

# Effects of Urea-Molasses-Multinutrient Block Supplementation on Reproductive and Productive Performance of Dairy Cattle under Smallholder Farms

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## Abstract

The effect of urea-molasses-multinutrient blocks (UMMB) as an energy and protein supplement on reproductive performance and milk yield of dairy cows was investigated in 18 crossbred cows from eight smallholder farms. In treatment 1 nine cows were fed a maximum of 1kg UMMB per cow per day in addition to the routine feeds (forage and maize bran) and in treatment 2 (control), nine cows were fed routine feeds only. The experiment started 4 weeks pre-partum and lasted for 120 days postpartum. Onset of ovarian activity was monitored through progesterone in 612 sequentially collected milk samples, and rectal palpation. In treatment 1, the intervals between calving to completion of uterine involution, first rise of milk progesterone, occurrence of first oestrus and conception were (mean  $\pm$  se) 24 $\pm$ 7, 65.3 $\pm$ 8, 99.7 $\pm$ 12.8 and 120.2 $\pm$ 10 days, respectively. In treatment 2, the intervals were 29.6 $\pm$ 5, 77.6 $\pm$ 9, 115.9 $\pm$ 15 and 133.7 $\pm$ 14 days, respectively. The treatment differences were not significant ( $P > 0.05$ ). Milk production in treatment 1 increased significantly by 1.21 ( $P < 0.001$ ), while in treatment 2 it decreased by 0.21. Body condition score (BCS) improved significantly by 0.15 ( $P < 0.05$ ) in treatment 1 compared to treatment 2 cows. Use of UMMB gave an overall profit of US\$ 0.34 per day of lactation from sale of milk that resulted from increased yield and milk due to shortened days open. It was concluded that dry season improvement of reproductive and productive performance of dairy cows under smallholder farms could be cost effectively achieved through supplementation with urea-molasses-multinutrient blocks.

**Keywords:** Dairy cows; milk yield, reproductive performance, urea-molasses-multinutrient blocks

## Introduction

Infertility of dairy cows is a serious problem in smallholder dairy sector in Tanzania. This is associated with the fact that cows are generally poorly fed, especially during the dry season. Affected cows fail to respond to therapeutic interventions possibly due to the nutritional inadequacy as the underlying cause of the problem

(Kanuya, 1992; Mujuni *et al.*, 1996; Nkya and Swai, 1999).

The roughage feeds provided are poor, lignified, and their digestibility values are low (Preston and Leng, 1987). Poor roughage consequently limits intake, rumen fermentation, and productivity. To improve on the utilisation of poor forages fermentation by rumen mi-

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cro-organisms can be achieved by providing fermentable carbohydrate, nitrogen and minerals combined with a small amount of nutrients that bypass the rumen. Molasses urea blocks or licks are examples of a useful supplement for dairy cows sustained on low quality forages in the tropics (Sansoucy *et al.*, 1992; van Houtert and Sykes, 1999).

Since dry season supplementation of dairy cows with urea molasses blocks has shown improvement in milk yield, reduction in feed costs (Msangi, 1995; Srinivas and Gupta, 1997; Plaizier *et al.*, 1999; Vu *et al.*, 1999) and increase in body weight in heifers (Aboud *et al.*, 1996), implicitly it may also improve reproductive performance.

In normal dairy herd situations, direct assessment of energy balance in individual cow is cumbersome, but changes in BCS provide an indirect measure. The severity and duration of undernutrition is primarily related to dry matter intake, which in turn, determines the body condition at calving. There is a direct correlation between fertility and BCS (Butler, 2000). Animals that have body condition and body weight increasing normally improve oestrus cyclicity. Changes in BCS and body weight of cows has been used as a practical indicator of nutritional status, while progesterone radioimmunoassay (RIA) and rectal palpation have also been used for evaluating reproductive status and identifying breeding management problems (Garcia, 1999).

This study was carried out with the objective of examining the effect of urea-molasses-multinutrient blocks (UMMB) on reproductive performance and milk production in the smallholder dairy cattle in peri-urban areas of Dar es Salaam during the dry season.

## Materials and methods

### Study area

Field study was carried out in Dar es Salaam, which is situated at latitude 6° 67' S, longitude 38° 84' E and an altitude of 14.3 metres above mean sea level. The annual rainfall and air temperature range from 1000-1400mm and 23.5-33.5°C, respectively. Mean relative humidity is 65% (range 55-85%). There are two rainy seasons: short rains, which start in mid October to end of December and long rains, which start in mid March to May.

### Animals

Eighteen crossbred cows were used in this experiment. The experimental cows were in their third parity and were selected from eight smallholder farms. The 18 cows under study were in their last month of gestation, and were from farms with more or less similar cow management systems. The cows were normally fed cut forage of common grass species available in the study area, which include *Panicum*, *Hyperthemia*, *Neonotonia*, *Peunisetum* and *Cynodon* (Sarwati and Mtengeti, 1990). In addition to forages, maize/wheat bran was offered as a supplement at milking times. Mineral lick or mix was also offered. During the dry season all farmers rely on dry grasses, maize stovers and/or rice straws.

### Preparation of UMMB

UMMB were prepared as described by Plaizier *et al.* (1999). The ingredients used included molasses (28%), urea (9.3%), limestone (4.6%), cement (13%), salt (2.3%), bone meal (2.3%), wheat bran (33.5%) and water (7%).

### On-farm feeding trial

Farms were assigned to experimental groups randomly such that cows for treatments 1 or 2, came from the same farm for easy implementation. Treatment 1 cows were offered 1kg UMMB per cow per day on top of routine feeds that included forages throughout and maize bran supplement at milking times. Treatment 2 cows (Control) never got UMMB but continued with the routine feeds only. Feeding of cows with the blocks started 30 days before calving and continued for 120 days after calving.

### Measurements

Dry matter intake by each cow was estimated daily by weighing the offered feed and mean calculated. Service and calving dates and nature of calving were recorded. Weekly rectal palpation was conducted starting 14 days postpartum to assess the size, position, contents and tone of the involuting uterus, and presence and number of ovarian structures (corpus luteum (CL) and/or follicles).

Milk progesterone concentration determined by RIA was used to estimate optimal insemination day (day 0), non-pregnancy and early em-

bryonic death. A cow was considered to be non-pregnant when progesterone concentration was low at 21 days after service on day 0 (oestrus day). Embryonic death or abnormal CL function was assumed when drop of elevated progesterone was confirmed >24 days post service. Other parameters determined were the interval between calving to first rise in progesterone concentration and calving to conception interval.

To monitor production response, daily morning and evening milk yields were measured in measuring cylinders, recorded and the two added to obtain daily yield. Also retrospective data for milk yields were obtained from the available farm records as category 1 for experimental cows before the study and as category 2 for control cows before the study for comparison of production trends. Body condition score of the experimental animals was determined biweekly on the 1-9 scale with palpation of the lumbar spines (Nicholson and Butterworth, 1986).

Oestrus detection was done through adequate (10-15 min) careful observation of individual cows at 8.00h, 14.00h and 18.00h for a standing to be mounted reflex, bellowing behaviour, and mucus discharge. Confined tethered animals were allowed to interact with each other and those lying down were made to rise for possible expression of homosexual behaviours. Rectal palpation and low progesterone concentrations in milk confirmed oestrus. Cows were bred through artificial insemination (AI) or natural service.

### Sample collection and analysis

Samples of forages and supplement for chemical analysis were collected biweekly by taking representative small amount of each feed from the feeding trough. These were then put into labelled paper bags and transported to the laboratory. Feed samples from each farm were dried to constant weight in an oven at 60°C and ground separately for proximate analysis. Finally the results obtained in the individual farms were used to calculate general mean of every ingredient under consideration. Feed samples were analysed for dry matter (DM), acid detergent fibre (ADF), neutral detergent fibre (NDF), crude protein (CP), calcium (Ca), phosphorus (P) and ash using standard procedures according to Association of Official Analysis Chemists (AOAC, 1990).

The amount of forage offered as a basal diet during the study was based on the cow's body weight at calving and energy balance from this diet was computed using the expression

$$\text{Total ME}_{\text{intake}} = \text{ME}_{\text{maintenance}} + \text{ME}_{\text{milk Synthesis}} \pm \text{ME}_{\text{liveweight change}}$$

and the equations and efficiency factors presented in McDonald *et al.* (1995), where ME is metabolisable energy.

### Sampling milk for RIA

Milk samples for progesterone RIA were collected twice a week, that is, Mondays and Fridays, starting 14 days postpartum. Sampling, processing, storage and assay procedures were according to self-coating progesterone RIA protocol (FAO/IAEA, 1999). Sensitivity of the assay was 0.2 nmol/L, while the specificity was 100% as validated using 6H11/14-mouse monoclonal antibody and <sup>125</sup>I progesterone as tracer.

### Cost benefit analysis

Cost benefit analysis was done on the financial gain from sale of milk resulting from UMMB supplementation and shortened days open. Taking into account the cost of feeding 1kg UMMB of Tanzania shillings (TAS) 180.7, milk price per litre of TAS 300, increased milk yield per day, the break even milk production was calculated. Annual economic loss (E) per cow due to increased days open is given by the formula:  $E = X \cdot Y \cdot P$ , whereby X stands for the increased days open from herd mean, Y stands for mean milk yield per cow per day, and P for price of milk per litre (Mdoe *et al.*, 1991).

Assuming the productive life of a reproductively sound cow (that calves annually) is 10 years and that it calves for the first time at 3-4 years old the number of calves produced can be calculated to be 7. Any observed increase in days open would reduce the number of calves born.

### Statistical analysis

Production data were averaged for each cow before, during and after the introduction of the blocks. Statistical analysis was conducted with these averages using SAS General Linear Model (GLM) procedure (SAS, 1990) using the average milk yield before the introduction of the blocks

as a covariate. Student's t-test was used to test differences of reproduction and productivity between the experimental and control groups. For the BCS, differences were obtained by deducting mean base score from biweekly mean score during the study. All data are expressed as mean  $\pm$  standard error of the mean (SEM).

## Results

### Field study

Two cows were transferred to a different farm during the study, remaining with only 16 cows under observation. The average amount of feeds offered to cows was  $6 \pm 2.7$  kg DM of forages and  $4 \pm 1.3$  kg DM of supplements per cow per day.

### Chemical composition of feeds

Urea-molasses-multinutrient blocks had increased level of CP, Ca and P compared with grasses and routine maize bran supplement used in the dry season (Table 1). From the table it is evident that the forages available for dairy cows during the dry season had low values of crude protein and minerals. However, the CP value in the cereal bran is higher than in maize bran alone, while the P value is lower than expected of cereal bran.

**Table 1: Chemical composition, on per cent dry matter (DM) basis, of feeds used in on farm study**

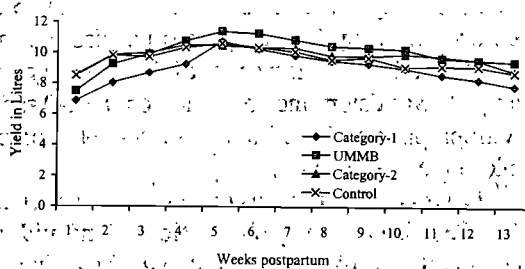
Feed	DM%	CP	ADF	NDF	Ash	Ca	P
Grass	92.8	5.4	38.9	74.9	12.0	0.40	0.33
Cereal bran	91.8	16.3	7.7	58.0	9.3	0.42	0.20
UMMB	85.5	35.3	3.6	29.5	31.0	2.01	0.75

UMMB= urea-molasses-multinutrient blocks; CP= crude protein; ADF= acid detergent fibre; NDF= neutral detergent fibre; Ca = calcium; P= phosphorus

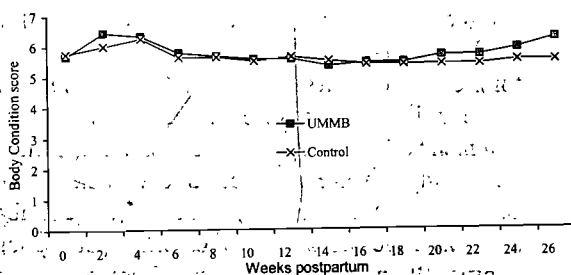
### Milk yield and BCS

Average milk yield before the study in treatment 1 cows was  $8.9 \pm 0.11$  while yield during the study rose to an average of  $10.1 \pm 0.11$  (Table 2). The corresponding mean values in treatment 2 were  $9.8 \pm 0.1$  and  $9.6 \pm 0.11$ , respectively. This shows an increased yield of 1.2l in treatment 1 and a drop of 0.2l in treatment 2 during the study. The

change in milk yield between the two groups was highly significant ( $p < 0.001$ ). The differences in BCS change for treatment 1 and treatment 2 cows were also statistically significant ( $P < 0.05$ ). Figures 1 and 2 respectively show milk yield and BCS patterns/trends during the study.



**Figure 1: Change in daily milk yield in dairy cows supplemented with UMMB. Category -1=experimental group before the study; category -2=control group before the study**



**Figure 2: Changes in body condition score in dairy cows supplemented with UMMB**

**Table 2: Changes in milk production and body condition scores (BCS) of dairy cows supplemented with urea-molasses-multinutrient blocks (UMMB)**

Parameter	Treatment (Mean±SEM)		Effect	P Value
	UMMB	Control		
Number of cows	9	8		
Milk yield before study (l)	8.9±0.1	9.8±0.1		
Milk yield during study (l)	10.1±0.1	9.6±0.1		
Change of milk yield (l)	1.21	-0.21	+1.4	***
BCS before study (1-9 scale)	5.67±0.25	5.75±0.27		
BCS during study	5.66±0.07	5.59±0.08		
Change of BCS	-0.01	-0.16	+0.15	*

\*\*\*=P<0.001; \*=P<0.05. Effect= change of parameter in the UMMB supplemented cows in relation to the control.

### Uterine involution

All the remaining 16 cows in this study calved without clinically observed complications. The interval between calving and completion of uterine involution in treatment 1 cows averaged 24±7 days, while in treatment 2 cows it averaged 29±5 days (Table 3). The difference between groups was not statistically significant (p>0.05).

### Resumption of oestrous cyclicity

First rise in milk progesterone concentration above 1 nmol/L in two consecutive samples collected within one week occurred 65±8 days after calving in treatment 1 cows, while in treatment 2 cows it occurred after 78±9 days. The difference in days between the two groups was not significant (p>0.05). Furthermore, 63% of all cows showed short cycles before establishment of cycles of normal length. These cycles averaged 13±0.5 days.

**Table 3: Effect of urea-molasses-multinutrient blocks (UMMB) supplementation on reproductive performance in dairy cows (P>0.05)**

Parameter	UMMB	Control	Effect
Calving to onset of Ovarian activity (days)	65.3±8	77.6±9	-12.3
Calving to first oestrus (days)	99.7±12.8	115.9±15	-16.2
Calving to conception (days)	120.2±10	133.7±14	+13.5
Calving to uterine Involution (days)	24±7	29±5	-5
Conception rate (%)	66.7	42.9	+23.8

When data on the remaining 16 cows in the study were pooled together, three cows (18.8%) resumed ovarian activity before 60 days, while 13 (81.2%) after 60 days. Interval from calving to visible signs of first postpartum oestrus in treatment 1 cows was 99.7±12.8 days, while in treatment 2 cows it averaged 115.9±15 days (Table 3).

### Financial consideration

Break-even milk production (production beyond which profit is observed) was calculated to be 0.6 L/d, while a profit of Tanzanian shillings (TAS) 179.30 (US\$ 0.22) was obtained from sale of increased milk per cow (US\$1=TAS800). A litre of milk sold at TAS 300 (US\$0.38).

A lactation loss of TAS 106,050 and 138,240 was observed respectively in treatment 1 and control groups. The difference between the two makes the value of shortened calving to conception interval, which is TAS 32,190, equivalent to TAS 94.70 (US\$ 0.12) per cow (lactation length for the treatment groups was 340 days).

The number of calves per productive life of a cow in each group was calculated to be six, indicating a loss of one calf per cow per productive life in each group. The value of milk per productive life of a cow was not calculated due to short duration of the study. The overall gain from milk increase and milk due to shortened days open in treatment 1 group total was TAS 274 (US\$ 0.34) per cow.

## Discussion

In this study, the average 6kg DM of forage fed to a cow per day was not adequate to meet maintenance and lactation needs, indicating underfeeding for most of the time. Depending on the weight of the cow, adequate values should be 10-13 kg DM for such roughage (NRC, 1988). Chemical analysis of the feeds showed low quality of the roughage with respect to crude protein and minerals content. The findings concur with those of Plaizier *et al.* (1999), who reported that most roughages used on smallholder farms during the dry season in Tanzania are low in crude protein and minerals content. Moreover rumen degradability characteristics obtained by Plaizier *et al.* (1999) are very low for the grass hay but high for maize bran. Feed evaluation results suggest the need to improve the digestibility of the dry grass and crop residues (maize stovers and rice straw) to improve feed intake. However, the CP value for the cereal bran in the study was much higher than in conventional (maize) bran alone hence what farmers consider as cereal bran is probably a locally compounded concentrate.

The findings on milk yield increase concur with those of other researchers elsewhere who observed a similar milk increase following molasses-urea block supplementation of dairy cows in the dry season (Msangi, 1995; Srinivas and Gupta, 1997; Plaizier *et al.*, 1999; Vu *et al.*, 1999). Reduced lactation yield of control cows was most likely indicative of energy deficiency in these cows. An improvement in BCS in UMMB fed cows is in agreement with findings reported by Long *et al.* (1999), who observed similar improvement in body condition following UMMB feeding. The general decline and slow recovery in body condition of lactating cows reflected the lack of stored energy to be mobilised at this critical period of their reproductive life, suggesting under nutrition.

The interval between calving and uterine involution in cows in this study concurs with that reported by Kanuya (1992) and Garcia *et al.* (1990). Various other studies have reported intervals between calving and resumption of ovarian cyclicity ranging from 18 to 36 days (Kessy *et al.*, 1985; Morrow, 1986). In the present study that interval was much longer (65.3±8 days). The late resumption of ovarian cyclicity can be associated with

underfeeding. Apart from underfeeding, other stresses acting on the cows in the present study include managemental and environmental, involving high ambient temperature and humidity that cause anoestrus and cessation of the oestrous cycle (Roberts, 1986).

Occurrence of first postpartum oestrous cycles of short duration prior to cycles of normal duration is in agreement with the findings by other researchers (Keeling *et al.*, 1992; Tegegne *et al.*, 1993). These cycles, considered to be due to intrauterine infections, are characterised by premature demise of the first CL as a result of premature release of prostaglandin F<sub>20C</sub> (PGF<sub>20C</sub>) by the uterus. Short cycles associated with low level of progesterone concentration are considered to be the necessary primer for subsequent cycles of normal length (Ramirez-Godinez *et al.*, 1982).

The interval between calving and first observed oestrus is longer than that reported from other areas by Garcia *et al.* (1990). This shows that either first ovulations after calving were not accompanied by overt oestrus, or that farmers failed to detect oestrus since cows were tethered indoors. Oestrus detection is also hindered by the fact that the farmers are either employed workers or part time crop farmers and therefore little time is allocated for oestrus detection. Oestrus detection rate (55%) was lower than 71% reported by Kanuya (1992) for other parts of Tanzania. Lower oestrus detection rate is associated with problems, such as missed oestrus, failure to exhibit overt oestrus, farmer's ignorance and delayed detection. Anoestrus was observed at a rate of 81.25%. Association between anoestrus with inadequate feeding has been reported in a number of studies (Alejandrino *et al.*, 1999; Butler, 2000). The interval from calving to conception (115.9 to 133.7 days) is within 74 to 134 days reported by Miettinen (1990). Supplementation with UMMB reduced the interval to within 120 days postpartum.

Improvement in reproductive performance and milk production when the ration was supplemented with UMMB may be explained by the fact that the ME: CP ratio was most likely balanced in the rations and the subsequent maintenance of ammonia (NH<sub>3</sub>) content in the rumen. This leads to an improved rumen environment for microorganisms. Ensuring optimal efficiency

of rumen fermentation in animals given low-quality tropical forages requires an adequate supply of fermentable ME, rumen degradable protein (RDP) and minerals (particularly P and S). Molasses is a good source of minerals and fermentable ME, while urea is one of the cheapest sources of RDP. Urea-molasses blocks or licks, therefore, are a useful supplement (van Houtert and Sykes, 1999). Therefore digestibility and dry matter intake of forages and other foodstuffs are increased (Ørskov, 1999; Preston and Leng, 1987). Energy is an important nutrient for dairy cattle and its provision both before and after parturition is essential for improved reproductive performance. Low plane of nutrition is a common problem during the dry season in the study area. When coupled with milk production, it can result into delayed resumption of ovarian cyclicity (Alejandrino *et al.*, 1999).

Supplementation with UMMB is cost-effective if the increase in milk production is higher than 0.6L/d. Providing the blocks to cows during the dry season on cost recovery basis gave overall gain of US \$ 0.34. Similar results were obtained by Plaizier *et al.* (1999) and Vu *et al.* (1999).

## Conclusion

Dry season improvement of reproductive performance and milk yield of crossbred dairy cows on smallholder farms could be cost effectively achieved through supplementation with urea-molasses-multinutrient blocks.

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## References

- Aboud, A.A.O., Kimambo, A.E., Moshy, D.P.K. and Laswai, G.H. (1996). Effect of Molasses urea block (MUB) supplementation on utilisation of poor quality roughages by yearling heifers. In: Proc. Fac. Agric. Annual Research Confer. Sokoine University of Agriculture, Morogoro, Tanzania, 2: 77-87.
- Alejandrino, A.L., Asaad, C.O., Malabayabas, B., De Vera, A.C., Herrera, M.S., Deocaris, C.C., Ignacio, L.M. and Palo, L.P. (1999). Constraint on dairy cattle productivity at the smallholder level in the Philippines. *Prev. Vet. Med.*, 38: 167-178.
- AOAC. (1990). Association of Official Analytical Chemists. Official Methods of Analysis. 15th edn. Washington, USA.
- Butler, W.R. (2000). Nutritional interactions with reproductive performance in dairy cattle. *Anim. Reprod. Sci.*, 60-61: 449-457.
- Food and Agricultural Organization/International Atomic Energy Agency. FAO/IAEA. (1999). Self-coating Milk Progesterone RIA Kit. Bench Protocol, version-ScRIA 3.1. FAO/IAEA Agriculture and Biotechnology Laboratory, Seibersdorf, Austria.
- Garcia, M.P. (1999). Development of supplementation strategies for milk-producing animal in tropical and sub-tropical environments. Preface. *Prev. Vet. Med.*, 38: 81.
- Garcia, M., Echevarria, L. and Huanca, W. (1990). Postpartum reproductive efficiency of pure- and cross-bred Zebu cattle under different management and nutritional conditions in the Amazon Basin of Peru. *Livestock Reproduction in Latin America*. IAEA, Vienna, p.181-198.
- Kanuya, N.L. (1992). Reproductive function and performance of postpartum dairy cows in Morogoro District. MVM Thesis. Sokoine University of Agriculture, Morogoro, Tanzania.
- Keeling, B., Rajaamahendran, R. and Ravindran, V. (1992). Detection of postpartum ovarian activity in cows using on-farm progesterone ELISA. *Vet. Rec.*, 131: 291.
- Kessy, B.M., Maurya, S.N. and Elsayed, M.J. (1985). Monitoring reproductive function and disorders in cattle by plasma and milk progesterone assay. In: Proc. Tanz. Vet. Assn. Scient. Conf. 3: 327-365.
- Long, R.J., Zhang, D.G., Wang, X., Hu, Z.Z. and Dong, S.K. (1999). Effect of strategic feed supplementation on productive and reproductive performance in Yak cows. *Prev. Vet. Med.* 38: 195-206.
- McDonald, P., Edwards, R.A., Greenhalgh, J.F.D. and Morgan, C.A. (1995). *Animal Nutrition*. 5th edition. Longman Scientific and Technical.
- Mdoo, N.Y.S., Mlay, G. and Msolla, P. (1991). Economics of infertility in smallholder dairy herds of highlands of Hai district, Kilimanjaro. In: Proc. Tanz. Vet. Assn. Scient. Conf., 9: 264-269.

- Miettinen, P.V.A. (1990). Effect of feeding on reproductive performance in dairy cows. *Acta Vet. Scand.*, 31: 453-458.
- Morrow, D.A. (1986). *Current Therapy in Theriogenology*. 2nd edn. W.B. Saunders Company, Philadelphia, USA.
- Msangi, B.S.J. (1995). The impact of multi-nutritional blocks on milk production in smallholdings along the coast of Tanzania. MSc. Thesis. Swedish University of Agricultural Sciences, Uppsala.
- Mujuni, P.F., Kanuya, N.L. and Mgongo, F.O.K. (1996). The incidence rates and relationships between ovarian cysts and ovarian activity of postpartum dairy cows in a tropical area. *Tanz. Vet. J.* 16, 23-35.
- National Research Council, NRC (1988). *Nutrient Requirements of Dairy Cattle*. 6th ed update 1989. 139-146.
- Nicholson, M.J. and Butterwoth, M.H. (1986). *A Guide to Condition Scoring in Cattle*. ILCA, Addis Ababa, Ethiopia.
- Nkya, R. and Swai, E.M. (1999). Some factors associated with reduced dairy cattle reproductive performance in small-scale farms in peri-urban areas in Tanzania. In: *Proc. Tanzania Vet. Assn. Sci. Conf.* Vol. 19:113-122.
- Ørskov, E.R. (1999). Supplement strategies for ruminants and management of feeding to maximise utilisation of roughages. *Prev. Vet. Med.* 38: 179-185.
- Plaizier, J.C.B., Nkya, R., Shem, M.N., Urio, N.A. and Micbride, B.W. (1999). Dry season supplementation of dairy cows with nitrogen molasses mineral blocks and molasses urea mix in the Morogoro Region. *Asian-Aus. J. Anim. Sci.* 12: 1-10.
- Preston, T.R. and Leng, R.A. (1987). Matching ruminant production systems with available resources in the Tropics and Sub tropics. Penambur Books, Armidale, Australia.
- Ramirez-Godinez, J.A., Kiracofe, G.H., Shales, R.R. and Niswender, G.D. (1982). Endocrine patterns in the postpartum beef cow associated with weaning. A comparison of the short and subsequent normal cycles. *J. Anim. Sci.* 55: 153-158.
- Roberts, S.J. (1986). *Veterinary Obstetrics and Genital Diseases*. 3rd edn. Woodstock, Vermont.
- Sansoucy, R., Aarts, G. and Leng, R.A. (1992). Molasses urea block. *Tropical feeds*. FAO, Rome.
- Sarwatt, S.V. and Mtengeti, E.J. (1990). The role of forage legumes in smallholder livestock production in Tanzania. In: *Proc. Scient. Conf. Tanz. Soc. Anim. Prod.* 17: 86-97.
- SAS, (1990). *Statistical Analysis Systems. SAS Users guide*, Version. 6 edition. SAS Institute Inc., Cary NC, USA.
- Srinivas, B. and Gupta, B.N. (1997). Urea Molasses Mineral block licks supplementation for milk production in crossbred cows. *Asian-Aus. J. Anim. Sci.* 10: 47-53.
- Tegegne, A., Entwistle, K.W. and Mukasa-Mugerwa, E. (1993). Plasma progesterone and blood metabolite profiles in postpartum Small East African Zebu cows. *Trop. Anim. Hlth and Prod.* 25: 101-110.
- van Houtert, M.F.J. and Sykes, A.R. (1999). Enhancing the profitability of pasture-based dairy production in the humid tropics through improved nutrition. *Prev. Vet. Med.* 38: 147-157.
- Vu, L.X.C., Chung, A.D. and Pham, H.H. (1999). Use of urea-molasses-multinutrient-blocks and urea treated rice straws for improving dairy cattle productivity in Vietnam. *Prev. Vet. Med.* 38:187-193.