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The influence of calf rearing methods and milking methods on performance traits of crossbred dairy cattle in Thailand

3. Calf performance

Abstract

The experiment to investigate the effect of restricted suckling (RS) and bucket rearing (BR) involved 40 calves from crossbred dairy cows with 75 % or 87.5 % Holstein-Friesian (HF) genes from 4 days after birth to weaning at 84 days of age.
From days 4 to 84 of age restricted suckling calves were allowed to suckle their dams up to 15 minutes post milking. Bucket reared calves were fed a total of 236 kg whole milk and received concentrate supplementation after day 56. All calves were kept indoor, received *Brachiaria ruziziensis* grass ad libitum from day 56 and had free access to water.
RS calves exhibited no losses and only 3 illnesses, whereas three BR calves died and nine developed illnesses.
Up to 84 days of age RS calves had a highly significant faster average daily gain (ADG) than BR calves (620 g vrs. 390 g) and a significant larger heart-girth.
RS and BR calves had an estimated adjusted daily metabolisable energy (ME) intake from milk of 18.9 ME and 12.6 ME and from the whole ration of 18.9 ME and 14.3 ME, respectively.
Intake of milk fat, milk protein, Ca and P were highly significant higher in RS calves. Total protein intake from the whole ration was higher in BR calves.
The daily intake of 18.9 MJ and 14.3 MJ ME for RS and BR calves exceeded the need for the realised ADG of 620 g and 390 g (average demand: 16.3 and 11.8 MJ ME) which suggest an oversupply of energy.
Demand calculation for protein of 115 g and 103 g crude protein for RS and BR calves corresponded to an intake of 107.7 g and 118.9 g crude protein, respectively. This indicates that the efficiency in utilisation of crude protein seems to be grossly underestimated in suckling calves.
Restricted suckling has been demonstrated to be an efficient method for calf rearing.

Key Words: calf, suckling methods, restricted suckling, calf performance

Zusammenfassung

Titel der Arbeit: **Leistungseigenschaften bei Kreuzungs-Milchkühen in Thailand. 3. Leistung der Kälber**
In einem Fütterungsversuch wurde der Einfluss des Kälberaufzuchtverfahrens (Eimeraufzucht, BR und restriktives Säugen, RS) auf die Wachstumsleistung und die Mortalitätsrate von Kreuzungskälbern ermittelt.
40 Kälber von Kreuzungskühen mit 75 – 87,5 % Holstein-Friesen (HF) - Anteil wurden über 80 Tage (4.-84. Lebenstag) auf der Milchfarm der Ubon Ratchathani Universität, Thailand im Stall aufgezogen.
Die Kälber der RS-Gruppe hatten über die gesamte Versuchsperiode die Möglichkeit täglich 2 x über 15 Minuten nach dem Melken zu säugen. Die dabei aufgenommene Milchmenge wurde durch Differenzwägung vor und nach dem Säugen ermittelt.
Die Kälber der BR-Gruppe erhielten aus dem Gesamtgemelk über die 80 Versuchstage insgesamt 236 kg Milch und vom 56. Tag an Kraftfutter.
Brachiaria ruziziensis (ab 56. Tag) und Wasser standen allen Tieren ad libitum zur Verfügung.
Die RS-Kälber hatten keine Verluste und nur 3 Tiere zeigten leichte Erkrankungen, dagegen starben in der BR-Gruppe 3 Kälber und 9 erkrankten im Verlauf des Versuches.
In der Wachstumsentwicklung waren die RS-Kälber den BR-Tieren deutlich überlegen mit 620 g täglicher Lebendmassezunahme gegenüber 390 g.
Die aus der Zusammensetzung der Milch und dem Konzentrat ermittelte durchschnittliche tägliche Energieaufnahme betrug in der RS-Gruppe 18,9 MJ ME bzw. 14,3 MJ ME in der BR-Gruppe.

Die Aufnahme von Milchfett, -protein, Ca und P war in der RS-Gruppe hoch signifikant höher als in der BR-Gruppe. Durch die Konzentratzulage hatte die BR-Gruppe einen gesteigerten Proteinkonsum.
Die tägliche Energieaufnahme überstieg für das realisierte Wachstum der Kälber den Bedarf in beiden Gruppen (18,9 MJ ME und 14,3 MJ ME gegenüber dem Bedarf von 16,3 und 11,8 MJ ME).
Die für das Wachstum notwendige Proteinmenge (Bedarfswerte nach NRC, 1989) wurde in der RS-Gruppe nicht aufgenommen (115 gegenüber 108 g / Tag). Das deutet auf eine höhere Effizienz der Verwertung des Proteins aus der Milch, als in den Bedarfstabellen angegeben, hin.
Es wurde nachgewiesen, dass restriktives Säugen eine sehr effiziente Form der Kälberaufzucht ist.

Schlüsselwörter: Kalb, Säugemethoden, restriktives Säugen, Leistungen der Kälber

Introduction

Small holder dairy production with crossbred cows in the tropics requires technologies to secure a sustainable production process which can often be constrained by udder health problems and high rates of calf mortality and morbidity (BOONBRAHM, 2002; BOONBRAHM et al., 2004a, 2004b).
This paper reports about results on the effect of calf rearing management on performance of crossbred dairy calves during the rearing period.

Materials and methods

Animals and husbandry

The study was carried out at the experimental farm of Ubon Ratchathani University (UBU), Ubon Ratchathani province, Thailand. The climate is strongly influenced by the monsoon. The southwest lasts from May to October (wet season) and the monsoon from November to April (dry season).
40 calves (21 male and 19 female) from crossbred cows (75 % or 87.5 % HF), 22 born in the wet and 18 in the dry season, were housed in a purpose-built calf barn with individual pens. The calf barn also contained the pens for suckled cows. The barn had a concrete floor and was well ventilated. It was cleaned regularly twice a day.
Calves were exercised every morning and evening for 1 hour in an exercise yard attached to the calf barn.
Ruzi grass *(Brachiaria ruziziensis)* was offered throughout day and night in small quantities, which were weighed using the spring balance, calibrated to read in increments of 50 g. The feeding trough was cleaned each morning and leftover Ruzi grass was weighed using a spring balance.

Experimental treatments

All calves were kept with their dams during the first 72 hours of life and were assigned from day 4 to 84 to either the restricted suckling (RS) or bucket rearing (BR) treatments.
RS calves were allowed to suckle dams for 15 minutes after milking twice daily. Milk intake was measured using the weigh-suckle-weigh method.
BR calves were fed milk at 10% of body weight up to 56 days, corresponding to the results of ALVAREZ et al. (1980a) for the milk consumption of 75 % HF crossbred calves at bucket rearing. The total amount of milk consumption by BR calves over 84 days of life is shown in Table 1.
From 56 to 84 days milk feeding was stepwise reduced from 3 to 1 kg /day and the nutrient intake adjusted through concentrate.

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Table 1
Course of milk feeding for bucket-fed-calves during the whole experimental time (Verlauf der Milchfütterung bei Kälbern mit Eimeraufzucht während des Versuches)

Days	Amount of milk (kg)	
	per day	total amount
4-28	3.0	75.0
29-56	3.5	98.0
57-70	3.0	42.0
71-77	2.0	14.0
78-84	1.0	7.0

The amount of supplemented concentrates fed to BR calves was calculated individually to meet the energy requirement (ME as recommended by NRC, 1978) for a daily growth rate of 650 g. The concentrate mixture was a composed calf starter feed with ME, CP, P and Ca content in the dry matter of 13.6 MJ, 17.1, 0.76 and 0.81 %, respectively.
Water was given ad libitum at all times in aluminium buckets of 10 litres capacity. Leftover water was removed every morning and evening.

Recording of traits

The milk energy content (MJ ME) and the calcium and phosphorus content of milk were estimated using regression equations represented by KEARL (1982).

ME (MJ/l) = 2.428 + 0.586 x fat %
Ca (g/l) = 1.9 + 0.2 x fat %
P (g/l) = 1.2 + 0.2 x fat %

To evaluate the availability of metabolisable energy for maintenance (MEm) and metabolisable energy for growth (MEg) obtained from fresh milk, the multipliers of 0.86 and 0.69 were used to calculate the efficiency of both ME utilisation, respectively (NRC, 1978). The MEm and MEg in concentrate were multiplied with the constant factors of 0.75 and 0.55 for MEm and MEg, respectively (adapted from ARC, 1980 and NRC, 1978).
The nutrient content of the milk was measured for the whole milk and for residual milk and the energy content was calculated according KEARL (1982) to estimate the intake by bucket reared calves and by restricted suckling calves.

Statistical analysis

The SAS procedure for General Linear Models (GLM) of the Statistical Analysis Systems Release 6.12. (SAS, 1998) was used for the analysis of variance. The following model was used for the traits listed:
Daily milk consumption, daily weight gain, milk conversion ratio, heart-girth measurement, nutrient consumption, mortality rate.

$$Y_{ijk} = \mu + C_i + S_j + B_k + e_{ijk}$$

were

$Y_{ijk...}$ = The dependent variable
μ = Overall mean
C = Calf rearing system$_i$
S = Sex of the calf$_j$
B = Season of birth$_k$
e = Random error$_{ijk}$

Results

Calf health and mortality rate

From the initial 40 calves only 37 could be included in the statistical analysis. Three animals of the BR group, born in the wet season, died during the first 3 weeks of the experiment due to diarrhoea (2) or pneumonia (1).

The health status during the experimental period, shown as incidence of illness, is described in Table 2. Bucket reared calves had a threefold higher illnesses incidence than restricted suckled calves.

Table 2
Incidence of morbidity and mortality during the whole experimental period (Day 4-84) [Häufigkeit von Krankheiten und Sterblichkeit während des Versuches (4.-84. Tag)]

Main effects	n	Cases of morbidity		
		Diarrhoea	Pneumonia	Mortality n
Rearing system				
Bucket rearing	20	6 (30 %)	3 (15 %)	3 (15 %)
Restricted suckling	20	2 (10 %)	1 (5 %)	0
Sex				
Male	21	3 (14 %)	2 (10 %)	2 (10 %)
Female	19	5 (26 %)	2 (11 %)	1 (5 %)
Season of birth				
Wet	22	5 (23 %)	3 (14 %)	3 (14 %)
Dry	18	3 (17 %)	1 (6 %)	0
Total	40	8	4	3

Calf performance parameters

The analysis of variance of effects of the rearing system, sex and season of birth on performance of calves shows a significant influence of the rearing system only. Male calves were heavier than female calves and calves born in the dry season grew faster than calves born in the wet season.

The effects of the rearing systems on average daily weight gain and heart girth- rate measurement are listed in Table 3.

Table 3
Influence of rearing system on daily weight gain and heart girth measurements of the calves (Results of GLM variance analysis) (Einfluss des Aufzuchtverfahrens auf die täglichen Zunahmen und den Herz-Umfang der Kälber)

Main effects	n	Birth weight kg	Average daily weight gain (kg) day 4 - 84	Heart-girth measurement	
				At birth	Day 84
Rearing system		ns	***	ns	*
Bucket rearing	17	29.06±0.84	0.39±0.02	71.59±0.94	89.62±1.64
Restricted suckling	20	29.73±0.76	0.62±0.02	71.04±0.85	94.88±1.48
n		37	37	37	37
LSQ mean ± sem		29.37±0.56	0.51±0.03	71.32±0.60	92.25±1.19

ns = non significant, * = $p<0.05$ and *** = $p<0.001$

Calf rearing management significantly ($p<0.001$) influenced daily weight gain. RS calves had a 72.5% higher average daily gain (ADG) than calves of the BR group.

Heart-girth corresponded closely to body growth. The heart-girth of the RS calves at day 84 was 5.9% higher than in the BR calves.

Milk consumption and nutrient intake

The milk consumption of BR calves was measured directly while in the RS calves it was measured indirectly by the weigh-suckle-weigh method.
The nutrient intake was calculated according to the chemical analysis of milk and concentrate feed. Energy intake was estimated using the fat content of milk.
The average milk consumed of BR calves was 2.91kg/calf/day or a total of 236 kg for the whole experimental period as specified in Table 1.
The average daily milk consumed by RS calves were 3.36 kg or 16.3% more that milk fed to BR calves (Table 4). The difference is highly significant ($p<0.001$).

Table 4
Effects of rearing system on daily milk and energy intake of calves (Results of GLM variance analysis) [Einfluss des Aufzuchtverfahrens auf die tägliche Milch- und Eneregieaufnahme der Kälber (Ergebnisse der Varianzanalyse)]

Main effects	n	Average milk intake	Estimated adjusted daily ME intake MJ[1/]	
		kg/day	Milk only	Whole ration[2/]
Rearing system		***	***	***
Bucket rearing	17	2.91±0.09	12.60±0.59	14.32±0.59
Restricted suckling	20	3.36±0.08	18.86±0.54	18.86±0.53
n		37	37	37
Mean ± sem		3.15±0.08	15.73±0.40	16.59±0.40

[1/]: Part of ME consumption from feed was adjusted to be equal to available ME from fresh milk. The efficiency of ME utilization from fresh milk by calf is assumed equal to 120 % (range 114.5-125.5 %) of ME from feed
[2/]: The ration during day 57-84 of age; milk and concentrate in artificial rearing group and only suckled milk in restricted suckling group
ns = non significant, ∗ = $p<0.05$ and ∗∗∗ = $p<0.001$

Table 5
Amount of fat, protein and the minerals (Ca and P) consumed by the calves (Results of GLM statistical variance analysis) during the whole experimental period [Aufnahme von Fett, Protein und Mineralstoffen (Ca und P) durch die Kälber während des Versuches]

	Bucket rearing (n = 17)	Restricted suckling (n = 20)	Significance
Fat intake g/day			
Milk only	94.99±6.74	183.76±6.08	***
Whole ration[1/]	99.89±6.72	183.76±6.06	***
g/average metabolic BW whole diet	5.78	9.16	
Protein intake g/day			
Milk only	92.78±3.85	107.68±3.47	***
Whole ration[1/]	118.89±3.86	107.71±3.49	*
g/average metabolic BW whole diet	6.88	5.37	
Ca intake g/day			
Milk only	7.40±0.30	10.01±0.27	***
Whole ration[1/]	8.63±0.30	10.01±0.27	**
P intake g/day			
Milk only	5.37±0.23	7.68±0.21	***
Whole ration[1/]	6.10±0.23	7.68±0.21	***

[1/]: The ration during day 57-84 of age; milk and concentrate in artificial rearing group and only suckled milk in restricted suckling group
ns = non significant, ∗ = $p<0.05$ and ∗∗∗ = $p<0.001$

The energy intake from milk and the total ration respectively was in the BR group 50% and 38% lower than in the RS group. This is a result of the lower milk intake and the different fat composition of the consumed milk.
During days 56 and 84 the average fat content in the residual milk consumed by the RS calves, was 5.71 % compared to 3.19 % fat in the milk fed to BR calves, which indicates a 78 % higher fat content in the residual milk.

The amount of fat, protein and the approximate P and Ca, comsumed by the two groups is shown in Table 5.

Given the similar milk protein content in the residual and whole milk and given the additional concentrate intake, BR calves had a 10 % higher protein intake ($p<0.05$) than RS calves.

The mineral content, estimated according to KEARL (1982), was strongly correlated to the fat content of milk and was therefore significantly higher in the RS group.

Based on the average metabolic body weight of the two groups the intake of energy, fat, protein, Ca and P of RS calves in comparison to BR calves is +13%, +58%, -28%, ±0% and +8%, respectively.

Discussion

Birth weights (29.37 kg) of the experimental calves (HF crossbreeds) were in the range of reported birth weights of HF crossbred calves (21-35 kg) in different tropical countries (SAHN et al., 1997; TAWAH et al., 1995; TEELUCK et al., 1981; GAYA et al., 1977; DOYLE, 1991; KIWUWA et al., 1983).

During the experimental period up to day 84 post partum the difference in the body weight between the two rearing methods amounted 19 kg.

With 620 g ADG the restricted suckling group achieved a growth potential which is considerably higher than in other reports for crossbred animals with a high HF proportion under tropical conditions (CARIAS and VACCARO, 1984; DOYLE, 1991; MEJIA et al., 1998; SAHN et al., 1995; SAHN et al., 1997; UGARTE, 1976).

The superiority of restricted suckling in comparison to bucket rearing is underlined not only by the higher ADG but also by a reduced disease susceptibility and mortality. The main reason for the improved growth of the restricted suckling calves is essentially the improved intake of energy and minerals from suckling residual milk in comparison to calves which were fed with whole milk.

The amount of milk offered to the BR group was calculated based on information from the literature (ALVAREZ et al., 1980b). The growing energy and nutrient demand after the 57 experimental day was satisfied through supplementary concentrate feeding. Thus, the question of an increased milk consumption in combination with its effect on growth was not relevant in this experiment. The milk consumed by restricted suckling tends to show a rather large variation (ALVAREZ et al., 1980b; GAYA et al., 1977; PAREDES et al., 1981; SAHN et al., 1995; UGARTE and PRESTON, 1972a, 1972b, 1973, 1975).

The daily intake of metabolisable energy was 14.3 MJ in the BR group and 18.9 MJ in the RS group. The realised daily gain of 390 g and 620 g for BR and RS calves, respectively, and a calculated average body mass of 44.7 and 54.5 kg would demand 11.8 and 16.3 MJ ME (respectively) if normal milk or milk replacer were fed (NRC, 2001). Thus, the experimental calves had a much higher energy intake than required.

With respect to the protein demand of calves during suckling the NRC publication (2001) remarks critically, that the respective information relevant for body masses below 100 kg are rather in complete and not reproducible.

According to BLAXTER and WOOD (1951), ROY, (1970), DONNELLY and HUTTON (1976), NRC (1978) and DAVIS and DRACKLEY (1998) the N demands for growth in calves is given as a constant of 30 g N/kg body mass gain.

Applied to this experiment it would represent a daily N demand of 73 g for the BR group and 116 g for the RS group. With additional consideration of maintenance demands for protein (different average body mass and a lower protein utilisation efficiency of protein in concentrates considered) a total demand of 103 g and 151 g crude protein per day was calculated for the BR and the RS group, respectively. While the demand was met in the BR group, the restricted suckling calves seem to have been exposed to a protein deficit. The discrepancy between the estimated protein intake and the protein demand can only be explained by a higher protein utilisation efficiency, caused by restricted suckling.

Three factors could have determinated the higher utilisation efficiency of milk by suckling calves: 1) the higher nutritional quality of milk consumed by suckling calves, 2) the more efficient closure of the oesophageal groove, and 3) the greater contact of milk with salivary enzyme.

Factor 1: The higher fat content in the suckled milk provides more energy to calves, and also improves the ability of curd formation in the abomasum. This appeared to be advantageous for the suckled calves because it slows the release of digesta out of the abomasum into the small intestine (PETIT et al., 1987). JENKINS et al. (1981) found that feeding calves with a milk replacer high in fat and casein resulted in the formation of a large and firm clot in the abomasum. The clot slows down the passage of protein, dry matter and fat (CRUYWAGEN et al., 1990). Consequently, a gradual and more complete digestion and absorption of the nutrients consistently occur between feedings (PETIT et al., 1987; CRUYWAGEN et al., 1990). In this study, the RS calves consumed more fat than BR calves (183.76 and 99.89 g day, respectively). This means that not only a greater amount of energy was consumed by RS calves compared to BR calves, but it is also to be expected that the RS calves had a better utilisation efficiency of nutrients.

Factor 2: Bucket fed calves and suckling calves have a different posture and body movement during the time of milk consumption. RUCKEBUSCH (1987) reported that the efficiency of closure of the oesophageal groove is higher in calves fed from an artificial nipple than in bucket-fed calves causing milk to enter the rumen later, which could retard digestion and assimilation of the products of milk digestion in pre-ruminal calves. ØRSKOV (1983) reported that the efficiency with which a liquid bypasses the rumen via the oesophageal groove is directly influenced by the psychological status of the animal.

Factor 3: BR calves needed only 5-7 minutes to finish the milk offered per feeding, while RS calves took 10-15 minutes to suckle the residual milk from their dams. This difference of milk ingestion duration could cause a difference in the digestion of some nutrients contained in milk due to the activation of salivary enzymes. WISE et al. (1976) reported a greater contact of milk consumed by RS calves with saliva than milk ingested by bucket-fed calves. This is because of the relatively slow rate of ingestion (WISE et al., 1976), the greater secretion of saliva (GROSSKOPF, 1965 cited by DOYLE, 1991) and the greater secretion of pre-gastric esterase by RS calves (WISE et al., 1947; YOUNG et al., 1960). OTTERBY et al. (1964) showed that pre-gastric esterases were the principal enzymes of fat digestion in the abomasum. The increased secretion of pre-gastric esterases with sucking could result in a more complete nutrient digestion in the abomasum.

Conclusions and recommendations

Restricted calf suckling as a method in crossbred dairy production has clearly demonstrated advantages for rearing healthy calves. In this experiment the total milk intake in restricted suckling calves was with 286 litres just 48 litres above the intake of bucked reared calves. This difference, does not account for the highly significant improved body weight development in restricted suckling calves (620 g ADG versus 390 g ADG). Main effects of restricted suckling are related to the higher energy intake due to the higher fat content of suckled milk versus the milk fed to bucket calves. Results of this experiment also indicate a superior mineral supply to restricted suckled calves despite a mineral supplementation and concentrate feeding to bucket fed calves. Restricted suckling therefore is a very important and sustainable method in smallholder dairy production to optimise output and efficiency, especially when conditions to maintain dairy hygiene and the availability of high quality concentrates for calves are less than optimal.

Protein requirements for restricted suckling are not available. It seems, that the efficiency of the protein utilization in the residual milk, with an increased fat content, is much higher than for the total milk fraction. To assure adequate protein supply a supplementation with a protein rich concentrate from the 9th week is recommended.

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