the milking stalls and as long as the calf was tied close to the cow, during a maximum of 15 minutes.
- Cow and calf behaviour after the milking. The restrictively suckling calves were allowed to suckle the cow and the artificially reared calves got milk from the bottle. The artificially milk-fed calves were observed for 30 minutes each. The observation started when the calves were given milk in bottles and they were released together in the paddock.

Behavioural observations were done by two persons. We made the observations of the restrictively suckling calves first, because they were fed before the artificially milk fed calves and before the cows were moved to the pasture by the cowboys. The frequency of social and sucking related behaviour was recorded within every minute. A stop-watch made a sound every minute and marked the change to a new minute.

The frequency of the following behaviours was recorded within each minute:

- Licking; cow or calf stretched out tongue, which repeatedly had contact with the body of another cow or calf.
- Sniffing; cow or calf had its muzzle in contact with or within 5 cm of another cow's or calf's body, sometimes inhalation of air through the nostrils was observed.
- Rubbing; cow or calf moved its head repeatedly along the body of another cow or calf.
- Cross-sucking; calf was sucking on any body part of another calf, which body part was recorded, i.e. belly (teats, scrotum, navel), mouth, ear, other body part.
- Licking/sucking interior; calf was licking on or sucking on any part of the interior of the pen around the cow during milking or the pen for calves after milking.
- Which teat was left un-milked on the cow which had a restrictively suckling calf.
- Sucking T1; the calf was sucking on the front left teat.
- Sucking T2; the calf was sucking on the rear left teat.
- Sucking T3; the calf was sucking on the rear right teat

- Sucking T4; the calf was sucking on the front right teat.
- How long time the artificially milk-fed calf was drinking from the bottle.
- Butting; the calf was making a quick hard push/butt with its muzzle and/or head against the udder/teats of the cow, or artificially milk-fed calf was performing a similar butt towards another calf or the interior, for ex. the bottle.



*Figure 3.* One of the observed calves tied up next to its mother during milking. The milking man is sitting in the background. (Photo: Anette Aspegren-Güldorff)



*Figure 4. Observations of cow and calf contacts after milking (Photo: Anette Aspegren-Güldorff).*

#### 4.6.2 Behavioural observations in the afternoon

The behavioural observations in the afternoon were performed between 17 and 19 o'clock and included behaviours in both groups of calves, restricted and artificially fed calves. The calves were observed as focal animals during 60 minutes each. The behaviours were recorded with 0-1 sampling at 1-minute intervals, with a stopwatch making a sound at each interval. If the specific calf performed any of the behaviours defined below, then one mark was made in the column for that behaviour (e.g. walk). When one recording had been done for a specific behaviour it could not be recorded again within the same time period. However, several behaviours could be recorded during the same time period. For example, during the first observation minute, the calf could walk, lick self, walk and drink, and then all the behaviours were recorded once.

The following behaviours were recorded:

- Lie; calf lying down in different positions.
- Stand; calf standing doing nothing, looking around.
- Walk; calf moving its leg so that the body was moving forward either in walk or trot.
- Eat; calf taking hay or concentrate into its mouth and chewing at it.



- Ruminates; calf-regurgitating bolus of food that was swallowed earlier, performing chewing movements with the mouth.
- Drink; calf swallowing water ingested from a water tank.
- Sniff ground; calf having its muzzle close to the ground and inhaling air through its nostrils.
- Play; calf running quickly or jumping and kicking in the air, either alone or with other calves.
- Lick self; tongue of the calf was touching its own body in repeated movements.
- Lick calf; tongue of one calf was touching the body of another calf, either once or with repeated movements.
- Social; calf sniffing, rubbing against, pushing head against head, or mounting another calf.
- Cross sucking; calf was sucking on some body part of another calf, which body part was recorded on the protocol, i.e. belly (teats, scrotum, navel), mouth, ear, other body part.
- Tongue rolling; the tongue of the calf was stretched out of the mouth and moved in a circulating way, or it was rolled around inside the mouth with half open mouth.
- Other; other behaviours of interest.

#### 4.7 Other recordings

##### 4.7.1 Weighing of calves

Every calf was weighed weekly on an exact scale at 100 grams (Revuelta). The weight was recorded three times, on each calf, before milk feeding and three times after the milk feeding. The mean value per weight time was recorded and the differences between the weights were showing how much milk the calves had ingested.

We also recorded how much milk the artificially fed calves ingested from the bottle, by weighing the bottle before and after drinking. However, some of the calves refused to drink the milk substitute and were forced to drink the milk. A lot of milk then ran outside the calf's mouth and thus we had to use the difference in the calf's weight before and after the feeding, for our results.

##### 4.7.2 Health control of calves

Calf defecations were observed during the morning and the afternoon observations. When the faeces were yellow, slack or flush out, it was classified as diarrhoea. At the same time as the weighing of the calves, we checked the general health. We recorded if the calves were feeble, infirm, had hazy eyes, if the fur was in a good condition or if they had hairless spots or oedema.

#### 4.7.3 Other activities in the study herd

During the study we also recorded the milk production, milk composition and udder health of the cows. We tested the cows that had got mastitis via a CMT test. The milk composition, i.e. fat, protein and lactose, was also tested. The data from this part will be published in a scientific paper.

Because the farm wanted to have the cows calving close in time they synchronized the heat with CDIR (a hormone). 90 days after calving the hormone was put in the cow's vagina for 9 days. After the implantation has been taken out the cows usually comes into oestrus within 24-48 hours. The artificial insemination was done 12 hours later. Blood sample for cortisol assessment and temporal weaning was included in parallel studies and this might have influenced our behavioural observation. Blood samples for cortisol assessment were taken every day from the calves at an age of 4-9 days. The results from those studies will be published in separate scientific papers.

#### 4.8 Statistical analyses

Statistical analysis was done on 11 restrictively suckling calves and 11 artificial milk-fed calves (4 calves fed whole milk more than half of the observation time, 7 calves fed milk substitute more than half of the observation time).

The data was put on Excel sheets and thereafter imported to SAS (Statistical Analysis System, vers. 8.2). Mean values and Standard Error of the mean (SE) were calculated for the two treatments. Statistical analysis was done with Wilcoxon Rank Sum test, two sample test. Chi<sup>2</sup>-test was calculated for statistical analysis of some variables.





## 5. RESULTS

### 5.1 Behavioural observations during milking

The cows tended to lick and sniff their calves significantly more during milking when their calves were suckling after milking (R-calves) than when their calves were artificially milk-fed after milking (A-calves) (Fig.5). There were no significant differences between R-calves and A-calves in the amount of licking and sniffing they made towards their mothers during milking (Fig.5). The A-calves tended to lick other calves more than the R-calves (Tab. 2). There were only few recordings of sniffing and licking other calves as well as rubbing between animals during the milking (Tab. 2). The behaviour “lick and sniff interior” was made more often by the A-calves than the R-calves (Fig.5). Under the behaviour “sniff and lick interior”, we observed that the calves often licked the molasses, which the cows got during milking. The A-calves were cross-sucking on other calves whereas the R-calves were not doing any cross-sucking at all (Fig.8).

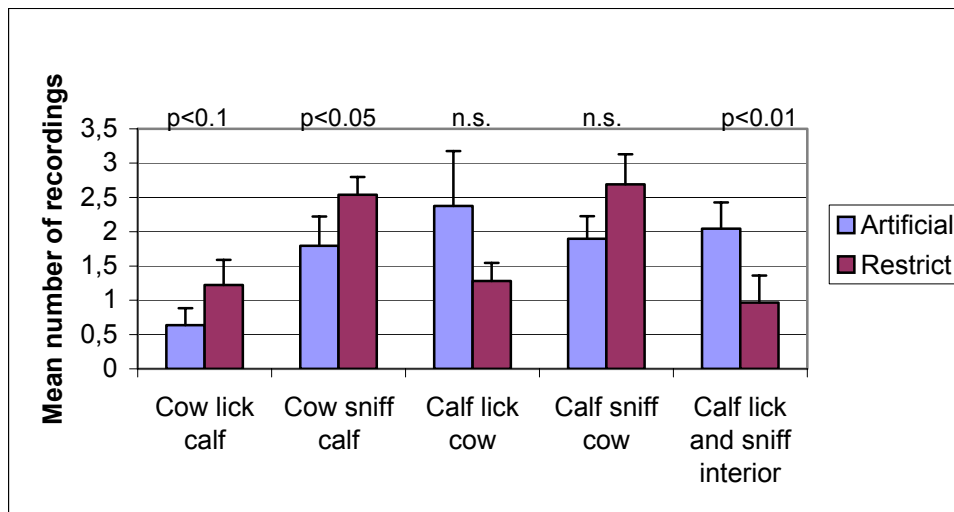


Figure 5. Mean number of recordings (+ SE) of cow lick her calf, cow sniff her calf, calf lick its dam, calf sniff and lick interior during milking in artificially milk-fed calves ( $n=11$ ) and restricted suckling calves ( $n=11$ ). Tested for significant differences with Wilcoxon Rank Sum test.

Table 2. Mean number of recordings ( $\pm$  SE) of behaviours during milking that were not significantly different between the treatments (R-calves = restrictive suckling and A-calves = artificial milk feeding). Tested for significant differences with Wilcoxon Rank Sum test

Behaviour	R-calves Means	SE	A-calves Means	SE	Significance
Calf sniffing calf	0.18	$\pm 0.03$	0.12	$\pm 0.03$	n.s.
Calf licking calf	0.02	$\pm 0.01$	0.09	$\pm 0.03$	$p < 0.1$
Calf rubbing calf	0.02	$\pm 0.02$	0.03	$\pm 0.03$	n.s.
Calf rubbing cow	0.18	$\pm 0.12$	0.05	$\pm 0.024$	n.s.
Cow rubbing calf	0.03	$\pm 0.03$	0.03	$\pm 0.01$	n.s.

## 5.2 Behavioural observations after milking

The A-calves licked, sniffed and cross-sucked other calves significantly more than the R-calves during the 30 minutes of observation after milking when R-calves were restrictively suckling and A-calves were fed milk in the calf pen (Fig. 6). There were no significant differences in the mean number of recordings of calf rubbing against calf between A-calves ( $0.12 \pm 0.03$ ) and R-calves ( $0.11 \pm 0.05$ , n.s., Wilcoxon Rank Sum test). The A-calves licked and sniffed the interior significantly more than the R-calves (Fig. 6).

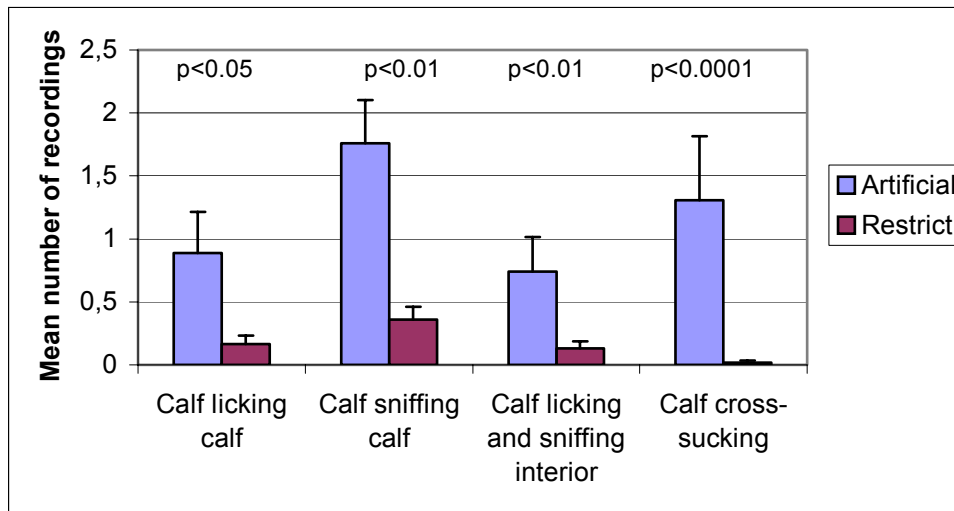


Figure 6. Mean number of recordings ( $\pm$  SE) per 30 minutes of calf licking, sniffing and cross-sucking other calf and licking and sniffing interior during the observations after milking in calves suckling restrictively ( $n=11$ ) and artificially milk-fed calves ( $n=11$ ). Tested for significant differences with Wilcoxon Rank Sum test.

After milking the artificially milk-fed calves were brought back to the calf pen and thus could not have any contact with their mother anymore. Therefore only mean values from

the cow-calf contacts were recorded for the R-calves (Tab. 3). The most common behaviour was that the cow sniffed her calf during restricted suckling (Tab. 3).

*Table 3. Mean number of recordings ( $\pm$  SE) per 30 minutes of behaviours between cow and calf during the observations after milking (n=11 calves)*

<b>Behaviour</b>	<b>R-calves</b>	<b>SE</b>
Calf sniffing cow	1.13	$\pm 0.22$
Cow sniffing calf	3.89	$\pm 0.5$
Calf licking cow	0.87	$\pm 0.39$
Cow licking calf	1.07	$\pm 0.34$
Calf rubbing cow	0.37	$\pm 0.12$
Cow rubbing calf	0.29	$\pm 0.09$

After changing from whole milk to milk substitute for the artificial calves many of them refused to drink the milk substitute and the cattleman needed to force the calves to drink. This made the milk feeding take much longer time than 5 minutes, and some of the calves completely refused to drink.

### 5.3 Behavioural observations during the afternoon

During the late afternoon, 17-19 o'clock, the calves could move freely between the three paddocks of pasture and the concrete pen (Fig. 2). The R-calves were then walking and sniffing the ground significantly more than the A-calves (Fig. 7). The A-calves ate concentrate and cross-sucked significantly more often than the R-calves (Fig. 7). The social behaviour, i.e. interactions between the calves, did not differ significantly between the A-calves and R-calves (Fig. 7). The calves started to play a lot when they became older, and there was a tendency for R-calves to play more than the A-calves (Fig. 7).

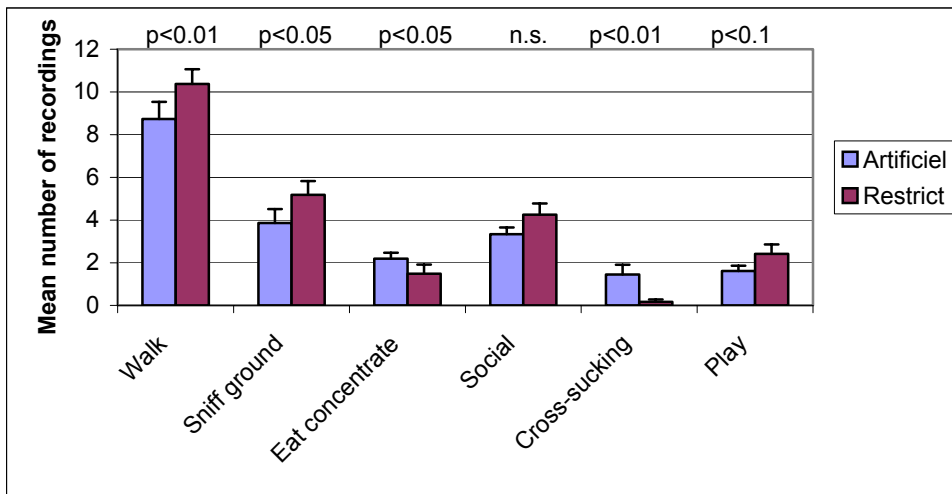


Figure 7. Mean number of recordings(+ SE) per hour of calf walk, sniff ground, eat concentrate, social interactions with other calves, cross-sucking and play during the afternoon observations, in calves suckling restrictively (n=11) and artificially milk-fed calves (n=11). Tested for significant differences with Wilcoxon Rank Sum test.

The remaining seven behaviours did not differ significantly between the A-calves and R-calves (Tab. 4). Tongue-rolling was never observed in any of the calves during the afternoon observations.

Table 4. Mean number of recordings ( $\pm$  SE) per hour of calf behaviours during the afternoon observations that were not significantly different between the treatments (R-calves = restrictive suckling and A-calves = artificial milk-feeding). Tested for significant differences with Wilcoxon Rank Sum test

Behaviour	R-calves	SE	A-calves	SE	Significance
Lie down	32.1	$\pm 1.73$	32.85	$\pm 1.61$	n.s.
Stand	28.53	$\pm 1.86$	27.43	$\pm 1.73$	n.s.
Graze	9.42	$\pm 1.82$	10.42	$\pm 2.14$	n.s.
Ruminate	1.86	$\pm 0.38$	1.93	$\pm 0.59$	n.s.
Drink water	0.67	$\pm 0.14$	0.89	$\pm 0.20$	n.s.
Lick other calf	1.18	$\pm 0.25$	1.21	$\pm 0.22$	n.s.
Lick itself	13.23	$\pm 1.24$	10.31	$\pm 1.14$	n.s.

#### 5.4 Cross-sucking from all observations

The A-calves were significantly more often cross-sucking than the R-calves (Fig. 8). During the about 15 minute long milking cross-sucking was lowest and no recordings at all were made in the R-calves ( $p < 0.05$ ). During the 30 minutes after milking cross-sucking was significantly higher in A-calves than in R-calves ( $p < 0.0001$ ). During the one hour long observation in the afternoon cross-sucking was significantly higher in A-calves than in R-calves ( $p < 0.01$ ).

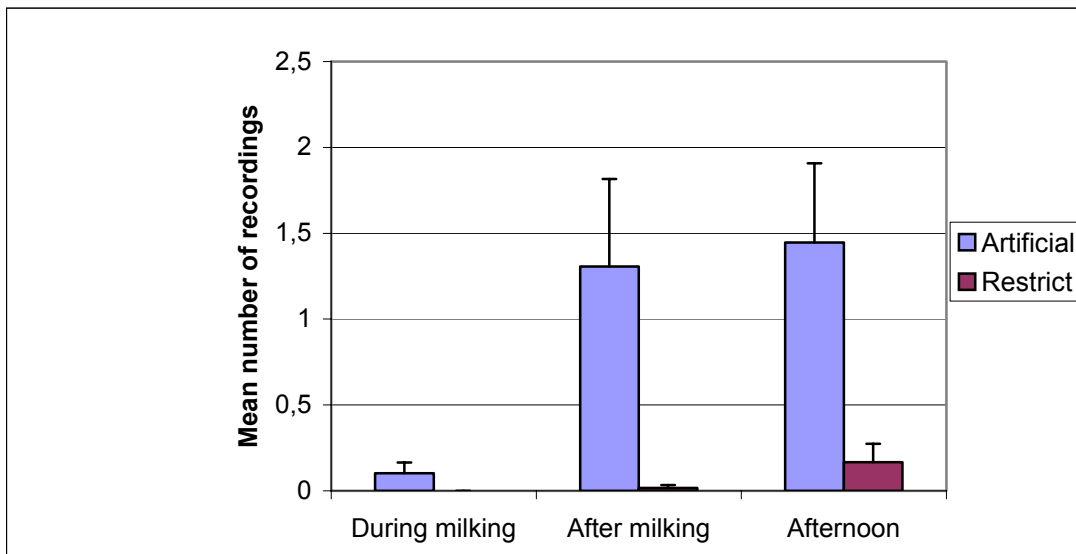


Figure 8. Mean number of recordings (+ SE) of cross-sucking from 15 min. during milking, 30 min. after milking and 60 min. during late afternoon.

#### 5.5 Weight gain

There was a tendency for a difference in weight gain over the first 56 days between the treatments ( $p < 0.1$ , Wilcoxon Rank Sum test) (Fig. 9). The lowest weight gain was found in the milk-fed calves that had to change to milk substitute and got it during more than half of the observation time (Fig.9). The highest weight gain was found in the calves that were suckling restrictively (Fig.9).

The milk intake was not different between the two treatments (A-calves mean 3.15 l. /feeding, R-calves 3.44 l. /suckling).

The cows mean milk production during the morning milking was 6.5 l. in the cows with artificially milk-fed calves and 7.3 l. in the cows with the restrictively suckling calves.

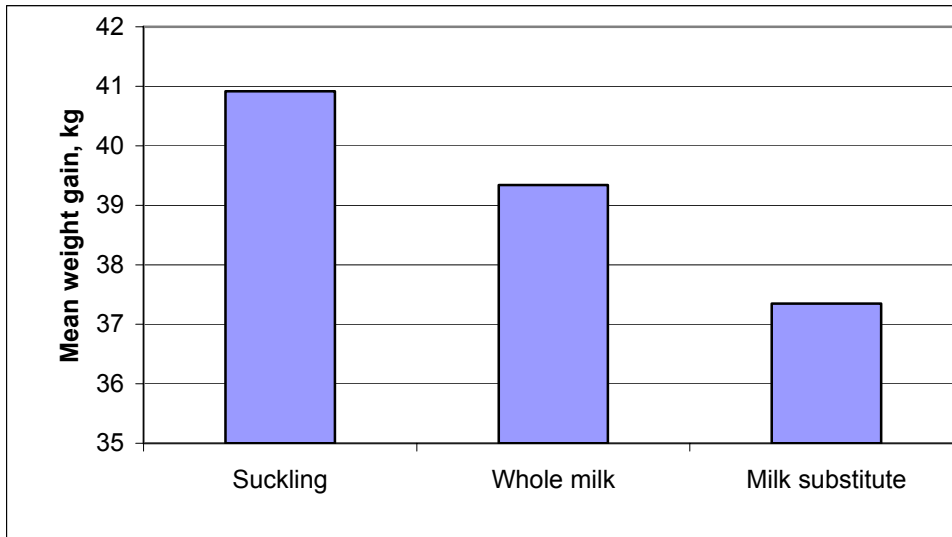


Figure 9. The calves mean total weight gain from birth to 56 days of age after the different milk feeding treatments. The observations included three different treatments after the change in feeding 14/6, suckling ( the restrictively suckling treatment), whole milk ( the calves got whole milk more than half of the observation time) and milk substitute ( the calves got milk-substitute more than half of the observation time).

## 5.6 Hairless spots or oedema

The observations of the coat condition of the calves showed that A-calves had more recordings of un-licked and not so shiny coat than the R-calves (Tab. 5).

Table 5. The percentage of calves recorded to have different degrees of coat condition in R-calves (restrictive suckling) and A-calves (artificial milk feeding). Small spots = area 2 cm<sup>2</sup>, medium spots = area 5 cm<sup>2</sup> and large spots = area more than 5 cm<sup>2</sup>

Degree of fur condition	R-calves %	A-calves %
Good condition	91,40	64,78
Good condition with small hairless spots	0	3,41
Good condition with medium large hairless spots	1,08	0
Good condition with large hairless spots	2,15	0
Not so shiny, in good condition	5,38	18,18
Not so shiny, in good condition, with small hairless spots	0	4,55
Not so shiny, in good condition	0	1,14
Un-licked and not shiny	0	6,82
Un-licked, not shiny with medium large hairless spots	0	1,14

## 5.7 Defecation

The artificially milk-fed calves were more often diagnosed with diarrhoea than the restrictively suckling calves ( $p < 0.05$ ,  $\chi^2 = 5.60$ ,  $DF = 1$ ,  $\chi^2$ -test) (Fig. 10). Some of the calves had no defecation during the observation time and are not included in the graphic, figure 10.

The defecation was as follows:

- 50% of the suckling treatment calves defecated during the observed time.
- 52% of the whole milk treatment calves defecated during the observed time.
- 57% of the milk substitutes treatment calves defecated during the observed time.

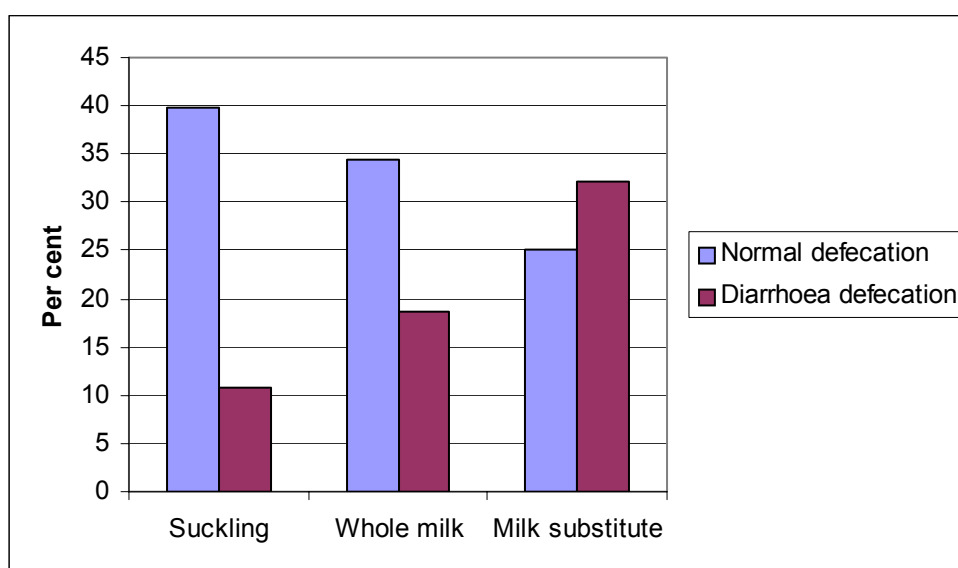


Figure 10. The percentage of observed defecations for the different treatment calves, normal or diarrhoea defecations. The observations included three different treatments after the change in feeding 14/6, suckling (the restrictively suckling treatment), whole milk (the calves got whole milk more than half of the observation time) and milk substitute (the calves got milk-substitute more than half of the observation time).





## 6. DISCUSSION

In this study, the observations during milking showed that the artificially milk-fed calves were cross-sucking, licking other calves, sniffing and licking interior more often than the restrictedly suckling calves. The reason could be that the calves did not have so much social contact with their mothers after milking and that the innate motivation to suck was strong. Other studies have shown that cross-sucking by calves occur most frequently after feeding from a bucket, i.e. when there is no sucking opportunity. For example Metz (1984) has shown that the taste of milk could account for the extra stimulation for this abnormal behaviour. Furthermore, Lidfors (1993) has shown that cross-sucking is mainly displayed during six minutes after the milk intake. The behavioural observations of the calves did not include the time before the milking of the cow, but I noticed more cross-sucking during this time than after the milk feeding. Possibly these calves did not perform more abnormal behaviours after the feeding because of the big amount of milk they were fed (3.6 litre each time). Often the calf became completely satiated and lied down directly after the feeding. Studies on cross-sucking before the milk feeding has not been found, and further research in this field is necessary.

The artificially milk-fed calves licked molasses from the interior more often during milking, possibly because these calves were hungrier in the morning than the restrictedly suckling calves. The artificially milk-fed calves were only fed once a day from when they got the milk substitute.

Some of the restrictively suckling calves did not get enough milk from their mothers and their hunger probably made them cross-suck. But these calves had the opportunity to perform the important suckling. This observation is well in line with what de Passillé & Rushen (1994) observed in their study.

In the end of my study, the artificial calves were milk-fed only once a day and the restrictedly suckling calves twice a day. This is a source of error in my study, as well as changes of the amount of milk, from two bottles in the morning and two bottles in the afternoon, to only two and a half bottles in the morning.

The calves hunger may also have affected the amount of eating concentrate during the afternoon observation. The artificially milk-fed calves more often performed this behaviour.

The artificially milk-fed calves showed more cross-sucking during all of the behavioural observations. As they had no access to any teat to suck, they licked the interior and performed cross-sucking instead of the more natural sucking behaviour.

During the afternoon when calves from both treatments were kept together the restrictively suckling calves performed more explorative behaviours than the artificially milk-fed calves. These results are in accordance with studies by Lidfors (1994). My study also shows that the restrictively suckling calves walked and sniffed more than the artificially

milk-fed calves during the afternoon. However, there were no significant differences between the treatments in playing and social interactions with other calves.

Earlier studies have shown that calves which were allowed to spend more time with their mother had a better health and weight gain (Metz, 1984; Weary & Chua, 2000; Flower & Weary, 2001). Also in this study the restricted suckling calves had a better health. Furthermore, the artificially milk-fed calves performed more abnormal behaviours. The two treatments showed a tendency of different weight gain but with no statistical significance. Less diarrhoea in dairy calves, which have been kept with their mother until 10 days after birth, have been recognized (Metz, 1984). The reason to why it is so important for the new born calf to get colostrum quickly after birth is that the immunoglobulin-level of the colostrum decline rapidly after calving (Skrivan et al., 1984). Calves with low concentrations of absorbed immunoglobulin are more susceptible to infectious causing diarrhoea (Petrie, 1984).

In this study, both the restrictedly suckling calves and the artificially milk-fed calves were allowed to suck colostrum from the dam during five days. However, the quality of the colostrum declines rapidly after calving and the first day is the most important for the calf's immunoglobulin intake. The results from this study show that the artificial calves fed with milk-substitute for more than half of the study much more frequently suffered from diarrhoea than the restrictedly suckling calves.

This study shows that the restrictedly suckling calves had better coat condition than the artificially reared calves. My interpretation is that the artificially milk-fed calves had less energy to take care of themselves. Also, the cows were licking on their restrictively suckling calves both during and after milking, thus helping them to take care of their coat.

Cows which had restrictively suckling calves made more social interactions with their calves than the cows which had artificially milk-fed calves. They sniffed and licked their calves more often. When a cow was nursing her calf, she often sniffed and licked it and pushed and kicked away other calves.

The artificially milk-fed calves vocalised a lot the first week after separation from their mothers. This has been found in previous studies (Lidfors, 1994; Weary & Chua, 2000; Flower & Weary, 2001). Studies on the vocalisation between cow and calf were not made in this study, but needs to be done.

The cows' milk yield was recorded after the milking. However, it is not possible to compare the milk yield from cows with calves suckling restrictively and cows with artificially milk-fed calves, because in the afternoon the restrictively suckling calves ingested milk from their mothers four teats. The artificial milk-fed calves were fed with the bottles of milk saved from the morning milking and mothers to these calves were not milked at all in the afternoon. The cows mean milk production during the morning milking was 6.5 litres in the cows with artificially milk-fed calves and 7.3 litres in the cows with restrictively suckling calves. Earlier studies have showed that the post-stimulation, i.e. the calves butting and sucking, increases the future milk yield (Lupoli et al., 2001; Orihuela, 1990; Wilde et al., 1995; de Passillé et al., 1992) and these results is in accordance with the results in this study.

Flower & Weary (2001) suggest that several days of suckling by calves have positive health benefits for the cow: 1) suckling is known to accelerate the involution of the uterus following calving, 2) suckling has been shown to reduce the risk of retained foetal membranes in some studies, 3) suckling can reduce the amount of residual milk left in the udder and thus reduce the incidence and duration of mastitis in dairy cows. The udder health of the cows in this study was followed, but is outside this ethological study and will be reported elsewhere.

On the research farm other studies were carried out, for example blood sample for cortisol assessment in 4-9 days old calves and the cow's synchronisation with CIDR, temporal weaning and heat. The blood sample from some of our seven day old calves was taken after the observations of behaviour "after milking". These procedures should not have had any major influence on the behavioural recordings.

When the cows were synchronized with CIDR, they had no contact with their calves for one day. This separation could have affected some of our restricted suckling calves.

Metz (1984) earlier studies have found that cows suckling calves for 10 days had a mean calving-conception interval of 66 days compared to 97 days for cows separated from calves immediately. On the other hand, suckling for longer periods has been reported to increase calving-conception intervals.

This study was like a pilot study, where so big changes were made during the on-going study and made not only the practical work harder but also the statistical part more difficult. I hope my work can help to improve future research to be more scientifically designed and that one never should make changes in research work in progress.

My results show that the restrictively suckling calves performed more natural behaviours than the artificially milk-fed calves did. They explored their environment more and their health was better.

The artificially milk-fed calves performed more abnormal behaviours. They licked and sniffed the interior more often and made more cross-sucking. They were also eating more concentrate, maybe because they were hungrier due to that many of them refused to eat the milk substitute. The artificially milk-fed calves also had more diarrhoea.

My end conclusion is that calves which were fed milk substitute, in tropical areas, had more problems with the heat and humid climate. This climate probably increased the amount of bacteria and lead to a bigger risk of dehydration. In this special case the salt from the cheese-water made the calves unwilling to drink the milk which led to more dehydration than if the milk substitute powder had been mixed with water of the right temperature. To feed calves with milk substitute or whole milk from a bottle created also more work for the calf-man.



## **7. CONCLUSION**

The conclusion of this study is that artificially milk-fed calves showed more abnormal behaviours and reduced health compared to restrictively suckling calves.

During milking cows performed more social behaviours towards their calves when they were restrictively suckling afterwards compared to when they were separated and artificially milk-fed. This suggests that in tropical areas restrictively suckling calves on cows cross-bred between Brahman and Holstein cows have a better welfare than artificially milk-fed calves.



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*Figure 11.* My daughter is hugging her favourite calf. (Photo: Anette Aspegren-Güldorff)





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