

Feeding Draught Milking Cows in Integrated Farming Systems in the Tropics - Ethiopian Highlands Case Study

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Abstract

The evaluation of multipurpose cattle (milk, meat and work) is of importance in many tropical regions because of its direct and indirect effects on livestock and crop production.

The costs and utilisation of dietary nutrients are major determinants in the evaluation of the biological efficiency of multipurpose cows. Work can lead to a competition for energy precursors which may affect milk production and reproductive efficiency.

This paper deals with studies on work output, feed utilisation and lactation of crossbred (F1 Friesian and Simmental x Boran) dairy cows used for draught in the Ethiopian Highlands. Over a period of three years, work output of dairy cows averaged more than 200 MJ per cow per year of net energy which was greater than that required by farmers for land cultivation. The diet fed to cows contained 18 g/kg of N, 613 g/kg NDF (composed of 75% natural pasture hay and 25% concentrate). Work increased dry matter intake of roughage and *in vivo* dry matter digestibility by 10.7 and 6%, respectively. Digestion kinetics could explain only partially the possible mechanisms responsible for greater

roughage intake and digestibility in working cows. How work could affect either rumen fermentation processes or digestion in the lower digestive tract, as well as other processes involved in intake regulation of roughage diets, is uncertain.

Milk yield of two consecutive lactations was not significantly different for non-working and working cows. On-farm milk production of cows over a period of two years was similar for working and non-working cows (2,620 v. 2,980 kg, respectively).

Supplementation of working cows reduced liveweight loss by 73% and doubled the number of conceptions and parturitions compared to non-supplemented cows. Working cows that lost more than 15% of calving weight conceived when they had recovered 55% of their weight and 106% of their body condition loss, respectively. Even after extended periods of underfeeding, acyclic and anoestrous cows resumed ovarian cyclic activity in an average of 46 days and conceived in 75 days when fed about twice their maintenance energy requirements.

The economic analysis indicated that the value of work more than compensated for the small reduction in milk production and longer calving interval found in working cows when supplementation took place to ensure adequate nutrition.

In conjunction with the technical factors, systematic consideration needs to be given to the effects at the micro-level of socio-economic factors, including institutional and structural factors. The successful introduction of crossbred cows for milk and traction not only requires new feed production, feeding and management systems on-farm, but also would induce substantial changes in present mixed farming system practices. Therefore, there is a need to identify those technical and socio-economic factors which might affect such changes and hinder or promote these technologies.

KEY WORDS: Draught animal power, multipurpose, cow, milk, feed, Ethiopia

Introduction

In many developing countries, draught animal power is the best alternative power source at the intermediate technology level, because low wages and small farm size make it unattractive to substitute tractors.

The efficiency of animal traction in the smallholder context could be increased by adopting multipurpose animals to be used for meat and milk production as well as for draught power. Cows can use feed resources more efficiently than oxen and, if properly fed, can provide adequate work output for most cultivation practices (Matthewman, 1987). The use of cows for draught would allow males to be fattened and sold younger, and could also lead to greater security of replacements. More productive animals on farms could result in a reduction in stocking rates and overgrazing, thus contributing to the establishment of a more productive, sustainable farming system. Peri-urban farmers would be more inclined to change or modify their management system since their proximity to urban services would help minimise production risks (Gryseels and Goe, 1984).

In a growing number of tropical regions, cows are being used for draught particularly in areas where human population pressure on land has reduced farm size and thus has caused a decrease in feed resources for livestock (Matthewman, 1987). Research on the evaluation of multipurpose cattle (milk, meat and work) is of primary importance because of its direct and indirect effects on livestock and crop production.

ILRI and the Ethiopian Institute of Agricultural Research (IAR) have studied different aspects of the use of dairy cows for draught work. This paper deals with on-station and on-farm studies on work output, feed utilisation and lactation of crossbred dairy cows used for draught in the Ethiopian Highlands. Information generated from ILRI and IAR research is used to elaborate the inter-play of factors affecting work output and lactation performance of dairy cows used for draught.

Work Output and Efficiency of Draught Dairy Cows

Results from Zerbini *et al.*, (1992) show that F1 crossbred dairy cows (Friesian x Boran and Simmental x Boran) were able to work at a rate of about 500 W. This represented about 14% of mean body weight with a

work efficiency ranging from 7% to 26%. Over a period of three years, work output of dairy cows averaged more than 200 MJ per cow per year of net energy which was equivalent or above that required by farmers for land cultivation.

Feed Utilization in Multipurpose Cows

Feed is a dominant factor in animal production because of its major effect on milk yield, reproduction and work capacity. Furthermore, the costs and utilisation of the energy and nutrients in the ration are of great importance in the evaluation of biological efficiency of a multipurpose animal. Feed efficiency in cattle is influenced by diet and other environmental factors, genetic potential and physiological state of the animal (Korver, 1988; Zerbini and Alemu G/Wold, 1995). Selection on gross feed efficiency could be relevant for multipurpose cows where the genetic correlation between work capacity or work output and feed efficiency has not yet been established.

Draught cows have higher nutrient requirements than oxen specially if they have to perform draught work during the early stages of lactation when nutrient supply has to cover the needs for work, lactation and reproductive activity. Under conditions where adequate feed is not available to maintain body weight, cows can still satisfactorily perform work by drawing on body reserves, but other functions such as lactation and reproduction could be impaired.

In multipurpose cows, especially those fed on poor quality diets, work may lead to competition for energy precursors which may in turn have an effect on milk production and reproductive efficiency. This effect could be greater than that occasioned simply by competition for energy-producing nutrients per se. When work is imposed on the lactating cow, it affects the partition of energy yielding substrates to the muscle and free fatty acids are mobilized from fat depots. At the same time, these metabolites are also precursors of milk components and competition will occur with other functions in the lactating, working cow. The diversion of amino acids away from protein synthesis might also be due to requirements by cows for glycogenic substrates to substitute for some of the roles that glucose normally plays under situations of glucose

sufficiency. This is especially important in the dairy cow where glucose and amino acids are being used for milk synthesis in the mammary gland or in the gravid uterus.

Genotype may be important in the selection of cows that will adapt to draught work with minimal disruption to lactation. In addition, different physiological priorities in beef and dairy breeds will affect the efficiency of energy use and maintenance. A desirable trait of the lactating, working cows would be a large food intake capacity. Larger animals could be of considerable advantage in situations where high fibre roughages are utilised. Larger animals are more efficient chewers and spend less time chewing per kg of ingested cell wall constituents.

Multipurpose Cows: Performance in the Ethiopian Highlands

On-station Studies

Location and diet

The study was carried out at the Holetta Research Centre of the Ethiopian Institute of Agricultural Research (IAR) which is located in the central highlands of Ethiopia, 50 km west of Addis Ababa, at an altitude of 2400 m and with an annual rainfall of 1060 mm. Mean maximum temperatures range from 18.7 to 24.0 deg. C.

Crossbred cows (Friesian x Boran and Simmental x Boran) worked 4 hours/day, 100 days/year for three years. Work started two weeks after and was stopped one month before the expected calving date. Mean body weight of the cows was 412 kg. The diet was formulated to meet nutrient requirements of cows for maintenance, milk production, pregnancy and work (Australian Agricultural Council, 1990) and included natural grass hay fed ad libitum, 3 kg of concentrate (mix of 800 g/kg of noug cake (*Guizotia abyssinica*), 150 g/kg of wheat midds, 30 g/kg salt and 20 g/kg bone meal; 25% CP and 11.4 MJ ME/kg DM) and mineral lick. Chemical composition and degradability parameters of the diet are shown in Table 1.

Table 1. Chemical composition and degradation characteristics(1) of the diet(2) fed to F1 crossbred cows used for draught.

	mean	s.d.
Dry matter	907	11
Organic matter	900	17
Nitrogen	18.0	2.1
NDF	613	40
a	18.9	0.7
b	52.9	4.8
c	0.03	0.004

1 Orskov and McDonald (1979)

2 Include 75% natural pasture hay and 25% concentrate.

Diet intake and utilization

Dry matter intake was greater for working compared to non-working cows (Table 2). Working cows increased DMI above that of non-working cows by 10.7% over a period of three years. Work increased DM and OM in vivo digestibility. Working cows must have absorbed more nutrients as indicated by the greater intake and greater digestibility of the feed. Digestion kinetics could explain only partially the possible mechanisms responsible for greater roughage intake and digestibility in working cows (Zerbini *et al.*, 1995).

A number of studies have reported no significant effect of work on feed intake in oxen (Lawrence, 1985) and buffalo cows (Bakrie and Teleni, 1991). Other studies indicate an increased feed intake in working buffalo cows (Ffoulkes *et al.*, 1987) and dairy cows (Gemedo *et al.*, 1995). Furthermore, some authors have reported negative or no effect of work on digestion in buffalo and cattle, depending on the diet fed (Pearson and Lawrence, 1992; Pearson, 1990), while others have shown a positive effect of work on digestibility (Pearson and Lawrence, 1992; Ffoulkes *et al.*, 1987).

Table 2. Organic matter digestibility and cumulative dry matter intake and work output of F1 crossbred cows used for draught over a period of three years.

Treatment	% n	Dry matter digestibility	Dry matter intake(kg)	Work output (MJ)
No work	10	51.0	10,603	-
Work	10	54.0	11,841	705.2
s.e.		0.7	375	-
F Work		P<0.05	P<0.05	-

How work could affect either rumen fermentation processes or digestion in the lower digestive tract, as well as other processes involved in intake regulation of roughage diets, is uncertain.

Degradation rate was not measured separately in working and non-working animals. It is, however, unlikely that physical work of the animal could affect the microbial degradation rate of fibre. Increased body temperature observed in crossbred cows at work (Zerbini *et al.*, 1992) could decrease gut motility, increasing retention time of feed in the rumen and feed digestibility. However, a decreased rumen retention time of solids due to work was not apparent.

Live-weight change and reproduction

Cows tended to maintain or gain body weight over three years. Body condition score was similar between working and non-working cows at the end of three years from the beginning of the study. Over a period of two years, supplementary feeding reduced body weight loss of cows by 80%. Supplementation of working cows reduced liveweight loss by 73% and doubled the number of conceptions and parturitions compared to non-supplemented cows.

Calving intervals of working cows (Table 3) were on average 90 days longer than those of non-working cows. Differences were greater and significant in the second calving interval.

It is possible that the depletion of body reserves to certain critical levels had signalled metabolic controls to switch off non-vital processes

such as ovarian function. A clear definition of body weight and condition at the start of the work season and rate of weight loss which are compatible with normal ovarian activity is desirable, as well as the effect of interaction between work and body reserve nutrients on cyclic activities in cattle and buffaloes.

Work did not influence the conception ability of supplemented cows, but had a substantial influence in non-supplemented cows.

Table 3. Calving intervals of F1 crossbred cows used for draught over a period of three years.

Treatment	Calving intervals			
	n	1	n	2
No work	10	415.6	8	397.8
Work	9	491.6	7	502.0
s.e.		31.2		31.5
F work		NS		P<0.05

Lactation parameters

Ninety per cent of non-working and 70% of working cows completed two lactations over a period of three years (Table 4). Milk yield of two consecutive lactations was not significantly different for non-working and working cows. However, days in milk were significantly greater for working cows.

The greater calving intervals observed in working cows is consistent with the delay in conception after parturition reported for working/supplemented compared to non-working/ supplemented cows by Zerbini *et al.* (1993). The relatively fewer number of lactations completed as well as conceptions, and greater days in milk of working cows, over a period of three years, reflects the delayed conception in working cows. Once pregnancy was established there was no effect of work on maintenance of pregnancy

Table 4. Lactation yield (kg) and days in milk of F1 crossbred cows used for draught

Treatment	Lactation 1			Lactation 2		
	n	milk yield	days	n	milk yield	days
No work	10	1777.7	321.0	9	1446.7	303.3
Work	10	2010.8	443.2	7	1685.5	427.0
s.e.		247.7	38.3		181.8	41.0
F work		NS	P<0.5		NS	P<0.07

Even under conditions where adequate feed supplementation was not available to maintain body weight, such as for working/ non-supplemented cows, animals could still satisfactorily perform work by drawing on body reserves and increasing dry matter intake. However, Gameda *et al.* (1995) indicated that if such a situation exists for as long as one year, cows could lose more than 15% of their calving body weight and reduce milk production by more than 50% compared to working/ supplemented cows.

Working cows that lost more than 15% of calving weight conceived when they had recovered 55% of their weight and 106% of their body condition loss, respectively. Body weight gain appears to lag behind condition score increases and recovery of body weight seems to be less important than recovery of body condition for conception to occur. Even after extended periods of underfeeding, acyclic and anoestrous cows resumed ovarian cyclic activity in an average of 46 days and conceived in 75 days when fed about twice their maintenance energy requirements. The economic implications of long periods of low productivity or maintenance in working and non-working cows, and the requirements for resuming reproductive activity, need to be evaluated in detail especially for farming systems with large fluctuations in availability of feed resources.

On-farm Studies in the Ethiopian Highlands

The on-farm testing of cow traction technologies was designed to evaluate the effect of draught work and management on production and economic performance of crossbred dairy cows on the smallholder farm. The approach used in testing the dairy-draught cow technology and its transfer on-farm has been interdisciplinary.

Pairs of crossbred cows (120 F1 Friesian x Boran) were purchased by selected farmers in 1993 and 1995 in the Holetta area. Stratification of participating farmers into low, middle and high income groups was based on land and livestock holdings, livestock type and labour availability, total farm assets and location.

Preliminary on-farm research results on cows performance (Table 5) have shown that milk production of working and non-working F1 crossbred cows on-farm was similar (2620 vs 2980 kg), ranging from 2010 to 3,400 kg for working cows and from 2018 to 3907 kg for non working cows. Calving intervals for working and non-working cows were 525 and 495 days, respectively. First lactation average milk yield and days in milk of working and non-working cows were 1,864 and 2252 and 376 and 410 days, respectively. Service per conception for working and non-working cows were similar. Over a period of two years cows worked an average of 26 days/year.

During working days, energy requirements of cows could increase by more than 1.5 maintenance. Increased feed requirements could be met by production and feeding of mixtures of grasses and legumes to increase digestibility and energy intake of cows to levels which would allow them to support both milk production, reproduction, and work with acceptable physiological body weight loss. Alternatively, feeding of natural pasture hays and improved quality crop residues associated with concentrate feeding or multipurpose tree foliage during early lactation and pregnancy could allow optimal performance of draught cows and make effective use of on-farm resources. Application of technologies for better use and conservation of natural sources of fodder during particular periods of the year needs particular attention.

Table 5. Performance parameters of draught crossbred cows under on-farm conditions.

Parameter	Working cows (n=14)	Non-working cows (n=14)
Milk Production (first Lactation, kg)	1,864	2,252
Milk Production (two years, kg)	2,620	2,980
Calving Interval (days)	525	495
Lactation Lengths (days)	376	410
Service per conception (No.)	2.1	1.9
Work days/Year	26	0

Anthropological Survey

An anthropological survey of farmers participating in the project and non-participating farmers suggests that, despite reservations, many farmers are willing to try cows for milk and draught work. Those who believe that cows can plough are younger and better educated, have slightly smaller households, and considerably smaller crop land, grazing land and herd size. More than a third of the farmers objecting to cow traction believe that there are pragmatic problems while less than a quarter believe there are cultural or technical problems. The most important technical problem mentioned by farmers relates to the cows' ability to plough and give milk simultaneously. Social reasons against cow traction relate to community pressure to stick to existing norms of behaviour, and the fear of acting in ways which do not conform. Cultural, moral and social reasons for not using cows for traction appear to be given when there actually are more important underlying reasons which can be overcome with sufficient farmer testing of the technology (Pankhurst, 1995).

While in the medium term the technical feasibility and the investment/cost ratio, as well as social factors, will affect the acceptance of cow traction technologies, in the long run, the diffusion of crossbred

cows will depend on the extension of the results of the study. The environment for dairy development, including government policies and services, especially credit, veterinary and breeding services, will also be critical.

Indicators for on-farm cow traction technology adoption could include: 1) farmers continuing to use cows for ploughing after the research project ends; 2) farmers who have received crossbred cows reducing the number of their local cattle; 3) farmers in the research area who were against cow traction changing their mind; and 4) new farmers spontaneously adopting cow traction technologies.

Economic Implications

The potential of the use of crossbred cows for milk production and traction was substantiated by simulating the production parameters and investment returns over a three-year period using the ILCA bio-economic herd model (Shapiro *et al.*, 1994). The effect over time of introducing crossbred dairy cows into a typical farm herd of local cattle for work and milk production were also simulated and compared to using the local cows for milk production and local oxen for traction. Then the financial implications were investigated using incremental benefit/cost analysis. The incremental benefit/cost ratio of having supplemented working cows over the traditional system of local cows and oxen is about 3.5 and the internal rate of return (IRR) is 78%. The incremental benefit/cost ratio is high because of the very high productivity of the crossbred cows (5-6 times milk yield) relative to local cows.

The value of work more than compensated for the small reduction in milk production and longer calving interval found in working cows when supplementation took place to ensure adequate nutrition. The greater returns on investment in supplemented, working crossbred cows was thus mainly a result of the higher value of the work output, in spite of the higher feed costs and lower off-take (milk and calves).

In conjunction with the technical factors, systematic consideration needs to be given to the effects at the micro-level of socio-economic factors, including institutional and structural factors. This research would also help policy makers to choose more effective policies and

programmes to develop and promote widespread diffusion of new technologies.

Conclusions

The results from this study indicate that draught work induced an increase in forage intake and digestibility. The attempt by working cows to increase intake to meet energy requirements even when fed relatively poor quality forage is important. Further experimentation needs to be conducted to identify and evaluate important traits in multipurpose cattle which could allow increased efficiency of resource utilisation. These traits could then be used in crossbreeding and selection programs to produce the most appropriate cattle type to optimise utilisation and equilibrium of on-farm resources. Genetic aspects of traits related to feed utilisation and work capacity should receive particular attention.

The successful introduction of crossbred cows for milk and traction not only requires new feed production, feeding and management systems on-farm, but also would induce substantial changes in present mixed farming system practices. Herd composition and requirements of farms are expected to substantially change, and result in a more efficient/higher productivity system (Shapiro et al., 1994). Therefore, there is a need to identify those technical and socio-economic factors which might affect such changes and hinder or promote these technologies.

As regards feeding multipurpose animals, much fundamental work still needs to be done to obtain a better understanding of the factors which affect the partition of nutrients between work, milk production and liveweight gain. In particular, their preference over oxen could contribute to a better utilisation of already scarce feed resources. Additional research should be done on the management and nutritional requirements of the lactating draught cow and possible ways to meet its nutrient needs, especially in early lactation when the high energy demand for lactation is associated with work energy needs. Research and extension must therefore determine ways of producing adequate feed on the farm for draught animals and to evaluate locally available sources of supplements. Multidisciplinary research projects should investigate the technical and economical relationships between alternative combinations of

animals, implements and soil in diverse regions. A system-analysis-approach-based model should be developed to describe the systems.

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