The potential of cow traction in the East African highlands

by

E Zerbini [1], Alemu Gebre Wold [2] and B I Shapiro [1]

1) International Livestock Research Institute (ILRI), PO Box 5689, Addis Ababa, Ethiopia
2) Institute of Agricultural Research (IAR), PO Box 2003, Addis Ababa, Ethiopia

Abstract

To test the feasibility of the use of dairy cows for draft the International Livestock Research Institute (ILRI) and the Insititute of Agricultural Research (IAR) in Ethiopia have studied a herd of F1 Friesien x Boran crossbred cows on-station over three years together with on-farm experiments and economic analyses.

The total number of days in milk of working cows was similar to that of non-working cows. However, days in milk of working supplemented cows were 14 to 39% greater than non-working or working non-supplemented cows over two years. Milk yield of non-supplemented cows, whether working or not, was approximately half that of supplemented cows. Even though, over a period of two years, milk production of working cows was not significantly different from that of non-working cows, working non-supplemented cows had the lowest milk yield among all groups. This indicates that work with inadequate feeding would not be a feasible option for a production system involving the use of lactating cows for draft. On the other hand, total milk production of working supplemented cows over three years was only 10% lower than that of non-working supplemented cows.

There was a dramatic decrease in percentage of cows showing oestrus and in conception rate when work was applied to non-supplemented cows. Once pregnancy was established there was no effect of work on maintenance of pregnancy.

Over a period of two years the productivity index of supplemented cows was greater than that of non-supplemented cows (0.38 and 0.24, respectively), but it was similar between working and non-working cows (0.35 and 0.33, respectively). Work output more than compensated for the small decline in milk production and number of calvings and greater daily metabolic intake of working supplemented compared to non-working supplemented cows. 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 incremental internal rate of return is 78%.

Introduction

Due to increasing population and livestock pressure on the land, farmers in many developing countries may not be able to continue maintaining draft oxen for work purposes. The use of dairy cows for traction could benefit total farm output and incomes through increased milk production, while alleviating the need to feed draft oxen year-round and to maintain a follower herd to supply replacement oxen (Gryseels and Goe, 1984; Gryseels and Anderson, 1985; Matthewman, 1987; Barton, 1991). Besides contributing to a better utilisation of scarce feed resources, the use of dairy cows for draft would allow males to be fattened and sold younger, and could also lead to greater security of replacements. More productive animals on farm could result in a reduction of stocking rates and overgrazing, thus contributing to the establishment of a more productive and sustainable farming system.

The primary need of the working animal is to increase feed and metabolic energy intakes to meet energy requirements for work and avoid deleterious body weight losses. This becomes more critical in working cows requiring extra energy for lactation and reproduction, and where the main feed source is roughage.

A number of studies have reported no significant effect of work on feed intake in oxen (eg Soller, Reed and Butterworth, 1991; Pearson and Lawrence, 1992) and buffalo cows (Bamualim, Ffoulkes and Fletcher, 1987; Bakrie and Teleni, 1991). Other studies indicate an increased feed intake in working buffalo cows (Ffoulkes, 1986; Ffoulkes, Bamualim and Panggabean, 1987) and dairy cows (Gemeda et al, 1994). Furthermore, some authors have reported negative or no effect of work on digestion in buffalo and cattle, depending on the diet fed (Bamualim, Ffoulkes and Fletcher, 1987; Pearson, 1990; Soller et al, 1991; Pearson and Lawrence, 1992), while others

This paper is published in: Starkey P and Kaumbutho P (eds), 1999. *Meeting the challenges of animal traction.* A resource book of the Animal Traction Network for Eastern and Southern Africa (ATNESA), Harare, Zimbabwe. Intermediate Technology Publications, London. 326p.

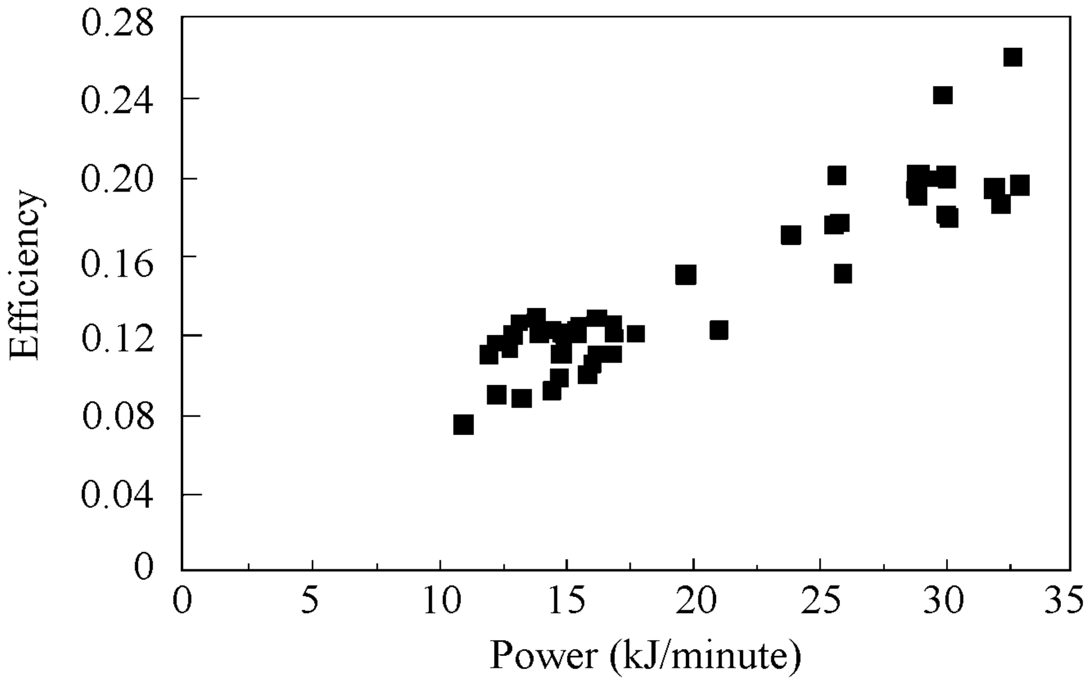

Figure 1: Work efficiency of the F1 Friesian x Boran cows used for draft

have shown a positive effect of work on digestibility (Ffoulkes, Bamualim and Panggabean, 1987; Pearson and Lawrence, 1992). 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.

Production performance of cows is an important factor which determines whether cows are adopted for draft power. Working cows could perform at higher levels of efficiency than oxen, but only if nutrient inputs are adequate to meet their greater requirements and milk production and reproduction are kept at levels comparable to non-working cows (Mathers et al, 1985; Matthewman, Djikman and Zerbini, 1994). Energy deficits during the working season could result in body weight and body condition losses, thus affecting the production and reproduction efficiency of cows (Teleni and Hogan, 1989; Teleni et al, 1989; Zerbini et al, 1993a).

ILRI and IAR have researched different aspects of the use of dairy cows for draft work. This paper deals with work output, milk production and reproduction of crossbred dairy cows used for draft. Information generated from ILRI and IAR research is used to elaborate the interplay of factors affecting work output, milk production, metabolism, physiological responses and the reproductive physiology and performance of dairy cows used for draft. The economic implications and the potential for adoption are also discussed. Highlights of an expert consultation on the transfer of technology for multipurpose cows in smallholder mixed farming systems organised by ILRI, FAO and ACIAR (Australian Centre for International Agricultural Research) in September 1995 in Addis Ababa are also reported.

Work output and efficiency of draft cows

Determination of the optimum work load that dairy cows can undertake is an essential component for successful adoption of cow traction technologies into smallholder mixed farming systems. Results of our investigation with crossbred cows in the Ethiopian Highlands (Zerbini et al, 1992) showed that dairy cows were able to work at a rate of about 500 W. This work rate, at a speed of 0.75 m/s, implies that the

Table 1: Cummulative work output (MJ) of the F1 crossbred cows used for draft over a period of two years

		Days	
Treatment	***n***	***0-365***	***0-730***
WNS	10	260	500
WS	10	270	508
se		6	12
F test		NS	NS

WNS - Working non-supplemented
WS - Working supplemented

sustainable horizontal draft force was roughly 670 N. This represented about 14% of mean body weight, in line with what would be expected (eg Barwell and Ayre, 1982). The work efficiency of cows increased from about 7% to 26% as the workload increased to its maximum (Figure 1). Cardio-respiratory measurements indicated that during work each additional heart beat transported approximately 72 ml of oxygen which is in turn equivalent to 1 kJ of additional mechanical work output (Zerbini et al, 1992). Over a period of two years, net work output of dairy cows averaged more than 200 MJ per cow per year, which was equivalent to or above that required by farmers for land cultivation (Table 1).

Lactation and reproduction performance

Dry matter intake

Dry matter intake was greater for working compared to non-working cows over a period of two years (Table 2). Working non-supplemented

Table 2: Average dry matter intake ($g/kg^{0.75}$) of the F1 crossbred cows over two years

	Days	
Treatment	***0-365***	***0-730***
NWNS	89	94
NWS	108	105
WNS	97	111
WS	121	117
se	4	4
Ftest		
Work	*	**
Supplement	**	***

NWNS - Non-working, non-supplemented
NWS - Non-working, supplemented
WNS - Working, non-supplemented
WS - Working, supplemented

cows increased roughage intake above that of non-working non-supplemented cows by 19% over two years. Similarly, working supplemented cows increased hay intake above that of non-working supplemented cows by 11%. Over a period of two years, dry matter intake of working cows increased by 15% compared to non working cows. Chemical composition of diet components is presented in Table 3.

Increased dry matter intake of working over non-working cows was also reported by Ffoulkes, Bamualim and Panggabean (1987) and is supported by findings of Zerbini et al (1994) who

Table 3: Mean chemical composition (g/kg) of diet components (n=14)

	Normal pasture hay	*Concentrate*
Dry matter	904	915
Organic matter	911	867
Nitrogen	9	45
Neutral-detergent fibre	696	364
Acid-detergent fibre	420	234

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Table 4: Cumulative days in milk of the F1 crossbred cows over a period of two years

	Days	
Treatment	***0-365***	***0-730***
NWNS	291	501
NWS	302	579
WNS	280	476
WS	355	662
se	22	37
Ftest		
Work	NS	NS
Supplement	*	*

NWNS - Non-working, non-supplemented
NWS - Non-working, supplemented
WNS - Working, non-supplemented
WS - Working, supplemented

Table 5: Cumulative milk yield (kg) of the F1 crossbred cows over a period of two years

	Days	
Treatment	***0-365***	***0-730***
NWNS	849	1226
NWS	1792	3186
WNS	802	927
WS	1770	3044
se	152	219
Ftest		
Work	NS	NS
Supplement	***	***

NWNS - Non-working, non-supplemented
NWS - Non-working, supplemented
WNS - Working, non-supplemented
WS - Working, supplemented

reported that work increases the utilisation of feed energy. 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, Zerbini et al (1994) indicated that if such a situation exists for as long as one year, cows could loose more than 15% of their calving body weight and reduce milk production by more than 50% compared to working supplemented cows.

Days in milk, milk yield and completed lactations

The total number of days in milk of working cows was similar to that of non-working cows (Table 4). However, days in milk of working supplemented cows were 14 to 39% greater than the other treatment groups over two years, respectively. Days in milk were greater for supplemented compared to non-supplemented cows (Table 5). Milk yield of non-supplemented cows, whether working or not, was approximately half that of supplemented cows. In addition, in year two, milk production of non-supplemented cows was only 30% that of year one, while in supplemented cows it was still 75% of that in year one.

In another study, Matthewman (1989) reported that cows using approximately 12 MJ metabolic energy per day for walking, reduced milk

Table 6: Number of completed lactations by the F1 crossbred cows

		Days	
Treatment	***n***	***0-365***	***0-730***
NWNS	10	6	13
NWS	10	7	16
WNS	10	6	11
WS	10	3	11
All	40	22	51

NWNS - Non-working, non-supplemented
NWS - Non-working, supplemented
WNS - Working, non-supplemented
WS - Working, supplemented

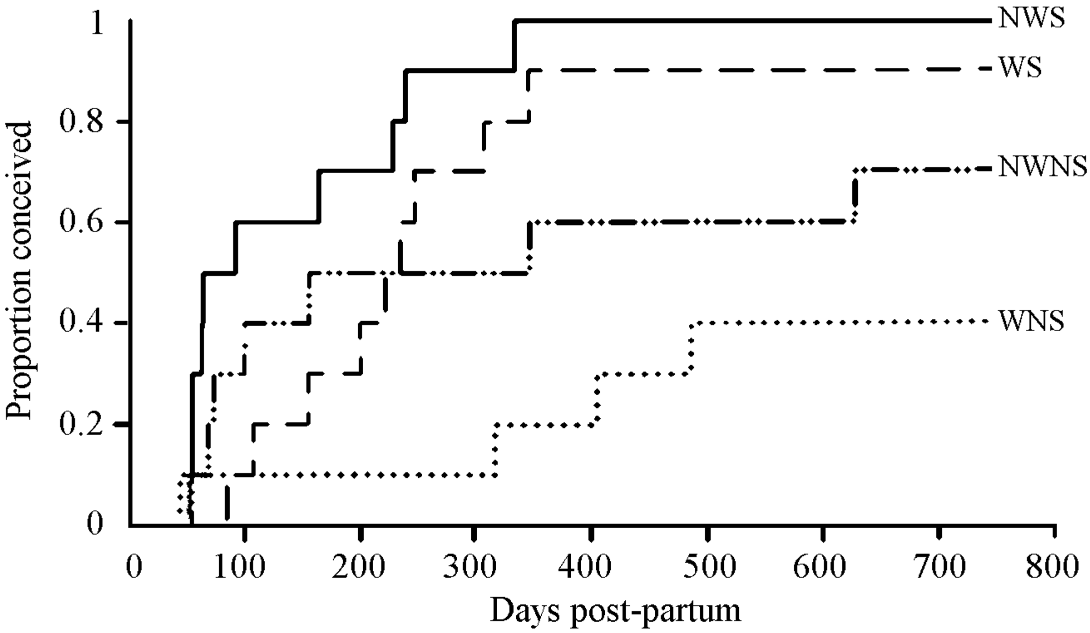

Figure 2: Distribution function of interval to conception after calving of the F1 crossbred cows. NWS - Non-working supplemented; WS - Working supplemented; NWNS - non-working non-supplemented; WNS - Working non-supplemented Source: adapted from Zerbini et al, 1993a

production between 7 and 14% depending on diet fed. Also, Barton (1991) reported lower milk production and reproduction in draft cows in Bangladesh. On the other hand, on-farm trials in the Ethiopian Highlands, indicated that the effect of work on lactation of crossbred cows used for draft was minimal when feed supply was adequate and work requirements were modest (Gryseels and Anderson, 1985; Agyemang et al, 1991a).

In our study, over a period of two and three years, lactations completed by working supplemented cows in two years were 31 and 25% lower than those of non-working supplemented cows, consistent with greater days in milk of working supplemented cows (Table 6).

Even though, over a period of two years, milk production of working cows was not significantly different from that of non-working cows, working non-supplemented cows had the lowest milk yield among all groups. This indicates that work with inadequate feeding would not be a feasible option for a production system involving the use of lactating cows for draft. On the other hand, total milk production of working supplemented cows over three years was only 10% lower than that of non-working supplemented cows. Differences could be attributed mainly to the lower number of parturitions and lactations completed among cows in this group.

Resumption of postpartum oestrus and conception

Bamualim, Ffoulkes and Fletcher (1987) indicated that in buffalo cows, work might reduce reproductive performance. On the other hand, the study by Winsugroho and Situmorang (1989) suggested that work, *per se*, was not a major factor influencing ovarian activity if energy reserves were adequate. Feed supplementation of thin working buffaloes induced a return to normal ovarian activity. Reh and Host (1985) reported that fertility was 6 to 7% lower in working than in non-working cows. However, research conducted in India, with working and non-working Red-Sindhi cows, over two lactations, showed no significant differences in milk production and length of lactation (Reh and Host, 1985). Agyemang et al (1991a) reported that the reproductive and productive performances of draft

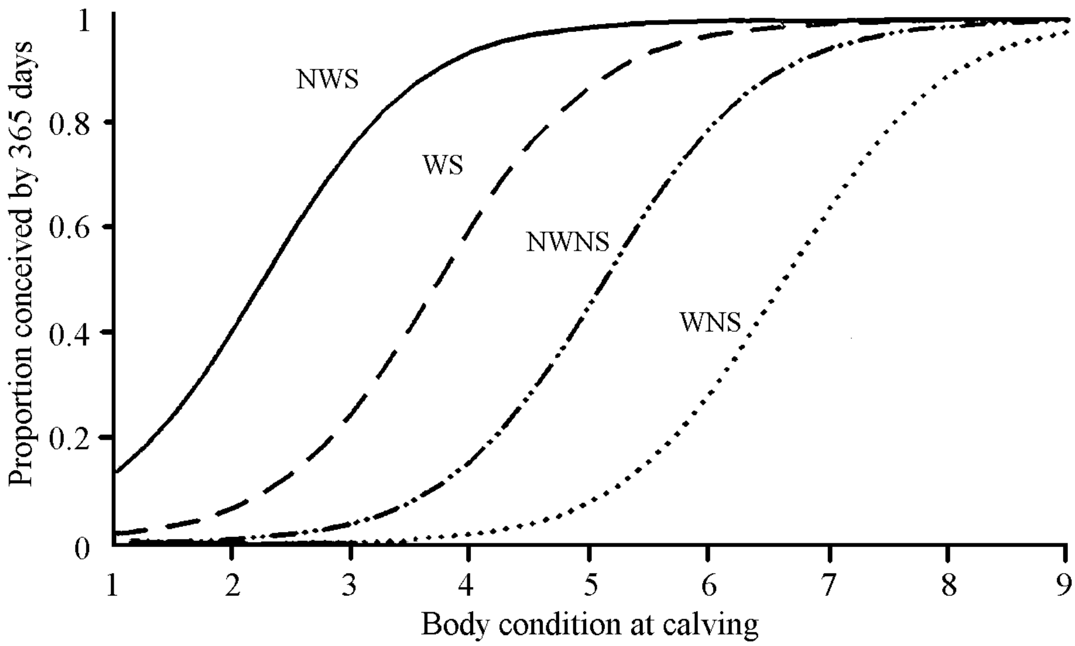

Figure 3: Predicted conception rate at 365 days vs initial body condition of the F1 crossbred cows. NWS - Non-working supplemented; WS - Working supplemented; NWNS - non-working non-supplemented; WNS - Working non-supplemented. Source: adapted from Zerbini et al, 1993a

and non-draft cows were similar. However, the work done was lower than the amount required by a smallholder farmer.

Zerbini et al (1993a) reported that diet supplementation significantly decreased days to first oestrus and days to conception in non-working and working cows. When work treatment was superimposed on non-supplemented treatment, the effect on reproduction was deleterious. Differences in the first 200 days post-partum, in onset of oestrus and conception between treatment groups, seem to be related to work in the first post-partum period. However, if a 365-day period was considered, the differences are related to a greater extent to diet supplementation , suggesting a longer term effect of the supplementation than work (Figure 2). In supplemented cows, work significantly delayed days to conception. However, by 365 days post-partum, conception rate was similar for supplemented non working and supplemented working cows. For occurrence of first oestrus, the diet effect was considerably larger than the work effect (a probability factor of five versus a probability factor of two). This was less pronounced for conception. This is contrary to results from other studies (Wells, Hopley and Holness, 1981) which indicated that supplementary feeding did not influence interval from calving to first ovulation, conception rate or interval from calving to conception. Body condition at calving significantly affected postpartum reproductive ability of non-working and working cows (Figure 3). This indicates that cows with greater body reserves at calving, and the ability to use these reserves during the post-partum period, can partly overcome the negative effect of dietary energy restrictions on oestrus onset and conception (Zerbini et al, 1993a).

The results of this study indicate a dramatic decrease in percentage of cows showing oestrus and in conception rate when work was applied to non-supplemented cows.

Postpartum anoestrous interval was extended in a larger proportion of working than in non-working cows. Work did not influence conception rate in supplemented cows, but had a substantial influence in non-supplemented cows. The significant delay

Table 7: Number of completed conceptions by the F1 crossbred cows

		Days	
Treatment	***n***	***0-365***	***0-730***
NWNS	10	6	8
NWS	10	10	17
WNS	10	2	4
WS	10	9	12
All	40	27	41

NWNS - Non-working, non-supplemented
NWS - Non-working, supplemented
WNS - Working, non-supplemented
WS - Working, supplemented

Table 8: Cumulative body weight changes (kg) of the F1 crossbred cows

	Days	
Treatment	***0-365***	***0-730***
NWNS	-60	-76
NWS	21	-10
WNS	-62	-86
WS	32	-23
se	13	10
Ftest		
Work	NS	NS
Supplement	***	***

NWNS - Non-working, non-supplemented
NWS - Non-working, supplemented
WNS - Working, non-supplemented
WS - Working, supplemented

of conception for supplemented working cows compared to supplemented non-working cows indicated that work output of cows might be associated with longer calving intervals and the economic trade-offs between the two factors should be examined in detail. Once pregnancy was established there was no effect of work on maintenance of pregnancy. A greater proportion of supplemented working cows cycled between 120 days and one year postpartum indicating that work applied soon after calving delayed, but did not suppress, oestrus and conception in subsequent resting or working periods (Zerbini et al 1993a, 1993b).

Table 9: Average condition scores of the F1 crossbred cows. Scoring was based on the ILCA system that uses values of 1–9, with higher numbers indicating better condition

	Days	
Treatment	***0-365***	***0-730***
NWNS	3.1	2.7
NWS	5.9	5.4
WNS	2.7	2.7
WS	5.8	4.9
se	0.3	0.3
Ftest		
Work	NS	NS
Supplement	***	***

NWNS - Non-working, non-supplemented
NWS - Non-working, supplemented
WNS - Working, non-supplemented
WS - Working, supplemented

Conceptions over multiple lactations

Gemeda et al (1994) found that the number of working supplemented cows which conceived in year one was similar to that of non-working supplemented cows. However, over a period of two and three years, the number of working supplemented cows which conceived was 29 and 20% lower than those of non-working supplemented cows. In addition, over a period of one year, number of conceptions of non-supplemented cows could be reduced by 78% compared to those of adequately fed cows (Table 7).

Body weight losses have been reported to impair ovarian activity in female buffaloes and cows (Teleni et al, 1989; Agyemang et al, 1991b).

Further, over a period of two years, supplementary feeding reduced body weight loss of cows by 80% and was associated with a 59 and 63% increase in the number of conceptions and parturitions, respectively, compared to a non-supplemented diet (Table 8). In particular, supplementation of working cows reduced liveweight loss by 73% and doubled the number of conceptions and parturitions compared to working non-supplemented cows (Gemeda et al 1994). Body condition score followed a similar pattern to that of body weight change over the two-year period (Table 9). The probability of conception was not greater than 20% in cows with a body condition score lower than three (range 1–9) and with body weight losses greater than 15% from calving body weight (average of 412 kg).

In year one the number of calves born from working supplemented cows was 80% lower than that from non-working supplemented cows, despite the fact that the number of working supplemented cows which conceived was similar to that of non-working supplemented cows. This is consistent with the delay in conception after parturition reported for working-supplemented compared to non-working supplemented cows by Zerbini et al (1993a). Relatively fewer lactations and parturitions, and greater days in milk of working supplemented cows, over a period of three years, reflects the delayed conception in working supplemented compared to non-working supplemented cows. This is due to both a direct effect of work *per se* and to a deficit of energy yielding substrates, particularly during the working/lactating periods. Over a period of three years, diet was the main factor which affected reproduction of dairy cows used for draft work (Zerbini et al, 1994).

Recovery after work: long term effects

Even after extended periods of underfeeding, acyclic and anoestrus cows resumed ovarian cyclic activity in an average of 46 days and conceived in 75 days when fed about twice their maintenance energy requirements (Zerbini et al, 1994). 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 feed resources availability.

Table 10: Average productivity index of the F1 crossbred cows over the two-year period

Treatment	*Productivity index*
NWNS	0.23
NWS	0.37
WNS	0.25
WS	0.39
se	0.03
Ftest	
Work	NS
Supplement	***

NWNS - Non-working, non-supplemented
NWS - Non-working, supplemented
WNS - Working, non-supplemented
WS - Working, supplemented

Productivity index (output/input)

Over a period of two years the productivity index of supplemented cows was greater than that of non-supplemented cows (0.38 and 0.24, respectively), but it was similar between working and non-working cows (0.35 and 0.33, respectively). While the productivity index of non-working supplemented and working supplemented cows remained relatively constant over three years, productivity index of non-working non-supplemented and working non-supplemented decreased by 21 and 34%, respectively (Table 10). This resulted mainly from reductions in milk yields and reproduction performance in non-supplemented cows.

The productivity index was used to describe the overall productivity of cows in each treatment group. Similar values of the productivity index for non-working supplemented and working supplemented cows over the total three-year period indicates that work output more than compensated for the small decline in milk production and number of calvings and greater daily metabolic intake of working supplemented compared to non-working supplemented cows. For on-farm situations working supplemented cows would

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Table 11: On-farm values of lactation and reproductive parameters of crossbred cows worked an average of 26 days per year

	First lactation			
Status	***Milk (kg)***	***Days***	***First 2 years' milk (kg)***	***Calving interval (days)***
No work	2252	410	2980	495
Work	1864	376	2620	525

provide the additional advantage of alleviating the need to maintain draft oxen year-round, could reduce stocking rates, and therefore could result in the allocation of more on-farm energy towards milk and meat production while maintaining draft power.

On-farm testing of cow traction in the Ethiopian highlands

The on-farm testing of cow traction technologies is designed to evaluate the effect of draft work and improved management on production and economic performance of crossbred dairy cows at the level of the smallholder farm. Pairs of crossbred cows (140 Friesien x Boran F_1) were purchased by selected farmers in 1993 and 1995 in the Holetta area. To ensure that even the poorest farmes can take advantage of these technologies, stratification of participating farmers into low, middle, and high income groups was carried out based on land and livestock holdings, livestock type, labour availability, total farm assets and location. Production and economic data of years 1993 and 1994 are presently being analysed and a whole-farm model based on the two years' data is being constructed.

During the first two years, milk production of working and non-working F1 crossbred cows on-farm was similar (2620 vs 2980 kg), ranging from 2010 to 3400 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 1864 and 2252 and 376 and 410 days, respectively. Average service per conception for working and non-working cows was 2.1 and 1.9, respectively. Over a period of two years cows worked an average of 26 days/year. These data are summarised in Table 11.

Economic implications and potential for adoption

Before going on-farm, the economic potential of the use of crossbred cows for milk production, meat, and traction was substantiated with the ILRI bio-economic herd model. Using the on-station results from three years, the production parameters and investment returns were simulated over a ten-year period (Shapiro, Zerbini and Geneda, 1994). The Incremental Internal Rate of Return (IIRR) of supplemented working cows over supplemented non-working cows was about 125%. This IIRR is very high because the incremental investment cost is very low while the benefits of work are large.

The simulation results show 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. The greater returns to investment in supplemented working crossbred cows were thus mainly a result of the higher value of the work output, in spite of the higher feed costs and lower offtake (milk, calves).

The effect over time of introducing crossbred dairy cows into a typical farm to replace the herd of local cattle for work and milk production were also simulated and compared to the traditional system of using the local cows for milk production and local oxen for traction. Again, 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 was about 3.5 and the IIRR 78%. The incremental benefit/cost ratio is high because of the very high productivity of the crossbred cows (5–7 times higher milk yield) relative to local cows.

Ethiopians are known as 'the people of the plow' because the rural culture has, for many centuries, been tied strongly to the use of oxen for draft work. Cultural attitudes could therefore also be obstacles to the adoption of crossbred cows for traction. Systematic, periodic anthropological surveys have been carried out to assess the evolution of attitudes of farmers participating in the on-farm trials, as well as neighbouring farmers who should be affected by the demonstration effect of having the on-farm trials being carried out in the vicinity of their farms. The first round of survey results showed that only 20% of those interviewed (on-farm trial participants, as well as non-participating neighbours) were unwilling to even consider using crossbred cows for traction. The other 80% said they would try using cows for traction and if it proved feasible they would use them regularly.

One conclusion of this first in-depth anthropological survey was that, in conjunction with the technical factors, careful study in the early part of the on-farm testing and adoption efforts needs to be made of the effects at the micro-level of socio-economic factors. Besides profitability, resource endowment has to be considered since it could hinder adoption by the poorer segments of the population, and access to supportive programmes such as credit and insurance could make a big impact on adoption. Such research would help policy makers to choose more effective policies and support programmes to promote widespread diffusion of new technologies.

The anthropological survey also concluded that 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 effective 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.

Expert consultation

In sub-Saharan Africa, the greatest impact of using crossbred cows for milk and traction is expected in high potential highlands regions (ie Ethiopia, Kenya and the Great Lakes Region – Uganda, Malawi, Tanzania, Rwanda, Burundi). The highlands have the highest population densities, market accessibility, and stocking rates found in sub-Saharan Africa. Disease pressure is relatively low and low wages and small farm sizes make it unattractive to substitute tractors for animal traction. Now that the crossbred cow technologies have proven to have considerable potential both on-station and on-farm under Ethiopian Highland conditions, it was decided to start the process of adaptive research and on-farm testing in other East and Southern African countries with conducive agroecological and market conditions. An expert consultation on the transfer of technology for multipurpose cows including feed technologies for milk, meat and traction in smallholder mixed farming systems was therefore organised by ILRI, FAO and ACIAR in Addis Ababa in September 1995.

There is a clear need to devise better methods of ensuring the transfer and hence impact of promising new technologies. Technologies developed by international agricultural research centres need to be field-tested and adapted by national-level centres and then diffused by national extension organisations, as well as by NGOs. According to a recently completed ISNAR study of technology transfer a critical requirement for success is establishing better coordination of technology transfer efforts and formal linkage mechanisms involving international and national research centres and extension organisations. This process could be assisted and facilitated greatly by the support of international organisations such as FAO.

The expert consultation took the form of a workshop with participants drawn from East African research and extension institutions that have indicated a strong interest in the technology. Traction experts also came from Asia to share their considerable experience with cow traction technologies and discuss the possibility of extending the project to appropriate Asian countries. One objective of the workshop was to develop a means of coordination, as well as

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linkage and transfer mechanisms to ensure the transfer of the cow-traction technologies. Setting up institutional arrangements with development organisations such as FAO, could help to ensure successful technology transfer.

The principal objective of the workshop was, however, to develop a funding proposal to implement and study the transfer of the IAR/ILCA multipurpose crossbred cow technologies to East African smallholders. The proposal included a formal means of coordination as well as linkage and transfer mechanisms needed to ensure the transfer of the technologies.

The secondary purpose of the workshop was to learn from the experiences of experts from countries in Asia where female buffalo and cow traction already exists and to discuss the possibility of extending the project to Asia, if additional funding can be found. The consultation also benefitted greatly from participation of the ACIAR Draught Animal Power (DAP) project. This project included "multidisciplinary studies of draft animal power systems in Southeast Asia and feeding and management strategies for production and draft power in large ruminants."

Some initial efforts of information sharing between Asian and ILCA traction experts began during the DAP project, but these efforts were not continued, or formalised into institutionalised relations, and did not result in joint projects. The occasion of the expert consultation was then used to set up mechanisms for information exchange and collaboration between scientists and development organisations involved in research and transfer of multipurpose cattle and buffalo technologies in East Africa and Asia. This process represents a further development of DAP collaborative programs initiated by ACIAR and centres of the CGIAR system.

FAO played a principal role in the expert consultation and will play the lead role in the regional technology transfer project. Along with other international development agencies, FAO addresses livestock development across a broad spectrum. It provides technical advice and assistance to the agricultural community, to governments and funding agencies. It collects, analyses, and disseminates information as well as advises governments on policy and planning and provides opportunities for government to meet and collectively discuss food and agricultural problems. Partnerships of this kind can provide essential critical mass, as well as state-of-the-art science, technology, and knowledge for the benefit of national research institutes.

The purpose of the proposed regional FAO/ILRI project is to promote proven IARC-developed technologies which are ready for diffusion to other countries. Included in the project will be national agricultural research centres and extension experts from countries in the region (more or less the same eco-region) where conditions conducive to the adoption of the technologies prevail. Each country project will be carried out with technical assistance from FAO experts, and with the ILRI scientists who developed the technologies acting as resource persons. An important innovation of these projects is the role of information sharing between regions. Although the projects are initially to be carried out in Eastern and Southern Africa, the possibilities of extending the project to Asia will be considered.

Conclusions

The results from this study indicate that draft work induced an increase in forage intake and digestibility in cows without decreasing solid phase transit time in the gut. Greater intake and digestibility could be related to increased retention time of the liquid phase and perhaps to increased gut volume. The attempt by working cows to increase intake to meet energy requirements even when fed relatively poor quality forage is important.

Over a period of three years, diet was the main factor which affected body weight and condition score, days in milk and milk production of crossbred cows, whether or not they were used for work. On the other hand, supplementation did not affect work output of cows. Work performed by supplemented cows had no adverse effects on lactation and reproduction. A similar productivity index for working and non-working supplemented cows over a period of three years indicates the potential of this technology to increase farm productivity and result in more efficient use of on-farm resources.

With appropriate feeding regimes dairy cows could be used for draft purposes without any detrimental effects on fertility, but calving intervals would be extended. Work, *per se,* does not influence postpartum ovarian activity when the energy reserve is adequate, but work does delay the interval from calving to conception in dairy cows.

Work increased the incidence of ovulations without oestrus and short luteal phases. However, these events did not influence pregnancy in subsequent normal oestrus periods.

Economic analysis based on on-station data showed that the greater returns to investment in supplemented working dairy cows compared to non-working cows or to the traditional system were mainly the result of the higher value of the work output, in spite of the higher feed costs and relatively lower offtake of milk and calves.

The results of the on-farm trials now being carried out are substantiating the potential of the cow-traction technologies to result in a more productive, more sustainable system than farmers' current practices. These results need to be carefully analysed within the whole farm context to ensure the fit of the cow-traction technologies into the farming systems, and to make sure that the technologies match farmer objectives and do not result in unsurmountable resource constraints.

There is a clear need to devise better methods of transferring promising new technologies to ensure impact. Technologies developed by international agricultural research centres and their national research colleagues need to be field-tested and adapted by other national research centres and then diffused by national extension organisations, as well as by NGOs. According to a recently completed ISNAR study of technology transfer, a critical requirement for successful transfer is establishing better coordination of technology transfer efforts and more formal linkage mechanisms involving international and national research centres, and extension organisations.

The technology transfer process could be greatly facilitated by the support of international organisations such as FAO. Substantial benefit could be derived from identifying proven technologies and encouraging adaptive testing and extension mechanisms and processes. Impact results would be improved, as well, if the process included an integrated study of the transfer process to provide feedback to the extension services and guidance for future technology transfer projects. The proposed FAO/ILRI regional project aims at achieving these objectives.

In terms of understanding the production characteristics of working cows, there is a need to quantify the energy partition to different functions by working, lactating and breeding cows. The nutrient demand of the multipurpose cow is complex and the success of a nutritional management strategy will depend largely on the level of feed intake and, over short periods, on the level of body reserves (Egan and Dixon, 1993). The mechanism by which body reserves contribute to the energy expenditure of working cows is not clear. Future research priorities should include defining minimal nutrient requirements for pregnant and/or lactating working animals to allow for optimal reproductive performance.

To optimise the postpartum anoestrus period, draft dairy cows must regain weight during lactation and farmers must have management skills to integrate strategically physiological events such as pregnancy and lactation with draft work requirements.

On-farm comparison of working supplemented crossbred dairy cows used for draft with the traditional system is now underway.

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