IAEA-TECDOC-1102

Development of feed supplementation strategies for improving the productivity of dairy cattle on smallholder farms in Africa

Proceedings of the final Research Co-ordination Meeting of a Co-ordinated Research Project organized by the Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture and held in Vienna, Austria, 7–11 September 1998

INTERNATIONAL ATOMIC ENERGY AGENCY

IAEA

July 1999

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Animal Production and Health Section
International Atomic Energy Agency
Wagramer Strasse 5
P.O. Box 100
A-1400 Vienna, Austria

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DEVELOPMENT OF FEED SUPPLEMENTATION STRATEGIES FOR IMPROVING THE PRODUCTIVITY OF DAIRY CATTLE ON SMALLHOLDER FARMS IN AFRICA
IAEA, VIENNA, 1999
IAEA-TECDOC-1102
ISSN 1011–4289

Printed by the IAEA in Austria
July 1999

FOREWORD

The Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture through co-ordinated research projects (CRP) supports studies aimed at improving livestock productivity in developing countries through the application of nuclear and related techniques. These studies have focused on animal nutrition, animal reproduction and more recently on animal nutrition/reproduction interactions with emphasis on smallholder farming systems.

Livestock are an important and integral part of farming systems in Africa. Apart from being a source of high quality protein (meat, milk and eggs), they contribute to the economic welfare of the people by providing hides, skins, manure, power and traction for agricultural purposes, increasing the productivity of smallholdings. They are also a 'living savings bank' and serve as a financial reserve for periods of economic distress and crop failure. Increasing 'urbanization' and income growth are also changing food consumption patterns of people living in and around major cities, often leading to an increase in the consumption of livestock products. Therefore, there is an urgent need to improve livestock productivity, especially in peri-urban areas, to cater to the increasing demand.

The primary aim of this CRP was to identify approaches for improving the productivity of dairy cattle maintained on smallholder farms in peri-urban areas. Central to the approach was to first obtain baseline information on productivity and reproductive efficiency and thereby identify nutritional and management constraints. Subsequently, corrective measures were developed and tested, keeping in mind the need for maximising the efficiency of current production systems and sustaining the nutrient supply through practical and economically feasible feed supplementation strategies developed using locally available feed resources. In addition the project envisaged contributing to enhancing the level of expertise within the national animal production research institutes in the region, to encourage close contact and interaction between scientists and institutions in Africa and to promote scientific information exchange on a regional basis.

Through the project substantial progress was made in understanding the relationship between nutrient supply and productive and reproductive functions in dairy cattle on smallholder farming systems. Most of the participating countries were able to develop and test cost-effective feed supplementation strategies which improved both milk production and/or reproductive efficiency.

The present publication contains the reports from participants of the project presented at the final Research Co-ordination Meeting held in Vienna from 7 to 11 September 1998.

The IAEA and FAO would like to express their sincere appreciation to all research agreement and research contract holders for their contribution towards the successful completion of the CRP. Special thanks are due to the research agreement holders who contributed enormously through their knowledge, expertise, personal commitment and advice which assisted the counterpart scientists with their research work in developing feed supplementation strategies for improving dairy cattle productivity. M.C.N. Jayasuriya, consultant to the Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture, was responsible for compiling this publication.

EDITORIAL NOTE

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SUMMARY OF THE CO-ORDINATED RESEARCH PROJECT ON DEVELOPMENT OF FEED SUPPLEMENTATION STRATEGIES FOR IMPROVING THE PRODUCTIVITY OF DAIRY CATTLE ON SMALLHOLDER FARMS IN AFRICA

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XA9952120

1. BACKGROUND

Livestock are an important and integral part of most farming systems in Africa. Africa has around 15% of the world's total cattle population, 18% of sheep, 32% of goats and 74% of camels. Directly they provide food such as meat and milk and non-food products such as hide and skin amounting to about 20% of the agricultural domestic product. Indirectly, they contribute over 30% to agricultural production by supplying essential inputs such as manure for replenishing soil fertility and restoring nutrients and animal traction and power for ploughing, hauling, pumping, transport and threshing, increasing the productivity of smallholdings. Livestock are also a 'living bank' for the rural poor as they serve as a financial reserve for periods of economic distress such as crop failure, as well as a primary source of cash income. But most importantly, they are the means of converting poor quality forages from marginal land, surplus crops, crop residues and by-products of agriculture and industry to high value commodities such as meat and milk, which increase income and hence enhance the economic viability of the farming system.

However, the contribution of livestock to the rural economy in Africa has not been commensurate with the number of animals or the extent of land resources available. The overall productivity is generally low mainly because the region is characterised by traditional production systems that rely on indigenous breeds and poor quality feeds.

The inability to feed animals adequately throughout the year is the most widespread constraint to improving animal productivity in Africa. In the drier regions the quantity of forage is insufficient for the number of livestock. In the wetter regions feed supplies are usually ample but the forages are of poor quality, and usually deficient in protein and mineral nutrients. Also, the crop residues and agro-industrial by-products that could be fed to livestock are largely wasted or inefficiently used because of poor infrastructure for transport and processing or lack of appropriate processing technologies.

Low levels of productivity of farm livestock is also associated with poor reproductive management which reduces the reproductive efficiency and the productivity of the animal. Poor nutrition in association with poor reproductive management leads to delayed puberty, inefficient oestrus detection, long post-partum anoestrus, low conception rates, high rates of embryonic mortality, long calving intervals and a general lowering in the fertility of the herd.

The development of the livestock sub-sector has been widely viewed as an instrument for social and economic advancement. Livestock farming should be considered as a means of sustainable income, employment and nutrition. Any development of this industry must not only be viewed as a means of providing food for the increasing human population but also as a livelihood in the existing habitat. The development of the livestock sector will help the African nations to increase the present level of production of food of animal origin. Although there are countries that export livestock and livestock products, many are dependent on imports. It will also reduce the migration of rural poor to urban environments in search of economic and social benefits. Although the potential for increasing production in such systems is considerable, this can only be achieved in a secure and sustainable way through comprehensive studies of their current production methods and constraints that prevent improvement. Only then can problem oriented approaches be developed and applied to overcome these constraints.

2. SCOPE AND OBJECTIVES OF THE PROJECT

Recent nutritional research has demonstrated the possibility of substantial increases in the productivity of milk-producing animals fed poor quality roughages through small alterations to the feed base. In some cases, improvements have been demonstrated at the farm level: milk yield has increased, body condition of the animals has improved and age at puberty and the interval between calvings have been reduced. These advances have been brought about by the addition of critical nutrients to the diet, e.g. nitrogen or minerals for the rumen micro-organisms or rumen non-degradable protein or all of these.

It is well recognized that poor nutrition is a major factor limiting peri-urban milk production in the African continent. The productivity of many milk-producing cattle in Africa is low because of low individual yield and poor fertility, the latter often reducing the proportion of animals in milk at any one time to less than 50 per cent of the mature cows. The reasons for the low productivity are complex, but include (a) the imbalanced nature of the nutrients that arise from digestion of forage resources, (b) the incidence of disease/parasitism and (c) poor reproductive management.

The introduction of improved feeding practices such as strategic supplementation using locally available feed resources (e.g. tree legume leaves, brewers waste, fish waste, multinutrient blocks, etc.) will not only enhance milk production but will also introduce a sustainable farming practice that will ensure a continuous supply of milk and milk products to local populations.

To introduce effective supplementation there is a need to identify the nutrient or combination of nutrients that are the limiting factors for achieving optimum rumen fermentative digestion of the basal diet or the efficiency of utilization of the major products of digestion. In many of the dairying systems operating in Africa this is far from easy, mainly because of the difficulties encountered in effectively measuring feed intake and selection and the efficiency with which the nutrients absorbed are used for productive purposes. In order to circumvent these difficulties it may be possible to measure biochemical indicators in the cows themselves that provide an assessment of nutrient status.

The specific objectives of the co-ordinated research project (CRP) were to:

— obtain baseline information on production and reproductive parameters using a comprehensive survey, progesterone radioimmunoassay and clinical observations, and thereby identify major nutritional and management constraints to productivity,
— investigate approaches for improving productivity in dairy cattle by increasing the utilization of basal diets and other locally available fed resources,
— monitor the effectiveness of nutritional and management interventions by measuring performance indicators such as body weight, body condition, milk production and reproductive performance (using radioimmunoassay and other clinical observations),
— establish whether differences in productivity correlate with selected metabolic indicators in blood, which might thereby prove useful as predictors of nutritional constraints.

3. PROJECT IMPLEMENTATION

On the basis of available funds and the quality of applications 14 research contracts and agreements were awarded to livestock research institutions in Algeria, Australia, Cameroon, Canada, Çote d'Ivoire, Ethiopia, France, Ghana, Kenya, Malawi, Mauritius, Morocco, Nigeria, Senegal, Sudan, the United Republic of Tanzania, United Kingdom and Zimbabwe. A Technical Contract was awarded to the Rowett Research Institute in the United Kingdom.

The first Research Co-ordination Meeting (RCM) of the CRP was held in Morogoro, the United Republic of Tanzania. At this meeting it was agreed that the first phase of the study (12–18 months) should be devoted to a comprehensive survey of the production system selected, to establish baseline data on feeding and management practices that are being used by the smallholder farmers and on the productivity of the animals (e.g. body weight, body condition, milk yield, reproduction etc.), and to identify major nutritional constraints in order to design corrective measures during the second phase of the project.

The second RCM was held in Rabat, Morocco. From presentations the existing dairy cattle production systems were well described and documented. Farms or herds included in the study conformed to systems of production which were typical of the region. All participants were able to collect information on live weight change, body condition score, milk yield, reproductive parameters, faecal egg counts, chemical composition of feeds, and wherever possible amounts of feed offered. The number of animals included in the observations were adequate or were close to the target of 80–100 in all projects.

Although blood metabolite analysis for establishing possible relationships between various metabolites and the nutritional status of the animal was identified as a major objective of the CRP at the commencement of the project, attempts were not made to measure blood metabolites, as a similar CRP covering Latin America and Asia after three years of research showed that nutritional metabolites were more helpful in identifying potential disease conditions and less helpful in identifying nutritional inadequacies.

Work plans for the coming 18 months considered the development and testing of suitable corrective measures which were within the practical and economic means of the farmer, for overcoming the nutritional and management constraints that were identified during Phase I.

The final RCM was held in Vienna in 1998 and the following conclusions and recommendations were made.

4. CONCLUSIONS AND RECOMMENDATIONS

4.1. Conclusions

4.1.1. General

The success of multi-disciplinary projects such as this CRP depended on participatory team approach including scientists, farmers and extension workers. All groups indicated that development of such teams ensured continued motivation and project completion.

4.1.2. Reproductive performance of cattle in peri-urban areas

Most studies involved mainly Friesian cattle and their crosses, but Ghana, Senegal and Cameroon used local breeds. Cameroon characterised the features of indigenous dual-purpose breeds in an extensive production system which allowed for only subsistence levels of milk production.

All countries were able to characterize the reproductive cycles of dairy cows under existing farming conditions. Most countries observed delayed resumption of oestrus (range 85–170 days), poor conception rates (range 1.5–2.6 services per conception) and long inter-calving intervals (range 380–513 days) during the survey phase (Phase I) of the project.

4.1.3. *Body condition score and other performance indicators*

The body condition score (BCS) was an important management tool for monitoring and assessing the nutritional status of animals. Body condition at calving and during early post-partum appeared to be correlated with reproductive parameters such as onset of heat, conception and calving interval. Loss of BCS after calving and cows with BCS <4 (on the International Livestock Research Institute score system of 1–9) at calving displayed poor fertility.

The introduction of simple and easy-to-use performance indicators such as BCS, body weight change, milk production records etc. into many farming communities through this project improved the knowledge and skills of the farmers leading to better management. In some communities, it lead to improved oestrus detection by the farmers.

4.1.4. *Seasonality of calving*

In conjunction with poor BCS it was evident that calving during the dry season, when availability of forages was low, had a negative impact on fertility parameters. This was particularly evident in Algeria, Sudan, Kenya, Tanzania, Senegal, Cameroon and Ghana.

4.1.5. *Nutritional interventions*

Strategic nutritional interventions (during Phase II) particularly during the dry season increased productivity and proved economically viable. Supplementation with tree legume leaves (*Sesbania sesban*) in Malawi, agro-industrial by-products (brewer's grain, bakery flour waste, molasses and ground nut cake) in Senegal, urea-molasses multinutrient blocks and a farm-formulated concentrate (maize bran, cotton seed cake and minerals) in Tanzania and fish silage blocks made out of fish waste (60%) and molasses (40%) in Morocco, and strategic pre- and post-partum supplementation with cotton seed cake in Mauritius brought about major improvements in milk production, body weight and body condition score and/or fertility parameters. When distinct nutritional constraints were identified, supplementation with locally available feed resources proved to be both cost-effective and sustainable. Cost:benefit ratios for milk production with the new interventions ranged from 1:2.6 in Tanzania to 1:3.8 in Senegal. These nutritional improvements would bring significant benefits to many countries if widely applied.

4.1.6. *Monitoring of ovarian activity*

Studies from all participating countries showed that the measurement of milk progesterone using radioimmunoassay (RIA) was useful for identifying fertility constraints and breeding management problems. For example, in Mauritius farmers could detect oestrus accurately, and although cows were cycling, problems associated with the artificial insemination (AI) service contributed to low fertility. Sudan showed that the failure of cycling cows to conceive was the major constraint to improving productivity and this was probably due to presence of disease.

No problems were encountered with the current RIA system using iodinated (^{125}I) progesterone. However, the development of a cheap and simple cow-side test would be useful.

4.1.7. *Blood metabolites*

In Sudan (the only country that carried out blood metabolite studies) elevated globulin levels suggested the presence of reproductive disease as a significant cause of poor fertility.

4.2. Recommendations

4.2.1. Awareness of production constraints

In any future CRP concerning livestock production, it is important to be aware of constraints to production prior to the introduction of problem solving technologies. This may involve issues such as health, reproduction, nutrition, agronomy, marketing, social and cultural aspects, etc. Such an approach will ensure that constraints being investigated are the most crucial to the community and the farming system. This approach follows modern extension philosophy.

4.2.2. Evaluation and monitoring of production systems

Parameters that were used to identify nutritional and management constraints e.g. RIA for measuring progesterone, body condition score, body weight measurement etc. proved to be useful practical tools for monitoring and evaluating production. They should continue to be used in future studies where such evaluations are required.

4.2.3. Integrated approach

The approach of using feed supplementation alone for improving livestock productivity on smallholder farms is too confining for identifying the multi-factorial influences that are often found in livestock production systems in developing countries. The approach needs to be broader to consider the whole-farm as a unit (holistic approach), including all aspects that may constrain livestock production. e.g. nutrition, management, reproduction, disease status etc.

4.2.4. The need for a statistical package

The integrated on-farm approach is multi-factorial in nature. Therefore, simple experimental statistical techniques have limitations and alternative designs need to be considered.

4.2.5. Extension strategies

For experimental results to have an impact there must be an effective extension of these results into the farming community. Therefore, an effective extension plan must be part of the experimental protocol, including documents on how to disseminate technical information to farmers. While some of the information on extension methodologies is already available, others need to be identified.

While it is important to assess the effects of interventions in the short term, long term monitoring may be important to assess the consequences of such interventions in multi-factorial production systems.

4.2.7. Importance of quality assurance for the future programmes

The importance of quality control for laboratory techniques, especially of RIA was highlighted. It is important that the RIA laboratories continue to be associated with a quality assurance programme, in order to ensure that results are applicable and comparable between institutions in different countries.

COUNTRY REPORTS

LINKS BETWEEN NUTRITION AND REPRODUCTION IN CATTLE

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Abstract

LINKS BETWEEN NUTRITION AND REPRODUCTION IN CATTLE.
Situations in which nutrition modulates reproductive function, and targets involved, are identified, particularly in relation to initiation of cyclicity (at puberty, during the post-partum period or after induction of ovulation), fertility and induction of ovulation. The usefulness and pertinence of measurements of body weight variations, body condition score, nutritional balance or blood metabolites (glucose, ketone bodies, free fatty acids, cholesterol, urea and amino acids) to evaluate nutritional status in this context is considered. Leptin could play a central role in causal mechanisms linking nutrition and reproduction, in conjunction with somatotropic axis, insulin, opioids, and neuropeptide Y.

1. INTRODUCTION

Nutrition is acknowledged as a modulator of reproductive function [1-4]. If the influence of quantitative variations of energy prevails, nitrogen [5, 6], vitamin [7] and mineral [7, 8] effects are also widely believed to be involved.

We shall identify here, situations in which such influences occur in cattle, and the target functions involved. Indicators which may reveal and quantify nutritional status of importance for reproduction will be explored and an attempt will be made to describe, on the basis of actual knowledge, mechanisms which could account for such effects.

Situations regarding females, especially energy metabolism, will be emphasised. But nutritional influences on male reproduction, which concern the onset of puberty as well as the components of the sexual activity of the adult (behaviour, semen production), underfeeding, overfeeding, protein deficiency, minerals and vitamins represent an important background for the management of animals for artificial insemination or natural service.

Practical situations in which nutrition affects female sexual activity are numerous, and differ as a function of production systems. In intensively managed dairy cows, the most frequently identified syndromes [9] concern too thin high producing dairy cows, primiparous females with high milk production, overfed dry cows with a fatty liver and developing ketosis, animals suffering from ration imbalance during the transition period and females with high blood urea concentrations in relation to excess protein intake and dietary energy shortage. Dairy cows, for whom conserved forage is an important part of the ration, and extensively managed cattle (e.g. European mountain-living breeds) face under-nutrition situations. It is the same for beef cows suffering both poor winter feeding, the consequences of suckling and difficult environmental factors. Flushing strategies can be used to override such energy-linked limiting conditions. In tropical *taurus* and zebu cows, underfeeding is generally very much marked in a seasonally-driven pattern, and in the context of suckling, pathological situations and environmental stresses.

2. FUNCTIONS RESPONSIVE TO NUTRITIONAL FACTORS

2.1. Cyclicity

2.1.1 Puberty

Age at puberty determines the age at first calving and the productivity of the cow during all its lifetime. In certain systems, early mating is sought, and growth controlled consequently, in order to obtain calving at two years of age. In other cases, puberty is "abnormally" delayed due to environmental and nutritional factors and action can be taken to reduce the inactive period. The influence of feeding on puberty is definitely proved with a block on first ovulation after the prevention of LH secretion when feeding is severely restricted. Correcting nutrition allowed an increase of gonadotrophine secretion at a given weight of the animals, and, consequently, steroid and gamete production [10]. The wide range of mean age at puberty recorded by Mukasa-Mugerwa [11] in zebu cows (from 16 to 40 months according to the breed and environmental conditions) implies a negative effect of inadequate feeding conditions on this parameter. This has been confirmed by the demonstration of an influence of the regime on the age at puberty [12] in experimental conditions, or by values as low as 14 months when conditions are satisfactory [13].

2.1.2. Post-partum

The post-partum resumption of ovarian cyclicity is a critical determinant of the calving interval and, therefore, of overall productivity in cattle, assuming that the one-calf-per-one-year postulation is valid in the economic circumstances of that environment. The occurrence of the first post-partum ovulation is the result of the removal of the negative feedback, and of the restoration of the positive feedback, of the oestrogens modulating the GnRH secretion, and, hence, ovarian activity. The interaction of nutrition, especially during energy restriction, with this system is well documented in the dairy cow [3, 14-17]. Under-nutrition during the post-partum period delays first ovulation and due to occurrence of a cyclic anoestrous period, the first oestrus [3, 18], while the most severe nutritional conditions produce true anoestrous situations.

In beef cows the post-partum period is longer due to low LH basal values and pulsatility, and weak oestradiol secretion by the follicles [19]. First ovulation tends to occur at the end of the third follicular wave, compared to the first wave for dairy cows [20]. Suckling and a low level of nutrition [21-26] prolong suppression of LH pulses: a 26-day difference was observed between low (0.7 x maintenance) and high (2 x maintenance) planes of nutrition [27]. In a field survey, Grimard [28] observed that cyclicity at 76 days post-partum was 15% for females with poor body condition score (BCS) (2.5) versus 25% for animals in better body condition; total controlled factors, including those relating to nutrition, accounted for 28% of the variability of post-partum cyclicity. In beef cows, suckling is not an absolute limiting factor, provided feeding is sufficient. On the other hand, in zebu cattle, suckling has a deeper influence, and ovulation is more likely to occur after weaning, if the nutritional status is adequate [29].

2.1.3. Response to the induction of ovulation

Grimard [28] observed that anoestrous primiparous Charolais cows loosing body weight after calving did not respond to a treatment of induction of ovulation, while 56% of those in increasing condition ovulated. A 22-day long flushing period beginning 10 days before the induction treatment had a positive effect on the percentage of ovulations (75 vs 56%) [30] in primiparous females. These responses can be explained by an action on the follicular development (number of follicles, maximal size) [31, 32].

2.2. Fertility

The success of mating or artificial insemination has been shown to be influenced as well by energy restriction (with variations of 12 to 25% between groups differing according to the extent of energy supplies [3]) and by protein imbalances: Diskin [33] showed that supplementation of dairy heifers by non rumen degradable protein during spring improved conception rate (76% vs 58%), believed at the time to be due to the negative effect of excess of degradable proteins and ammonia at the beginning of the grazing period.

2.3. Fecundity

The ability of the cow to produce multiple ovulations, spontaneously or after a super-ovulation treatment as practised for embryo transfer, is sensitive to nutrition. Lucy *et al* [34] observed that cows ovulating spontaneously two or more ovocytes during the post-partum period had a greater energy balance (7.58 Mcal/day) than cows with 1 (3.89 Mcal/day) or no (3.82 Mcal/day) ovulation. The response to a super-ovulation treatment [35, 36] is affected both by under-nutrition and by over-nutrition. We have shown that, in farms, nutritional parameters account for 30% of the variability of embryo collection [37]; where energy supplies were low (10 Forage Units (FU)/cow/day), total embryos (5.1 ± 3.2) and freezable embryos (2.5 ± 2.4) were significantly lower than when energy was high (16 FU) (8.9 ± 5.7 and 5.6 ± 3.3 for total embryos and freezable embryos, respectively). On the other hand, overfeeding animals, which is frequent in intensive dairy cow production, based on maize silage rations, may have a depressive effect on embryo collection [38-41], which is in accordance to the positive effect of a transitory feed restriction ("negative flushing") in overfed beef heifers [42].

As mentioned above, underlying mechanisms of nutritional effects on reproductive functions are numerous and concern central as well as peripheral levels. Control of gonadotrophin secretion, particularly of LH, is obviously involved in a great proportion of these actions [17, 21, 43, 44]. Modulation of the sensitivity of hypothalamic nuclei to feedback of steroids is postulated. Response of the hypophysis to GnRH may also play a role. At the peripheral level, the capacity of steroid secretion by the follicles, the number and development of follicles have been reported to respond to nutritional factors [31, 32, 45-47]. It remains to be determined what metabolic signals are responsible for the interaction with these targets.

3. THE SEARCH FOR RELEVANT INDICATORS OF NUTRITIONAL STATUS

There is a need to evaluate the effect of feeding (resulting from management decisions, or dependence on pasture conditions) on the animal, first quantitatively and secondly qualitatively, to search for key elements taking part in the causal relationships.

3.1. Weight variations

At puberty, a threshold value of weight, more than age, is assumed to explain the onset of sexual activity [10]. Conversely, cyclicity of heifers or of post-partum cows seems to be mostly associated with changes (gains or losses) in weight. According to Grimard [28], cyclicity of beef cows is affected when females loose more than 30 kg after calving. We observed, in post-partum dairy cows [18], that identical regimes had different impacts on the weight variations of cows from different breeds and on the resumption of sexual activity. Hence, weight variations may not be the best indicator of the level of nutrition. Its measure, even if easy, is not very precise, and concerns mainly long-term variations of the status of the animals.

3.2. Body condition

Mean calving interval in beef cows is influenced by body reserves, estimated by BCS, as demonstrated by a large field study [48]. In dairy cows, [49], females with high (3.0) BCS at first breeding had 8.8 fewer days to first AI and 6.4 fewer days to conception than cows with lower BCS; Butler and Smith [15] observed that the loss of one unit of BCS resulted in 15 days more to first ovulation, and in a marked reduction of the conception rate (17% compared with 65% for cows loosing less than 0.5 unit of BCS). Recent observations on zebu cows have shown that cows able to maintain their body condition through the early post-partum period had shorter interval to first oestrus [50], and that post-weaning supplementation could reduce the interval to first ovulation in poor condition females, as one unit loss (on a scale of 9) led to a 40 % increase of the time to return to cyclicity after weaning [29].

3.3. Nutritional balance

In the post-partum dairy cow, a correlation has been observed (r = -0.60) between the calving to ovulation interval and the mean energy balance for the first 20 days [51]. Energy balance affects the number of follicles per cow and the pattern of follicular distribution [34]. But, more than quantitative absolute values, it seems that the dynamics of energy balance during the post-partum period accounts for the induction of the first ovulation. Canfield and Butler [52] observed that the increase of LH pulsatile secretion preceding ovulation occurs in a close time-relationship with the minimal value of energy balance (r = 0.76). Accordingly, this parameter appears to be of the utmost importance for the understanding of the relationships between nutrition and the central control of reproduction. The question arises as to how such information is transmitted to the nervous system. Calculation of a nutritional balance requires the knowledge of the inputs (i.e. individually controlled feeding of animals, and known nutritional value of feedstuffs), and of the requirements, according to genotypes and physiological situations, which is not yet achieved in all circumstances.

3.4. Blood metabolites

Blood metabolic profiles have been developed, from the beginning of the 70's, to predict energy and nutrient intakes, milk production, and reproductive variables on an herd-basis [53, 54]. Basically, a negative energy balance induces hypoglycemia, hypoinsulinemia, and high cortisol, GH and epinephrine levels, which result in a mobilization of body reserves (lipids and proteins); lipolysis leading to an increase of free fatty acids and ketone bodies in the circulation [15, 55, 56]. Use of such profiles is however dependent on specific situations (breed, production system, management), and the metabolic parameters may not always be indicative of reproductive status of the herd, as pointed out in dairy [57], or zebu [58] cows. Suitable reference values have to be considered for each given situation. Pertinent indicators to assess nutritional status would respond to alimentary imbalances, and would be associated with reproductive disorders.

3.4.1. Glucose

Blood glucose (and also blood β-hydroxybutyrate) responds to both quantitative and qualitative variations of the ration in ruminants [27, 55, 59]. Clear associations with reproductive parameters have been demonstrated: in experimental herds, Miettinen [60] observed a positive relationship between blood glucose and reproductive performance (delay for uterine involution, onset of ovarian activity, interval to conception) in dairy cows; Whitaker [61] found a better prediction of the same parameters when glucose and β-hydroxybutyrate values measured at the beginning of the post-partum period were combined. In a survey involving 18 dairy herds in Sweden [62], high glucose values at the first insemination were found to be correlated with higher rates of pregnancy. In practice the collection of blood samples and analysis for glucose is quite difficult to achieve consistently. A direct action of glucose on the central nervous system can be suspected from experiments manipulating specifically blood glucose levels: the infusion of phlorizine, which inhibits renal reabsorption of glucose and induces hypoglycemia, lowers LH concentrations and pulse amplitude in cycling cows [63]. Similarly, 2-deoxy-glucose injections block ovulation in cattle [64]. While secondary effects of hypoglycemia cannot be excluded, the glucose availability as an energy fuel for the cells of the CNS could act as a signal for metabolic status on neuronal control of GnRH secretion.

3.4.2. Ketone bodies

Elevated oxidation of free fatty acids in liver in case of an imbalance of energy metabolism gives rise to ketone bodies (β-hydroxybutyrate and aceto-acetate). Particularly, accumulation of reserves and excess fattening of cows during the dry period predisposes to ketosis (fat cow syndrome). In such cases, a negative effect on fertility has been established [60, 61]. A correlation ($r = 0.51$) between β-hydroxybutyrate and interval between calving and first service have been observed in an experimental herd [65]. In a large field study conducted in 474 herds [66], ketosis, estimated by milk acetone, was associated with a lengthening of interval from calving to first service, a decrease of fertility and an increase of ovarian cysts.

3.4.3. Free fatty acids (FFA)

High levels of FFA are the sign of lipomobilization and negative energy balance, and are well documented in underfed animals [15, 17, 27, 55, 56]. However, depletion of lipid reserves in extreme conditions leads to low levels of blood FFA, as shown by Yameogo [67] in N'Dama × Zebu crossbred cattle during the dry season in Senegal. Whereas glycemia fell (from 0.55 to 0.35 g/L) from January to June, due to a shortage of feed, FFA values remained low (0.17 to 0.22 Eq/L) and increased only after the rainy season (0.35 Eq/L in October), probably after mobilization of reconstituted lipid reserves. We observed (unpublished data) similar low levels of FFA in food-deprived dairy heifers in negative growth (0.20 vs 0.38 Eq/L in control heifers), in association with small adipose cells size (65μ vs 142μ in control).

Post-partum energy restriction of suckled beef cows [32] affected plasma concentrations of FFA (0.309 vs 0.168 Eq/L), with a significant negative correlation with LH pulse frequency (r = -0.61) at 30 days post-partum. A direct effect of FFA on LH secretion has not been demonstrated after elevation of blood FFA by lipid infusion [17, 68].

3.4.4. Cholesterol

As energy intake seems to have no effect on cholesterolemia, which is rather influenced by qualitative aspects of the composition of the ration [69], this parameter cannot be used as an indicator of the energy status. Nevertheless, a clear association has been demonstrated between post-partum cholesterol level and fertility (days-to-conception) in Holstein cows [70]. Elevated cholesterolemia consequence to a high-fat diet supplementation during the post-partum period in Brahman cows [71] or in beef heifers [68] was associated with increases in the number of medium-size follicles. Steroid synthesis by the follicle [71] or the corpus luteum [69, 72] are activated in such situations. As a consequence of these ovarian effects, high cholesterol levels result in better embryo collection in superovulated cows [73-75]. We observed similar effects in a field study [76]: in farms in which mean level of glycemia and cholesterolemia were simultaneously high, the number of transferable embryos (8.8 ± 7.4 vs 4.9 ±2.7, P <0.15) and of freezable embryos (6.5 ± 5.4 vs 2.6 ± 2.2, P <0.06) were higher than in farms in which females had low levels of these two metabolites.

3.4.5. Urea and Amino acids

The digestion of proteins results in ammonia, which is partly converted to urea in the liver. In this way, blood urea can be used as a marker of protein nutrition. Blood urea responds also to the protein/energy balance of the ration, and reflects the protein reserve use. On the basis of a large scale field study, Lee [53] confirmed the relationship between protein intake and blood urea. When the protein content of the ration was increased from 14 to 20% of CP [6], blood urea levels rose from 127 to 293 mg/ml. On the other hand, when the degradability of proteins were enhanced, uremia increased [43, 77]. High values of uremia are associated with an increase of calving to first service (r = 0.75) and calving to fertilisation (r = 0.63) intervals in dairy cows [65]. However, a review of the literature has failed to show evidence of direct causal links between high blood urea and poor fertility [Whitaker, personal communication]. Mobilization of body protein, which can be assessed by 3-methylhistidine blood levels, has not been found to be correlated with duration of post-partum anovulation in dairy cow [78].

4. CANDIDATE MECHANISMS

4.1. Growth hormone and insulin-like growth factors (GH-IGF1)

Growth promoting, galactopoïetic, anabolic, lipolytic and diabetogenic effects of the somatotrophic axis are mediated by growth hormone (GH) and insulin-like growth factors (IGF's) [79]. Their blood concentrations are influenced by nutrition: GH is elevated and IGF1 lowered during feed restriction in cattle [80], as in other species. The relationships between this system and reproduction can be suspected on the basis of observations and experimental interventions. Cows selected for high twinning frequency (29.8 vs 6.2% in controls) had greater IGF1 concentrations in their large follicles (327 ± 28 vs 243 ± 29 ng/ml) and more large follicles than control animals [81]. Significant correlations have been calculated between IGF1 blood concentrations and luteal function [72], and between GH and IGF1 levels and follicular growth [82] in dairy cows. Chronically low IGF1 blood levels, caused by a GH receptor deficiency in cows, resulted in abnormal patterns of follicular waves, slow development of corpora lutea, and low progesterone levels [83]. Conversely, the administration of exogenous GH to cows treated for super-ovulation significantly increased the number of fertilised oocytes (4.5 ± 4.6 vs 2.2 ± 3.1) and of transferable embryos (3.8 ± 4.3 vs 1.9 ± 2.7) collected [84].

4.2. Insulin

The pancreatic homeostatic hormone, insulin, plays a central role in the regulation of metabolism, and its peripheral concentrations are linked to the level of feed intake in ruminants [27, 85]. In these species, no direct effect of insulin on LH secretion has been demonstrated [17]. Peripheral actions are more likely, as insulin receptors have been demonstrated in the gonads, and as insulin induces *in vitro* proliferation of the granulosa cells and activation of steroid synthesis (either by a direct action, as on 3 β-hydroxysteroid dehydrogenase, or in synergy with FSH, as on aromatase) [86]. Systemic administration of insulin in heifers treated for super-ovulation by FSH increased the diameter of the largest follicles [87], or the number of ovulations in underfed animals [88]. The question arises as to whether these effects are direct ones, or are mediated through IGF1, as insulin is known to induce IGF1 synthesis in ovarian follicles.

4.3. Opioids

The mediation of opioids in the regulation of LH secretion by nutrition have been intensively studied, particularly in the rodent model. Involvement of endogenous opioids in inhibition of LH secretion in post-partum suckled beef cows has been shown by the stimulation of LH secretion by naloxone, the opioid antagonist [89] in rat, pig and ewe. Opioids inhibit excitatory noradrenergic neurones controlling GnRH neurones. This action is exerted by enkephalin, outside the hypothalamus, or by endorphin in the basal hypothalamus [15]. In beef cows fed 70% of the maintenance needs, met-enkephaline concentrations in the pre-optic area was increased [90].

4.4. Neuropeptide Y

Neuropeptide Y (NPY), a neurotransmitter present in areas of the hypothalamus involved in food intake and neuroendocrine control, seems to be a major link between nutrition and reproduction. NPY administration stimulates feeding behaviour. NPY neurones are activated in negative energy balance conditions, and inhibited by insulin. In ewes [91], its concentration is increased in the cerebrospinal fluid of long-term food-restricted animals. Its intra-cerebroventricular administration to ovariectomized females led to significantly reduced blood levels of LH, as observed in other species. NPY is assumed to inhibit noradrenergic neurons involved in the pulsatile secretion of GnRH [92].

4.5. Leptin

The product of the gene OB, the mutation of which determines obesity in the mouse, is a protein synthesized by the adipocytes, and named leptin. It has been identified in 1994 [93-95]. When it is not secreted, as in the case of ob/ob animals, obesity and infertility are jointly observed: plasma levels of gonadotrophins and gonadal steroids are low, and cyclicity is blocked. The administration of leptin to such obese mice lowers feed intake, increases thermogenesis and oxidative metabolism, and restores gonadotrophin secretion. The leptin secretion is regulated positively by glucose, insulin, glucocorticoids, and negatively by catecholamins. In normal situations, leptin parallels the mass of adipose tissue of the organism and plays the role of a lipostat, mainly by the way of inhibiting the secretion of neuropeptide Y in the hypothalamus. Such a direct action has been confirmed for the ewe by the effects of intra-cerebroventricular injections and by the localization of the leptin receptor in the hypothalamus [96]. Evidences of implication of such a mechanism in nutrition-reproduction interrelations are accumulating. The administration of leptin to female rats prevents the block of pulsatile LH secretion produced by fasting [97]. This effect is observed in the absence of oestrogens, in ovariectomized females, indicating that the mechanism does not involve the negative feed-back of these steroids on GnRH secretion. Similarly, the injection of leptin induces sexual maturity in food-restricted pre-pubertal rats [98]. The central effects of leptin on GnRH secretion has been confirmed by the observation of LH secretion after intra-cerebral injection of leptin and *in vitro*, by leptin-induced secretion of GnRH by median eminence and arcuate nucleus explants [92].

The hypophysis can also be a target for the leptin action on reproduction: leptin receptors have been identified in the pituitary [96], and leptin induces gonadotroph secretion by cultured pituitary cells [92]. Peripheral direct actions are also indicated by the existence of leptin receptors in the ovary, the adrenal and the pancreas, and the inhibitory effect of leptin administration on insulin and cortisol secretion [99], or induction of an insulin resistance [95]. Moreover, leptin attenuates insulin-induced steroidogenesis of thecal cells from bovine follicles cultured *in vitro* [100].

5. CONCLUSIONS

With the leptin hypothesis, a global comprehension of the nutrition-reproduction relationships appears possible. Leptin seems to be the missing link between nutrition (feed intake, regulation of body reserves) and reproduction (control of GnRH and LH secretions, peripheral actions), at least as far as energy metabolism is concerned (Figure 1). It remains to be determined what would be its respective role beside alternative or concurrent mechanisms. While this model has been developed in laboratory animals and primates, very few observations concern ruminants and none cattle. The gene for leptin has been recently cloned in the bovine species [101], and this will give rise to specific molecular tools and the opportunity to explore the validity of such mechanisms in cattle.

More generally, gaps in the knowledge of nutrition-reproduction relationships in cattle still exist: there is a need for comparative studies to come up to a finer understanding of the specificities of given situations (production systems, external conditions, etc.). African cattle have received too little attention in this respect. Tropical *taurus* and zebu cattle are models of adaptation to survival in harsh conditions of environment, nutrition, pathology and by their ability to serve as multipurpose (milk, meat, work) animals [102].

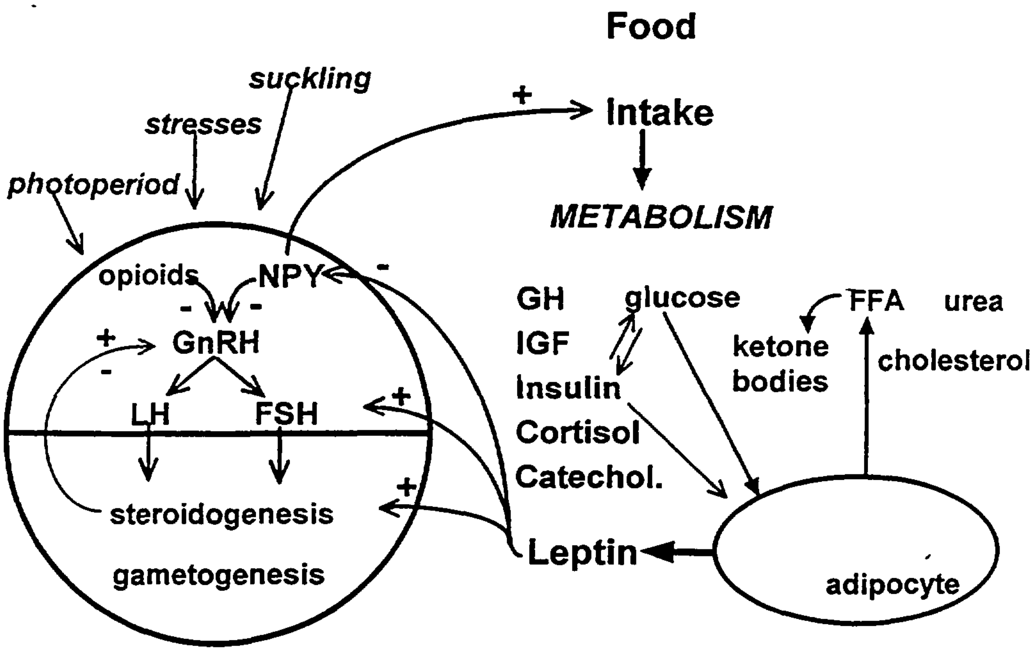

FIG.1. Nutrition-reproduction interactions in cattle with special reference to the putative role of leptin.

The determination of the physiological basis of these performances should certainly be profitable. From a practical point of view, understanding of nutrition-reproduction relationships is necessary to develop tools aimed at diagnosis of the causes and targets of nutritional effects, choosing adapted responses (providing supplementation strategies, adjusting management practices etc.) and assessing consequences of interventions on production systems.

REFERENCES

[1] SHORT, R.E., ADAMS, D.C., Nutritional and hormonal interrelationships in beef cattle reproduction, Can. J. Anim. Sci. **64** (1988) 714-727.

[2] SWANSON, L.V., Interactions of nutrition and reproduction, J. Dairy Sci. 72 (1989) 805-814.

[3] RANDEL, R.D., Nutrition and post-partum rebreeding in cattle, J. Anim. Sci. **68** (1990) 853-862.

[4] FERRELL, C.L., "Nutritional influences on reproduction", Reproduction in domestic animals, (CUPS, P.T. Ed.), Academic Press (1991) 577-603.

[5] FERGUSON, J.D., CHALUPA, W., Impact of protein nutrition on reproduction in dairy cows, J. Dairy Sci. 72 (1989) 746-766.

[6] SONDERMAN, J.P., LARSON, L.L., Effect of dietary protein and exogenous gonadotrophin-releasing hormone on circulating progesterone concentrations and performance of Holstein cows, J. Dairy Sci. 72 (1989) 2179-2183.

[7] HURLEY, W.L., DOANE, R.M., Recent developments in the roles of vitamins and minerals in reproduction, J. Dairy Sci. 72 (1989) 784-804.

[8] ATHERTON, D., The effect of mineral nutrition on bovine fertility with particular reference to embryo transfer, 10th A.E.T.E. Meeting, Lyon, 9-10 Sept. (1994) 105-114.
[9] STUDER, E., A veterinary perspective of on-farm evaluation of nutrition and reproduction, J. Dairy Sci. **81** (1998) 872-876.
[10] SCHILLO, K.K., HALL, J.B., HILEMAN, S.M., Effects of nutrition and season on the onset of puberty in the beef heifers, J. Anim. Sci. **70** (1992) 3994-4005.
[11] MUKASA-MUGERWA, E., A review of reproductive performance of female *Bos indicus* (zebu) cattle, ILCA Monograph 6 (1989) 134p.
[12] OYEDIPE, E.O., OSORI, D.I.K., AKEREJOLA, O., SAROR, D., Effect of level of nutrition on onset of puberty and conception rates of Zebu heifers, Theriogenology **18** (1982) 525-539.
[13] MBAYE, M., NDIAYE, N., "Etude de l'activité ovarienne cyclique chez les génisses prépubères et chez les vaches en post-partum de race Zébu Gobra au Sénégal", Improving the productivity of indigenous African cattle. IAEA-TECDOC-708, IAEA, Vienna (1993) 81-90.
[14] STEVENSON, J.S., BRITT, J.H., Relationships among luteinizing hormone, estradiol, progesterone, glucocorticoids, milk yield, body weight and post-partum ovarian activity in Holstein cows, J. Anim. Sci. **48** (1979) 570-577.
[15] BUTLER, W.R., SMITH, R.D., Interrelationships between energy balance and post-partum reproductive function in dairy cattle, J. Dairy Sci. **72** (1989) 767-783.
[16] SAVIO, J.D., BOLAND, M.P., HYNES, N., ROCHE, J.F., Resumption of follicular activity in the early post-partum period of dairy cows, J. Reprod. Fertil. **88** (1990) 569-579.
[17] SCHILLO, K.K., Effects of dietary energy on control of luteinizing hormone secretion in cattle and sheep, J. Anim. Sci. **70** (1992) 1271-1282.
[18] MARIE, M., PARRASSIN, P.R., TROMMENSCHLEGGER, J.M., BAZARD, C., HUMBLOT, P., Répercussions d'une sous-alimentation énergétique des vaches laitières sur la reprise de l'activité sexuelle post-partum et le taux de gestation, Renc. Rech. Rumin. **3** (1996) 167-170.
[19] MURPHY, M.G., BOLAND, M.P., ROCHE, J.F., Pattern of follicular growth and resumption of ovarian activity in post-partum beef suckler cows, J. Reprod. Fertil. **90** (1990) 523-533.
[20] ROCHE, J.F., CROWE, M.A., BOLAND, M.P., Post-partum anoestrus in dairy and beef cows, Anim. Reprod. Sci. **28** (1992) 371-378.
[21] RICHARDS, M.W., WETTEMANN, R.P., SCHOENEMANN, H.M., Nutritional anoestrus in beef cows: body weight change, body condition, luteinizing hormone in serum and ovarian activity, J. Anim. Sci. **67** (1989) 1520-1526.
[22] RASBY, R.J., WETTEMANN, R.P., GEISERT, R.D., WAGNER, J.J., LUSBY, K.S., Influence of nutrition and body condition on pituitary, ovarian, and thyroid function of non-lactating beef cows, J. Anim. Sci. **69** (1991) 2073-2080.
[23] WRIGHT, I.A., RHIND, S.M., SMITH, A.J., WHYTE, T.K., Effects of body condition and estradiol on luteinizing hormone secretion in post-partum beef cows, Dom. Anim. Endocrinol. **9** (1992) 305-312.
[24] WRIGHT, I.A., RHIND, S.M., WHYTE, T.K., SMITH, A.J., Effects of body condition at calving and feeding level after calving on LH profiles and the duration of the post-partum anoestrus period in beef cows, Anim.,Prod. **55** (1992) 41-46.
[25] RHINDT, S.M., BRAMLEY, T.A., WRIGHT, I.A., McMILLEN, S.R., FSH and LH receptor concentrations in large ovarian follicles of beef cows in high and low levels of body condition at nine weeks post-partum, Reprod. Fertil. Dev. **4** (1992) 515-522.

[26] VIZCARRA, J.A., WETTEMANN, R.P., SPITZER, J.C., MORRISON, D.G., Body condition at parturition and post-partum weight gain influence luteal activity and concentrations of glucose, insulin, and non-esterified fatty acids in plasma of primiparous beef cows, J. Anim. Sci. **76** (1998) 927-936.

[27] EASDON, M.P., CHESWORTH, J.M., ABOUL-ELA, M.B.E., HENDERSON, G.D., The effect of under nutrition of beef cows on blood hormone and metabolite concentrations post-partum, Reprod. Nutr. Dev. **25** (1985) 113-126.

[28] GRIMARD, B., HUMBLOT, P., PAREZ, V., MIALOT, J.P., THIBIER, M., Synchronisation de l'oestrus chez la vache Charolaise : Facteurs de variation de la cyclicité prétraitement, du taux d'ovulation après traitement et du taux de fertilité à l'oestrus induit, Elev. Insémin. **250** (1992) 5-17.

[29] JOLLY, P.D., McSWEENEY, C.S., SCHLINK, A.C., HOUSTON, E.M., ENTWISTLE, K.W., Reducing post-partum anoestrous interval in first-calf *Bos indicus* crossbred beef heifers. III. Effect of nutrition on response to weaning and associated variation in metabolic hormone levels, Aust. J. Agric. Res. **47** (1996) 927-942.

[30] KABANDANA, F., GRIMARD, B., HUMBLOT, P., THIBIER, M., Effet d'une supplémentation alimentaire sur l'efficacité des traitements d'induction et de synchronisation de l'oestrus chez la vache allaitante. Référence particulière aux primipares non cyclées, Elev. Insémin. **258** (1993) 1-26.

[31] LUCY, M.C., BECK, J., STAPLES, C.R., HEAD, H.H., de la SOTA, R.L., THATCHER, W.W., Follicular dynamics, plasma metabolites, hormones and insulin-like growth factor-I (IGF-I) in lactating cows with positive or negative energy balance during the pre-ovulatory period, Reprod. Nutr. Dev. **32** (1992) 331-341.

[32] GRIMARD, B., HUMBLOT, P., PONTER, A.A., MIALOT, J.P., SAUVANT, D., THIBIER, M., Influence of post-partum energy restriction on energy status, plasma LH and oestradiol secretion and follicular development in suckled beef cows, J. Reprod. Fertil. **104** (1995) 173-179.

[33] DISKIN, M.G., SREENAN, J.M., The effect of feeding a protein or energy supplement during the spring early summer period on cow conception rate, Proc.45th Ann. Meet. EAAP, Edinburgh, 5-8 Sept. (1994) 220.

[34] LUCY, M.C., STAPLES, C.R., MICHEL, F.M., THATCHER, W.W., Energy balance and size and number of ovarian follicles detected by ultrasonography in early post-partum dairy cows, J. Dairy Sci. **74** (1991) 473-482.

[35] LAMOND, D.R., The effect of Pregnant Mare Serum Gonadotrophin (PMSG) on ovarian functions of beef heifers, as influenced by progestins, plane of nutrition, and fasting, Aust. J. Agric. Res. **21** (1970) 153-161.

[36] SCARRAMUZZI, R.J., MURRAY, J.F., The nutrient requirements for the optimum production of gametes in assisted reproduction in ruminant animals, 10th A.E.T.E. Meeting, Lyon, 9-10 Sept. (1994) 85-103.

[37] DELACHARLERIE, P.F., MANCIAUX, L., CHARREAUX, F., MARIE, M., Relationships between diet and response to super-ovulation in dairy cows, 11th A.E.T.E. Meeting, Hanover, 8-9 Sept. (1995) 160.

[38] DUFOUR, J.J., ADELAKOUN, V., MATTON, P., Limited multiple ovulation in heifers fed high plane of nutrition before PMSG stimulation and steroid hormone concentrations in single, twin and multiple ovulators, Theriogenology **15** (1981) 433-441.

[39] MANTOVANI, R., ENRIGHT, W.J., KEANE, M.G., ROCHE, J.F., BOLAND, M., Effect of nutrition and dose of follicle stimulating hormone (FSH) on super-ovulatory response in beef heifers, 9th A.E.T.E. Meeting, Lyon, 10-11 Sept. (1993) 234.

[40] McEVOY, T.G., BROADBENT, P.J., GEBBIE, F.E., DOLMAN, D.F., WATT, R.G., HIGGINS, L.C., Progesterone profile and super-ovulatory response of Simmental heifers in relation to pre-ovulatory energy intake and progesterone priming treatment, Theriogenology **45** (1996) 330.

[41] HUMBLOT, P., NEGRAO, S., MARIE, M., JEANGUYOT, N., NIBART, M., Relationships between diet content, metabolic status and embryo production following superovulation in Prim Holstein dairy cattle, J. Reprod. Fertil. Abstr. Ser. **20** (1997) 24.

[42] NOLAN, R., O'CALLAGHAN, D., DUBY, R.T., LONERGAN, P., BOLAND, M.P., Influence of short-term nutrient changes on follicle growth and embryo production following super-ovulation in beef heifers, 13th A.E.T.E. Meeting, Lyon, 13-14 Sept. (1997) 188.

[43] RUSCHE, W.C., COCHRAN, R.C., CORAH, L.R., STEVENSON, J.S., HARMON, D.L., BRANDT, R.T., MINTON, J.E., Influence of source and amount of dietary protein on performance, blood metabolites, and reproductive function of primiparous beef cows, J. Anim. Sci. **71** (1993) 557-563.

[44] IMAKAWA, K., DAY, M.L., GARCIA-WINDER, M., ZALESKY, D.D., KITTOK, R.J., SCHANBACHER, B.D., KINDER, J.E., Endocrine changes during restoration of oestrous cycles following induction of anoestrus by restricted nutrient intake in beef heifers, J. Anim. Sci. **63** (1986) 565-571.

[45] MURPHY, M.G., ENRIGHT, W.J., CROWE, M.A., McDONELL, K., SPICER, L.J., BOLAND, M.P., ROCHE, J.F., Effect of dietary intake on pattern of growth of dominant follicles during the oestrous cycle in beef heifers, J. Reprod. Fertil. **92** (1991) 333-338.

[46] WILLIAMS, G.L., Influence of dietary fat intake and metabolism on follicular growth in cattle, Reprod. Dom. Anim. **31** (1996) 539-542.

[47] GUTIERREZ, C.G., OLDHAM, J., BRAMLEY, T.A., GONG, J.G., CAMPBELL, B.K., WEBB, R., The recruitment of ovarian follicles is enhanced by increased dietary intake in heifers, J. Anim. Sci. **75** (1997) 1876-1884.

[48] AGABRIEL, J., GRENET, N., PETIT, M., Etat corporel et intervalle entre vêlages chez la vache allaitante : Bilan de deux années d'enquête en exploitation, INRA Prod. Anim. **5** (1992) 355-369.

[49] HEUWIESER, W., FERGUSON, J.D., GUARD, C.L., FOOTE, R.H., WARNICK, L.D., BREICKNER, L.C., Relationships between administration of GnRH, BCS and fertility in Holstein dairy cattle, Theriogenology **42** (1994) 703-714.

[50] BOLANOS, J.M., MENESES, A., FORSBERG, M., Resumption of ovarian activity in Zebu cows (*Bos indicus*) in the humid tropics : Influence of body condition and levels of certain blood components related to nutrition, Trop. Anim. Hlth. Prod. **28** (1996) 237-246.

[51] BUTLER, W.R., EVERETT, R.W., COPPOCK, C.E., The relationships between energy balance, milk production and ovulation in post-partum Holstein cows, J. Anim. Sci. **53** (1981) 742-748.

[52] CANFIELD, R.W., BUTLER, W.R., Energy balance and pulsatile LH secretion in early post-partum dairy cattle, Domest. Anim. Endocrinol. **7** (1990) 323-330.

[53] LEE, A.J., TWARDOCK, A.R., BUBAR, R.H., HALL, J.E., DAVIS, C.L., Blood metabolic profiles : their use and relation to nutritional status of dairy cows, J. Dairy Sci. **61** (1978) 1652-1670.

[54] KRONFELD, D.S., DONOGHUE, S., COPP, R.L., STEARNS, F.M., ENGLE, R.H., Nutritional status of dairy cows indicated by analysis of blood, J. Dairy Sci. **65** (1982) 1925-1933.

[55] FLUX, D.S., McKENZIE, D.S., WILSON, G.F., Plasma metabolite and hormone concentrations in Friesian cows of differing genetic merit at two feeding levels, Anim. Prod. **38** (1984) 377-384.
[56] CHILLIARD, Y., BOCQUIER, F., DOREAU, M., Digestive and metabolic adaptations of ruminants to under nutrition, and consequences on reproduction, Reprod. Nutr. Dev. **38** (1998) 131-152.
[57] PARKER, B.N., BLOWEY, R.W., Investigations into the relationship of selected blood components to nutrition and fertility of the dairy cow under commercial farm conditions, Vet. Rec. **98** (1976) 394-404.
[58] TEGEGNE, A., ENTWISTLE, K.W., MUKASA-MUGERWA, E., Plasma progesterone and blood metabolite profiles in post-partum small east African zebu cows, Trop. Anim. Hlth. Prod. **25** (1993) 101-110.
[59] HERDT, T.H., STEVENS, J.B., LINN, J., LARSON, V., Influence of ration composition and energy balance on blood b-OH butyrate and blood glucose concentration in dairy cows in early lactation, Am. J. Vet. Res. **42** (1981) 1177-1180.
[60] MIETTINEN, P.V., Metabolic balance and reproductive performance in Finnish dairy cows, Zentralbl. Veterinarmed. **37** (1990) 417-424.
[61] WHITAKER, D., SMITH, E.J., Da ROSA, G.O., KELLY, J.M., Some effects of nutrition and management on the fertility of dairy cattle, Vet. Rec. **133** (1993) 61-64.
[62] PLYM FORSHELL, K., ANDERSSON, L., PEHRSON, B., The relationships between the fertility of dairy cows and clinical and biochemical measurements, with special reference to plasma glucose and milk acetone, Zentralbl. Veterinarmed. **38** (1991) 608-616.
[63] RUTTER, L.M., MANNS, J.G., Follicular phase gonadotrophin secretion in cyclic post-partum beef cows with phlorizin- induced hypoglycemia, J. Anim. Sci **66** (1988) 1194-1200.
[64] McCLURE, T.J., NANCARROW, C.D., RADFORD, H.M., The effect of 2-deoxy-D-glucose on ovarian function in cattle, Austr. J. Biol. Sci. **31** (1978) 183-186.
[65] NÜSKE, S., GRAF, F., Relations between feeding, dairy performance, fertility and some blood parameters in German Friesian cows, Revue Méd. Vét. **145** (1994) 185-189.
[66] ANDERSSON, L., GUSTAFSSON, A.H., EMANUELSON, U., Effect of hyperketonemia and feeding on fertility in dairy cows, Theriogenology **36** (1991) 521-536.
[67] YAMEOGO, N.A., Variations saisonnières du statut nutritionnel et des paramètres de reproduction des vaches dans les petits élevages traditionnels de la zone péri-urbaine de Dakar, Mémoire de DEA, Université Cheikh Anta Diop, Dakar (1997) 76p.
[68] GRUMMER, R.R., CARROLL, D.J., Effects of dietary fat on metabolic disorders and reproductive performance of dairy cattle, J. Anim. Sci. **69** (1991) 3838-3852.
[69] RYAN, D.P., SPOON, R.A., WILLIAMS, G.L., Ovarian follicular characteristics, embryo recovery, and embryo viability in heifers fed high-fat diets and treated with follicle-stimulating hormone, J. Anim. Sci. **70** (1992) 3505-3513.
[70] KAPPEL, L.C., INGRAHAM, R.H., MORGAN, E.B., ZERINGUE, L., WILSON, D., BABCOCK, D.K., Relationship between fertility and glucose and cholesterol concentrations in Holstein cows, Am. J. Vet. Res. **45** (1984) 2607-2612.
[71] WEHRMAN, M.E., WELSH, T.H., WILLIAMS, G.L., Diet-induced hyperlipidemia in cattle modifies the intra-follicular cholesterol environment, modulates follicular dynamics, and hastens the onset of post-partum luteal activity, Biol. Reprod. **45** (1991) 514-522.
[72] SPICER, L.J., FRANCISCO, C.C., Adipose obese gene product, leptin, inhibits bovine ovarian thecal cell steroidogenesis, Biol. Reprod. **58** (1998) 207-212.

[73] KWEON, O.K., KANAGAWA, Y., TAKAHASHI, Y., MIYAMOTO, A., MASAKI, J., UMEZU, M., KAGABU, S., IWAZUMI, Y., AOYAGI, Y., Plasma endocrine profiles and total cholesterol levels in super-ovulated cows, Theriogenology **27** (1987) 841-857.

[74] MARUO, Y., SAWADA, T., INABA, T., KONISHI, K., SAITO, N., MORI, J., Relationship between plasma total cholesterol and ovarian response in super-ovulated Japanese Black cows, Jpn. J. Zootech. Sci. **58** (1987) 711-713.

[75] BALAKRISHNAN, M., BHASKAR, B.V., CHINNAIYA, G.P., Total cholesterol concentration in relation to super-ovulatory responses in crossbred cows, Theriogenology **40** (1993) 643-650.

[76] MARIE, M., DELACHARLERIE, P.F., MANCIAUX, L., High glucose and cholesterol blood levels are associated with better embryo collection results in superovulated Montbéliarde dairy cows, J. Reprod. Fertil. Abstr. Ser. **20** (1997) 36.

[77] GARCIA-BOJALIL, C.M., STAPLES, C.R., THATCHER, W.W., SAVIO, J.D., RISCO, C., Effect of dietary protein degradability and calcium salts of long chain fatty acids (CaLCFA) on reproductive performance of lactating Holstein cows, J. Dairy Sci. **75** Suppl.1 (1992) 203.

[78] ZUREK, E., FOWCROFT, G.R., KENNELLY, J.J., Metabolic status and interval to first ovulation in post-partum dairy cows, J. Dairy Sci. **78** (1995) 1909-1920.

[79] GLUCKMAN, P.D., BREIER, B.H., DAVIS, S.R., Physiology of the somatotropic axis with particular reference to the ruminant, J. Dairy Sci. **70** (1987) 442-466.

[80] BREIER, B.H., BASS, J.J., BUTLER, J.H., GLUCKMAN, P.D., The somatotrophic axis in young steers : influence of nutritional status on pulsatile release of growth hormone and circulating concentrations of insulin-like growth factor-I, J. Endocr. **111** (1986) 209-215.

[81] ECHTERNKAMP, S.E., SPICER, L.J., GREGORY, K.E., CANNING, S.F., HAMMOND J.M., Concentrations of insulin-like growth factor-I in blood and ovarian fluid of cattle selected for twins, Biol. Reprod. **43** (1990) 8-14.

[82] WEBB, R., GONG, J.G., BRAMLEY, T.A., Rôle of growth hormone and intra-follicular peptides in follicle development in cattle, Theriogenology **41** (1994) 25-30.

[83] CHASE, C.C., KIRBY, C.J., HAMMOND, A.C., OLSON, T.A., LUCY, M.C., Patterns of ovarian growth and development in cattle with a growth hormone receptor deficiency, J. Anim. Sci. **76** (1998) 212-219.

[84] HERRLER, A., FARRIES, E., NIEMANN, H., A trial to stimulate insulin-like growth factor-I levels to improve super-ovulatory response in dairy cows, Theriogenology **33** (1990) 248.

[85] McCANN, J.P., HANSEL, W., Relationships between insulin and glucose metabolism and pituitary-ovarian functions in fasted heifers, Biol. Reprod. **34** (1986) 630-641.

[86] DORRINGTON, J.H., BENDELL, J.J., CHUMA, A., LOBB, D.K., Actions of growth factors in the follicle, J. Steroid. Biochem. **27** (1987) 405-411.

[87] SIMPSON, R.B., CHASE, C.C., SPICER, L.J., VERNON, R.K., HAMMOND, A.C., RAE, D.O., Effect of exogenous insulin on plasma and follicular insulin- like growth factor I, insulin- like growth factor binding protein activity, follicular oestradiol and progesterone, and follicular growth in super-ovulated Angus and Brahman cows, J. Reprod. Fertil. **102** (1994) 483-492.

[88] HARRISON, L.M., RANDEL, R.D., Influence of insulin and energy intake on ovulation rate, luteinizing hormone and progesterone in beef heifers, J. Anim. Sci. **63** (1986) 1228-1235.

[89] WHISNANT, C.S., KISER, T.E., THOMPSON, F.N., BARB, C.R., Opioid inhibition of luteinizing hormone secretion during the post-partum period in suckled beef cows, J. Anim. Sci. **63** (1986) 1445-1448.

[90] CONNOR, H.C., HOUGHTON, P.L., LEMENAGER, R.P., MALVEN, P.V., PARFET, J.R., MOSS, G.E., Effect of dietary energy, body condition and calf removal on pituitary gonadotrophins, gonadotrophin-releasing hormone (GnRH) and hypothalamic opioids in beef cows, Dom. Anim. Endocrinol. **7** (1990) 403-411.

[91] McSHANE, T.M., MAY, T., MINER, J.L., KEISLER, D.H., Central actions on neuropeptide-Y may provide a neuromodulatory link between nutrition and reproduction, Biol. Reprod. **46** (1992) 1151-1157.

[92] YU, W.H., KIMURA, M., WALCZEWSKA, A., KARANTH, S., McCANN, S.M., Role of leptin in hypothalamic-pituitary function, Proc. Natl. Acad. Sci. U.S.A. **94** (1997) 1023-1028.

[93] WOLF, G., Leptin : The weight-reducing plasma protein encoded by the *Obese* gene, Nutr. Rev. **54** (1996) 91-93.

[94] WEIGLE, D.S., Leptin and other secretory products of adipocytes modulate multiple physiological functions, Ann. Endocrinol. **58** (1997) 132-136.

[95] HOUSEKNECHT, K.L., BAILE, C.A., MATTERI, R.L., SPURLOCK, M.E., The biology of leptin: a review, J. Anim. Sci. **76** (1998) 1405-1420.

[96] DYER, C.J., SIMMONS, J.M., MATTERI, R.L., KEISLER, D.H., Leptin receptor mRNA is expressed in ewe anterior pituitary and adipose tissues and is differentially expressed in hypothalamic regions of well-fed and feed-restricted ewes, Domest. Anim. Endocrinol. **14** (1997) 119-128.

[97] NAGATANI, S., GUTHIKONDA, P., THOMPSON, R.C., TSUKAMURA, H., MAEDA, K.I., FOSTER, D.L., Evidence for GnRH regulation by leptin : leptin administration prevents reduced pulsatile LH secretion during fasting, Neuroendocrinology **67** (1998) 370-376.

[98] AUBERT, M.L., PIERROZ, D.D., GRUAZ, N.M., d'ALLEVES, V., VUAGNAT, B.A., PRALONG, F.P., BLUM, W.F., SIZONENKO, P.C., Metabolic control of sexual function and growth: role of neuropeptide Y and leptin, Mol. Cell. Endocrinol. **140** (1998) 107-113.

[99] BORNSTEIN, S.R., UHLMANN, K., HAIDAN, A., EHRHART-BORNSTEIN, M., SCHERBAUM, W.A., Evidence for a novel peripheral action of leptin as a metabolic signal to the adrenal gland : leptin inhibits cortisol release directly, Diabetes **46** (1997) 1235-1238.

[100] SPICER, L.J., VERNON, R.K., TUCKER, W.B., WETTEMANN, R.P., HOGUE, J.F., ADAMS, G.D., Effects of inert fat on energy balance, plasma concentration of hormones, and reproduction in dairy cows, J. Dairy Sci. **76** (1993) 2664-2673.

[101] JI, S., WILLIS, G.M., SCOTT, R.R., SPURLOCK, M.E., Partial cloning and expression of the bovine leptin gene, Anim. Biotechnol. **9** (1998) 1-14.

[102] CHENOWETH, P.J., Aspects of reproduction in female *Bos indicus* cattle : a review, Aus. Vet. J. **71** (1994) 422-426.

INVESTIGATIONS INTO FACTORS AFFECTING THE REPRODUCTIVE EFFICIENCY OF DAIRY CATTLE IN PERI-URBAN AREAS OF SUDAN

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XA9952122

Abstract

INVESTIGATIONS INTO FACTORS AFFECTING THE REPRODUCTIVE EFFICIENCY OF DAIRY CATTLE IN PERI-URBAN AREAS OF SUDAN.

A survey of the productivity, feeding and fertility of 63 cows from 6 farms and a second survey of 49 cows from 5 farms, including in both surveys one with pure bred Holstein Friesians and the rest with cross breeds, showed that those calving in thinner body condition had significantly poorer subsequent fertility. This implied that nutrition in late pregnancy may be an important determining factor in fertility in dairy cows in the peri-urban areas of Khartoum. Cows calving during the dry season were more at risk. No clear advantages or disadvantages were identified for pure-bred cows. Laboratory analysis of feeds, some assessment of intakes and some blood metabolite measurements suggested that neither dietary protein nor phosphate were constraints. The number of days to first progesterone rise on all farms was not extended and many cows conceived in less than 83 days after calving. Many others did not conceive at all but the number showing no evidence of oestrous cycles was small. Failure to conceive seemed to have been a greater problem than failure to cycle. With 27% of blood samples showing evidence of chronic inflammation through high globulin values, investigations into possible disease causes of poor fertility are needed.

1. INTRODUCTION

Currently the interval between successive calvings is very long in many Sudanese dairy cattle. Furthermore, indigenous cows produce relatively small amounts of milk. With the increasing demand for milk and milk products in urban areas an improvement in reproductive efficiency would provide a useful increase in the production of milk per cow per year, particularly if the daily yield potential was higher as well. The importation of cattle of higher yield potential from temperate parts of the world, particularly of the Holstein Friesian breed, has been widespread in an attempt to achieve this end. Cross breeding with indigenous cattle has been practised but some farms now have pure bred Holstein Friesian herds whose overall productive performance has been questioned. This project was initiated to try and identify factors affecting reproductive efficiency in peri-urban herds around Khartoum, including an attempt at a judgement of the value or risk of using pure bred Holstein Friesians instead of crossbreds.

2. MATERIALS AND METHODS

2.1. Environment

The farms used in this study are located in the semi-arid zone of Sudan. The two major seasons are rainy (July to September) and dry (October to June). The highest temperatures are in the dry season and rise to about 42°C. The lowest are in the wet season dropping no lower than 15°C.

2.2. Animals

In the first survey (Survey 1) six farms were used (identified A, B, C, D, E and F). Herd size varied from 22 to 64 cows. Farm F was excluded in the second survey (Survey 2). One other was recruited but the data collected from it was too sparse to be analysed. Farm E contained 50 pure bred Holstein Friesians only. Cows on the other farms were mainly local zebu cattle cross bred with Holstein Friesians. There were a few pure bred indigenous animals as well. A pure bred Holstein Friesian bull was kept at each farm and used for natural service; however, the time of mating was controlled by the farmer.

2.3. Farm Management

Cows were housed in earth yards with areas of shade from the sun provided by corrugated iron roofing. Farms A and E had areas of concrete for cows to lie on. Milking was by hand twice daily after calves had brief access to their mothers to stimulate milk let-down. After milking calves were left with the cows for approximately 15 minutes. On Farm E calves were not suckled at all but fed entirely from buckets.

2.4. Feeding

Zero grazing was practised in all farms. Fresh green fodder, *Vulgare bichlorr,* was offered when in season, at 2-3 kg/d per 100 kg body weight. When available, green fodder was also purchased in large quantities, stored and fed dry at other times. Otherwise forages consisted of mature pasture and crop residues (wheat straw, sorghum stovers). Water was available freely. Concentrates, consisting of varying mixtures of wheat bran, groundnut cake, cottonseed cake and a concentrate mixture made from by-products of the sugar cane industry, were also offered twice daily in equal amounts. The rate of feeding practised was generally 1 kg/d per 100 kg body weight.

2.5. Measurements

Body condition score (BCS) using the method of Nicholson and Butterworth [1] scoring 1-9 and body weight assessment by heart girth measurement using a graduated band pulled to a tension of 5 kg were carried out at calving and thereafter at 30, 60 and 90 days.

Milk yield was recorded on one day every month after calving. Milk samples were collected weekly from 2-4 weeks after calving until pregnancy was confirmed by rectal palpation. Milk samples were preserved with sodium azide and the milk fat was subsequently removed. The fat-free portion was kept at -20°C until radioimmunoassy (RIA) was carried out for progesterone measurement using the FAO/IAEA Solid-Phase RIA kit [2]. Ovarian cyclic activity was deemed to have started when the first progesterone rise above 2 nmol/L was recorded. Conception was deemed to have taken place at the first of five consecutive results above 5 nmol/L and pregnancy had been confirmed by subsequent rectal palpation.

Once a month the total food offered in a day was weighed and divided by the number of cows having access to it to provide an assessment of average daily fresh weight intake. Representative samples were taken and analysed for dry matter, crude protein and ash content.

A number of blood samples were collected into vacutainers containing lithium heparin anticoagulant, placed immediately in ice, separated at the laboratory, frozen and analysed later for blood metabolites total protein, albumin, urea and inorganic phosphate. Globulin was calculated as the difference between total protein and albumin. Blood and faecal samples were also examined for the presence of parasites.

2.6. Statistical analyses

Pearson Correlation Coefficients were used to look at potential relationships between data in individuals and Student's t-test was used to compare sets of data.

3. RESULTS AND DISCUSSION

3.1. Feeding

Table I shows the approximate feed intakes and chemical composition of the feeds supplied during Survey 1. Total daily dry matter intakes where only one forage was supplied varied from 8.3 kg per cow/d in Farm B to 10.8 in Farm D. On the other farms the proportions of green fodder and sorghum stalks was not consistent from day to day and so an estimate of average dry matter intake was not possible but it was not likely to be outside the above two figures.

TABLE I. AVERAGE COMPOSITION OF FEEDS IN SURVEY 1 AND FRESH WEIGHT INTAKES PER COW/DAY

Farm	Feed type	Dry matter (DM) (%)	Crude Protein (% DM)	Ash (% DM)	Average fresh weight intake of total forages (kg/cow/d)	Average fresh weight intake of concentrates (kg/cow/d)
A	Green fodder	54	7.7	6.6		
	Sorghum stalks	96	5.1	7.0	10	3
	Concentrate-local	96	18.9	5.1		
	Concentrate-imported	95	16.0	6.8		
B	Sorghum straw	97	3.0	6.8	6	2.5
	Concentrate-local	97	18.7	5.1		
C	Green fodder	41	6.6	5.5		
	Sorghum stalks	95	3.7	8.0	9	3.5
	Concentrate-local	97	28.2	5.0		
D	Green fodder	58	8.1	7.5	12	4
	Cotton seed cake	97	23.7	5.2		
E	Green fodder	28	6.8	2.4	8	3.5
	Concentrate-protofeed	98	20.7	12.8		
	Concentrate-imported	97	19.7	9.6		
F	Green fodder	58	6.8	9.7	10	2
	Concentrate	93	21	5.5		

3.2. Body condition score, body weight and milk yield

The overall mean body weight of the cows in Survey 1 declined over the first month of lactation (Table II), the losses being highest on Farm C at an average of 1.5 kg/d and on Farm E at 1.0 kg/d. But mean body weight losses on an individual farm basis were only recorded on three out of the six farms in the first 30 days of lactation, with slight gains on the other three. Mean BCS dropped on all farms except B within one month of calving. At 60 days post calving mean BCS had started to recover on all farms except E - the pure bred Holstein Friesians - where recovery of condition appeared to have started later. By 90 days after calving both body weight and BCS were restoring on all farms. Mean BCS at 90 days after calving exceeded BCS at calving on two farms (A and B) and weight at 90 days exceeded weight at calving on five out of the six farms, raising the possibility that condition loss may take place during late lactation or the non-lactating period before calving on these farms. This is a point of potential interest if BCS at calving is an important factor in subsequent fertility.

TABLE II. AVERAGE BODY WEIGHT, BCS AND MILK YIELD (± SD) IN 63 COWS FROM CALVING TO 90 DAYS POST CALVING IN SURVEY 1

Farm *	Body weight (kg)				BCS				Milk yield (kg/day)		
	calving	days after calving			calving	days after calving			days after calving		
		30	60	90		30	60	90	30	60	90
A (4)	401	411	390	421	6.5	6.0	6.8	7.3	9.7	12.4	12.1
	± 61	± 47	± 6	± 41	± 0.9	±0.7	± 0.4	± 0.4	± 1.8	± 1.1	± 0.8
B (4)	362	367	374	384	5.5	5.5	5.5	6.3	12.5	13.9	14.5
	± 62	± 41	± 43	± 58	± 1.6	±1.7	± 1.1	± 1.5	± 0.6	± 1.3	± 0.9
C (11)	444	400	438	440	7.0	6.5	6.7	6.9	14.5	17.2	17.1
	± 96	± 74	± 78	± 79	± 0.5	±0.8	± 0.8	± 0.7	± 2.8	± 4.2	± 3.9
D (12)	389	396	393	394	6.7	6.0	6.8	6.8	11.2	13.5	13.5
	± 93	± 77	± 75	± 73	± 0.7	±0.5	± 0.4	± 0.5	± 4.9	± 4.7	± 3.9
E (11)	508	479	499	522	6.7	6.5	6.3	6.5	16.6	16.9	16.2
	± 37	± 17	± 128	± 129	± 0.4	±0.5	± 0.4	± 0.7	± 2.3	± 4.5	± 4.6
F (21)	396	389	309	406	7.3	6.6	6.8	7.1	8.8	11.5	11.1
	± 41	± 39	± 37	± 37	± 0.5	±0.6	± 0.6	± 0.6	± 2.0	± 2.0	± 2.5
Mean	499	404	414	429	6.6	6.2	6.4	6.8	12.2	14.3	14.3
(63)	± 68	± 34	± 47	± 58	± 0.8	±0.4	± 0.5	± 0.4	± 3.0	± 2.4	± 2.1

* Number of cows within parenthesis

The Holstein Friesians on farm E produced more milk than the cross bred cows on four farms but only more than on farm C at 30 days after calving. At 60 and 90 days post calving cows on farm C produced more milk than the pure bred cows. This suggests that there may not necessarily be a disadvantage in milk production from using cross bred stock of theoretically lower potential in this part of the country.

Table III shows the data from Survey 2 and presents a broadly similar picture of weight loss in three of the five farms in the first month after calving. Once again farm C showed the greatest change. In this survey BCS loss in the first month was not apparent on any farm but it was notable that the pure Holstein Friesians on farm E were in general, more than one unit of BCS thinner than in Survey 1. Milk yields were again highest on farm C reinforcing the lack of advantage of pure bred cows.

TABLE III. AVERAGE BODY WEIGHT, BCS AND MILK YIELD (± SD) IN 49 COWS FROM CALVING TO 90 DAYS POST CALVING IN SURVEY 2

Farm *	Body weight (kg)				BCS				Milk yield (kg/day)		
	calving	days after calving			calving	days after calving			days after calving		
		30	60	90		30	60	90	30	60	90
A (8)	487	462	460	463	6.8	6.1	6.8	6.7	9.3	10.1	10.5
	± 92	± 77	± 85	± 85	± 0.5	± 0.8	± 0.5	± 0.5	± 2.9	± 3.3	± 3.4
B (3)	472	472	458	478	7.0	7.0	7.0	7.3	6.7	9.0	8.0
	± 37	± 45	± 50	± 52	± 1.0	± 1.0	± 1.0	± 0.5	± 1.5	± 1.7	± 2.8
C (8)	477	442	441	431	6.8	6.8	6.6	6.5	16.8	16.8	17.5
	± 48	± 48	± 50	± 49	± 0.5	± 0.5	± 0.5	± 0.9	± 4.0	± 4.0	± 2.5
D (8)	485	484	481	480	6.6	6.8	6.6	6.6	11.5	11.0	12.1
	± 113	± 115	± 119	± 117	± 0.9	± 0.9	± 0.8	± 0.9	± 2.7	± 2.7	± 2.8
E (24)	498	483	491	497	5.2	5.5	5.4	5.3	5.3	5.5	5.3
	± 99	± 106	± 100	± 103	± 1.0	± 0.8	± 0.9	± 0.8	± 1.0	± 0.8	± 0.8
Mean	485	474	477	478	5.9	5.9	5.9	5.9	14.6	13.8	14.1
(49)	± 63	± 95	± 92	± 95	± 0.9	± 0.9	± 1.0	± 1.0	± 4.9	± 5.1	± 4.5

* Number of cows within parenthesis

In neither survey was it possible to detect any relationship between apparent feeding levels (Table I) and performance (Tables II and III). This was partly due to the difficulty of assessing individual intakes of feed and partly to the variations in feeds used according to price and availability.

3.3. Fertility

3.3.1. Overall Results

The fertility data in Survey 1 is presented by farm in Table IV. Of the 93 cows assessed 12 showed no evidence of ovarian cyclic activity 233 days after calving. Eighty-one showed evidence of progesterone cycles (87%), of which 38 did not conceive (47%). This is 41% of the whole group of 93 cows. As the intervals from calving to first rise in progesterone were quite good in all farms and as calving to conception intervals of those which did get in calf were good with the exception of farm F, failure to conceive seems to have been a more important constraint on fertility than delay of the return to cyclicity or failure to cycle at all. Furthermore, as many cows conceived to their first service less than three months after calving (Table IV - lower end of the range of calving to conception intervals), it is unlikely that failure to conceive was a function of bull infertility. Disease in the cows seems most likely. Mismanagement of service time - i.e. cows inseminated when not in oestrus which can cause this type of problem - is unlikely where natural as opposed to artificial insemination is practised.

In Survey 2, which covered a maximum of 270 days from calving (Table V), calving to the first progesterone rise figures were similar to Survey 1 and also quite good. Seventy four percent showed evidence of ovarian cycles which is a lower proportion. Twenty one percent of these did not conceive. In this survey failure to conceive was most prominent in Farms C and E, the highest yielding, with Farm E the pure Holstein Friesians. Body weight loss after calving was also substantial on these two farms (Table III).

With farm E, the only one where calves were bucket fed, there was no apparent effect of suckling on onset of cyclic activity after calving as cows on the other farms had similar intervals to first progesterone rise in both surveys.

TABLE IV. FERTILITY DATA IN 93 COWS OVER THE SURVEY PERIOD - WITH A MAXIMUM 233 DAYS INCLUDED FOR COWS NOT CYCLING

Farm (number surveyed/herd size)	Mean number of days from calving to first progesterone rise (range)	Mean number of days from calving to conception (range)	Number of cows not cycling during survey	Number of cows showing progesterone cycles	Number of cows not conceiving during survey
A (10/64)	38 (26-56)	77 (63-101)	0	10	3
B (4/25)	46 (12-101)	69 (61-71)	1	3	2
C (11/22)	44 (23-119)	89 (58-112)	1	10	0
D (12/25)	43 (25-62)	100 (70-140)	2	10	5
E (26/50)	42 (17-77)	83 (56-163)	2	24	10
F (30/50)	53 (28-77)	129 (77-154)	6	24	18

TABLE V. FERTILITY DATA IN 57 COWS IN SURVEY 2 OVER A MAXIMUM PERIOD OF 270 DAYS INCLUDED FOR COWS NOT CYCLING

Farm (number surveyed)	Mean number of days from calving to first progesterone rise (range)	Mean number of days from calving to conception (range)	Number of cows not cycling during survey	Number of cows showing progesterone cycles	Number of cows not conceiving during survey
A (8)	30 (15-60)	134 (108-184)	1	7	1
B (3)	48 (37-58)	228[1]	0	3	0
C (8)	44 (26-73)	94 (63-159)	2	6	3
D (8)	49 (18-110)	96 (68-149)	3	5	0
E (30)	47 (13-120)	160 (61-303)	8	22	8

[1] First service was delayed intentionally on this farm for eight months

Statistical significance in fertility data is difficult to achieve without large numbers of cows. Only 63 were available in Survey 1 with full data and 57 in Survey 2. In the hope of identifying the most important influences from BCS and body weight (BW) changes, the following relationships were examined: BCS at calving, BCS and BW changes from calving to 30, 60 and 90 days after calving and milk yield at 30, 60 and 90 days after calving with the number of days to the first rise in milk progesterone, with the number of days to conception and between the number of cows ovulating and not ovulating in a maximum 233 days in Survey 1 and 270 in Survey 2 since calving. BCS at calving was negatively correlated with the number of days to the first detected rise in milk progesterone ($P < 0.05$) in both surveys and the difference between mean BCS at calving in those ovulating and those not was highly significant in Survey 1 ($P < 0.001$), where fewer cows did not cycle, but not in Survey 2 although the trend was the same. With body condition at calving dictated to a large extent by nutrition during the non-lactating period these findings are potentially important because they imply that nutrition in late pregnancy is a critical determining factor in successful fertility in Sudan. This conclusion is similar to findings in Israel [3] and in the UK [4]. Better feeding during late pregnancy to increase BCS at calving may provide considerable productivity gains in Sudan.

Greater body weight loss in the first 30 days after calving was associated with a longer calving to conception interval in Survey 1 ($P < 0.05$) but no statistically significant relationships were demonstrated with BCS or BW change longer into lactation than that. This suggests that, although the failure of nutrition to meet the needs of the cows in early lactation may have had a role in the success of fertility [5], but the influence of feeding at the end of pregnancy appears to have been greater.

There were clear negative relationships between calving to conception interval and milk yield at 30 ($P < 0.01$), 60 ($P < 0.01$) and 90 ($P < 0.01$) days post calving in survey 1. This is difficult to explain as there was no apparent parallel relationship between milk yield and return to ovarian cyclic activity. This relationship is therefore unlikely to have a cause and effect aspect and may be an association only with another single common cause for both parameters. Disease is a possibility. It may have suppressed, on one hand, milk production, and on the other fertility bringing about a delay in conception.

3.3.2. Fertility in pure bred Holstein Friesians (Farm E) and crossbreds

Tables IV and V do not show any clear differences in the fertility performance of pure Holstein Friesians on Farm E by comparison with the crossbreds on the other five farms. In fact the mean interval from calving to onset of cyclicity in Survey 1 (Table IV) was less in Farm E at 42 (± 14.5 sd) days compared to 50.0 (± 18.9 sd) in the others but this was not repeated in the second survey. The mean calving to conception figure was less in the Holstein Friesians too at 83.1 (± 33.0 sd) days compared to 101.4 (± 32.9 sd) in the first set of data but higher in Survey 2. But 25% of the Holstein Friesians (18 out of 72 cows) did not conceive when the two sets of data were taken together. This is a higher percentage than on four of the farms where the crossbreds were in Survey 1. On the fifth farm (farm F), 34% did not conceive and on Farm C neither did three out of eight cows in Survey 2. No safe conclusions can therefore be arrived at over disadvantages from poorer fertility in pure bred Holstein Friesian cows from this small survey.

3.3.3. Fertility in cows calving in the dry and wet seasons in Survey 1

Cows calving in the dry season showed a significant negative correlation between BCS at calving and the number of days to the onset of cyclicity ($P < 0.01$) and the number of days to conception ($P < 0.05$). No such relationships were apparent in cows calving in the wet season. This suggests that pre-calving nutrition in the dry season had a greater effect on fertility. With BCS generally, and on some farms body weight as well, greater at 90 days into lactation than at calving, it is possible that under-nutrition in the dry season in cows in late pregnancy while still milking, as well as during the non-lactating period before calving, may be important. As the weather is dry for the majority of the year, this is a potentially important observation even though there were no significant differences in intervals from calving to onset of cyclicity and to conception between the two groups because the number of cows not conceiving at all during the survey was quite large.

3.4. Blood metabolite results

One hundred and ten blood samples were collected during Survey 1. The results of the analysis for certain metabolites are presented in Table VI. With respect to protein it is interesting that albumin values mostly fell into the optimum range [6] with only 3% being low. This indicates that the vast majority of cows tested maintained satisfactory long term protein status and so implies that dietary protein was unlikely to have constrained productivity to any extent. This fits in general with the crude protein analyses of the concentrates used (Table I). Urea results, which reflect current daily intake of rumen degradable protein and thus can be influenced by short term variations in food availability and individual appetite, were in the optimum range in 76% of samples. Most of the time, therefore, protein intake was adequate. Most of the low urea results occurred in the dry season, when green fodder was less readily available, and in cows tested before calving, when potential appetite was at its lowest.

Nearly all the inorganic phosphate results were within the optimum range. Dietary phosphate intakes were therefore quite adequate.

Over a quarter of the blood samples had high globulin results. Globulin values such as these indicate the presence (now or recently) of some chronic inflammatory disease process [6]. How high the globulin is does not relate either to how severe the condition might have been or how recently before the sampling the disease event took place. Chronic problems such as mastitis, metritis and lameness are the commonest causes of raised globulins in temperate climates [6]. The implication is that one quarter of the cows in the project may have had a disease problem of this type. As the fertility data has drawn attention to the possibility of disease, this is a question which could usefully be investigated further. Lameness and mastitis occur quite commonly on these farms. An assessment of the extent of disease in general and the possible effects on productivity should be carried out. No evidence of blood parasites was found in the samples collected. There was no evidence found of parasites in the faecal samples collected either.

TABLE VI. METABOLITE VALUES IN 110 BLOOD SAMPLES COLLECTED OVER THE SURVEY PERIOD AND THE PERCENTAGE OF VALUES FALLING OUTSIDE THE OPTIMUM RANGES [6]

	Urea (mg/dL)	Albumin (g/dL)	Phosphate (mg/dL)	Globulin (g/dL)
Mean	30.3	3.6	5.6	3.6
(± SD)	(13.1)	(0.50)	(1.1)	(0.49)
% outside	24	9	3	27
optimum range	(below 21.0)	(below 3.0)	(below 4.3)	(above 5.0)

4. CONCLUSIONS

The two surveys have indicated that underfeeding in late pregnancy and the presence of disease are the most likely constraints on fertility in dairy cattle in the peri-urban areas of Sudan. Investigation to identify what diseases are present which may be affecting fertility and to assess the economics of control measures are desirable and perhaps a priority. Dissemination of the information to farmers that improving nutrition in late pregnancy will help with fertility should be carried out, but unless disease is controlled the benefits of initiating ovarian cyclic activity earlier will not be realised. Successful conception in early lactation in considerable numbers of cows tends to rule out bull sub-fertility as a main cause of the failures to conceive. No clear advantage or disadvantage to productivity was derived from using pure bred Holstein Friesians. They may have shorter lives which would mean that they would be less productive in total. Neither dietary inorganic phosphate nor protein were constraints on productivity.

REFERENCES

[1] NICHOLSON, M.J., BUTTERWORTH, M.H., A guide to condition scoring of Zebu cattle, ILCA, Addis Ababa (1986).

[2] PLAZIER, J.C.B., "Validation of the FAO/IAEA RIA Kit for the measurement of progesterone in skim milk and blood plasma", Improving the Productivity of Indigenous African Livestock, IAEA-TECDOC-708, Vienna (1993) 151-156.

[3] MARKUSFELD, O., GALON, N., & EZRA, E., Body condition score, health, yield and fertility in dairy cows, Vet. Rec. **141** (1997) 67-42.

[4] WHITAKER, D.A., SMITH, E. J., DA ROSA, G.O., KELLY, J.M., Some effects of nutrition and management on the fertility of dairy cattle, Vet. Rec. **133** (1993) 61-64.

[5] CANFIELD, R.W. & BUTLER, W,R., Energy balance, first ovulation and effects of naloxone on LH secretion in early post partum dairy cows, J of Anim.Sci. **69** (1991) 740-746.

[6] WHITAKER, D.A., Interpretation of metabolic profiles in dairy cows, Irish Vet. J. **50,** no.8 (1997) 498-501.

IMPROVING THE PRODUCTIVITY OF DAIRY CATTLE ON SMALLHOLDER FARMS IN MZUZU MILKSHED AREA IN MALAWI: CONSTRAINTS AND POSSIBLE INTERVENTIONS

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Abstract

IMPROVING THE PRODUCTIVITY OF DAIRY CATTLE ON SMALLHOLDER FARMS IN MZUZU MILKSHED AREA IN MALAWI: CONSTRAINTS AND POSSIBLE INTERVENTIONS.

A study was carried out in the Mzuzu milk shed area in Northern Malawi, to identify major constraints to dairy cattle production systems prevailing in the area (Phase I) and develop a sustainable feed supplementation intervention (Phase II) based on tree legume leaves of *Sesbania sesban* for increasing milk production. Phase I of the study revealed that the major constraint to increasing productivity was poor nutrition related to the fluctuating supply of quality and quantity of feed. Body weights of cows averaged 301 ± 81.3 kg and ranged from 189 to 550 kg whereas the body condition score (BCS, on 1-9 scale) averaged 5.73 ± 1.35 and ranged from 2.00 to 9.00. Average milk production was 6.1 ± 5 kg/d and ranged from 1.5 to 19.0 kg/d. Post-partum reproductive status varied considerably. Cows consumed 10.6 ± 6.2 kg/day of roughage and 2.96 ± 1.45 kg/day of concentrates. The quality of the feeds was moderate. Roughages contained 1.56 ± 0.12% N while concentrates contained 1.88 ± 0.04% N. Poor reproductive management and prevalence of internal parasites were also identified as constraints.

The intervention (Phase II) based on supplementation with tree legume leaves of *Sesbania sesban* significantly ($P < 0.05$) improved the performance of dairy cows. Cows supplemented with tree legume leaves showed significantly higher body weights (368 ± 65.5 vs 348.7 ± 59.2 kg) and BCS (6.3 ± 0.9 vs 5.3 ± 1) compared to their counterparts receiving a supplement according to the present management practice. Daily milk yields of cows on the experimental diet averaged 8.6 ± 3.2 kg whereas those on control diet averaged 5.4 ± 1.7 kg. Significant differences in milk yields between the two groups of cows could have been due to higher dry matter intake from the supplementary diet. Cows on experimental diet consumed 3.5 ± 1.2 kg of supplementary feed as compared to 2.2 ± 0.7 kg by cows on the control diet.

1. INTRODUCTION

In Malawi, the productivity of dairy cattle is low due to poor nutrition caused by inadequate supply of good quality feed. The situation is worsened by the fact that smallholder farmers have limited resources available for feeding their ruminant livestock. Unlike in developed countries, smallholder farmers in developing countries are unable to select their basal diet according to the requirement for production. The strategy for improving production has therefore been to maximise the efficiency of utilization of the available feed resources in the rumen by providing optimum conditions for microbial growth, and then supplementing to provide dietary nutrients to complement and balance the products of digestion to requirements of the animal.

In Mzuzu milk shed area, like in the two other milk shed areas of Malawi (Lilongwe and Blantyre), the productivity of crossbred dairy cattle is low because of low individual yield and poor fertility. The reasons for the low productivity are complex but include the imbalanced nature of the nutrients that arise from the digestion of the forage resources and other low quality feeds, the incidence of diseases and parasitism and poor reproductive management.

On-station nutritional research has demonstrated the possibility of substantial increases in the productivity of crossbred dairy cattle fed low-quality roughages through small alterations to the feed base. In some cases, these improvements have been demonstrated at the farm level in that milk yields have increased and the reproductive efficiency of these animals has improved [1].

Commercially formulated dairy cattle rations are too expensive for use on smallholder farms in Malawi. Soil fertility is declining at a fast rate and inorganic fertilizers, which can improve soil fertility are also expensive for routine use. Therefore, tree legumes play a multi-purpose role. They provide high quality fodder for animals, fertilizer in the form of mulch, fuel wood, poles and timber for the building trade and shade and shelter from wind for humans.

These studies were therefore conducted to collect baseline information on the existing dairy cattle production systems in the Mzuzu milk shed area in Northern Malawi, through monitoring of feeding practices, milk production, reproduction, body weights and body condition scores for identifying constraints to milk production, and then to develop a sustainable feed supplementation intervention based on tree legume leaves from *Sesbania sesban* for improving productivity.

2. MATERIALS AND METHODS

2.1 Geographical location of smallholder farms

The studies were carried out on smallholder farms belonging to five Bulking Groups (Farmers' Associations) in the Mzuzu milk shed area in Northern Malawi. This area is situated on the Viphya Plateau at an altitude of 1200 m above sea level. Climate is characterized by two distinct seasons, a rainy season commencing in December and ending in May/June and a dry season extending from June to November. The average annual rainfall is 1750 mm of which about 70% falls between December and March. The average minimum temperature is 18 °C, July being the coldest month. The average maximum temperature is 21°C, November being the warmest month. The area is characterized by *Brachystegia* woodland savannah vegetation while the soils which are acidic (pH 5.1) are mostly deep red sandy-clay ferrisols.

The farms involved in the study were located within 20-50 km from Lunyangwa Agricultural Research Station situated at an altitude of about 1342 m above sea level.

2.2. Farm characteristics

The average farm size was 14.6 ± 12.8 ha and ranged from 3.0 to 50.0 ha. Of the total farm size 3.1 ± 2.2 ha was under pasture (range, 1.0 - 20.0 ha) and 4.3 ± 3.2 ha was under food crops (range, 1.0 - 12.0 ha).

The Mzuzu milk shed area is basically agricultural. Major crops grown in the area included food crops such as maize, millet and sweet potatoes, fruits and vegetables. There was also a reforestation programme for planting pine trees. Most of the agricultural activities were performed by family labour (4.8 ± 2.3 workers per household) and the rest by hired labour (2.3 ± 1.8 workers per household).

Farmers in the area kept cattle mainly for milk production. Around 90% of the cattle population were dairy type and the rest were dual purpose type. Friesian x Malawi Zebu crossbred cattle were mainly kept for milk production and steers and Malawi Zebu cattle were kept for beef production. On an average each farmer had 3.5 ± 2.1 dairy cows. Of the total population of cattle kept by farmers in the area, 45.6% were dairy cows, 32.2% heifers, 8.8% bull calves, 2.5% bulls and 10.9% a mixture of steers and Malawi Zebu cows.

Dairy animals grazed for 7.7 ± 1.9 h/day. Cows were milked twice a day and calves were allowed to suckle at each milking, but for a total period of 63.0 ± 34.7 min/d. (range, 3.0-120 min.). They were weaned at 4-5 months of age.

As a result of having few dairy bulls in the area the majority of the cows (60%) were bred by artificial insemination (AI). Around 27% were served by both AI and natural mating and around 13% were served by natural mating only. For natural mating, farmers usually used their neighbours' bulls and sometimes bulls from the Government farms. Although AI was the major method of breeding, its use was limited because of lack of adequate transport for the AI technician and poor record keeping by farmers.

Apart from cattle, other types of livestock kept by farmers included chicken, sheep, goats, doves and ducks.

Land was not a major constraint to agricultural productivity in the milk shed area. The bulk of the roughage fed was natural pastures; cultivated pastures such as Napier (*Pennisetum purpureum*), Rhodes (*Chloris gayana*), Hamil panic (*Panicum maximum*) and Guatemala (*Tripsacum laxum*), crop residues (maize stover, bean haulms and banana leaves) and small amounts of silver leaf desmodium (*Desmodium uncinatum*) formed the rest of the forage. The major concentrates available in the area were maize bran and dairy mash. Salt was usually mixed with maize bran. Since a large proportion of land carried natural pastures, farmers in the area rarely planted improved pastures for the animals. The land tenure system in the area was communal. The natural pastures were communally grazed and therefore, over grazing was a common feature. As a result of this, animals did not have adequate grazing resources during the dry season and the condition of the animals during this period was poor. The majority of the farmers grazed their animals on natural pasture (75%) and the rest (25%) partially stall fed their animals. Animals were housed in loose barns (67.7%), open paddocks (25.8%) or other types of houses (6.5%), e.g. roofed kraals. The open types of housing predisposed the animals to major diseases and parasites, especially during the rainy season when these structures had muddy conditions. Herd health management programmes were practised in the area through a routine de-worming programme for control of internal parasites and spraying with acaricides for control of tick-borne diseases. However, since the drugs were extremely expensive only a few farmers carried out routine disease and parasite control programmes.

2.3. Studies undertaken during the project period

The project had two phases. Phase I, the monitoring phase was aimed at identifying constraints to dairy cattle productivity through monitoring of feeding practices, milk production, reproduction, body weights and body condition scores as well as parasitic egg counts in the faecal samples. Phase II of the study, the intervention phase was aimed at developing a sustainable feed supplementation intervention based on tree legume leaves of *Sesbania sesban* for improving productivity, especially during the dry season.

2.3.1. Collection of baseline data- Phase I

2.3.1.1. Selection of farms and animals

Initially, 32 farms and 115 dairy cows were selected for the study. However, complete data sets were collected using 97 crossbred dairy cows belonging to 27 farms having an average of 3.5 ± 2.1 dairy cows each. These selected farms were assigned numbers and the animals were identified with eartags.

Of the animals that were used in the study, the majority were crosses of Friesian and Malawi Zebu with 75% Friesian blood. The mean parity of the crossbreds was 2.9 ± 2 and the mean body condition score (BCS) was 5.2 ± 1.8 at calving.

2.3.1.2. Sampling procedure and measurements on feeds and animals

The study was conducted over a period of 18 months from September, 1994 to February, 1996. Farms involved in the were visited weekly, but feeds were sampled monthly. A total of 151 feed samples were collected during the study for dry matter (DM), ash, and nitrogen (N) determination [2]. The amount of feed offered per day for each cow was also recorded for the cows that were stall fed during the monthly visits to the farms.

Monthly, body weights (BW) of cows were determined through heart girth measurement using a weigh band, while the body condition score (BCS) of cows were recorded using the 1-9 scale [3]. Daily milk yields were recorded during monthly visits to the farms and milk samples were collected weekly from the cows two months post-partum until pregnancy was confirmed by rectal palpation, for progesterone determination by radioimmunoassay (RIA) [4]. Rectal palpations (45-60 days post-partum) were carried out once a month to establish ovarian status of the cows until confirmed pregnant.

To assess the health status of the cows, faecal samples were collected (2-3 months post-partum) once every 3 months. The parasitic worm eggs were counted using the Faecal Floatation Test (concentrated salt solution) using a scoring scale of 0 = no worm eggs; 1-500 eggs/g of faecal sample = slight infestation; and >500 to 5000 eggs/g of faecal sample = moderate infestation.

2.3.2. Tree legume leaf supplementation - Phase II

2.3.2.1. Experimental farms, animals and feeds

The intervention phase was carried out during the dry seasons of 1996 (June to December) and 1997 (June to October). Cows used were in their second lactation and had calved in June. They were put on the feeding trial 2-3 weeks after calving.

The study involved 32 smallholder farms and 86 crossbred dairy cows. A mixture of tree legume leaves (*Sesbania sesban*) and maize bran was used to prepare a high quality supplement (15% CP) and was fed to the experimental group of cows (47 cows from 16 farms) during the dry season. The control group of cows (39 cows from 16 farms) utilized a mixture of dairy mash (made from soybean, maize, salt and minerals) and maize bran (the present method of supplementation) as the supplement. All cows in both groups received a basal diet of forage *ad libitum*. At the beginning of the trial cows on both control and experimental diets produced 4.6 ± 1.2 kg milk/cow/d. In both cases, the supplements were fed at the rate of 1.0 kg per every 2.5 kg of milk produced per cow/d.

2.3.2.2. Sampling procedure and measurements on feeds and animals

The same protocol and recording procedures that were used for feeds and animals in Phase I were followed. However, in the Phase II of the study, body weights, BCS and milk yields of cows were monitored, as well as post-partum ovarian activity using RIA. Faeces samples were not collected for faecal egg counts.

2.4. Statistical methods

The data collected during Phase I was recorded and stored using data entry forms and files developed by the Animal Production and Health Section, Joint FAO/IAEA Division, using dBase IV application. The descriptive statistics on the data were carried out using the SYSTAT statistical package [5].

Data from Phase II of the study were entered directly into the database in the statistical package SYSTAT and descriptive statistics and t-test for independent groups were carried out to investigate the effects of the supplementary diets on the amounts of supplements fed, body weights, body condition scores and milk yields of the cows.

3. RESULTS AND DISCUSSION

3.1. Phase I Baseline data

Table I shows the amounts of roughages and concentrates consumed and the production characteristics of the cows used in the study.

TABLE I. AMOUNT OF ROUGHAGES AND CONCENTRATES CONSUMED AND PRODUCTIVE CHARACTERISTICS OF DAIRY COWS DURING PHASE I OF THE STUDY

Parameter	Values
Amount of roughages consumed (kg)	10.6 ± 6.2
Amount of concentrates consumed (kg)	2.96 ± 1.45
Body weight (kg)	301 ± 81.3
Body condition score (1 - 9 scale)	5.73 ± 1.35
Daily milk yields/cow (kg)	6.08 ± 5.02

Napier and Rhodes grasses as well as natural pastures were the major roughages available for consumption by the cows. Maize bran fed alone or mixed with dairy mash was the major concentrate offered.

The performance of the cows depended on the availability and the quality of the feeds in the area. The level of milk production was less than expected for crossbred dairy cows with 75% Friesian blood. Presumably, the level of feeding was not adequate for the cows to produce milk to their genetic potential. During the dry season, forages became scarce and were of low quality. The situation became worse during the drier months of the year (e.g. October and November and December to some extent) and the condition of animals deteriorated considerably during this period.

Table II shows the nutritive values of roughage and concentrate samples obtained from the study area during the monitoring period. The feeds were of moderate quality and the quality varied considerably during the year. The roughages tended to have a higher content of nitrogen during the wet months (January to May) compared to the dry months of the year.

TABLE II. DRY MATTER (DM) NITROGEN (N) AND ASH CONTENTS OF ROUGHAGES AND CONCENTRATES SAMPLED DURING PHASE I

Month	Roughages			Concentrates		
	DM	N	Ash	DM	N	Ash
January	91.3 ± 1.6	1.6 ± 1.2	17.6 ± 1.5	90.6 ± 0.9	1.7 ± 0.2	5.6 ± 3.7
February	92.3 ± 1.0	2.5 ± 0.9	12.4 ± 5.3	91.3 ± 0.3	1.9 ± 0.5	5.6 ± 2.6
March	93.3 ± 1.1	1.3 ± 0.1	12.9 ± 2.6	92.7 ± 1.2	1.8 ± 0.6	14.7 ± 1.4
May	94.9 ± 0.4	1.8 ± 0.4	6.8 ± 1.5	92.7 ± 0.6	2.0 ± 0.4	6.3 ± 4.5
June	94.6 ± 0.2	1.3 ± 0.4	9.6 ± 4.2	93.1 ± 0.7	2.0 ± 0.6	6.4 ± 4.9
November	91.1 ± 1.7	1.8 ± 0.8	16.4 ± 4.5	90.6 ± 0.7	1.8 ± 0.3	10.8 ± 7.9
December	90.8 ± 1.0	1.4 ± 0.6	13.1 ± 5.4	90.9 ± 1.9	1.8 ± 0.4	6.4 ± 4.4
Mean	92.3 ± 0.3	1.6 ± 0.1	13.2 ± 0.8	91.9 ± 0.1	1.9 ± 0.04	7.4 ± 0.6

Standard error within parenthesis

Apart from diseases such as those transmitted by ticks, internal parasites were a threat to the animals. The animals were severely infested after calving. Eight major internal parasites were identified from faecal samples collected from the cows during the monitoring period (Table III). Of the eight species of parasites identified, three caused a moderate degree of infestation. Most of these species were roundworms except for *Moniezia* species (tapeworms) and *Coccidia* species which were protozoa. During the monitoring period, a few farmers had access to deworming drugs and they routinely dewormed their animals. However, the majority of the farmers could not afford these drugs due to their the high cost.

TABLE III. MAJOR SPECIES OF INTERNAL PARASITES AND THEIR DEGREE OF INFESTATION IN DAIRY COWS DURING PHASE I OF THE STUDY

Species	Degree of infestation in dairy cows
Gastrointestinal *Strongyolides*	++
Haemonchus contortus	++
Moniezia	++
Trichostrongylus	+
Bunostomum	+
Coccidia	+
Cooperia	+
Strongyloides	+

++, moderate (> 500 to 5000 eggs/g of faecal sample)
+, slight (1-500 eggs/g of faecal sample)

3.1.1 Post-partum reproductive status of the cows

Although milk samples were collected weekly from 66 cows post-partum during the monitoring studies of Phase I, the progesterone data appeared to be inconclusive and therefore they are not included here.

In Mzuzu milk shed area, poor reproductive performance of the cows was also identified as a constraint. Cows had long calving intervals (more than 12 months). This was presumably due to limitation of transport for the AI technician, poor record keeping by farmers, and more importantly seasonal fluctuations in feed availability and quality. The success of a dairy cattle production system depends greatly on the reproductive performance of the herd, since sustained levels of milk production could be obtained only if reproduction is satisfactory. Nutrition is considered to be an important factor affecting cattle performance in the tropics [6].

3.2. **Phase II** Supplementary feeding

The effects of tree legume leaf supplementation on body weight, body condition score, and milk yields of cows during the intervention phase are presented in Table IV.

Tree legume leaf supplementation significantly improved ($P < 0.05$) the performance of dairy cows. Cows that were offered the experimental diet of tree legume leaves produced higher milk yields (8.6 ± 3.2 vs 5.4 ± 1.7 kg) and consumed more of the diet (3.5 ± 1.2 vs 2.2 ± 0.7 kg) compared to cows that were offered the control diet which is the present method of supplementation in the milk shed area.

TABLE IV. AMOUNTS OF SUPPLEMENTARY DIETS CONSUMED, MONTHLY BODY WEIGHTS, BCS AND DAILY MILK YIELDS OF COWS DURING THE INTERVENTION PHASE

Variable	Diets of cows	
	Control group[1]	Experimental group[2]
Amounts of supplements consumed (kg)	2.2 ± 0.7	3.5 ± 1.2
Body weight (kg)	349 ± 59.3	368 ± 65.5
Body condition score (1- 9 scale)	5.3 ± 1.0	6.3 ± 0.9
Milk yields (kg)/cow	5.4 ± 1.7	8.6 ± 3.2

[1], Farmers' present practice of supplementation
[2], Tree legume leaf supplementation
Standard error within parenthesis

Cows on experimental diet had higher body weights (368 ± 65.5 kg) and body condition scores (6.3 ± 0.9) than cows on control diet whose body weights and body condition scores were 349 ± 59.3 kg and 5.3 ± 1.0, respectively.

The nutritive values of the control and the experimental diets are shown in Table V. The experimental diet was of higher quality with 2.39 ± 0.66% N compared to the control diet which contained only 1.4 ± 0.5% N.

The control supplementary diet, the present method of supplementation, consisted of maize bran and dairy mash made from soybean meal, maize bran, salt and minerals. The experimental supplementary diet consisted of maize bran and tree legume leaves. Dairy mash is a commercially formulated, well balanced concentrate containing 15% CP. However because of its high cost farmers tend to add more maize bran reducing its quality. Although only one part of tree legume leaves was mixed with four parts of maize bran, the mixture was of higher quality, containing approximately 15% CP.

The main tree legume leaf used in this study was that of *Sesbania sesban*. Studies carried out at ILCA in Addis Ababa, Ethiopia showed that several *Sesbania* species were excellent livestock feed, both as fresh fodder as well as dried hay [7]. If appeared that dairy mash (CP = 15%) could easily be substituted with dried *Sesbania* as a source of protein (CP = 26%) for lactating dairy cows in Malawi.

TABLE V. NUTRITIVE VALUES OF CONTROL AND EXPERIMENTAL DIETS FED TO COWS DURING THE INTERVENTION PHASE

Feed component	Diets of cows	
	Control diet[1]	Experimental diet[2]
Dry matter (%)	92.9 ± 1.0	91.6 ± 3.7
Nitrogen (%)	1.35 ± 0.5	2.39 ± 0.7
Ash (%)	7.6 ± 3.6	9.8 ± 4.6

[1], Farmers' present practice of supplementation
[2], Tree legume leaf supplementation
Standard error within parenthesis

The tree legume hay supplementation had little influence on first progesterone (P4) rise post partum. Although the sample size of cows on both control and experimental diets was small the P4 results were reliable. Nine cows on the control diet had first P4 rise (>4.0 nmol/L) in 40.8 ± 21.4 days (range, 20-86 days) after calving. On the other hand eleven cows on the experimental diet had first P4 rise in 36.8 ± 9.4 days (range, 21-57 days) after calving. However, the difference between the two groups was not significant.

4. CONCLUSIONS

The results of these studies clearly indicate that nutritional deficiencies were the major constraints to improving productivity of crossbred dairy cattle kept on smallholder farms in the Mzuzu milk shed area in Northern Malawi. Apart from nutritional deficiencies internal parasites and poor reproductive management were also identified as constraints. The farmers' present method of supplementation based on a mixture of dairy mash and maize bran could be substituted with a diet consisting of tree legume leaf hay and maize bran. The use of tree legumes as protein supplements for dairy cattle on smallholder farms in would be a possible nutritional intervention for improving the productivity of these crossbred dairy cattle. Although, the economic impact of this intervention on dairy cattle production and reproduction was not evaluated, tree legumes have obvious advantages. They play a multi-purpose role. A farmer would need to grow 0.1 ha of *Sesbania sesban* trees to supply adequate amount of dry leaf for one animal/year.

ACKNOWLEDGEMENTS

I wish to express my gratitude to the Joint FAO/IAEA Division for funding these studies reported herein under Research Contract No. 7647/RB. Additional funding for these studies was provided by the Ministry of Agriculture and Irrigation of the Government of the Republic of Malawi. The technical inputs provided by Dr. Noble Jayasuriya of Animal Production and Health Section of Joint FAO/IAEA Division and Dr. Dennis Poppi, of the Department of Agriculture, University of Queensland, Australia, are greatly appreciated. I acknowledge the valuable inputs provided by collaborators, Messrs F. Nyondo and H. D. C. Msiska. The services provided by Messrs H. H. Nyasulu, I. L. Chatuwa, A. M. Nyirongo, O. Y. Kanyika, A. Z. K. Soko and J. A. Kumwenda and the co-operation of the farmers involved in the studies are gratefully acknowledged. I am very grateful to Prof. L. A. Kamwanja and his laboratory personnel, especially Mr. A. V. Gondwe of Animal Science Department, Bunda College of Agriculture for carrying out progesterone measurements and the technicians at the Central Veterinary Laboratory of the Department of Animal Health and Industry for analytical work. Special thanks are also due to Mr. O. L. Chirwa for his secretarial services.

REFERENCES

[1] PRESTON, T.R., LENG, RA.A, Matching ruminant production systems with available resources in the tropics and sub-tropics, Penambul Books, Armidale, Australia (1987).

[2] ASSOCIATION OF OFFICIAL ANALYTICAL CHEMISTS, Official Methods of Analysis (13th Edn.), Association of Official Analytical Chemists, Washington D.C. (1972).

[3] NICHOLSON, M.J., BUTTERWORTH, M.H., A guide to condition scoring of Zebu Cattle, ILCA, Addis Ababa, Ethiopia, (1986).

[4] PLAIZIER, J.C.B., "Validation of the FAO/IAEA RIA kit for the measurement of progesterone in skim milk and blood plasma", Improving the productivity of indigenous African livestock, IAEA-TECDOC-708, Vienna, Austria (1993) 151-156.

[5] SYSTAT, SPSS Inc, Chicago, Illinois, USA.

[6] MARTINEZ, N., ESCOBAR, A., LOPEZ, S., COMBELLA, L., GABALDON, L., "Effect of strategic feed supplementation on productive and reproductive performance in dual-purpose cows", Development of feed supplementation strategies for improving ruminant productivity on smallholder farms in Latin America through the use of immunoassay techniques, IAEA-TECDOC-877 (1996) 135-144.

[7] ONIM, J.F.M., SEMENYE, P.P., FITCHUGH, H.A., Small Ruminants in African Agriculture, Proceedings of a Conference held at ILCA, Addis Ababa, Ethiopia (1985).

[8] INTERNATIONAL LIVESTOCK CENTRE FOR AFRICA - ANNUAL REPORT, International Livestock Research Institute, P.O. Box 5689, Addis Ababa, Ethiopia (1988).

IMPROVING THE PRODUCTIVITY OF DAIRY COWS ON SMALLHOLDER FARMS IN MAURITIUS THROUGH STUDIES ON NUTRITION AND REPRODUCTION

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Abstract

IMPROVING THE PRODUCTIVITY OF DAIRY COWS ON SMALLHOLDER FARMS IN MAURITIUS THROUGH STUDIES ON NUTRITION AND REPRODUCTION.

Two phases made up this project. The Phase I was a survey of the reproductive performance of 150 smallholder cows in 3 different climatic areas of the country. Phase II examined an intervention strategy whereby cottonseed cake was introduced into the production system and the effect on milk production and resumption of ovarian activity were monitored. 30 cows were targeted per area. In Phase I, 62, 62 and 80% of the cows resumed ovarian activity by 90 days in the 3 areas, respectively. The overall mean interval from calving to first ovulation was 86 ± 38 days. The average conception rate was only 36% with 2.5 services per conception. The efficiency and accuracy of oestrus detection were 31 and 87%, respectively. In Phase II supplementation significantly increased milk production and was highly cost effective. However, supplementation had no significant effect on the interval from calving to first oestrus. Forty seven, 75 and 85% of the cows resumed ovarian activity by 90 days. Conception rate and late resumption of ovarian activity were clearly identified as 2 major factors affecting the long inter-calving interval. The factors affecting the reproductive performance are discussed.

1. INTRODUCTION

The number of dairy cattle in Mauritius has decreased alarmingly, from about 40,000 in 1973 to 14,000 in 1995. The main causes for this decline have been constraints associated with nutrition and reproduction, drain of labour into the expanding industrial sector, an acute shortage of young breeding stock and reduced availability of farming space due to continued expansion of built-up areas.

Cattle rearing in the village smallholdings in Mauritius is a family business and generally a part-time activity. The small farms consist of 1-4 cows per household. The cows are hand-milked twice a day, generally at about 0530 and 1800 h. All cattle are zero grazed and kept indoors. The stables vary in their construction, from very simple ones built out of poles with a thatched roof to improved ones with concrete walls and a roof of iron sheets.

Due to increasing purchasing power the demand for beef, milk and milk products has been increasing steadily during the last decade. However, the self-sufficiency ratio for fresh milk and beef is only about 5 and 4%, respectively. The Government policy is to increase the level of self-sufficiency in milk and beef production and, accordingly, an attractive package of incentives is offered to existing and prospective dairy farmers.

Prior to the initiation of this project, an on-farm study involving about 90 cows from the 3 climatic zones in the country, dry, humid and super-humid zones, indicated that milk production was on average 6, 8 and 10.5 kg/d, respectively. The interval from calving to resumption of ovarian activity was around 90 days. Animals were fed some protein concentrate during both pre-calving and post-calving periods.

The objective of this study was therefore, to introduce cottonseed cake as a protein supplement into the production system and measure its effectiveness on milk production and reproductive parameters.

2. MATERIALS AND METHODS

There were two phases to the present project. Phase I monitored farms in 3 different climatic regions according to an IAEA protocol to obtain baseline information and Phase II examined the effect of an intervention strategy on milk production and reproductive parameters.

2.1. Sites

Three different geographical sites having different climatic conditions were selected for implementing this on-farm study. They were the Bambous area (dry to sub-humid with an annual rain fall <1250 mm), Rempart area (humid with an annual rain fall between 1250-2500 mm) and Henrietta area (super-humid with an annual rain fall >2500 mm).

There are 2 main seasons in Mauritius. Summer is the rainy season with a mean temperature of 25°C lasting from October to April. Winter is the dry season with a mean temperature of 18 °C lasting from May to September.

2.2. Phase I

Phase I was a survey and therefore there were no controls. Data were collected from over 150 cows from the three regions over a period of 2.5 years. They were recruited to the study as they calved. No supplement was provided by the project. Milk samples were collected weekly for the determination of ovarian activity by the RIA technique. Body condition score (BCS) on a scale of 1-5, and milk production were determined monthly. Fodder intake was measured regularly and the calves were weighed at birth.

2.3. Phase II

In Phase II, cows that had been confirmed pregnant by rectal palpation were selected. Their BCS was determined and the cows were allotted alternately to each of 2 treatments namely, Control, where farmers used their own method of supplementation (no supplement was provided by the project), and Treatment, where cottonseed cake was provided by the project. The cottonseed cake supplement was provided at the rate of 1 kg/d for about 5 weeks before the expected calving date, 3 kg/d during the week after calving and 0.25 kg/L of milk produced thereafter.

It was not possible to have control and treatment animals on the same farm. Therefore, Control farms were different from Treatment farms and each farm constituted an individual experimental unit. Thus, 15 cows were allotted to each of the control and treatment groups in each geographical area.

2.4. Diet

2.4.1. Fodder

During the sugar-cane harvesting season cane tops were fed *ad libitum* together with mixed grasses that were collected from the neighbourhood. During the non-harvesting season mixed grasses, creepers, leucaena and other legumes, some tree foliage and vegetable crop residues were fed.

2.4.2. Concentrate

It is common practice for farmers to feed a locally compounded concentrate, popularly called 'cowfeed' (18% crude protein), to their cows. This is done mostly during the last few weeks of pregnancy and the first few weeks or months of lactation. The practice can be regular or irregular. During this trial farmers continued to feed 'cowfeed' and cows in both treatment groups received some 'cowfeed' through out the experimental period. Cows in the Treatment group also received 15g/d of a mineral mixture, in addition to cottonseed cake.

2.5. Measurements

2.5.1. Animals and feeds

The BCS of the cows, was determined along with the milk yield (mean of 7 consecutive days) once a month. The progesterone level in milk was measured weekly by the radioimmunoassay (RIA) technique. Calves were weighed at birth and thereafter at regular intervals until weaning at 3 months of age. The amount of forages offered and refusals over a period of 24 h were measured during 7 consecutive days in each month. The amount consumed was calculated as the difference between the amount offered and the amount refused. The amount of cottonseed cake that was eaten daily during 7 consecutive days was also recorded.

2.5.2. Chemical composition

Representative samples of forages and concentrates were taken regularly for analysis of dry matter, crude protein and ash by standard procedures.

2.5.3. Other

All samples were collected by 3 research officers assisted by 3 labourers. Supplementary data on type of housing, management practices, heat detection procedure, follow-up on artificial insemination etc. were also recorded.

3. RESULTS

In Phase I, a total of 150 cows were monitored, with 40-50 from each region. During Phase II, milk yield and calf weight were recorded from 70 cows, a lesser number than the target. However, it was possible to collect samples for progesterone measurement in milk from more cows (83), though still short of the target.

Some farmers recruited to the study did not co-operate, especially from the control group where they did not see any tangible benefit from participating in the project. This was particularly so in the Rempart area. Others stopped from participating in the project after some time so that new farms had to be identified and recruited. Another reason for the fewer number of cows in Phase II compared to Phase I was the delay in identifying pregnant cows to start the experiment, which also reflected the long inter calving interval.

3.1. Phase I

The mean DM intake from fodder was 13.6, 15.6 and 15.1 kg for the Bambous, Henrietta and Rempart areas, respectively. The crude protein intake (on DM basis) was 1.52, 1.75 and 1.69 kg, respectively for the 3 areas. The body condition score values were mostly 3 over the duration of the experiment. The mean birth weight of calves was 31 kg (range 24-36 kg). Analysis of faecal samples from cows for parasites showed that the occasional level of infestation did not require any intervention.

3.1.1. Resumption of ovarian activity and ovarian cycles

Ovarian activity was identified when the first progesterone rise persisted for two weeks and was followed by a week of basal values. The results of the sequential progesterone determinations for each cow were plotted. The cumulative percentage of cows resuming ovarian activity after different periods is shown in Table I.

TABLE I. CUMULATIVE PERCENTAGE OF COWS RESUMING OVARIAN ACTIVITY AFTER CALVING

	Region		
Days post calving	Bambous	Henrietta	Rempart
30	18	0	3
60	40	47	16
90	62	80	62
120	88	97	84
Total number of animals	40	30	32

A few cows resumed ovarian activity within 30 days after calving in the Bambous and Rempart areas and there were none in the Henrietta area. The proportion of cows resuming ovarian activity by 90 days was 62% in the Bambous and Rempart areas and 80% in the Henrietta area.

The mean interval from calving to first ovulation for all three regions was 86 ± 38 days as shown in Table II. The values ranged from 30 to 150 days indicating a wide variation in the resumption of ovarian activity. This interval was longer in imported cows than in local animals. All cows showed normal oestrous cycles after resumption of ovarian activity until they were diagnosed pregnant.

3.1.2. Conception rate

The average conception rate and the average number of services per conception was 36% and 2.4, respectively, when all three regions were considered together (Table II). In the Rempart and Henrietta areas the number of services per conception was less (2.2) than in the Bambous area (2.9). For imported cows the conception rate was only 13% and the number of services per conception was 3.6.

3.1.3. Accuracy and efficiency of heat detection.

The individual progesterone profiles for all cows were examined in relation to the dates of heat reported by the farmers. As revealed by progesterone profiles, the average efficiency of oestrus detection was only 31%, and ranged from 29-34% for the three regions. However, out of 164 cases where the farmer had called the A.I. service (i.e. farmer had detected heat), 142 were associated with low progesterone levels, giving an accuracy of detection of 87%. The highest accuracy (94%) was recorded in the Henrietta area (Table II).

TABLE II. REPRODUCTIVE PARAMETERS OF COWS AND THE ACCURACY AND EFFICIENCY OF HEAT DETECTION IN THE THREE CLIMATIC ZONES

Reproductive parameter	Bambous	Henrietta	Rempart	Average	Imported cows
First service conception rate (%)	31	42	45	36	13
Number of services per conception	2.9	2.2	2.2	2.5	3.6
Calving to first P4 elevation (days)	74 ± 36	70 ± 25	84 ± 25	86 ± 38	158 ± 66
Calving interval (months)	15.5 ± 3	15.0 ± 3	14.5 ± 1.5	15.5 ± 3.	17.0 ± 4
Accuracy (%)	80	94	87	87	-
Efficiency (%)	29	30	34	31	-

3.2. Phase II

The BCS was a mean of 3 measurements over the experimental period. Some animals reached 3.5-4.0 but there was no discernible pattern of change. According to the farmers 'cowfeed' was fed at the rate of 0-6 kg/d during lactation in the Bambous and Henrietta regions. The mean intakes were 4.4 and 3.8 kg/d for Bambous and Henrietta areas, respectively. For Rempart, the cows in the Treatment group received 3.0 kg/d of 'cowfeed' while no data could be collected for the control group. The consumption of cottonseed cake was at the allocated levels. The estimated intake of dry matter and crude protein from fodder as well as the percentage of fresh fodder refused are shown in Table III.

TABLE III. ESTIMATED INTAKE (kg/d) OF DRY MATTER FROM FODDER IN THE 3 ZONES

	Bambous		Henrietta		Rempart	
	Treatment	Control	Treatment	Control	Treatment	Control
Dry matter (kg/d)	12.6 (9.7-14.3)	11.3 (9.9-13.8)	14.1 (12.3-16.2)	14.7 (11.9-17.2)	13.6 (13.1-14.5)	- -
Number of data sets (7 days each)	57	16	23	19	60	-
Fodder refusals (% of offered)	4.3	4.7	20.8	19.8	3.6	-

Range within parenthesis

The chemical composition of the feeds used during the intervention period are shown in Table IV. Sugar cane tops were lower in crude protein content than the assorted fodder. 'Cowfeed' had 17% crude protein and appeared to be a good source of nitrogen.

TABLE IV DM CONTENT AND CHEMICAL COMPOSITION (% DM) OF FEEDS

Feed type	DM (%)	Crude protein	Calcium (% DM)	P_2O_5
Cane tops	26.5	7.8	0.43	0.15
Assorted fodder	21.8	11.8	0.37	0.43
Cowfeed	84.2	17.4	1.10	0.9
Cottonseed cake	90.5	41.1	0.17	2.5

Table V shows the average daily milk production, by treatment, month and the area under observation. The number of observations is given within parenthesis.

TABLE V. AVERAGE MILK PRODUCTION (kg/d) OF COWS FROM THE 3 REGIONS OVER A PERIOD OF 4 MONTHS. (VALUES FOR THE FIRST 3 MONTHS HAVE 3 kg/d ADDED TO ACCOUNT FOR MILK LEFT FOR THE CALF TO SUCKLE)

Regions	Months				
	1	2	3	4	Average
Milk production (kg/d) (± SD)					
Bambous					
Control	11.3 ± 1.9 (10)	11.1 ± 2.3 (10)	9.4 ± 1.8 (10)	8.9 ± 2.5 (9)	10.2^{a} ± 2.3
Treatment	13.8 ± 1.7 (16)	13.8 ± 1.7 (16)	13.1 ± 1.8 (16)	12.3 ± 1.2 (16)	13.2^{b} ± 1.7
Henrietta					
Control	11.5 ± 3.1 (15)	12.5 ± 3.0 (15)	14.1 ± 3.0 (15)	14.4 ± 2.8 (14)	13.1^{c} ± 3.1
Treatment	12.4 ± 2.6 (14)	13.7 ± 2.8 (14)	15.8 ± 2.3 (13)	16.5 ± 2.9 (11)	14.5^{d} ±3.0
Rempart					
Control	-	-	-	-	
Treatment	11.0 ± 3.3 (15)	11.4 ± 2.0 (15)	11.5 ± 2.0 (15)	-	11.3 ± 2.4

SD, Standard deviation; figures within parenthesis give the number of observations
a,b, c,d, Values with different superscripts in the same column are significantly different ($P < 0.05$)

Statistical analysis was performed on data from Bambous and Henrietta areas only, as data were inadequate for the Rempart area. Supplementation with cottonseed cake significantly increased milk production and cows in the Henrietta region gave the highest milk yield (Table V).

The average birth weight of calves was 30.6 and 30.5 kg for the Control and Treatment groups in the Bambous region and 38.1 and 38.7 kg for the Control and Treatment groups in the Henrietta region, respectively. This suggested that supplementation with cottonseed cake prior to calving had no significant effect on calf birth weight in both regions. Rempart was not included in this comparison for lack of sufficient data. However, the birth weight of calves between Bambous and Henrietta regions for both Control and Treatment groups was significantly different ($P < 0.05$); Henrietta caves being heavier (38.1 and 38.7 kg) than Bambous calves (30.5 and 30.6 kg).

The intervals from calving to resumption of ovarian activity are shown in Table VI and the cumulative percentage of cows that showed a P4 rise up to 120 days is given in Table VII.

TABLE VI. MEAN INTERVAL (DAYS) FROM CALVING TO RESUMPTION OF OVARIAN ACTIVITY OF COWS IN BAMBOUS AND HENRIETTA REGIONS

	Treatment	Control	Total
Bambous			
number of cows	15	9	
mean interval	111 (± 49)	88 (± 21)	103^{a} (± 41)
range	26-227	59-124	
Henrietta			
number of cows	14	12	
mean interval	68 (± 31)	62 (± 33)	65^{b} (± 31)
range	39-152	22-140	
Rempart			
number of cows	12	12	
mean interval	71 (± 38)	67 (± 28)	69^{b} (± 32)
range	23-140	43-136	

SD within parenthesis

a,b, Values in the same column with different superscripts are significantly different ($P < 0.05$)

TABLE VII. CUMULATIVE PERCENTAGE OF COWS SHOWING OVARIAN ACTIVITY FROM 30-120 DAYS IN THE THREE CLIMATIC REGIONS

	Bambous		Henrietta		Rempart	
Days	Treatment	Control	Treatment	Control	Treatment	Control
30	6.5	0	0	8.3	8.3	0
60	13	11	50	67	50	42
90	40	55	86	83	67	83
120	60	89	93	92	83	92
Total Number of cows	15	9	14	12	12	12

4. DISCUSSION

4.1. Phase I

4.1.1. Resumption of ovarian activity, ovarian cycles and accuracy and efficiency of heat detection

The study has shown that the time taken for resumption of ovarian activity after calving (86 ± 38 days) is long. It is in contrast with other studies elsewhere [3, 4] which have reported a range of 25-30 days. Ovarian activity in Holstein cattle raised in the tropics has been found to be as early as 20 days post-partum [5]. On the other hand our data tend to agree with many other studies carried out under African conditions [6-8]. The delay in resumption of ovarian activity in our study could have been due to two major factors, suckling and poor nutrition. It is well known that suckling [9-11] and poor nutrition during 2-3 months before calving and early post calving periods [5, 12, 13] could delay the resumption of ovarian activity.

In our study most of the cows were suckled twice daily and the calves were tied close to the dam. It can be surmised that this management practice has an influence on the resumption of ovarian activity. The BCS of most cows was in the range of 3-4 at calving, indicating that the cows were probably adequately supplemented during the last 2-3 months before calving. Butler *et al* [14] reported that energy balance during the first 20 days of lactation is important in determining the onset of ovarian activity. It is therefore postulated that the cows in the study were not in a favourable energy balance during post-partum period to allow them to resume ovarian activity. Hence it is suggested that these two factors, either alone or in combination, may have caused the long delay in resumption of ovarian activity.

The general patterns of progesterone levels determined throughout the oestrous cycle, and the oestrous cycle length (21 ± 3 days) are in accordance with data available for cattle in the tropics [15]. Once the cows started to cycle they continued to show a normal oestrous cycle until conception. These observations also suggest that there were no major factors inhibiting cycling once the cows had resumed ovarian activity.

The results revealed that many ovulations were missed both before and after service. However, the problem is more acute after the cow has been inseminated, because the calving interval will be increased by 21 days for every heat lost. This problem might be related to the misconceptions of the cow-keeper who has been made to understand that he/she should wait for three months after calving or unsuccessful insemination before inseminating his/her animal again. This is presumably why cow-breeders pay less attention to the detection of returns to heat after calving or first insemination. Some heats are undetected because they occur when the farmer is not at home or busy with household activities while others are missed because the farmer is not able to call the AI service in time. Although the cow-keepers miss a number of ovulations, the results show that the farmers are accurate when heat detection is reported. In 87% of the cases, AI was done when the progesterone levels were low indicating that the cow was most likely to be on oestrous.

4.1.2. Conception rate

The conception rate registered in the study was 36% (Table II), where as elsewhere in the tropics rates in the range of 63-71% have been reported [15]. The reasons for this low conception rate in Mauritius could be related to factors such as the accuracy of heat detection, fertility of the cow, timing of insemination, semen quality and inseminator technique [16].

Although the study has shown that in 87% of the cases AI was done when progesterone level was low, it is not possible by this technique of milk progesterone assay to know exactly whether the cow was inseminated at the optimum time of the heat. Since the study has shown that the farmer was accurate in detecting heat when the AI service was called and the cows were fertile, it is inferred that an incorrect timing of insemination may have contributed to this low conception rate. Although other factors such as unfavourable environmental conditions (high ambient temperature, humidity etc.) could have been involved, the data suggests that the major contributory factors were problems associated with the AI service.

4.2. Phase II

Table III shows that in the Henrietta area (super-humid) cows consumed the highest amount of dry matter from the forages. They also consumed cottonseed cake during the supplementation programme. However, the data regarding 'cowfeed' consumption, which were stated by the farmers and could not be verified, may not be reliable. With respect to fodder quality Table III shows that the Henrietta cows, under both Control and Treatment groups, had a greater opportunity to select from the fodder that was offered to them. This was reflected in the high refusal rates by both groups. In the other areas however, refusals were less than 5%. Similar data have been recorded by Boodoo *et al* [2] in a previous on-farm trial. The better nutrition of the Henrietta cows perhaps explains their higher milk production (Table V) as well as the higher calf birth weights.

Statistical analysis showed that there was no significance difference between the Treatment and Control groups in the number of days from calving to P4 elevation in all three regions. However, there was a significant difference in the number of days from calving to P4 elevation ($P < 0.05$) between the 3 regions, Bambous showing a longer interval than Henrietta or Rempart (Table VI). 94% (74 out of 79) of the cows in the trial were cycling within an overall mean interval of 79 (± 39) days after calving. As the trial had to be stopped prematurely no data are available for intervals from calving to conception. The long interval to resumption of ovarian activity however, needs attention but once ovarian activity started the animals appeared to cycle regularly. In Phase I, a slightly longer interval (86 ± 38 days) from calving to first P4 rise was observed and the inter calving interval was 15.5 ± 3 months. The percentage of cows resuming ovarian activity by 90 days was 62 in the Bambous and Rempart areas and 80 in Henrietta. Where as in Phase II the corresponding values are 47, 75 and 85, respectively. A decrease was observed in the Bambous area where as the values have changed only slightly for the other 2 areas.

The conception rate from AI in Phase II could be assumed to have remained similar to that of Phase I as no change was made to the AI procedure. The long inter calving intervals that continue to prevail can therefore be attributed to the long period from calving to resumption of ovarian activity and the poor conception rate to A.I. once cows started cycling. This did not appear to be related to heat detection, the accuracy of which was high at 87% [1], but rather to failure to conceive. The supplementation with cottonseed cake as used here did not reduce the time to P4 rise. Unfortunately, the BCS was not conducted sensitively enough to elucidate if this was involved.

There was no change in BCS throughout the intervention period. Animals were categorized as 3 or 4 rather than 3 + or - 4 etc, and this may have masked the changes that were occurring. So the results should be interpreted with caution. However, they do indicate that animals were in an appropriate body condition and that there were no marked changes over the experimental period. The treatment significantly increased milk production by 11-30% (Table V). With the cost of cottonseed cake this accounted for a 2:1 return and was therefore economical.

5. CONCLUSION

This study has shown that there are long inter-calving intervals and moderate levels of milk production in Mauritius, the latter reflecting the moderate levels of nutrition from the local feed sources. The time to onset of oestrous was long but conception was clearly identified as a major factor in the long inter-calving interval and appeared related to the A.I. service. Supplementation with cottonseed cake had a major effect on milk production, which was cost effective, but it had no effect on time to first oestrous.

REFERENCES

[1] BOODHOO, K., TOOLSEE, P., RANGASAMY, M., MOONEERAMSING, M., BOODOO, A.A., "An assessment of the reproductive performance of smallholder dairy cows using the milk progesterone radioimmunoassay technique", Annual Meeting of Agricultural Scientists, Food and Agricultural Research Council, Mauritius (1997).

[2] BOODOO, A.A., RAMJEE, R., HULMAN, B., DOLBERG, F., ROWE, J.B., "The effect of supplementation of cowfeed and cottonseed cake on milk production in Mauritian villages", Milk and Beef Production in Mauritius, Proceedings of a Seminar organised by the Ministry of Agriculture, Fisheries & Natural Resources and The United Nations Development Programme, Mauritius (1988).

[3] BULMAN, D.C., LAMMING, G.E., Milk progesterone levels in relation to conception, repeat breeding and factors affecting acyclicity in dairy cows, J. Reprod. Sci. Fertility **54** (1978) 447-458.

[4] McCLEOD, B.J., WILLIAMS, B.E., Incidence of ovarian dysfunction in post-partum dairy cows, Veterinary Record **9** (1991) 121-124.

[5] SHARPE, P.H., KING, G.J., Post-partum ovarian function of dairy cows in a tropical environment, J. Dairy Sci. **64** (1981) 672-677.

[6] MUKASA-MUGERWA, E., TEGEGNE, A., KETEMA, H., Patterns of post-partum oestrus onset and associated plasma progesterone profiles of cows in Ethiopia, Anim. Reprod. Sci. **24** (1991) 73-84.

[7] KASSA, T., TEGEGNE, A., "Reproductive performance of the indigenous Zebu and Friesian Zebu crossbred cows under smallholder management conditions in Ethiopia", Studies on reproductive performance of cattle in African regions, IAEA-TECDOC-708, Vienna (1993) 113-120.

[8] KANUYA, N.L., NKYA, R., KESSY, B.M., "Reproductive performance of Tanzanian mpwapwa cattle at puberty and post-partum", Studies on reproductive performance of cattle in African regions, IAEA-TECDOC-708, Vienna (1993) 49-58.

[9] PETERS, A.R., LAMMING, G.E., Lactational anoestrous in farm animals, Oxford Rev. Reproductive Biol. **12** (1990) 254-288.

[10] SHARIFUDDIN, W., JAINUDEEN, M.R., AZIAZUDDIN, K., "Monitoring reproductive performance of cross bred dairy cattle on smallholder farms in Malaysia", Studies on the Reproductive Efficiency of Cattle Using Radioimmunoassay Techniques, Panel Proceedings Series, IAEA, Vienna (1990) 35-44.

[11] WILLIAMS, G.L., Suckling as a regulator of post-partum rebreeding in cattle. A review, J. Anim. Sci. **68** (1990) 831-852.

[12] PETERS, A.R., Reproductive activity of the cow in the post-partum period. I Factors affecting the length of the post-partum acyclic period, Br. Vet. J. **140** (1984) 74-84.

[13] BUTLER, W.R., SMITH, R.D., Interrelationships between energy balance and post-partum reproductive function, J. Dairy Sci. **72** (1989) 767-787.
[14] BUTLER, W.R., EVERETT, R.W., COPPOCK, C.E., The relationships between energy balance, milk production and ovulation in post-partum Holstein cows, J. Anim. Sci. **53** (1981) 742-752.
[15] GALINA, C.S., ARTHUR, G.H., Review of cattle reproduction in the tropics Part 4: Oestrous cycles, Anim. Breeding Abs. **58** (1990) 899-925.
[16] ESSELMONT, R.J., Measuring dairy herd fertility. Vet. Record **131** (1992) 209-212.
[17] GALINA, C.S., NAVARRO-FIERRO, R., "Genotype and Environment interactions in cattle in the tropics", Isotope and Related Techniques in Animal Production and Health. Proceedings of a Symposium, IAEA, Vienna (1991).

DRY SEASON SUPPLEMENTATION OF DAIRY COWS WITH UREA MOLASSES MINERAL BLOCKS AND MOLASSES–UREA MIX IN THE MOROGORO REGION IN TANZANIA

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Abstract

DRY SEASON SUPPLEMENTATION OF DAIRY COWS WITH UREA MOLASSES MINERAL BLOCKS AND MOLASSAS-UREA MIX IN THE MOROGORO REGION IN TANZANIA.

The effects of supplementation with urea molasses mineral blocks and molasses-urea mix during and immediately prior to the dry season on the production of dairy cows were studied on-station and on small holder peri-urban farms near Morogoro, Tanzania. Supplementation of on-station cows receiving *ad libitum* grass hay and 6 kg/d of maize bran with urea molasses mineral blocks (UMMB), increased milk production from 6.7 L/d to 11.2 L/d ($P < 0.05$) and dry matter intake from 10.1 kg/d to 12.0 kg/d ($P < 0.05$), but did not significantly affect milk composition, intake of hay and live weight change. This increase in milk yield is mainly explained by increased intakes of energy and nitrogen. Supplementation with the molasses urea mix increased daily milk yield from 6.7 L/d to 8.8 L/d ($P < 0.05$), but did not significantly affect the other measured production parameters. The on-farm supplementation with blocks increased daily milk yield by 1.7 L/d in the dry season ($P < 0.01$). This supplementation did not increase milk yields prior to the dry season, since quality forage was still available. Taking the production costs into account, supplementation with the blocks and supplementation with molasses mix was cost effective if milk yields increased by 0.7 L/d.

1. INTRODUCTION

A major constraint on the production of dairy cows on small holder farms throughout the tropics, especially during the dry season, is that the roughage feeds provided are unbalanced in terms of energy, protein, minerals and vitamins. Also, they are lignified, and their digestibility is low [1]. This limits feed intake, rumen fermentation and productivity. The use of poor quality forages can be improved by satisfying the requirements of the rumen microorganisms to ensure efficient fermentation of fiber resulting in an increased production of fermentative outputs [2-4]. This can be achieved by providing a supplement of fermentable carbohydrates, nitrogen and minerals combined with a small amount of nutrients that bypass the rumen [1, 4]. Mixtures of molasses, a nitrogen source, e.g. chicken litter, urea or urine, carbohydrates and minerals are used as such supplements. Supplementation with such a mixture can increase the intake of poor quality forages by up to 40% [4-6].

The urea molasses mineral mixture is normally prepared in a block form, and referred to as Urea Molasses Mineral Blocks (UMMB). Advantages of these blocks over supplementation with the individual components are that they are easy to handle and use, and that urea can be well mixed and incorporated, thus avoiding toxicity problems. In addition, they are palatable due to the taste and smell of molasses [4].

Supplementation of UMMB to cows and buffaloes fed a basal feed of cereal straw, lignified grass and/or maize stover has shown to increase milk yields and reduce feed costs of cows and buffaloes in India [7, 8], Indonesia, [9], Pakistan [10] and Bangladesh [11]. If good quality forages can be provided, then the increase due to the provision of UMMB is limited [4, 9]. UMMB have been used in Tanzania, but this is not well documented. In the Tanga region the use of these blocks on smallholder dairy farms resulted in a non-significant increase in milk production of between 0.2 and 1.1 L per cow/day [12]. The use of a liquid molasses urea mix (MUM) resulted in increased intakes of poor quality forages and increased milk production on smallholder dairy farms in the Kilimanjaro region of Tanzania [13]. The dry season in Morogoro, Tanzania, can extend from May to November, and a second dry period commonly occurs in January and February. The use of UMMB during the dry season could increase milk production in smallholder farms in this region.

The objectives of this study were to, i) investigate the effect of supplementation with UMMB and MUM during the dry season on productivity of dairy cows in Central Tanzania in a controlled study on-station, ii) conduct a cost/benefit analysis of supplementation with UMMB and MUM and iii) to introduce and investigate the effect of supplementation with UMMB during the dry season on productivity of dairy cows in peri-urban smallholder dairy farms in Central Tanzania.

2. MATERIALS AND METHODS

2.1. Preparation of MUM and UMMB

The composition of the MUM and the UMMB used are given in Table I. For the preparation of the UMMB the cold process described by Sansoucy *et al.* [4] was used with the modification that the content of maize bran was increased and that of molasses was decreased in order to obtain sufficient hardness of the blocks. Next, to these components fertilizer grade urea, lime stone, salt and bone meal were included. Cement was used as a binder to solidify the blocks. All solid components were mixed by hand. The salt was ground and mixed with water. The water and salt mixture was added to the molasses. The liquid mixture was added to the solid mixture, and mixed thoroughly by hand. The resulting mixture was transferred into wooden molds (0.25 m x 0.2 m x 0.2 m) and pounded with wooden poles until satisfactory consistency was obtained. Following this, the blocks were removed from the molds and air dried for at least two days.

TABLE I. COMPOSITION OF MUM AND UMMB (% INCLUSION BY WEIGHT)

Component	MUM	UMMB
Molasses	80	28
Urea	3	9.3
Limestone	0	4.6
Cement	0	13
Salt (NaCl)	0	2.3
Bone meal	3	2.3
Maize bran	0	33.5
Water	14	7

2.2. On-station trial

The study was conducted at the Magadu Dairy Farm of the Sokoine University of Agriculture in Morogoro between July 11 to August 29, 1997. The experiment involved 15 dairy cows, which were crosses between non-indigenous breeds, including Friesian, Ayrshire and Jersey. The average live weight of these cows was 390 (± 10.9) kg. They ranged in body condition score from 2.5 to 3.5 with an average of 2.9 (± 0.12) on a scale 1-5 according to Edmonson *et al.* [14].

Cows were blocked according to milk yield prior to the experiment and randomly assigned to three treatments namely, supplementation with UMMB or MUM, and a control. All cows received grass hay (*Urochloa mosambicensis*) twice daily *ad libitum* after each milking. At each milking all cows received 3 kg of maize bran. Cows in the UMMB group received a maximum of 2 kg of UMMB/day. This was achieved by providing a quarter of a block weighing between 1.7 and 2.4 kg after each morning milking. Cows in the MUM group received 1 L of MUM mixed with grass hay after each milking.

Cows were milked twice daily around 0700 and 1700 h. Milk yields were determined daily for each cow at both milkings. Milk fat and protein contents were determined weekly by the Gerber method and by Kjeldahl method using a Kjeltec system 1002 (Tecator AB, Hoganas, Sweden), respectively, in samples collected during an afternoon milking. Live weight was measured weekly using a weighing scale. Intakes of hay (or hay mixed with MUM) were determined daily for all cows.

Feed samples were analyzed for dry matter (DM) by drying them to constant weight in an oven at 60°C for 48 h. The samples were then ground. Nitrogen (N) and ash contents were determined by standard procedures according to AOAC [15]. Acid detergent fiber (ADF) and neutral detergent fiber (NDF) were determined according to the methods described by AOAC [15] and Goering and van Soest [16], respectively. Minerals elements Ca, P, Na, K, and Mg were analyzed using inductively coupled plasma spectroscopy [15] using a Perkin Elmar Optima 3000 spectrophotometer.

Rumen degradability of grass hay and maize bran were measured using the nylon bag technique [17] in the rumen of a non-lactating Holstein Friesian cow and a Hereford steer fitted with permanent rumen cannula. Both animals were being fed grass hay *at libitum*. The curve fitting was carried out using the SAS Nonlinear regression procedure [19].

The N content in the non-degraded feed was determined with a Leco Nitrogen/Protein Determinator FP 428 (St. Joseph, MI, USA) using the Dumas method [15].

The first week of the trial was regarded as an adaptation period to the diets. Analysis of variance was carried out using the SAS General Linear Models procedure with the repeated measurement statement [19]. Treatment means were compared using Duncan multiple range tests at the 5% level of significance [20].

2.3. On-farm trial

The trial was conducted between July 5 and September 27, 1997, and included 37 cows kept on 14 peri-urban dairy farms around Morogoro. Each farm had between two and four dairy cows. Cows were of the Friesian or Ayrshire breed or crosses between these and other non-indigenous breeds. The average live weight of the cows was 315 ± 9.1 kg, and body condition scores ranged between 2 and 3.5 (± 0.1) (scale 1-5). Farms were blocked by geographic location and randomly assigned to treatments. The design consisted of five blocks. Treatments included the provision of UMMB and control. UMMB were provided to the farmers as from July 22. Farmers were asked not to alter existing feeding practices with the exception that farmers receiving UMMB were requested to feed a maximum of 2 kg of block/day (a quarter of a block) individually to all lactating cows.

Animals were milked twice daily. Milk yields at all milkings were recorded by the farmer or the farm assistant. Live weights were recorded every 2 weeks using a weighing tape. Forage and supplement samples were collected twice a week from one farmer per geographic location chosen at random. Feed samples were analyzed for DM, N, NDF, and ADF as described in the on-station trial. Farmers were visited at least weekly to monitor the implementation of the protocol and scrutinize the data recording.

Production data were averaged for each cow before the introduction of the blocks, after the introduction of the blocks, and between August 27 and the end of the trial on September 27. Statistical analysis was conducted with these averages using the SAS General Linear Models procedure [19] using the average milk yield before the introduction of the blocks as a covariate.

3. RESULTS AND DISCUSSION

3.1. On-station trial

The chemical composition of the feeds used in this trial is given in Table II. The grass hay used in the trial had a CP content of 5% and ADF and NDF contents of 39.8 and 73.4%, respectively. Net Energy lactation (NEl) values of the feeds were not measured. For the grass hay the NEl value of Pangola grass (sun cured, 43 - 56 days growth, containing on dry matter basis, 5.5% CP, 77% NDF and 46% ADF) was used [21]. For the maize bran the NEl value of hominy feed given by FAO [22] was used, as this was thought to give the best available estimate for the maize bran used in this study. The NEl values of UMMB and MUM were estimated on the basis of the NEl values of their components.

TABLE II. CHEMICAL COMPOSITION OF FEEDS USED IN ON-STATION STUDY

Feed Material	DM (%)	N	ADF	NDF	Ash	Ca	P	K	Mg	Na	NEl
		(% DM)									
Grass hay	88.3	0.8	39.8	73.4	7.3	0.27	0.18	0.87	0.15	0.02	0.9[a]
Maize bran	90.9	1.8	7.2	30.1	2.4	0.01	0.63	0.81	0.29	0.01	1.7[b]
UMMB	93.0	6.0	3.6	9.4	25.2	8.56	0.92	1.57	0.34	1.02	1.0
MUM	60.3	1.9	0	0	*	0.58	0.28	1.74	0.24	3.40	1.5

*, Not determined; NEl, Mcal/kg DM
[a], Value estimated from NRC [21]; [b], value estimated from FAO [22]

The rumen degradability characteristics of the grass hay and the maize bran are given in Table III. The rumen degradability of the maize bran was high, and only slightly lower than the 94.6% DM degradability after 48 h reported by FAO [22] for corn grain. The rumen degradability of the grass hay was very low, the potential degradability was only 48.3 %. This was lower than all the potential degradabilities for Tanzanian forages reported by Shem *et al.* [23], and in the range of the rumen DM degradabilities reported by FAO [22] for straws. The 48 h rumen degradability of N in the grass hay was very low. That of the N in the maize bran was high at 80.9% and close to that reported by FAO [22]. The low CP content of the grass hay combined with its very low rumen degradability highlight the extreme importance of supplementation with N during the dry season.

TABLE III. RUMEN DEGRADABILITY CHARACTERISTICS OF FEEDS

	Feed	
	Grass hay	Maize bran
A + B (%)	48.3 (1.9)	91.5 (1.0)
B (%)	35.6	
c (h^{-1})	0.034 (0.02)	0.056 (0.004)
24 hr degradability DM	32.6	75.8
48 hr degradability DM	41.4	87.4
48 hr degradability N	12.6	80.9

The group averages for production parameters are given in Table IV. This table shows that supplementation with UMMB and MUM resulted in substantial increases in milk production (P <0.05) of 4.5 L/d and 2.1 L/d, respectively, but that live weight changes were not affected. The UMMB group had a significantly higher average milk production than the MUM group (P <0.05). The milk fat content of the UMMB group was lower than that of the other groups, but this was not significant. Milk protein levels were not affected by treatment.

TABLE IV. GROUP AVERAGES FOR PRODUCTION PARAMETERS AND LEVELS OF SIGNIFICANCE (P)

Parameter	UMMB	MUM	Control	P
Milk yield (L/d)	11.2^{a}	8.8^{b}	6.7^{c}	0.0001
Milk fat (%)	2.7	3.2	3.1	ns
Milk protein (%)	2.6	2.7	2.7	ns
DMI (kg/d)	11.9^{a}	10.4^{b}	10.0^{b}	0.01
Weight change (kg/d)	0.29	0.23	0.15	ns
Hay intake (kg DM/d)	4.9	nd	4.6	ns

Means within a row with no common superscripts are significantly different (P <0.05)
nd, Not determined as MUM was mixed with hay
ns, Not significant

The cows receiving UMMB consumed on average 1.6 kg DM of block per day. Hence, supplementation with UMMB, without consideration of a possible effect on the intake of hay, increased the intake of NEl and N by 1.6 Mcal/d and 96 g/d, respectively. This increased intake of macro-nutrients could result in an increase in milk yield (3% fat) of 2.5 kg/d [21], provided other nutrients did not limit the response. Hence, the increased milk production due to the supplementation with UMMB is mainly explained by the increased intakes of energy and nitrogen. The cows receiving MUM received on average 1.15 Mcal/d and 22 g N/d with the mix. Supplementation with MUM could, therefore, without consideration of the possible effect on the intake of hay, result in an increase in milk production (3% fat) of 1.8 kg/d [21]. Hence, the increased milk production by cows receiving MUM is also mainly explained by increased energy and nitrogen intakes.

The average milk production prior to the experiment was 13.3 kg/d. Hence, all cows, including those receiving UMMB dropped in milk yield during the trial. This was expected, as the study was to simulate a dry season feeding scenario on small holder farms, which required that less supplements and a much poorer quality base feed was provided than what was common on the Magadu dairy farm.

The UMMB fed cows had a significantly higher dry matter intake (P <0.05) than the control and the MUM cows. This was due to the intake of blocks, as the intake of hay was not significantly different between the UMMB and the control group. This is not in agreement with Sansoucy *et al*. [4] Badurdeen *et al* [5], and Rafiq *et al.* [6] who observed increase in the intake of poor quality forage due to the supplementation with UMMB. This can be explained by the better quality of the grass hay compared to the forage used by these authors and the provision of the maize bran. The maize bran would have provided at least some of the requirements for microbial fermentation, so that the impact of supplementing UMMB was not as great as that observed by the other authors where the only feed supplement provided consisted of these blocks. MUM did not result in an increase in intake of DM.

The animals in the control group, which only received grass hay and maize bran, had intakes of Ca and Na of 20.0 and 1.6 g/d respectively. The requirements for these animals based on their level of production (Table III) and maintenance requirements [21] were 35 g/d and 22.8 g/d, respectively. Hence, these cows were deficient in these minerals. However, signs of such deficiencies were not observed during the experiments. The P, K, and Mg intake of the animals in the control group were 44, 91, and 24 g/d, respectively, which were equal to or slightly higher than NRC [21] requirements. The UMMB had a much higher Ca and Na content than the hay and maize bran, and supplementation with these blocks will have removed the deficiencies in these minerals. Due to the inclusion of limestone and cement in the UMMB, the Ca content of the blocks was high (8.6% on DM basis). However, due to its source, the availability of this Ca would have been very low. Supplementation with MUM alleviated the Na deficiency, but did dot entirely remove the Ca deficiency.

3.2. On-farm trial

The chemical composition of the forages fed in the smallholder farms were similar to those used in the on-station trial (Table II), with a low crude protein content and high ADF (47.5-58.5) and NDF (67.6-71.4%) contents. At the beginning of the trial this basal feed consisted mainly of grass, where as towards the end of the trial it consisted mainly of maize stover. The average CP content of these feeds was 9.0% on DM basis in the second week of July, but this dropped to 3.1% in late September. In all farms cows received a supplement on top of the basal feed. Supplements included maize bran, brewer's spent grain, cotton seed cake, and rice polishings. The amount of supplement given depended on availability, price and preference of the farmer, and therefore, it was not possible to accurately record the amounts of supplements fed.

The average milk yields for the farms using UMMB and the control farms are given in Figure 1. Prior to August 27, there was no significant difference in milk yield between UMMB and control farms. However, during the last month of the trial, i.e. between August 27 and September 27, UMMB farms on an average had 1.7 L/d (P <0.01) higher milk production than the control farms. The average weight increase of cows on UMMB farms (0.19 kg/d) was significantly (P <0.01) higher than that on control farms (-0.04 kg/d).

The increase in milk production due to the provision of UMMB during the on-farm study was much lower than that observed in the on-station study, but close to that reported by Habbib *et al.* [10], Hendratno *et al* [9], and Msangi [12], who reported increases of up to 1.6, 1.9 and 1.1 kg/d, respectively. A reason for the lack of response during the first part of the experiment, would have been that the dry season and the accompanying decrease in the quality of the basal feed had not yet started. This is illustrated by the CP content of the basal feed at the beginning of the trial. Although it was not possible to record the amount of supplement fed, it is believed that farmers on average provided more supplements than what was given during the on-station trial, and that farmers receiving the UMMB substituted other supplements for the blocks. Some cows on the smallholder farms had very low milk yields, down to 2 L/d. The cows of the on-station trial all had a higher level of milk production before the trial, with an average of 13.2 L/d, which is 2.1 L/d higher than the average milk production of the UMMB cows. The average milk production on-farm prior to the introduction of UMMB was 6.8 kg/d. Hence, prior to the introduction of blocks, cows on station had a substantially higher milk yield. This will have been due to a combination of better nutrition and production potential of the herd. This could explain why cows on-station were able to have a higher response to the supplementation of UMMB. Smallholder farms within the treatment differed significantly in milk yield and live weight changes. This was expected, as farmers varied in their feeding practices, disease prevention, age, production potential and reproductive performance and stage of lactation of the cows

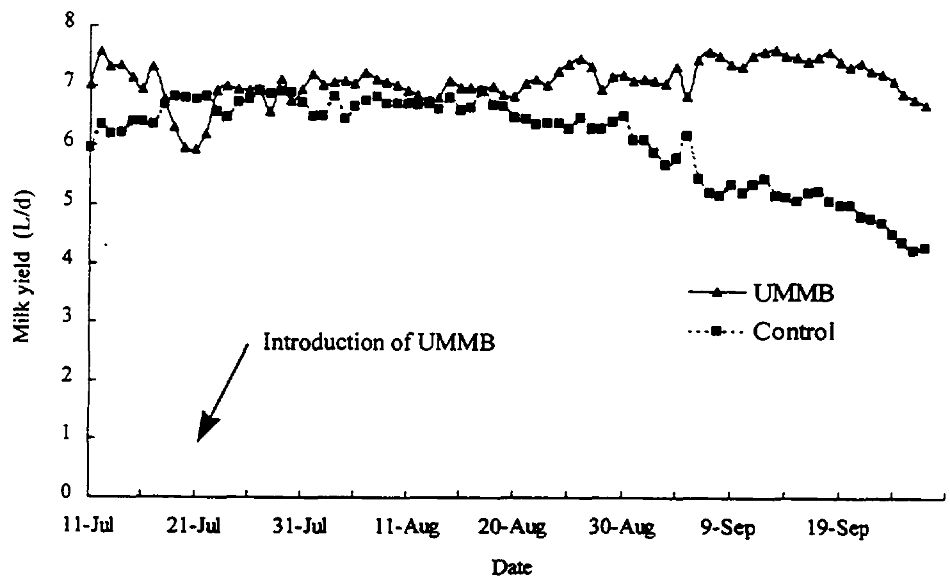

FIG. 1. Average milk yields in the on-farm trial for Control and UMMB groups.

3.3. Financial considerations

The cost/benefit analyses for supplementation with UMMB and MUM are given in Table V. Supplementation with UMMB and MUM are cost-effective if the increase in milk production is higher than 0.7 kg/d. Both in the on-farm and on-station trials UMMB increased milk production more than 0.7 kg/d. However, in the on-farm trial such an increase was only observed after August 27, i.e. when a reduction in the quality and availability of the basal feed due to the dry season had become evident. Also, several cows in the on-farm study had milk yields as low as 2 L/d. In these animals a cost effective increase in milk yield due to the supplementation with UMMB could not be expected. Hence, if UMMB can be provided on a cost-recovery basis, then providing these blocks to cows during the dry season can be recommended. Supplementing outside of the dry season, or giving the blocks to cows with very low milk yields, does not appear to be cost effective. If blocks could not be provided on a cost-recovery basis by a farmers cooperative, but were to be produced by a commercial company that needs to include a profit margin, then the cost effectiveness of the UMMB could be jeopardized as this could increase the "break even" production increase level.

TABLE V. COST-BENEFIT ANALYSES OF FEEDING UMMB AND MUM

Source	
Cost UMMB (Tanz. Sh./kg)	102
Cost of feeding 1.6 kg/d UMMB (Tanz. Sh.)	163
Cost of feeding 2 L/d MUM	170
Milk price (Tanz. Sh/kg)	250
Break even milk production increase (L/d)	0.7
Observed milk production increase UMMB on-station (L/d)	4.5
Observed milk production increase UMMB on-farm (L/d)	1.7
Observed milk production increase MUM on-station (L/d)	2.1

ACKNOWLEDGEMENTS

The authors wish to thank the Environmental Capacity Enhancement Project (ECEP) for their financial support, and Ms. M. Mbwana, Mr. I. Majaliwa, and the staff of the Magadu farm for their technical assistance.

REFERENCES

[1] PRESTON, T.R., LENG, R.A., Matching ruminant production systems with available resources in the tropics and sub tropics, Penambul Books, Armidale, NSW, Australia, (1987).

[2] TIWARI, S.P., SINGH, U.B., MEHRA, U.R., Urea molasses mineral blocks as a feed supplement: effect on growth and nutrient utilization in buffalo calves, Anim. Feed Sci. Technol. **29** (1990) 333-341.

[3] GARG, M.R., GUPTA, B.N., Effect of different supplements on the degradability of organic matter, cell wall constituents, in vitro gas production and organic matter digestibility of wheat straw, Anim. Feed Sci. Technol. **38** (1992) 187-198.

[4] SANSOUCY, R., AARTS. G., LENG, R.A., "Molasses Urea Blocks", Tropical Feeds, (Gohl Ed.) Food and Agriculture Organization of the United Nations, Rome. (1992).

[5] BADURDEEN, A.L., IBRAHIM, M.N.M., RANAWANA, S.S.E., Methods to improve utilization of rice straw. III Effect of urea ammonia treatment and urea molasses block supplementation on intake, digestibility, rumen and blood parameters, AJAS 7 (1994) 363-372.

[6] RAFIQ, M., JADOON, J.K., MAHMOOD, K., NAQVI, M.A., Economic benefits of supplementing lambs with urea molasses blocks on ranges of Pakistan, AJAS **9** (1996)127-132.

[7] LENG, R.A., KUNJU, P.J.G., "Feeding Strategies for Improving Milk production from milk Animals owned by Small farmers in India", Domestic Buffalo Production in Asia, Proc. Final Research Coordination Meeting, Rockhampton, Australia, International Atomic Energy Agency, Vienna, Austria (1990) 3-20.

[8] SRINIVAS, B., GUPTA, B.N., Urea-Molasses-Mineral block licks supplementation for milk production in crossbred cows, AJAS **10** (1997)47-53.

[9] HENDRATNO, C., NOLAN, J.V., LENG, R.A., "The importance of urea-molasses multinutrient blocks for ruminant production in Indonesia", Isotope and Related Techniques in Animal Production and Health, International Atomic Energy Agency, Vienna, Austria (1991) 157-170.

[10] HABBIB, G. BASIT ALI SHAH, S., WAHIDULLAH, JABBAR G., GHUFRANULLAH, "The importance of urea-molasses blocks an bypass protein in animal production: The situation in Pakistan", Isotope and Related Techniques in Animal Production and Health, International Atomic Energy Agency, Vienna, Austria (1991) 133-144.

[11] SAADULLAH, M., "The importance of urea-molasses blocks an bypass protein in animal production: The situation in Bangladesh", Isotope and Related Techniques in Animal Production and Health, International Atomic Energy Agency, Vienna, Austria (1991) 145-156.

[12] MSANGI, B.S.J., The impact of Multi-nutritional blocks on milk product in smallholdings along the coast of Tanzania, MSc thesis, Swedish University of Agricultural Sciences, Uppsala (1995).

[13] SHEM, M.N., Dry season feeding practices in smallholder farms in the Kilimanjaro Region, Tanzania, M.Sc Thesis, University of Guelph, Canada (1986).

[14] EDMONSON, A.J., LEAN, I.J., WEAVER, L.D., FARVER, T., WEBSTER, G., A body condition scoring chart for Holstein dairy cattle, J. Dairy Sci. **72** (1989) 68-78.

[15] ASSOCIATION OF OFFICIAL ANALYTICAL CHEMISTS, Official methods of analysis, AOAC Inc., Arlington, VI (1990).

[16] GOERING, H.G., VAN SOEST, P.J., Forage fibre analysis (apparatus, reagents, procedures, and some applications), Agricultural handbook, US Department of Agriculture, no. 379 (1970).

[17] ORSKOV, E.R., HOVELL, F.D., DEB, AND MOULD, F., The use of the nylon bag technique for the evaluation of feed stuffs, Trop. Anim. Prod. **5** (1980) 195.

[18] McDONALD, I, A revised model for the estimation of protein degradability in the rumen, J. Agric, Sci. Cambridge **96** (1981) 251-252.

[19] STATISTICAL ANALYSIS SYSTEMS, SAS User's guide, Version 6 Edition, SAS Inst., Inc., Cary NC (1990)

[20] STEEL, R.G.D., TORRIE, J.H., Principles and procedures of statistics, Second Edition, McGraw-Hill Publishing Company, New York(1960).

[21] NATIONAL RESEARCH COUNCIL, Nutrient requirements of dairy cattle, 6^{th} rev. ed. (update), National Research Council, NRC, Natl. Acad. Sci., Washington, DC (1989).

[22] FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS. Tropical Feeds, B. Gohl Ed., FAO, Rome (1992).

[23] SHEM, M.N., E.R., ORSKOV, E.R.,, KIMAMBO, A.E., Prediction of voluntary dry - matter intake, digestible dry-matter intake and growth rate of cattle from the degradation characteristics of tropical foods, Anim. Sci. **60** (1995) 65.

IMPROVING THE PRODUCTIVITY OF IMPORTED DAIRY CATTLE ON SMALL-HOLDER FARMS IN MOROCCO THROUGH SUPPLEMENTATION WITH FISH SILAGE BLOCKS

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Abstract

IMPROVING THE PRODUCTIVITY OF IMPORTED DAIRY CATTLE ON SMALL-HOLDER FARMS IN MOROCCO THROUGH SUPPLEMENTATION WITH FISH SILAGE BLOCKS.

The present study was designed to identify problems that lower the productivity of imported dairy cattle in Morocco. For this purpose, a comprehensive survey was carried out on 8 small-holder farms over a period of two years. Analysis of the data collected indicated that in most of the herds reproductive performance was adequate (calving intervals ranging from 338 ± 11 to 420 ± 31 and services to conception ranging from 1.14 ±0.13 to 1.91 ± 0.3), but the animals had difficulty in meeting the nutrient requirements for milk production. Although some farmers provided supplements to their animals they were either expensive or not available at the required time. One possible way of alleviating the problem was the introduction of a fish by-product into the dairy cattle ration. Two experiments were conducted, one at the Institute experimental farm and the other at a private farm selected for the survey. In both experiments, fish silage blocks were incorporated into the ration of dairy cattle in replacement of an equal amount of the most commonly used supplements. The introduction of fish silage blocks in the ration did not affect their intake or body condition. In addition, the yield and quality of the milk were maintained. This substitution allowed the farmer to utilize by-products from the fish industry which are readily available and less costly than most conventional supplementary feeds. It is concluded, that the proposed utilization of fish silage blocks will reduce the production costs and improve the economic efficiency of the small-holder farms.

1. INTRODUCTION

Rapid urbanization around large cities of Morocco has led to increased demand for milk from peri-urban small-holder cattle and has been behind the development of a new dairy cattle production system. Within this system, encouraged by the Moroccan Department of Agriculture, the small holder farmers have been replacing their local low-milk producing cattle by imported European Friesian. Also, several centers for production of Holstein semen for artificial insemination were created to maintain the genetic improvement of the dairy cattle. Little irrigation is practised from wells and green fodder contributes less than 10% to the total feed. There are indications that milk production averaged 4000 kg for a 305 day lactation period from the imported cattle, which are supposed to produce almost twice as much. They also suffered from poor reproductive performance, especially prolonged post-partum acyclicity during the dry season. However, poor nutrition has been identified as a major factor contributing to the low production of imported dairy cattle and there is the need to improve the nutrition of cows through supplementation with protein and energy sources. There are several feed resources that the farmer can buy from the market. However, the feeds needed are expensive and not found at the right time of the year. One possible way of alleviating the problem is the introduction of fish silage blocks as a feed supplement during the most critical stages of the production cycle. Fish silage blocks are easy to prepare and cost half the price of the most commonly used concentrates. It should be noted that large quantities of fish wastes are generated from seafood processing and urban fish markets. Disposal of these wastes presents a major problem because of their objectionable odour and high moisture content. Research has confirmed that fish wastes are a useful protein source for swine [1], poultry and ruminants [2]. The possibility of incorporating fish silage blocks into the ration was proposed and accepted by small-holder farms, especially when considering that the cost of fish silage is only about half the price of any concentrate feed having a similar composition.

The present work was designed to identify some of the problems that lower the productivity of the herd and periods of high risk when nutritional and management strategies are required. The first phase of the study, (December 1994 to December 1996) was devoted to a comprehensive survey of the production system selected, based on data collected from 8 farms. In the second phase, fish silage blocks were introduced into the dairy cattle ration to investigate possible beneficial effects of replacing the most commonly used concentrate feeds which are expensive and not always available.

2. MATERIALS AND METHODS

2.1. Characteristics of the farms selected

More than 20 dairy farms were visited and 8 of them were retained according to predetermined criteria of selection (breed of cattle, production system, flexibility and willingness of the farmer to co-operate). All the farms selected were located in a flat area about 40 km south of Rabat. This region is characterized by a temperate and humid climate (near the Atlantic Ocean) with temperatures ranging from 10°C in winter to 30°C during summer. The selected farms have herds composed of imported Friesian cattle. Artificial insemination is practised and milk is transported daily to the city for commercial processing. The characteristics of the selected farms are shown in Table I.

TABLE I. CHARACTERISTICS OF THE SELECTED FARMS

Farms	1	2	3	4	5	6	7	8
Farm size (ha)	7	8	20	100	15	15	48	8
Irrigated area (ha)*	2	1	2	4	2	1	2	1
Rain fed area (ha)*	3	2	5	36	5	3	18	2
Number of cows	11	14	12	50	7	8	18	12
Number of cows selected	11	14	12	37	7	8	18	12

* Irrigation was practised during the dry season by pumping water from wells, whereas the fodder production in the rain fed area was depending on the rain-fall

2.2. Parameters studied

One hundred and fifteen cows were selected from the eight different farms. The farms were visited weekly for collection of milk samples for progesterone assay, and monthly in order to record the production and reproduction parameters. Information on age, breed type, health status, parity, date of calving and date of breeding were collected from each cow selected for the study. During the monthly visits, feed intake, milk production and the nutritional status, including body condition score (BCS) and heart girth measurements of the cows, were assessed and feed samples were taken for chemical analysis. Milk samples for progesterone assays were collected once a week from newly calved cows until confirmation of pregnancy by rectal palpation. Potassium dichromate tablets were used as a preservatives and the collected milk samples were centrifuged for 10 min and then the skim-milk was refrigerated until progesterone assay. The milk production of individual cows was measured by the farmers, who were supplied with a measuring container, on the day before the monthly visit. For farms where suckling was allowed, usually a quarter of the udder was reserved to the calf and its production was estimated. For feed intake, the inventory of feed types (roughage, concentrate and green fodder) and amounts fed (kg/cow/d) were recorded and accordingly, estimated monthly for the herd of the same farm. Sub-samples of feeds were collected from every farm and dry matter was determined by drying the sample at 105°C for 24h. Ash content was determined by overnight ashing of the sample at 550°C and Kjeldhal technique was used to determine the nitrogen content of feeds [3]. The net energy value of rations used at different farms was estimated from tables of net energy values [4].

2.3. Preparation of fish silage blocks and utilization by dairy cattle

Fish waste, collected from the fish market in Rabat, was mixed with sugar cane molasses in a silo (60% fish waste and 40% molasses) made at the farm. The mixture was stirred daily for two weeks in order to allow fermentation of soluble sugars of molasses by naturally present lactic acid bacteria and the decrease of pH from 5.8 to 4.5. At this pH, the mixture became stable and fish odour disappeared. The fish silage was then hardened by adding about 10% wheat bran, formed into blocks of 2 to 5 kg and dried under the sun for several days. Blocks were fed to dairy cattle to substitute an equal amount of the most commonly used concentrate feed. Two experiments were conducted, one at the Institute experimental farm and the other at a private farm (farm number 7) from those selected for Phase I of the study.

2.3.1. Experiment at the Institute farm

Ten crossbred, (Holstein x Brown of Atlas) multiparous dairy cows were chosen from the experimental dairy farm of the institute. The cows were at their 6th week of lactation at the start of the experiment with an average body weight of 450 kg and average daily milk production of 15 kg. All cows were housed in individual stalls and were given a basal diet of 40 kg of berseem fodder daily. They were randomly divided into two groups of five cows each, receiving two different concentrates. Concentrate A, a control diet of 3 kg (Group A), composed of 70% wheat bran, 26% sunflower meal and 4% salt, vitamins and mineral supplement and Concentrate B, a treatment diet of 3 kg (Group B), composed of 100% of fish silage blocks. The fish silage block diet was used to substitute gradually an equal amount of Concentrate A over a two week period of adaptation. Feed intake and milk production were measured daily from the 6th week of lactation onwards until the 19th week. Milk samples were collected weekly and analyzed for milk fat, protein and lactose.

2.3.2. Experiment at private farm

Sixteen multiparous Holstein cows were selected from Farm 7 and allocated to two groups, Fish silage group and Sunflower meal group. Cows were paired according to the stage of lactation and parity. The experiment started with an adaptation period of three weeks in which the two groups of cows received a ration composed of 40% oat forage and 60% concentrate. The concentrate was made of 40% barley grain, 40% wheat bran and 20% sunflower meal for the sunflower meal group while in the fish silage group, a progressive substitution was made to replace 40% of the concentrate by fish silage blocks at the end of the control period. In the second period (trial period) of four weeks, the sunflower group received the same concentrate feed of the adaptation period, while in the fish silage group the total amount of sunflower meal and half of the barley grains of the concentrate were replaced by fish silage blocks. This substitution was made based on the chemical analysis of the concentrate feed ingredients which indicated that 1 kg of fish silage blocks contained a similar amount of crude protein and energy as compared to 0.5 kg of barley grain and 0.5 kg of sunflower meal. The trial period was followed immediately by a control period in which the 2 groups of cows received the same ration of the sunflower meal group. Feed intake and milk production were measured weekly while body weight of cows was estimated by heart girth measurement. Milk samples were taken weekly and analyzed for fat, protein and lactose contents. Sensorial analysis of the milk was assessed using 40 human subjects who received samples of milk coming from the two group of cows during the trial period. The test subjects were asked to detect any difference in milk taste.

2.4. Statistical analysis

Data collected during Phase I were entered in a dBbase IV program, and was used to investigate the effects of farm, season and ration composition on the investigated parameters. The data are presented in the proceeding tables as means with the standard of deviation. For the experiment at the institute farm, Student's t test was used to investigate the treatment effects. The paired t test was used for the experiment at the private farm to compare statistically, means of body weight, feed intake, milk production and milk composition. To evaluate the results of the sensorial analysis, the probability of false or true response was determined and compared with the probability of binomial distribution with a significance level of 5% :

3. RESULTS AND DISCUSSION

3.1. Phase I

Diet composition and chemical analysis of rations fed for two successive production cycles are presented in Table II. Concentrate feed, composed of grains and agricultural by-products contributed to more than 50% of the ration whereas, the amount of fodder varied from an average of 0.2% in dry season (July to December) to 8.7% in the rainy season (January to June). Although, some farms (Farms 4 and 7) have a substantial land area for fodder production, water for irrigation was very limited, especially in the dry season. During the rainy season, the average dry matter intake (as a percentage of live body weight) was slightly lower and the average crude protein content of the ration was higher compared to the dry season implying that cows received more balanced ration for milk production during the rainy season. Minerals and net energy content of the rations were similar for both seasons. However, during the second production cycle, cows received a higher amount of concentrate with a higher energy and protein content in the ration which may be due to more rain-fall observed in 1996.

Dry matter intake, the production and composition of milk at peak lactation for the farms investigated are presented in Table III. The average dry matter intake per farm measured at peak of lactation varied from 14.1 kg (for Farm 4) to 16.0 (for Farm 6). Although dairy cattle in the farms studied have the same genotype, comparable live body weight and parity, significant differences in milk production were noticed which were the result of quality of feed received by the animals. Highest peaks in milk production were observed on Farms 7 and 8 with an average of 22 kg milk/d from cows receiving a ration containing an average of 4.4 MJ of net energy and 145 g of crude protein/kg DM. The lowest peaks of milk production were observed on Farms 5 and 6 with an average of 14 kg of milk/d from cows of the same genotype receiving a ration containing an average of 3.6 MJ of net energy and 103 g of crude proteins/kg DM. The performance of Farm 1 and 3 were intermediate with respect to feed quality and milk yield. Milk production at peak of lactation was positively correlated with protein content of the diet when considering the data of all the farms($r = 0.947$, $P < 0.01$). It appears from the present data that the imported cows have the genetic potential for a higher milk production and farms applying the feeding standards for dairy cattle are showing better production.

TABLE II. PHYSICAL AND CHEMICAL COMPOSITION OF FEEDS AND THEIR VARIATION WITH SEASON OVER TWO SUCCESSIVE PRODUCTION CYCLES*

	Production cycle 1995		Production cycle 1996	
	Dry season	Rainy season	Dry season	Rainy season
Diet composition (%)				
Concentrate	49.8 ± 15.05	51.9 ± 8.2	63.4 ± 11.06	57.4 ± 12.3
Roughage	51.0 ± 9.6	39.4 ± 5.3	36.1 ± 7.14	34.7 ± 7.4
Green fodder	0.2 ± 0.12	8.7 ± 2.0	0.5 ± 0.31	7.9 ± 3.0
Chemical analysis				
DM intake (%LW)	3.61 ± 1.08	3.30 ± 0.87	3.56 ± 0.68	3.28 ± 0.63
Crude Protein (%DMI)	11.98 ± 2.27	12.82 ± 2.42	12.14 ± 3.2	13.65 ± 3.71
Net Energy (MJ/kg DM)	3.66 ± 1.43	3.66 ± 1.40	4.71 ± 1.06	4.38 ± 1.19
Minerals (%DMI)	7.53 ± 1.55	7.16 ± 1.44	7.69 ± 1.88	7.61 ± 2.05

* Means and standard deviations for data collected during the monthly visits to each farm. January to June was considered as the rainy season, whereas July to December was considered as the dry season. LW and DMI are live weight and dry matter intake, respectively

TABLE III. NUTRIENT INTAKE AND MILK PRODUCTION AT PEAK LACTATION FOR THE STUDIED FARMS

Farms	1	2	3	4	5	6	7	8
Dry matter intake (kg)	15.1 ± 0.6	14.3 ± 0.6	15.1 ± 0.7	14.1 ± 0.5	15.8 ± 1.2	16.0 ± 0.9	15.1 ± 0.8	15.9 ± 1.0
Crude protein (g/kg DM)	129 ± 0.5	124 ± 0.4	126 ± 0.5	116 ± 0.4	99 ± 0.5	106 ± 0.6	153 ± 0.6	139 ± 0.4
Net Energy (MJ/kg DMI)	5.1 ± 1.9	4.2 ± -0.8	3.9 ± -0.9	4.6 ± 1.3	3.8 ± 1.4	3.5 ± 0.9	4.4 ± -0.6	4.4 ± 0.9
Milk production (kg)	18.9 ± 1.3	15.8 ± -0.8	19.0 ± -0.9	14.4 ± -0.4	13.6 ± 1.6	14.6 ± 1.4	22.8 ± 0.6	21.1 ± 0.9

* Means and standard deviations of 24 determinations of dry matter and crude protein intake. The net energy of feeds was estimated [4] and milk production at peak lactation was averaged for all cows selected for the study

Changes in live body weight and body condition during the post-partum period of 105 days are presented in Table IV. It is considered that 105 days is the necessary time for any body tissue losses to occur due to milk production and after this period dairy cattle gain weight. Changes in body weight and body condition scores were positively correlated for all farms. Cows on Farms 7 and 8 showed less body tissue mobilization and less variation in body condition score during the post-partum period whereas, cows on Farms 1 and 5 had more body tissue mobilization for milk production. The amount and the extent of body tissue reserves mobilized for milk production by cows at different farms were in the range of values observed in other dairy cattle breeds [5].

TABLE IV. VARIATIONS IN BODY WEIGHT AND BODY CONDITION DURING 105 DAYS POST-PARTUM

Farms	1	2	3	4	5	6	7	8
				Body weight (kg)				
Days post-partum								
0	480±17	478±10	482±10	468±6	468±18	495±15	470±9	465±14
15	477±15	475±9	477±12	464±7	466±15	493±15	466±10	463±13
45	454±14	462±9	469±12	459±6	450±13	490±16	461±12	460±10
75	450±16	465±8	464±13	461±6	452±13	484±14	462±12	459±14
105	458±17	467±8	460±12	464±8	449±13	481±15	459±11	457±13
Body weight change (kg)*	-30	-16	-22	-9	-19	-14	-11	-8
				Body condition score				
Days post-partum								
0	3.8±0.2	4.3±0.2	5.0±00.2	3.8±0.1	4.4±0.3	3.9±0.3	4.2±0.2	4,5±0.2
15	3.7±-0.1	4.2±0.1	4.9±-0.3	3.6±0.2	4.3±0.2	3.8±0.4	4.1±0.1	4.4±0.3
45	3.4±-0.1	3.8±0.2	4.6±-0.3	3.5±-0.1	3.8±-0.2	4.0±0.3	4.0±0.1	4.3±0.2
75	3.3±-0.2	3.9±0.3	4.7±0.2	3.6±-0.1	3.8±-0.2	3,8±-0.3	4.0±0.2	4.4±-0.2
105	3.3±-0.2	3.7±0.2	4.6±-0.2	3.7±-0.2	3.8±-0.3	3.6±0.4	4.1±-0.1	4.3±0.1
Body condition change*	-0.5	-0.6	-0.4	-0.3	-0.6	-0.4	-0.2	-0.2

* Body weight and body condition (1 to 9 scale) change were calculated as the difference between body weight and condition at calving and the body weight and body condition after 105 days post-partum

Data on post-partum intervals and the number of services per conception are shown in Table V. The interval between calving to progesterone rise ranged from 29.4 days for Farm 2 to 107.8 days for Farm 6 with an average of 51.8 days for all the studied farms. Calving to mating interval averaged 93.8 days for all farms with higher values for Farms 1 and 6 and lower value for Farms 3 and 8, indicating a delay of up to 42 days from the first post-partum ovarian cycle to the subsequent mating. The calving to conception intervals and calving intervals recorded for all farms averaged 109 and 383 days, respectively, which are in the range of values observed under more favourable dairy production systems [6]. However, it should be noted that the calving interval was significantly (P <0.05) longer for Farms 5 and 6 and significantly (P <0.05) shorter for Farms 3 and 8. The number of services per conception averaged 1.45 and was higher for Farm 5 and lower for Farms 7 and 8. A negative correlation was obtained between the duration of calving to conception interval and the protein content of the diet for all farms (r = 0.914, P <0.01). Farms 7 and 8 showed better reproductive performance compared to Farms 5 and 6.

TABLE V. REPRODUCTIVE PERFORMANCE OBSERVED IN THE STUDIED FARMS

Farms	Number of observations	Calving to 1st P4 rise (days)	Calving to Mating (days)	Calving to Conception (days)	Calving interval (days)	No. of services per conception
1	12	49.3±13.2	104.8±18.1	110.1±18.5	380.1±23.2	1.17±0. 11
2	20	29.4±4.5	85.5±7.3	103.9±10.9	373.8±15.8	1.45±0.17
3	18	40.2±5.2	78.9±6.1	102.2±10.8	372.1±15.5	1.39±0.11
4	66	43.7±8.2	96.2±7.7	125.9±8.9	395.9±14.5	1.46±0.09
5	9	65.1±0.3	94.3±6.8	142,6±22.9	412.6±27.8	1.78±0. 31
6	11	107.8±14.2	112.3±21.5	150.4±26.4	420.4±31.3	1.91±-0.30
7	33	41.7±6.2	88.2±6.8	102.9±7.9	372.9±13.1	1.33±0.13
8	7	37.6±3.9	62.2±9.2	68.1±6.3	338.1±11.4	1.14±0.13
Mean	--	51.8±8.2	93.8±6.5	109.1±8.8	383.2±8.6	1.45-±0.09

* For some farms the number of observations is higher than the number of animals because the reproductive performance of most of cows were studied for two successive production cycles. The low number of observations for farm 8 was due to participation in the survey for one year only

3.2. Fish silage supplementation phase

The fish silage blocks after drying in the sun for several days had a dry matter content of 80% ± 5. It had a crude protein content of 26.7%, fat content of 7.52% and soluble sugar content of 30.2%, on DM basis. It was high in ash (18.2%) and contained 1.2% calcium and 0.9% phosphorus.

3.2.1. Experiment at the Institute farm

Data on dry matter intake and milk yield of cows used for the experiment carried out at the Institute farm are presented in Table VI. Total dry matter intake did not differ significantly with respect to the type of concentrate. However, there was a trend for greater intake of roughage in cows supplemented with fish silage blocks. Although not statistically significant, milk production was numerically greater (10% higher) for cows fed fish silage blocks compared to those fed the sunflower meal supplement. The data on milk production were regressed against time for the three month period of the study and comparable regression coefficients were obtained for the control diet (r = -0.053 ± 0.012) and the fish silage diet (r = -0.054 ± 0.014) indicating that the pattern of the lactation curve was not affected by the ration composition.

Milk was analyzed for its composition during the 6th, 10th, 14th and 18th week of lactation and the data are presented in Table VII. Unlike milk yield, milk fat content was lower in cows which received the fish silage blocks. However, the difference was not statistically significant. There was a trend for a decrease in milk fat percentage with the course of lactation. Concerning milk proteins and lactose, there was no significant difference which could be related to ration composition and the data obtained were comparable for the two groups of cows.

TABLE VI. DRY MATTER INTAKE AND MILK PRODUCTION AT DIFFERENT STAGES OF LACTATION WITH RESPECT TO THE TYPE OF SUPPLEMENTATION

Weeks of lactation	6th	9th	12th	15th	18th
Dry matter intake (kg)					
Group A (sunflower)	15.4 ± 0.6	12.8 ± 1.1	10.5 ± 0.7	12.3 ± 1.2	12.8 ± 0.5
Group B (fish silage)	15.8 ± 0.7	12.2 ± 1.2	12.0 ± 0.9	13.1 ± 0.6	13.3 ± 0.5
Milk production (kg)					
Group A (sunflower)	14.6 ± 1.2	12.6 ± 1,1	12.8 ± 0.8	12.5 ± 0.8	8.3 ± 0.6
Group B (fish silage)	15.3 ± 0.6	14.5 ± 0.8	14.2 ± 1.7	14.1 ± 1.1	9.1 ± 0.8

* Data are means and standard deviations for each group of 5 cows during 18 successive weeks of lactation

TABLE VII. MILK COMPOSITION AT DIFFERENT STAGES OF LACTATION IN DAIRY CATTLE FED TWO DIFFERENT FEED SUPPLEMENTS

Weeks of lactation	6th	10th	14th	18th
Milk fat (g/kg)				
Group A (sunflower)	40.9 ± 1.6	36.7 ± 0.9	32.7 ± 1.7	34.7 ± 1.3
Group B (fish silage)	36.0 ± 2.1	34.4 ± 1.3	29.5 ± 2.3	31.5 ± 1.6
Milk protein (g/kg)				
Group A (sunflower)	29.1 ± 0.3	26.8 ± 0.2	28.4 ± 0.1	29.9 ± 0.5
Group B (fish silage)	28.0 ± 0.6	26.7 ± 0.4	28.6 ± 0.3	29.1 ± 0.6
Milk lactose (g/kg)				
Group A (sunflower)	51.8 ± 0.3	48.1 ± 0.5	47.7 ± 0.7	49.0 ± 0.4
Group B (fish silage)	50.1 ± 0.2	50.1 ± 0.3	49.4 ± 0.6	50.3 ± 0.8

* Data are means and standard deviations for each group of eight cows during 18 successive weeks of lactation

3.2.2. Experiment at the private farm

During the adaptation period of 2 weeks, fish silage blocks were introduced in the ration progressively up to 40% of the concentrate distributed to the treatment group. The fish silage was well accepted and the total ration was fully consumed by both groups. No significant changes in dry matter intake and live body weight were observed between the 2 groups (Table VIII) indicating that the substitution in the ration did not affect the feeding behaviour of the cows. Milk production was declining with the stage of lactation but was not influenced by the fish silage substitution in the ration and comparable levels of production were obtained in the two groups (Table IX). Milk composition was not affected by the treatment and more variations were observed between cows belonging to the same group.

TABLE VIII. DRY MATTER INTAKE AND LIVE WEIGHT CHANGE IN EARLY LACTATION IN TWO GROUPS OF COWS RECEIVING DIFFERENT SUPPLEMENTS

Weeks of lactation*	2nd	4th	6th	8th
Dry matter intake (kg/d)				
Sunflower group	17.01 ± 4.05	15.1 ± 3.5	14.85 ± 4.29	14.59 ± 3.66
Fish silage group	17.27 ± 3.08	15.4 ± 3.9	14.36 ± 3.51	15.03 ± 3.49
Live body weight (kg)				
Sunflower group	493.6 ± 74.4	480.0 ± 67.5	472.1 ± 65.1	479.6 ± 62.4
Fish silage group	544.5 ± 58.5	511.6 ± 42.5	505.3 ± 45.2	518.9 ± 50.2

* The data are means and standard deviations for measurements done during successive weeks of lactation on eight cows of each group.

TABLE IX. MILK PRODUCTION AND COMPOSITION WITH RESPECT TO THE TYPE OF FEED SUPPLEMENTATION IN DAIRY CATTLE

Weeks of lactation*	2nd	4th	6th	8th
Milk production (kg/d)				
Sunflower group	18.33 ± 5.31	18.66 ± 3.97	17.0 ± 4.26	16.71 ± 4.60
Fish silage group	18.50 ± 4.15	16.85 ± 6.24	16.57 ± 4.53	16.57 ± 4.58
Milk fat (g/L)				
Sunflower group	35.95 ± 2.12	34.43 ± 5.66	36.18 ± 5.32	35.06 ± 4.47
Fish silage group	35.53 ± 7.98	32.57 ± 5.28	33.14 ± 6.15	34.92 ± 6.92
Milk proteins (g/L)				
Sunflower group	28.68 ± 3.26	32.07 ± 3.03	33.52 ± 3.80	33.28 ± 3.40
Fish silage group	31.56 ± 2.81	31.08 ± 2.06	33.57 ± 3.58	32.58 ± 3.07
Milk lactose (g/L)				
Sunflower group	46.0 ± 3.30	47.28 ± 2.68	47.56 ± 1.29	47.37 ± 2.40
Fish silage group	46.78 ± 2.15	47.33 ± 1.09	47.69 ± 1.38	47.54 ± 1.90

* The data are means and standard deviations for measurements done on eight cows of each group

The sensorial analysis of the milk was assessed by 40 human subjects receiving milk samples coming from the two groups of cows. This test of milk tasting was done twice, during the control period and the trial period where both groups of cows received a ration of similar composition. During the trial period, 18 out of 40 declared a difference in the taste of milk while in the control period the ratio was 19 out of 40. The statistical analysis of the data showed no difference in the taste of the milk coming from the two groups of cows.

3.2.3. Analysis of fish silage utilization in dairy cattle

The fish silage blocks were used as concentrate in the diet of dairy cattle and no effect on the palatability of the ration was observed. In addition, there was no change in quality, taste or odour of the milk produced. Surprisingly, in the trial conducted at the Institute experimental farm, milk yield was about 10% higher and milk fat was about 9% lower in cows receiving fish silage blocks. However, the data on milk protein and lactose were similar for the two groups indicating that the variation in volume and composition of milk was not a result of sample dilution of milk, but presumably related to a nutritional factor. In this regard, Enjalbert [7] reported that protein and lactose content of milk are less dependent on nutrition than the fat content and Sutton [8] found that with high amounts of soluble carbohydrate the milk production increased by 280 g and milk fat decreased by 1 g/kg. Alvarez [9] reported that in dairy cattle an excess of soluble sugar in the ration reduced the acidity of the rumen and increased the ratio of C3 to C2 VFA which is not favourable for milk fat. Milk production and milk fat content can be modified by dietary lipids. According to Enjalbert [7], diets rich in lipids, especially in unsaturated fatty acids, depresses the cellulolytic activity in the rumen and increases the ratio of C3 to C2 VFA's. Therefore, milk production was increased and milk fat content was depressed in dairy cows receiving a high amount of lipids and carbohydrates in the diet. In the present study, the fish silage blocks were rich in soluble sugar (molasses) and lipids (7.52% of DM with high amount of unsaturated fatty acids), which may explain the observed difference in milk production and composition in agreement with Enjalbert [7] and Sutton [8]. To our knowledge, the literature on the utilization of fish silage in dairy cattle is very limited. A study done in Norway by Kjos [10] indicated that the incorporation of 6% of fish silage in rations of dairy cattle had no influence on feed intake, milk production and milk composition. However, when a concentrate was incorporated in the fish silage the fat content decreased and milk protein increased as compared to pelleted concentrate fed with fish silage. Kjos [11] suggested that the mixing process reduced the effective ruminal degradability of fish silage protein which improved the protein content of the milk. In another study done in Cuba, Perez [12] reported data indicating that the addition of 1kg of fish silage to the daily diet of grazing dairy cattle during the winter season maintained milk production at a level comparable to that obtained during the wet season.

4. CONCLUSION

The data analyzed from Phase I indicated that some farms have limited reproductive performance and had difficulties in meeting the nutrients requirements of their cows. Some farmers lacked information about feed quality and the importance of meeting the protein and minerals requirements of their dairy cattle and the variation in feed requirements with respect to the level of production. However, some were aware of the importance of feed supplementation but were unable to do so because of the high cost and the poor availability of most conventional supplementary feeds. It has been shown from the present studies done at the institute and private farms that fish wastes from the market or processing factories, fermented in molasses and formed into blocks, can replace more conventional sources of concentrate feed for dairy cattle at low cost. The utilization of fish silage blocks in the ration up to 40% did not affect the appetite and body condition of cows. In addition, the yield and the quality of the milk were maintained. This substitution in the ration allowed the farmer the utilization of fish by-products which reduced the production cost and improved the economic efficiency of the small farms.

REFERENCES

[1] SAMUELS, W. A., FONTENOT, J. P., ALLEN, V.G., ABAZINGE M.D.A., Seafood processing wastes ensiled with straw: utilization and intake by sheep, J. Anim. Sci. **69** (1991) 4983-4992.

[2] TIBBETTS, G. W., SEERLY, R. W., McCAMPBELL, H. C. and VEZEY, S. A., An evaluation of an ensued waste fish product in swine diets, J. Anim. Sci. **52** (1981) 93-100.

[3] ASSOCIATION OF OFFICIAL ANALYTICAL CHEMISTS, Official Methods of Analysis (14th Ed.), Association of Official Analytical Chemists, Arlington, VA (1984).

[4] NATIONAL RESERACH COUNCIL, Nutrients requirements of dairy cattle, National Academy of Science, Washington. D.C., USA (1989).

[5] BRAUN, R. K., DONOVAN, G. A., TRANT, T.Q., MOHAMMED, H.O., Importance of body condition scoring in dairy cattle, Bovine Proc. **19** (1987) 122-126.

[6] BUTLER, W.R., SMITH, R.D., Interrelationship between energy balance and postpartum reproductive function in dairy cattle, J. Dairy Sci. **72** (1987) 767-783.

[7] ENJALBERT, F., Alimentation et composition du lait de vache, Point Veterinaire. vol. **25** No 156 (1993) 769-778.

[8] SUTTON. J.D., Altering milk composition by feeding, J. Dairy Sci. **72** (1989) 2801-2814.

[9] ALVAREZ, R. J., A comparative study of the nutritional value of the protein from ensiled fish, Cuba. J. Agric. Sci. **6** (1972) 219-222.

[10] KJOS, N.P., Fish silage in the feeding of dairy cows, Proceedings of the 45th EAAP, Annual Meeting, Edinburgh, Scotland (1994).

[11] KJOS, N. P., Protection of silage protein against degradation in the rumen by extrusion processing of concentrate mixtures containing fish silage, Proceedings of the 44th EAAP, Annual Meeting. Arhus, Denmark (1993).

[12] PEPEZ, R., "Fish silage for feeding livestock", World Animal Review, FAO, Rome **82** (1) (1995) 35-42.

IMPROVING THE PRODUCTIVITY OF SMALLHOLDER DAIRY CATTLE IN PERI-URBAN MOROGORO, UNITED REPUBLIC OF TANZANIA

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Abstract

IMPROVING THE PRODUCTIVITY OF SMALLHOLDER DAIRY CATTLE IN PERI-URBAN MOROGORO, TANZANIA.

The work reported was conduced in two Phases. In Phase I, a sample survey was conducted in the peri-urban areas of Morogoro, Tanzania, to gather information on smallholder farming activities. Fifty-two smallholder farmers provided information on the existing livestock production systems and related family activities, including constraints to dairy production in the area. During Phase II, 24 smallholder farmers keeping a total of 65 cows participated in a field trial aimed at investigating the suitability of a farm formulated concentrate (FC) as a dry season supplement.

Phase I survey results showed that 49% of smallholder farmers practised zero grazing (ZG), while 34.5% of farmers practised partial grazing (PG). Zero grazed cows received an estimated 28.2 ± 7.6 kg cut grass per cow/d, while PG cows received 8.1 ± 1.1 kg cut grass per cow/d, in addition to 6-9 h grazing. The average herd size per farm unit was 4.8 and 5.3 cows for ZG and PG farms, respectively. 27.3% of farms maintained mature bulls. All cows received around 2.4 ±1.3 kg/cow/d of a supplement, based mainly on maize bran, during milking in two equal amounts. In addition to natural pastures, feed resources included crop by-products, green fodder, crop residues, minerals and other non-conventional feeds such as brewer's waste. Thus, it appeared that farmers rarely supplemented their animals with good protein concentrates and as a result animals often experienced protein deficiency during the dry season. Supplementation with 0.8 kg of FC comprising of maize bran (70%), cottonseed cake (28%) and minerals (2%), per litre of milk produced, during the dry season in Phase II, improved milk yield (34%), and maintained body condition (2.8-3.1). In relation to reproductive performance post-partum anoestrus period was reduced from 86.3 ± 6.6 to 71.2 ± 5.3 days and calving to conception from 102.4 ± 5.1 to 80.4 ± 4.7 days. Feeding 0.8 kg FC per litre of milk was cost effective if there was an increase in milk yield by more than 1.0 litres per day (break even increase).

1. INTRODUCTION

Dairy production is an enterprise for many people in peri-urban Tanzania. Such dairy farming in Tanzania is mainly for milk production for family use, to improve child nutrition and as a means of integrating crop and animal production through the use of crop residues as feed and recycling nutrients via excreta [1]. Also, milk production is attractive in that it gives a regular source of cash income for women from sale of excess milk [2]. The smallholder farmers keep 2-3 dairy cows in the back yard, mostly under zero grazing. Smallholder dairy sector contributes substantially to the national economy and well-being of women who mostly look after the animals [3].

A combination of several factors including genetic, physiological, management and environmental, are considered to cause low animal productivity [4]. The major technical constraint to livestock production is the inability to feed the animals adequately throughout the year as is the case in most sub-Saharan African countries [5]. This is caused by the scarcity and poor quality of on-farm feed resources and the high cost of purchased concentrate supplements, thus rendering the dairy cows deficient in protein especially during the dry season. Therefore, diets often do not meet both maintenance and production requirements [6]. Farm formulated concentrates (FC) have been shown to improve smallholder dairy cattle performance [7]. However, farmers rarely supplement their animals with protein concentrates in the dry season, because of the expense. They use only maize bran at milking time. To enhance the stability and sustainability of smallholder dairy cattle feeding it is necessary to develop low cost feed resources which are typical of the environment. The objectives of this study were to i) collect information on the dairy enterprise with the aim of identifying the major constraints to productivity, and ii) to evaluate the effect of a concentrate feed which could be mixed on-farm based on available crop by-products on smallholder dairy cattle performance during the dry season in peri-urban Morogoro.

2. MATERIALS AND METHODS

This work was conducted in two phases in Morogoro, a semi-arid region of Eastern Tanzania located at an altitude of 528 m, with a mean maximum temperature of 32.4°C in November to February and a minimum temperature of 14.8°C between June and October. Mean annual rainfall range between 800 to 1200 mm, received in two peaks of long and short rains. Pastures and forages consist of *Panicum maximum, Hyperrheni rufa, Neonotonia wightii, Pennisetum* and *Cynodon species* and *Pennisetum purpureum* (Elephant grass). They are the major forage sources used by all farmers in the area. The major forage for animals during the dry season is dried grass and/or maize stover.

2.1. Phase I

Between October 1996 and December 1996, a sample survey was conducted in peri-urban Morogoro to gather information on smallholder farming activities (Phase I). Fifty-two smallholder farmers participated in the study that involved a survey using data entry forms provided by the IAEA to collect information on demographic data, livestock enterprise and other related family activities as well as by direct observation of the management and feeding of the dairy cattle. The salient features covered in the forms and interviews were: family size, labour, herd size and composition, livestock management and performance and constraints to dairy production. Production and reproduction parameters were monitored as follows: body weight by heart girth measurement, body condition score (BCS) by 1-5 scale, milk yield once monthly by taking the weekly average, reproductive efficiency by monthly rectal palpation and weekly milk progesterone concentrations as determined by radioimmunoassay (RIA) technique. Feed analyses for major feeds were conducted monthly for proximate composition according to methods described by AOAC [8].

2.2. Phase II

Between October 1996 and September 1996, a trial was carried out to investigate the suitability of FC for incorporation as a dry season animal feed in smallholder farms of peri-urban Morogoro. Twenty four smallholder farmers, keeping a total of 65 milking cows participated in the trial. The farmers represented different wards of the Morogoro municipality (Table I) and were randomly allocated to Treatment and Control groups. Cows were crosses of dairy breeds (Friesian, Ayrshire and Jersey) with the local indigenous Zebu and Boran breeds. The supplement to be tested was given to cows during post-partum for 90 days. Animals were as far as possible balanced for previous lactation yield (3-12 L/d), number of previous parturitions (2-4), and BCS (2-3.5).

TABLE I. DISTRIBUTION OF FARMERS AND NUMBER OF COWS PER TRIAL IN DIFFERENT WARDS OF MOROGORO

Wards	Treatment		Control	
	Farmers	Cows	Farmers	Cows
Kihonda/Mazimbu	2	7	2	4
Misufini/Kindege	3	7	1	2
SUA/Kididimo	2	4	2	5
Liti/Boma Rd	3	9	1	4
Forestry	2	4	2	6
Kingani/Mjimpya	2	6	2	7
Total	14	37	10	28

The experimental supplement was formulated using maize bran (MB) and cotton seed cake (CSC). Its proportional composition (fresh weight) was as follows: 70%, MB, 28% CSC, 1% minerals (Maclick) and 1% common salt. Thirty-seven cows in the Treatment group were fed 0.8 kg FC per litre of milk produced per day while 28 cows in the Control group received 0.6 kg MB per litre of milk produced per day, to reflect farmers practice. Production and reproduction parameters were monitored as in Phase I. Also, the economics of the supplementation was determined. Statistical comparison of survey data on the farms and supplementation trial data was made by analysis of variance using general linear model procedure.

3. RESULTS AND DISCUSSION

The survey data for the farms are shown in Table II. Forty-nine percent of smallholder farmers practised zero grazing (ZG) while partial grazing (PG) was practised by 35%. Full time grazing (FG) was practised only by 16.4% of the farmers. The grazing practices differed in that ZG cows were stall fed on cut grass estimated to average about 28.2 ± 7.6 kg/cow/day throughout the day, while PG cows grazed for 7.8 ± 1.6 (6-9) h during the day and received some cut grass (8.1 ± 1.1 kg/cow/day) after grazing. FG cows grazed 10-11 h during the day and never received cut fodder after grazing. The significant difference in the amount of feed offered is explained by the nature of the system itself. Because of the limited number of FG herds, results are given for the two major systems (ZG and PG) of animal keeping only. The average family had 5.3 and 6.1 persons for ZG and PG (range 3-9 people per household), respectively. On average, a farmer owned 1-1.2 ha of land for cultivation of food crops; only 6% of the farmers had a small portion allocated for pasture development. Family was the major source of farming labour, but additional hired labour was required in most of the farms mainly for dairy cattle management. The cost of the hired labour ranged from Tanzania shillings (Tshs) 3,000 to 9,000, with an average of 6,854 ± 388 per month (1 USD = Tshs 670). The average herd size per farm unit was 4.8 and 5.3 cows for ZG and PG farms, respectively, most being milking cows (3.1 ± 1.3). Only 27.3% of farms kept mature bulls. Therefore, most farmers relied on artificial insemination, or natural service with a bull from another herd. All animals received at milking around 2.4 (± 1.3) kg/cow/d of a supplement, given during milking, in equal amounts. The supplement was based on maize bran only in

93% farms, and in 7% it was mixed with cotton seed cake or brewers' waste, and occasionally some mineral mix. Feed resources included natural pasture, crop by products, green fodder, crop residues, minerals, and non-conventional feeds (e.g. brewers' waste). These findings show that farmers rarely supplemented their animals with protein concentrate, implying that animals often experienced protein deficiency during the dry season when quality of the forage decreases. These findings are in agreement with those of Msangi *et al.* [9] and Mlozi *et al.* [10].

TABLE II. SUMMARY OF FARM PERFORMANCE PARAMETERS FOR THE ZG AND PG ANIMALS

Parameters	ZG	PG	Significance
Family size (number)	5.3 ± 1.2	6.1 ± 1.4	NS
Land owned (ha)	1.2 ± 0.1	1.0 ± 0.1	NS
Herd size (cows)	4.8 ±0.2	5.3 ± 0.2	NS
Hired labour (%)	92	96	NS
Forage (kg/cow/d)	28.2 ± 4.6	8.1 ± 1.1	P <0.05
Supplement (kg/cow/d)	2.4 ± 1.3	1.6 ± 1.0	NS
Milk yield (L/cow/d)*			
-wet period	10.6 ± 0.2	8.6 ± 1.2	NS
-dry period	6.7 ± 0.13	5.9 ± 0.12	NS

*, Data on milk yield for wet and dry periods differ significantly, P <0.05
NS, Not significant

Composition of major feeds used by farmers in the dry season and that of the experimental supplement is shown in Table III. From the table it is evident that dry season forage has a low content of crude protein [11]. This was the general observation for all forages used by the farmers. A similar study conducted by Shem [6] in Western Tanzania showed that nitrogen content of grazing pasture and cut-and-carry grass differed significantly between wet and dry seasons (P <0.05).

TABLE III. COMPOSITION OF FEEDS

Component	DG	MS	MB	FC
DM (%)	93.0	93.6	90.9	94.3
		(% DM basis)		
Crude protein	3.1	2.7	11.3	16.3
Crude fibre	33.3	37.1	30.1	46.8
Calcium	0.2	0.1	0.06	1.3
Phosphorus	0.16	0.1	0.6	0.22

DG - dry grass; MS - maize stover; MB - maize bran; FC - farm formulated concentrates

Table IV shows the reproduction indices according to the periods of the year and animal grazing management system. Rectal palpation findings were correlated with milk progesterone concentrations. The sensitivity of the assays was 0.5 nmol/L, while intra- and inter-assay coefficients of variation were 8.8 and 12.6%, respectively and well within acceptable limits. Progesterone concentrations showed that animals experienced ovarian cyclicity 27-34 days after calving. The first 1-3 cycles post-partum were of short duration. This observation is in agreement with previous findings of Peters and Lamming [12]. The short cycles occur because of the deficient early post-partum endocrine function. Corpora lutea formed under deficient endocrine control are sub-normal and are short lived. In this study amplitude of short oestrous cycles was small implying sub-functional corpora lutea. This phenomenon is considered beneficial in that progesterone production in short cycles act as a primer for resumption of normal cycles.

TABLE IV. FERTILITY INDICES ACCORDING TO GRAZING SYSTEM AND PERIOD OF THE YEAR (MEAN ± SE)

Period of year/ grazing system	Calving to 1st Service	Services per conception	Calving to conception	Calving Interval
Wet Period				
ZG (n = 36)	82.3 ± 6.4	2.1 ± 0.2	123 ± 12.2	407.1 ± 12.5
PG (n = 32)	66.1 ± 8.8	1.7 ± 0.2	118.6 ± 16	378.2 ± 14.4
Dry Period				
ZG (n = 30)	115.1 ± 10.1	2.6 ± 0.2	151.7 ± 14.2	477 ± 13.3
PG (n = 24)	97.4 ± 8.2	1.8 ± 0.3	126.9 ± 14.0	414 ± 12.2

From Table IV, it is evident that PG cows had better reproductive indices as compared to ZG cows, most probably because animals were exposed to exercise and social interaction [13]. Animals in the PG group for most of the day interacted with bulls in the grazing areas and therefore had greater chance of being detected in heat and be served by the bull; thus the lower inseminations per conception of 1.7 and 1.8 for the wet and dry seasons, respectively. In the case of ZG group animals required 2.1 and 2.6 inseminations per conception for the wet and dry seasons, respectively, presumably because they have not had that exposure. Observations in the ZG farms showed that heat detection was by the herdsman normally at milking and cleaning times. In general, heat detection was not properly done, it was too brief or sometimes not done at all. This accounted for most animals remaining open for a long period, thus prolonging the inter-calving interval, which was slightly higher than the range of 380-440 reported elsewhere in Eastern Africa [14, 15]. Heat detection has to be given enough time in order to observe the cows for several minutes, normally 15 to 20, and preferably three times a day, morning, afternoon and evening. Also, animals in PG farms had greater access to a wider choice of feeds and could feed to satisfaction in the grazing areas. Normally farmers incurred extra expenditure to feed animals during the dry season so as to maintain their performance.

Farmers reported shortage of dry season forage, lack of improved low quality forage feeding strategies, high cost of concentrates, unreliable insemination services and low price of milk as severe constraints to improving milk production. Available excess forage production during the rainy season has not been put into optimum utilization due to lack of knowledge in conservation techniques. There was a difference between farmers in terms of constraints and hence allocation of labour and capital.

The mean production and reproduction performance for the supplemented animals are shown in Table V. From the table it is evident that supplementation during the dry season substantially improved milk yield, maintained body condition and reproductive efficiency in the treatment group compared to the control group.

TABLE V. MEAN PRODUCTION AND REPRODUCTION PERFORMANCE OF COWS IN SUPPLEMENTED AND CONTROL GROUPS

Parameter	Supplemented (n = 37)	Control (n = 28)	Significance
Milk yield (kg/d)	8.4 ± 0.12	6.8 ± 0.12	NS
Body condition change	0.2 ± 0.01	-0.1 ± 0.01	NS
Body weight change (kg)	0.6 ± 0.1	0.2 ± 0.1	NS
Interval from calving			
- to first oestrus	71.2 ± 5.3	86.3 ± 6.6	NS
- to conception	80.4 ± 4.7	102.4 ± 5.1	NS
- conception rate	68.0 ± 3.9	50.7 ± 3.3	NS
insemination/conception	1.3 ± 0.01	1.94 ± 0.07	NS

SE within parenthesis; NS, Not significant

Feeding 0.8 kg FC per litre of milk produced per day was cost effective if there was an increase in milk yield by more than 1.0 litre per day (break even increase). Supplementation increased milk yield by 1.6 L/cow/d. In terms of money this was equal to Tshs 400 at a price of Tshs 250 for a litre of milk. The cost of feeding 0.8 kg FC per day was Tshs 256 leaving a profit margin of Tshs 144 which is clearly cost effective under Tanzanian conditions. Other small advantages gained by supplementation were improved body condition, reduced calving to conception interval and reduced number of inseminations per conception.

ACKNOWLEDGEMENT

The authors wish to thank the Joint FAO/IAEA Division, IAEA, for financial support and the smallholder farmers in peri-urban Morogoro for their assistance.

REFERENCE

[1] TANNER, J.C., HOLDEN, S.J., OWEN, E., GILL, M., "Feeding livestock for compost production; a strategy for sustainable upland agriculture on Java", Livestock and sustainable nutrient cycling in mixed farming systems of sub-Saharan Africa, Vol II Proc. Intern. Confer., Addis Ababa, Ethiopia (1995) 22-26.

[2] HOLDEN, S.J., COPPOCK, D.L., Effect of distance to market, season and family wealth on pastoral dairy marketing in Ethiopia, J. Arid Environ. **23** (1992) 321-334.

[3] MDOE, N.S.Y., Constraint to milk marketing in the Kilimanjaro highland of Hai district, Proc. Tanzania Society of Animal Production Scientific Conference (1993) 247-256.

[4] OMORE, A.O., MCDERMOTT, J.J., KILINGO, J., GITAU, T., STAAL, S., A comparison of relative returns to different enterprises on mixed smallholder crop-dairy systems in central Kenya, Epidemiol. Sante Anim. **31-32** (1997) 2-9.

[5] WINROCK INTERNATIONAL, Assessment of Animal Agriculture in sub-Saharan Africa, Winrock International Institute for Agricultural Development, Morrilton, Arkansas (1992)162.

[6] SHEM, M.N., Development of supplementary feed diets based on *Leucaena leucocephala* leaf meal for dairy cattle in urban and peri-urban areas of Shinyanga municipality, Research Report, ICRA, Nairobi, Kenya (1996).

[7] JINGURA, R.M. AND SIBANDA, S., Lactation performance, live weight and body condition change of dairy cows supplemented with two different concentrates on the smallholder dairy sector in semiarid tropics, Paper presented at the British Society of Animal Science International conference on Food, Lands and Livestock: Setting Research Agendas for Animal Science, Nairobi, Kenya (1998).

[8] ASSOCIATION OF OFFICIAL ANALYTICAL CHEMISTS, Official Methods of Analysis, AOAC Inc., Arlington (1990).

[9] MSANGI, B.S., BRYANT, M., DJIKMAN, T., THORNE, P., Characteristics of small scale dairying in urban, sub-urban and peri-urban areas of coastal Tanzania, Paper presented at International Conference of the British Society of Animal Science, Nairobi, Kenya (1998).

[10] MLOZI, M.R.S., LUPANGA, I.J., MVENA, Z.S.K., Urban Agriculture. The livestock dimension and its implications, Proc. Tanzania Soc. Anim Prod. Sci. Confer. (1989) 16-20.

[11] KIDUNDA, S.R., The yield and nutritive value of some tropical grasses and legumes at different stages, M.Sc. Thesis, Sokoine University of Agriculture, Tanzania (1988).

[12] PETERS, A., LAMMING, G.E., Regulation of ovarian function in the cow, Endocrine model, Vet. Rec. **118** (1986) 236-239.

[13] EGER, S., SHEMESH, M., SCHINDLER, S., AMIR, S., FOOTE, R.H., Characterisation of short luteal cycles in the early post-partum period and their relation to reproductive performance of dairy cattle, Anim. Reprod. Sci. **16** (1988) 215-224.

[14] KATYEGA, P.M.J., Performance of Jerseys on the slopes of Mount Meru, Tanzania, World Animal Review **65** (1988) 24-50.

[15] MUJUNI, P.F., Post-partum ovarian disorders affecting dairy cows in selected areas in Tanzania, M.Sc. Thesis, Sokoine University of Agriculture, Tanzania (1992).

[16] CHESWOTH, J., Ruminant Nutrition, CTA and Macmillan Press Ltd, London (1992) 101-102.

USE OF METABOLIC PROFILES IN DAIRY CATTLE IN TROPICAL AND SUBTROPICAL COUNTRIES ON SMALLHOLDER DAIRY FARMS

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XA9952128

Abstract

USE OF METABOLIC PROFILES IN DAIRY CATTLE IN TROPICAL AND SUBTROPICAL COUNTRIES ON SMALLHOLDER DAIRY FARMS.

Metabolic profile testing has generally been used as part of a multi-disciplinary approach for dairy herds in temperate climates. Our goal was to evaluate the effectiveness of the technique for identifying constraints on productivity in small herds in environments less favourable for milk production. Metabolites tested were chosen for stability in the sample after collection of blood, ease of analysis and practical knowledge of the meaning of the results. Blood levels of five different metabolites in low producing dairy cows belonging to smallholders in tropical and subtropical environments were measured. The study involved 13 projects with 80 cows in each, carried out in six Latin American, six Asian and one southern European country. Data was also collected on feeding, body condition (BCS) and weight change, parasitism and reproduction. In Chile, Mexico, Paraguay, Philippines, Uruguay and Venezuela globulin levels were high in more than 17% of cows sampled on each occasion. Globulin levels were also high in Turkey and Viet Nam on one or more occasions. In Paraguay 49% of cows had high globulin levels at 2-3 months after calving. These results suggest that inflammatory disease was present to a potentially important degree, although this was not always investigated and not always taken into account. In all countries except Mexico and Venezuela high β-hydroxybutyrate (BHB) levels before calving in many cows highlighted the presence of condition loss in late pregnancy, an important potential constraint on productivity and fertility. Fewer cows showed high BHB levels in lactation where change in BCS and weight was more sensitive for measuring negative energy balance. Urea concentrations were only found to be low in small numbers of cows suggesting that dietary protein shortages were not common. Albumin values were low mainly in cows

where globulin values were high and so did not generally provide additional information. The exception was in China where pregnant yaks over winter had high BHB and low albumin values suggesting that they were seriously underfed. This observation stimulated a successful nutritional intervention in the following winter. Inorganic phosphate values were within the reference range in most countries most of the time suggesting, contrary to expectation, that this mineral was not commonly a constraint. The use of metabolic profile testing proved valuable in drawing attention to important potential constraints on productivity in dairy cows in tropical and subtropical environments and in confirming those which were not.

1. INTRODUCTION

Metabolic profiles in dairy cows were used initially in Britain in the 1960's [1]. Success was limited for a number of reasons, the main one being the expectation that all biochemical concentrations in bovine blood would reflect nutritional intake and status at all times [2]. However practical value was found in the approach as an aid to nutritional management [3]. In the late 1970's the approach was reassessed and re-instituted culminating in a programme for farmers looking at health and productivity using metabolic profile blood analysis as an integral part of the package [4] and involving a multi-disciplinary approach. This programme has developed in the light of practical experience into a system used by around 250 dairy farmers in Britain each year from herds of average size of 130 cows producing lactations averaging over 6000 L each. The system depends on a team approach involving farmer, veterinarian and agricultural adviser. The blood testing part, if useful information is to be obtained, also depends critically on following a set of firm criteria for selection of small groups of typical cows within each herd, on timing of testing in relation to concentrate feeds, feed changes and stage of lactation, and on the collection of other data about the cows such as body weight and condition, productivity and feeding. These details have been described [5]. Others [6, 7] have also developed the metabolic profile approach along similar lines as an aid to the management and nutrition of dairy cattle in temperate climates. The successful approach has been to look, following specific times of nutritional change, at metabolite levels in strictly defined small representative groups of cows within each herd in conjunction with information on body condition and weight, milk performance and feeding. Comparison with optimum values, the degree of variation from them and comparisons between groups within herds have allowed information about nutritional constraints on productivity to be made available to farmers more quickly and more specifically than by any other means. Simple data on the incidence of disease - essential for decisions to be made on control and preventive approaches - have been collected as well. The challenge of the FAO/IAEA Co-ordinated Research Project (CRP) entitled "Development of Supplementation Strategies for Milk-Producing Animals in Tropical and Subtropical Environments" on smallholder farms was to study if a similar approach could be adapted to be of use in subtropical and tropical environments for identifying any factors which were constraints on productivity and to clarify those that were not; with the additional problems that the farms were located in areas of great fluctuation in nutrient availability, where groups of cows are not available on blood sampling occasions, where genetic variation is wide and where production levels are generally lower.

2. METERIALS AND METHODS

Studies under the CRP were initiated in 13 countries - Brazil, Chile, China, Indonesia, Mexico, Paraguay, Philippines, Sri Lanka, Thailand, Turkey, Uruguay, Venezuela and Viet Nam. Guidelines commencing with a field survey of a minimum of one year on prevailing cattle production systems were set down. Data were stored in a computer database specifically designed for these studies. Printed data sheets resembling computer on-screen forms were used in data collection in the field. In each case 80 cows from representative farms of similar type were selected avoiding animals which were untypical and/or experiencing clinical problems. Cows were usually crosses between local native and European breeds such as Holsteins. In China the animals used were yaks, *Bos grunniens*, which provide milk, meat and wool. Blood sampling for metabolite analysis was carried out between 1-2 weeks before calving and between 10-20 days and 2-3 months after calving. Cows were assessed once a month for body condition score (BCS) on a scale from 1-5 [8, 9]. Body weight was determined by heart girth measurement using a weighband pulled to a constant tension of 5 kg. Milk yield was recorded monthly. Calves, if suckling, were weighed at birth and monthly until weaning. Assessments of feed intake, content and type were made monthly. All feeds (pastures and supplements) were analysed for dry matter, 48 hour degradability, organic matter, nitrogen and ash. Similar concentrates were pooled. Milk samples were collected once a week from 2-4 weeks calved until pregnancy was confirmed by rectal examination. Milk samples were preserved with sodium azide and the milk fat subsequently removed. The fat-free portion was kept frozen at -20°C until radioimmunoassay (RIA) was carried out for progesterone level using the FAO/IAEA Solid-Phase RIA Kit [10]. Cyclic activity was deemed to have started at the first of two consecutive samplings where progesterone was above 3 nmol/L. Gastro-intestinal parasitic infestation was also assessed in some of the projects from faecal samples collected at three month intervals.

Blood metabolites to be analysed were chosen on the grounds of stability after collection, ease of analysis and known relevance to likely nutritional constraints. β-hydroxybutyrate (BHB) level was used as a measure of energy balance. Urea level was used to assess protein intake. Albumin and globulin values were measured to assess long term protein status, as well as the presence of chronic inflammatory disease. Inorganic phosphate levels in blood provided an indication of dietary phosphate intake and haemoglobin was measured to assess the presence of anaemia. Reference values for metabolites were taken from Whitaker *et al.* [5]. Blood samples were collected into vacutainers containing lithium/heparin anti-coagulant and transported in a cool box to the laboratory. Samples were centrifuged within 24 hours and plasma subsequently removed. If analysis was not carried out immediately, plasma was stored at -20°C. Analysis was carried out on batches of plasma samples using kits provided by the FAO/IAEA Agriculture and Biotechnology Laboratory, Seibersdorf, and manually operated colorimeters. The methods used were: BHB using an end point UV enzymatic (3-HBDH) NAD dependent method, urea by Urease-Berthelot, total protein by Biuret, albumin by Bromo Cresol Green, globulin by the difference between total protein and albumin, phosphorus by Molybdate and hemoglobin by Drabkin-Cyanmethemoglobin.

Guidelines were provided on an individual basis for each study on the preparation of the data for analysis. The database included background data on the farm and cows, productive parameters at the time of sampling, metabolite results, haemoglobin levels, milk fat percentage, body weight and condition score and reproductive events. The database, which contained this data in six separate files, was organised into query files in dBase 4[a]. The queries allowed two or more portions of the data files to be merged. They allowed the creation of calculated fields, the addition of fields to existing files and the indexing of resulting files for efficient organising of the data for analysis. The analysis that is reported in this paper was completed using the Systat 5[b] statistical programme. It was limited to calculating the mean and standard deviation for each metabolite at three different stages of lactation. The percentage of values outside the reference range was calculated assuming a normal distribution, such that 68.3, 95.4 and 99.7% were within one, two and three standard deviations respectively.

[a] Ashton Tate, Torrance, California

[b] SPSS Inc, Chicago, Illinois

3. RESULTS

In order to maintain a reasonable length to this paper no attempt has been made here to present or discuss feed analysis, milk yield, weight or body condition score data collected in these studies. These details can be found in the individual country reports presented elsewhere [11].

Mean and standard deviation of BHB and inorganic phosphate values obtained are shown in Table I. Values for urea, albumin and globulin are in Table II. There was some variation in the number of cows blood sampled in each country, with the minimum sample size being 40 cows. In assessing metabolite values the mean is sometimes important but the variation from it, particularly the number of samples outside the reference ranges is more relevant for interpretation [5]. This is shown as percentages in Figures 1a, 1b, 1c, 1d and 1e.

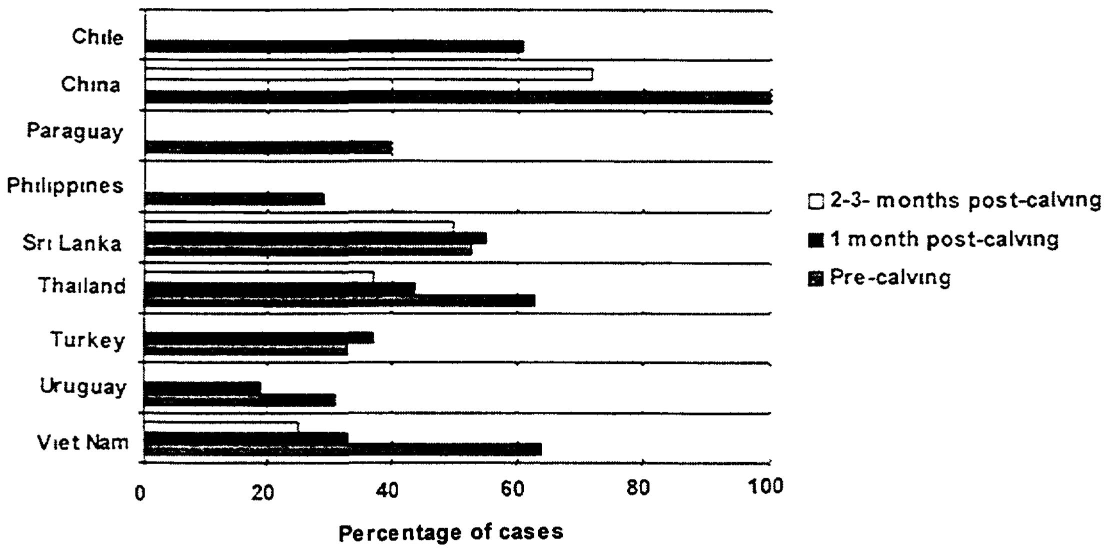

FIG 1a. Percentage of β-hydroxybutyrate values in blood plasma of dairy cows outside reference range (> 0 6 mmol/L precalving, > 1 0 mmol/L postcalving [5])

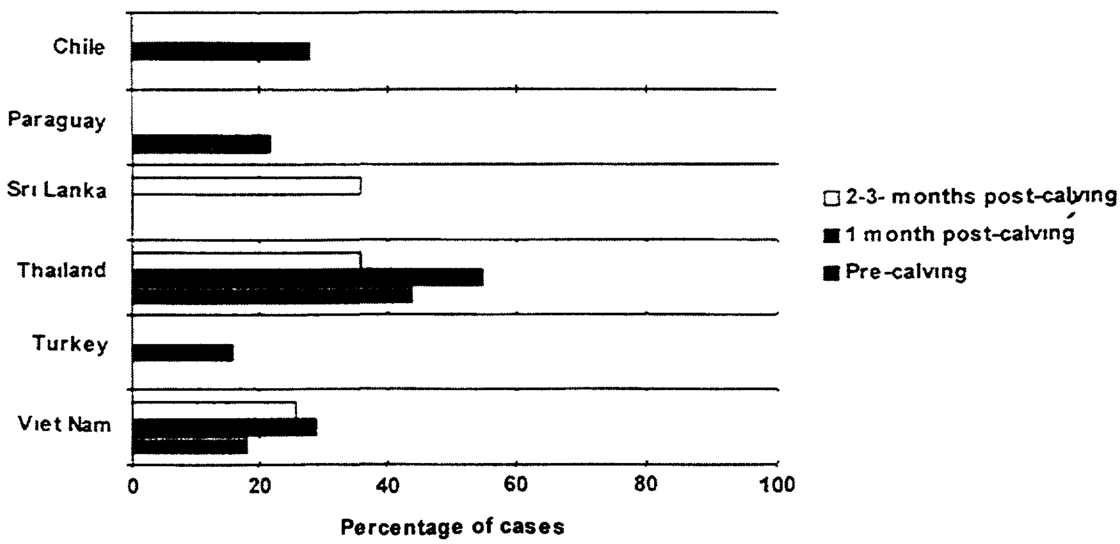

FIG 1b. Percentage of urea values in blood plasma of dairy cows outside reference range (< 3 6 mmol/L [5]

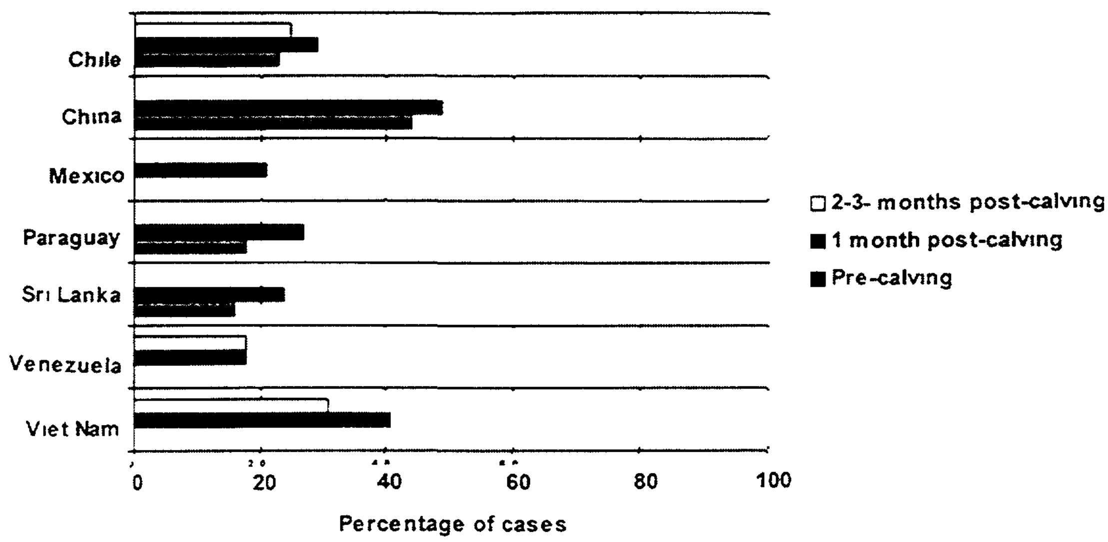

FIG 1c Percentage of albumin values in blood plasma of dairy cows outside reference range (<30g/L [5]

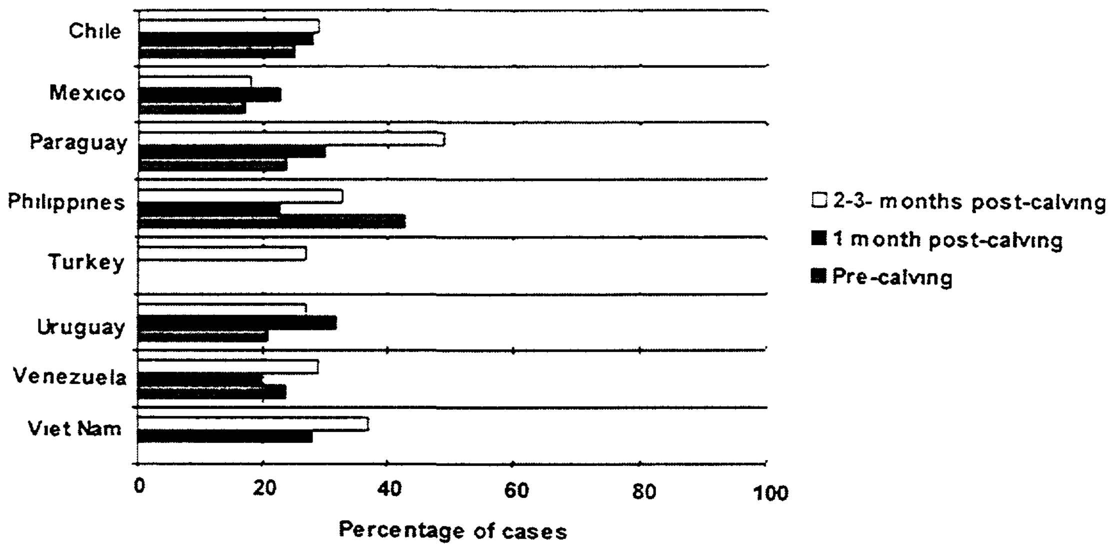

FIG.1d Percentage of globulin values in blood plasma of dairy cows outside reference range (> 50 g/L [5]

In nine countries, BHB was above the reference value in over one third of cows blood sampled before calving (Figure 1a). This implies that negative energy balance in late pregnancy was widespread. In the Philippines there was a significant positive correlation between pre-calving BHB levels, BCS loss and body weight loss and interval from calving to conception. Paraguay showed a relationship between BHB pre-calving and calving to first service interval as well as better fertility in cows with higher BCS at calving. In five countries BHB was above the reference value for lactating cows at one month calved in considerable percentages of them (Figure 1a). The figures were highest in Sri Lanka and Thailand, where BCS decrease and weight loss after calving was particularly marked Half of the cows tested in Sri Lanka still had high BHB values at 2-3 months after calving. In Turkey, some of the highest individual BHB values were recorded at one month after calving together with marked BCS loss and some clinical cases of ketosis.

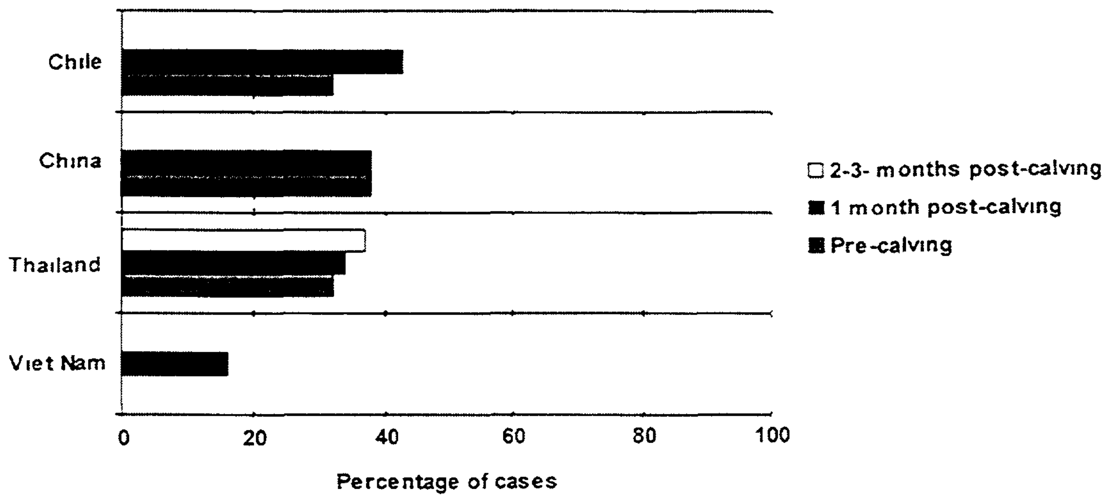

FIG 1e Percentage of inorganic phosphate values in blood plasma of dairy cows outside reference range (< 1 4 mmol/L [5]).

Inorganic phosphate values were within the reference range in seven of the countries. Only in Brazil (Table I) and Thailand (Figure 1e) were there low values at 2-3 months after calving.

TABLE I. MEAN AND STANDARD DEVIATION OF β-HYDROXYBUTYRATE (BHB) AND INORGANIC PHOSPHATE VALUES IN BLOOD PLASMA FROM DAIRY CATTLE IN 13 COUNTRIES AT THREE DIFFERENT STAGES OF LACTATION

Country	β-hydroxybutyrate (mmol/L)			Inorganic phosphate (mmol/L)		
	pre-calving	1 month post-calving	2-3 months post-calving	pre-calving	1 month post-calving	2-3 months post-calving
Brazil	0.5	0.6	0.4	1.8	1.4	1.3
Chile	0.7 ± 0.3	0.7 ± 0.3	0.7 ± 0.2	1.7 ± 0.6	1.5 ± 0.5	1.7 ± 0.3
China	0.9 ± 0.2	0.5 ± 0.2	1.3 ± 0.5	1.5 ± 0.3	1.5 ± 0.3	2.2 ± 0.3
Indonesia	0.3	0.4	0.4	1.8	1.8	1.8
Mexico	0 4 ± 0.04	0.3 ± 0.03	0.4 ± 0.03	NA	NA	NA
Paraguay	0.5 ± 0.4	0.6 ± 0.3	0.6 ± 0.2	2.2 ± 0.4	2.3 ± 0.4	2.2 ± 0.4
Philippines	0.5 ± 0.2	0.7 ± 0.3	0.5 ± 0.2	2.0 ± 0.3	2.0 ± 0.4	1.9 ± 0.3
Sri Lanka	0.7 ± 0.9	1.1 ± 0.6	1.0 ± 0.9	2.4 ± 0.7	2.8 ± 0.7	2.6 ± 0.6
Thailand	0.8 ± 0.6	0.9 ± 0.6	0.8 ± 0.5	1.8 ± 0.8	1.8 ± 0.9	1.7 ± 0.9
Turkey	0.5 ± 0.2	0.8 ± 0.6	0.6 ± 0.3	1.9 ± 0.4	1.8 ± 0.3	1.7 ± 0.3
Uruguay	0.5 ± 0.2	0.7 ± 0.3	0.6 ± 0.3	1.9 ± 0.2	1.8 ± 0.4	1.8 ± 0.3
Venezuela	0.4 ± 0.2	0.4 ± 0.2	0.4 ± 0.2	2.0 ± 0.4	2.9 ± 0.4	2.0 ± 0.3
Viet Nam	0.8 ± 0.5	0.7 ± 0.6	0.7 ± 0.4	2.1 ± 0.5	2.0± 0.6	2.0 ± 0.5

Sample size was > 40 cows in each country

TABLE II. MEAN AND STANDARD DEVIATION OF UREA, ALBUMIN AND GLOBULIN VALUES IN BLOOD PLASMA FROM DAIRY CATTLE IN 13 COUNTRIES

Country	Urea (mmol/L)			Albumin (g/L)			Globulin (g/L)		
	Pre-calving	1 month post-calving	2-3 months post-calving	Pre-calving	1 month post-calving	2-3 months post-calving	Pre-calving	1 month post-calving	2-3 months post-calving
Brazil	3.3	3.0	2.6	35	33	36	47	46	49
Chile	6.5 ± 2.3	5.2 ± 2.5	5.5 ± 1.7	34 ± 5.1	33 ± 4.2	33 ± 4.2	42 ± 11.0	43 ± 11.0	45 ± 8.4
China	8.2 ± 1.6	6.9 ± 1.1	5.6 ± 1.2	31 ± 6.5	30 ± 6.4	40 ± 2.7	32 ± 8.7	34 ± 7.7	32 ± 6.9
Indonesia	7.0	8.1	8.2	31	33	34	40	45	42
Mexico	6.8 ± 0.7	6.9 ± 0.7	7.0 ± 0.7	34 ± 3.2	33 ± 3.6	34 ± 3.5	44 ± 6.3	45 ± 6.5	44 ± 6.7
Paraguay	5.6 ± 2.5	7.6 ± 2.3	7.3 ± 3.0	35 ± 5.5	35 ± 7.7	36 ± 4.2	42 ± 10.6	44 ± 10.3	50 ± 10.1
Philippines	5.5 ± 1.8	5.3 ± 1.5	5.7 ± 2.0	38 ± 4.5	39 ± 5.5	39 ± 5.5	48 ± 11.0	45 ± 6.5	46 ± 8.5
Sri Lanka	7.0 ± 6.2	6.0 ± 2.0	4.0 ± 1.0	34 ± 4.1	34 ± 5.3	42 ± 4.5	39	37	32
Thailand	3.9 ± 1.8	3.4 ± 1.3	3.7 ± 1.5	36 ± 3.4	36 ± 4.1	36 ± 6.0	34 ± 9.5	36 ± 7.8	40 ± 4.0
Turkey	5.4 ± 1.7	5.7 ± 2.1	5.6 ± 1.2	36 ± 3.0	37 ± 3.0	37 ± 3.0	37 ± 9.0	39± 9.0	44± 9.0
Uruguay	6.4 ± 1.5	6.2 ± 1.8	6.4 ± 2.2	37 ± 3.1	36 ± 3.7	36 ± 4.8	44 ± 7.1	46 ± 7.6	45 ± 7.8
Venezuela	5.2 ± 1.4	5.3 ± 1.3	5.4 ± 1.6	35 ± 3.1	34 ± 4.3	34 ± 4.4	43 ± 9.4	43 ± 8.0	45 ± 8.3
Viet Nam	5.9 ± 2.5	5.0 ± 2.4	5.0 ± 2.0	40 ± 9.9	32 ± 9.1	35 ± 9.1	36 ± 12.2	42 ± 12.5	45 ± 13.8

Sample size was > 40 cows in each country

In six countries (Chile, Mexico, Paraguay, Philippines, Uruguay and Venezuela) globulin values were high on all three sampling occasions in more than 17% of cows (Figure 1d). In Chile more than 25% of cows had high globulin values in every period and in Paraguay so did nearly 50% by 2-3 months after calving. In a further two countries (Turkey and Viet Nam) there was a similar percentage of high values on one or more occasions. These results indicate the presence of significant chronic inflammatory disease in at least eight out of the thirteen countries. In Thailand, one of the countries without raised globulin results, mean haemoglobin values of 8.9, 8.4 and 7.5 g/dL at the three sampling occasions respectively, suggested the presence of blood parasitic disease as well - such as babesiosis or theileriosis. In seven countries, albumin values were below the reference level in 16 to 49% of samples (Figure 1c). In disease situations when globulin values go up albumin often goes down. This was probably the explanation in Chile, Mexico, Paraguay, Venezuela and Viet Nam. Albumin levels can also be affected by dietary protein supply but urea levels were only significantly low in cattle in Viet Nam (Figure 1b) of the seven countries where albumin was low. In Viet Nam therefore, dietary protein shortage was the more likely cause of low albumin levels.

Urea levels were low in up to 29% of cows tested in Viet Nam and up to 55% in Thailand (Figure 1b) and the group mean was below the reference range in Brazil (Table II). Only in these countries therefore was it likely that low dietary protein was a constraint productivity. In four countries the mean urea value exceeded 6.7 mmol/L (Table II), the level believed by Butler *et al.* [12] to be detrimental to fertility. Until the controversial question of the possible depressing influence of high blood urea on fertility is resolved, the significance of these results is uncertain but interestingly conception rates above 50% were reported in Indonesia where the highest blood urea values were seen.

Yaks in China were unlikely to be similar to other cattle in these studies and were therefore given some separate consideration. Yaks calve in the spring and a large part of pregnancy is during a long non-lactating period in the winter. If they do not become pregnant again during the short summer breeding season, they stop lactating in the autumn and start again the following summer. This second lactation produces about half the milk of one following a calving. Their blood metabolite values showed high BHB levels before calving (Figure 1a) and a high percentage with low albumin results (Figure 1c) but normal globulin levels (Figure 1d). This suggests considerable under-nutrition during the winter. Albumin values were still poor at one month after calving but were all within the reference range by 2-3 months after calving. With the restoration of better nutritive status during the summer, BHB values were satisfactorily low at one month after calving but were high again later in lactation. This may have been due to seasonal change in grazing availability. Based on the metabolite results in late pregnancy, a trial was conducted to assess the value of supplementary feeding from December to April. Yaks were either fed no supplement (n = 41), oat hay (n = 30) or barley straw (n = 33). In the following summer pregnancy rates were 54, 77 and 73%, respectively. The supplemented animals produced more milk per day, lactated for 29 and 25 days longer, respectively and lost less weight. Unfortunately metabolite results were not available. Blood testing was not continued due to the great practical difficulty of obtaining samples.

4. DISCUSSION

The use of metabolic profiles was pioneered in temperate climates in cows producing relatively large amounts of milk and often under considerable nutritional stress. Cows have an ability to adapt their output and their biochemistry to the food available. This applies in particular to situations where energy supply is inadequate. Cows can experience a severe energy constraint, adapt their output and end up a few weeks later much thinner, with low milk yield but also with BHB, glucose and non-esterified fatty acid levels in blood within optimum ranges because energy balance has been re-established. Even in temperate climates with high producing cows it has been found necessary to control the timing of blood tests within the productive cycle to identify periods of significant negative energy balance through blood metabolite levels [5]. Frequent body condition scoring can provide the same information but it does require frequency to measure change whereas the blood test - strategically timed - can provide the same information from one measurement.

Even in conditions in temperate climates with blood tests carried out on groups of cows within herds at similar stages of production and with careful timing within feeding season, it became apparent that other information than just metabolite values was essential to derive consistently useful and practical information for the benefit of farm productivity [4, 5]. It became clear that the technique was most useful as an aid to management. It can provide information either not available by other means, not available with the same precision by other means or not available early enough within a season or calving pattern to enable helpful adjustments to be made for the benefit of the majority of a herd. It is not unusual to find that the information derived from a metabolic profile is already suspected at the farm and by its advisers beforehand but is not being acted upon for a range of reasons, including a lack of conviction. It is also common to find that the suspicions on the farm before the metabolic profile is carried out are incorrect. So the value of confirming what constraints are not present (negative results) may be as important as those which are, because this allows intervention to be precisely directed. In a research programme negative results are often considered to represent failure and are rarely published. But they may be of just as much value to the advance of scientific knowledge and its practical application.

In temperate climates assessment of metabolite values is made by looking at the group means within each herd and the individual variations within the group. In parallel, level of production, stage of lactation, BCS, body weight and feeding are taken into account. This allows judgements to be arrived at about the reasons for the individual variations in metabolite levels. Comparisons are also made between groups within the herd at the time of the sampling adding to the strength of any conclusions. In this CRP, blood sampling of groups of cows at similar stages of production within a herd at the same time was not possible because farmers owned too few cows. But data were collected over time to assess changes both within and between measures representing nutrition, reproduction and production. Representative farms of the smallholder type with similar nutritional management were included and the criteria for selecting cows within their productive cycle and within season were followed. With the data from BCS, body weight and milk yield as well, it has still been possible to use metabolite results in the CRP in a similar way to identify some constraints and demonstrate the absence of some others.

The metabolite results in isolation showed that negative energy balance was present in cows in late pregnancy in nine out of the 13 countries. With the non-lactating period intended to be one of restoration of reserves and with the evidence that late pregnancy nutrition and BCS at calving can influence subsequent fertility [13, 14], interventions with supplementary feeding for a relatively short period before calving should be considered. Blood testing for BHB levels can be used as a means of identifying the presence of the risk and monitoring the effectiveness of intervention. BCS change can provide similar information but it requires more than one visit whereas cows blood sampled two weeks before expected calving need to be seen only once. With smaller percentages of high BHB values found in cows after calving there is a strong indication that it is the late pregnancy period which presents the best opportunity for intervention.

The small number of projects where low urea levels was found indicates the lesser importance of dietary protein as a primary constraint compared to energy. The exceptions were Brazil, Thailand and Viet Nam. In Brazil, protein may have been a primary constraint as BHB values were mainly within the reference range. But in Thailand and Viet Nam the large percentage of cows with high BHB results, showing that dietary energy was constraining as well, imply that the cows were short of food rather than a particular nutrient. The same judgement applies to the yaks in winter and to the cows in Sri Lanka based on high percentages of high BHB and low albumin results.

Measuring albumin level seems, with the exception of the yaks, to have provided the least useful information directly. But the assessment of globulin level, the difference between total protein and albumin, has been very useful. With many of these above the reference range in so many countries it is clear that disease was widespread and needs further investigation. In some cases such as Chile, the cause of the high globulin and low albumin values was believed to be infection with *Fasciola hepatica* and treatments were initiated. But in many countries the presence of disease was not investigated before or after metabolite testing. So the significance of disease was not determined even though nutritional intervention strategies were planned. This illustrates the need for research to take a broader view of potential constraints in case there is one not identified, such as disease, which prevents cows responding to supplementary feeding as anticipated.

Only a few countries showed low inorganic phosphate levels, suggesting that low dietary phosphate levels were not widespread. In most cases where there were low values they were only just below the reference range. In Thailand this may have indicated an inadequate total food intake as suggested by the BHB and urea results. In Brazil the only really low phosphate figures were found at 2-3 months after calving which were just below the reference range. This coincided with low urea values and may have been a reflection of the pasture availability.

Yaks are untypical of the rest but the metabolite testing can be judged as being useful in that it identified a period of specific nutritional constraint which, when action was taken, produced a productive and reproductive response. In spite of the practical difficulties in blood sampling yaks, one sampling can be used to demonstrate an important point. Quite a large percentage of yaks had low phosphate results in late pregnancy and at one month after calving (Figure 1e). The response to winter feeding with supplementary forage was such that low dietary phosphate was unlikely to have been a primary constraint. These low blood phosphate levels may be within the reference range for yaks. This illustrates that the blood sampling had the additional advantage of providing some needed base line data in this species.

The collection of blood required the presence of a trained person and in some studies there was some reluctance by farmers to allow it. This may have been partly because of lack of experience with the method of sampling, which can be undertaken without distressing the cow in any way according to the skill of the sampler and the effectiveness of the restraint of the cow. Since it is easier to collect milk samples, in the future metabolite testing might be done on milk if methods of analysis are satisfactorily developed. But that approach would be very limited compared to these studies because it would not reveal the main findings, the presence of energy problems before calving and widespread chronic inflammatory disease.

5. CONCLUSIONS

Metabolite testing provided useful information showing the presence of poor energy balance before calving and the presence of disease and so helped to direct attention towards areas of fruitful further investigations. It also provided information of a negative but nevertheless useful nature in demonstrating the rarity of dietary shortages of protein and inorganic phosphate. But there were a few instances of shortages of these nutrients as well, to be identified. To make sure that important constraints are not overlooked and that other constraints are not erroneously assumed to be present, metabolite testing should continue to be used sporadically as part of multi-disciplinary dairy cow development programmes.

ACKNOWLEDGEMENTS

This work was all carried out with the support and encouragement of the Animal Production and Health Section, Joint FAO/IAEA Division, International Atomic Energy Agency, Vienna, Austria. We would like to acknowledge also the enthusiasm, interest and co-operation of the participants in the CRP from Brazil, Chile, China, Indonesia, Mexico, Paraguay, Philippines, Sri Lanka, Thailand, Turkey, Uruguay, Venezuela and Viet Nam.

REFERENCES

[1] PAYNE, J. M., DEW, SALLY M., MANSTON, R., The use of a metabolic profile test in dairy herds, Vet. Rec. **87** (1970) 150-158.

[2] PARKER, B.N.J., BLOWEY, R., Investigations into the relationship of selected blood components to nutrition and fertility of the dairy cow under commercial conditions, Vet. Rec. **98** (1976) 394-404.

[3] BLOWEY, R., A practical application of metabolic profiles, Vet. Rec. **97** (1975) 324-327.

[4] KELLY, J.M., WHITAKER, D.A., SMITH, E.J., A dairy herd health and productivity service, Br. Vet. J. **144** (1988) 470-481.

[5] WHITAKER, D.A., KELLY, J.M., EAYRES, H.F. Use and interpretation of metabolic profiles in dairy cows, Department of Veterinary Clinical Studies, University of Edinburgh (1995).

[6] BERTONI, G., CAPPA, V., Il profilo metabolico nella vacca produzione di latte, Biochim. Clin. **8** (1984) 131-133.

[7] WITTWER, F., BOHMWALD, H., CONTRERAS, P., PHIL, M., FILOZA, J., Análisis de los resultados de perfiles metabólicos obtenidos en rebaños lecheros, Chile Arch. Med. Vet. **19** (2) (1987) 35-45.

[8] ANONYMOUS, Condition scoring-dairy cows, Advisory leaflet 100, East of Scotland College of Agriculture, Edinburgh (1976).

[9] EDMONDSON, A., LEAN, I., WEAVER, L., FARVER,T., WEBSTER, G., A body condition scoring chart for Holstein dairy cows, J. Dairy Sci. **72** (1989) 68-78.

[10] PLAIZIER, J.C.B., "Validation of the FAO/IAEA RIA kit for the measurement of progesterone in skim milk and blood plasma", Improving the Productivity of Indigenous African Livestock, IAEA-TECDOC-708, IAEA, Vienna (1993) 151-156.

[11] PREVENTIVE VETERINARY MEDICINE **38** (1999) (in press).

[12] BUTLER, W.R., CALAMAN, J.J., BAM, S.W., Plasma and milk urea nitrogen in relation to pregnancy rates in lactating dairy cattle, J. Anim. Sci. **74** (1996) 858-865.

[13] WHITAKER, D.A., SMITH, E.J., DA ROSA, G.O., KELLY, J.M., Some effects of nutrition and management on the fertility of dairy cattle, Vet. Rec. **133** (1993) 61-64.

[14] WRIGHT, I.A., RHIND, S.M., WHYTE, T.K., SMITH, A.J., Effects of body condition at calving and feeding level after calving on LH profiles and the duration of the post-partum anoestrus period in beef cows, Anim. Prod. **55** (1992) 41-46.

XA9952129

SOME EFFECTS OF PARTIAL SUCKLING ON MILK YIELD, REPRODUCTION AND CALF GROWTH IN CROSSBRED DAIRY CATTLE IN NORTH EAST COASTAL TANZANIA

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Abstract

SOME EFFECTS OF PARTIAL SUCKLING ON MILK YIELD, REPRODUCTION AND CALF GROWTH IN CROSSBRED DAIRY CATTLE IN NORTH EAST COASTAL TANZANA.

Two experiments are described where a progeny of *Bos taurus* x *Bos indicus* crossbred cows were reared by partial suckling or bucket rearing (Experiment I), and partially suckled calves were weaned at 12 or 24 weeks of age (Experiment II). The results of Experiment I suggest that calf rearing method had no significant effect in the yield of milk extracted from the cows by hand milking although there were effects on the shape of the lactation curve. Cows showed similar patterns of live weight and body condition losses and gains and there were no significant effects on the length of the post partum interval. Suckled calves were lighter at weaning ($P < 0.01$) but there were no differences in live weight between treatments at 52 weeks of age. The main advantage of partial suckling was that the calves took advantage of residual milk which was estimated as 28-29% of the total yield. The results from Experiment II suggest that there were no advantages in terms of milk yield or calf growth by extending the suckling period to 24 weeks. The post partum intervals observed in Experiment II were substantially longer than those in Experiment I, possibly because of greater live weight/body condition losses experienced by cows in the second experiment.

1. INTRODUCTION

Calf rearing in smallholder dairying systems is frequently by means of restricted suckling. In north east coastal Tanzania, a survey [1] found that 90% of respondents reared calves in this way. Calves were suckled on average for 4.6 months, with a range of 3 to 10 months. The same survey found that restricted suckling was practiced in various forms. The calf was allowed to suckle to initiate milk letdown, the cow was then milked out and the calf allowed to suckle again to remove residual milk (i.e. milk not able to be removed from the udder by the process of milking). A simplified version of this method was to allow the calf to suckle only after the cow had been milked out. An alternative practice was to allow the calf to suckle one quarter throughout milking.

Numerous advantages are claimed for rearing calves by restricted suckling: these include increased milk production, increased lactation persistency and increased lactation length, reduced incidence of mastitis and reduced risk of calf diarrhoea [2]. The relative magnitude of the advantages of restricted suckling must depend on the form it takes and the genotype of the cows. Restricted suckling where the calf may be required to initiate milk letdown and maintain the lactation, such as appears to be essential in *Bos indicus* cows, is clearly of considerable advantage [3]. Calf stimulation is not essential for milk letdown and persistency in *Bos taurus* nor the majority of crossbreds arising from mating between *Bos* *taurus* and *Bos indicus* breeds. With such cattle, restricted suckling where the calf makes use of only residual milk remaining in the udder after the cow has been milked out, is likely to be the practice that tenders the most advantage. Calves may then be reared on a source of milk that is not available for sale nor the cow keeper's own consumption; hence calf rearing does not compete directly with milk extraction for human use, with possible advantages to the calf. Calf and cow health may also benefit.

This paper describes two studies, of the effects of partial suckling where calves were allowed only residual milk, on the productivity of crossbred dairy cows and their calves. The objectives were to firstly, quantify the likely benefits to be gained from partial suckling in smallholder dairy production systems and secondly to establish if age at weaning the calf might influence productivity.

2. MATERIALS AND METHODS

The experiments were carried out at the Tanga Livestock Research Centre situated on the north east coast of Tanzania (5°S, 39°E) at an altitude of 66 m. The mean annual rainfall ranges from 1100 to 1400 mm and is bimodal in its pattern of distribution.

2.1. Experimental designs

Experiment I compared the effects of partial suckling to bucket rearing. Thirty-six cows were allocated alternately at calving to treatments 'partial suckling' (PS) or 'bucket rearing' (BR). Experiment II compared the effects of partial suckling to 12 or 24 weeks after calving. Thirty-six cows were allocated alternately at calving to treatments 'suckling to 12 weeks' (S12) or 'suckling to 24 weeks' (S24).

2.2. Animals and management

The cattle used in the experiments were crosses from Holstein and Jersey bulls on East African Zebu cows. The level of *Bos taurus* inheritance in the cows varied from 50 to 87.5%. The calves were a result of *inter se* mating. The cows grazed improved pastures from 0730 to 1500 h and for a further hour after afternoon milking, daily. They were subsequently confined to night paddocks. Morning milking occurred at 0600 h. Cows received 2 kg of a concentrate, consisting of 680 g maize and wheat brans, 200 g rice mill feed, 80 g copra cake and 40 g dried leucaena per kg fresh weight, at each milking throughout the lactation. All milking was by hand. Cows were dried off either at 308 days after calving, when they were 7 months pregnant or when the daily milk yield fell below 1 L for 7 consecutive days, which ever was the sooner.

New-born calves had free access to their dams on the first day of life. Bucket-reared calves were fed 2 L of colostrum after each milking for the following three days and 2 L of fresh milk after each milking from day 5 to weaning. Suckled calves were allowed to suck their dams for 1 h twice daily for days 2 to 4. From day 5 the calves were allowed to suckle residual milk from their dams for 30 min after the cow had been milked out. All calves were housed in covered yards and allowed free access to pasture daily. From 12 weeks of age the calves grazed under the supervision of a herdsman. At 6 months of age the calves were separated by sex.

Calves in Experiment II but not in Experiment I received a concentrate supplement, consisting of 700 g maize bran and 300 g copra cake, per kg fresh weight. Calves were individually penned overnight and offered the concentrate from week 2, starting at 200 g/day with weekly increments of 100 g/day to a maximum offer of 1 kg/day. Concentrate feeding ceased when the calves were 24 weeks of age.

2.3. Measurements

Daily milk yield was measured volumetrically throughout the cows' lactations. Cows were weighed and body condition score (BCS) taken immediately after calving and thereafter at 2 week intervals up to 24 weeks (Experiment I) or 40 weeks (Experiment II) after calving using a defined 0-5 point scale with half points [4, 5]. Calves were weighed at birth, thereafter at weekly intervals up to 24 weeks and thereafter at 4-week intervals up to 52 weeks of age. Concentrate consumption was measured by collecting refusals daily and drying at 100°C to establish dry matter remaining (Experiment II only).

The cows were observed daily in the presence of a vasectomized bull in order to detect signs of oestrus behaviour. Oestrus cows were mated by a nominated bull at a supervised service if the cow had shown a previous oestrus or if the cow had calved 45 days or more previously. Pregnancy was determined by rectal palpation two months following mating.

2.4. Statistical analysis

Most analyses were carried out using general linear model procedures [6]. Models included the factors genotype, calf rearing method, lactation number, season of calving and sex of calf, if appropriate. In some instances, rainfall during the month of calving and live weight or BCS at calving or another time point were included as covariates. Due to lack of observations in some classes, body condition scores could not be analyzed using linear model procedures and therefore, descriptive statistics were used. Data for reproductive traits had a skewed distribution and log transformation was applied before analysis.

3. RESULTS

All calves survived up to weaning although some cows and calves contracted anaplasmosis and East Coast fever during the course of the experiment.

3.1. Milk yield

Aspects of milk yield are shown in Table I. There was no statistical difference in milk yield from calving to 12 weeks, from 13 to 24 weeks or for the full lactation between BR and PS cows in Experiment I or the suckled cows in Experiment II. The residual milk taken by calves was calculated from previously published conversion factors [7, 8], from the conversion ratio established from the bucket reared calves in Experiment I, and from the ME requirements for growth of the calves [9]. The estimates ranged from 2.2 to 2.6 L/day and the mean result represented 28 to 29% of total milk yields in suckled cows in both Experiments I and II. For the purposes of calculating total milk yield in Experiment II, the residual milk taken by calves from 13 to 24 weeks was calculated as 29% of the total yield, as in the period from calving to 12 weeks. Table I also shows estimated milk yields that include milk extracted by hand milking plus milk extracted by the calves. Clearly, partial suckling increases the extraction of milk compared to bucket rearing, and allowing calves to suckle to 24 weeks further increases milk production. The advantage of partial suckling becomes compelling when milk yield is presented as 'offtake', used here to describe the volume of milk that may be consumed by the cowkeeper or sold. In the case of bucket reared calves some extracted milk must be given to the calves. In Experiment I the advantage of partial suckling was to provide an additional 365 L of milk as offtake.

TABLE I. EFFECTS OF BUCKET REARING COMPARED TO PARTIAL SUCKLING (EXPERIMENT I) AND PARTIAL SUCKLING TO 12 WEEKS COMPARED TO PARTIAL SUCKLING TO 24 WEEKS (EXPERIMENT II) UPON LEAST SQUARES MEANS (STANDARD ERRORS) OF VARIOUS MEASUREMENTS OF MILK YIELD (L)

	Experiment I		Experiment II	
	Bucket rearing (BR)	Suckle 12 weeks (S12)	Suckle 12 weeks (S12)	Suckle 24 weeks (S24)
Daily milk yield				
0-12 week	6.5 (± 0.41)	6.2 (± 0.41)	6.3 (± 0.4)	5.7 (± 0.5)
13-24 week	5.7 (± 0.43)	5.5 (± 0.30)	6.6 (± 0.4)	5.7 (± 0.5)
Lactation yield				
milked	1563 (± 104.6)	1592 (± 88.1)	1806 (± 102.0)	1705 (± 129.1)
suckled (estimate)*	-	202	210	412
total (estimate)	1563	1794	2016	2118
offtake**	1227	1592	1806	1705

* For methods of estimate see text

** Offtake is defined as milk that may be consumed by the cowkeeper or sold

The lactation curves for PS and BR cows of Experiment I are shown in Figure 1. It can be seen that PS cows achieved a more modest peak yield that was maintained to a greater extent than BR cows. Lactation persistency (P) was estimate using the expression P = A-B/B, where A is milk yield for the first 180 days and B is the milk yield for the first 90 days [10, 11]. Covariance analysis showed that the rearing method was a significant source of variation (P <0.001) in persistency. The lactation curves for S12 and S24 cows in Experiment II are shown in Figure 2. Lactation curves of both groups of cows were very flat once peak yield was achieved, except for marked secondary peaks in daily yield following weaning at both 12 and 24 weeks. There was no significant difference in persistency in Experiment II. Lactation length was not affected by rearing method in either experiment.

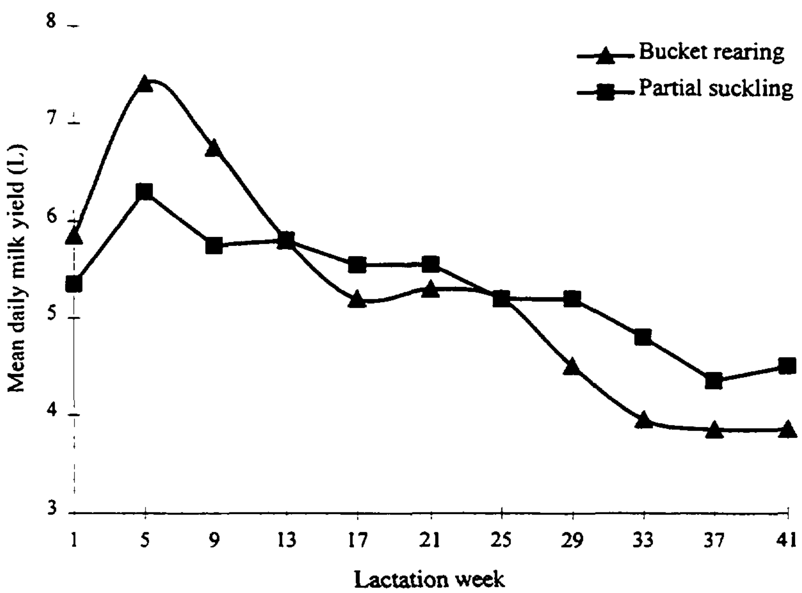

FIG. 1. LSM daily milk yield (L) throughout lactation in Experiment I.

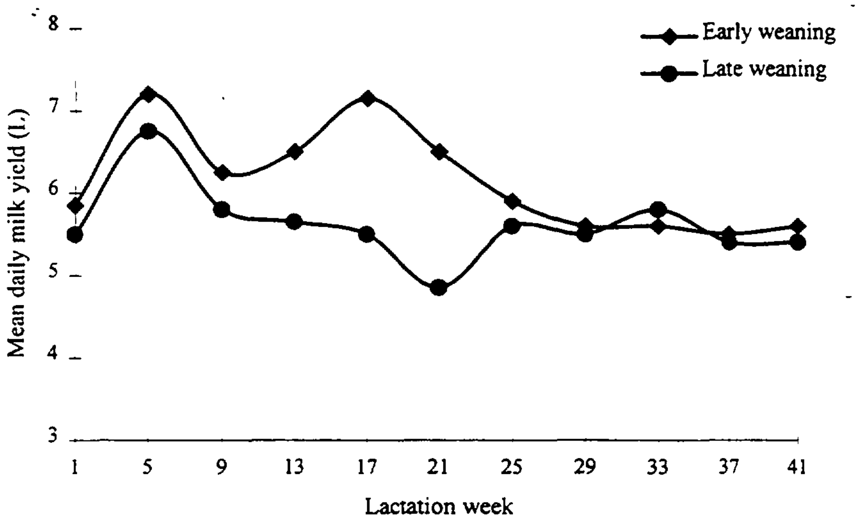

FIG.2. LSM daily milk yield (L) throughout lactation in Experiment II.

3.2. Changes in live weight and BCS

Changes in live weight and body condition score of the cows in Experiment I up to 24 weeks of lactation are shown in Figures 3 and 4, respectively. All cows lost live weight immediately after calving. Cows in the bucket rearing group tended to maintain weight until week 16 when live weight began to increase. Cows in the suckling group gained weight during the first 12 weeks of lactation but suffered a loss following weaning of the calves. There were no significant differences in live weight changes between treatments. The BCS of the cows declined to 12 weeks from when they started to improve again. There were only slight, non-significant differences between rearing methods. Condition score at calving and at weaning, when included as a covariate in the models, contributed significantly ($P < 0.001$) to the variance. There was a negative relationship between BCS at the beginning of the period and the loss in condition that occurred during the period.

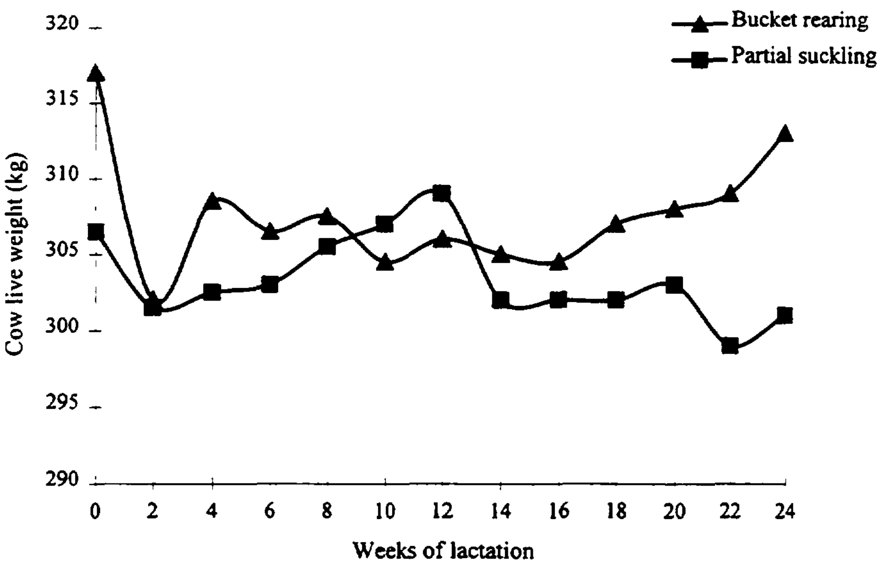

FIG.3. LSM cow live weights (kg) during first 24 weeks of lactation in Experiment I.

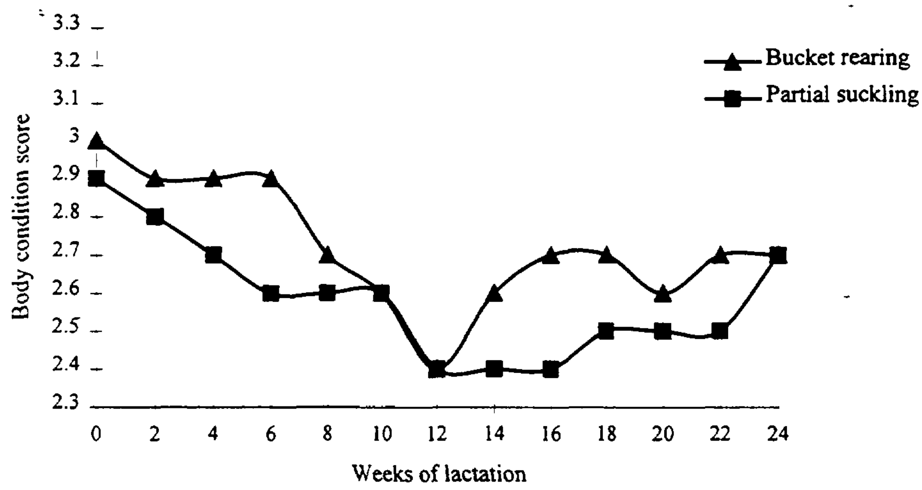

FIG.4. Mean cow body condition score during first 24 weeks of lactation in Experiment II.

Figures 5 and 6 show changes in live weight and BCS, respectively, to 40 weeks of lactation of the cows in Experiment II. Cows in Experiment II continued to lose live weight until later in lactation than cows in Experiment I and although some gains occurred subsequently, neither S12 nor S24 cows had regained their calving live weights by 40 weeks of lactation. S24 cows had a mean net loss of 15.3 kg compared to 7.0 for S12 cows, which was not significant. Mean BCS of both S12 and S24 cows declined during lactation, stabilizing from approximately 24 weeks of lactation. BCS had not returned to post-calving score by week 40 of lactation. As in Experiment I, BCS at the start of a period was negatively related to change in body condition during that period.

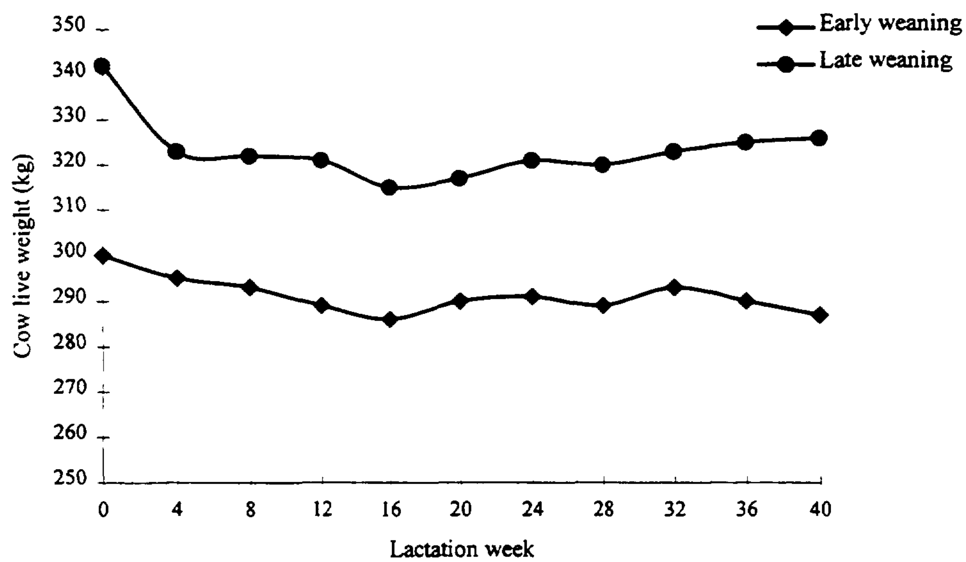

FIG.5. LSM cow live weights (kg) throughout lactation in Experiment II.

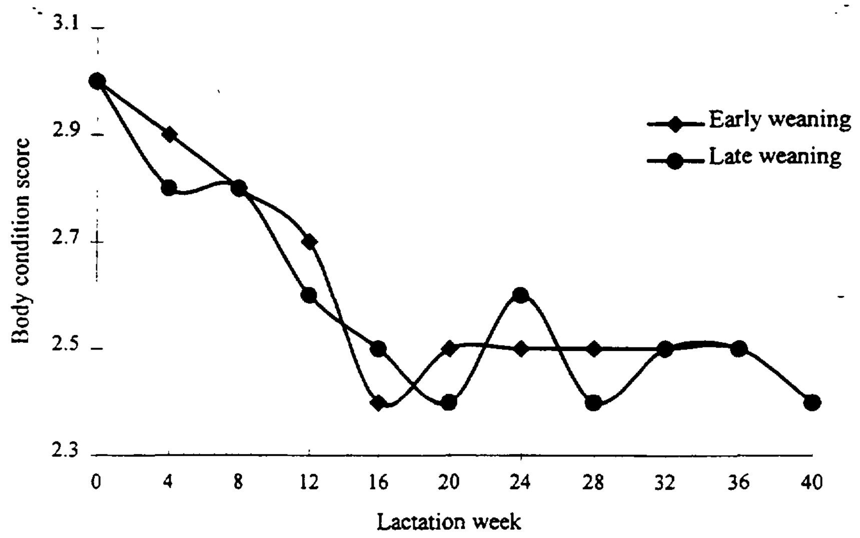

FIG.6. Mean cow body condition score throughout lactation in Experiment II.

3.3. Oestrus, insemination and conception

Days from calving to first oestrus, first insemination and conception are shown in Table II. Of the 36 cows that started in Experiment I, one from each rearing treatment did not show oestrus behaviour. Thirty-three cows had conceived up to the end of the study. Differences between BR and PS cows were small and non-significant, although there was a trend for BR cows to show oestrus, be inseminated and conceive earlier than PS cows.

TABLE II. EFFECTS OF PARTIAL SUCKLING COMPARED TO BUCKET REARING (EXPERIMENT I) AND PARTIAL SUCKLING TO 12 WEEKS COMPARED TO PARTIAL SUCKLING TO 24 WEEKS (EXPERIMENT II) ON LEAST SQUARES MEANS (LOG LEAST SQUARES MEAN ± SE) OF DAYS FROM CALVING TO FIRST OESTRUS, FIRST INSEMINATION AND CONCEPTION

	Experiment I		Experiment II	
	Bucket rearing (BR)	Suckle 12weeks (S12)	Suckle 12weeks (S12)	Suckle 24weeks (S24)
Calving to first oestrus	47 (1.6 ± 0.11)	57 (1.8 ± 0.06)	120 (2.1 ± 0.06)	158 (2.2 ± 0.09)
Calving to first insemination	74 (1.9 ± 0.07)	81 (1.9 ± 0.06)	144 (2.2 ± 0.04)	158 (2.2 ± 0.09)
Calving to conception	115 (2.1 ± 0.08)	126 (2.1 ± 0.08)	198 (2.3 ± 0.05)	239 (2.4 ± 0.07)

All cows in Experiment II showed oestrus but the post partum period was prolonged in comparison to Experiment I. S12 cows were on average 38 days earlier to reach first oestrus, although the difference was not statistically significant. Five cows, two from S12 and three from S24, failed to conceive. Of the remainder, S12 cows conceived on average 41 days earlier than S24 cows but the difference was not statistically significant.

3.4. Live weight gains of the calves

Changes in live weight of the calves over the first year of life are shown in Figures 7 and 8 for Experiments I and II, respectively. In Experiment I, BR calves were significantly (P <0.01) heavier at weaning than PS calves but differences resulting from the rearing treatment had largely disappeared by 52 weeks of age. In Experiment II, the calves from S12 and S24 treatments grew along similar pathways. S12 calves consumed more concentrate supplement (P <0.05) than S24 calves from 13 to 24 weeks and were thus able to maintain similar live weight gains to their contemporaries allowed to suck up to 24 weeks of age.

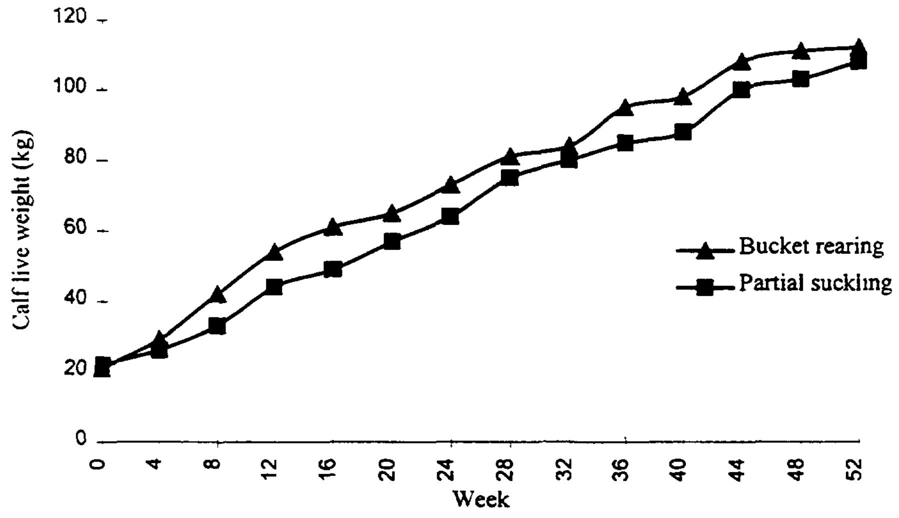

FIG. 7. LSM calf live weight (kg) to one year of age in Experiment I.

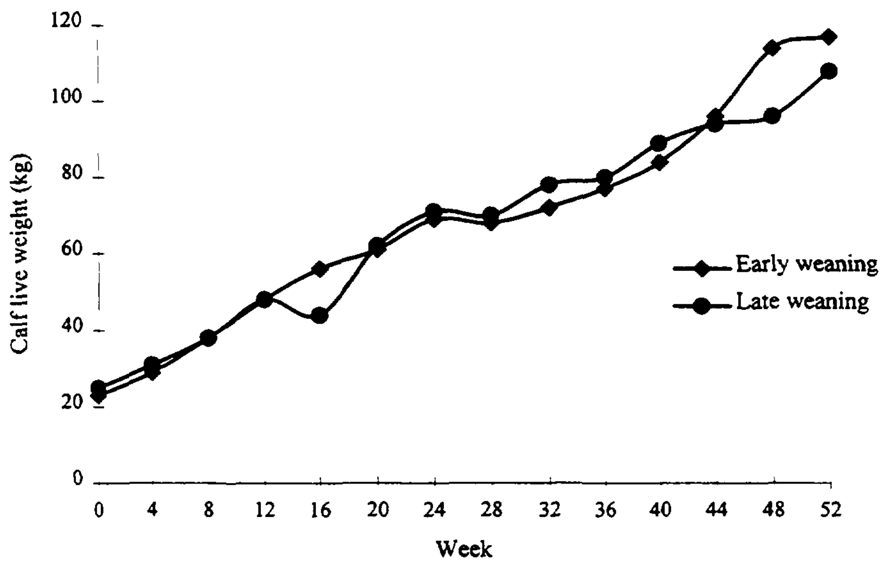

FIG. 8. LSM calf live weights (kg) to one year of age in Experiment II.

4. DISCUSSION

There were few significant differences between rearing methods. Restricted suckling was associated with a different shape to the lactation curve suggesting greater persistency and therefore agreeing with some previous findings [12, 13]. However, this was not associated with a longer lactation or greater lactation milk yield for human consumption, as claimed by other workers [14, 15]. Lactation milk yield was increased when milk sucked by calves was taken into account. The estimate of residual milk was similar in both experiments and greater than the range of 10 to 25% quoted elsewhere [16-18], suggesting that cows may learn to 'hold back' milk when they are accustomed to suckling a calf following milking. The major advantage to restricted suckling in this experiment was that calves were reared entirely on residual milk and therefore none of the milk removed from the udder by hand had to be given to calves. With bucket reared calves being given 4 L of milk per day, the increase of saleable milk from suckling cows over cows whose calves were bucket reared was approximately 1.3L. It is probably unlikely that smallholder farmers would be prepared to forego as much as 4 L of saleable milk to feed the calf and so the advantage of restricted suckling is almost certainly an overestimate.

An apparent disadvantage to restricted suckling was the relatively modest gains made by the calves in the first 12 weeks of life. The provision of a concentrate supplement in Experiment II failed to improve matters as the calves ate little up to 12 weeks, while calves continuing to suckle their dams failed to consume substantial quantities up to 24 weeks. Because of compensatory gains, there were no differences in calf live weight at 52 weeks, confirming the finding that generous feeding of calves during the pre-weaning period may be of little advantage in a production environment where the seasonal effects on feed availability are large or variable [19].

A major, well-recognized concern related to partial suckling is the effect of the continuing suckling stimulus on the inhibition of ovulation in the post partum cow. The results from Experiment I were encouraging as the effects of partial suckling on the time taken to first oestrus were negligible compared to bucket rearing. However, post partum anoestrus was substantially extended in Experiment II. Since the cows of Experiment II lost more live weight over a longer period of lactation, it is tempting to suppose that this may be the explanation for the differences on length of the post partum interval between treatments PS in Experiment I and S12 in Experiment II. It is well established that the resumption of reproductive activity is delayed in both *Bos taurus* and *Bos indicus* cows that are in negative energy balance and/or poor body condition [20, 21]. There is also evidence to show that the effects of suckling and nutritional status interact to modify the length of the post partum interval to ovulation and oestrus [22].

In conclusion, it seems that partial suckling releases more milk for human consumption without unduly jeopardizing the growth and welfare of the calf. However, there seems to be little advantage to continue the practice beyond 12 weeks. More research is needed on the interactions between suckling, the nutrition of the cow, and return to ovarian activity.

REFERENCES

[1] MSANGA, Y.N., The smallholder dairying in Northeast Coastal Tanzania. Productivity of crossbred cattle and calf rearing systems, PhD Thesis, The University of Reading (1997).

[2] PRESTON, T.R., VACCARO, L., "Dual purpose production systems", New Techniques in Cattle Production, (C.J.C. Phillips Ed.), Butterworths and Co. (1989) 20-32.
[3] TEGEGNE, A., GELETO, A., OSUJI, P.O., KASSA, T., FRANCESALLIN, R., Influence of dietary supplementation and partial suckling and body weight on lactation and reproductive performance of primiparous Boran (*Bos indicus*) cows in Ethiopia, J. Agric. Sci., Cambridge **123** (1994) 267-273.
[4] LOWMAN, B.G., SCOTT, N., SOMMERILLE, S., Condition scoring of cattle, East of Scotland College of Agriculture, Bulletin No 6 (1973).
[5] PULAN, N.B., Condition scoring of White Fulani Cattle, Trop. Anim. Hlth. Prod. **10** (1978) 118-120.
[6] STATISTICAL ANALYSIS SYSTEMS UNIT, Statistical Analysis Systems Users Guide, North Carolina Statistical Analysis Systems Unit (1988).
[7] DREWERY, K.J., BROWN, C.J., HORNEA, R.S., Relationships among factors associated with mothering ability in beef cattle, J. Agric. Sci., Cambridge **18** (1959) 938-946.
[8] MAULE, P.J., "Calculation of the amount of milk consumed by suckling Zebu calves", The Cattle of the Tropics, Redwood Press limited, Mellesham, Wilts (1990) 211.
[9] NATIONAL RESEARCH COUNCIL, Nutrient Requirements of Dairy Cattle, 6th Edition, National Academy Press, Washington, D.C. (1989).
[10] KOZELSKII, V.C., IVANOVA, O.A., Lactation and its relationship with some other productive characteristics in cows, Anim. Breeding Abst. **49** (1981) 5690 (Original paper in Russian, Belorrushaya Sol'skohozysitivennaya Akademiya **61** (1980) 52-55.
[11] DANELL, B., Studies on lactation yield and individual test day yields of Swedish dairy cows, II Persistency of milk yield and its correlation with lactation yield, Acta Agricultura Scandinavia **32** (1982) 93-101.
[12] URGATE, J., PRESTON, T.R., Rearing dairy calves by restricted suckling. 3. The effect of reducing frequency to once daily after the fourth week on milk yield and growth of calf, Cuban J. Agric. Sci. 7 (1973)147-154.
[13] LITTLE, D.A., ANDERSON, F.M., DURKIN, K.W., Initial suckling of crossbred dairy cows in milk offtake and calf growth in the Ethiopia highlands, Trop. Anim. Hlth. Prod. **23** (1991) 108-114.
[14] STOBBS, T.H., Management of the Small East African Zebu in relation to milk yield, calf growth and mortality, East African Agric. Forestry J. **32** (1967) 250-255.
[15] EVERRIT, G.C., PHILLIPS, D.S., Calf rearing by multiple suckling and the effects on lactation performance of the cow, Proc. New Zealand Society of Anim. Prod. **31** (1971) 22-40.
[16] LANE, G.T., DILL, C.W., ARMSTRONG, B.C., SWITZER, L.A., Influence of repeated oxytocin injection on composition of dairy cow milk, J. Dairy Sci. **53** (1970) 427-433.
[17] SCHMIDT, G.H., VAN VLECK, L.D., Principles of Dairy Science, W.H. Freeman and Company (1974) 85-98.
[18] URGATE, J., Rearing calves by restricted suckling. 10. Residual milk in cows suckling of not suckling their calves after milking, Cuban J. Agric. Sci. **11** (1977) 253-262.
[19] AGYEMANG, K., CLIFFORD, D., LITTLE, D.A., An assessment of the biological and economic efficiency in conversion of milk to growth in N'dama calves, Anim. Prod. **56** (1993) 165-170.
[20] BUTLER, W.R., SMITH, R.D., Interrelationships between energy balance and postpartum reproductive function in dairy cattle, J. Dairy Sci. **72** (1989) 767-783.

[21] FITZPATRICK, L.A., “Advances in the understanding of post-partum anoestrus in Bos indicus cows”, Strengthening Research on Animal Reproduction and Disease Diagnosis in Asia through the Application Radioimmunoassay Techniques, IAEA-TECDOC-736 IAEA, Vienna (1994) 19-35.
[22] WILLIAMS, G.L., Suckling as a regulator of postpartum re-breeding in cattle; a review, J. Anim. Sci. **68** (1990) 831-852.

THE EFFICIENCY OF MICROBIAL PROTEIN PRODUCTION FROM TROPICAL FORAGES AND ITS MEASUREMENT USING SPOT SAMPLES OF URINE AND CrEDTA CLEARANCE FROM THE PLASMA

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Abstract

THE EFFICIENCY OF MICROBIAL PROTEIN PRODUCTION FROM TROPICAL FORAGES AND ITS MEASUREMENT USING SPOT SAMPLES OF URINE AND CrEDTA CLEARANCE FROM THE PLASMA.

The efficiency of microbial crude protein production (MCP) expressed as g MCP/kg digestible organic matter (DOM) was much lower ($P < 0.05$) in cattle consuming pangola grass hay (P, a tropical grass) than rye grass hay (R, a temperate grass) (87 vs 191 g MCP/kg DOM respectively). This agreed with a collation of experimental data from the authors' laboratory indicating that tropical forages always had lower values than the values in international feeding standards. The excretion of creatinine was too variable for it to be used as an internal marker in spot samples (0.76-1.45 mmole/$W^{0.75}$/d). The fractional disappearance rate of CrEDTA from the plasma was similar for cattle consuming either hay (1.26-1.54%/min). The glomerular filtration rate (GFR) estimated from urinary creatinine excretion was significantly different (289 L/d vs 793 L/d, P vs R respectively). The ratio of predicted allantoin clearance determined by reference to plasma volume and FDR of CrEDTA to the actual urinary excretion was 6.7 and 9.6 for R and P respectively. This difference meant that clearance of CrEDTA could not be used as a technique in association with plasma concentration of allantoin to estimate urinary excretion of allantoin.

1. INTRODUCTION

The efficiency of microbial crude protein (MCP) production is assumed to be within 130-170 g MCP/kg digestible organic matter (DOM) in most feeding standards [1-3]. Poppi *et al.* [4] in a recent review collated data from low quality forages which showed that most values were less than 130 g MCP/kg DOM. Quite significant increases in protein supply to the intestines will result if efficiency is increased. Factors such as rumen degradable N (RDN) supply, water soluble carbohydrates (WSC), rumen dilution rate and amino acid supply will influence this value.

The purine derivative (PD) method [5, 6] offers a means of measuring this in intact animals but total collection of urine is required. Spot samples can be used in association with an internal marker, e.g. creatinine to measure this in the field, but Chen *et al.* [6] and Manuel *et al.* [7] have shown that the variation in creatinine excretion is too great for sufficient accuracy. Chen *et al.* [8] suggested that creatinine excretion and differences in glomerular filtration rate (GFR) between animals and diets needed to be accounted for. A single injection of CrEDTA [9] into the jugular and measuring its fractional disappearance rate (FDR) may provide a simple field based method to account for these animal and feed differences on the principle that differences in FDR of CrEDTA will reflect differences in GFR of creatinine and clearance rate of allantoin.

This experiment measured MCP production, GFR and FDR of CrEDTA in steers consuming a rye grass hay (*Lolium multiflorum*) or a pangola grass hay (*Digitaria eriantha*). The paper also collates data from our laboratory on allantoin and creatinine excretion in *Bos indicus* cross bred cattle.

2. MATERIALS AND METHODS

2.1. Animals and management

The experiment was carried out at the Mt. Cotton property of the University of Queensland. Four, 2 year old Brahman-cross steers (349 $\pm$ 15.4 kg) were used in this trial. The animals were allowed a 2 week preliminary feeding period in pens and were fed on either rye grass hay (*Lolium multiflorum*) or pangola hay (*Digitaria eriantha*) in a cross-over design. For the 7 day experimental period, the steers were moved into metabolism crates and fed at a feeding level calculated as 95% of the *ad libitum* amount, as determined from the preliminary feeding period. Diets were offered once daily and fresh water was available freely.

2.2. Measurements and chemical analyses

After a 2 week preliminary feeding period on each of the diets, dry matter intake and urine and faeces production were measured for each steer over a 7-day collection period. Sub-samples of both the feed offered and feed refused were stored daily and bulked. At the completion of the 7-day measurement period, further sub-samples were taken from the bulk feed offered and refused. All feed samples were weighed and dried for DM analysis and reweighed and ground through a 1 mm screen for OM, neutral detergent fibre (NDF) and N analyses.

A 10% sub-sample of faeces was collected daily and frozen. At the end of the measurement period, these samples were mixed and stored in a freezer prior to freeze-drying. Following this, freeze-dried samples were ground through a 1 mm screen for OM, NDF and N analyses. Separate faecal samples were also taken for DM analysis.

Urine was collected daily into trays containing specific amounts of 10% sulphuric acid (H_2SO_4) so that the pH was kept below 3. Urine volumes were measured and a 2% sub-sample was taken and bulked for each animal and stored in a refrigerator. At the end of the 7-day measurement period, samples of the bulked urine were taken and frozen for subsequent N and PD analysis. The samples for PD analysis were processed immediately prior to storage via the following procedure. A 5 ml urine sample was taken from each of the bulked urine samples. This was mixed with 1 ml of internal standard (allopurinol) in a 50 ml test tube and the sample diluted to 50 ml with ammonium phosphate buffer (0.1M $NH_4H_2PO_4$). This sample was frozen until analysis by the modified HPLC method [9].

2.3. Marker injection procedure

The morning prior to the 7-day measurement period (in both periods 1 and 2), the 4 steers were individually sampled in a crush. A spot urine sample was taken from each of the steers and stored for analysis of PD. A 20 ml blood sample was taken from the jugular, followed by an injection of either 50 or 20 ml of CrEDTA marker. The marker concentration varied from 4.53 mg Cr/ml in the first injection period, when a 50 ml injection was used, to approximately 11.92 mg Cr/ml, when 20 ml injections were given, such that the dose rate was approximately 0.732 mg Cr/$W^{0.75}$. Following injection of the marker, 10 ml blood samples were taken at periodic intervals of roughly 5-10, 15, 30, 45, 60 and 75 or 90 min post-marker injection. A separate 10 ml sample for blood PD analysis was taken prior to injection and at 75 or 90 min post-injection. As blood samples were taken, they were stored in heparin tubes on ice until they were centrifuged for 10 min at 3 000 rpm. After centrifuging, the plasma was stored in a freezer prior to analysis for chromium and PD.

The procedure was repeated on the afternoon of the day following the 7-day experimental period. Morning injections and samples were taken from 0800 h, whilst afternoon sampling was done from 1200 h.

2.4. Analytical procedures

Dry matter in the feed, residues and faeces was determined gravimetrically after oven drying at 60°C. Organic matter of the feed, residues and faeces was determined by ashing. NDF was measured using the Goering and Van Soest method [10], whilst N analyses of the feed, residues, urine and faeces was carried out using the Leco combustion method, on the LECO CNS 2000 Analyser.

PD analysis of the blood and urine samples were carried out using the HPLC Method [9]. Chromium analysis of the blood was done via ICP (Inductively Coupling Plasma Emission Spectrometer). Plasma samples were prepared for the ICP by using equal volumes of plasma and 10% TCA (50:50 ratio) to deproteinize the sample. These samples were then mixed and centrifuged, the supernatant decanted and chromium analysed after direct aspiration into the ICP. Standards used were in a background matrix of TCA and plasma and a recovery test was performed using the chromium standard.

2.5. Calculations

The chromium concentration data taken at various sampling times was fitted to a single pool model with an equation of:

$$Cr_{(t)} = Cr_{(o)}e^{-kt}$$

The intercept at time zero (t_o) was used to calculate pool size. The pool size and the slope (FDR) were used along with allantoin and creatinine concentration in plasma to calculate the predicted excretion rate of allantoin and creatinine at the two sampling times. The clearance rate (L/d) as estimated from CrEDTA was calculated as:

Clearance rate (L/d) = pool size x FDR x 24 x 60

The GFR of creatinine and the clearance rate of allantoin were calculated as the measured urinary excretion of creatinine or allantoin ÷ plasma concentration of creatinine or allantoin.

The amount of MCP (g/day) was calculated using the equation for cattle, as determined by Chen *et al.* [5].

2.6. Statistical analysis

The experiment used a cross-over design, utilising 4 steers in total. Urinary PD data was analysed statistically by analysis of variance with one missing plot.

3. RESULTS

The rye grass hay had more crude protein and less NDF than the pangola grass hay. Rye grass also had a higher intake, digestibility and N balance than pangola grass and had a higher efficiency of MCP production (Table I).

The allantoin:creatinine ratio (A:C) was 1.43 ± 0.200 and 0.95 ± 0.086 for rye grass and pangola grass respectively. The creatinine excretion was higher for animals on rye grass than pangola grass (1.45 ± 0.159 vs 0.76 ± 0.036 mmole/$W^{0.75}$/d respectively $P < 0.05$).

The FDR of CrEDTA from the plasma was not significantly different between morning and afternoon sampling times nor between diets. The GFR of creatinine and the clearance rate of CrEDTA and allantoin differed significantly between compounds and between diets (Table II).

TABLE I. CHEMICAL COMPOSITION, MEAN VOLUNTARY DM INTAKE (DMI), DM DIGESTIBILITY (DMD), OM DIGESTIBILITY (OMD), N BALANCE AND MCP PRODUCTION FOR RYE GRASS AND PANGOLA GRASS

	Rye grass	Pangola grass
Chemical composition		
DM (g/kg)	940	950
OM) (g/kg DM)	943	990
Crude protein (g/kg DM)	194	50
NDF (g/kg DM)	577	760
Intake, digestibility and N balance		
DM intake (g/kg LW/d)	19 ± 0.5^{a}	12 ± 1.1^{b}
DMD (%)	66 ± 0.4^{a}	49 ± 2.7^{b}
OMD (%)	68 ± 0.3^{a}	51 ± 2.5^{b}
N balance (g/d)	18.4 ± 10.8^{a}	-5.3 ± 2.76^{b}
Microbial protein production		
MCP (g/d)	779 ± 48.4^{a}	179 ± 13.1^{b}
MCP (g/kg DOM)	191 ± 7.4^{a}	87 ± 10.3^{b}

Different superscripts denote a significant difference ($P < 0.05$)

TABLE II. THE PLASMA VOLUME AS ESTIMATED FROM CrEDTA DILUTION, FDR OF CrEDTA FROM PLASMA, GFR OF CREATININE AND CLEARANCE RATES OF CrEDTA AND ALLANTOIN IN STEERS CONSUMING RYE GRASS OR PANGOLA GRASS

	Plasma volume (L)	FDR (%/min.)	GFR (L/d)	Clearance rate (L/d)	
			Creatinine	CrEDTA	Allantoin
Ryegrass	61.7^{a}	1.54	793^{a}	1566^{a}	230^{a}
(SE)	(± 5.73)	(± 0.11)	(± 68.1)	(± 215)	(± 32.8)
Pangola grass	45.6^{b}	1.26	289^{b}	825^{b}	114^{b}
(SE)	(± 1.92)	(± 0.06)	(± 18.6)	(± 87.1)	(± 26.2)

Different superscripts within the same column denote a significant difference ($P < 0.05$)

4. DISCUSSION

This experiment has clearly shown that efficiency of MCP production from tropical forages is lower than from temperate forages (Table I) with the value for rye grass agreeing with the literature [1-3]. Prior *et al.* [11] found a similar value for the same rye grass hay in a different experiment, of 185 g MCP/kg DOM whilst values for 2 tropical forages (buffel grass and spear grass) ranged from 85-117 g MCP/kg DOM. Bolam *et al.* [12] found MCP production from rhodes grass hay to range from 62-92 g/kg DOM. In a collation of a large number of experiments Poppi *et al.* [4] found that most low quality diets had MCP values ranging from 33-130 g/kg DOM, well below the 130-170 g MCP/kg DOM used in most international feeding standards. With the same rye grass hay as used here, Prior *et al.* [11] measured rumen ammonia at 112 mg N/L compared to 24-48 mg N/L for the 2 tropical forages which indicates that RDN supply was most likely limiting. The water soluble carbohydrates would also be low for tropical forages as would rumen water dilution rates of 0.042-0.068/h [13].

The significance of these results is the large increase in protein supply to the intestines which would result if efficiency of MCP was increased to expected levels. For example, increasing the efficiency of MCP production from the observed 87 to the minimum expected value of 130 g MCP/kg DOM would result in an increase in total MCP supply from 179 to 275 g MCP/d (0.51 to 0.79 g MCP/kg LW/d). The current IAEA programme involving smallholder dairy farmers in Africa, documents the low quality of feedstuffs usually used with shortages in RDN, water soluble carbohydrates, pre-formed amino acids for the bacteria and most probably very low dilution rates. In seeking to increase efficiency of MCP production it will be important to determine which of the main factors have most influence (RDN, water soluble carbohydrates, synchrony of energy and protein release or amino acids and dilution rate). Bolam *et al.* [12] through various supplementation strategies at rates up to 2% LW could not increase the efficiency of MCP production rapidly, and needed to supplement at least at the 1.5% LW level to reach the 130 g MCP/kg DOM level. In most situations in developing countries this would be too high a level of supplementation and very low levels of supplementation are usual, certainly no greater than 0.5% live weight. In the experiment of Bolam *et al* [12] they used 4 supplement types: molasses (highly degradable sugars), barley (highly degradable starch), sorghum (medium degradable starch) and cottonseed meal (medium degradable fibre). All supplements were balanced for RDN requirements. This suggests that the low efficiency of MCP production from low quality forages may be difficult to increase markedly by common strategies of RDN and WSC supply.

The PD method used here to quantify MCP supply offers a means of measuring the microbial response to low quality roughages and any supplements used in smallholder dairy farms. Where total urine collection is possible then good results are possible. However, this is often not the case, especially with grazing animals and the use of creatinine as an internal marker has been proposed. Chen *et al.* [6], Faichney *et al.* [14], Perez *et al.* [15] and Bolam [16] have shown that there may be significant errors in using creatinine in this way. Bolam *et al* [16] analyzed 60 individual creatinine excretion values for *Bos indicus* cross bred steers of around 250 kg live weight over a range of intakes and supplements. Whilst the mean creatinine excretion (0.93 mmol/$W^{0.75}$/d) was similar to the accepted value reported in literature, of 0.91 mmol/$W^{0.75}$/d, there was far too much variation (0.66-1.28 mmol/$W^{0.75}$/d) for it to be useful. It increased with increasing growth rate in a similar fashion to that observed by Manuel *et al.* [7]. In the current experiment the differences between the diets in creatinine excretion was large (1.45 vs 0.76 mmole/$W^{0.75}$/d) and indicates the nature of the problem.

Chen *et al.* [8] suggested that differences in GFR between diets and between animals would need to be accounted for if plasma allantoin levels were to be used to measure urinary excretion. The proposition investigated here was that clearance of CrEDTA could be used to provide an estimate of allantoin clearance. The predicted clearance of allantoin was calculated as follows:

Predicted allantoin clearance (mmol/d) = Cr pool size (L) x [allantoin in plasma] x FDR CrEDTA x 60 x 24.

The ratio of predicted allantoin clearance to actual allantoin excretion was calculated to be 6.7 $\pm$ 1.36 and 9.6 $\pm$ 1.30 for rye grass and pangola diets, respectively. The value for clearance is numerically much larger than the measured because allantoin will not behave like CrEDTA and there will also be some tubular resorption. Nevertheless it might be expected that a constant proportion would be maintained. This did not occur and suggests that differences in allantoin clearance cannot simply be determined by reference to CrEDTA clearance.

Measured plasma clearance of CrEDTA, creatinine and allantoin yielded interesting results (Table II). There were significant differences between diets for all three parameters. The order of difference CrEDTA > creatinine > allantoin agrees with other studies [7, 17]. The GFR (from creatinine) was of a similar order to cows and sheep [1, 17]. Diet influenced plasma volume (as estimated from CrEDTA) with animals on rye grass having a higher volume, possibly related to the higher nutrient and N intake (Table II). The FDR of CrEDTA did not differ between diets and this constancy will be interesting to pursue further (Table III). The disappearance of CrEDTA was fitted to a single exponential equation for which the r^2 was always greater than 0.86. There was an indication of a 2 pool model but insufficient samples were taken in the first 15 min to delineate this [18]. Samples were taken at about 5, 10 and 15 min post-injection during this period. Whilst this may account for errors in estimating plasma volume and hence clearance of CrEDTA and allantoin, the procedure of more frequent sampling would be impractical in a field based method.

It may be concluded that the efficiency of MCP production for tropical forages is much lower than that recommended by international feeding standards. The FDR of CrEDTA from plasma does not appear to offer a simple field based method for estimating urinary allantoin excretion nor for accounting for differences in creatinine excretion.

REFERENCES

[1] AGRICULTURE AND FOOD RESEARCH COUNCIL, Nutritive requirements of ruminant animals: protein, Technical committee on responses to nutrients, Report No. 9, Nutr. Abstr. Rev. (Series B) **62** (1992) 787-835.

[2] NATIONAL RESEARCH COUNCIL, Nutrient requirements of beef cattle, Seventh revised edition, National Academic Press, Washington, D.C. (1996).

[3] STANDING COMMITTEE ON AGRICULTURE, Feeding standards for Australian livestock. Ruminants, CSIRO publications, Melbourne, Australia (1990).

[4] POPPI, D.P., MCLENNAN, S.R., BEDIYE, S., VEGA, A. DE, ZORRILLA-RIOS, J., Proc. XVIII International Grassland Congress (1998) (in press).

[5] CHEN, X.B., ORSKOV, E.R., HOVELL, F.F. DE B., Brit. J. Nutr. **63** (1990) 121-129.

[6] CHEN, X.B., MEJIA, A.T., KYLE, D.J., ORSKOV, E.R., J. Agric. Sci., Cambridge **125** (1995) 137-143.

[7] MANUEL, J., POPPI, D.P., MCLENNAN, S.R., Proc. Aust. Soc. Anim. Prod. **21** (1996) 489.

[8] CHEN, X.B., KYLE, D.J., ORSKOV, E.R., HOVELL, F.D. DE B., Exp. Physiol. **76** (1991) 59-65.

[9] BALCELLS, J., GUADA, J.A., CASTRILLO, C., GASA, J., J. Agric. Sci., Cambridge **116** (1991) 309-317.

[10] GOERING, H., VAN SOEST, P., Forage fiber analysis, Agric. Research Service, U.S. Department of Agriculture. Handbooks N° 21 (9970) 31 p.

[11] PRIOR, S.J., POPPI, D.P., MCLENNAN, S.R., Animal Production in Australia **22** (1998) 315.

[12] BOLAM, M.J., CONNORS, M.T., MCLENNAN, S.R., POPPI, D.P., Animal Production in Australia **22** (1998) 398.

[13] POPPI, D.P., MINSON, D.J., TERNOUTH, J.H., Aust. J. Agric. Res. **32** (1981) 109-121.

[14] FAICHNEY, G.J., WELCH, R.J., BROWN, G.H., J. Agric. Sci., Cambridge **125** (1995) 425-428.

[15] PEREZ, J.F., BALCELLS, J., CEBRIAN, J.A., MARTIN-ORUE, S.M., Brit. J. Nutr. **79** (1998) 237-240.

[16] BOLAM, M.J., Manipulation of the supply of protein and energy to ruminants consuming tropical forage through supplementation strategies, PhD Thesis, University of Queensland, Brisbane, Australia.

[17] DELAQUIS, A.M., BLOCK, E., J. Dairy Sci. **78** (1995) 604-619.

[18] DOWNES, A.M., MCDONALD, I.W., Brit. J. Nutr. **18** (1964) 153-162.

PERFORMANCE OF DAIRY CATTLE UNDER TWO DIFFERENT FEEDING SYSTEMS, AS PRACTICED IN KIAMBU AND NYANDARUA DISTRICTS OF CENTRAL KENYA

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Abstract

PERFORMANCE OF DAIRY CATTLE UNDER TWO DIFFERENT FEEDING SYSTEMS, AS PRACTICED IN KIAMBU AND NYANDARUA DISTRICTS OF CENTRAL KENYA.

A study was carried out in Central Kenya to compare the performance of dairy cattle under two different feeding systems, stall feeding in Kiambu and grazing in Nyandarua. A total of 23 dairy farmers were randomly selected, 11 from the Kiambu district with a total of 61 cows and 12 from Nyandarua district with a total of 102 cows. Data on milk production and reproduction was collected over a period of two years.

Stall-fed cattle showed a significantly higher milk yield ($P < 0.05$) than the grazed animals over a 10 month lactation period (3,150 vs 2,299 kg/lactation). In both feeding systems Ayshires performed better than the other breeds. The cross-bred animals compared well with pure-breds in the grazing system. Lactation yield increased with parity for the stall-fed animals while for grazed animals, milk yield declined from the 5th parity onwards. The calving intervals were long for both feeding systems (437 vs 513 days, stall-fed vs grazed, respectively). Services per conception were significantly lower ($P < 0.05$) for stall-fed (1.85 vs 2.36) compared to grazed animals. Calving season did not have any significant effect on milk yield in both feeding systems but animals calving during the wet season, on average, had a slightly higher milk yield. Lactation curves for animals in both feeding systems did not show a distinct peak. Body weight and body condition score varied with the stage of lactation.

1. INTRODUCTION

Small scale dairy farmers own 80% of dairy cows in Kenya [1]. Lactation yields of these animals are low compared to large scale farmers. Inappropriate feeding has been cited as one of the major limiting factors to increased productivity. The feeds are either poor in quality and/or insufficient in quantity [2]. Fertility is also poor resulting in decreased herd productivity as indicated by long calving intervals (568-681 days) [3].

Two distinct feeding systems exist in smallholder dairy farms in Kenya. In high potential areas, where there is a scarcity of land, farmers opt for stall feeding where forage (mainly Napier grass) is grown and brought to the animals. In addition, there is heavy input of off-farm feeds like commercial concentrates. In areas where land holdings are large, animals are grazed and receive supplementary feeding (e.g. home grown fodder or commercial concentrates) during milking.

In both feeding systems, despite genetic improvement through the use of artificial insemination, milk yields are low compared to commercial farms in the same localities. Reproductive performance is also poor.

Therefore, nutritional intervention is necessary if productivity of these animals is to be improved. To enable the design of nutritional packages which are both cost effective and sustainable, it is necessary to collect baseline information on available feed resources, milk production and reproductive performance of the existing production systems.

This study was designed to collect baseline data (Phase I) on the performance of dairy animals in the two feeding systems i.e. stall-fed and pasture-grazed. Phase II of the study involved designing strategic feed supplementation packages to improve both individual cow and herd productivity. The results presented in this paper are the baseline data (Phase I) on animal performance in these two feeding systems.

2. MATERIALS AND METHODS

2.1. Study area

The study was carried out in Kiambu (Githunguri division) and Nyandarua (South Kinangop division) districts of central Kenya. These two districts have a combined population of more than 400,000 cows. They fall under agro-ecological zone 1 and 2. The average annual rainfall in the study area in Kiambu district is between 1,200 and 1,400mm and is bimodal in nature. In Nyandarua district the average annual rainfall is between 950 and 1,200mm.

2.2. Selection of Farms

With the help of government livestock extension staff, 14 farms were randomly selected in each of the two study areas. Some of the farmers refused to cooperate early in the project and therefore, were dropped leaving 11 farmers (61 milking animals) in Kiambu district and 12 farmers (102 milking animals) in Nyandarua district.

2.3. Data collection

By means of a questionnaire, farm characteristics (e.g. farm size, number of cows, other livestock, feeds grown on the farm, feeds purchased etc.) as well as the history of cows reared (age, breed, parity, date of last calving, date of last heat etc.) were recorded. All milking animals were examined to ascertain their body condition score (BCS) on a scale of 1-5, [4] and reproductive status (by rectal palpation). Body weights were estimated with a weigh band.

To estimate milk yields, farmers were provided with graduated cups and pre-prepared record sheets. Yield was recorded fortnightly and this data was used to estimate the lactation yield. Occurrence of calving, heats, inseminations and diseases were also recorded.

Milk for progesterone assay was collected weekly 30 days after calving until confirmed pregnant by rectal palpation. The farmers were visited monthly when body weights, BCS, pregnancy diagnosis and feed availability were recorded.

3. RESULTS

A summary of the characteristics of the farms selected in the two study areas are shown in Table I. Land holdings were bigger in Nyandarua district compared to Kiambu and more area was under pasture. Table II shows the composition of the most common feedstuffs in the two study areas.

TABLE I. CHARACTERISTICS OF FARMS SELECTED IN THE TWO STUDY AREAS

	Kiambu (stall-fed)	Nyandarua (pasture-grazed)
Number of farms	11	12
Average farm size (ha)	6.6 ± 6.8	16.2 ± 10.1
Pasture area (ha)	1.5 ± 1.7	14.2 ± 5.9
Average number of milking cows	6.6 ± 4.6	8.7 ± 3.7

The distribution of the breeds were 67% Friesian, 14% Guernsey, 9% Ayrshire and 10% crosses. Cows were housed in loose barns in Kiambu and open paddocks in Nyandarua. In both areas calves were not allowed to suckle.

TABLE II. CHEMICAL COMPOSITION OF COMMON FEEDSTUFFS IN THE TWO STUDY AREAS

Feed material	DM (%)	CP	Ash
		(% DM)	
Nyandarua district			
Napier grass	17.1	6.3	16.6
Kikuyu grass	22.3	11.7	10.5
Lucerne	16.0	16.8	-
Fodder oats	19.2	10.9	12.4
Green maize	21.5	7.7	7.4
Cabbage	5.0	19.1	13.2
Turnip	4.5	16.6	25.4
Rutabaga	5.5	16.3	13.0
Kiambu district			
Commercial Dairy Meal	89.9	14.0	10.8
Green Maize	20.0	9.2	6.6
Maize Germ	87.6	-	1.8
Multicums	87.9	8.7	-
Napier Grass	20.0	9.0	16.0
Kikuyu grass	20.0	15.4	11.4

The influence of breed, parity and calving season on lactation milk yield, standardized to a 10-month lactation period to allow comparison, for the different feeding systems are shown in Table III.

The milk yield was significantly higher ($P < 0.05$) for stall-fed cows. The Ayrshire recorded the highest yield for both feeding systems. The performance of cross breeds were similarly under both feeding systems. Milk yield for stall-fed animals increased with parity while for grazed animals milk yield decreased with parity.

TABLE III. INFLUENCE OF BREED, PARITY AND CALVING SEASON ON 10-MONTH LACTATION MILK YIELD

	Feeding system		
	Stall-fed	Grazed	Mean
	lactation milk yield (kg/cow)		
Type of breed			
Ayrshire	3936 (7)	2514 (8)	3225
Friesian	3621 (43)	2346 (63)	2983
Guernsey	3206 (8)	2282 (15)	2747
Crosses*	1839 (3)	2054 (15)	1706
Mean	3150	2299	2665
Parity			
1 and 2	2753	2230	2492
3 and 4	3043	2527	2785
>5	3304	1828	2751
Season			
Dry	3069	2352	2711
Intermediate	3172	2185	2681
Wet	2945	2313	2969

* Crosses mainly between exotic and East African Zebu
Number of animals within parenthesis

The calving seasons were divided into 3 based on rainfall pattern. The seasons were classified as dry (January to March), wet (April to August) and intermediate (September to December). As shown in Table III the season of calving did not have any significant effect on lactation milk yield.

The 10 month lactation curve for the stall-fed and grazed animals is shown in Figure 1. Animals under the grazing system did not reach a peak after calving and the curve took a downward trend. Stall-fed animals had a slight increase in milk production during the second month.

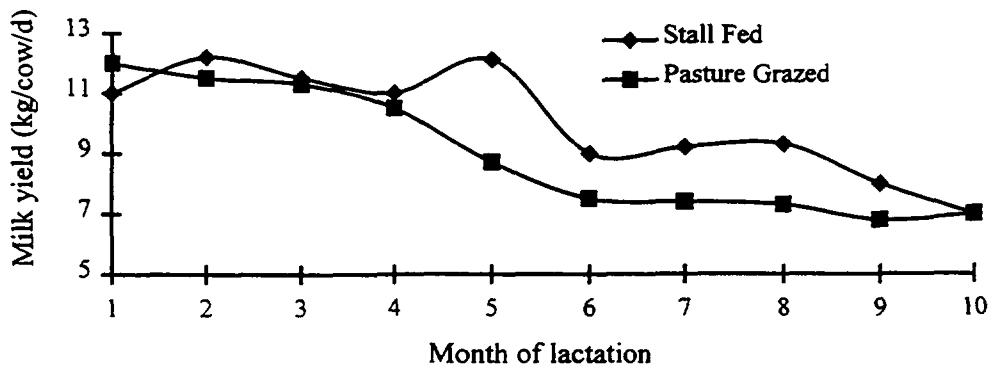

FIG. 1. Lactation curves for stall-fed and grazed cows.

Body weight and body condition scores varied with month of lactation and feeding system (Figure 2). For the stall-fed animals, body condition and body weight improved over the lactation period, the highest increase being during the last month of lactation. For grazed animals there was an initial loss of body condition and weight with an improvement from 6 months of lactation. The stall-fed animals in Kiambu were of higher body weight and better condition than the grazed animals in Nyandarua, throughout the lactation.

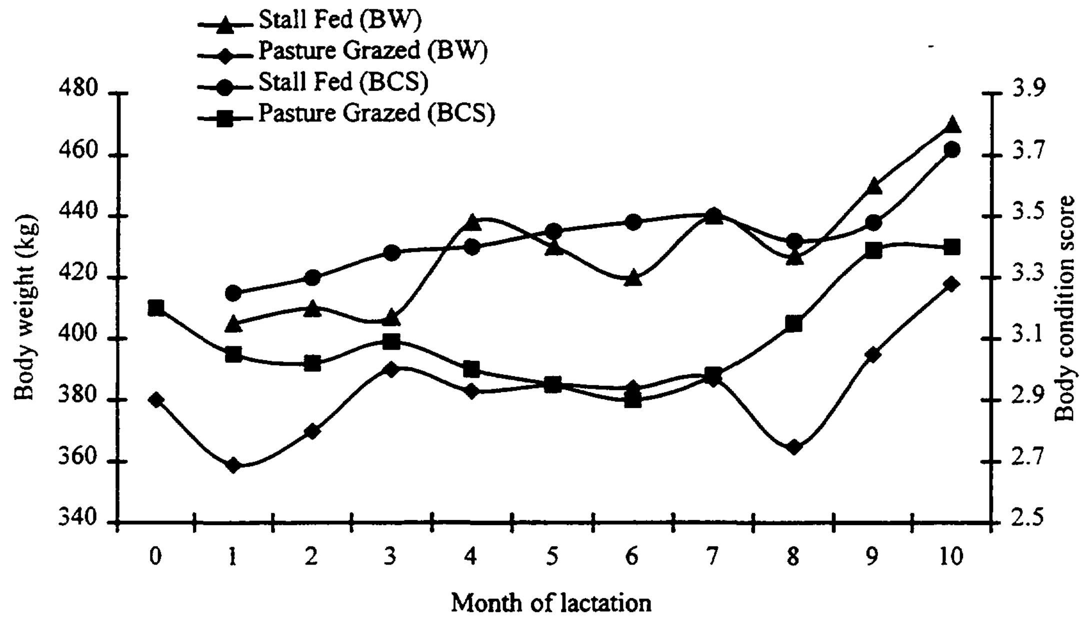

FIG.2. Body weight and BCS for stall-fed and grazed cows.

The reproductive performance of cows under the two feeding systems are shown in Table IV. 47% of stall-fed animals came into heat during the first 70 days post calving compared to 32% for grazed animals. Stall-fed cows showed significantly ($P <0.05$) shorter calving intervals and required fewer services per conception.

TABLE IV. DAYS FROM CALVING TO FIRST OBSERVED HEAT, MEAN SERVICES TO CONCEPTION AND CALVING INTERVALS FOR THE TWO FEEDING SYSTEMS

	Feeding system	
	Stall-fed	Grazed
Percentage showing oestrus		
Within 50d	16	9
51-70d	47	32
71-100d	58.3	55.5
>100d	100	100
Services per conception	1.85	2.36
Calving interval	437 ± 103	513 ± 123

4. DISCUSSION

The higher lactation milk yield for stall-fed animals could be attributed to better feeding and management of these animals. Although the yields were higher than 2,800 kg per lactation quoted by Stotz, [5] they were still lower than the value of over 4,000 kg reported in large scale commercial farms in the same locality. Some of the animals found in this area had been purchased from these commercial farms.

Although the land holdings are smaller in Kiambu district compared to Nyandarua (Table I), there was a greater tendency for farmers to purchase feeds off farm (either fodder or concentrates) to supplement the home grown feed. This led to better nutrition of the animals resulting in higher yields. Although there was a wider variety of feeds in the pasture grazing system, animals were normally grazed and some supplement was given during milking. Some of the feeds used for supplementation had very low dry matter content (e.g. cabbage, turnip) and this might have limited dry matter intake. Due to proximity to the city (about 50 km) there was a readily available milk market, thus enabling the farmers to purchase commercial concentrates. Conversely, there was a problem of milk marketing in Nyandarua due to lack of adequate infrastructure.

The superior performance of the Ayrshires compared to other breeds was surprising as over the years, the Friesians have been known to perform better. Probably the Friesians perform better in a production system where quality and quantity of feed are not limiting. Another factor might have been due the fewer number of Ayrshires recorded in the farms (67% vs 9%). Performance of the crossbreds in the grazing system was comparable to the exotic breeds suggesting lack of any clear advantage of rearing pure breeds over crossbred animals especially when nutrition could be a constraint.

The increase in milk yield with parity as was observed in Kiambu was to be expected. However, in Nyandarua district the reduced milk yield after parity 4 could not be well explained other than to point at inadequate feed supply as a possible reason.

The lactation curve for both feeding systems did not show a distinct peak. This agrees with earlier reports from Kiambu district [6] and has been attributed to inadequate nutrition post calving. Adequate feeding post calving is critical to minimize weight and body condition loss and maximize milk yield. During the study it was observed that pasture-grazed animals lost both weight and body condition post calving and regained the same two months later. The stall-fed animals lost neither body weight nor condition. Therefore, they should have been expected to show a peak lactation at the second month of lactation. The lactation curve (Figure 1) did show a small rise which was not maintained. The loss in body weight and body condition for grazed animals could have contributed to the delayed onset of heat and low conception resulting in longer calving intervals of 437 and 513 days for stall-fed vs grazed animals (Table IV). This is clearly an area that needs addressing for both regions.

Attempts to use progesterone levels in milk as indicator of ovarian activity were not successful due to logistical problems. These have now been addressed for the second phase. Reasons for the larger number of services per conception could not be clearly identified as a result of a lack of information on ovarian activity but this area could be improved for grazed animals.

5. CONCLUSION

Stall-fed animals performed better than grazed animals. This was attributed to better feeding. There is room for improvement in both feeding systems. Body condition scoring proved to be a useful tool for assessing nutritional status of animals.

REFERENCES

[1] MINISTRY OF AGRICULTURE, LIVESTOCK DEVELOPMENT AND MARKETING, Annual report, Animal Production Department, Nairobi, Kenya (1993).

[2] OMORE, A.O., MCDERMOTT, J.J., ARIMI, S.M., OUMA, D, How do you diagnose sub-clinical mastitis in low producing dairy cows?, Kenya Veterinarian **18** (1994) 116-118.

[3] ODIMA, P.A., MCDERMOTT, J.J., MUTIGA, E.R., Reproductive performance of dairy cows on smallholder dairy farms in Kiambu district, Kenya: Design, methodology and development considerations, Kenya Veterinarian **18** (1994) 366-368.

[4] EDMONSON, J., LEAN, I.J., VERSTEEG, J, A body condition scoring chart for Holstein dairy cows, J. Dairy Sci. **72** (1989) 68.

[5] STOTZ, D, Production techniques and economics of small holder livestock production systems in Kenya, Farm management handbook of Kenya, Ministry of Livestock Development, Animal Production Division, Nairobi (1983).

[6] OMORE, A.O., Epidimiology and economics of mastitis in Kiambu district, Kenya, MSc Thesis, University of Nairobi, Kenya (1996).

IMPROVEMENT OF ZEBU CATTLE PRODUCTIVITY IN THE SAHEL REGION: FEED SUPPLEMENTATION ON SMALLHOLDER FARMS IN PERI-URBAN DAKAR

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Abstract

IMPROVEMENT OF ZEBU CATTLE PRODUCTIVITY IN THE SAHEL REGION: FEED SUPPLEMENTATION ON SMALLHOLDER FARMS IN PERI-URBAN DAKAR.

Two studies were conducted in the peri-urban area of Dakar to collect baseline information on feeding, milk production, reproduction, body weight and body condition (Phase I), and to examine the influence of supplementation with local by-products on productive and reproductive parameters of indigenous cattle in traditional smallholder farms (Phase II).

Baseline data collected from smallholder farms between 1994 and 1996 indicated delayed first calving, long calving intervals, decreasing body condition score (BCS) and body weight and low milk yields as major problems associated with cattle productivity in the region. Fertility was related to forage availability; animals showed high fertility after the rainy season and low fertility during the dry season. Supplementation during the critical period of the dry season using agro-industrial by-products (brewer's grains, molasses, groundnut cake, oytser shell and salt) had beneficial effects on productivity. Supplementation reduced loss in body weight and body condition, maintained milk yield and growth rate of the calves during the dry season and reduced length of 'days open' and the calving interval.

1. INTRODUCTION

There is a paucity of research data on the performance of zebu cattle raised under traditional management conditions in Senegal. The little information available shows that these animals have poor reproductive performance [1-3] characterised by delayed puberty and first calving, prolonged post-partum acyclicity and high rates of mortality among calves. While inadequate nutrition has been identified as a major factor contributing to the poor performance of tropical cattle, there is a lack of information on the relationship between nutrition and reproduction of zebu cattle in the tropics.

The following studies were conducted in two phases. Phase I was aimed at collecting baseline data on feeding, milk production, reproduction, body weight and body condition of the animals. Phase II, examined the influence of supplementation with local agro-industrial by-products on productive and reproductive parameters of indigenous cattle on traditional smallholder farms.

2. MATERIALS AND METHODS

2.1. Phase I Baseline data collection

2.1.1. Location of farms

Five smallholder farms, located not far from Dakar (35-50 km) in the region of 'Niayes', were selected for the study. The climate in this region has four seasons, a rainy season (wet and warm, from July to September), post-rainy season (dry and warm, from October to November), dry and cool season (December to February) and dry and hot season (from April to June). The annual rainfall varies from 300 to 500 mm, there being only one rainy season, between July and September. Temperature ranges from 18°C (November-February) to 31°C (May-June) with a relative humidity varying from 30 to 90%.

2.1.2. Animals

Animals selected were of dual purpose (milk-meat) zebu type (crossbred with N'dama) and maintained on natural pastures. They sometimes received a supplement during the dry season, depending on the resources available to the owner. A total of 127 cows and heifers located on 5 smallholder farms (37 to 61 animals per farm) were selected for the study, which was carried out from October 1994 to February 1996.

2.1.3. Herd management

Animals on all farms were grazed from 0730 to 1700 h during the rainy and post-rainy seasons and from 0730 to 1900 h during the dry season, on natural grasslands. Some farms practised night grazing during the rainy season as well as the dry season. The grasslands consisted largely of *Parinari macrophylla* and *Pennisetum pedicellatum* species. All farms practised natural mating with service bulls running freely with the females. Calves were weaned at ages ranging from 8-14 months. Older calves were allowed to graze while younger ones were isolated and penned until the return of the dams. Cows were hand-milked after allowing the calf to suckle, to stimulate milk let-down. Milking was carried out twice a day, except during the dry season when milking was completely stopped. Routine disease prevention included annual vaccination against rinderpest and spraying regularly to control ectoparasites, mostly ticks. Deworming was done at three-month intervals.

2.1.4. Data collection, sampling and measurements

The parameters studied included, intervals from calving to resumption of ovarian cyclicity and post-partum mating, body condition score (BCS) and abortions. The age at puberty and the resumption of post-partum ovarian cyclicity were determined by measuring progesterone in plasma (heifers and dry cows) or in milk (lactating cows). Milk and blood samples were collected twice weekly. Potassium dichromate tablets were used as the preservative for milk. The samples were kept at ambient temperature and were subsequently stored at 4°C for about 30 min before being centrifuged at 4°C. Skim milk and plasma samples were stored at -20°C until assayed. Progesterone concentration of 1.0 nmol/L or more in plasma and of 6.0 nmol/L or more in milk was taken as evidence of ovarian activity. Pregnancy was confirmed by elevated progesterone levels at 21 and 42 days after mating. The occurrence of oestrus on all farms was detected by the herdsman with the aid of behaviourial signs. BCS, on a scale of 1-9, was assessed once a month according to the system developed by Nicholson and Butterworth [4]. Body weight was determined monthly by weighing, or by heart girth measurement. Calf milk intake was measured monthly (morning and evening) from November '94 onwards by weighing the calf before and after suckling. Feed samples were collected twice a month, from December '94 to May '95, for determination of dry matter, crude protein and ash. Milk and blood progesterone concentrations were determined by the radioimmunoassay (RIA) technique [5].

2.2. Phase II On-farm supplementation

2.2.1. Study site and experimental animals

The study was carried out from February to July '96 at the same site as in Phase I. Animals were selected from two of five farms monitored during 1993 to 1996 (Table I). They were randomly assigned to two groups in every farm; supplemented vs non-supplemented.

TABLE I. SELECTION OF ANIMALS FOR SUPPLEMENTATION TRIAL

	Farm 1 (Diamniado)	Farm 2 (Diakhirate)	Total
Lactating cows	21	22	43
Heifers	5	7	12
Calves	14	15	29
Total	40	44	84

2.2.2. Measurements

Cows and calves were weighed and BCS recorded every month in the morning before grazing. Milk production was recorded every week during the experimental period. The amount milked was recorded at each milking and the amount suckled was recorded weekly by weighing the calves before and after suckling.

To evaluate the resumption of ovarian activity, milk samples were collected from lactating cows and blood samples from dry cows and heifers, once a week. Milk and blood samples were prepared and stored for progesterone assay, as described previously [5]. The sensitivity of the assay was 1nmol/L, and intra and inter-assay coefficients of variation were 5.6 and 3%, and 12 and 10% for low and high control samples, respectively.

The first ovulation was considered to have occurred at the first progesterone rise of over 1 nmol/L in the plasma and 3 nmol/L in the milk.

2.3. Statistical analysis

The data were analysed by ANOVA. Scheffe's method for multiple comparisons was used to test significant differences between supplemented and non-supplemented groups.

3. RESULTS AND DISCUSSION

3.1. Phase I

3.1.1. Biomass production and chemical composition of pasture

Biomass production was saitisfactory in December (826 kg DM/ha.) but decreased with advancing dry season (209 kg DM/ha in May). Chemical analysis indicated clearly, that pasture was unsastifactory, both in quantity and quality, during this period. Although there was an increase in the crude protein content (Table II), which was due to the high proportion of leguminous plants, the forage was highly fibrous and presumably of low quality. The only periods when animals obtained their full requirement of nutrients were during the rainy and post-rainy seasons.

TABLE II. BIOMASS PRODUCTION AND CHEMICAL COMPOSITION OF FEEDS

Month	BP (kg DM/ha)	DM (%)	OM	CP
			(% DM)	
December	826	89.9	73.8	8.5
January	530	90.9	74.6	8.2
February	567	90.8	71.0	9.6
March	535	90.4	68.2	11.1
April	455	91.3	68.2	13.1
May	209	90.8	64.3	12.4
June	225	91.0	61.8	12.4

BP, Biomass production; DM, dry matter; OM, organic matter; CP, crude protein

3.1.2. Age at fisrt calving

The average age at first calving was 51 ± 9 months. This is in general agreement with data reported by other workers. Wagenaar *et al* [6] found that mean age at first calving was 50.2 ± 9.1 months for Fulani-type cattle in Niger, while Chicoteau [7] observed a mean of 55.8 months in African zebu under traditional management. Age at first calving of zebu cattle is generally longer than in *Bos taurus* [8]. Most reports [9-11] suggest that it is advantageous to feed heifers kept on pasture with a balanced concentrate supplement to reduce age at first calving. Minimum age at first calving was 3 years and was seen only in 15% of the heifers. 54% of heifers calved at the age of 4 years and the rest calved after 5 years or more.

3.1.3. Live weight and BCS

Monthly changes in live weight and BCS are shown in Figure 1. Both live weight and BCS was high after the rainy season (July-September), because of better feeding and cooler temperature. Animals started to loose weight and body condition from February, the early dry season. The pastures at this time were less satisfactory both in quantity and quality. In the late dry season, between May and July, the pastures were poor and unsatisfactory and animals lost the maximum body weight and body condition during this period.

3.1.4. Distribution of calving and calculated fertile mating

Distribution of calving showed seasonality (Figure 2). Most of the calving (68%) occurred between the months of June and August; 22% of calvings occurred between the months of November and January. Calving percentage during the first season was higher (50%) than the second (30%). 20% of calvings took place between the two seasons.

The majority of cows resumed ovarian activity around October/November, presumably because of better nutrition at this time of the year. Over 20% fertile matings occurred between October and December. However, this lead to calving in June/July, with cows going through their last three months of pregnancy in the dry season, with poor quality pasture as their main source of nutrients. A second smaller peak of mating occurred between March and June. Seasonality of calving has also been reported by previous workers [7] who suggested that adequate feeding could eliminate seasonality of fertile mating in both heifers and cows.

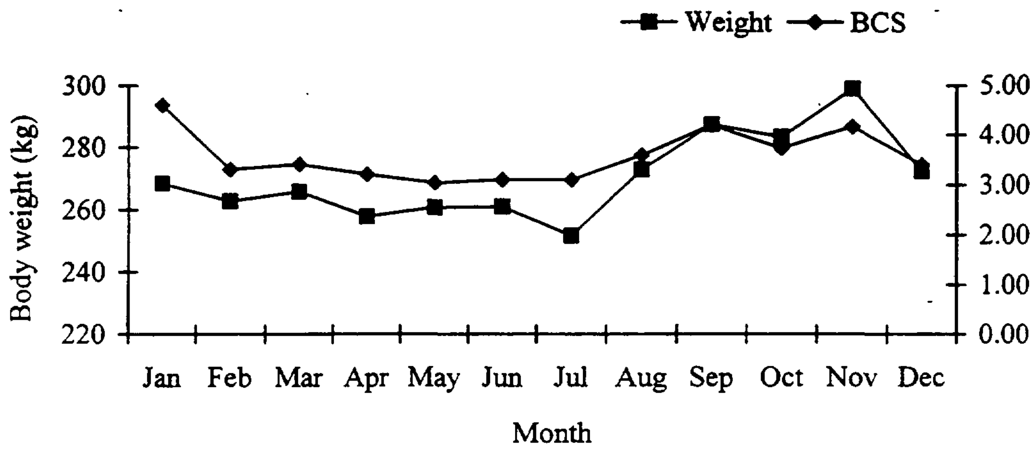

FIG.1. Changes in live weight and body condition score with season.

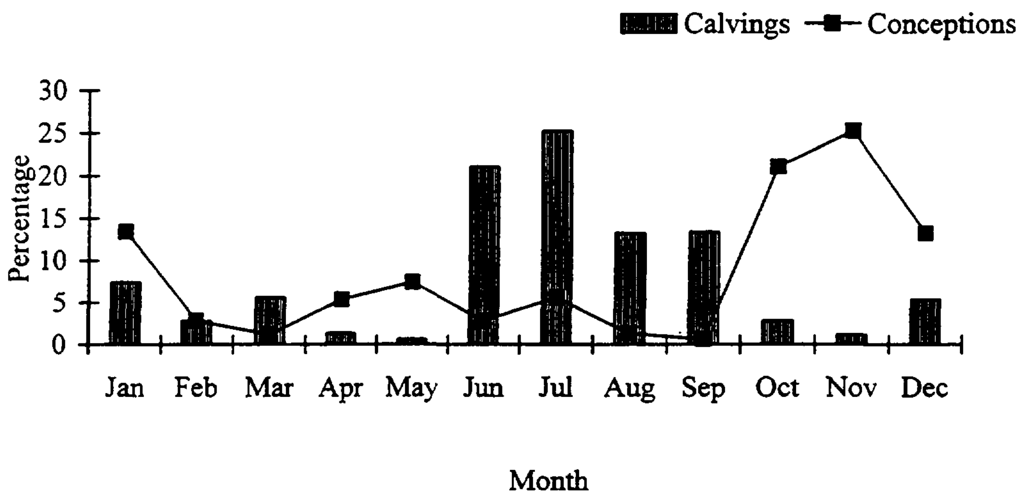

FIG.2. Distribution of calving and fertile mating according to season.

Cows calving before August and September were underfed during the last third of pregnancy and well-fed after parturition. Those that calved in December and January were well-fed before parturition and underfed after calving. Thus, cows that calved between September and November took advantage of satisfactory feeding before and after calving.

The reproductive performance of the postpartum cow is related to nutritional status [12, 13]. Cows fed a high energy diet after calving conceived sooner than those with a lower energy intake [9, 12, 14, 15]. High levels of feeding before calving reduced the postpartum anoestrous period in taurine cows [16]. In addition, more cows exhibited oestrus before the breeding season and subsequent pregnancy rates were increased. King [17] estimated that a 1% change in body weight would result in a 1% change in first service conception rate. Similar results have been achieved in zebu cattle. Seasonality of calving depends on seasonality of mating that is related to the level of feeding.

3.1.5. Resumption of ovarian activity

Although ovarian activity resumed around the 3rd month, only 20% of cows showed ovarian activity at 6 months. 50% ovulated by about the 11th month while over 80% had ovulated in 16 months (Figure 3). This was in contrast to the findings of Galina [2] who reported that usually 50% of cows in tropical pastures show post-partum anoestrus of around 120 days. Eduvie [3] on the other hand observed a post partum anoestrus of 15-20 months in Bunaji cattle under pastoral management. The delayed post partum anoestrus could be ralated to nutrition [14], since zebu cows on-station have shown shorter post-partum anoestrus periods.

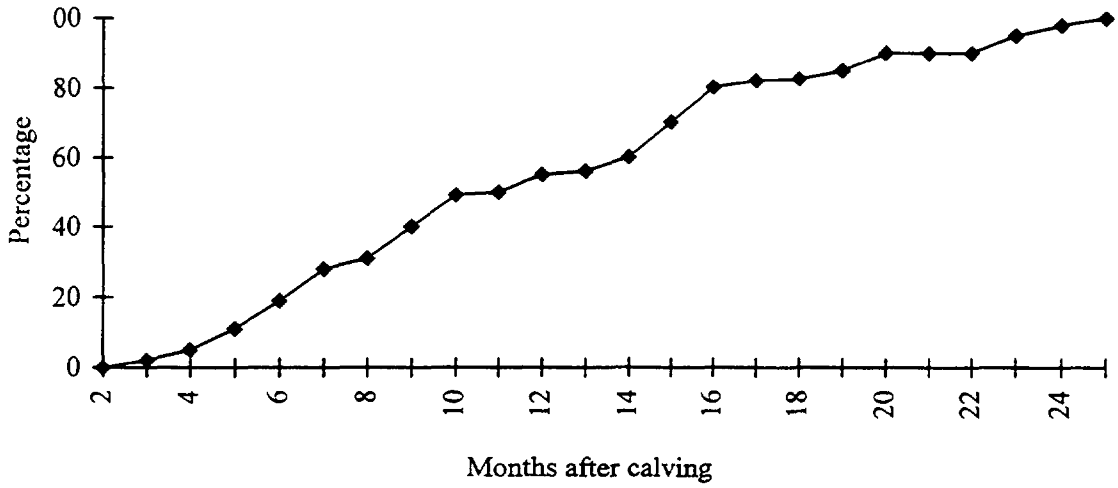

FIG.3. Resumption of ovarian activity.

From the time of calving, body weight and body condition score declined regularly for the first 3 months due to unsatisfactory nature of the pastures. Cows did not resume ovarian activity until its weight and BCS increased. This period for improving weight and BCS, lasted for 11 months after calving.

The relationship between body condition and reproduction has been emphasised by Ward [18] who suggested that every cow has an optimum body weight or BCS for conception, the so-called "target" or "critical" value. Animals weighing less than this 'target' value are less able to reproduce. Wiltbank *et al* [9] added that breeding cows must have an improving body condition during the mating period.

3.1.6. Calving interval

Calving interval was long and averaged 616 ± 150 days. Cows showed a long postpartum anaoestrus period. Average time for the resumption of ovarian activity was 16 months. This would have been responsible for the long calving interval observed in the present study. These results, agree with those of Chicoteau [7] who reported that calving interval ranged from 15.6 to 28.4 months, with an average of 21.4. Denis and Valenza [19] reported a shorter calving interval of 15.5 months for zebu cattle in Senegal. Raised under comparable conditions, *Bos taurus* cows showed early resumption of ovarian activity compared to *Bos indicus* cows [7].

Seasonal effects on calving have been reported by Oliveira [20] and Oyedipe *et al* [1]. They observed in Nellore cattle and in White Fulani heifers a shorter calving interval for cows calved in the dry season compared to those that calved in the wet season. Landais *et al* [21] in

Côte d'Ivoire noted that cows calved in October usualy conceived again in the following January, while those calved in January were unlikely to conceive during the subsequent mating period. Level of feeding after calving appeared to have an important effect on the resumption of ovarian activity.

3.1.7. Milk production

Milk production decreased with advancing dry sason, from around 2-3 kg/d in Decemebr to 1-2 kg/d in May-July (Figure 4). Milk production at calving averaged 2.80 L and decreased to 1.80 L at 10 months. Underfeeding of cows reduced milk production, thus calf growth was also reduced and puberty delayed.

3.1.8. Calf birth weight, growth, weaning and mortality

Birth weight of calves averaged 20 ± 3 kg. Calf growth rate decreased from around 543g/d during the first 4 months to 83.3g/d during 4-8 months. Calves were weaned around 12 months of age. Their mortality was influenced by herd management, age and season: high mortality (90 % of total mortality) was recorded during the dry season.

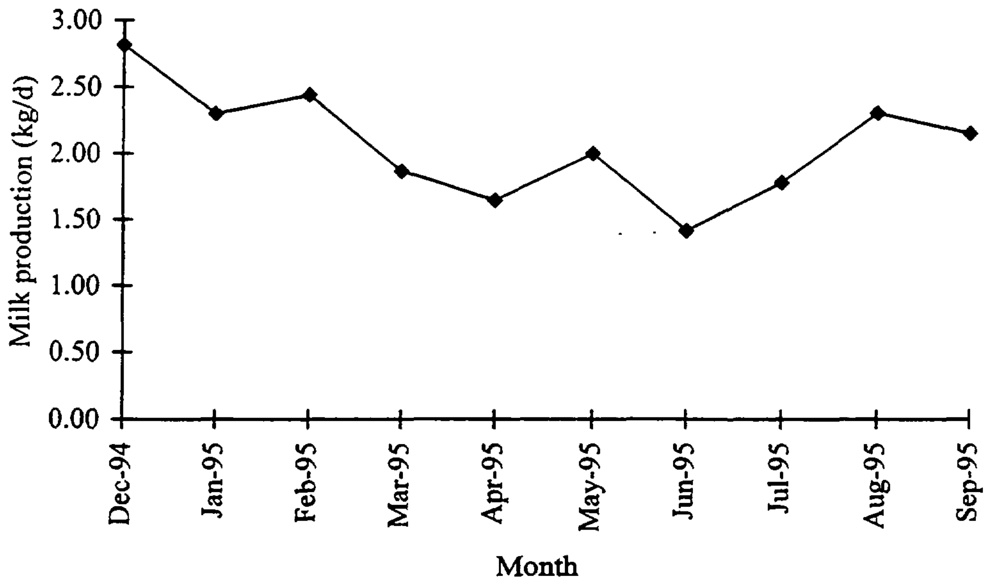

FIG.4. Average daily milk production according to season.

3.2. Feed supplementation on farm

The composition and chemical characteristics of the concentrate supplement used for on-farm supplementation is given in Table II. The supplement was prepared using locally available feed ingredients such as brewer's grain, molasses, groundnut cake, bakery flour waste, oyster shell power and common salt. It had a dry matter content of 73.5% and crude protein content of 19.7%, on DM basis.

TABLE II: CONCENTRATE COMPOSITION, DIET CHARACTERISTICS

Components	Quantity (kg)	DM (%)	Energy (kg DM)	CP	Ca	P
					(g/kg DM)	
Brewer's grain	1.00	87	0.63	162.3	2.9	4.3
Groundnut cake	0.25	25	0.44	113.5	0.25	1.4
Molasses	0.50	42	0.44	3.8	6.3	0.13
Bakery flour waste	1.00	87	0.77	122	1.3	10.79
Oyster shell + salt	0.03	-	-	-	11.7	-

*, Forage Units; DM, dry matter; CP, crude protein; Ca, calcium; P, phosphorus

3.2.1. Production performance

3.2.1.1. Body weight and body condition score

As expected, the supplemented groups lost significantly less body weight compared to the non-supplemented groups between December and August (295 to 274 vs 294.5 to 243 kg) (Figure 5). A similar trend was observed with BCS; supplemented animals lost less body condition compared to non-supplemented animals (from 5.75 to 3 vs 5.75 to 2).

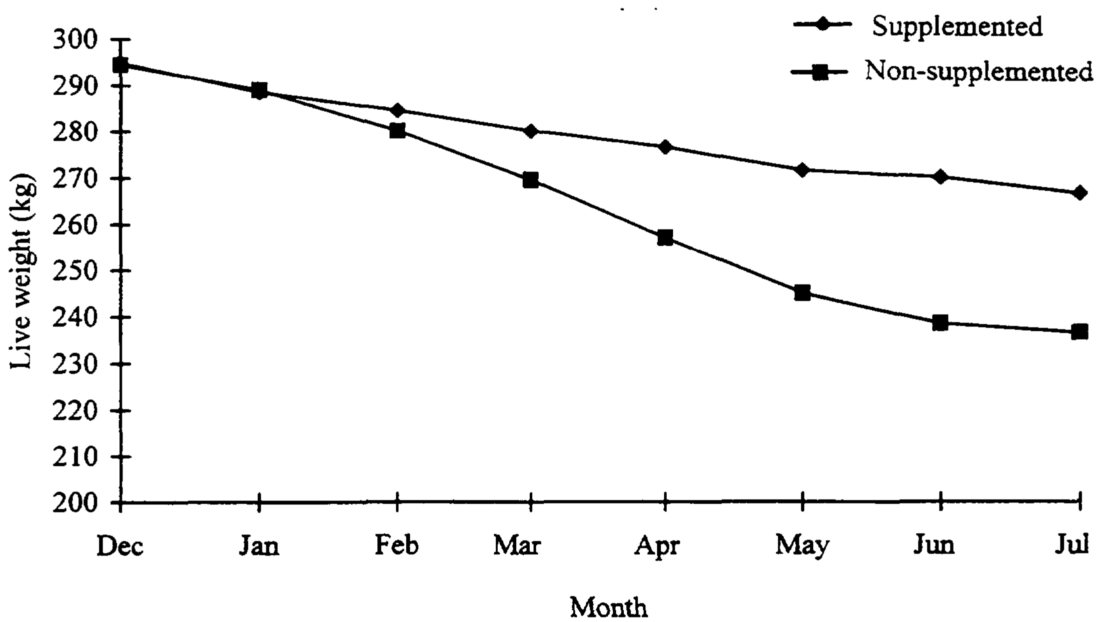

FIG.5. Change in live weight between supplemented and non-supplemented groups.

Forage availability during the dry season is known to affect body weight and body condition of animals maintained under extensive management on native pastures, without additional supplementary feeding. In the Sahel region, quantity and quality of forage decreased from February to July, thus animals lost weight and BCS because of failure to obtain their requirements for maintenance and production.

This study agrees well with those of others [22, 23] who have shown that feed availability is one of the major constraints to improving animal productivity in the Sahel region.

3.2.1.2.Milk production

The effect of supplementation on milk production is shown in Figure 6. Average milk yield was significantly higher in the group receiving supplements compared to the non-supplemented group (2.68 ± 0.36 vs 1.39 ± 0.06). Similar results have also been reported in the tropics and in temperate areas [24, 25].

3.2.1.3.Body weight at birth and growth performance of calves

Body weight at birth of calves from supplemented cows was significantly higher (20.13± 1.1 kg) than from non-supplemented cows (17.3 ± 0.8 kg, $P < 0.05$). Average daily gain was higher in supplemented cows than from non-supplemented animals. This appears to be an effect of supplementation of cows during the late dry season. Calves from cows that received the supplement grew faster than those in the non-supplemented group. Increased milk production in the supplemented group could have affected average daily gain of calves. Both the birth weight and average daily gain in the two groups were similar to those that have been reported by others [19, 26].

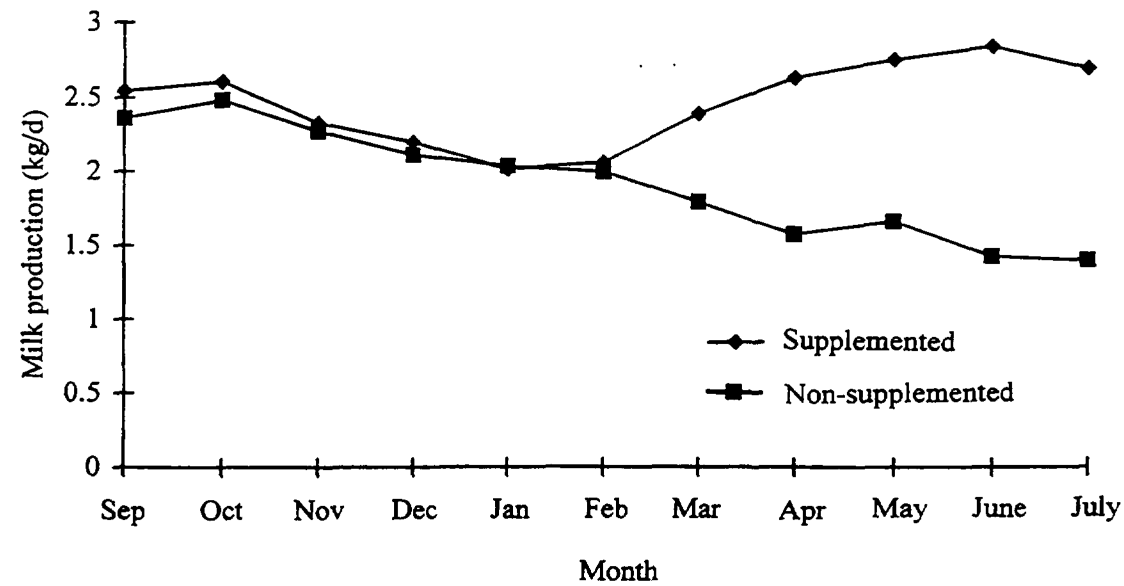

FIG.6. Effect of supplementation on milk production.

3.2.2. Reproductive performance

The resumption of ovarian activity was 52.6 and 100% in supplemented cows compared to 18.5 and 38.8% in the non-supplemented animals at 5 and 9 months post-partum, respectively. Additionally, there was a significantly ($P < 0.05$) shorter calving interval in the supplemented group (14.7 ± 2 months) compared to the non-supplemented animals (21.5 ± 3 months).

The effects of supplementation on body weight and BCS reflected in earlier resumption of ovarian activity. Cows that were able to maintain their body condition, regardless of the nutritional level, had a shorter interval to first post-partum oestrus than cows which had lost body weight.

3.2.3. Profit margin of supplementation

Additional milk production was 0.625 and 1.22 kg/cow/d and 95.6 and 186.6 kg for the supplementation period, for Farm 1 and 2, respectively. Milk price at the local market (Niayes) was 300 FCFA/litre (1USD = 600 FCFA) and in Dakar market was 450 FCFA/litre. The total cost of the supplement per cow during the supplementation period was 22010 FCFA. The profit margin if the milk was sold at the local market or at Dakar market would have been 6680 and 33990 FCFA and 11460 and 43320 FCFA for Farm 1 and 2, respectively.

4. CONCLUSION

It is generally agreed that the reproductive efficiency of *Bos indicus* cattle in tropical areas is poor compared to *Bos taurus* in temperate environments. Feed availability throughout the year is a major constraint to animal productivity in the Sahel region, since the traditional production system is based on native pasture. Therefore, during the late dry season cattle are underfed due to low quantity and quality of forages, which results in acute and chronic under-nutrition.

Nutritional deficiencies can affect milk production and fertility, and in the long term the productive life of the cow. Adequate nutrition is necessary for body weight maintenance, growth and reproductive functions. Supplementation during the late dry season, because it avoids loss of weight and body condition, can maintain milk yield and the growth rate of calves during the dry season and reduce length of 'days open'. Supplementation with agro-industrial by-products at strategic periods during the dry season, can be a cost-effective means of improving productivity on traditionally managed smallholder farms.

ACKNOWLEDGEMENTS

The authors are grateful to the Joint FAO/IAEA Division of the International Atomic Energy Agency for the FAO/IAEA Research Contract 7864/RB. The participation of smallholder farmers is gratefully acknowledged. The authors are also grateful to Ecole Inter-Etats des Sciences et Médecine Vétérinaires de Dakar, Senegal and students for their participation.

REFERENCES

[1] OYEDIPE, E.O., OSORI, D.I.K., AKEREJOLA, O., SAROR, D., Effect of level of nutrition on onset of puberty and conception rates of zebu heifers, Theriogenology **18** (1982) 525-539.

[2] GALINA, C. S., ARTHUR, G.H., Review of cattle reproduction in tropics. Part 3, Post-partum, Anim. Breeding Abs. **57** (11) (1989) 679-686.

[3] EDUVIE, L. O., BAWA, E.K., DAWUDA, P.M, OYEDIPE, E.O., OLORUNJU, S. A. S., BALE, J.O., SEKONI, V.O., "Factors affecting the reproductive performance of Bunaji cattle under different pastoral management systems in the Guinea savane zone of Nigeria", Improving Productivity of Indigenous African Livestock, IAEA-TECDOC-708, IAEA, Vienna (1993) 31-37.
[4] NICHOLSON, M.J., BUTTERWORTH, M.H., Rille de notation de l'état 'engraissement des zébus, Addis Ababa, CIPEA (1989).
[5] PLAZIER, J.C.B., "Validation of the FAO/AIEA Kit for the measurements of progesterone in skim milk and blood plasma", Improving the Productivity of Indigenous African Livestock, IAEA-TECDOC-708, IAEA, Vienna, (1993) 151-156.
[6] WAGENAAR, K.T., DIALLO, A., SAYERS, A.R., Productivité des bovins peuls transhumants dans le Delta intérieur du Mali, Addis Ababa, CIPEA (1988).
[7] CHICOTEAU, La reproduction des bovins tropicaux, Rec. Méd. Vèt. **167** (1991) 241-247.
[8] MUKASA MUGERWA, E., A review of reproduction performance *Bos indicus* (Zebu)-cattle, Addis Abeba, CIPEA (1989) (Monograph 6).
[9] WILTBANK, J.N., ROWDEN, W.W., INGALLS, J.E., ZIMMERMAN, D. R., Influence of post partum energy levels on reproductive of Hereford cows restricted in energy intake prior to calving, J. Anim. Sci. **23** (1964) 1049-1053.
[10] AHMAD, Z., AHMAD, M. Z., Effect of age and first calving on lenght of first lactation period and calving interval in Sahiwal cows, Agriculture Pakistan **25** (1974) 45-48.
[11] BASU, S.B., BHATNAGAR, D.S., TANEJA, V.K., RAO, V.P., Comparative performance of Indian dairy breeds, Indian J. Dairy Sci. **36** (1979) 207-210.
[12] DUNN, R.T., INGALLS, J.E., ZIMMERMAN, D. R., WILTBANK, J.N., Reproductive performance of 2-year old hereford and Angus heifers as influence by pre-and post-calving energy intake, J. Anim. Sci. **52** (1969) 118-1229.
[13] VAN NIEKERK, A., The effect of body condition as influenced by winter nutrition, on the reproductive performance of the beef cows, South African J. Anim. Sci. **12** (1982) 383-387.
[14] WILTBANK, J.N., ROWDEN, W.W., INGALLS, J.E., GREGORY, K.E., KOCH, R.M., Effects of energy level on Reproductive phenomena of mature Hereford cows, J. Anim. Sci. **21** (1962) 219-225.
[15] HILL, J.R., LAMOND, D., HENRICKS, D., DICKEY, J.F., NISWENDER, G.D., The effects of undernutrition on ovarian function and fertility in beef heifers, Biology of Reproduction **2** (1970) 78-84.
[16] SHORT, R.E., BELLOWS, R.A., COSTER, E.E., Physiological mechanisms controlling anoestrus and infertility in post-partum of beef cattle, J. Anim. Sci. **68** (1990) 799-816.
[17] KING, J.O.L., The relationship between conception rate and changes in body weight, yield and S.N.F. content of milk in dairy cows, Veterinary Record **83** (1968) 492.
[18] WARD, H. K., Supplementation of beef grazing on veld, Rhodesia J. Agric. Res. **6** (1968) 93-101.
[19] DENIS, J.P., VALENZA, J., Extériorisation des potentialités génétiques du zébu peul sénégalais(Gobra), Rev. Elev. Med. Vét. Pays trop. **24** (3) (1972) 405-418.
[20] OLIVEIRA, F.E.B., Age at first calving, service period and calving interval in a Nellore herd. Thesis. Universidade Federal de Minas Gerais, Brazil (1974).
[21] LANDAIS, E., Recherches sur la reproduction du cheptel taurin sédentaire du Nord de la côte d'Ivoire : utilisation des intervalles entre vêlage; aspects méthodologiques et premiers résultats. Rev. Elev. Méd. Vét. Pays Trop. **33** (3) (1993) 193-204.

[22] DENIS, J.P., THIONGANE, A.I., Influence d'une alimentation intensive sur les performances de reproduction des femelles zebus Gobra au CRZ de Dahra, Rev. Elev. Méd. Vét. Pays Trop. **31** (1978) 85-90.

[23] GUERIN, H., FRIOT, D., MBAYE, N., RICHARD, D., Alimentation des ruminants domestiques sur les pâturages naturels sahéliens et sahélo-soudaniens. Etude méthodologique dans la région du Ferlo au Sénégal, Maisons-Alfort: IEMVT. (Etudes et synthèse de l'IEMVT) (1988).

[24] DENIS, J.P., CALVET, H., Promotion laitiere chez les paysans du Cap Vert Dakar, Seminaire sur la production animale, LNERV, Dakar (1981).

[25] PAGOT, J., L'élevage en pays tropicaux, Techniques Agricoles et Productions Tropicales, ACCT; Maisonneuve et Larose, Paris (1985).

[26] JOUVE, J.L., LETENNEUR, L., Influence de la supplémentation sur la croissance des bovins zébu élevés sur pâturage pauvre, Rev. Elev. Méd. Vét. Pays Trop. **25** (2) (1972) 317 – 324.

XA9952133

CATTLE PRODUCTIVITY ON SMALLHOLDER FARMS IN THE WESTERN HIGHLANDS OF CAMEROON

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Abstract

CATTLE PRODUCTIVITY ON SMALLHOLDER FARMS IN THE WESTERN HIGHLANDS OF CAMEROON.

A study of the traditional cattle production systems in the Western Highlands of Cameroon was carried out between August 1994 and September 1997. Fifty two cows selected from 14 farms in 4 locations were monitored monthly. Data were collected on calf and dam weight, dam's body condition, milk offtake and forage quality. Reproductive performance was monitored by measuring progesterone levels in milk sampled weekly. Crude protein content of grazed pastures rose from 12.5% in July to 14.5% in October and declined steadily to reach 4.5% in February. With such a decline in forage quality during the dry season, cows are unable to obtain their nutrient needs, thus productivity was low. Body condition score declined from medium (5.6) at calving to upper low (4.5) 4 months after the initiation of milk offtake. Body weight of cows decreased by nearly 14% during the same period. The interval between calving to first progesterone rise, calving to conception, and inter-calving intervals were 172 ± 116, 185 ± 106 and 448 ± 86 days, respectively. Milk offtake averaged 1.29 ± 0.44 kg/cow/day for a lactation length of 10.5 months. A significant effect of season was detected in milk offtake ($P < 0.001$), body condition score ($P < 0.05$), body weight of cows ($P < 0.05$), intervals from calving to first progesterone rise ($P < 0.05$), calving to conception ($P < 0.05$) and inter-calving interval ($P < 0.01$). Supplementary feeding during the dry season and early lactation to cover the nutrient requirements of the cows in the traditional production system of Western Highlands of Cameroon is recommended and forms the purpose of the second part of this study which is now underway.

1. INTRODUCTION

Cameroon has a surface area of 475,000 km^2, stretching from the rain forests near the Equator to the Sahelian zone towards Lake Chad. In 1995, the population was estimated at 13.5 millions with 46% below 15 years of age. This population is expected to reach 15.5 millions in the year 2000 and 20.5 millions in 2010 [1]. The urbanization rate which was 28% in 1976 increased to 43.5% in 1995 and will continue to increase by 4.9% yearly. The active population is 37% of the total, out of which 75% are farmers. The per capita income was estimated at US $ 796 in 1993 (before the 50% devaluation of the regional currency, the Franc CFA, in 1994).

The importance of milk in human nutrition can no longer be over emphasized. However, annual per capita consumption of milk in West Africa is the lowest in the world, 13.3 kg [2], and estimated to be 10 kg in Cameroon. Meanwhile per capita production stands at 5.1 kg [1]. To satisfy the increasing demand, Cameroon has been importing milk and dairy products worth US $ 13.3 million a year. The recent devaluation of the currency has drastically cut down on imports.

Cattle constitute the primary source of milk and meat for the population. Production depends largely on the traditional pastoralists who rely almost exclusively on native pasture to meet the needs of their animals. Seasonal variations on the production and nutrient content of pastures have been correlated to the poor performance of cattle elsewhere in the tropics [3-5]. However, in the Western Highlands of Cameroon, quantitative assessment of the extent of this effect on cattle productivity are not well known. Any strategy to improve cattle productivity must take into account the type and level of constraints which affect their potentials. This study was therefore undertaken to estimate cattle productivity under the traditional system and to design strategies to improve it.

2. MATERIALS AND METHODS

2.1. Study site

The Western Highlands of Cameroon lie between latitudes 5° and 7° North and longitude 9° and 11° East of the Equator. With a size of 31,180 km^2, they cover 1/16 of the total land area of the country. Altitudes range from around 300 to 3 000 m above sea level. Rainfall varies between 1300-3000 mm with peaks occurring between mid-July and mid-September. The rainy season extends from mid-March to mid-November. The maximum temperatures vary between 20 and 32°C. The dominant vegetation is residual savannah. This region is characterized by a rapid population growth, most of whom live in rural area (67.8%) and depend on crop and livestock activities. It is the third major cattle producing area, with 500,000 Zebu cattle [1], and one of the most important agricultural production zones of the country.

2.2. Experimental design

The study started in 1994. A total of 78 cows from 18 farms in 4 locations in the Western Highlands of Cameroon were sequentially included in the study. During the first visits, information was collected on the general management of the farm and the herds, in order to characterize the production systems. Animals were recruited into the study one month prior to the expected date of calving. Selected animals were identified using ear tags and information was recorded about their age, parity and breed. Following parturition, the farms were visited monthly by a research team and weekly by the resident technician to collect information on the animals. Only cows kept at home for milk production and which did not travel during the transhumance movements were considered in this study.

2.2.1. Animals

Heart girth measurement of cows and calves was recorded monthly using a weigh band, to estimate body weight. Body condition score (BCS) of cows was determined monthly based on a 1-9 scale [6]. Milk offtake of individual cows was measured weekly with a graduated cup, until the end of lactation. From two weeks after calving, 10 ml of milk were collected weekly in a tube containing a milk preservative (Sodium Azide) by a trained resident technician for progesterone assay [7]. Weekly sampling of milk continued until the cow was confirmed pregnant.

2.2.2. *Forage*

From July 1995 to February 1996, grab samples of forage (*Sporobulus africanus*) were collected consistently each month from one farm, at a height similar to that grazed by cows on natural pastures. Samples were oven dried, ground and analyzed [8] for dry matter, cell wall, crude protein and ash contents.

2.3. Progesterone assay

Progesterone level in milk was determined by radioimmunoassay using the FAO/IAEA solid-phase RIA technique. [7]. A cow was considered in the luteal phase when the P4 level in milk was equal to or greater than 3 mmol/L, and pregnant when this level persisted over 4 consecutive weeks. This level is comparable to those reported in earlier studies for pregnant cows [9].

2.4. Data analysis

Four farmers dropped out in the course of the study, so data used for the analysis were obtained from 52 out of the initial 78 cows. Data were submitted to the analysis of variance using the GLM procedure of the Statistical Analysis System [10]. Relationship among variables was tested with the Pearson correlation.

3. RESULTS AND DISCUSSION

3.1. Description of the production system

The initial field survey revealed the existence of two basic cattle production systems in the Western Highlands of Cameroon; the traditional pastoralism which is a more extensive cattle farming system practised by the Fulani who were formerly nomads, and the agro-pastoralism practised by the Tikar (native) population. Cattle production is the main stay of the Fulani tribe. Their life revolves around this activity and most of their income is derived from it. Crop production is marginal and is carried out by hired labor: 86% of the farmers produce food crops near their home on an average farm size of 0.6 ha.

The average herd size is 86 cattle per farm. Major cattle breeds found in the study zone are the Gudali (41.7%), the Red Fulani (27.8%) and the White Fulani (8.3%). Some farms now have their first crossbreds (Holstein x Gudali) by artificial insemination, mainly for milk production purposes. Milk produced is used mainly for family consumption. In each family farm, a small nucleus of about 10 to 50 cows are kept around the compound for milk production. and are not taken on transhumance. The number of cows being milked depends on several factors amongst which the general condition of the cow and calf, and the family needs are considered most important. In order to ensure their daily supply of milk, farmers aim for sustained yield rather than high output over a short period of time and this production objective is reflected in their management practices. Thus, cows are milked once a day in the mornings. Milk offtake starts from 1 to 3 months post-calving. This time interval ensures adequate growth of the calves during their early age. Calves are restrained near the compound during the day while dams are being grazed. They are released in the evening and allowed to suckle overnight. When milk offtake starts, calves are restrained in the evening and only allowed to suckle the dam the following morning after a quantity of milk has been extracted for family consumption. They are weaned at 10.5 months. Some calves may continue to suckle for over 12 months of age or until pregnancy is advanced.

3.2. Seasonal availability of forage

Cattle production is extensive on communal grazing lands which constitute the sole feed base all year round. Grazing areas are essentially made of native grass species of *Sporobulus africanus* (Table I).

TABLE I. SEASONAL VARIATION IN THE NUTRITIVE VALUE OF NATIVE PASTURE (*Sporobulus africanus*)

Month (1995/1996)	Dry matter (%)	Crude protein	Cellulose	Ash
		(% DM)		
July	17.0	12.5	33.5	7.5
August	19.5	13.0	30.0	9.0
September	14.0	15.0	26.0	8.0
October	18.0	14.5	32.0	8.0
November	22.5	12.0	28.5	8.5
December	27.0	7.0	23.5	12.0
January	29.0	6.0	19.0	13.0
February	32.0	4.5	15.0	14.5

Around the settlements, it is common to find spots of *Pennisetum clandestinum*. In recent years, there have been some attempt to improve the pasture by growing *Brachiaria ruziziensis*. Average size of improved pastures is 1.2 ha. These pastures are used as dry season fodder reserves which are exploited prior to the strategic transhumance between February and April, around a radius of about 75 km. Forage quality and quantity is closely related to seasons of the year: poor during the dry season and rich during the rainy season. Transhumance movement of cattle during the dry season is designed to improve their nutrition at a time when the usual feed base is depleted. Apart from salt supplied monthly to cattle, there is basically no other supplement given throughout the year.

Grazing time varies with the seasons of the year: in the rainy season, cattle graze an average of 6 h, while in the dry season, grazing is extended to 10.5 h a day. Longer grazing times during the dry season allow cattle to increase their forage intake.

3.3. Calving season

In the traditional production system, breeding is closely related to the availability of forage. Figure 1 presents the monthly distribution of calvings. It indicates that 90.2% of calvings occurred during the rainy season, from June to November, with a peak in the month of October (29.2%). This means that 90% of successful matings occurred between September and February and very few during the dry period and the early part of the rainy season (March to August). The period of successful matings coincided with the period when forage was available. After the dry season with severe feeding stress, cows had 5 to 6 months of good quality forage to replenish their body reserves, making it possible for them to cycle and to be fertile. The effect of nutrition on fertility of cows has been described in many tropical environments [2-4, 11]. In the extensive farming system of Northern Cameroon [11], it was indicated that cows become fertile only during the short rainy season when pasture is freely available.

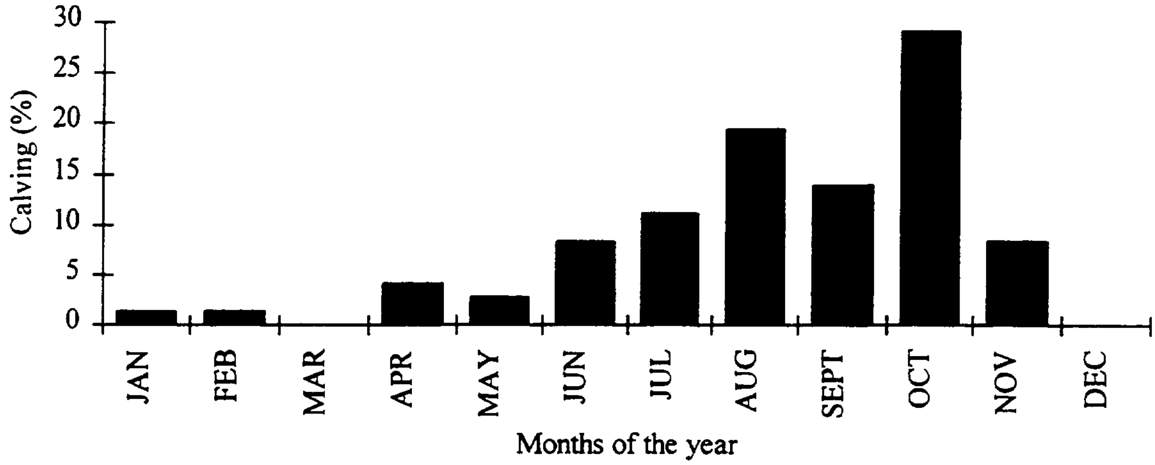

FIG.1. Monthly distribution of calvings in the traditional cattle production system in the West Highlands of Cameroon.

3.4. Body condition and weight change of cows

3.4.1. Body condition change

The average condition score of cows was 4.0 ± 1.44 (M-). It was affected by the season of the year. It showed a steady increase from July (4.0) which coincided with the period of abundant and relatively good quality forage, to attain a peak (5.0) in November. Thereafter it declined to reach its lowest values (3.2) in March, the most critical period of the year when animals have to go on transhumance. This implies that forage quality and quantity are insufficient to keep zebu cows in good condition during the dry season. It would appear that after a stressful period of under-nutrition in the dry season, cows take 3 to 6 months in the rainy season to replenish their body reserves.

The average body condition at calving was high (5.6 ± 1.28). During the first month of lactation, it dropped to 4.5, suggesting a mobilization of body reserves to meet the milk production requirements for the calf. From the beginning of milk offtake at 2 to 3 months after calving, body condition continued to decline up to 6 months post-calving (Figure 2).

3.4.2. Body weight of cows

Average body weight of cows was 313 ± 50.2 kg. Body weight of cows was positively correlated with body condition score ($R^2 = 0.65$; $P < 0.001$). Body weight declined consistently from 345 ± 35.7 kg at calving to 298 kg at 6 months post-calving (Figure 2). The onset of milk offtake by farmers, although of smaller amounts, might have resulted in additional stress imposed on the cows, especially when available forage was not adequate to ensure maintenance and production needs. Even in intensive systems of production with heavy supplementation, cows are often unable to maintain a state of positive energy balance, thus leading to negative effect on weight and body condition [12], that might affect the reproductive profile of the cows.

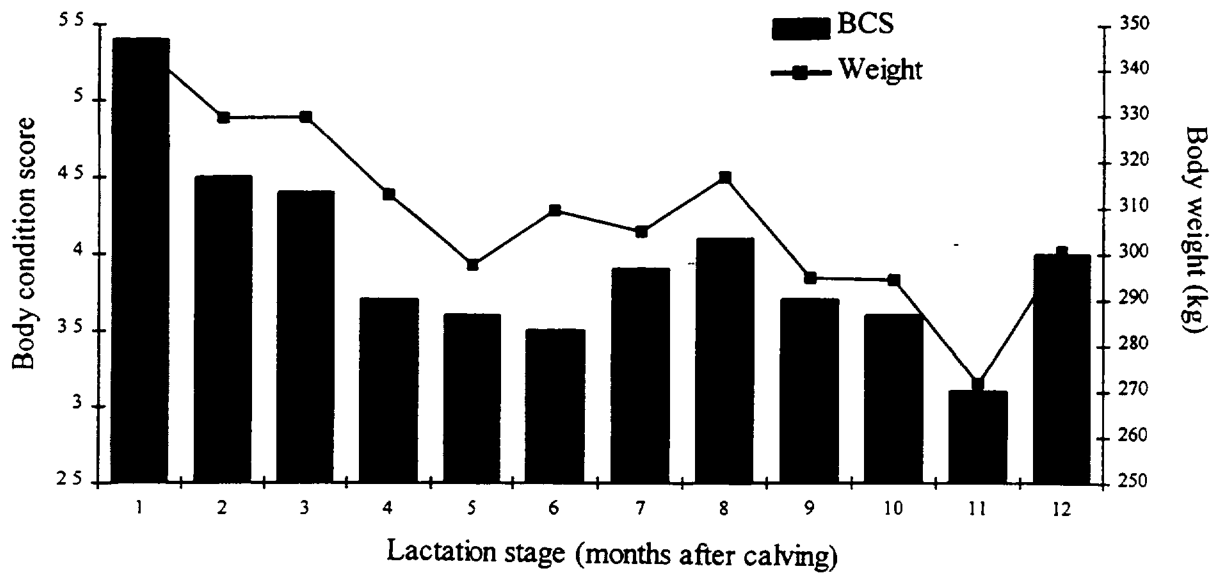

FIG.2. Variation in body condition score and body weight with lactation.

3.5. Reproductive profile

3.5.1 Interval from calving to first progesterone rise

The interval from calving to first progesterone rise in milk averaged 172 ± 116 days (Table II). Analysis of variance showed a significant seasonal trend ($P < 0.05$). This interval was longer than 107 days reported in Ghana [13] on zebu cows, probably due to difference in the feeding regime. Nevertheless, more than 50% of cows showed ovarian activity within 120 days after calving (Figure 3). It is also possible that several earlier progesterone rises might have been missed in some cows. The interval was highest for calvings between May and July (early rains), averaging 255 ± 170 days, and lowest for calvings between August and December (late rains), averaging 147 ± 128 days. The difference in interval from calving to first progesterone rise between these two periods is probably related to the difference in the BCS of cows. The BCS was highest between the second half of the rainy season compared with the first half of the rainy season, a situation linked to the availability of quality forage. Forage is abundant and of good quality during the late rainy season compared to the dry season; therefore, animals calving during that period are exposed to sufficient good quality feed which enable them to remain in favorable condition for early post-partum resumption of ovarian function. On the contrary, animals calving in or before the early rainy season are affected by a poor pre-calving feeding regime and consequently poor body condition. Shorter intervals from calving to oestrus have been reported in studies where pre-calving forage allowance was increased [12].

The poor body condition and low body weight prolonged the interval from calving to first progesterone rise and is indicative of delays in ovarian function postpartum, since oestrus rarely occurs before the first progesterone rise [12]. In the current cattle production system where feeding is solely based on poor native pastures, the combined effect of suckling and milk offtake may have resulted in decreasing body weight and BCS of the dam which further delayed the resumption of reproductive events.

TABLE II. REPRODUCTIVE PERFORMANCE OF COWS IN THE TRADITIONAL PRODUCTION SYSTEM OF THE WESTERN HIGHLANDS OF CAMEROON

	Calving to first progesterone rise (days)	Calving to conception (days)	Calving interval (days)
Calving season	Mean ± SD	Mean ± SD	Mean ± SD
Dry season	155 ± 52[a] (4)	151 (1)	529 ± 46[a] (5)
Early rains	255 ± 170[b] (11)	294 ± 174[a] (9)	502 ± 194[a] (9)
Late rains	147 ± 128[a] (35)	154 ± 129[b] (30)	404 ± 92[b] (21)
Overall	172 ± 116 (50)	185 ± 106 (40)	447 ± 86 (35)

Number of cows within parenthesis
[abc] Values in the same column with different superscripts are statistically different ($P < 0.05$)

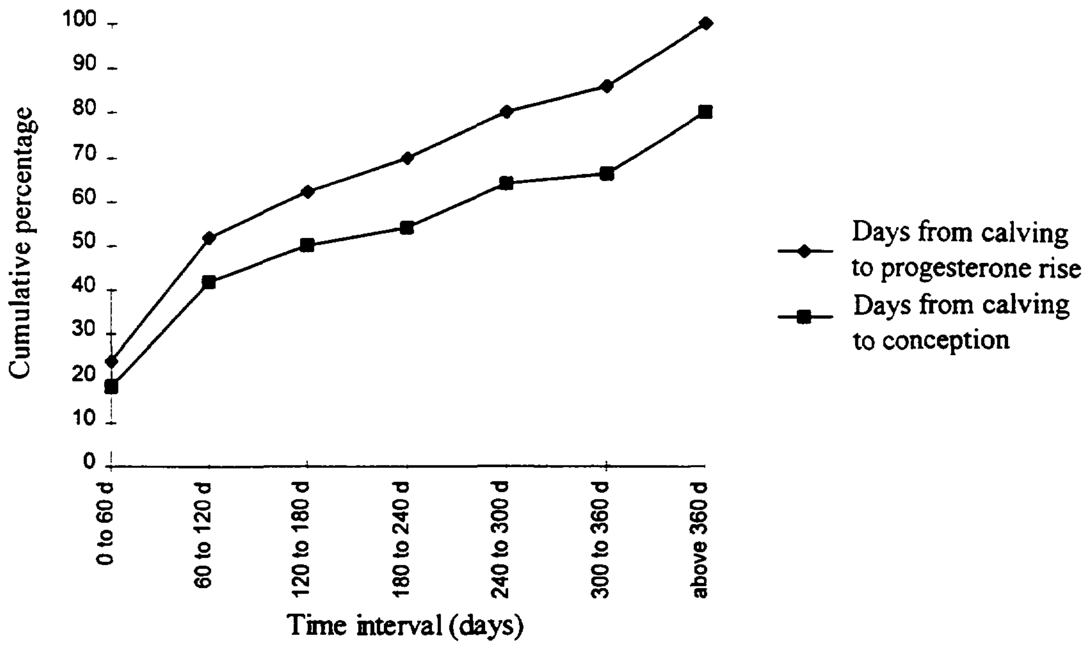

FIG.3. Resumption of ovarian activity in the traditional cattle production system in Western Highlands of Cameroon.

3.5.2. Calving to conception interval

The mean calving to conception interval averaged 185 ± 105 days. Over 40% of cows conceived by 120 days after calving. Cows that calved during the early rains had the longest interval from calving to conception (294 ± 174 days), while those that calved during the late rains had the shortest (154 ± 129 days). The distribution trend showed that season is a major determinant of reproductive events in this cattle production system. Most cows remained acyclic during the dry season and early rainy season (30%) and only exhibited sexual activities towards the end of the rainy season. Conception rate was only 2% from February to June and 98% between July and January. A high correlation was found between the interval from calving to first progesterone rise and the calving to conception interval ($R^2 = 0.79$; $P < 0.001$). In most cows, the first progesterone rise coincided with the initiation of a sustained and high release of progesterone in milk, indicating conception. This finding was further confirmed by the short interval between the initiation of progesterone rise in milk and conception (14 days), illustrating free ranging situations with natural breeding in which oestrus behavior can precede a post-partum rise in progesterone concentration [12].

Negative relationships were found between cows' body condition, body weights and the calving to conception interval ($R^2 = -0.30$, $P < 0.01$ and $R^2 = -0.31$, $P < 0.01$, respectively). Poor nutrition before and after calving and its effect on the dam's body condition has been shown to be a major factor affecting calving to conception interval [5 11, 14, 15] and seems to be the major problem in our farming system.

3.5.3. Calving interval

Calving interval was obtained for cows which had at least two consecutive parturitions in the course of the study. Mean calving interval was 447 ± 86 days or 14.9 months (Table II). It was significantly ($P < 0.05$) affected by the season of calving. It was shorter for cows that calved during the late rains (404 ± 92 days). This interval was relatively short compared to most values reported under similar conditions [5, 11, 15]. In the Sudano-Sahelian Northern Cameroon [11] the calving interval is 18.5 months, against 16 months in Niger Delta of Mali [5] and 18 months in Malawi [16]. The shorter intervals obtained during the later part of the rainy season are indications that improving nutrition would considerably improve the reproductive parameters of the cows in this extensive farming system

3.6. Milk production

3.6.1. Milk offtake

The average milk offtake was 1.29 ± 0.44 kg/cow/day. It is close to values in Northern Cameroon, a liter per cow per day under no supplementation [15]. It varied with season and dam's body condition. It was highest ($P < 0.001$) between June and October averaging 1.50 kg/cow/day (Figure 4) and lowest from November to May (1.09 kg/cow/day). The difference in offtake by season followed the monthly rainfall distribution closely and could be linked to the availability of forage, both quantitatively and qualitatively (Table I). A similar effect of season of calving on milk offtake was shown to be significant up to 240 days in transhumant Fulani herds in the inner Niger Delta of Mali [5]. A positive correlation ($R^2 = 0.25$; $P < 0.001$) was observed between the body condition score of the dam and the milk offtake. Increased milkofftake depended on the apparent good condition of the dam which was highest during the rainy periods. Parity and stage of lactation appeared to have little effect on milkofftake. This indicates that contrary to the important effect of these factors on commercial dairy production system where milk extraction is maximized in order to achieve economic gains, farmers lay more emphasis on the survival and physical condition of both their cows and calves.

3.6.2. Lactation length

The average length of extraction of milk for family consumption was 8 months. Milk offtake started between 1 and 3 months post-calving, prior to which the entire production was consumed by the calf. The length of the period of milk offtake correlated negatively with body condition score ($R^2 = -0.23$; $P < 0.001$) and the weight of the dam ($R^2 = -0.26$; $P < 0.001$). Some cows continued to be milked as long as calves growth was not compromised. Similarly, poor condition and reduced weight contributed to cows being dried off earlier.

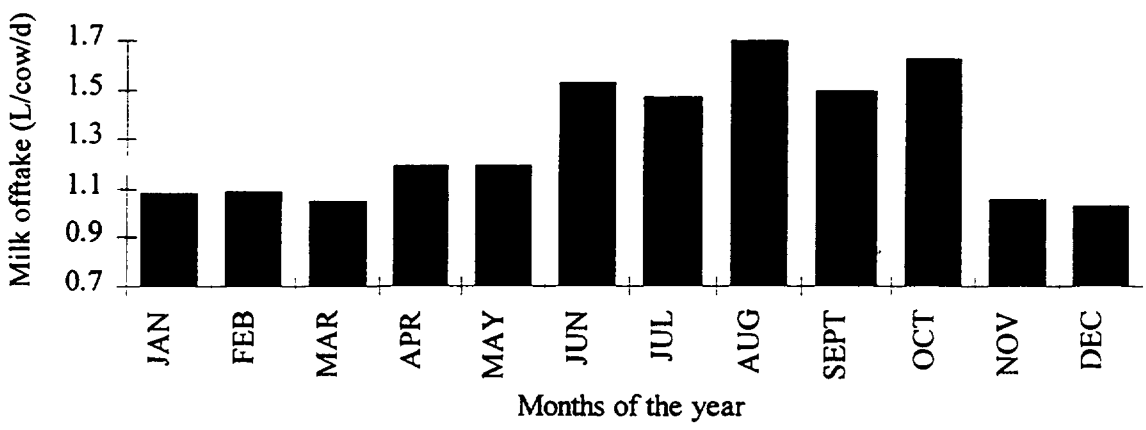

FIG.4. Monthly variation in milk offtake.

3.7. Calf growth rate

The average weight of calves before 7 days of age was 36.3 ± 3.00 kg. Although not significant, calves born in the rainy season tended to be heavier (36.6 kg) than those born in the dry season (33.6 kg). This was probably due to the good quality of the pasture. Calf birth weight was not related to body condition score of the dam at calving. The growth rate of calves was linear up to 9 months of age (Figure 5). The average daily weight gain was 0.237 kg over a twelve month period. Calf growth rate was similar to that obtained in traditional farms in Northern Cameroon where calves reach 120 to 140 kg by 12 months of age [11]. This study also indicated a substantial increase in milk yield, body condition score and weight gain of lactating cows supplemented with cottonseed cake, as well as that of their calves. That implies that substantial production can be obtained by providing the protein rich supplement to cattle in the Western Highlands of Cameroon.

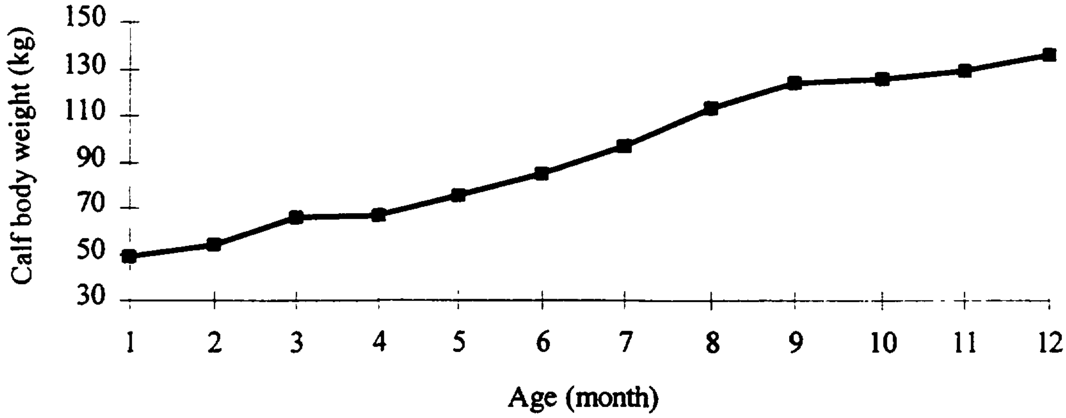

FIG.5. Growth rate of calves up to 12 months of age.

4. CONCLUSION

This study has characterized the production and reproduction parameters in the traditional cattle production system in the Western Highlands of Cameroon. It has also identified constraints limiting production and strategies to improved it. Results indicate that milk offtake is very low and reproduction performance very poor. The natural pasture is the basis of cattle feeding and its quality fluctuates during the year due to the variability of rainfall. Season appears to be the most significant factor affecting cattle productivity. It affects the distribution of calvings, the amount of milk offtake, the body weight and body condition of the cows, the interval between calving and the first progesterone rise and calving interval.

Many studies in tropical countries as well as in Northern Cameroon have indicated that dry season feed supplementation improves the body condition of the cows and reduces the intervals between calving and conception and calving intervals. In the extensive cattle production system of the Western Highlands of Cameroon, such strategies need to be studied and the impact on cattle productivity measured. However, the supplementary feeding should target the pre- and post-calving periods when the demand for biological and physiological functions of cows are increased. For that purpose, a new trial has been set up using cottonseed cake as the feed supplement, which is largely available in Cameroon. It will be fed at 2 kg per cow/d one month before calving up to June when forage is abundant and of good quality or to about 6 months after calving, and the impact on the body condition and the reproductive parameters measured and compared with a control, un-supplemented group. Such supplementation can easily be adopted by farmers in the study zone as it has been with those in the Northern Cameroon in recent years. This study which is underway will indicate the impact of supplementary feeding on the productivity of zebu cows on farms. The study will be completed with more data on forage quality round the year and the forage intake by grazing cows in order to plan for more appropriate supplementation strategies that should meet requirements for better productivity. Furthermore, it is possible that early weaning of calves hastens the commencement of ovarian activity; this is another aspect which merits future study.

ACKNOWLEDGEMENTS

This study was supported by the Cameroon Government and the Joint FAO/IAEA Division, International Atomic Energy Agency under Research Contract 7581/RB.

REFERENCES

[1] CIRAD-EMVT, BPDA-SCETAGRI, Etude du secteur élevage au Cameroun (1995).

[2] CENTRE INTERNATIONAL POUR L'ELEVAGE EN AFRIQUE, Recueil statistique sur la production animale en Afrique, Addis Ababa, Ethiopia, CIPEA (1994).

[3] SELK, G.E., WETTEMAN, R.P., LUSBY, K.S., OLTJEN, J.W., MOBLEY, S.L., Rasby, R.J., GARMENDIA, J.C., Relationship among weight change, body condition and reproductive performance of range beef cows, J. Anim. Sci. **66** (1988) 3153.

[4] OTCHERE, E., The productivity of White Fulani (Bunaji) cattle in the pastoralist herds on the Kaduna plains of Nigeria, ILCA Programme Document, Kaduna, Nigeria (1983).

[5] WAGENAAR, K.T., DIALLO, A., SAYERS, A.R., Productivity of transhumant Fulani cattle in the Niger delta of Mali, International Livestock Center for Africa, Research Report No 13 (1986).

[6] NICHOLSON, M.J., BUTTERWORTH, M.H., A guide to body condition score of Zebu cattle, ILCA (1986).
[7] PLAZIER, J.C.B., "Validation of the FAO/IAEA RIA Kit for the measurements of progesterone in skim milk and blood plasma", Improving the productivity of indigenous African livestock, IAEA-TECDOC-708, IAEA, Vienna (1993) 151-156.
[8] ASSOCIATION OF OFFICIAL ANALYTICAL CHEMISTS, Official Methods of Analysis (14th Ed.), Association of Official Analytical Chemists, Washington, DC (1984).
[9] GAO, Y., SHORT, R.V., FLETCHER, T.P., Progesterone concentration in plasma, saliva and milk of cows in different reproductive states, Br. Vet. J. **144** (1988) 262.
[10] STATISTICAL ANALYTICAL SYSTEM, User's Guide, Statistics, Release 6.03 ed., SAS Inst. Inc., Cary, NC (1990).
[11] NJOYA, A., BOUCHEL, D., NGO TAMA, A.-C., MOUSSA, C., MARTENCHAR, A., LETENNEUR, L., Systèmes d'élevage et productivité des bovins en milieu paysan au Nord-Cameroun, Rev. mond. Zootech. **89** (1997) 12-23.
[12] PETERS, A.R., Reproductive activity of the cow in the post-partum period, 1. Factors affecting the length of the postpartum acyclic period, Br. Vet. J. **140** (1984) 76.
[13] OSEI, S.A., KARIKARI, P.K., TUAH, A.K., GYAWU, P., OPOKU, R.S., ASIAMA, M., HEATHCOTE, D.C., "Studies on the reproductive performance of indigenous beef cattle breeds raised on-farm in Ghana", Improving the productivity of indigenous African livestock, IAEA-TECDOC-708, IAEA, Vienna (1993) 103-112.
[14] SYNGE, B.A., "Milk production under extensive systems", Proceedings of Animal disease research and control on livestock production in Africa, (Huhn, J.E. Ed.), OAU/ILRAD/ILCA/DSE, Nairobi (1980).
[15] ADYEMANG, K., NKHONJERA, L.P., Evaluation of the productivity of crossbred dairy cattle on smallholder and government farms in the Republic of Malawi, International Livestock Center for Africa, Research Report No 12 (1986).
[16] NJOYA A, X. LACMENE, R. NJWE., Response to supplementary feeding by lactating Zebu cows in northern Cameroon, *Ann Zootech.* **44** (1995) 375.

STUDY OF NUTRITIONAL AND REPRODUCTIVE CONSTRAINTS OF FRIESIAN DAIRY CATTLE IN THE MITIDJA AREA OF ALGERIA

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Abstract

STUDY OF NUTRITIONAL AND REPRODUCTIVE CONSTRAINTS OF FRIESIAN DAIRY CATTLE IN THE MITIDJA AREA OF ALGERIA.

This work aims to improve reproduction and milk production of Friesan dairy cows used under the environmental conditions of the Mitidja Plain (Central region of Algeria) by analyzing the quality of feeding and studying the resumption of ovarian activity of cows after calving.

The first phase of the study started during 1995/96, by surveying a sample of 47 livestock farms in the Mitidja area in order to identify available feed resources and husbandry practices and to record data on reproduction parameters, individual body weights, body condition score and milk production. Ovarian activity was monitored by radioimmunoassay of progesterone in blood and milk samples collected twice a week, after 15 days post-partum.

The second phase was conducted in 1996 and 1997 in two dairy farms. Data were collected on the same parameters of reproduction and production. During the second year, the results of dairy herds were better than those in the first year. That was probably due to monitoring provided by the research project.

1. INTRODUCTION

In Algeria, mixed farms consisting of dairy cattle and crops are a dominant farming system in the plain areas and the majority of the cattle population are kept in small farms of less than 5 ha. However, new livestock farming systems have recently developed in peri-urban areas, where milk production predominates with feedstuffs being bought at the market. The milk production is extensive on a relatively small agricultural area (3.16%) because land exploitation is strongly dependent on rainfall. The increase in cattle population has been slow which is mainly due to nutritional and reproductive constraints. The annual calving rate has been about 60% with a long interval between calvings [1].

Available feed resources are: 38% cultivated forages, 10% fallows, 28% rangeland, 15% concentrate feed and 9% by-products. Cattle consume around 30% of these feed resources. The annual availability of concentrate feed is about 1.6 million tons and only 7% have been ear marked as ruminant feed. Comparison between feed availability and animal requirements indicate a deficit which may be reduced by utilizing by-products and minerals in animal feeding.

The effects of dairy herd managment on reproduction and milk production have been studied through a Coordinated Research Project of the Joint FAO/IAEA Division, IAEA. This paper presents results from these studies conducted during 1995/1996 and 1997.

The study aims to contribute to increased productivity and milk production of dairy cows in farms monitored by the project. It consists of a study of reproduction parameters by using radioimmunoassay (RIA) of progesterone in milk and blood samples of cows after calving, the introduction of milk recording to develop the productivity of dairy herd and the monitoring of other production parameters such as body condition score (BCS) and body weight.

2. MATERIALS AND METHODS

2.1. Surveys

Surveys were carried out on livestock farms in the Mitidja plain to determinate the characteristics of their feeding systems and dairy herd management in order to examine the possibilities of utilizing the feed resources for increasing the contribution of dairy cattle to producer income. The Mitidja area was chosen because of it contrbutes to the milk supply of the peri-urban population of Algiers. A total of 47 questionnaires were completed after consultation with farmers in the study area. The data collection focused on the kind of feeds provided to animals throughout the year.

2.2. Livestock farms selected

After carrying out surveys, two livestock farms A and B were chosen to collect data on the characteristics and the performance of dairy cows. The two farms are located in the Mitidja plain (fifty kilometers around Algiers) at an altitude of 200 metres above sea level. The soils are clay-loams with good fertility. The climate is typically mediterranean with an average annual rainfall of 370 mm. The average temperature varies between 7°C in December to 32°C in August.

2.3. Animals

Farms surveyed had a total number of 650 cows. The herd size varied from 4 to 50 cows with a majority of smallholders possessing less than 12 head. All cows involved in the study were Friesan, typical of those in the Mitidja plain. The number of cows considered in Farm A was 67 for the first period (1995/96) and 40 for the second period (1996/97), respectively. In Farm B, the study was carried out only in the second period using 30 cows. In both cases, cows were stall-fed but grazed on natural pasture when the weather was good. Data were collected on all cows of the farms chosen during the second phase of the study. The herds of these farms were chosen because they presented better working conditions to evaluate feeding strategies and the performance of dairy cattle.

2.4. Observations on herd feeding

Samples of forages were collected monthly from the farms to determinate the chemical composition (dry matter, ash, crude protein). The diet changes were calculated monthly. All cows were kept and housed in tie-stalls for feeding. The cow requirements and feed composition were estimated in French units for energy (UFL) and nitrogen (MAD).

2.5. Measurements

Resumption of ovarian activity post-partum of cows was determinated only on Farm A during the two periods (1996 and 1997). Blood samples were collected once a week from the 15th day post-partum by jugular venipuncture using heparinized vacutainer tubes. Blood samples are centrifuged immediately at 4°C for 15 minutes at 2 000 *g*. After decantation, plasma samples were stored in the freezer until progesterone assay. The progesterone measurement was carried out by radioimmunoassay (RIA) technique using FAO/IAEA solid-phase RIA kit. The inter-assay coefficient of variation for the low and high concentrations as calculated from a duplicate analysis of plasma controls plasma were 4.2% and 4.4%, respectively. The resumption of ovarian activity was defined as the moment at which the concentration of progesterone was greater than 2 nmol/L for plasma.

Cow weights and heart girth measurements were recorded in both Farms A and B using a weigh band for cattle. Monthly, BCS of cows was determined using the 1-9 scale method [2]. Individual data on milk production were collected monthly for each cow on both farms.

3. RESULTS AND DISCUSSION

3.1. Survey results

The chracteristics of farms surveyed during Phase I of the study are presented in Table I. Three farm types could be recognized. Farm Type I is characterized by a relatively small area of land, high number of cows and a very low milk yield. These farms belong to private farmers that possess small fodder areas and often buy forages at the market.

Farm Type II is characterized by a structure intermediate to one and three. They are situated in the peri-urban zone. The average milk yield is better than the other farm types.

Farm Type III represents farms which possess a larger land area as well as cows, than the other two types. The milk production is low relative to available resources. These farms belong to the co-operative or state sector. They are characterized by a system of polycultures associated with animal production. The two Farms A and B selected for the study belonged to Type I and III, respectively.

In the study area, the importance of feed resources varied according to their origin; it was 38.4% dried forages, 10.5% fallows, 27.6% natural pasture, 14.8% concentrates and 8.7% by-products. However, field-dried hay (78% of the whole forage area) was the dominant forage crop; green fodder areas represented only 22%. These observations are illustrated by the results of surveys [3] which showed that the majority of farms have winter and summer rations with poor forages such the hay of Vicia-avena (Tables II).

TABLE I. CHARACTERISTICS OF FARMS SURVEYED (MEAN ± SD)

	Type I	Type II	Type III
Number of farms	11	22	14
Farm area (ha)	7.5 ± 2.8	10.9 ± 7.4	71.4 ± 53.2
Fodder area (%)	41.5 ± 29.1	61.4 ± 35.3	66.8 ± 16.2
Irrigated area (%)	11.5 ± 19.1	6.6 ± 11.3	11.4 ± 12.
Number of cows	18.9 ± 10.6	13.1 ± 7.5	43.2 ± 25.8
Number of bulls	2.0 ± 1.0	1.0 ± 1.0	2.0 ± 1.0
Percentage of calves	30.6 ± 7.1	22.4 ± 19.2	18.2 ± 14.7
Percentage of heifers	8.2 ± 7.5	3.9 ± 8.5	6.1 ± 9.3
Milk yield (kg)	2724.5 ± 518.7	4168.0 ± 1244.7	3317.1 ± 931.9

TABLE II. NATURE OF RATIONS USED IN THE FARMS DURING WINTER AND SUMMER

	Farm number	Percentage of farms
Winter ration (basal forage)		
Trifolium	5	10.6
Vicia avena	20	42.6
Avena	19	40.4
Others	3	6.4
Winter ration (supplement)		
Bran	22	46.8
Bran + brewer's grain	14	29.8
Bran + concentrate	5	10.6
Others	6	12.8
Summer ration (basal forage)		
Vicia avena	16	34.0
Avena	9	19.0
Sorghum	7	15.0
Sorghum + Vicia avena	8	17.0
Sorghum + avena	7	15.0
Summer ration (supplement)		
Bran	30	64.0
Bran + brewer's grain	9	19.0
Bran + concentrate	2	4.0
Bran + carob	6	13.0
Total	47	100

The data in Table II above indicate that the system of cattle feeding in the Mitidja region is based essentially on the utilization of hay and oat fodder which is of low quality (0.4 UF and 10-20 g of MAD) [4]. Concentrate feed is expensive and farmers have a tendency to replace it by wheat bran which is relatively cheaper. Furthermore, a previous study [5] has shown that there exists in Algeria a strong dependence of livestock on cereals. 75% of ruminant feeding is based on cereals and their by-products. Cultivated forages and spontaneous herbs represent only 25% of the total feeding. Estimations [6] show that in the year 2000 the deficit would be 32% in energy (UF) and 61% in nitrogen (MAD). These estimations agree with the forage balance realized in 1989 [5]. They indicated a deficit of 31.2% of energy.

The deficiency of the feed base seems to be a major constraint for low milk production The increase in production is possibe by improving breeding methods and by utilizing feed resources, by-products and minerals as supplements in the animal's diet.

3.2 Feeding practices

The chemical analysis of forages used in Farms A and B are given in Tavle III. The daily requirements and supply of energy and nitrogen in winter (December to February) and summer (June to September) rations are shown in Table IV.

TABLE III. DRY MATTER (DM) AND CHEMICAL COMPOSITION (% OF DM) OF FEED GIVEN TO DAIRY COWS

Farm	Type of feed	DM (%)	Crude protein	Ash
			(% DM)	
A	Avena (hay)	86.7 ± 3.9	4.7 ± 0.5	9.2 ± 0.9
	Sorghum (green)	25.2 ± 2.4	61.4 ± 10.6	6.8 ± 2.0
	Concentrate	88.5 ± 0.5	15.4 ± 2.1	5.4 ± 0.7
B	Bran	87.1 ± 0.7	16.3 ± 0.5	4.9 ± 0.7
	Brewer's grain (fresh)	22.0 ± 0.1	29.9 ± 1.6	4.4 ± 0.5
	Vicia Avena (hay)	85.6 ± 4.5	13.3 ± 1.9	8.2 ± 0.4
	Cabbage (green)	14.3 ± 0.4	15.6 ± 2.2	12.8 ± 1.1

The daily requirement of energy and nitrogen were estimated on the basis of the average body weight of cows of 455 ± 5.4 and 585 ± 10.9 kg and average milk yield/cow/d of 9.4 ± 2.9 and 10.7 ± 1.4 kg, for Farms A and B, respectively. The daily nutrient supply was estimated by DM intake of the ration provided during the summer and winter. The nutritional value of the forage consumed by animals was determinated from the results of chemical analysis, which compared well with INRA tables [7] and those from the Institut National Agronomique, Algiers.

When comparing the nutrient supply and animal requirements it appears that in Farm A, the winter ration is deficient in energy (22%) but balanced in nitrogen because of the availability of green forage and the use of high levels of concentrate. However, the summer ration appeared to be deficient in both energy and nitrogen; the deficit being 37 and 23%, respectively. This is due to the low availability of green forage and concentrates; the hay provided in the summer being of poor quality. However, the observations were different for Farm B where both energy and nitrogen were in excess during winter as well as the summer. Farmers used wheat bran and brewer's grain at a 1:1 ratio as a supplementary feed. This type of mixture which contained high levels of energy and nitogen was consumed well by the cows.

TABLE IV. DAILY NUTRIENT REQUIREMENT OF COWS DURING WINTER AND SUMMER IN FARMS A AND B

Farm	Season	DM intake (kg)			Total DM intake	Daily requirement		Daily supply	
		Hay	Green	Conc.	(kg)	Energy (UFL)	Nitrogen (g MAD)	Energy (UFL)	Nitrogen (g MAD)
A	Winter	2.8	2.6	3.5	8.9	8.6	846	6.7	846
A	Summer	3.5	1.2	2.6	7.3	8.6	846	5.4	648
B	Winter	6.7	2.6	4.2	13.5	9.9	984	10.9	1574
B	Summer	1.4	4.3	7.0	12.7	9.9	984	12.0	1984

3.3. Reproductive performance

3.3.1. Distribution of calvings

Figure 1 shows the distribution of calvings in the two farms. In Farm A majority of calvings (73%) took place between January and March during the period 1995/96. However, during 1996/97 calvings were spread out between September and March, the month of October recording over 20%. In Farm B calvings were distributed throught the year; the highest (65%) occurring between the months of June and August.

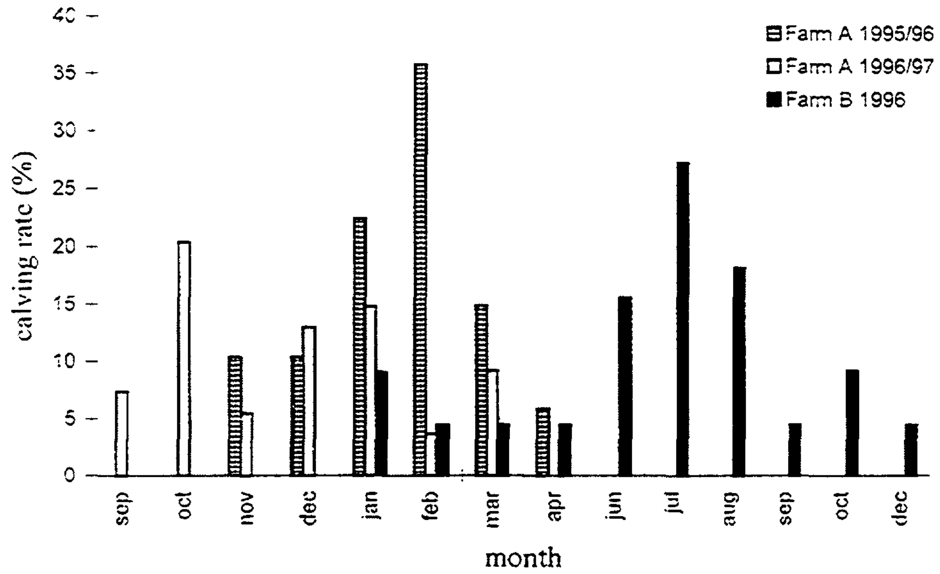

FIG.1. Distribution of calvings in Farms A and B during 1995, 1996 and 1997.

3.3.2. Resumption of ovarian activity post-partum

As shown in Table V, the rate of resumption of ovarian activity recorded at 35 days post-partum was relatively low during the two study periods 1996 and 1997 (37.3 and 20%, respectively). The average anoestrus duration was 26.3 ± 5.9 and 32.2 ± 2.1 days, for the two periods, respectively. However, at 60 days post-partum the rate of resumption of ovarian activity recorded was high for the first period (70%) compared to the second period (40%); but these results were poor compared to those recorded previously [8-10].

TABLE V. CUMULATIVE PERCENTAGE OF COWS RESUMING OVARIAN CYCLICITY POST-PARTUM

Interval from calving	Period 1 (n = 67)		Period 2 (n = 40)	
	Number of cows	(%)	Number of cows	(%)
< 35	25	37.3	8	20.0
< 45	35	52.2	11	25.5
< 60	47	70.1	16	40.0
< 90	60	89.5	28	70.0

3.3.3. Fertility indices

The fertility rate is generally assessed by two criteria which are the first sevice conception rate and the percentage of cows inseminated 3 times or more. Results recorded in Farm A during both study periods and in Farm B during the second indicated poor conception rates. For Farm A the first service conception rate was 33.3 and 42.5% for the two periods, respectively. The first service conception rate was 16.7% in farm B during the second study period. The percentage of cows inseminated 3 times or more was 12.6 and 35.0% for Farm A and 36.7% for Farm B (Table VI). The delay to serve cows after calving depends on a complete uterine involution, resumption of ovarian activity and oestrus. Observations indicated low percentage of cows being inseminated on Farm A soon after calving; 7.6 and 2.5% respectively, for the two periods studied. However, on farm B 27.8% of cows were being inseminated soon after calving. Cows inseminated between 40 and 90 days after calving were 66.6 and 85% on Farm A for the first and second periods, respectively. On Farm B 33.3% of cows were being inseminated between 40-90 days.

TABLE VI. FERTILITY INDICES OF POST-PARTUM COWS

Fertility index	Norms*	Farm A Period 1	Farm A Period 2	Farm B Period 2
First sevice conception rate (%)	>60	33.3	42.5	16.7
% of cows inseminated 3 times or more	<15	12.6	35.0	36.7
Calving to first service		(n=66)	(n=40)	(n=18)
Mean ± sd (days)	65	81.1±47.4	66.6±38.0	75.2±38.0
Distribution (days)				
< 40 days	0 %	7.6	2.5	27.8
40 to 90 days	100 %	66.6	85.0	33.3
> 90 days	0 %	25.8	12.5	38.9
Calving to conception		(n=50)	(n=40)	(n=18)
Mean ±sd (days)	90	149.5±86.3	126.5±58.9	152.7±52.0
Distribution(days)				
< 40 days	0 %	0	0	0
40 to 110 days	85 %	46.0	52.5	27.7
> 110 days	<15 %	54.0	47.5	72.2

* From INRA; Number of cows within parenthesis

These values do not agree with stated norms for Algeria. They are not only the result of a delayed ovarian activity, but also the consequence of poor reproductive management, constraints in heat detection and the general lack of an animal health plan, especially during the peri-partum period. An increase in the average duration of calving to first sevice interval is related to the delay in the resumption of ovarian cyclicity post-partum. For the 44 inseminations carried out 43.2% appeared to have been carried out before the resumption of ovarian activity and 36.4% during the luteal phase of the cycle. The mean values recorded for the interval between parturition and conception were 149.5 ± 86.3 and 126.5 ± 58.9 days respectively, for the first and second periods on farm A, and 152.7 ± 52.0 days for farm B. The percentage of cows inseminated after 110 days was 54.0%, 47.5% and 72.2%, respectively. According to norms for the same interval the data recorded can be the onsequence of the prolonged delay in the resumption of ovarian activity or that of the interval between calving to first insemination.

Other observers have also indicated the low fertility of dairy cattle. The percentage of cows which did not conceive at 110 days post-partum were 27.5 and 33.2% respectively, in the Mitidja and the western region [11]. A low conception rate was also observed by Benabdelaziz [12].

3.3.4. Body weight and BCS of dairy cows

The average weight of cows in Farm A was 455.0 ± 5.4 kg with a range of 448 to 462 kg. In Farm B the weight was higher with a mean of 584.7 ± 10.9 and a range of 573 to 603 kg. The BCS was also better in Farm A than in Farm B. The mean was 6.1 ± 0.3 and 5.2 ± 0.8, for the two farms, respectively. The change of body weight and BCS of cows in the two farms over a period of 7 months are shown in Figures 2 and 3. Cows in Farm B maintained a higher body condition than those in Farm A probably due to the higher energy intake compared to those in Farm A. Cows in Farm B received a higher level of concentrate than those in Farm A.

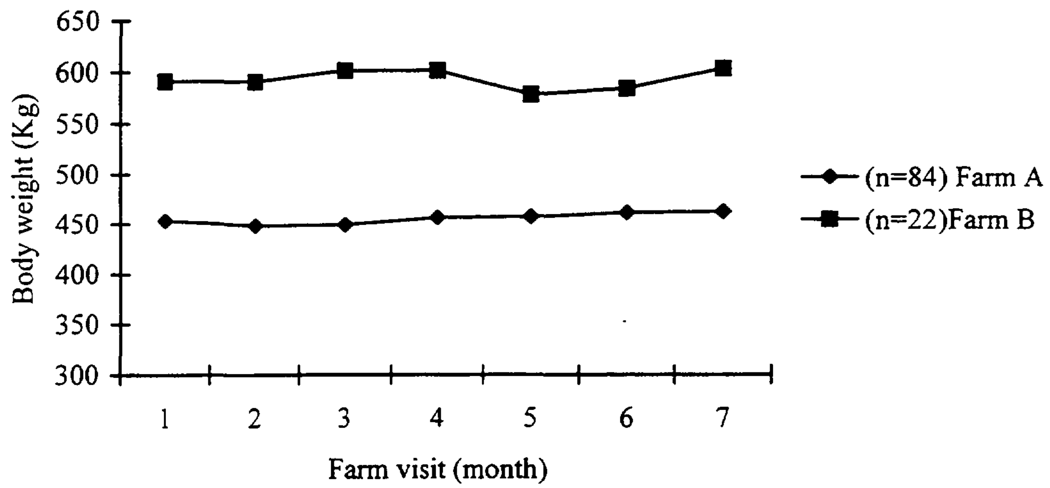

FIG.2. Change in body weight over 7 months in Farms A and B.

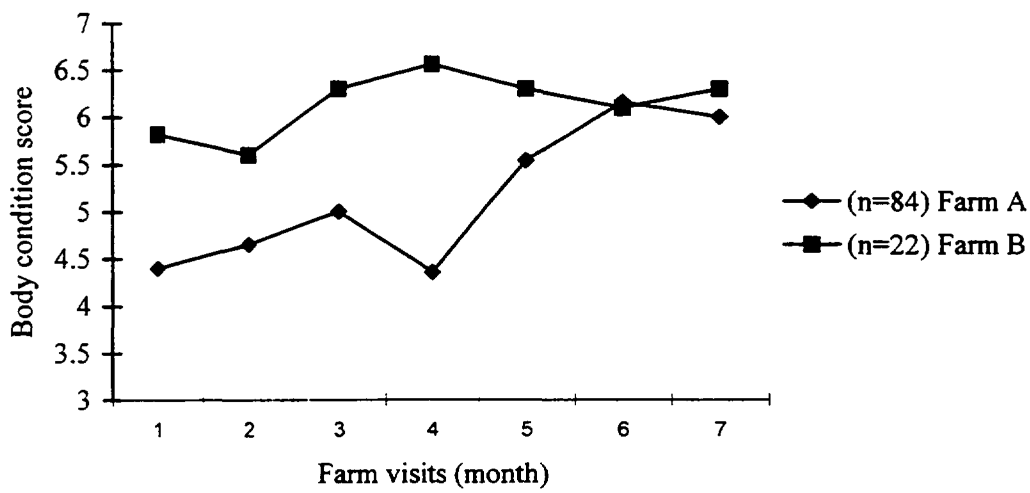

FIG.3. Change in body condition score over 7 months in Farms A and B.

3.3.5. Factors affecting dairy cow reproduction performances

The analysis of data on reproductive perfomance of dairy cows on Farm A during the second period (Table VII) shows a significant effect (P <0.05) of calving season and BCS at calving on the interval to first ovulation.

TABLE VII. LEAST SQUARE MEANS AND VARIANCE (sd) FOR REPRODUCTIVE TRAITS OF DAIRY COWS

Source of variation	Interval from calving to First ovulation n	mean ± sd	Conception n	mean ± sd
Overall	40	71.0±32.7	40	126.5±58.9
BCS[1]				
4	8	88.0±34.2 (a)	8	138.2± 65.9
5	26	72.5±30.4 (a)	26	119.1± 55.6
6	6	48.8±24.2 (b)	6	129.0± 65.2
Season[2]				
Fall	18	76.2±29.5 (a)	18	121.6± 50.6
Winter	17	76.5±34.2 (a)	17	132.9± 68.2
Spring	5	33.8± 8.8 (b)	5	122.6± 64.3

[1] BCS = Body condition score (1-9 scale)
[2] Fall, (Sep-Nov); Winter, (Dec-Fev); Spring, (Mar-May)
a,b Means with different superscripts indicate significant differences (P <0.05)

Cows which calved with a BCS of 6 (on a scale of 1-9) and above had ovarian cyclic activity earlier (48.8 ± 24.2 days) than those with a BCS of 4 and 5 (88.0 ± 34.2 days and 72.5 ± 30.4 days, respectively). This suggests that cows having BCS below a critical level have poor reproductive performance [13], although cows calving during spring had shorter interval to first ovulation 33.8 ± 8.8 days than those calving during fall and winter, These results are in accordance with those obtained by Gary *et al.* [9]. These authors found a significant différence (P <0.05) between the cyclicity rates of cows calved in January, February and March (29.1, 40.4 and 58.6%, respectively).

The BCS at calving and season of calving did not influence the interval to conception. However Kassa and Tegegne [13] found that cows with a BCS of 2-3 at calving had longer service to conception intervals than those with a BCS >4.

3.3.6. Milk production

Levels of milk production in the two farms studied were similar and the analysis of variance showed no significant difference bewtween the two farms. The average yield/cow was 9.4 and 10.7 kg/d for Farms A and B, respectivley, during a lactation period of 210 days.

There was a similarity in the average lactation curves between the two farms. Statistically, the two curves seem to be characterized by a similar level of production at the peak and a same daily production per cow. However, there was a difference at the fourth month of lactation where the curve declined for Farm A which was probably due to a feed deficit. On the contrary in farm B, a persistant lactation curve was observed which could be explained by the better feeding with high levels of concentrates (4-7 kg DM/cow/d). Nevertheless this excess feed in Farm B did not bring about a high milk production.

4. CONCLUSIONS

Results of the survey in the Mitidja region revealed a diversity of production types. Their management was often limited to constraints of environment such as as husbandry and feed availability. These aspects have been confirmed in the two studied farms. Observations indicated a deficiency of energy and nitrogen in the feed resources during the summer season. This could be attributed to inadequate forage stocks and poor feeding management. This situation has an impact on the body condition of cows, level of milk production and the resumption of ovarian activity after calving. In fact, the intervals from calving to the resumption of ovarian activity and conception were long and the percentage of cows served between 40-90 days after calving were relatively small. The resumption of ovarian activity was shorter in cows which calved with BCS of 6 and above compared with those having a BCS of 4 and 5, and in cows calving in spring than those calving in fall and winter.

The results on the two farms indicate poor reproductive managment and a low nutrional status of cows at calving which have an impact on post-partum ovarian activity. The forage production does not cover all feed requirements of animals and farmers often tend to buy feed from outside theirs farms. A decline in milk yield was observed in the two farms which are characterized by constraints related to management of reproduction and nutrition which have a direct impact on herd productivity. It shows particulary the influence of level of feeding on BCS for the first 100 days after calving. The study suggest the need for supplementing the dairy cattle. Any technical intervention concerning animal feeding must take in account the whole environment of each livestock farm studied.

ACKNOWLEDGEMENTS

The authors gratefully acknowldge the financial support given by the Joint FAO/IAEA Division, IAEA (Vienna) and the CDTN (Algiers) and the facilities provided by the farmers which made this study possible. They thank Drs. M.C.N. Jayasuriya, W.J. Goodger, T.Bennet, B.M.A.O. Perera, M. Jeggo and all the staff of the Joint FAO/IAEA Division. They thank also the Agreement Holders (Drs. M.Marie, B. McBride, D. Poppi and D. Whitaker) and all the Contract Holders of this study.

REFERENCES

[1] BENYOUCEF, M.T., Situation actuelle et rôle futur des bovins dans les systèmes d'élevage mixtes: le cas de l'Afrique du Nord. Réunion de la Fédération Européenne de Zootechnie, Madrid (1992).

[2] NICHOLSON, M.J., BUTTERWORTH, M.H., A guide to condition scoring of Zebu cattle, ILCA, Addis Ababa, Ethiopia (1986).

[3] BENYOUCEF, M.T., DJOGHLAL, NETAMMI, A., Etude de la production laitière dans la Mitidja: Enquetes dans les élevages bovins laitiers, A paraître (1996).

[4] I.T.E.B.O., Fiches de rationnement bovin et ovin, Janvier (1988).

[5] BOUTONNET, J. P., La spéculation ovine en Algérie. un produit-clé de la céréaliculture, Economie et sociologie rurales/Montpellie, Série Notes et Documents No. 90, (1989).

[6] NEKKAL, T., Etude du taux de satisfaction des besoins alimentaires du cheptel en Algérie, Mémoire d'Ing. Agro., Institut National Agronomique, El-Harrach (1990).

[7] INRA, Alimentation des bovins ovins et caprins, Ouvrage collectif dirigé par R. Jarrige (1988).

[8] CHUPIN, D., PELOT, J., AGUER., D., Pour maîtriser les cycles sexuels des vaches. Les méthodes: leur but leurs résultats, Rev. Elev. Bov. Mars (1982) 85-91.

[9] GARY, F., HUMBLOT, P., CAPY, C., GOUFFE, D., THIBIER, M., Facteurs de variation de la réponse d'activité ovarienne après vêlage en race Blonde d'Aquitaine et leurs effets sur les paramètres de reproduction, Rev. Elv. et Ins. **222** (1987) 12-28.

[10] BENYOUCEF, M.T., BENABDELAZIZ, A., KHELILI, R., Etude de l'anoestrus post-partum d'un troupeau de vaches laitières de race améliorée, Rapport interne-CDTN, Alger (1995).

[11] SIDI-IKHLEF, C., Contribution à l'étude de l'anoestrus post-partum chez les bovins laitiers, Mémoire Ing. Agro., INA, Alger (1989).

[12] BENABDELAZIZ, A., Etude des moyens et des méthodes de maîtrise de l'oestrus chez les bovins laitiers, Mémoire Ing. Agro., INA, Alger (1989).

[13] KASSA, T., TEGEGNE, A., "Reproductive performance of the indigenous Zebu and friesian × Zebu crossbred cows under smallholder management conditions in Ethiopia", Improving the productivity of indigenous African liverstock, IAEA-TECDOC-708, IAEA, Vienna (1993) 113-120.

[14] JOURNET, M.,Alimentation des vaches laitières avec des rations à fortes proportion d'aliments concentrés, Ann. Zootech. **21** (1972)191-205.

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