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Milk secretion rate in tropical dual purpose cows (*B. taurus* × *B. indicus*)

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ABSTRACT

Cumulative milk volume (CMV) and milk secretion rate were estimated in eight *B. taurus* x *B. indicus* cows. Cows were in peak lactation (~45 days), routinely milked twice a day, supplemented at each milking with about 3 kg DM in concentrate and grazing star grass (*Cynodon nlemfluensis*) with the main herd as to cover the AFRC (1993) energy and protein requirements. CMV and secretion rate were estimated by milking each cow at 3, 6, 9, 15 and 24 h intervals. Each milking interval measurement was on different days within the same week. Measurements were performed four times for each time interval in four weeks. Empty udder volume (EUV) was measured during the 2nd week of the experiment. Five IU i.m. oxytocin was used both at previous and scheduled milking interval as well as for the EUV measurement to ensure complete udder emptiness. For 3, 6, 9, 15 and 24 h milking intervals, CMV (L) were 0.38, 0.74, 1.237, 1.69 and 2.40±0.041 per L EUV, while, milk secretion rate ($L \cdot h^{-1}$) were 0.125, 0.123, 0.137, 0.113 and 0.100±0.004 per L EUV, respectively. A significant relationship was found between milk yield (MY) and EUV (MY=4.136 (±2.259) + 2.129 EUV (±0.396); R^2=0.491). The MY loss as result of having a 24 h milking interval in comparison with having 15+9 h intervals was on average 17±1.9% (MY=2.69 (± 1.16) – 0.349 MY (±0.071); R^2=0.449). Udder productivity of *B. taurus* × *B. indicus* cows is similar to dairy cattle. CMV and milk secretion rate must be taken in consideration when designing milking and restricted suckling regimes for this type of cattle.

KEY WORDS: milk yield, secretion rate, dual purpose cow

INTRODUCTION

Milking management routines should be designed to minimize milk production losses. It is known that in dairy cattle milk secretion will stop after about 35 h without

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milking (Ávila, 1986) and that 18 to 20 h is the maximum period tolerated without milk production losses (Elliot, 1959; Tucker et al., 1961; Wheelock et al., 1966).

Milk yield (MY) is partially a function of both intrinsecal and extrinsecal factors affecting secretory cell number and differentiation, and the local regulation of secretion activity. Different alveolar size and cell numbers at onset of lactation were found in beef cows as compared to dairy cows. These observations can be ascribed to differences in cell mass and udder parenchyma (Akers, 2000). However, little is known about the characteristics resulting from crossing tropical beef breeds like Zebu (*Bos indicus*) with dairy breeds (*B. taurus*) like Holstein-Friesian or Brown Swiss. These crosses are commonly used in tropical dual purpose system for milk production where cows are usually managed as dairy breeds with contrasting results. Adaptation and design of management routines for this type of systems should rely on the understanding of the biological mechanisms controlling milk production.

Tropical cross breed cattle (*B. indicus* × *B. taurus*) has variable milking and suckling regimes which influence milk production by means of more efficient removal of the residual milk (Sandoval-Castro et al., 1999). It is now known that the removal of residual milk by the calf resembles a milking of high efficiency, meaning that the feedback inhibitor of lactation (FIL) is also greatly removed (Wilde and Peaker, 1990), thus milk production takes longer to decay as the FIL no longer remains at alveolar level. However, milking and suckling regimes were initially designed with the farmer's experiences or needs and without taking into account knowledge on biology of lactation, mainly due to the scarcity of information for this type of cattle.

It can be considered that empty udder volume (EUV) is an indicator of mammary secretory cell number, while, MY at different milking intervals indicates the udder's secretory rate, both, important factors for the appropriate design of milking practices. Thus, in order to provide knowledge for the future design of management practices in this type of cattle, the objectives of this work were to determine milk secretion rate at peak lactation and to asses the udder secretory capacity of *B. indicus* x *B. taurus* dual purpose cows.

MATERIAL AND METHODS

Secretory rate was estimated using eight dual purpose cows, ~45 days in lactation, calved in the same week. Animals were routinely managed at star grass (*Cynodon nlemfluensis*) as part of the main herd. Cows were under twice a day milking and supplemented at the parlour about 3 kg DM of concentrate feed per milking as to cover the AFRC (1993) energy and protein requirements. Cows were milked at different milking intervals (3, 6, 9, 15 and 24 h) on different day of the same week, during four weeks, thus each cow was milked 4 times at each time interval

(32 observations per time interval). At least one normal milking was performed between each time interval measurement. The standard management of the cows included the suckling for about 30 s to stimulate milk letdown. However, during all milking interval measurements, suckling stimulus from the calf was avoided, and 10 IU i.m. exogenous oxytocin (Hipofisina, Intervet, México) was used to stimulate milk letdown instead of suckling, both at the previous and the scheduled interval measurement to obtain complete udder emptiness in both occasions. This procedure was applied to guarantee an empty udder without residual milk in both milking, hence avoiding secretion rate to be overestimated due to residual MY from a previous milking being measured in a subsequent scheduled milking.

Empty udder volume was measured during the 2nd week (middle of the trial) after milking, also using exogenous oxytocin to ensure udder emptiness. For EUV estimation udder casts were obtained using aluminium foil as molding material (Magaña-Sevilla and Sandoval-Castro, 2003).

Secretory rate ($L \cdot h^{-1}$) was calculated from the amount of milk collected at each milking time interval. Both, cumulative milk volume (CMV) and secretory rate were expressed in absolute values for each cow at each milking time interval and relative to udder volume (L) (MY/EUV) to account for differences in udder size between cows. A potential daily MY was defined as the sum of the MY at 9 and 15 h intervals and compared with the actual MY at 24 h interval (the 9 and 15 h intervals were the normal routine management at the farm and were chosen instead of setting a 12 h interval). Difference between potential MY (9+15 h) and actual 24 h MY, and the relationships between EUV and MY were assessed with linear regression analysis. Secretory rates per time interval were analysed, using the GLM procedure, accounting for the effects of cow and milking time interval. All analyses were done with Minitab 12 (1997).

RESULTS AND DISCUSSION

A linear accumulation was observed for CMV (Table 1) similar to the pattern observed with dairy cattle by Davis and Hughson (1988) and Knight et al. (1994) but different to the observations by Carruthers et al. (1993) where there seems to be a nonlinear accumulation up to 24 h. Plotting the CMV seems to show a trend for two different slopes, however, probably due to the number of "*x*" data point (5 time measurement), an the variation among the cows in their udder size, a nonlinear CMV pattern was not significant ($P>0.05$). The differences observed between the different hours ($P<0.001$) only shows that MY was progressively accumulated as the milking time interval increased from 3 to 24 h, thus it was the expected result.

Table 1. Cumulative milk (L) at different milk intervals in dual purpose cows (*B. taurus* × *B. indicus*)

	Cumulative milk per cow, h					Cumulative milk per litre of udder, h				
Cow	3	6	9	15	24	3	6	9	15	24
1	2.39	5.33	8.68	12.00	16.68	0.40	0.89	1.45	2.00	2.78
2	1.65	2.50	4.00	6.38	8.08	0.55	0.83	1.33	2.13	2.69
3	2.06	3.25	6.15	7.30	11.35	0.51	0.81	1.54	1.83	2.84
4	2.79	3.90	5.78	7.55	11.75	0.48	0.67	1.00	1.30	2.03
5	1.82	5.51	8.10	12.75	16.00	0.28	0.84	1.23	1.93	2.42
6	1.72	3.53	6.73	7.75	13.03	0.30	0.62	1.18	1.36	2.29
7	1.74	4.73	7.50	10.78	14.53	0.24	0.66	1.04	1.50	2.02
8	1.90	3.65	7.03	9.38	13.30	0.31	0.59	1.13	1.51	2.15
SEM[1]	0.101	0.218	0.333	0.445	0.535	0.024	0.031	0.050	0.066	0.073
P[1] =	0.080	0.001	0.018	0.0001	0.0001	0.240	0.222	0.164	0.005	0.006
Mean[2]	2.01^a	4.05^b	6.74^c	9.23^d	13.09^e	0.38^a	0.74^b	1.237^c	1.69^d	2.40^e
SEM[3]	0.261 (P<0.001)					0.041 (P<0.001)				

[1] between cows; [2] different letters between hours differ at P<0.001; [3] between hours

Milk secretion rate ($L \cdot h^{-1}$) when expressed by cow or udder size (Table 2) was similar at the 3, 6 and 9 h intervals, significantly decreasing after longer intervals (P<0.05), suggesting that at some point about 15 h milk secretion rate

Table 2. Milk secretion rate ($L \cdot h^{-1}$) in dual purpose cows (*B. taurus* × *B. indicus*)

	Milk secretion rate per cow, h					Milk secretion rate per litre of udder, h				
Cow	3	6	9	15	24	3	6	9	15	24
1	0.788	0.888	0.965	0.800	0.698	0.131	0.148	0.161	0.133	0.116
2	0.550	0.415	0.443	0.425	0.338	0.183	0.139	0.148	0.142	0.113
3	0.685	0.543	0.685	0.488	0.473	0.171	0.136	0.171	0.122	0.118
4	0.813	0.653	0.643	0.503	0.490	0.140	0.113	0.111	0.087	0.085
5	0.603	0.918	0.898	0.848	0.668	0.091	0.139	0.136	0.128	0.101
6	0.573	0.590	0.748	0.518	0.545	0.100	0.104	0.131	0.098	0.096
7	0.580	0.788	0.833	0.720	0.608	0.081	0.109	0.116	0.100	0.084
8	0.635	0.610	0.780	0.625	0.553	0.102	0.098	0.126	0.101	0.089
SEM[1]	0.0277	0.0365	0.0372	0.0296	0.0223	0.0076	0.0053	0.0055	0.0044	0.0030
P[1] =	0.229	0.001	0.019	0.0001	0.0001	0.106	0.245	0.172	0.005	0.006
Mean[2]	0.653^{ab}	0.675^a	0.749^a	0.615^{bc}	0.546^{bc}	0.125^{ab}	0.123^{ab}	0.137^a	0.113^{bc}	0.100^c
SEM[3]	0.029 (P<0.001)					0.004 (P<0.001)				

[1] between cows; [2] different letters between hours differ at P<0.00; [3] between hours

start to slow down. Hence, if more measurements would have been included (i.e. 12, 18, 21 h) probably a nonlinear trend in CMV would have detected as reported by Carruthers et al. (1993), confirming that 18 to 20 h is the maximum period tolerated without MY losses (Elliot, 1959; Tucker et al., 1961; Wheelock et al., 1966).

Milk secretion rate (MY/L EUV) varied from 0.08 to 0.18 L·h^{-1}. Value closely related to those reported for dairy cows of 0.06 to 0.11 L·h^{-1} (estimated from 24 h secretion rate reported by Knight and Dewhurst, 1994). This finding might suggest that either smaller functional udder capacity (elasticity) or reduced storage capacity (likely cisternal udder volume) as compared with dairy breeds as the factors causing a faster cessation of milk secretion, similar results have been found when comparing Jersey and Holstein cows (Carruthers et al., 1993). In previous work (Magaña-Sevilla and Sandoval-Castro, 2003) we have found small udder sizes, and although, the cisternal:alveolar ratios were not measured, seems that that udder size is a limiting factor. This is of particular importance in tropical systems, because once daily milking is a common practice and if a second milking or suckling is not allowed milk losses would be expected (Sandoval-Castro et al., 1999) if cows are not selected for their storage capacity, either selecting larger udders or ideally selecting for larger cisternal volume.

Empty udder volume and total milk production were related (Figure 1), although at lesser extent than previous observations with this type of cattle (Magaña-Sevilla and Sandoval-Castro, 2003). Different rates of cell differentiation (into secretory tissue) or the existence of fat reservoirs and non secretory tissue in the udder could account for the lower correlation found (Knight and Dewhurst, 1994). However, it is clear that those *B. indicus* × *B. taurus* cows with more secretory tissue will have higher MY. Nevertheless, under tropical conditions higher udder volume (as in

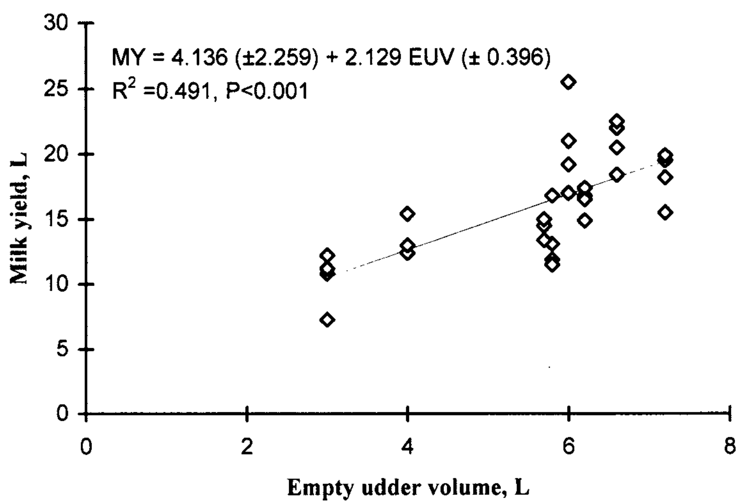

Figure 1. Relation between empty udder volume (EUV) and daily (15 + 9 h milking interval) milk yield (MY) in *B. indicus* × *B. taurus* cows

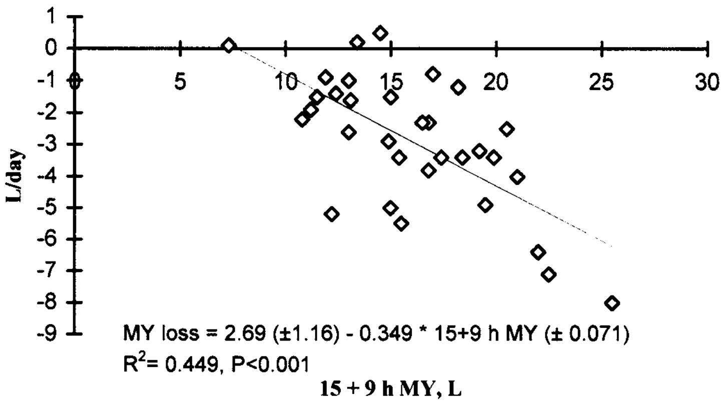

Figure 2. Differences between milk production with 24 h interval and estimated potential milk yield (15 + 9 h MY) in *B. indicus* × *B. taurus* cows. The negative values indicate MY loss due to extended milking interval

high producing cows) may lead to the need for enhanced conditions (nutritional, management skills, facilities, etc.), for the cows as found by Ponpiachan et al. (2000). Thus, before advising the farmers to introduce higher yielding animals, careful assessment has to be done on the farm with respect to economical and technological capacities.

In many tropical production systems, cows are milked once daily and the calf is allowed to stay with the dam to suckle residual milk for a variable amount of time after milking. If the cows do not have a second milking or suckling after at least 12 h, this type of management might likely cause a reduction in MY, which would have more impact in cows with higher MY (Figure 2). Under these circumstances, some anatomical and physiological characteristics which are likely to minimize production losses include: production of concentrated milk, possession of a large cistern (functional udder capacity) (Davis and Hughson, 1988) and good drainage of the alveolar compartment. In this respect, Magaña and Sandoval-Castro (2002) found from lactation curve analysis, in cows milked and suckled twice a day, that the efficiency of milk offtake in tropical dual purpose systems seems to be high, probably due to the inclusion of the suckling stimulus and consumption of residual milk by the calf causing a good drainage of alveolar milk thus limiting its inhibitory effect (Sandoval-Castro et al., 1999) together with a relatively low MY which makes possible to achieve complete milk extraction by milking and suckling. Finally, the milk (in this study) was not more concentrated (fat 32.4±0.82, protein 34.4±1.56 and lactose 48.8±0.56 g/kg^{-1}) than the average milk from dairy breeds cows (Avila Tellez, 1986). Thus, milk distribution in the udder (cisternal and alveolar fractions) is the remaining factor to be explored.

In spite of the relatively small udders (EUV ranged from about 3 to 7 L), the differences between potential MY (9 h +15 h MY) and the MY obtained with 24 h milking interval are negatively correlated (-0.67; $P<0.05$) with daily MY, but not (-0.295; $P>0.05$) with EUV (Figure 2). Thus, it is not the tissue quantity (EUV) which determines milk losses, but it is the quantity of milk produced itself, and likely, affected by capacity of cisternal storage. The observed MY loss in the present study (17.11%±1.93) for extended milking intervals closely resembles the values between 10 and 25% found by Carruthers and Copeman (1990), Carruthers et al. (1993) and Knight and Dewhurst (1994). It is also within the range previously found as a 16% MY loss for this type of cattle (*B. indicus* × *B. taurus*) and 8% MY loss for Holstein-Friesian cows was observed when twice a day milking and suckling was compared with once a day milking and restricted suckling after milking (milking was performed every 24 h, about 20 h after suckling) (Sandoval-Castro et al., 1999). Thus, the results confirm the hypothesis made above about dual purpose milking/suckling management as factors directly involve in potential MY losses. Milk losses due to longer milking intervals was thought to be minimal in low yielding cows as those frequently found in tropical systems (*B. indicus* × *B. taurus*), either due to lower udder productivity (low sercretion rate) or production of a concentrated milk. However, our results showed evidence that in *B. indicus* × *B. taurus* cows udder productivity is similar to dairy breed cows and their milk is not more concentrated. Hence, differences in cisternal volume might be the factor regulating MY. The MY loss resulting from extended milking intervals are of similar proportion as in high yielding dairy breeds, an effect likely mediated by the FIL (Wilde and Peaker, 1990).

CONCLUSIONS

In *B. indicus* × *B. taurus*, dual purpose cows, EUV was related with MY. Milk secretion rate ($L \cdot h^{-1}$) per unit of EUV (L) decreased after 15 h milking intervals. During extended milking interval MY loss was higher in those cows which produced more milk. Thus, when using this type of cattle, management should aim to allow milk extraction, either by milking or suckling, at time intervals not longer than 15 h. A variety of milking/suckling regimes can be set according to the objectives of the farm (milk or calf) and labour cost.

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