

## EFFECT ON MILK PRODUCTION AND CALF PERFORMANCE OF MILKING CROSS BRED EUROPEAN/ZEBU CATTLE IN THE ABSENCE OR PRESENCE OF THE CALF, AND OF REARING THEIR CALVES ARTIFICIALLY

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Five hundred and thirty nine lactations of crossbred European/Zebu conga, were analysed to study the effect of milking, with or without the presence of the calf, on the performance of cows and calves. The study was carried out in Tabasco State, in conditions of the humid tropics, the feeding system being grazing with minimum supplementation when pasture growth was in short supply.

Approximately 40% of the cows that were milked without the calf being present had short lactations and this reduced the amount of saleable milk to an average of 621 litres/lactation of 197 d. Cows that appeared to give acceptable lactation length, and production, without the presence of the calf in their first lactation, showed a significant tendency to reduce their level of milk production and to become dry prematurely in subsequent lactations under the same system of management. The cows that became dry prematurely when milked without the presence of the calf gave normal yields (968 litres in 268 d) in their subsequent lactation, when they were milked with the presence of the calf and with the restricted suckling after milking.

The restricted suckling system was considered to be the most appropriate since over a total of 230 lactations the average yield of saleable milk was 1120 litres in 262 d. There was also a reduced incidence of subclinical mastitis in the cows that were milked with their calves.

A low rate of growth (277 g/d) and a high mortality were observed when the calves were reared artificially. These problems were reduced significantly when the calves were reared by restricted suckling, as growth rate increased to an average of 464 g/d and mortality was reduced to 6%.

**Key words:** Cattle, dual purpose, restricted suckling, artificial rearing, cross breeding, European/Zebu breeds

In the traditional milk producing areas in the world, it is common practice to use specialized cattle breeds such as the Holstein, managed in intensive systems and fed high quality forages and large amounts of concentrates. In such systems the cows invariably are milked without their calves, which often are slaughtered soon after birth or are reared artificially. The levels of production achieved in these specialised herds usually exceed 4000 litres per lactation. Unfortunately these intensive systems are becoming ever more costly due to their almost complete dependence on concentrate feeds which frequently are imported and competed for by other species.

The adaptation to the tropics of European cattle breeds specialized for milk production has proved to be difficult because of climatic and disease problems as well as the high level of management and feeding that this type of cattle require and which is difficult to provide in such regions. As a result, the introduction of these types of cattle to the tropics, has frequently led to serious difficulties especially when attempts have been made to manage them as pure breeds. It now appears that a

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better strategy is to use these specialized European milk breeds in crossing programmes with native breeds, thus developing a dual-purpose type of animal, with better adaptability and greater resistance, for milk and beef production in the arduous conditions of the humid tropics (Preston 1977).

The separation of the calf from its mother, within a few hours of birth, and rearing it artificially thereafter is a common practice in specialized systems with purebred European type cattle. This practice facilitates management during the milking operation. However, attempts to milk Zebu crossbred cows without their calves has caused problems with respect to milk let down at the moment of milking giving rise to short lactations (Hayman 1974; Ugarte & Preston 1972).

The artificial rearing of calves in the tropics has also presented many problems, due to a multitude of factors which affect growth rate and health. Often these factors have led to very high levels of mortality, which have made it quite uneconomical to pursue this type of rearing system.

The objective of the research described in this paper was to evaluate, at a commercial level, the effect of milking crossbred European/Zebu cattle with and without their calves in order to obtain information concerning the suitability of such systems for tropical conditions, both with respect to milk production and to calf rearing.

## Materials and Methods

*Location:* The trials were carried out between 1974 and 1979 in the Demonstration Centre for Animal Production (C-41), of the Agricultural Development Division (FIRA) of the Bank of Mexico, The Project is situated in the collective farm (Ejido) C-41, in the Chontalpa Plain, Huimanguillo Tabasco, Mexico, approximately 26 km from Cardenas, Tabasco.

*Climate:* The climate is hot sub-humid with summer rains (Am). The annual rainfall is approximately 2000 mm and the relative humidity varies from 80 to 88%. The average annual temperature is 26.4°; the average minimum monthly temperature is 11.9° (February) and the maximum monthly temperature 40 (May). The months of highest light intensity are March to June with an average of 14 to 19 cloudless days monthly; those with least light intensity are September to February with three to five cloudless days monthly. The predominant winds come from the Northeast in summer and Northwest in winter, the latter known as the "north" winds, being both cold and wet.

*Soils:* : The land is flat with deep alluvial soils of heavy clay texture and deficient in drainage. The farm is situated in an area with a comprehensive drainage network, to prevent flooding. The original vegetation was medium to high forest, predominating the genera *Terminalia*, *Switenia* and *Tabebuia*.

*Buildings:* The principal installations are a milking shed with 8 stalls of walk-through, abreast type, with pipeline milking machine; calf pens, working corrals, race and weighbridge.

*Pastures:* A rotational grazing system is used. Initially, in 1974 the greater part of the area was covered with grass and legume associations of the following species:

*Setaria phacelata*, var. *Kazangula*, *Cynodon plexostachyus* (Bermuda Cross 1) and Santo Domingo star grass; associated with the legumes *Glycine wightii* cv. *tinaroo*, *Macroptillium atropurpureum* (Siratro), *Centrocema pubescens* (Centro), *Desmodium intortum* and *Stylosanthes guyanensis* cv *Schofield*.

Two years after the associations had been established, the greater part of the legumes had disappeared; only the stoloniferous grasses such as Bermuda Cross 1 and Santo Domingo star grass remained. It did prove possible however, to establish the leguminous tree *Leucaena leucocephala* planted in compact areas.

*Animals:* The programme began with the acquisition in the region of heifers with different proportions of European and Zebu blood. The proportion of European blood varied from 25 to 75%, with an average estimated at around 50 to 60%. Two types of European milk breeds were represented: The Holstein and Brown Swiss.

*Treatments:* Observations were made on the general performance of the herd in Phases I and III; the two phases involved two different systems of management. In Phase II a number of different experiments was carried out as it was found necessary to analyse some alternative management systems.

#### *Phase I:*

In the first phase of the project, which covered the years 1974 to 1976, the following management practices were applied:

- Milking without the presence of the calf
- Machine milking twice daily
- Artificial rearing of the calves
- Exclusive use of artificial insemination

These management practices were evaluated with the objective of trying to establish milk production as a specialized activity, rather than as a secondary component of beef production.

#### *Phase II:*

This period was considered to be experimental and transitory because of the need to find alternative procedures to overcome the problem of cows which became dry prematurely when their calves were separated permanently from them at birth. Sixty one animals were selected. These calved during the first three months of 1977, when the following experiments were carried out:

*Experiment 1:* Two groups of 14 and 12 pregnant cows were selected on the basis of having let down their milk, without the presence of the calf, in the previous lactation. In the experimental lactation these groups were milked without (Trial 1) or with the calf being present (Trial 2) at the time of milking<sup>1</sup>.

*Experiment 2:* Eighteen pregnant cows were selected which had not let down their milk in the previous lactation. In the subsequent lactation they were milked with the calves being present at milking, and with restricted suckling following milking.

*Experiment 3:* Eighteen heifers were selected and divided between two treatments: (a) with the presence of the calf at milking followed by restricted suckling after milking; or (b) without the calf being present at milking, being reared artificially on cows milk given in buckets.

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<sup>1</sup> The calf was brought into the shed when its mother was to be milked. Generally it was allowed to suck each teat for a few seconds: it was then tied near the head of the cow; after milking was completed, the calf was permitted to suck the residual milk in the udder.

*Experiment 4:* This experiment consisted of observations on a large number of cows which let down their milk without the presence of the calf in successive lactations. Observations were made on 45 cows in two successive lactations and on 5 cows in three successive lactations.

*Experiment 5:* Samples were taken at 3 monthly intervals from all the quarters of the udders of 92 cows divided between the two systems of milking with calves reared artificially (n=45) or with (n=47) the presence of the calves at milking time followed by restricted suckling. The milk samples were tested by the California mastitis test.

#### *Phase III:*

In this third Phase of the project, which related to information obtained between 1977 and 1979, the management practices were changed in line with the results obtained from the experimentation in Phase II. The management scheme which was implemented was as follows:

- Milking with the calf present at milking time
- Mechanical milking once daily
- Calf rearing by restricted suckling
- Use of artificial insemination during the first 150 days after calving and subsequently natural mating

This programme was carried out with the objective of putting into practice a dual-purpose system with emphasis on simple management and improved efficiency both for milk and beef production.

Measurements and statistical analysis: Records were made daily on individual milk production. Measurements were also made of incidence of mastitis' reproductive traits, birth weight and growth rate of the calves. The results were analysed by analysis of variance and by "t" test.

## Results and Discussion

#### *Phase I:*

*Performance of cows milked without the presence of their calves:* In this first Phase, data were collected from all the cows (309 lactations) that calved during the period 1974 - 1977 and which were milked without the presence of the calves; the latter were reared artificially. The results for this period are shown in Tables 1 and 2.

Total milk production (at milking) was 981 litres and the length of lactation 197. These results were affected negatively by a high percentage of cows which, under this management system, had very short lactations (Table 2). Of the milk that was produced, approximately 360 litres were used to rear the calves. This reduced the final milk sold per cow to levels of 621 litres/ cow/lactation. In fact, the milk sold from the herd per cow calved was even less, since it was necessary to feed some calves milk from cows which went dry shortly after calving.

The mean calving interval of 474 days indicates a certain inefficiency in reproduction, which can be attributed in large part to the difficulty of detecting heats in the insemination programme which was used exclusively without assistance from back-up bulls. This resulted in a high percentage of cows which failed to become pregnant for some considerable time.

The cows were classified according to the length of lactation. They were judged to have "let-down" their milk if they continued producing for more than 150 days; they were classified as 'becoming dry prematurely' if they produced for a shorter time. It was found that 40% of the cows (Table 2) had very short lactations (34 days on

Table 1:  
Observations on the performance of European/Zebu crossbred cows milked without the stimulus of the calf.

	Mean	SD	Range
No of lactations	309		
Liveweight after calving, kg	413	78	277-639
Length of lactation, d	197	156	1-623
Milk production, litres			
At milking	981	967	1-5080
Consumed by the calf <sup>1</sup>	360		
Saleable <sup>2</sup>	621		
Reproduction			
No of observations	258		
Days to let service	113	68	36-387
Calving interval, d	474	145	312-1200

<sup>1</sup> In artificial rearing

<sup>2</sup> Milk produced at milking - Milk consumed by -the calf

Table 2:  
Effect on milk production and reproductive performance of milking crossbred European/Zebu cows without the calves (mean values  $\pm$  standard deviation)

	Lactations above 150 d		Lactations less than 150 d	
	Mean $\pm$ SD	Range	Mean $\pm$ SD	Range
No	185		124	
Days in milk	305 $\pm$ 102	151-623	34 $\pm$ 36	1-140
Milk production, litres				
Total at milking	1571 $\pm$ 820	293-5080	103 $\pm$ 168	1-179
Consumed by the calf <sup>1</sup>	360		360	
Saleable <sup>2</sup>	1211		-257	
Calving interval, d	480 $\pm$ 157	312-1200	461 $\pm$ 128	316-933

<sup>1</sup> In artificial rearing

<sup>2</sup> Milk produced at milking - Milk consumed by the calf

Table 4: :  
Performance of cows that let-down their milk without the stimulus of the calf in the previous lactation and which in th subsequent lactation were milked without (Trial 1) or with (Trial 2) the stimulus of the calf

Trial No.	1				2			
	Previous (without the calf)	Actual (without the calf)	Diff±SE <sup>1</sup>	Prob <sup>2</sup>	Previous (without the calf)	Actual (without the calf)	Diff±SE <sup>1</sup>	Prob <sup>2</sup>
No of cows <sup>3</sup>	14	14			12	12		
Dry before 150 d, %	0	50			0	0		
Length, d	300	149	157±28	0.001	343	259	99.3±29	0.01
Milk production, litres								
At milking	1632	6433	987±173	0.001	1765	1075	688±215	0.01
Consumed by the calf	360 <sup>4</sup>	360 <sup>4</sup>			360 <sup>4</sup>	518 <sup>5</sup>		
Saleable	1272	299			1405	1075		
Total/lactation	1632	6436			1765	1593		
Total/d	5.44	4.32			5.15	6.15		

<sup>1</sup> Mean difference + SE

<sup>2</sup> Probability according to the "t"

<sup>3</sup> The same animals on the two systems of management in successive lactations

<sup>4</sup> 360 litres/calf in artificial rearing

<sup>5</sup> By restricted suckling

<sup>6</sup> The data refer:only to the cows which continued milking beyond 150 d

Table 5 :  
Performance of cows that became dry prematurely when milked without the stimulus of the calf and which were managed at the subsequent calving with stimulus of the calf and restricted suckling (X±SE<sub>X</sub>).

	Without the calf	With the calf	Prob.
No of cows <sup>1</sup>	18	18	
Length of lactation, d	29±7	268±12	0.001
Milk, litres			
At milking	77±26	968±64	0.001
Consumed by the calf <sup>2</sup>	360	536	
Saleable	-283	968	
Total <sup>3</sup>	377	1504	

1 The same cows under different systems of management in successive lactations

2 360 litres in artificial rearing and approximately 2 litres/calf/d by suckling

3 Saleable + Milk consumed by the calf

average). Similar data have been reported by Mahadavan et al (1962), Ugarte and Preston (1972) and Hayman (1974). The production of milk from these cows decreased notably, coinciding with the report by Huertas (1972, cited by Pearson 1974), that criollo cows produced less milk when they were milked without the calves being present at the side of the mother.

Within the group of cows which did "let-down" their milk, the average production was 1571 litres in a lactation of 305 d, giving an average daily yield of approximately 5.1 litres/cow. However, this was achieved only by eliminating 40% of the lactations which produced an average of 103 litres during 34 d (3.03 litres/d). This is completely uneconomical. Furthermore, the calves from these latter cows required an additional 257 litres of milk which had to be taken from the cows which "let-down" their milk. The calving interval for the two groups of cows (480 and 461 d) was relatively long probably due to the exclusive use of artificial insemination.

Performance of the calves in artificial rearing: One of the main problem<sup>1</sup> encountered was in the rearing of the calves. The system of artificial rearing that was employed gave rise to very poor growth rates and high levels of mortality (Table 3). The predisposing cause of the mortality appeared to be the poor growth of the calves; as a result, the parasites and other disease causing organisms caused greater damage particularly in the weakest animals.

Table 3:  
Performance of calves reared artificially

No.	273
Weight at birth (X±SD)	30±4.2
Weight at 6 months, kg	97.6
Daily gain, g	277
Mortality, %	
0 to 8 months	46
0 to 24 months	59
Culled, % <sup>1</sup>	17

<sup>1</sup> From the animals remaining after 12 months of age due to a poor development which made them unsatisfactory for reproduction

The mortality rate increased when the number of calves in the herd increased, because of the greater management and health problems that this caused.

### *Phase II:*

*Experiment 1:* The results of this experiment are given in Table 4. Although the cows had been selected for having "let-down" their milk without the presence of their calves in their first lactation, only 50% (Trial 1) manifested this characteristic in the subsequent lactation when they were also milked without the calf. In this subsequent lactation, the cows averaged only 643 litres in 149 d. This was a reduction of some 60% in milk production, as well as in length of lactation, in comparison with the previous lactation. Hayman (1974) reported that 70% of the cows in the Australian Milking Zebu breed (created from Jersey and Sahiwal breeds) showed this same tendency in the F1, F2 and F3 generations; and despite a strong selection against this

characteristic, the problem continued to appear in some 10% of the animals in subsequent generations.

The cows in Trial 2 that let-down their milk in the first lactation and were milked with the presence of the calf in the next lactation gave slightly less milk in the latter. This can be attributed to the extremely long lactations in the previous calving (343 d) and because in the subsequent lactation (when the calves were present) the cows were milked only once daily. In fact, the average daily production was in favour of the restricted suckling treatment (5.15 vs 6.15 litres/d for without and with the calf in restricted suckling).

*Experiment 2:* The results given in Table 5 show clearly that the main reason that the cows became dry prematurely in the previous lactation was because of the absence of the stimulus of the calf. When this stimulus was utilized in the subsequent lactation, all the cows without exception produced much higher lactation yields.

*Experiment 3:* Table 6 shows the results of this trial. There was a marked difference in milk production and length of lactation in favour of the treatment of

Table 6:  
Performance of crossbred European/Zebu cows milked with or without the stimulus of the calf

	Without the calf	With the calf and suckling
No of cows	9	8
Dry <150 d	7	0
Length of lactation, d	73±26	287±11
Milk production, litres		
Milked	218±91	910±113
Consumed by the calf <sup>1</sup>	360	560
Saleable	-142	910
Total produced <sup>2</sup>	218	1470

<sup>1</sup> 360 litres/calf in artificial rearing; and approximately 2 litres/calf in restricted suckling

<sup>2</sup> Saleable + consumed by the calf

restricted suckling. Moreover, the variation around the mean was less with the restricted suckling treatment indicating that there was a more uniform response from the cows when they were managed with the calf present at milking and with restricted suckling afterwards. It is interesting to note that in the case of two of the cows that became dry prematurely, it was possible to recover the lactation (within a lapse of 7 to 15 days) by incorporating the calf again in the milking system.

*Experiment 4:* Tables 7 and 8 summarise= arise the data for 47 and 5 cows which were observed for two and three successive lactations respectively. There was a linear reduction in yield in successive lactations (Figure 1). This is contrary to the normal tendency observed in specialized milk producing breeds which normally show increases in productivity in the second as compared with the first lactation (Smith 1962). This effect can be attributed to the fact that crossbred European/Zebu cows behave in a special way, when milked without their calves.



Figure 1:  
Relation between production of milk and number of calvings in crossbred Zebu/European cows milked without the presence of the calf.

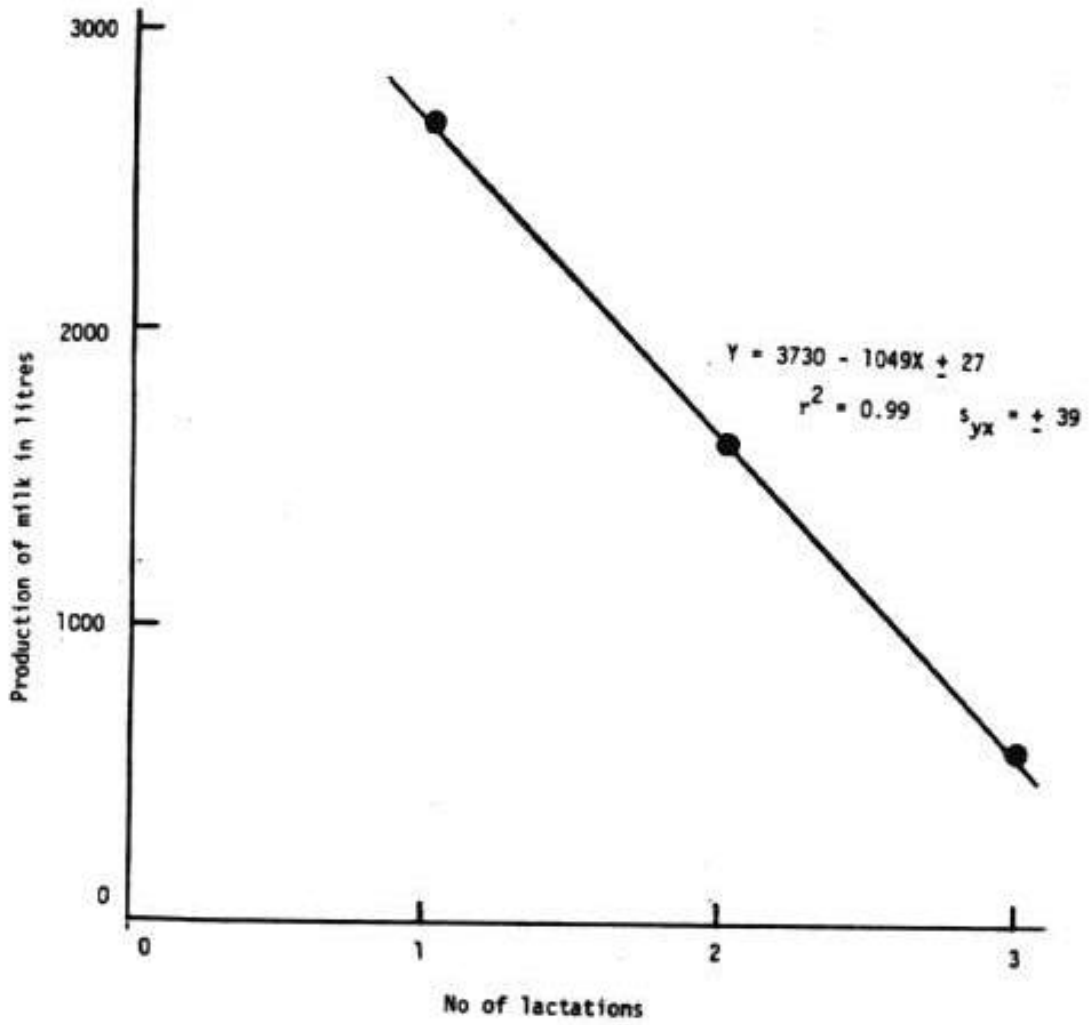


Table 7:  
Performance of crossbred Zebu/European cows milked without the presence of the calf

	Lactation	
	First	Second
No of cows <sup>1</sup>	47	47
Length of lactation, d	339 ± 14	258 ± 14
Milk, litres		
Total	2037 ± 121	1324 ± 105
Daily	6.0	5.1
Reproduction		
No of observations	41	43
Interval between calving, d	443 ± 22	434 ± 15

<sup>1</sup> The a cows in successive lactations

Table 8:  
Mean values ( $X \pm SE_x$ ) for milk production in crossbred European/Zebu cows that were milked without the stimulus of the calf during three successive lactations

	Lactation		
	First	Second	Third
No of cows <sup>1</sup>	5	5	5
Length of lactation, d	349 ± 8	262 ± 37	142 ± 27
Total milk, litres	2698 ± 257	1601 ± 348	599 ± 158
Daily milk production, litres	7.7	6.1	4.2

<sup>1</sup> The data correspond to the same cows in three successive lactations

Table 9:  
Observations on the incidence of subclinical mastitis in crossbred European/Zebu cows milked with and without the stimulus of the calf

	With the calf		Without the calf	
	No	%	No	%
No of cows sampled	47		45	
Repetitions (monthly)	3		3	
Total No of quarters sampled	560		540	
Negative (-)	294		54.4	
Suspicious (+)	80	14.4	72	13.3
Positive (++)	32	5.7	114	21.1
Highly positive (+++)	5	0.9	60	11.1
Clinical mastitis			7	
Lost quarters			2	

<sup>1</sup> California mastitis teat repeated at monthly intervals

*Experiment 5:* The classification of the milk samples for incidence of mastitis according to the California test (Table 9) confirms that the udder health was better in cows which suckled their calves. Similar findings were reported by Weiser et al (1969), Seifert (1971), Ugarte & Preston (1975) and Charlotte et al (1976).

### *Phase III*

#### *Performance of cows in the restricted suckling system:*

In table 10 are set out the data for cows which were managed according to the system of once daily milking, with the calf used to stimulate letdown and later in restricted suckling. Similar results from crossbred cows (European/Zebu) milked with calves alongside and later in restricted suckling, have been reported by a number of researchers in Mexico and other tropical countries (See Table 11).

Table 10:  
Performance of crossbred European/Zebu cows milked with the stimulus of the calf and restricted suckling (1977-1979)

	Mean value	SD	Range
Total lactations	230		
Liveweight after calving, kg	454	± 61	310-646
Length of lactation, d	262	± 61	132-468
Milk production, litres			
Saleable	1120	± 394	523-2747
Consumed by the calf <sup>1</sup>	524		
Total milk	1644		
Reproduction:			
No of observations	164		
Days to let service	96	± 52	21-277
Calving interval, d	416	± 69	314-638

<sup>1</sup> Estimated according to the difference in liveweight of the calf before and after suckling

In the present trial, the average milk consumption during restricted suckling was approximately two litres daily. Data reported in the literature for milk consumption on this system are: 1.93 litres (Fernandez et al 1977), 1.9 to 5 litres (Ugarte 1976), 1.96 to 4.15 litres (Alpuche et al 1976) and 1.43 to 4.15 litres (Alvarez & Preston 1976; Alvarez et al 1977).

The calving interval in this trial (416 d) was less than in Phase I (474 d). Probably these figures reflect the use of insemination exclusively in Phase I and until 150 d after calving in Phase III. In any event, it seems that milking the cow with its calf at foot and with restricted suckling later, had no negative effect on reproduction in comparison with the system of separating the calf at birth and rearing it artificially; perhaps because of the short time the calf is with the cow, in the restricted suckling system. This conclusion is supported by the reports of Fernandez et al (1977), Ugarte & Preston (1975) and Veitia & Simon (1971).

Performance of the calves: Observations on 191 calves raised by the restricted suckling system are presented in Table 12. The growth rate of the calves on restricted

Table 11 :  
Milk production and length of lactation in crossbred (Zebu/European) cows that were milked once daily and with restricted suckling

Breed	Saleable milk production (litres)	Length of lactation (d)	Country	Authors
Holstein/Zebu	1742	295	Dominican Republic	Fernandez et al 1977
Friesian/Zebu	1124-1282	247-262	Zambia	Cruickshank et al 1972
(Holstein and Swiss) -Zebu	1120	262	Mexico	This work
Swiss-Zebu	954	260	Mexico	Trevino et al 1976
Swiss-Zebu	790	221	Mexico	Alpuche et al 1976
Swiss-Zebu	778	167	Mexico	Ramon 1977

Table 12:  
Performance of calves reared with restricted suckling (1977-79)

No of observations	191
Liveweight at birth, kg (X ± SD)	32 ± 5.2
Liveweight at six months, kg	145.2
Daily gain to 6 months, g/d	464
Mortality, %	
0 - 8 months	6
0 - 24 months	8

suckling (464 g/d) was similar to that reported by Fernandez et al (1977) for calves on the same system (517 g/d) and very much superior in comparison with the artificial rearing used in Phase I (277 g/d). For artificial rearing the feeding system, in addition to cows' milk, was principally based on grazing and balanced concentrates; while on restricted suckling the system was grazing, supplemented with byproducts such as molasses/urea, protein cakes and *Leucaena* forage. Mortality was only 6% with restricted suckling in Phase III compared with 46% for artificial rearing in Phase I.

### Conclusions

The system of milking crossbred European/Zebu cows without the calf being present at milking led to 40% of the cows producing short lactations (approximately 34 d) which reduced significantly the saleable milk production.

The cows which did give reasonable milk production without the stimulus of the calf at milking, gave reduced quantities of milk in shorter lactations under the same management system in subsequent lactations.

The criterion of eliminating crossbred European/Zebu cows that did not let-down the milk without the calf stimulus did not appear to be a reasonable one, since these cows gave acceptable lactation yields when they were milked with their calves.

The system of calf stimulus and restricted suckling was the most efficient since this avoided the cow becoming dry prematurely, permitted a significant reduction in calf mortality and was associated with a reduced incidence of subclinical mastitis,

### References

- Alpuche O, Alvarez F J & Wilson A 1976 Observations on milk production and calf Growth rate in Holstein compared with dual purpose Swiss/Zebu cows fed on sugar cane Tropical Animal Production 1: 238
- Alvarez F J & Preston T R 1976 Leucaena leucocephala as protein supplement for dual purpose milk and weaned calf production on sugar cane based rations Tropical Animal Production 1:112
- Alvarez F J , Wilson A & Preston T R 1977 Sugar cane and molasses/urea with restricted grazing of Leucaena leucocephala or supplementation with rice polishings compared with continuous grazing for dual purpose milk and weaned calf production in the wet season Tropical Animal Production 1:119
- Cruikshank D K R, Hatakwti P J 6 Nyobvu A C 1972 Research to produce more meat and milk in Zambia. Increasing milk and beef production with Friesian-Cross-Indigenous cows Research Branch Department of Agriculture Central Research Station PO Box 50 Mazabuka Zambia
- Charlotte R, Ugarte J & Boucourt R 1976 Rearing dairy calves by restricted suckling VII Effect on mastitis development caused by Staphylococcus aureus Cuban Journal of Agricultural Science 10:37
- Fernandez A, Macleod N A & Preston T R 1977 Production coefficients in a dual purpose herd managed for milk and weaned calf production Tropical Animal Production 2:44
- Hayman R H 1974 Development of the Australian milking Zebu World Animal Review 11:31-35
- Mahadevan P, Balukande e B & Black J G 1962 A genetic study of the Sahiwal grading-up scheme in Kenya Animal Production 4:337
- Pearson de V L 1974 Dairy cattle breeding in South America World Animal Review 12:8
- Preston T R 1977 A strategy for cattle production in the tropics World Animal Review 21:11
- Ramon P H 1977 Efecto de diferentes factores en la produccion de leche en clime tropical Segundo die del ganadero en el Centro Experimental Pecuario Tizimin Yucatan INIP
- Seifert G W 1971 Ecto and endoparasitic effects on the growth rates of Zebu cross breed and British cattle in the field Australian Journal of Agricultural Research 22:839
- Smith V R 1962 Fisiologia de la lactancia IICA Costa Rica
- Trevino S, Ramirez A & Preston T R 1976 Observations on the production of milk and growth rate of calves in dual purpose production systems Tropical Animal Production 1:52
- Ugarte J & Preston T R 1972 Rearing dairy calves by restricted suckling 1. Effect of suckling once or twice tally on milk production and calf growth Revista cubana Ciencia Agricola (English edition) 6:173-182
- Ugarte J & Preston T R 1975 Restricted suckling VI. Effect on milk production reproductive performance and incidence of clinical mastitis throughout the lactation Cuban Journal of Agricultural Science 9:15-26
- Ugarte J 1976 Rearing dairy calves by restricted suckling 8 effect of weaning age on milk production and calf performance Cuban Journal of Agricultural Science 10:137
- Veitia J L & Simon L 1971 Efecto de dos sistemas de amamantamiento restringido sobre la produccion de leche y el crecimiento de los terneros III Seminario Cientifico CNIC Habana Cuba
- Weiser R S, Queen M & Pearsall N N 1969 In Fundamentals of immunology Lea and Febiger Philadelphia

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