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☆ The ‘Research and Development Projects’ section has been well subscribed this year. Please continue to send in news of your project and any findings you think will be useful to others. This section does reflect the whole range of activities that are happening in projects concerning the use of animal power. A reminder, the articles are not peer reviewed, so sending in a report of the work does not prevent you publishing a more scientific article elsewhere.

☆ Because of a shortage of space in this issue the ‘Recent Publications’ section has been held over to DAN 41.

☆ Draught Animal News accepts articles in Spanish and French, as well as in English. If you submit an article in Spanish or French we would also like a short summary in English to accompany it. For those sending in articles, notes and news we prefer you to send us your input (especially if it is a longer article), on a 3” disk (using Microsoft Word, Word perfect or rich Text Format) or via email. If you wish to include photographs, please ensure these are original and of good quality because of losses in the reproduction process. High-resolution photographs saved in .tif format are preferable (using Wipzip to compress the file if necessary). We always acknowledge the person taking the photograph so please give us the name. For those without access to a computer, contributions are especially welcome, hand-written or typed.

☆ We are always pleased to hear of any meetings, forthcoming events, new books and useful websites that can be advertised in the newsletter. Letters from draught animal owners, users or those people wanting information on a particular topic or problem are always welcome. Please send in articles and news to the editor, Dr R.A Pearson, Editor, Draught Animal News, Centre for Tropical Veterinary Medicine, Easter Bush Veterinary Centre, Roslin Midlothian, EH25 9RG, Scotland, UK (fax +44(0)131 651 3903; email: anne.pearson@ed.ac.uk).

☆ The drawing on the front cover by Archie Hunter is taken from a photograph of a boy in the Indian brickkilns near Delhi, looking after his donkey, taken by Anne Pearson.

☆ This publication is currently funded by the UK Department for International Development (DFID) for the benefit of developing countries. The views expressed in it are not necessarily those of DFID.

CONTENTS

RESEARCH AND DEVELOPMENT PROJECTS

1. AFRICA

(a) Tanzania

The adoption and use of animal traction by the agropastoral Maasai and Arusha people in Northeastern Tanzania

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Introduction

The Maasai people of Tanzania and Kenya are most often viewed as pastoralists who do not grow crops or use animal traction (Starkey and Mutagubya, 1992). However, numerous researchers have discussed the use of draught animals by pastoralists, and a few have reported on the use of oxen by the Maasai people specifically (Pingali *et al.*,1987, Ndagala, 1992, Spear, 1993 and 1997, Meindertsma and Kessler, 1997). This mention of their use of oxen inspired this study of the Maasai agricultural system and animal traction use in Northern Tanzania.

This research showed that the Maasai in the Kilimanjaro and Arusha regions of Tanzania were the masters of animal traction. Their handling of oxen was exemplary (Plate 1). Their interpretation was that they understood cattle more than other ethnic groups. To some degree this could be correct, but it was more likely a function of the early handling of cattle, who as calves often live inside the Maasai homes. (Sperling and Galaty, 1990, Conroy, 1999).

Cattle were and will continue to be a major resource for the Maasai, who use cattle as a source of capital, regular income, equity, insurance, and prestige (Rigby, 1992, Spear, 1997). However, this study showed that not only have the Maasai people adopted the use of oxen and donkeys as draught animals, they have done so with amazing skill and success (Conroy, 2001). Throughout their territory Maasai people have been adopting a more sedentary lifestyle, as they have been under a great deal of pressure to integrate themselves into the agricultural economy, both as a way to increase their income and protect their land resource.

Maasai men continue to adhere to the principle of disliking the use of a hand held hoe. However, oxen were considered an intermediary, which allowed men to cultivate the land, without actually hoeing it themselves. This cultural change was the basis for studying the sustainability of the Maasai adoption of animal traction and crop growing. Politics, land tenure, economics, population growth, weather, geography, and culture,

Plate 1 Maasai oxen working in NE Tanzania (A. Conroy)

all had an influence on the adoption and use of animal power and the sustainability of the agricultural system. However, for this article, I will focus exclusively on the animal traction component of the study.

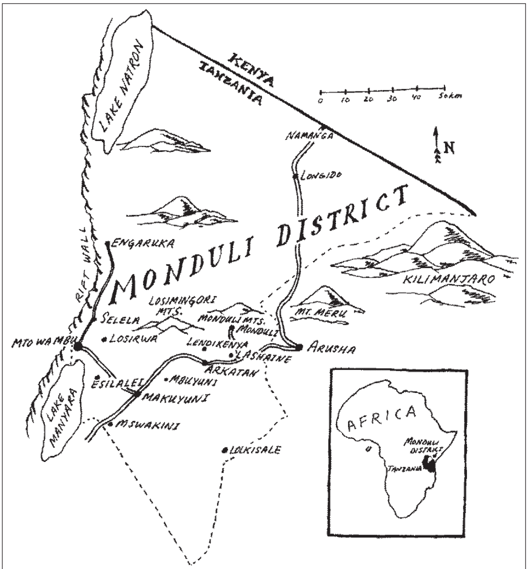

Figure 1: The research area

Research area and methods

This work was a case study of the Maasai and Arusha people of the Southern part of the Monduli district, traditionally known among the Maasai as *'Kisongo'* . They are two related, but self identified different ethnic groups in Tanzania. Both groups speak 'Maa', but the Arusha have long resided on the hillsides of Mt. Meru, Tanzania's second largest mountain, where they were often considered the agricultural Maasai (Spear, 1997). In fact, they are often called Maasai because of their inclination toward wearing similar clothing, but the differences are clear to any Maasai or Arusha person.

Our intention was to document, at one time, the people, their agriculture, their use and adoption of oxen, and the environmental impact of their adoption of crop growing in an area that may be largely ill suited to such endeavours. The agropastoral Maasai and Arusha people were interviewed in ten major villages, including Arkatan, Engaruka, Esilalei, Lashaine, Lendikenya, Lolkisale, Losirwa, and Mbuyuni, Mswakini, and Selela, as well as numerous related subvillages. (Figure 1) using Rapid Rural Appraisal (RRA) techniques (Upton, 1986, Lindberg 1996) in 1996, 1998 and 1999. 130 *bomas, enkangs* or homesteads were selected for interviews. There we met with 395 agropastoral Maasai and Arusha men of each communal homestead, with roughly half of the sample coming from each group. A semi-structured interview, as well as village transects, agricultural crop, draught animal and livestock evaluations were conducted.

Results and discussion

The transfer of animal traction

In areas of widespread animal traction, including the Monduli District, the use of formal extension services appears to have had a minimal effect on the transfer of draught animal technology (Sosovele, 1994, Starkey *et al.*, 1994). Among the Maasai in Monduli District, the adoption of oxen was done with primarily an informal transfer of the technology. The Arusha have been familiar with oxen since the earliest white settlers arrived in Arusha. They quickly adopted the technology and used it on their own small farms (Kjaerby, 1986, Spear, 1997). As land became scarce near Mt. Meru, many of the Arusha moved off the mountain and onto the nearby Kisongo Plains and Monduli Highlands, taking with them their oxen (Spear and Nurse, 1992, Spear, 1997). The Arusha's use of oxen was undoubtedly observed by the Maasai. Early on they might have looked disapprovingly at this use of cattle, as they had "*strict prohibitions against cultivation*" (Jacobs 1965). However, over time the economic and environmental reality changed the Maasai. They have adopted oxen and they have done it easily and very successfully.

When the Arusha moved in the last 25 years to traditionally Maasai areas, such as Monduli district, the use of animal traction spread rapidly. Most Arusha men said they had learned this technology from their father. Sixty-five (65%) of the Arusha men had been using oxen for 30 years. Eighteen percent (18%) of the Arusha had family members who had been using oxen for at least 40 years. Another 12% of the Arusha men had been using oxen over 50 years. Two (2%) said their family had been using oxen for at least 60 years. These findings correspond with Mothander *et al.* (1989), Starkey and Mutagubya (1992), and Spear (1997). Many of the Arusha men brought the animal traction technology with them when they moved to the Kisongo Plains, as indicated earlier by Spear (1993, 1997). Eight percent (8%) of the Maasai men interviewed said they learned how to use oxen directly from the Arusha who introduced oxen to the lower Monduli District. However, 40% of the Maasai men interviewed said the real reason they decided to adopt oxen was because of Ujamaa and the former president Nyerere's Villagization scheme. The remaining 52% of the Maasai interviewed observed the use of draught animals by other Maasai and slowly began to adopt the technology.

Cropland expansion

Animal traction can increase the total production by increasing the amount of land in agricultural production (Gulliver, 1961, Boserup, 1965, Sosovele, 1991). One farm with a few teams of oxen could expand their land base in a very short period of time, versus a farmer who was dependent solely on hand labour (Panin and Ellis Jones, 1994).

Seventy-four percent (74%) of the farmers interviewed said they had expanded their crop fields by using oxen. A number of these farmers said they tried to increase the size of the fields by 1–2 acres/year. Another 8% said they have expanded their crop fields with the use of a tractor, but then they used oxen after the tractors ploughed the virgin sod. The remaining 18% of the farmers in my study responded that they would like to expand, but in villages such as Lashaine and Engaruka, the available crop land has been taken, and the village would not allocate additional land, so they did not have this option.

Efficiency gains in agricultural operations

Among the Maasai and Arusha, the use of oxen was seen as a way to get one's fields ploughed faster than a hand hoe when the seasonal rains come, and in many cases even faster than a tractor. Waiting for a tractor to plough the fields was seen as a major constraint, as most fields in any given area needed to be ploughed at the same time. Waiting for a tractor could delay planting, which could often mean having a poorer crop for the season. Even for tractor owners they often relied on oxen as a backup in case of breakdowns.

Animal traction improved profitability

When asked how draught animals changed the profitability of the farm, many farmers responded that they now have more food (42% of farmers surveyed), which allowed them to not only feed their family, but they also did not have to sell livestock to buy the food (38% of farmers surveyed). In fact, the profits generated using oxen allowed most men to increase their livestock herd (42% of farmers surveyed). The extra crops also help to pay school fees, buy clothes and meet other family needs (24% of farmers surveyed). Others pointed to assets like a tin roof, a shop they owned in town, or ox-carts and tractors that they purchased with the profits realized from the sale of crops grown in fields ploughed and planted with oxen (8% of farmers surveyed). Four percent (4%) of the farmers that responded that the use of oxen had allowed them to pay the dowry for a new wife.

One Arusha man in his fifties from Mswakini, described the profits he gets from oxen in this way, *"There are big profits from using oxen. You see this boma, I have a big family (many wives and children). I can take care of all their food needs because of oxen. I have bought livestock from selling crops. Some people even buy tractors or cars from selling crops that they have grown using oxen."*

Intensifying agriculture with animal traction

In combination with other agricultural inputs and improved management strategies animal traction can be viewed as a timely and appropriate technology in many regions of Tanzania (Sosovele, 1991, Starkey and Mutagubya, 1992). The combination of animal traction, increased fertilizer and manure use, as well as the adoption of hybrid seeds, has led to the increased production of both food and cash crops (Birch-Thomsen, 1990, Meertens, 1996). These practices allowed the Maasai and Arusha men to participate in the marketplace and purchase the required inputs and technology that maximized the benefits of animal traction (Boserup, 1980).

One Maasai farmer interviewed in Lendikenya when asked about the advantages of oxen in the farming system, responded, *"The advantage I get is (more) food because* *of using oxen. It is not easy to grow crops by hand. Even using everyone in this boma (which was at least 40) I could not grow crops like I can using oxen."*

Animal traction's advantages over tractors

The Maasai and Arusha in this study were quick to point out the costs and disadvantages of tractors and the advantages of oxen, despite not being asked this question. However, their general opinion was if they could plant more crops, in a more timely manner, and were relatively sure the rainfall was adequate (early rains) they did not hesitate to use a tractor to expand their cropping area. Furthermore they would use a tractor almost exclusively to break new soils or grasslands. This was considered very difficult given the thick sod and often hard soils, and once the tractor had broken the sod, the oxen took over in subsequent years. Farmers in the research pointed out the following advantages of oxen over tractors: 29% responded they did not have to sell cattle to pay for or rent a tractor; 5% responded they preferred oxen, because they did not have to wait for a tractor during the rainy season; 3% responded that they could grow more crops with lower cash expenses; and 2% responded that they could sell the larger oxen and buy smaller ones, making a profit, and another 2% responded that oxen did not require fuel or spare parts.

Alternatives to animal traction

One of the justifications for former President Nyerere's village schemes was the potential for large mechanized farms. However, the use of tractors has actually dropped each year since the early 1970's (Birch-Thomsen, 1999, Sosovele, 1999b). In contrast, despite earlier government programs promoting the use of tractor power, animal traction use has increased at least three fold in the same time period (Starkey and Mutagubya, 1992, Sarris, 1993). While there are success stories of farmers using tractors, these are primarily on farms with foreign backing or owned by expatriates. It was quite common to see tractors in the countryside, even seeing one in a Maasai or Arusha *boma* was not uncommon. However, many of these were not operational. There was often some status associated with owning them, as they were a large investment. Yet there was also the underlying problem of keeping them running and the need to maintain oxen to either compliment the work of the tractor or use as a back-up when the tractor breaks down. One Arusha farmer from Mbuyuni pointed out, *"Even if someone gives you a tractor you cannot manage to afford it, because of the high price of spare parts, oxen do not have these problems."*

There was no shortage of farmers interested in using tractors. In fact, most farmers expressed their desire to use tractors if they could afford it. The young men were particularly interested in tractors despite the huge economic obstacles that must be overcome, in order to purchase or use them. (Panin and Ellis Jones, 1994).

Tractor ploughing ranged in price from \$14–\$25/acre US (\$34.50–\$61.80/ha). The average price was \$18 US. This was substantially higher than ox ploughing which averaged just \$10/acre or \$24/ha. Interestingly, Panin and Ellis-Jones (1994) noted that in Sub-Saharan Africa the price is for hiring tractors is usually twice that of using oxen, which was almost exactly what I was told. The combination of both tractors and oxen, was noted by Panin and Ellis-Jones (1994) as an increasingly important option for even commercial farmers in Africa.

The Arusha men used the tractors more often than the Maasai. The Maasai usually saw oxen as a way to avoid cash inputs into their agricultural operations. Maasai more often used tractors for breaking new sod, but this might be due to the more recent expansion of Maasai farms, whereas the Arusha have been growing crops steadily over a longer period in Monduli district.

Table 1: Tractor use by Maasai and Arusha in Southern Monduli District

Tractor use	Maasai	Arusha
Using tractors and oxen	25.4%	55.4%
Not using tractors	32.2%	21.5%
Used tractors only for breaking virgin sod	17.0%	4.6%
Used tractors in the past	25.4%	18.5%

Renting oxen

Renting oxen differed considerably from village to village. None of the Maasai and Arusha farmers in the villages Lendikenya, Lashaine, Mswakini and Mbuyuni hired out their oxen. In Lendikenya and Lashaine, they considered this a bad business. However, in Engaruka and Selela, where there was land scarcity and more intensive agriculture, 76% of the Maasai hired their oxen out in trade. They frequently plough one acre with a span of oxen (either 4 large oxen or 6 smaller ones) in exchange for a female goat or in exchange for grazing the crop aftermath. In these villages, renting out oxen for ploughing and harvesting was an added bonus and way to diversify the use and costs of keeping and training the animals. There were a few farmers in nearby Losirwa and Esilalei that also hired out their oxen. The sharing of oxen with neighbours, was seen as a definite advantage over tractors, especially for poor farmers. In Lendikenya one man pointed out, *"A person that is poor can be helped (by a neighbor) with oxen, but a poor person won't get any help with a tractor.*"

Interestingly many Maasai had never heard of hiring out their oxen, and in fact saw this as a bad business, based on their traditions of sharing with other Maasai in times of need (called *Uijirani Mwema*). Below is a quote from Maasai man in, when asked he hired out their oxen for ploughing and other work. *"No, you just help people. It is a shame to have such a business in Maasailand."*

This sharing of a resource like oxen was admirable, especially as many farmers face disease problems that could wipe out their oxen or frequently face some other dilemma that makes ploughing with tractors far out of their financial reach. How long this cultural tradition holds out is directly related to the intensity of the agricultural operations, as more people in intensive agricultural areas all over Tanzania use this strategy of hiring out oxen as an income generating resource (Kjaerby, 1989, Sosovele, 1991, Boesen and Ravnborg, 1992).

Oxen versus donkeys

Oxen were not the only draught animal with potential in the research area. It should be noted that 91% of the farmers interviewed said oxen were their preferred draught animal. Donkeys were the other choice. Despite the vast majority of the farmers admitting oxen were preferred over donkeys, 53% of all the farmers interviewed said they had used donkeys for ploughing and planting crops. The Maasai and Arusha described this more as a measure of desperation. Donkeys were simply not considered as strong as oxen, as noted above. Donkeys would also replace oxen if they were sick or died. They would be yoked with oxen, as the yoke would ride more comfortably on a donkey if it was yoked with an ox.

It was expected that the Arusha men would have had a higher adoption rate of donkeys, due to owning less livestock and being in more arid sections of the research area. However, 60% of the Maasai farmers said they used donkeys, compared to 51% of the Arusha. Thus the adoption of donkeys was slightly higher among the Maasai, which seemed unlikely given their reverence for cattle. However, donkeys were more numerous in Maasai bomas, as most wives owned donkeys. Interestingly, as women often used the donkeys for transport with packs or saddles, it was often the women that had to capture and yoke the donkeys. The men had little contact with the donkeys and were more afraid of men.

When asked why they preferred oxen to donkeys, the typical response in the research area was: "*Donkeys are lazy".* The perception of donkeys being weak or lazy, was the result of a poor harnessing system for donkeys, as they simply wore the same yoke as the oxen. Rather than any physiological weakness (Pearson *et al*., 1999), their anatomical difference with a higher held head forced them to push into the yoke straps from the front of their neck or throat, rather than the hump, which was pronounced on all the oxen. Donkeys cannot perform adequately with a yoke designed for oxen. The donkeys would plough reluctantly, but only with the strong persuasion of men with whips.

Only 6.5% of the farmers interviewed said they preferred donkeys over oxen. These were all Arusha men. The donkeys were more easily trained, more disease resistant and better able to work after a drought than were oxen.

Donkeys were the preferred animals to use on a cart (Plate 2), as they could be more easily and more accurately directed in tight places. The ox yoke was used when

Plate 2: Donkeys carting loads for Maasai in Tanzania (A. Conroy)

donkeys pulled a cart, but the heavy tongue weight and wheels on the cart made pulling a cart more bearable for the donkeys. The donkeys used the top of their neck to move the cart, rather than the throat as they were forced to do when ploughing, allowing them to spread the load over more heavily muscled and larger surface area. This operation was much more comfortable for the donkeys.

For both ethnic groups donkeys were a readily available power source, and in times of need, during droughts or epidemics of disease when cattle and oxen were suffering. In this light, donkeys seemed to perform an important function in this area, offering a measure of insurance for farmers that were growing crops, reducing their reliance on tractors or hand hoeing for cultivation.

Carts and sleds

Most Maasai and Arusha in this study used oxen only for fieldwork. Many Maasai and Arusha women used donkeys with packs made from cow skins for transport (Starkey and Mutagubya, 1992). A few Arusha farmers used donkeys with carts. They were preferred over oxen, because they could be more easily handled, and were faster than oxen on roads. These carts were used for hauling water in drums, harvesting crops and carrying crops for sale to local markets. Only 9% of the farmers had carts, but the majority of men expressed their desire to own a cart. Animal drawn carts were not readily available in local villages, and the greatest challenge for a Maasai or Arusha was not so much the price, but the transport cost of getting it to the more remote villages and the maintenance of carts once they get them there (Urasa, 1994).

Most Maasai and Arusha farmers who did not have a cart did use a locally made sled, which was simply a large forked branch with small poles nailed across the branches to provide a surface on which the harvest, water drums or a plough could be placed. The oxen were hitched to the front of this sled by a chain. These were also used to take sick or dead animals back to the boma, and in a few cases were also used to take sick people to the road for transport to the hospital. A disadvantage of these locally made sleds was that they were thought to contribute to gully erosion on the roads and paths, as they removed vegetation while being dragged behind the oxen. Farmers recognize the advantage of carts, but the sleds were made entirely of local materials and were one of the few options readily available to reduce the drudgery associated with harvesting, water collection and moving other objects (Starkey and Mutagubya, 1992).

Oxen in logging operations

Oxen were not used by Maasai and Arusha for commercial logging, but were employed for gathering building materials from the forest and bush, for building both kraals and homes. They were not used often for hauling firewood, as this was largely a woman's job, but donkeys were sometimes employed for this work. This was also a training exercise used by the Maasai and Arusha for young animals, and also a conditioning exercise for older oxen prior to the ploughing season.

The challenges facing animal traction

Describing only the many advantages oxen have in an agricultural system does not tell the whole story. There were many problems the farmers faced in trying to use and adopt the animals. Obstacles like the promoting the use of draught animals by women can be more easily overcome than obstacles such as cattle diseases that plague the region. Livestock diseases were a major issue for the Maasai and Arusha, this particular topic was one that generated far more data than initially expected. It not only highlights the obstacle this creates in keeping oxen, but also portrays the constant struggle against disease that face all cattle raised by the farmers in the research area.

Once the draught animals are adopted and put to use, the next issue was controlling the damage to the environment. Most farmers admit they can expand the agricultural operation, but in the initial stages this is often done with complete disregard for soil conservation measures and the impact on grazing areas.

Development policies

In Tanzania, despite the official policies supporting animal traction (URT, 1997), there continues to be a lack of support and especially funding for this policy area. This lack of enthusiasm for animal traction was especially true among the young and educated, who expressed their desire for tractors in the future. There were many examples in the research area where the men were afraid their sons were going to try to move away from using oxen, despite their success and profits with the using these animals. One Maasai man said this, *"The coming generation will run for tractors. Everyone works so that maybe they can have a tractor."*

Animal traction use by women

There has been a gender bias noted with the use of oxen by women in Africa (Sylwander, 1994). However, in the Maasai culture women use donkeys to assist them in their transportation activities. Maasai women maintain control over the donkeys and use them regularly to move water and supplies. When donkeys are yoked, for ploughing or other activities, it was often the women who had to capture and initially restrain the animals for the men. In contrast, the care and use of cattle and oxen in agricultural activities was the sole responsibility of men. Only in certain instances of hardship were women used to drive or plough with oxen on Maasai and Arusha fields. The farmers I interviewed who permitted and used women during ox ploughing or other ox related operations did so because they lacked *morani* or other men in their family who might do this work.

Twenty-eight (28%) of the households interviewed said that their Maasai and Arusha women are using or have used oxen. This was not an ideal scenario for the men, and it seemed from the responses, that the use of oxen by their women was not something they wanted others to know about. Largely for cultural reasons and pride men would have preferred the women to stay in the home, but this is not always the case.

It was interesting to see that while numerous researchers have pointed out the genuine bias against women using oxen, among the Maasai there was actually a large percentage of women who used the animals. Given the generally perceived low status of women in Maasai culture, it was quite surprising to hear so many men admit to having their wives use cattle for what is generally considered men's work.

Acquiring the animals and necessary implements

Most young men striking out on their own did not have the resources to buy cattle, implements, seeds, and other agricultural inputs, without some type of assistance (Starkey and Mutagubya, 1992). In many villages, young men were assisted by their families. In villages with limited crop land, the typical low crop yields and prices for crops were generally not enough to allow direct purchase by the majority of farmers lacking cattle, ploughs or improved seeds. Most young farmers without any livestock assets to fall back on relied on wages or crops grown with minimal inputs to get their start in agriculture. The lack of credit facilities or cash crops that can support the purchase of cattle in areas that have the potential for draught animals, can be a serious economic constraint (Shetto *et al.*(no date), Tangaka, 1999). Kjaerby (1983) examined several studies in Tanzania and found that on average the farmers using draught animal power were wealthier than those farmers in the same region using the hand hoe (jembe). The results of this study would suggest the same, but also suggests that draught animal power will not be available to all farmers, given the nature of human drive, desires, and motivation (Galema, 1994, Mwanakulya, 1999).

The Maasai were more willing to loan oxen to young or poor farmer in order to allow them to get started in farming, than were Arusha farmers, although the sharing of animals was expressed by both groups. Once the fields are ploughed, the young farmer still has to acquire the seeds, plant the crop, and weed it throughout the season. Most of these plots used by young men were quite small.

The price for a mature team of oxen could be in the hundreds of dollars, so most young men hoped to buy a few young bulls or steers and train and grow them at the same time. There was risk with owning animals in this disease prone area (as will be described later). However, the payback was often substantial, in both the labour derived from the animals, the possibility of hiring them out, and ultimately in their sale, as oxen normally bring a higher price than do other cattle, except large bulls, in the market. The one major item requiring purchase was always the plough, which at about $90 (63,000 Tsh) in 1999, was never mentioned as an impediment to agricultural production in my study. Furthermore, unlike what was reported in 1989, by Mothander *et al.*, where there had been a shortage of ploughs available to farmers, there did not seem to be a shortage of ploughs or local means by which to purchase them at the time of this study. Animal drawn carts were rare, but were highly desired by Maasai and Arusha farmers, as they often expressed the hope that this research would result in greater availability of carts.

Need for improvements

The self identified problems related to draught animal use among the Maasai and Arusha, was the risk of loss to disease, the need for improved yokes, and the need for carts. There was little need for improvements in training or ploughing. The men interviewed used a series of sequential steps beginning with early handling, then tying animals, and following this with yoking young teams between larger teams. Prior to heavy work like ploughing, they initiated the ‘new oxen’ to light work such as dragging firewood and home building materials, to both build their confidence and stamina. Their self identified shortfall was in yoking the animals, and they were interested in ideas for improved yoke designs. The Maasai oxen were as well trained and conditioned to the work, as any I had ever driven. The use of ploughs was also well done, with regard to controlling the animals and getting them to do what was desired. There was great concern over the impact of agriculture on the environment and a call for improvements in ridging the fields to reduce erosion, and constructing roads, that were not prone to gully formation.

Poor land preparation and delayed or inadequate weeding were considered major causes of low crop yields. Crop based agriculture was limited for the poorest farmers, as they had less access to resources. These poorer farmers lacked: the ability to cultivate a larger land area, the ability to adopt improved technology, improved management practices, and finally, needed assistance with more timely planting and harvesting (Lyimo and Kessy, 1997). It is at this most basic level of agricultural technology that animal traction offers a number of prospects for the future.

Finally, the major constraint has been the lack of government policies that effectively encourage and promote draught animal power (Starkey *et al.*, 1994). Policies that provide incentives such as adequate farm prices, veterinary care, viable and dependable transportation options, and adequate extension support are basic necessities if animal traction is to be encouraged and utilized (Starkey and Mutagubya, 1992, Panin and Ellis Jones ,1994). In many rural areas there was a severe lack of transportation to major markets especially during the planting season, when major inputs and supplies were needed to compliment the use of animal traction (Starkey *et al.*, 1994). There was also the lack of village support, as demonstration plots, field days, and even village leaders sometimes inadvertently discourage the use of animal traction (Mwakitwange, 1994, Sosovele, 1999). While the latest Tanzanian policies for agriculture and livestock speak of promoting animal traction, it points out that NGO and Private Sector monies will be necessary to implement much of their policy ideas (URT, 1997).

In some regions cattle rustling was a major problem. This was especially true among the Maasai, despite their statements that it really does not occur these days (Jonsson, 1993). Farmers in Ngulu (Mwanga district, Kilimanjaro Region) frequently expressed worries that Maasai in nearby areas would come at night and steal their cattle. The investment in oxen was seen as a risky venture in most areas because of both cattle rustling and disease. Their worries were not unfounded, as it was common to hear about cattle being lost to rustlers. We met Maasai men who had been arrested for cattle rustling, others that had been jailed, and others (Maasai, Arusha, Pare, and even expatriates) who had been the farmers that had had their cattle stolen. Wildlife predators were numerous in Monduli district, and although the Maasai and Arusha take great care of their livestock, cattle were regularly lost to predators. Most often these were the younger animals, but oxen could be lost as well.

Diseases

The prevalence of cattle diseases and the lack of veterinary care was also a real constraint to the use and adoption of oxen in some areas (Mwakitwange, 1994). Among the Maasai and Arusha, we hated to ask this question, because it was one where the interviewees became increasingly animated to make sure we understood their dilemma in this regard. There are many parasitic and contagious diseases endemic to this area (Starkey and Mutagubya, 1992, Meindertsma and Kessler, 1997). The most common disease problem was East Coast Fever, followed respectively by the Tsetse fly, Foot and Mouth Disease, Anthrax, Babeosis, Heartwater, Rinderpest, and Malignant Catarrhal Fever. The tick and the tsetse fly were the main vectors of disease, and both were common in Monduli District.

Diseases have been such a problem that many of the men interviewed in my study said they have to use crop sales to replace dead livestock. One Maasai from Selela said, *"Growing crops has changed my herds. If I get good yields I will buy another cow. Diseases are a problem, so I have to use crops to replace dead cows."*

Disease control

Over the years, both the Colonial and Independent governments have offered support for controlling cattle diseases that most often plague the area (Ford, 1971, Raikes, 1981), but this support has changed over time. In Tanzania, there had been a large amount of government and NGO subsidies to veterinary care, and the Maasai and Arusha had come to depend on this (Meindertsma and Kessler, 1997). In 1984, free cattle dips were stopped and prior to 1992 all biologicals (vaccines and bacterins) were also subsidized by the government. This support for vaccines and other biologicals was slowly withdrawn since 1992. This change was a constant complaint voiced by the farmer/herders in this study. The risk associated with investing in oxen can be greatly reduced by adopting strategies to reduce and control disease. The Maasai and Arusha understood the diseases that are endemic to the region, and the losses are significant (Meindertsma and Kessler, 1997), but frequently risked disease rather than make the investment in preventative medications.

Oxen and the environment in Monduli District

For centuries humans have used animals and tools to shape the landscape to suit their needs. For the Maasai and Arusha the use and adoption of oxen has created opportunities, but also problems. Some of these conflicts and problems can be predicted based on past cases in Africa. In Monduli District the environmental problems that can be attributed to the use of oxen were not very different than what has been seen in other areas in Tanzania or Africa. Environmental issues have been described previously, such as: soil erosion (Christiansson, 1986, Blench, 1999, Kilemwa, 1999), the loss of soil fertility (Ravnborg, 1990, Birch-Thomsen, 1993, Mung'ong'o, 1995), deforestation (Sosovele, 1991, Blench, 1999), decreased grazing areas (Kjaerby, 1986, Ravnborg, 1990), the loss of soil moisture due to increased water run-off and higher rates of evaporation (Sinclair and Wells, 1985, Sinclair and Fryxell, 1985), and also the spread and proliferation of weeds (Sinclair and Fryxell, 1985, Kilemwa, 1999).

In this study, the men were asked how draught animals had changed the environment. Sixty-seven percent (67%) of the men interviewed said that oxen had not changed the environment. However, there were certain villages, like Arkatan, Lashaine, Lendikenya, and Mbuyuni faced many of the environmental challenges and conflicts outlined in Figure 2**.** Thirty-three percent (33%) of the farmers said environmental problems were caused by the poor use of oxen. The largest majority came from the villages of Lashaine, Lendikenya, due to their topography and Mbuyuni due to it s shallow soils.

Out of the total number of men interviewed, 22% said soil erosion in their village was due to oxen and related activities. The remaining men that believed oxen caused problems answered either the problem was a loss of grazing lands (6% of the men interviewed) or that ox farming causes tree cutting and/or a 'lack of rain' (the final 6% of the men interviewed).

Boserup (1965) discussed how most cultures will not adopt more sustainable and often more labour-intensive methods until they are forced to do so. The environment in Monduli certainly seemed to be moving towards a crisis state. Maybe this will be the impetus for change. The use of animal traction has allowed them to expand their crop base and adopt crops that work easily with this system. This has largely been done with little regard for the environment.

Is animal traction appropriate for Monduli District?

Animal traction can provide a cheap and effective power source to add to or replace human labour in the agricultural sector. There are multiple paths toward technological and agricultural development (Inns, 1994). However skipping the animal traction stage has been shown to be a poor option. Technology is often used to substitute for more expensive factors in the production of any commodity. Where labour, land or capital limit the ability of farmers to expand their agricultural production level, the use of animal traction becomes a viable technology in a nation like Tanzania. (Rempel, 1993).

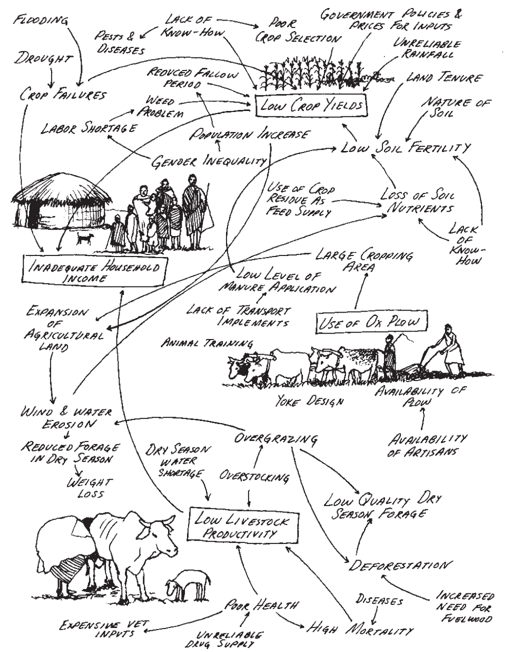

Figure 2: Monduli Maasai agricultural systems diagram

Overcoming constraints such as disease problems or lack of expertise in controlling erosion can be more difficult to achieve than importing more food, or following other less sustainable development paths (Starkey and Mutagubya, 1992, Sosovele, 1999). However, for the long term food security of the people, the adoption of better practices would pay great dividends.

There was also a need for increased use of animal traction because the size of most farms in the Monduli precludes the economic use of tractors. There were serious labour constraints in Monduli District due to the seasonality of the rains, the agro-pastoral mode of production and the use of the jembe on the majority of farms. Furthermore, the promotion of draught animal power has been a national priority after numerous failed schemes using other sources of farm power (Starkey and Mutagubya, 1992, Starkey *et al*., 1994, URT, 1997).

The use and expansion of animal traction in Monduli District largely depends on policies that promote the use of animals, given serious consideration of the individual culture, the physical characteristics of the land, land availability, and the appropriateness of the cattle themselves (Starkey and Mutagubya, 1992). Where cattle (including oxen) can be fed crop residues or allowed to graze without degrading the natural environment around the farmstead oxen are usually cost effective, provided there is a need for their power. At the same time the oxen are performing agricultural tasks they can gain weight and grow in value. This provides a value that every Maasai and Arusha farmer recognized. Most farmers would buy young oxen after selling an old pair. The older pair would be sold in their prime, at about 7–8 years old. The men interviewed, acknowledged this was the best time to cash in on their investment. With the sale of large oxen, 2–3 pairs of young oxen (about 1–2 years old) can be purchased. This not only increased the value of one's herd, it provided the ever important function of insurance against bad times in the ever changing Tanzanian economy.

Tanzania has been considered one of the world's poorest nations, with tremendous capacity to do better, given its natural resource base and political stability. Monduli District could be considered very typical of the nation at large. While animal traction could not be the answer to all problems, it can be used to increase agricultural production. Animal Traction is a simple technology that utilizes local resources to improve productivity in both the agricultural and rural transportation sector. To ignore this possibility in the hope of an easier path to development defies all notions of self-reliance and sustainability. Yet to use the technology with complete disregard for the environment and soil conservation practices, will inevitably lead to an environmental disaster. Draught animal adoption, primarily oxen, as a technology, has been widely adopted in this region. For the Maasai this has brought with it many of the challenges that have plagued agriculturists for centuries around the world.

References

Birch-Thomsen, T. (1990). Agricultural change – prospects for the future: a case study from the Southern Highlands of Tanzania. *Quarterly Journal of International Agriculture*. **29**(2), 146–160.

Birch-Thomsen, T. (1993). Effects of land use intensification – introduction of animal traction into farming systems of different intensities: the case of South-Western Tanzania and Northern Zambia. PhD Dissertation, Institute of Geography, University of Copenhagen, Denmark.

Blench, R. (1999). Animal traction in Africa: analyzing its environmental impact. In: Starkey, P., Kaumbutho, P (eds): *Meeting the Challenges of Animal Traction*. A resource book for the Animal Traction Network for Eastern and Southern Africa (ATNESA), Harare, Zimbabwe, Intermediate Technology Publications, London. pp. 52–59.

Boesen, J. and Helle M.R. (1992). *Peasant Production in Iringa District, Tanzania*. Centre for Development Research (CDR), Copenhagen, Denmark.

Boserup, E. (1965). *The Conditions of Agricultural Growth*. George Allen & Unwin Ltd, London; Aldine Publishing Company, Chicago.

Boserup, E. (1981). *Population and Technological Change*. The University of Chicago Press, Chicago.

Conroy, D. (1999). *Oxen, A Teamster's Guide*. Rural Heritage, Gainesboro, Tennessee, USA.

Conroy, A. (2001). *Maasai Oxen, Agriculture and Land-use Change in Monduli District Tanzania.* PhD Dissertation, University of New Hampshire, USA.

Ford, J. (1971). *The Role of the Trypanosomiases in African Ecology – A Study of the Tsetse Fly Problem*. Clarendon Press, Oxford.

Galema, A. (1994). Towards a sustainable system for animal traction technology transfer: experiences from the Kilimanjaro Region, Tanzania. In: Starkey, P., Mwenya, E., Stares, J. (eds) *Improving Animal Traction Technology*. Proceedings of the first workshop of the Animal Traction Network for Eastern and Southern Africa (ATNESA) held 18–23 January 1992, Lusaka, Zambia. Technical Centre for Agricultural and Rural Cooperation (CTA) Wageningen, The Netherlands. pp. 321–325.

Inns, F.M. (1994). Animal draught tillage systems: the need for an integrated approach. In: Starkey, P., Mwenya, E., Stares, J. (eds) *Improving Animal Traction Technology*. ibid. pp. 214–217.

Kilemwa, A.M. (1999). Environmental impact of animal traction in Rukwa Region, Tanzania. In: Starkey, P., Kaumbutho, P (eds): *Meeting the Challenges of Animal Traction*. ibid. pp. 68–71.

Kjaerby, F. (1986). The development of agricultural mechanisation in Tanzania". In: Boesen, J., Havnevik, K.J., Koponen, J., Odegaard, R. (eds) *Tanzania – Crisis and Struggle for Survival*. Scandinavian Institute of African Studies, Uppsala.

Lyimo, M., Kessy, B. (1997). *Animal Traction Training Manual*. Mechanisation Unit, Tanzania Ministry of Agriculture and Cooperatives, Avalon House and Sasakawa-Global 2000.

Meindertsma, J.D., Kessler, J.J. (January 1997). Planning for a better environment in Monduli District. Netherlands Economic Institute (NEI), Consultants for Water and Environment (IWACO) and Agro-Industrial Services Ltd. (AGRIS).

Meertens, H.C.C., Fresco, L.O., Stoop, W.C. (1996). Farming system dynamics: impact of increasing population density and the availability of land resources on changes in agricultural systems. The case of Sukumaland, Tanzania. *Agriculture, Economics and Environment.* **56**. 203–215.

Mung'ong'o, C.G. (1995). Social processes and ecology in the Kondoa Irangi Hills, Central Tanzania. PhD Dissertation. Department of Human Geography, Stockholm University, Stockholm, Published by Arash Tryck and Forlag, Stockholm.

Mwakitwange, G. (1994). Transfer of animal traction technology in Mbozi District, Tanzania. In: Starkey, P., Mwenya, E., Stares, J. (eds) *Improving Animal Traction Technology*. ibid. pp. 328–330.

Ndagala, D.K. (1992). Territory, Pastoralists, and Livestock: Resource Control Among the Kisongo Maasai. Published Thesis, 192 pp. Uppsala Studies in Cultural Anthropology, Uppsala, Sweden.

Panin, A., Ellis-Jones, J. (1994). Increasing the profitability of draught animal power. In: Starkey, P., Mwenya, E., Stares, J. (eds) *Improving Animal Traction Technology*. ibid. pp. 94–103.

Pearson, R.A., Nengomasha, E., Krecek, R. (1999). The challenges of using donkeys for work in Africa. In: Starkey, P., Kaumbutho, P (eds): *Meeting the Challenges of Animal Traction*. ibid. pp. 190–198.

Pingali, P., Bigot, Y., Binswanger, H.P. (1987). *Agricultural Mechanization and the Evolution of Farming Systems in Sub-Saharan Africa*. The Johns Hopkins University Press. Baltimore, MD.

Raikes, P. (1981). *Livestock Development and Policy in East Africa*. Africana Publishing Company, New York, NY.

Rempel, E.G. (1993). Factors affecting the use of draught oxen: Mbeya, Tanzania. MSc Thesis. University of Manitoba, Winnipeg, Manitoba.

Rigby, P. (1992). *Cattle, Capitalism and Class – Ilparakuyo Maasai Transformations*. Temple University Press, Philadelphia.

Sarris, A., van den Brink, R. (1993). *Economic Policy and Household Welfare During Crisis and Adjustment in Tanzania.* New York University Press, New York & London.

Shetto, R.M., Mkomwa, S., Mkoga, Z.J., Marti, U. (no specific date written somewhere between 1995 and 1998). Role of animal traction technology in alleviating labour constraints in rural households in Southern Highlands. (Address of authors: PO Box 400, Mbeya, Tanzania. Working Paper given to me by SARI (Sahelian Agricultural Research Institute), Arusha, Tanzania.)

Sinclair, A.R.E., Fryxell, J.M. (1985). The Sahel of Africa: ecology of disaster. *Canadian Journal of Zoology*. **63**, 987–994.

Sinclair, A.R.E., Wells, M.P. (1989). Population growth and the poverty cycle in Africa: colliding ecological and economic processes?" In: Pimmental, D., Hall, C.W. (eds) *Food and Natural Resources*. Academic Press, Inc., New York, London, Boston. pp. 439–484.

Sosovele, H. (1991). The development of animal traction in Tanzania: 1900–1980's. PhD Dissertation. University of Bremen, Germany.

Sosovele, H. (1994). Transfer of animal traction technology: cultural and social issues in the Tarime District, Tanzania. In: Starkey, P., Mwenya, E., Stares, J. (eds) *Improving Animal Traction Technology*. ibid.

Sosovele, H. (1999). The challenges of animal traction in Tanzania. In: Starkey, P., Kaumbutho, P (eds): *Meeting the Challenges of Animal Traction*. ibid.

Spear, T., Nurse, D. (1992). Maasai farmers: the evolution of Arusha agriculture. *The International Journal of African Historical Studies*, **25**(3), 481–503.

Spear, T. (1993). Being 'Maasai', but not people of cattle – Arusha agricultural Maasai in the nineteenth century. In: Spear, T., Waller, R. (eds) *Being Maasai*. James Curry Ltd, London and Ohio University Press, Athens. pp. 1–18, 120–136.

Sperling, L., Galaty, J.G. (1990). Cattle, culture and economy: dynamics in East African pastoralism. In: Galaty, J.G., Johnson, D.L. (eds) *The Worlds of Pastoralism*, Ch. 2. Guilford Press, New York, London. pp. 69–97.

Starkey, P., Mutagubya, W. (1992). *Animal Traction in Tanzania*. Natural Resources Institute, Chatham, UK and The Ministry of Agriculture, United Republic of Tanzania.

Starkey, P., Mwenya, E., Stares, J. (1994). *Improving Animal Traction Technology*. Proceedings of the first workshop of the Animal Traction Network for Eastern and Southern Africa (ATNESA) held 18–23 January 1992, Lusaka, Zambia. Technical Centre for Agricultural and Rural Cooperation (CTA) Wageningen, The Netherlands.

Sylwander, L. (1994). Women and animal traction technology. In: Starkey, P., Mwenya, E., Stares, J. (eds) *Improving Animal Traction Technology*. ibid. pp. 260–265.

United Republic of Tanzania (URT) Presidents Office-Planning Commission and Ministry of Finance (1996. *The Rolling Plan and Forward Budget for Tanzania for the Period of 1996/97 and 1998/99.* Vol. 1. Government Printer, Dar es Salaam.

United Republic of Tanzania (URT) Ministry of Agriculture and Cooperatives (1997). *Agricultural and Livestock Policy*, January 1997. Government Printer Dar es Salaam.

Upton, M. (1987). *African Farm Management*. Cambridge University Press, Cambridge, UK and New York, USA.

Urasa, R.L.S. (1994). A note on issues to be addressed in the transfer of animal traction technology in Tanzania. In: Starkey, P., Mwenya, E., Stares, J. (eds) *Improving Animal Traction Technology*. ibid. pp 326–328.

Western, D. (1994). Ecosystem conservaton and rural development: the case of Amboseli. In: *Natural Connections-Perspectives in Community-Based Conservation*. Island Press, Washington, DC. pp. 15–52.

Western, D. (1997). *In the Dust of Kilimanjaro*. Island Press, Washington, DC.

(b) Mozambique

Reintroduction of animal traction in Chokwe Agricultural Research Station

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Introduction

Chokwe is a town located 200 kms northwest of Maputo in the province of Gaza. Those who remember the terrible floods in Mozambique in the year 2000 may have heard of Chokwe as it was one of the areas seriously affected by those floods.

Chokwe district is famed in Mozambique and neighbouring countries for possessing a large irrigation scheme, the largest in the country. This scheme was built by the Portuguese at the end of the colonial period and was designed to exploit the water of the Elephant and Limpopo rivers for commercial agricultural production based on rice. The total area covered by the scheme was initially 46,000 hectares, all of it levelled, divided into rectangular blocks of 16 hectares and equipped with irrigation and drainage canals. All irrigation is by gravity. Production from the scheme only really started after independence in 1975.

After independence, all production in the scheme was centralised through large, soviet style, collective farms. Neither private farms nor farmers were permitted. The majority of the peasant population living in the area was excluded from the scheme. Production was mechanised and the use of oxen inside the scheme was negligible although outside the scheme many small-scale farmers used oxen for ploughing and transport.

By the early 1980's, the centralised system was showing its deficiencies. Production was dropping and the tractors and combine harvesters were not being replaced. Those that still worked were old and unreliable. In response, the government made a policy change, decentralising management through a number of smaller production units, allowing peasant farmers to enter the scheme with their oxen and permitting the cultivation of private plots. With the entry of almost 10,000 small-scale farmers and their oxen between 1983 and 85, production increased greatly and yields were as high as under mechanised production. An FAO study visit in 1985 estimated that there were 1,700 pairs of oxen working inside the scheme.

Although the scheme did produce rice and other crops under irrigation up until the mid 1980's, its full agricultural potential was never been realised for a variety of reasons. The long civil war in Mozambique was one of these (reasons) and the irrigation scheme was largely abandoned from 1986 to 1995 because of the associated insecurity. During the war, many of the cattle were slaughtered or stolen and draught animal numbers remain very low in relation to pre-war levels. This is steadily being address through cattle restocking programmes carried out by the government and various NGO's, for example VETAID.

With the end of the war the government embarked on an ambitious reconstruction plan for the Chokwe irrigation scheme as part of a long-term food security strategy based on the exploitation of this and other similar, smaller schemes in various parts of the country. Rehabilitation of the irrigation infrastructure is being carried out with the assistance of the international donor community and, as a result, agricultural production is steadily increasing. The main crops grown are rice in the hot (rainy) season and tomatoes in the cool (dry) season. There is much interest in the future potential of the scheme to provide large quantities of food crops both for domestic consumption and for export.

Promoting animal traction

The Japanese government has been the largest contributor to the restoration of the Chokwe irrigation scheme to date, with extensive rehabilitation of the main canal and water control structures. Further to this, the Japanese International Cooperation Agency in Maputo (JICA) wishes to assist farmer associations within the irrigation scheme to improve production and productivity. This will be done through providing support in the areas of animal traction, promoting more efficient land use, mixed cropping and providing agricultural credit. The main project has yet to be approved for funding but an advance, three-month, pilot animal traction project was implemented this year with the objective of promoting the wider use of draught animals in small-farm systems based on rice.

Chokwe Agricultural Research Station

Chokwe Agricultural Research Station (CARS) is one of several such institutions in Mozambique dedicated to improving and diversifying agricultural production through trials and investigation of many different food crops. Much of the research is linked to production in the irrigation scheme and is coordinated through the National Institute for Agronomic Investigation. Non-governmental bodies also carry out research at CARS. For example, JICA currently has a number of rice trials at CARS where many different varieties are being tested.

Adjacent to CARS is situated the Chokwe Agricultural School with around 200 students studying for a national certificate or diploma in agriculture. Student practicals are carried out in the trial fields at CARS. There are thus existing linkages between education and research that can be strengthened further.

Until the early 1990's, CARS also had a herd of milking cows that provided milk for the staff and for sale to the public. This herd was decimated by war and today does not exist.

CARS has recently been selected by the government as the regional centre for agricultural investigation (south Mozambique), thereby guaranteeing funds for future research activities and ensuring wider publicity and recognition. It was partly for this reason that JICA, after consultation with various governmental entities, and with the full collaboration of CARS, decided to establish a small animal traction promotion unit at CARS. A memorandum of understanding was drawn up and signed between CARS and JICA that defined the responsibilities of each entity. In summary, CARS provided the land and labour and JICA financed the establishment of the animal traction training centre (ATTC).

The pilot project had a three-month duration between January and March 2004. It comprised the following components:

- building of essential infrastructure
- purchase of animals and implements
- training of animals and personnel
- promotional seminar.

The project was implemented by the author, in collaboration with CARS and JICA staff. The infrastructure at the ATTC is built of locally available materials. It consists of a corral, a fenced training area and a small store shed for equipment. JICA purchased 6 male animals for work (Plate 3) and 6 females for breeding/work. The author trained the male animals during the month of March 2004. Simultaneously, training was given to three CARS staff members and three extensionists from the Chokwe agricultural directorate. This training included:

- Selection and training of draught animals
- Use and maintenance of implements and equipment
- Animal health and production.

Implements

JICA purchased a number of different draught animal implements for the project. These included ploughs, spike-toothed harrows, cultivator/weeder, ridger, ox cart. The ox cart was made by the CARS carpenter using an axle and wheel set purchased from the Kanes company in Maputo. All of these implements were utilised during the training of the animals at CARS (Plate 4).

An implement for 'puddling' in rice fields was developed and tested based on a design used in Kenya. Results were encouraging but modifications to the implement are necessary to increase its stability and efficiency.

Plate 3 Oxen being hitched for work in Chokwe, Mozambique (A. Mattick)

Plate 4 Training oxen at CARS, Mozambique (A. Mattick)

Promotional seminar

During the pilot project, a one-day seminar was organised to promote the wider use of draught animals in small-farm systems based on rice. The seminar was attended by 22 persons for various governmental and non-governmental institutions working in or around Chokwe. Representatives of three farmer associations were also present. Interest in the subject was high and participation was excellent. The seminar included a visit to the ATTC where a demonstration was given and also the showing of animal traction videos made at Palabana in Zambia.

Sustainability

The animals are now being used at CARS for land preparation and transport. Draught animal power has been allotted a place within the existing trial and research programme alongside the two tractors that CARS already has.

The proximity to the Chokwe Agricultural School means that students will be exposed to animal traction as part of their training. The director of the school says he will push to include animal traction as an official part of agricultural mechanisation classes. Training in animal traction is already a part of the curriculum in the two main agricultural colleges in Mozambique.

The extensionists that were trained in the training and use of draught animals work in different parts of the irrigation scheme. These persons have already identified areas in which improvements can be made in draught animal technology at the farmer level. They are keen to organise short courses to exchange knowledge with farmers and promote improved techniques.

The females (heifers) that were purchased by the project are mainly for breeding to guarantee the continuation and expansion of the herd. Reproduction will ensure a constant supply of young male animals for animal traction plus, eventually, a saleable excess.

(c) Cameroon

Utilisation de la traction bovine et asine par les paysans sédentaires du canton de Boboyo (Extrême-Nord Cameroun) possédant des ruminants. [Use of cattle and donkey for draught by sedentary farmers keeping ruminants in the canton of Boboyo (Far North Cameroon)]

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Résumé

Chez les paysans agriculteurs de la province de l'Extrême-Nord Cameroun, l'élevage représente la seconde source de revenu. L'énergie animale est de plus en plus utilisée dans les systèmes de production agricole. Une enquête transversale a été menée dans le canton de Boboyo parmi les paysans sédentaires possédant des ruminants (bovins, ovins ou caprins) afin de mieux cerner l'utilisation des animaux dans la traction et d'avoir des données de référence pour de futurs projets dans le cadre de la sécurité alimentaire. Le canton compte 8.300 habitants pour 150 km^2. Le cheptel bovin a été estimé à 2.334 bovins. Les bovins, mais surtout les ânes, sont les animaux les plus utilisés dans la traction. 89,9% des chefs de concession ont recours à la traction animale. 40,7% des sédentaires ne possédant pas de bovins mais au moins des petits ruminants et 38,5% de ceux possédant des bovins ont des ânes. L'utilisation de la traction est, en premier lieu, dépendante de la possession du matériel de trait et ensuite du lieu d'habitation. Les villages situés au Nord du canton utilisent plus la traction que ceux situés au sud.

Abstract

Use of cattle and donkey for draught by sedentary farmers keeping ruminants in the canton of Boboyo (far north Cameroon)

Livestock keeping is the second economic activity of households of the Far North Province of Cameroon. Animal power is more and more used in the agricultural systems. A single visit survey was conducted in the canton of Boboyo among households keeping ruminants (cattle, sheep or goats) for a better understanding of animal draught, and to collect data useful for future actions related to food security. There are approximately 8,300 inhabitants in the canton on an area of 150 km^2. In total there are about 2,334 cattle. 89.9% of the households involved in the survey use cattle or donkeys for animal traction. 40.7% of the households keeping only sheep and goats and 38.5% of those with cattle are keeping donkeys. The use of animals for draught is in the first place depending from the possession of plough equipment and, in the second place, from the location. Households living in villages from the north of the canton used more draught animals than those who are located in the south of the canton.

Introduction

Dans les régions sèches, l'élevage représente le principal moyen de subsistance (Kurt, 1999). De plus en plus, l'énergie animale est utilisée dans la culture attelée et le transport. La traction animale a connu un essor considérable dans le cadre de projets de développement des cultures industrielles comme le coton et l'arachide (Vall *et al.,* 2002). Dans les pays d'Afrique subsaharienne francophone, le cheptel de trait était estimé à 1,4 millions de têtes en 2000 et les équipements agricoles à 2 millions d'unités (Havard *et al.,* 1998). Le même phénomène a été observé dans l'Extrême-Nord du Cameroun, en général (Anonyme, 2003), et dans le canton de Boboyo en particulier. Le canton de Boboyo est situé dans le département du Mayo Kani et est presque exclusivement habité d'agriculteurs sédentaires. C'est un canton vaste de cent cinquante kilomètres carrés (150 Km^2). Sa population est d'environ 8.300 habitants (Ziébé, 2003). Les relevées pluviométriques de la station météorologique de Kaélé, chef-lieu du Département, indiquent une pluviométrie moyenne de 980 mm pour ces onze dernières années. 75% des précipitations ont lieu en juillet, août et septembre. Le canton de Boboyo compte neuf villages: Kani, Goudjoing, Boboyo Chefferie, Zapili, Kassilé, Gadas, Po-Ouoré, Zaklang et Gazaro.

L'introduction de la culture attelée dans la Province de l'Extrême-Nord a eu lieu pour la première fois pour la province durant les années 1930 dans la région de Kaélé, pays '*Moundang*'. Elle a été facilitée par la culture du coton qui a entraîné la possession des animaux de trait et l'augmentation des surfaces cultivées (Seignobos, 1998). Cette intensification agricole a créé des rapports sociaux tendus de par l'utilisation saisonnière des ressources pastorales par des éleveurs transhumants venus des cantons environnants. Des conflits apparaissent régulièrement entre eux et les paysans sédentaires (Ziébé, 2003).

La mise en place future d'un programme d'appui au développement de l'élevage dans le canton nous a permis d'organiser une enquête et d'étudier la pratique de la culture attelée par les paysans du canton possédant des ruminants afin d'en connaître l'ampleur et les aspects sociaux, culturels et économiques qui sous-tendent sa pratique. L'objectif final était de proposer des actions d'amélioration pouvant être appliquées durant le projet.

S'inscrivant dans une étude plus large sur l'utilisation des pâturages (Ziébé, 2003), cette étude n'inclut que les paysans sédentaires possesseurs de ruminants. Elle devra être complétée plus tard.

Matériel et méthodes

Enquête

L'enquête s'est limitée au canton de Boboyo. L'unité d'observation était un paysan ou une paysanne à la tête d'une concession située dans le canton, possédant au moins un ruminant (bovin, ovin ou caprin) et ayant un ou plusieurs ménages sous sa responsabilité. La concession constitue l'unité d'habitation, appelée *yan* en *Moundang* (Seignobos, 1998).

Un recensement exhaustif des chefs de concession et leur possession ou non d'animaux d'élevage a permis de constituer la base de sondage pour l'enquête transversale. Les chefs de concession répondant aux critères mentionnés ci-dessus ont été scindés en deux groupes: (i) les paysans sédentaires possédant des bovins (Sédentaires BV); (ii) les paysans sédentaires ne possédant pas de bovins, mais ayant au moins des ovins ou des caprins (Sédentaires PR). La totalité des 262 Sédentaires BV recensés ont été inclus dans l'enquête, ainsi que 312 des 730 Sédentaires PR recensés, choisis aléatoirement.

Analyse statistique des données

Les comparaison statistiques ont été réalisées à l'aide du logiciel STATA (Stata Corp., 2001). Le logiciel CART (Steinberg & Colla, 1995 ; Breiman *et al.,* 1984) a été utilisé pour établir un arbre de classification avec comme variable dépendante 'utilisation d'animaux de trait' et comme variables explicatives 'Taille ménage', 'Nombre d'épouses', 'UBT', 'type de l'éleveur', 'Village', 'Sexe du chef de concession', 'Possession d'un sarcleur', 'Possession d'une charrette', 'Possession d'une charrue', 'Possession de matériel agricole', 'Connaissance du pâturage', 'Utilisation du pâturage', 'Fenaison', 'Contact avec les transhumants' et 'Conflit ou non'. Le logiciel CART est basé sur une méthode non paramétrique de segmentation dichotomique qui permet d'analyser les liens entre une variable choisie au préalable et d'autres variables. Les liens identifiés entre les données sont présentés sous la forme d'un organigramme, composé de nœuds intermédiaires et de nœuds terminaux (Speybroeck *et al.*, 2004).

Résultats

Le recensement initial a révélé que dans le canton, 13% des concessions ne possédaient pas d'animaux. Les bovins, les chevaux et les ânes étaient les espèces animales utilisées comme animaux de trait. Le canton comptait au total 2.334 bovins, 28 chevaux et 607 ânes (Tableau 2). Parmi les chefs de concession qui possédaient des ruminants, les Sédentaires BV possédaient significativement plus de chevaux que les Sédentaires PR (Tableau 3). 97,32% des sédentaires BV utilisaient leurs bovins dans les travaux agricoles. 83,65% des Sédentaires PR pratiquaient la culture attelée, mais seulement 43,6% d'entre eux possédaient leurs propres animaux, des asins en l'occurence. Les autres louaient (18,9%) ou empruntaient des animaux (20,2%) ou s'associaient (0,1%). Le tableau 4 montre le pourcentage de pratique de la culture attelée et le mode d'accès aux animaux de trait. 89,9% de l'ensemble de l'échantillon avait recours à la traction animale pour leurs cultures.

Tableau 2: Nombre d'éleveurs de ruminants du canton Boboyo possédant des bovins, des chevaux et des ânes

	Nombre enquêté	Bovins		Chevaux		Anes	
		Nombre	%	Nombre	%	Nombre	%
Sédentaires BV	262	262	100	14	5,3	101	38,5
Sédentaires PR	312	0	0	3	1,0	127	40,7
Cheptel canton		2334	28	607			
UBT Total		1751	28	307			
UBT par Km^2		11,7	0,2	2,4			

Tableau 3 : Moyenne et écart type du nombre de chevaux et d'ânes par éleveur de ruminants du canton de Boboyo

	Sédentaires BV	Sédentaires PR	Valeur de p
Chevaux	0,1±0,5	0,01±0,1	0,002 (Significatif)
Anes	0,7±1,5	0,6±0,9	0,08 (non significatif)

Tableau 4 : Pourcentage d'utilisation et mode d'accès aux animaux de trait (bovins et asins)

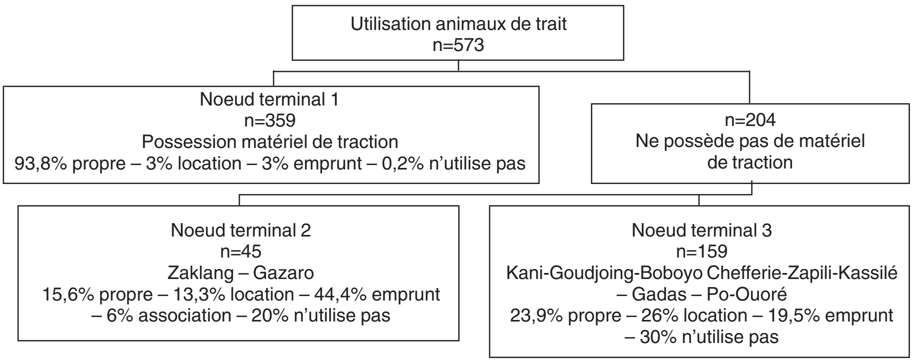
	Nombre enquêté	Mode d'accès (%)				Pourcentage Utilisation
		propre	location	emprunt	association	
Sédentaires BV	262	97,3				97,3
Sédentaires PR	312	43,6	18,9	20,2	0,1	83,7
Total	574	68,1	10,3	11,0	0,1	89,9

La pratique de la culture attelée implique l'utilisation de matériel de traction. La charrue a été le matériel le plus utilisé (87%). Les Sédentaires BV avaient un équipement relativement plus important que celui des Sédentaires PR (tableau 5).

Tableau 5: Pourcentage de Sédentaire BV et Sédentaire PR possédant du matériel de traction

	Nombre enquêté	Sarcleur	Buteur	Charrette	Charrue	Matériel
Sédentaires BV	262	36,6	29,4	16,0	87,0	87,4
Sédentaires PR	312	2,6	2,9	0,6	44,9	44,9
Total	574	17,9	15,0	7,7	64,1	64,3

L'arbre de classification est représenté par le graphique 3. L'utilisation des animaux de trait était principalement déterminée par la possession du matériel de traction. Le nœud terminal 1 (NT 1) englobe les chefs de concession possédant du matériel de traction. 93,8% de ces chefs de concession possédaient en propre leurs animaux de trait (bovins et asins), 3% louaient, 3% empruntaient, et 0,2% ne les utilisaient pas. Pour ceux qui ne possédaient pas de matériel de traction, habiter dans un certain village est apparu comme la variable prédictive la plus prépondérante. NT 2 regroupe ceux des villages de Zaklang et Gazaro. Seulement 15,6% des chefs de concession possédaient leurs animaux, 13,3% louaient, 44,4% empruntaient, 6% se sont associés et 20% ne pratiquaient pas de culture attelée. NT 3 comprend les chefs de concession des autres villages du canton avec 23,9% qui possédaient leurs propres animaux, 20% louaient, 19,5% empruntaient et 30% ne pratiquaient pas de culture attelée.



Graphique 3: Analyse en arbre avec "Utilisation animaux de trait" comme variable dépendante

Discussion

L'analyse n'a concerné que les chefs de concession possédant des ruminants. Elle omet donc les agriculteurs qui n'élèvent pas ces espèces animales mais qui pourraient utiliser des asins ou un autre mode de prêt ou de location d'animaux. Cet aspect devra être étudié plus tard. Comme les bovins, les équidés sont également utilisés dans la traction animale, mais le cheval est peu utilisé par notre échantillon comparativement à l'âne ou au bovin. Ceci pourrait provenir du fait que, dans la région, le cheval a surtout été considéré comme un animal rattaché à la chefferie et utilisé dans la fantasia. Ce n'est que vers les années 1990 qu'un effort de vulgarisation a été fait pour l'utiliser comme animal de trait (Vall *et al.,* 1997). En effet, avec la crise économique et la diminution des revenus issus du coton, le cheval fut proposé comme animal alternatif pour produire une force plus importante que celle de l'âne et pour un coût plus bas que celui d'une paire de bovins. Au vu de notre enquête cela ne semble pas avoir donné les résultats escomptés dans le canton.

L'âne est utilisé essentiellement dans les travaux agricoles (Plate 5). Notre étude montre qu'on le retrouve dans près de 40% (tableau 3) des concessions des paysans possédant des ruminants, pourcentage supérieur aux 27% rapportés par Bello & Yaouba (1999) et aux 25% rapportés par Vall *et al.,* (2002b). Vall & Boukar (1997) montrent également que le rendement énergétique net de travail de l'âne (26–29%) est supérieur à celui du cheval (24–27%) et du zébu (16–20%). Son bas prix par rapport au cheval et au bovin fait qu'il est généralement la première étape vers une mécanisation agricole et qu'il conviendrait aux besoins des paysans ayant un faible revenu et les économiquement moins nantis (Leegwater, 1999). Ce succès de l'âne s'expliquerait également par les facteurs agro-écologiques. L'attelage asin et sa charrue sont particulièrement bien adaptés à des exploitations de petites tailles (2–3 ha) en culture pluviale et efficace sur les terrains pierreux où la mécanisation légère s'avère plus maniable (Seignobos, 1998).

A Boboyo, l'utilisation des animaux de trait est déterminée par la possession du matériel de traction. 6,2% des paysans possèdent du matériel de traction mais n'ont pas d'animaux de trait. Ce sont des paysans qui ont été décapitalisés. Ils l'ont vendu pour des raisons diverses ou ont simplement perdu leurs animaux. Pour Bello & Yaouba (1999), ces paysans n'attendent qu'une 'bonne' saison agricole (qui suppose de dégager un revenu excédentaire) pour racheter des animaux de trait. C'est le revenu du coton qui finance pour une large partie l'équipement de culture attelée des agriculteurs (Roupsard, 1987 cité par Vall *et al.,* 1997).

Quant à ceux qui ne possèdent pas de matériel agricole, nous constatons dans les villages au Nord du canton (Zaklang et Gazaro) que 80% utilisent les animaux de trait. Cette partie du canton est considérée comme le grenier du canton. Gazaro, par exemple, a été fondé il y a une cinquantaine d'année par des paysans allés s'y installer pour exploiter les champs vierges. Cependant, dans le village Kani, au Sud du canton, le pourcentage de ceux qui utilisent les animaux est plus faible. C'est le village le plus peuplé et le plus 'urbanisé'. Les habitants de ce village s'adonnent à des activités autres que l'agriculture et l'élevage (agents de l'état, commerçants, …). Par ailleurs, les formes de solidarité mise en œuvre pour l'utilisation des animaux de trait ou des outils agricoles se révèlent intéressantes. La location, l'emprunt ou l'association sont des formes d'utilisation qui peuvent pallier la sous-productivité. Dans les systèmes où la possession des animaux de trait est supérieure à 40%, le marché de la location des animaux est faible (Vall *et al.,* 2002a).

Etre dépourvu de matériel de traction influence négativement le rendement agricole (Bello & Yaouba, 1999). En effet, la totalité de la pluviométrie utile tombe en 2–3 mois. Il faut donc emblaver un maximum de superficie et sarcler rapidement pour ne pas voir ses parcelles envahies par

Plate 5: A young man with a pack donkey in Cameroon (E. Thys)

les adventices. L'utilisation de la force animale devient donc capitale pour respecter ce calendrier agricole serré. Pour les paysans désireux de s'équiper, l'âne est le premier choix à faire du fait de son prix d'acquisition modeste et sa rusticité. Ceci explique qu'on le retrouve dans 40% des concessions de notre échantillon d'éleveurs possesseurs de ruminants et, que, chez les Sédentaires BV, c'est un animal fort présent.

Conclusion

L'énergie animale est fortement utilisée dans les systèmes de production du canton de Boboyo. 89,9% des paysans y ont recours. Mais la possession en propre des animaux pour les paysans est encore faible. Ceci se remarque encore plus quant au niveau d'équipement des paysans. Pour améliorer la sécurité alimentaire, il faudrait faciliter l'accès aux animaux de trait et aux équipements de traction. Une vulgarisation du cheval comme animal de trait accrocherait très peu. Un encadrement des utilisateurs des animaux de trait devrait, en plus des aspects sanitaires, prendre en compte les thématiques liées à la fertilisation des sols et au transport. L'augmentation de la capacité d'équipement doit également être considéré tout en consolidant les structures associatives d'utilisation commune des animaux de trait et du matériel de traction.

Remerciement

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Références

Anonyme (2003). Document de Stratégie de Réduction de la Pauvreté. République du Cameroun, Yaoundé, 219pp.

Bello, N., Yaouba A. (1999). Résultats de l'enquête agricole permanente. Annuaire statistique CSE/SDCC 98/99, Garoua, Cameroun.

Breiman, L., Friedman, J.H., Olshen, A., Stone, C.J. (1984). *Classification and Regression Trees*. Wadsworth Inc, Monterey, USA.

Kurt, J.P. (1999). Elevage et sécurité alimentaire – quelles conséquences pour l'environnement? *Agriculture et développement rural* **6:** 41–46.

Leegwater, P. (1999). Working oxen, more than traction alone. International Agricultural Centre, Wageningen, 13pp.

Seignobos, C. (1998). Le pays Mundang du "Progrès" au "Développement durable". DPGT-SODECOTON-ORSTOM, Garoua, Cameroun. 121pp.

Speybroeck, N., Berkvens, D., Mfoukou-Ntsakala, A., Aerts, M., Hens, N., Van Huylenbroeck, G. & Thys, E. (2004). Classification Trees versus Multinomial Models in the analysis of urban farming systems in Central Africa. *Agricultural Systems*, **80**: 133–149.

Steinberg, D., Colla, P.L. (1995). CART: Tree-Structured Non parametric Data Analysis. *Salford Systems*. San Diego, US.

Stata Corp. (2001). Stata Statistical software, Release 7.0 College Station, TX: Stata Corporation.

Vall, E. & Abakar, O. (1997). Optimalisation du couple animal-outil Applications aux cas du zébu, de l'âne et du cheval au Nord-Cameroun. In : Seiny, B. L., Poulain, J. F., Faure, G. (Eds), *Agricultures des savanes du Nord-Cameroun: vers un développement solidaire des savanes d'Afrique centrale*. pp227–238. Actes de l'atelier d'échange, Garoua, Cameroun, 528pp.

Vall, E., Ebangui, A.L., Cardinale, E., Njoya, A. & Dugué, P. (1997). Exploitation de l'énergie animale. Diversité de la traction animale et pratique de la culture attelée. In : Seiny, B.L., Poulain, J.F., Faure, G. (Eds), *Agricultures des savanes du Nord-Cameroun: vers un développement solidaire des savanes d'Afrique centrale*. pp137–147. Actes de l'atelier d'échange, Garoua, Cameroun. 528pp.

Vall, E., Dongmo Ngoutsop, A.L., Abakar, O. Meyer, C. (2002a). La traction animale dans le nouveau contexte des savanes cotonnières du Tchad, du Cameroun et de la République

centrafricaine I. Diffusion de la traction animale et sa place dans les exploitations. *Revue Elev. Méd. Vét. Pays Trop*. **55**: 117–128.
Vall, E., Dongmo Ngoutsop, A.L., Abakar, O. Meyer, C. (2002b). La traction animale dans le nouveau contexte des savanes cotonnières du Tchad, du Cameroun et de la République centrafricaine II. Quelle priorité pour la recherche et le développement. *Revue Elev. Méd. Vét. Pays Trop*. **55**: 117–128.
Ziébé, R. (2003). Gestion des ressources pastorales : facteurs décisionnels et rapports sociaux dans le canton de Boboyo, Extrême-Nord Cameroun, Thèse MSc Vét, IMTA, n°115, 53pp.

2. LATIN AMERICA

(a) Mexico

Field performance of animal drawn tillage ploughs in dryland Mexico

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Abstract
Animals are the main source of power for crop production in rainfed areas of Mexico. Ploughs used for soil tillage turn the soil over promoting soil water loss through evaporation. These tools can have different construction features and as the power available from animals is limited, it is important to measure their power requirements. In this study, a mouldboard plough, a V-shaped sweep tool for horizontal tillage, and a two-sided wings plough were tested and comparisons on their performance were made. Measurements were made on available soil moisture and draught power requirements. The soil with the best moisture conservation was where the mouldboard plough was employed, however, the two-sided wings plough required the minor draught, and the horizontal-cut tillage plough required the largest draught.

Introduction
In Mexico modern agriculture uses advanced technology and greatly efficient crop production techniques. However, there is a large group of small-farmers that cannot afford this highly developed technology. This small-scale sub-sector represent 2,243,138 holdings that cultivate 5,574,770 ha, with an average farm size of 2.5 ha. Constraints for adopting this technology do exist, of which the most important are probably the existence of uneconomic-sized holdings, the production of crops generating low-returns, the employment of traditional methods of production, the existence of restrictive conditions to cropping pattern and, in many instances, inadequate access to agro-support services. This is also associated to subsistence agriculture practised by peasants who occupy rolling lands with poor soils in dryland areas with low and erratic rainfall.

Regarding power application for crop production, three basic energy sources are used for agricultural work in Mexico: farmer/manual tools, farmer/animal power, and farmer/machine systems. In fact, these systems are usually found side by side, though they vary in their size, distribution and relative importance (Table 6) (Rubio, 2000). The distribution of power application in agriculture shows that human, animal traction and a combination of mechanical power and work animals systems are located in low-resource areas. 25% of total power provided to agriculture comes from bovines and equines (3,765,774) (INEGI, 1994).

Table 6: Numbers of holdings and agricultural land according to type of power source

Power source	Holdings	Farmland (000 ha)
Tractor	828,258	3,492.6
Animal	796,785	5,885.4
Animal-Tractor	1,011,643	7,993.6
Human	717,267	10,706.1
Human-Animal-Tractor	444,940	2,440.9
Total	**3,798,893**	**30,518.6**

More than 50% of Mexican territory is semi-arid where human activity in agriculture depends upon low, seasonal and ill-distributed rainfall. However, despite the wide range of climatic, soil types, topography and agricultural production systems draft animals are still widely used by small farmers. Draught animals are mainly employed to farm less than 10 ha plots. However, there is a high risk of soil degradation as farmers utilize inadequate farm practices. It is estimated that in these regions 8 out of 10 farmers rise crops for their own consumption. In these less fertile regions, mechanical mechanisation still is relatively expensive for the farmer, and better animal-drawn implements remain the most suitable means of increasing productivity.

Traditional tillage tools are always the more economical assets that small-farmers use with draught animals. In the past, several attempts were made in order to introduce improved ploughs even multiple-purpose devices, however, just a few considered in their design that water conservation was a functional priority. According to Hopfen (1970), mouldboard plough is an appropriate tool for soil tillage in temperate regions with an even distribution of rainfall. Although, it is not recommended for being used in dryland areas small-farmers still use it. Therefore, a change for alternative farm practices or the employment of suitable tillage tools is needed.

Tillage by making a cross horizontal cut to the direction of travel into the soil is considered a less aggressive technique to work the soil, as there is less soil movement and transportation. As there is less contact between soil and steel it is being assumed that the draught requirement is much less than other tillage ploughs (Bouza *et al*., 1997).

The objective of this study was to evaluate the field performance of three ploughs for draught animals by measuring draught power requirements and soil water conservation whilst soil loosening is performed in the dryland region of Mexico.

Materials and methods

A testing site was selected within a farm plot. Soil at the experimental site had a silt texture. Regarding soil moisture characteristics, the parameters measured were: moisture at field capacity = 29%; permanent wilting point = 13%; and available moisture =16%.

Soil preparation for seeding was carried out by a ploughing operation using the tested ploughs (Figure 4): mouldboard; two-sided wings and V-shaped leading blade for horizontal cut. The mouldboard plough consists of a support beam (2) with multiple hitching points (5), a handle (1), a share for cutting (4) and a mouldboard (3) for inverting the soil. The two-sided wings plough also called '*ranchero*' is constituted with a handle

(1), a hitching beam (2), a soil-engaging part (3) made of cast iron with a treaded strut (6) for adjusting the draught line, incorporating adjustable wings (5) to both sides and a share (4) for cutting. The plough with a V-shaped sweep for horizontal cut consists of two handles, a slightly horizontal beam with multiple hitching points, a delta-shaped horizontal blade and a share for cutting.

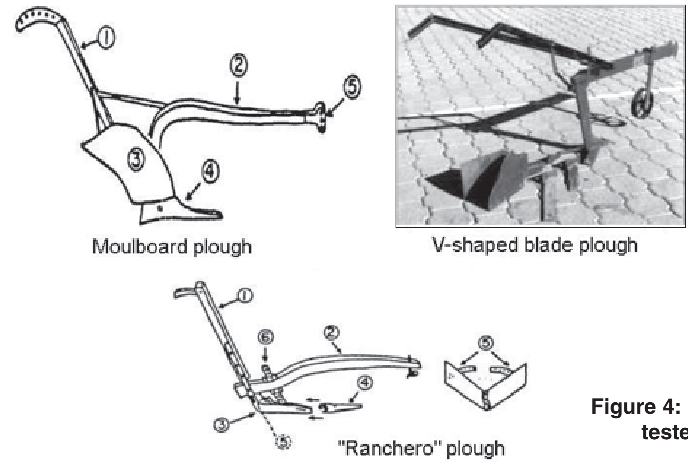

Figure 4: Draught animal tested ploughs

Oat was broadcasted applying a dosage of 100 kg/ha and fertilised with a formulae of 80–40–00. After seeding, seeds were covered by a harrowing operation by dragging a long steel beam. Four water applications were programmed for crop growth.

Determination of dry matter of oat

Samples of oat biomass at maturity (156 days after seeding) were taken from an area of one sq. metre from each test trip. This biomass was oven dried in order to obtain the amount of dry matter.

Draught power measurement

Draught power measurement was realised while ploughing. The measuring and sensing equipment (Ortiz, 1998) consisted of: (a) a portable datalogger for data recording and storing, (b) a load transducer constructed to resist a stress of 6–8 kg/mm² for measuring the draught force, (c) a rotary potentiometer to measure the draught angle from the soil surface and (d) a bicycle-type voltage generator, mounted on a mechanism of sprockets and chains to measure the real forward travel speed of animals pulling the plough (Plate 6).

All instruments and devices were programmed and carefully calibrated in the laboratory. All sensors had a linear response. At testing, sensors were attached to the datalogger and starting and ending phases were established for each run. Data stored in the datalogger was transferred to a computer for data manipulation.

Results

Working operation of draught animal ploughs

The mouldboard functioned by cutting, lifting and inverting the soil strata. Soil is transported along the width of the mouldboard. Precious soil moisture is lost through

Plate 6: Instruments for measuring speed, draught angle and draught force in Mexico (H. Ortiz-Laurel)

evaporation by handling the soil in this way. Conversely, the two-sided wings '*ranchero*' plough created an array of furrow and ridge for each pass. The ridge was destroyed and the soil returned to the furrow bottom in the next adjacent pass, and so on, thus soil was completely loosen and strata fairly put back to its original location. The V-shaped sweep plough did not performed a complete non-inverting soil tillage operation because the soil was partially turn over, however, crop and weeds residues remained over the soil surface. Working depth for the three plough was kept constant at 150 mm.

Bulk density

The value obtained before ploughing was 1.32 g/cm³, and after crop harvesting a new sample for determining it was taken and the lowest value obtained was in the site where the two-sided wings '*ranchero*' plough was used (Table 7).

Table 7: Average soil bulk density after harvesting obtained for the tested ploughs

Plough	Bulk density (g/cm³)[1] before ploughing = 1.32
Mouldboard	1.33^{a}
V-shaped sweep	1.29^{ab}
Two-sided wings	1.26^{b}

[1]Different subscripts indicate significant differences at 5% level

Oat biomass production

This parameter was sampled during crop development and the largest biomass yield obtained was in the sites where the two-sided wings and mouldboard were used (Table 8).

Table 8: Average oat biomass production as obtained from cultivation operation by the tested ploughs

Plough	Oat dry matter(kg/m^2)
Mouldboard	1.273
V-shaped sweep	0.862
Two-sided wings	1.271

Draught power requirement

Data from draught force, draught angle and real forward travel speed were combined to obtain the power demanded by each plough. It was determined that the two-sided wings '*ranchero*' plough required less draught power than the other two. Conversely, the V-shaped sweep plough required more draught power than the other two ploughs. It is assumed that one of its drawbacks is that it is heavily constructed (Table 9).

Table 9: Average values of draught power requirement for tested ploughs

Plough	Draught power requirement[1](kW)
Mouldboard	0.487^{ab}
V-shaped sweep	0.507^{a}
Two-sided wings	0.444^{b}

[1]Different subscripts indicate significant differences at 5% level

Conclusions

The soil bulk density produced by the two-sided wings '*ranchero*' plough was 4.5% less than the value obtained before ploughing. This was also the lowest for all three ploughs. The largest yield of biomass was achieved with '*ranchero*' and mouldboard plough. Power requirement for 'ranchero' plough was 0.44 kW – the lowest. On the other hand, The V-shaped leading blade plough required 0.51 kW – the largest.

References

Bouza, G.H.C., Ronzoni, R.G., Serpa, R.I., Martínez, M.P., Fagundo, G.F., Sánchez, A.P., Cardenal, N.yJ., Ledezma, R. (1997). Nuevo implemento para uso racional de tracción animal. En: Cruz, L.A.D., Rivera, M.yJ.J., Arredondo, A. (Eds) *Memoria del Primer Foro Nacional sobre el Empleo de Animales de Trabajo en la Agricultura y el Desarrollo Sustentable*. Centro Regional Universitario Centro Occidente, Universidad Autónoma Chapingo. Morelia, Michoacán. p. 167–178.

Hopfen, H.J. (1970). Aperos de labranza para las regiones áridas y tropicales. Cuaderno de Fomento Agropecuario No. 91. FAO. Roma, Italia. 154 pp.

INEGI (1994). (National Institute for Statistics, Geography and Informatics) – VII Censo Nacional Agropecuario (National Agricultural-Livestock Census). Tomos I y II. Mexico.

Ortiz, L.H. (1998). Instrumentación para medir la aplicación de la potencia de los caballos de tiro. Proceedings of the Third International Colloquium on Working Equids. México. pp184–191.

Rubio, G.E. (2000). Catálogo de Tecnología Intermedia (Intermediate Technology Catalogue). Secretaría de Agricultura, Ganadería y Desarrollo Rural. Mexico. 3–26.

ASIA

(a) Pakistan

Use of camel as draught animal in Pakistan

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Abstract

Pakistan possesses 1.2 million heads of camel. Out of it almost 0.2 to 0.3 million male camels and equal number of female camels are engaged in draught purposes either as pack animals or pulling carts or other work. They work from 2.5 to 10 hours /day depending upon the nature of job and localities (rural or urban areas). During the work these animals are exposed to different cruelties and stresses. Amongst these stresses, improper housing and beating by sticks were the most common and ranged from 19 and 16%, respectively. The cases of use of sick, wounded and weak animals were found to be 12, 11 and 14 %, respectively. The share of camel work in daily income was never less than 50% and it was a significant contribution. It was observed that animals in cities were more prone to different types of cruelties than rural ones. The comparison of cruelties locality wise indicated that use of sticks was the highest in urban (19%) than rural (7%) locations and was almost double. The economic pressure and people's behaviour may be the reasons for the differences.

Introduction

Draught animals are a unique form of renewable energy, converting the solar energy through plant life–into useful products and services.

Draught animal power (DAP) simply refers to the 'muscle power' of draught animals. The draught animals are mainly kept for:

- ploughing the agriculture land
- hauling carts
- pulling agricultural implements
- running certain other devices such as Persian wheels, sugarcane and seed crushers etc.
- use as pack animal (to carry load on their backs)
- handling, dragging and stacking timber logs in the forests
- mobile grocery shops (selling goods on animal driven carts)
- a sports animals (racing, hunting, polo, tent pegging, riding etc).

Significance of draught animal power

It is reported that by the year 2000 agriculture production should be double and to meet this requirement, ample amounts of energy are needed for various agricultural activities. Animal draught is still a main component of many small farm holders in developing countries. According to an estimate about 250 million working animals provide the draught power to approximately 28% of the world's arable land, equivalent to 52% of total cropping land in developing countries. In South-Eastern and East Asia, animal draught is decreasing in importance as rapid mechanisation takes place but on the other hand its use in cities as ADVs (animal driven vehicles) is increasing. In Africa mixed farming systems are developing in which draught animals playing a key role (World Bank, 1995).

In developing countries, animal power is used to cultivate about 52% of the 480 million hectares of cropland (FAO, 1994). DAP provides between 25–64% of the energy needed for cultivation in the irrigated systems of the world. The replacement of DAP is only possible if:

- farmers' income increases substantial
- farm size increases
- technical and maintenance facilities become available at cheaper rates and at farmers' doorstep.

In Pakistan there is need of 0.49 HP/ha farm power but so far availability is only 0.25 HP/ha and out of it 60–70% power is supplied by DAP. On the other hand the annual increase in tractor numbers is only 10%. In 1988–89 Pakistan had 8 million heads of draught power (Hanjra, 1994) that have been increased to 10.8 million heads (35%) by 1998 (Raza *et al*., 1998). It was further estimated that to replace this DAP Pakistan would need Rs 5.76 billion and it is an impossible task (Table 10).

Table 10: Replacement of DAP with mechanisation

Species	Draught Animal (mil.)	Tractors (mil.)
Cattle	6.70	0.87
Buffalo	0.60	0.09
Camel	0.83	0.14
Donkey	2.28	0.136
Mule	0.08	0.01
Horse	0.30	0.04
Total	**10.79**	**1.281**

Amongst the animals mentioned in Table 10, camels plays a significant role in providing draught power for various jobs at farm or on road (Plate 7). The camel is used as a pack animal, ploughing, hauling the goods and as a racing animal.

The present study was conducted to examine the use of the camel in draught power in Pakistan and problems associated with it.

Camels

Pakistan possesses the following breeds of camel:

1. ***Riverine type:*** Maracha, Mahra or Bikaneri; Bagri Booja; Brela; Thari, Dhatti or Dhatt; Larri or Sindhi; Kharai
2. ***Mountainous type:*** Kachi; Makrani or Lassi; Barahvi or Brohi; Pishin

Collection of data

The data were collected through a pre-tested questionnaire and owners were interviewed for 30–45 minutes duration. The questionnaire included topics on management, housing, feeding treatment, health care, cruelties, income etc. During the survey 140 (50% from rural and 50% from urban) owners were interviewed in details to get the information that could help in understanding the problems, set up of draught animals keeping systems, constraints and cruelties under study.

Selection of site

The respondents were selected at random from rural and urban localities around the Faisalabad (Pakistan). Faisalabad City is the centre of textile industry. Along with heavy textile mills, a wide network of small units of electric looms is present around and with in the city. DAP plays a pivotal role in this industry. Animals are used to transport yarn and finished goods to and from factories. DAP is the best solution to coop this task due to the small and unpaved streets, narrow paths and short distances.

Plate 7: A Camel owner harnessing his animal in Pakistan (S.H. Raza)

Data analysis

The collected data were analysed to draw the valid information on different parameters and objectives discussed in the previous sections.

Results and discussion

Table 11: Inventory of camel numbers in rural and urban areas and source

	Rural		Urban	
	Male	**Female**	**Male**	**Female**
Home produced	5	8	4	35
Purchased	1	–	9	1
Total	6	8	13	36

The inventory of draught camels kept by rural and urban owners in given in Table 11. It was worth observing that number of home produced females was much higher than males both in urban and rural localities. Both the localities followed the similar trend. The main reason for such trend was found that owners prefer to keep and raise females as future breeder and as well as source of income by selling the milk. In this way they get double benefit. They get draught power and milk also. In comparison to donkeys, the trend was reverse. In urban localities the trend of female raising (90%) was much higher than rural areas (62%). A possible reason could be the economic return associated with their keeping.

Table 12: Working of pack animals (hours/day) in rural and urban areas

	Rural				Urban			
	Winter		Summer		Winter		Summer	
	Male	Female	Male	Female	Male	Female	Male	Female
Donkey								
Pack animal	8		8					
Tanga/cart	6.5–10	8	6.5–12		4.5–13	9	4.5–10	3.5– 5.5
Draught	9		8.0–10					
Horse								
Pack animal	1					8		8
Tanga/cart	6.5–8	8	6.5– 9		6.0–12	7.5–11	5.5–10	6.5–11.0
Draught								
Camel								
Pack animal	2.5–7.5	7.5	5.0– 9	7.5–9	5.0– 8	5–8		8
Tanga/cart	8		10		5.5– 9	8	5.0– 9	
Draught								

Working profile

The hours worked of different animals used for the draught purposes during 'summer and winter' in 'rural' and urban 'localities' is given in Table 12. Working hours for camels ranged from 2.5 – 8 hours and 5–10 hours when used as pack and draught animals, respectively. The working hours for female and male camels were almost equal, with the exception that use of the 'female' animals used for carting, which was only in urban areas during the winter season. Females were not used for pulling carts in rural areas. But their use as pack animal was in vogue in rural areas in both the seasons. The male animals were used as pack animal in both the localities except in summer in urban areas. The working hours in rural areas for pack animals were longer than for those in urban. The traffic laws and municipality ordinance could be the possible reasons.

Cruelties in draught animals

During performing the draught work these animals were subjected to the different kinds of cruelties and stresses by the owners due to various reasons. A complete list of cruelties and their ranking is given in Table 13. The use of improper and poor housing was found the most significant (19%) factor of stress in camels. The second in the rank cruelty was 'use of stick' (16%). The use of weak (14%) and sick (12) camels was the next in the ranking. The percentage of use of wounded animals was also quite high (10%).

The comparison of cruelties by locality indicated that the use of a stick was the highest in urban locality (19%) than rural (7%) and was almost double (Table 14). The incidences of overloading were slightly higher in urban (10 vs 7%). The incidence of improper housing was higher in rural than urban areas. The use of sick animals in urban area was almost double that in rural areas (Table 14). The economic pressure could be the one reason for this trend as animal feed and other costs are quite expensive in cities. The percentage of wounded animals was almost the similar in the both localities.

The use of preventive measures against different diseases was very low and only a small percentage (1.5%) adopted a vaccination programme in rural communities. The most probable reason could be that when a vaccination programme in rural area is started each year (when veterinary staff go to villages) at that time camels are also vaccinated. In cities no owner bothers to take his animal to a veterinarian for vaccination. The most probable reasons for the different types of cruelties are given in Table 15. 77% of cruelties were in urban and 23% in rural areas.

Table 13: Overall cruelties inflicted (%) on camels

Types	Camel
Spike	0
Stick	16
Leather strip	3
Tail twist	0
Tail biting	0
Over load	9
Wounded animal	11
Weak	14
Sick	12
Improper housing	19
Lack of weather protection during winter	7

Table 14: Comparison of cruelties in rural and urban areas

Sources	Rural	Urban
Spike	0	0
Stick	7	0
Leather strip	0	19
Tail twist	0	4
Tail biting	0	0
Over load	7	0
Wounded animal	11	9
Weak	14	11
Sick	7	14
Improper housing	21	14
Weather protection: winter	14	18
Weather protection: summer	18	5
Disease control	0	5
Flies control	0	1

Table 15: Reasons for cruelties imposed on DAs (%)

Reasons	Rural	Urban	Total
Financial Constraints	29	35	31
No other source of income	40	20	31
Education level	21	25	23
No answer	10	21	15

Share in daily income

The share of working camels in daily income of owners either as pack animals or pulling carts was significant (Table 14). Camels make a large monitory contribution ranging from 45–50% of daily income, US$ 6–7 (Rs. 360–375) per day.

Recently, the situation has started to change. The new traffic laws, people's awareness about the air and road pollution, increasing mechanisation in urban localities and strict civic laws have forced the owners to find the alternatives to

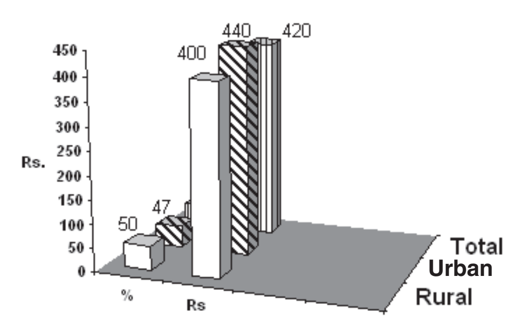

Figure 5: Share of camel work in daily income

camel power. The owners are selling their camels and buying old tractors and using the same camel-cart with very little modifications.
If an owner does not find a job to do, the machine can stand idle but the animal needs feed and looking after. In this way animal traction power is becoming expensive in cities, but still there are certain jobs that can only be done by animal traction power.

Problems related to draught power

The people expressed their views about the problems and constraints related to draught animal business during this study (Table 16).

Table 16: Constraints and problems associated with working camel keeping

Constraints and problems	Rural (%)	Urban (%)
Disease control	6	6
Treatment problem	10	8
Medication	10	11
First aid training	6	5
Equipment	7	8
Govt. Policies	3	6
Feed/constraints	8	12
Automation	8	5
Low return to income	14	7
Status complex	9	3
Children education	12	11
Traffic laws	1	5
Loan for purchase of animals	6	10

People living in both the localities seem to face similar problems with little bit lower or higher intensity. It was good to observe that people showed their concern about their children education. The problem of traffic laws was more important in urban areas because with the new developments many areas have been prohibited for slow and animal-drawn vehicles and in this way draught business is being affected.

Recommendations

- Camel as draught animals will play a pivotal role for many decades to come, therefore, it is necessary that a comprehensive research programme for their rational and efficient use in future be formulated.
- Short courses on draught camel management, disease control, health cover, handling, breeding, training, welfare, housing, feeding and first-aid should be launched in rural and urban areas for DAP users.
- There is dire need to conduct research on animal-driven vehicles, implements and other equipment to make them more appropriate for animals from a welfare point as well as for their efficiency.
- Trained manpower on DAP should be prepared to carry on intensive research work on DAP and its practical implementation.
- There is need to start social and participatory programmes for uplift of the rural and urban draught camel owners through vocational training of females. This training will increase the family income and save animals from undue stresses and cruelties.

References

Hanjra, S.H. (1994). Draught animals management. *In:* Shah, S.I., Bashir, E. & Bantel, R. (Eds) *Animal Husbandry*. 1st edit. National Book Foundation, Islamabad, Pakistan. pp. 279–292.

Raza, S.H., Ahmed, S. and Iqbal, A. (1998). *Ready Recknor for Animal Scientists*. Soft Logo, University of Agriculture, Faisalabad.

World Bank (1995). Potential and constraints of the Indian livestock sector. Internal Report. World Bank, Washington D.C.

FAO (1994) Livestock: Recognizing their role in sustainable agriculture. Rome. Italy.

(b) India

Shoeing of work animals in India

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Draught bullocks intended for work on hard ground need shoeing regularly. It is one of the important husbandry activities in a draught animal management system. The splitting of horny cover, undue wear can be prevented by shoeing. It also provides additional grip while walking. In cattle hooves anatomically little wall is present and it is thin. This is unsuitable for high nailing. The claw forms a 30º angle with the ground. The ground surface is slightly concave at the front and wider behind. It forms a prominent bulb of soft thin horn, which continues with the skin.

In shoeing, nails must be driven only into outer wall. Nail holes hence are small and near to the edge of the hoof. The thin sole and weak heal must be protected with a wide flat shoe of suitable size. The bearing must be leveled. The shoe must be flat and cover the whole sole.

Tools used

Hammer (large and small), Chisels of various sizes, pincers (sharp and blunt), iron file and the shoes (hand made), shoe nails (two inch long), rope of about 20 feet length either coir or cotton, (Plate 8), a foot stand or bedding material for resting the foot. The heads of the nails are made in such a way that the nail head is accommodated exactly in the fuller.

Plate 8: Tools needed to shoe bullocks in India (N. Kumaravelu)

Man power required

For casting and restraining the animal two to three men are required and one skilled person for trimming and shoeing is required.

Casting the animal

The place of shoeing should be leveled, soft or a sand pit is preferred. In an area where a sand pit is not available bedding material like straw or hay is used to avoid injury to animal. The country method of casting is generally followed. Cotton or coir rope is passed around the flank region and held at the level of para lumbar fossa around its girth and tightened by one person simultaneously the animal is pushed to its right side (Plate 9), in order to avoid any damage to the rumen (due to increase in the intra abdominal pressure the animal loses its balance). After falling down on the ground the head is held towards the flank, the rope is released and the hind limbs are fastened together then left fore limb is secured with the hind limbs now the hind limbs are brought back the right forelimb and is fastened with the rest of the limbs. The head is released and made to rest on a gunny bag filled with bedding material on the ground, to protect its eye.

Plate 9: Casting a bullock for shoeing in India (N. Kumaravelu)

Plate 10: Shoeing a bullock in India (N. Kumaravelu)

Shoeing

The limbs are supported in a raised position using a shoeing stand or a gunny bag filled with straw or any other bedding materials (Plate 10). The old shoes are removed by removing the nails using the pincers. The hoof is trimmed using a chisel. A shoe of appropriate size is chosen. The nails are driven through the holes of the shoe and the horn of the hoof from the bottom (upward and out ward direction) three or four nails are driven in such a way that the bent part of the nail is projecting outward from the horns. The projecting part of the nails are cut at the level of horns and bent down to the level of the hoof surface. The shoe is tightened with the help of hammer. Lateral hoof of all the four limbs are shoed first, now the animal is turned over its back towards the opposite side (left side) and procedure is repeated for all the four medial side hooves. The projections in the shoed area are rasped, smoothened and finally some kerosene is poured to the nailed area (being a disinfectant). For road work and dry ploughing a

Plate 11: Newly shod bullock in India (N. Kumaravelu)

three nailed shoe is sufficient, for heavy work four nailed shoe is preferable (Plate 11), for wet ploughing and puddling shoes may not be required. Shoeing may be done once in a month for tar roadwork and once in three months for animal's works on earthen ground.

The entire operation will be completed by 15–20 minutes. The cost of shoeing per animal is around Rs.75–100 (roughly about US 2$). In India skilled artisans are available in rural and urban areas exclusively for this job.

(c) Indonesia

Bali cattle (*Bos sondaicus*) for draught animal power

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Abstract

A review and questionnaire have been conducted to study Bali cattle used as draught animals in Bali, including a general history and numbers used for work. The literature suggests that wild Bali cattle were domesticated in Java, meanwhile, other literature suggest domestication in Bali. Bali cattle have been employed as draught animals for ploughing in Bali in particular, and carting in and beyond Bali. The male is more favoured for work than the female. Bali cattle are found in all regencies of Bali province. Bulls, steers, male calves, castrated males, cows, heifers and female calves are all found. There are fewer castrated males than the other classses. Purebred Bali cattle are spreading in all regencies of Bali province and are predominantly employed as draught animals.

Introduction

Bali cattle have been recognised as a dual purpose animal for both draught animal power and meat. Bali cattle are one of the few purebred cattle in Indonesia, developed and sustained on the island of Bali. Little information is published internationally about such cattle. Therefore, this review article is carried out to identify the general history, role of Bali cattle, population numbers and specific problems associated with using them for work.

Materials and methods

A literature review and questionnaire in Indonesia were conducted to see what was known about working Bali cattle.

Results and discussion

General history

Bali cattle as one of the purebred cattle in the Indonesia archipilago, were domesticated from wild cattle (*Bos sondaicus*). The wild cattle are still found in several places in Java island (Merkens, 1926; Aalfs, 1934; Meijer, 1962; Payne and Rollinson, 1973; and Darmadja, 1980). These observations are based on some common types and characteristic between domesticated and wild cattle. A blood test is probably the best way to prove such relationships (Namikama and Widodo, 1978).

Scientists cannot agreed as to when Bali cattle domestication started. For example, Meijer (1962), stated that domestication was conducted on Java island, the island about 11 times larger than Bali island and located west of Bali. However, according to Slijper (1954), the Bali cattle were the result of domestication of wild cattle in Bali. Payne and Rollinson (1973), agreed that the Bali cattle as a as purebred originated in Bali island, because Bali island is central to the distribution of Bali cattle for breeding purposes to other islands. The Bali cattle was imported to other islands and developed as local cattle in particular in East Java, South Sulawesi, West Timor as well as other places in Indonesia.

Role of Bali cattle

Up to now Bali cattle is maintained as a purebred on the island of Bali. This role is particularly based on the law and its regulations as a result of Indonesian Veterinarian conference conducted in 1934. Since then, the island of Bali has been declared as a central place for the breed in Indonesia, to assist other islands in improving the quality of local cattle for draught animal power as well as meat. Bali cattle were introduced to Lombok, island located east t of Bali about the same size as Bali island. On this island the Bali cattle developed very well, probably because of sufficient food and favourable climatic conditions. In addition, Bali cattle reproduce easily even where food is in short supply. Payne and Rollinson (1973), Copland (1974) and Darmadja (1980) observed that Bali cattle have a high reproductive performance (70–80% birth rate). In South Sulawesi, the Bali cattle did not develop as well as on Lombok, and according to Klasen (1929) this was probably because South Sulawesi was dominated by swamp buffalo rather than cattle at that time.

Bali cattle cannot be crossed with other breeds, such as, Indian breeds on the island of Bali. However, beyond Bali island crossing is permitted in order to improve the quality of local breeds.

Bali cattle for draught animal power

Male and female Bali cattle are used for ploughing in Bali in both irrigation paddy fields and dryland areas (Plate 12) during both major climatic seasons, the hot/dry (March to September) and the cool/humid (or “rainy” October till February) seasons. Ambient temperatures (DB) during the hot/dry season are the highest, by 5–10 °C, but relative humidity in that season is 20–25% less (at about 70%) than during the cool/humid season (Table 17).

Herweijer (1947) pointed out, that Bali cattle were only used for draught animal power for ploughing since the second world war. Prior to that time, Bali cattle were bred by the king’s family, and were less accessible to farmers (Klasen, 1929).

Table 17: Environmental temperatures during fields trials with Bali cattle at Sangsit village, Bali, Indonesia in cool/humid and hot/dry seasons

		Cool/humid season: D.B. °C	W.B. °C	max. °C	min. °C	Hot/dry season: D.B. °C	W.B. °C	max. °C	min. °C
day 1:	7.00	28.5	26.5			21.0	20.0		
	9.00	29.5	27.0			32.0	24.0		
	11.00	33.5	29.5	35.0	25.5	39.5	30.0	37.0	22.0
day 2:	7.00	26.5	25.5			20.0	19.0		
	9.00	32.5	29.0			29.0	25.0		
	11.00	34.5	30.5	39.0	24.5	37.0	29.0	37.0	22.0
day 3:	7.00	25.0	24.0			21.0	19.0		
	9.00	30.5	28.5			32.0	27.0		
	11.00	32.5	29.0	35.0	25.0	36.0	28.0	32.0	22.0
day 4:	7.00	25.0	24.0			22.0	20.0		
	9.00	27.0	26.5			32.0	26.0		
	11.00	27.5	27.0	29.0	24.5	42.0	32.0	42.0	19.0
day 5:	7.00	24.5	24.0			21.0	19.0		
	9.00	26.5	26.0			31.0	27.0		
	11.00	31.5	29.5	32.5	24.0	43.0	33.0	43.0	20.0
day 6:	7.00	27.0	26.0			22.0	21.0		
	9.00	28.5	27.0			37.0	30.0		
	11.00	31.0	28.5	34.0	27.0	43.0	32.0	41.0	21.0
mean:	7.00	26.1	25.0			21.2	19.7		
	9.00	29.1	27.3			32.2	26.5		
	11.00	31.8	29.0	39.5	24.0	40.1	30.4	43.0	19.0

From: Kasa (1995)

Plate 12: A pair (male and female) of Bali cattle ploughing dryland in Indonesia (I.W. Kasa)

In some places in Bali, particularly the Northern part, the time between cool/humid and hot/dry seasons is usually used for bull racing festivals. Farmers in that time have finished harvesting their crop yields, especially paddy-rice, where farmers usually have enough foodstuffs to fulfil their daily life. Therefore, such time is used for entertaining among others by celebrating with bull racing festivals. Recently, the situation has changed and bull racing can be performed everyday as a tourist attraction.

When used for draught animal power, Kasa *et al.* (1997) suggested there were differences in physiological responses between the sexes (male and female Bali cattle). The male was more stressed than the female (Table 18). A similar patter was also reported in difference sexes of swamp buffalo (Kasa, 1998).

Population number

Based on their status, the Bali cattle are divided into bull, steer, male calf, castrated, cow, heifer and female calf. Kasa (2001), pointed out that population numbers of Bali cattle from 1991 to 1995 on such division are shown in Table 19.

Table 18: Mean respiration rate (RR/min) and rectal temperature (RT °C) of male and female Bali cattle working in the field during the cool/humid and hot/dry seasons

Seasons	Cool/humid	Hot/dry	SEM	Level of significance
RR:	52a	75b	0.400	**
RT:	39.1a	39.5b	0.002	**
Sexes:	**Male**	**Female**	**SEM**	**Level of significance**
RR:	66a	61b	0.040	*
RT:	39.4a	39.2b	0.002	**

Values within lines with dissimilar superscripts differ significantly (***P<0.001; **P<0.01 and *P<0.05).
After: Kasa *et al.* (1997)

Table 19: Mean population (heads) of Bali cattle as draught animal power from 1991 to 1995 in Bali

Year:	1991	1992	1993	1994	1995		SEM	Level of significance
	65875	67384	69098	71425	73382		965	ns
Status:	**Bull**	**Steer**	**Male calf**	**Castrated**	**Cow**	**Heifer**	**Female calf**	**SEM**	***
	71859 a	52718 bf	57841 be	7032 c	175670 d	62103 e	58805 ef	1402	

Values within lines with dissimilar superscripts differ significantly (ns not significant; ***P<0.001).
After: Kasa (2001)

There has been no significant change in numbers of Bali cattle on Bali from 1991 to 1995 (Table 3), however, statistical differences (P<0.001) are found between status.

The mean population of castrated male cattle is the lowest. . The highest is cows which are numerically almost 25 fold numbers of castrated cattle. Bali cattle as a dual purpose breed in both draught animal power and meat arecurrently (2003) found throughout the nine regencies of Bali island (Table 20).

Table 20: Bali cattle population on nine regencies of Bali province

Regency	Bull	Steer	Male calf	Castrated	Cow	Heifer	Female calf	Total
Denpasar	85	601	829	44	2669	1450	1344	7022
Badung	5040	6227	5129	108	13603	6743	5676	42526
Gianyar	7642	7873	6061	–	19152	6873	6092	53693
Klungkung	4364	4441	5755	32	17975	5229	5516	43312
Karangasem	21526	18251	15518	85	43032	18091	16945	133448
Bangli	21533	18387	9260	–	14458	6200	5799	75637
Buleleng	11383	13383	13851	555	33426	13646	13299	99543
Jembrana	625	1658	2974	525	13098	4616	4289	27785
Tabanan	8432	10987	6369	–	17880	7236	5911	56815
Total	80630	81808	65746	1349	175293	70084	64871	539781

From: Anon. (2003)

From the table it can be seen that most of the Bali cattle population is concentrated in the two regencies of Karangasem and Buleleng. Factors affecting such spreading could be natural condition of each regency, e.g. environmental temperature, rainfall, soil fertility etc. Moreover, all of those factors will influence the availability of feedstuff such as, green forage, grass, legume, straw and others. This will in turn influence stocking rate as well as carrying capacity of the area. Such a fact is supported by Nitis, *et al.* (1989), Teleni and Hogan (1989) and Ffoulkes and Bamualim (1989). For example, Nitis *et al.* (1989) pointed out that carrying capacity (animal unit/ha) improved from 1.0 to 2.8 when green forage availability increased from 812 kg to 2023 kg respectively. Therefore, the conclusion would be, better natural conditions will increase population number of Bali cattle in both regencies of Karangasem and Buleleng.

References

Aalfs, H.G. (1934). De Rundeveeteelt op het Eiland Bali, Proefschrifi, H.J.Smith, Utrecht.

Anonymous (2003). Animal husbandry census data of Bali province. p.1.

Copland, R.S. (1974). Observations on Banteng cattle in Sabah. *Trop.Anim.Hlth.Prod*. **6**: 89–94.

Darmadja, S.G.N.D. (1980). Husbandry of traditional cattle under agricultural ecosystem in Bali during fifty years period. Doctorate thesis, Padjadjaran University, Bandung, Indonesia. Available in Indonesian language.

Ffoulkes, D. and Bamualim, A. (1989). Improving the nutrition level of draught animals using available feed. In: Hoffmann, D., Nari, J. and Petheram, R.J. (eds) *Draught Animals in Rural Development*. Proceeding of an International Research Symposium, Cipanas, Indonesia, 3–7 July 1989. pp. 134–145.

Herweijer, C.H. (1947). De Ontwikkeling der Runderteelt in Zuid Celebes en de Megelijkheid tot het Stichten van Ranch Bedrijven; *Hemera Zoa*, **56**: 222.

Kasa, I.W. (1995). Heat tolerance and evaporative cooling in goats, buffalo and cattle under tropical conditions and during exercise. Ph.D. thesis, Department of Animal Science, UNE, Armidale, NSW–2351, Australia.

Kasa, I.W. (1998). Physiological responses of male and female black swamp buffalo working in the field during the hot/dry and cool/humid seasons in Bali, Indonesia. *Draught Animal News*

(Center for Tropical Veterinary Medicine, Edinburgh, UK), **28**: 17–22.

Kasa, I.W. (2001). Development of Bali cattle population within 5 year periods (1991–1995) in Bali province. *Journal of Biology*, **5**(1): 28–31. Available in Indonesian language.

Kasa, I.W., Hill, M.K., Thwaites, C.J., and Baillie, N.D. (1997). The effects of seasons (hot/dry and cool/humid) on thermoregulatory responses of male and female Bali cattle working in the field. *Asian-Australasian Journal of Animal Sciences.* **10**: 64–69.

Klasen, J.H. (1929). Enkele Mededelingen Omtrent de Runder Fokkerij in Zuid Celebes; ned Ind. Bl.v. Diergeneeskunde, **41**: 69.

Meijer, W.C.P. (1962). Das Balirind. A. Zieman Verslag Wittenberg Lutherstandt. Merkens, J. (1926). De Paarden en Rundenteelt in Nederlandsch IndieVeeartsenijkundige Mededeeling No.51. Departement van Landbouw Nijverheid en Handel.

Namikawa, T. and W.Widodo (1978). Electrophoretic variation of hemoglobin and serum albumin in the Indonesian cattle including Bali cattle. *Jap. Journ. of Zootech. Sci.* **49**(11).

Nitis, I.M., Lana, K., Suarna, M., Sukanten, W., Putra, S. and Arga, W. (1989). Three strata forage system for cattle feeds and feeding in dryland farming area in Bali. Final Report to IDRC, Canada. 252 pp.

Payne, W.J.A. and D.H.L. Rollinson (1979). Bali cattle. *World Anim.Rev.* **7**: 13–21.

Slijper, E.J. (1954). Mens en Huisdier; J.B. Wolters, Utrecht.

Teleni, E. and Hogan, J.P. (1989). Nutrition of draught animals. In: Hoffmann, D., Nari, J. and Petheram, R.J. (eds) *Draught Animals in Rural Development.* Proceeding of an International Research Symposium, Cipanas, Indonesia, 3–7 July 1989. pp. 118–133.

SHORT NOTES AND NEWS

■ News from ACT

ACT the African Conservation Tillage Network are changing format and are looking for your views especially as to how the newsletter should be presented. Comments can be sent to Richard Fowler rmfowler@iafrica.com or actnownews@iafrica.com. The website is at www.fao.org/act-network. Martin Bwalya is running the network and co-ordinating the initial planning for the third World Conservation Agricultural congress, more in the next issue of DAN on this. Martin can be contacted at actsecre@africaonline.co.zw.

■ A new transport website

www.sustranssa.co.za is a new information and networking website devoted to sustainable mobility in South Africa. The site focuses on improvements to public transport, non-motorised transport services and infrastructure in South Africa. If you would like to receive an email alert with the latest news from SusTrans SA please email: sustransa@csir.co.za

■ DFID Livestock Production Programme

have a new look to its website: www.lpp.uk.com. The emphasis of the site is now more on providing users with information on the outputs of the programme. Any comments on the site should be sent to Tina Rolland at t.rowland@nrint.co.uk.

■ NEW JBF (Scotland) website

JBF who are a charity working with cattle in India have just redesigned their website http://indiacattlecare.org to reflect their specialised involvement with Indian cattle largely in urban areas.

■ Tillers International

Tillers International have moved to a new farm 10515 East OP Avenue, Scotts, Michigan 49088 see their website www.wmich.edu/tillers/home.

■ Rural Heritage update

The following books are new in the Rural Bookstore:

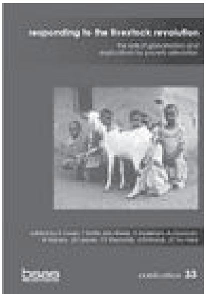
- Heavy Horses
- Guide to Raising and Showing Mules
- Identifying Horse-Drawn Farm Implements
- Essential Guide to Carriage Driving
- Stonework

New Videotapes include:

- Fundamentals of Driving Mules, Vol. I
- Logging with Horses, Oxen and Mules

For more information see http://ruralheritage.com or RURAL HERITAGE, 281 Dean Ridge Lane, Gainesboro, TN 38562–5039.

NEW BOOK



NOTTINGHAM University Press

responding to the livestock revolution

The role of globalisation and implications for poverty alleviation

BSAS Publication No. 33

Edited by E Owen, T Smith, MA Steele, S Anderson, AJ Duncan, M Herrero, JD Leaver, CK Reynolds, JI Richards and JC Ku-Vera

Paperback 354 pages • ISBN 1–904761–518 • £35.00 (£25.00 to delegates)

This book discusses the Livestock Revolution which is occurring in some developing countries and is foreseen to become a wider phenomenon over the next 20 years, due to increases in population, urbanisation and incomes. As a result, a gigantic increase in demand for meat and milk is predicted. The many implications for animal agriculture in developing countries, and globally, are considered. The recurring question addressed is whether the Livestock Revolution will help or hinder the alleviation of poverty amongst resource-poor livestock farmers.

As well as the Livestock Revolution, topics addressed include poverty mapping, impact of trade agreements, bio-security constraints to trade, environmental implications, the role of animal science research and GM technology, development aid, knowledge management and dissemination, and case studies of the milk sector in Bolivia, Kenya and Nepal.

The book will be invaluable to all concerned with animal agriculture and poverty alleviation, be they lecturers, students, policy makers, researchers or practitioners, including farmers and their advisers.

Order from: Nottingham University Press, Manor Farm, Church Lane, Thrumpton, Nottingham NG11 0AX, UK
Tel: +44(0)115–983 1011 • Fax: +44(0)115–983 1003
email: orders@nup.com • website: www.nup.com

LETTERS TO THE EDITOR

■ **Rob Johnson from Australia writes:**

"I wish to make up an Ox Collar in the 'after Eggerts'style (*Modern Harness for Working Cattle*, Dr Rolf Minhorst) and would like any help if possible. Is there anyone out there with experience in this style of collar?

I have a pair of 'Steinmetz-Boss', and find the bullocks prefer them, and work happier and better than in a yoke , but I would like to try the 'Eggerts' style. I would like to hear from anyone with any experience in this subject."

Rob Johnson (email: rjohnson@netcon.net.au)

■ **Barney Muckle from Kenya writes in response to M.L. Mautsa's letter in DAN39 re soyabean harvesters**:

"I read with interest your letter in the current edition of DAN [DAN 39] and am sending some thoughts on the problem which I have had over the years:

I first came into contact with the problem in N Africa where the crop was chick peas but growing in rows as with most of the pulses. The cost of harvesting was high as was the levels of loss and the difficulties of finding labour to work in mid summer temperatures up to 50 degc! You may be aware of the efforts of the (then) NIAE at Silsoe with a single row tractor powered twin belt lifter for sprouts and other vegetables. It was intended to be multi purpose.

I do not know the details of what happened when it went commercial but the lifting system was simple and could be ground wheel driven and steered by an operator. Soil conditions for ground wheel drive are good at harvest time.

My vision is to have a lifter loading into a box(s) which would be tipped on a plastic sheet to avoid losses from shattering. The remaining operations may vary from hand threshing to a engine powered stationary machine. The lifting part may well have application as a contractors tool for small farms where lifting and moving to a threshing site is highly labour intensive. It could have application to all most of the pulse crops grown in Eastern Africa. —Your comments appreciated."

Barney Muckle, Triple W Engineering Ltd, P.O. Box 176 Naro Moru 10105, Kenya (email: muckletb@africaonline.co.ke)

■ **From Gracia Matondo in The Democratic Republic of the Congo a request for drawings or samples of animal-drawn equipment to help in fabrication [or even some technical support]**

"L'armée du salut en République Démocratique du Congo vient de lancer un projet de promotion de la traction animale. Les forgerons locaux sont entrain de fabriquer des équipements comme charrues, herses, semoirs, charrettes mais avec beaucoups d'erreurs et ca décourage des paysans. Voudriez vous nous aider avec des fiches techniques sur la fabrication des ces différents équipements?

y a t'il possibilité pour une ONG de nous envoyer quelques équipements originaux que nous pourrion adapter avec précision et assurer la diffusion?"

Gracia Matondo, Major, Secrétaire au Développement, Armée du Salut/Salvation Army, pour Congo Kinshasa & Angola, BP 8636 Kinshasa Gombe, Rép. Dém. du Congo (email: Gracia_matondo@kin.salvationarmy.org)

■ **Abdul-Rahman Mustapha a lecturer writes from the Yobe State College of Agriculture in Nigeria to**:

"request literature concerning draught animals, with particular reference to bulls and donkeys, which are the common animals for that purpose in my area. I hope to undertake a research proposal concerning the blood chemistry of these animals with particular interest in donkeys, such information is lacking in my area."

Abdul-Rahman Mustapha, Yobe State College of Agriculture, Gujba, PMB 1104, Damaturu, Yobe State, Nigeria.

■ **Paul Starkey from UK writes in response to Peta Jones' letter requesting information on donkeys controlling crop insects in Sri lanka (DAN39 Letters)**:

"I certainly came across this in Sri Lanka. In the central/southern wet areas there are few donkeys, but those that are kept are often kept simply to protect their coconut palm plantations. I cannot remember the insects or the proposed mechanism, but everyone knows it works!"

Paul Starkey, Oxgate, 64 Northcourt Avenue, Reading RG2 7HQ, UK (email: P.H.Starkey@reading.ac.uk)

Mohamed Salim Azzouz writes from the USA

"Although, my field of study – Solid Mechanics – is away far from Ecological Agriculture,my interests in the area of Renewable Energy have prompted the present letter.

Considering Draught Animals as an interesting potential to produce Bio-Renewable Energy, I'm asking for information about Draught Animals used to produce electricity. I searched the Internet without success. The idea to use Draught Animals in the field of Energy Production is complementary to the idea to use Draught Animals in the Agricultural Field using modern technology.

The basic idea of my research comes from a simple fact that huge new wind turbines use slow motion blades, 9–20 rpm. Through mechanical gearboxes or power electronics they can produce a great deal of electricity. The parallel between a wind turbine and a Draught Animal is the slow rotating motion. A question arises then, can we use the slow rotating motion combined with the power of Draught Animals as a potential to produce electricity. The electricity will be produced using the new generation of slow variable speed electricity generators, like ABB's Windformer generator?

With respect of what was said in the above paragraphs, many technological and economical questions arise. Known that on an average basis a Draught Horse can pull during 10 hours a day a load of 180 pounds, How many Draught animals are needed to fit a particular electricity generator, let's say 10 Kw? Is it economically viable? What would be then the Kwh price? Is it competitive? Keeping in mind that the animals have to be fed and maintained in good health. Can we imagine a series of electricity generators driven by a huge number of Draught Animals? In that case what would be the electrical output power? Can we use the aforementioned principle of electricity production to produce Hydrogen through electrolyte circuits? The question has been recently raised to use wind farms for that purpose. Many questions can further be asked.

I believe that the feasibility of electricity generation systems through the use of Draught Animals deserves to be thoroughly studied in the academia. It is an inter-disciplinary area that needs the cooperation between the Animal traction community and the Renewable Energy Community. The economical outcome of such perspective could have many implications in shaping the future of energy production. I'll be glad, if you can supply me with some useful information concerning the aforementioned field."

Mohamed Salim Azzouz, PhD Candidate, Aerospace Department, 241 Kaufman Hall, Old Dominion University, Norfolk, Virginia, 23518, USA (email: asali001@odu.edu)

MEETING REPORTS

ISRA CIRAD IRAD Association TIN TUA

Main conclusions of the International Exchange Workshop:

Animal traction and operator strategies: what kind of research and services in view of State decommitment?

Held 17 to 21 November 2003 at Bobo Dioulasso in Burkina Faso

CIRDES, IRAD, ISRA, Association Tin Tua, CIRAD
Financial backing CIRAD and CTA, report by Eric Vall

Introduction

In the savannah areas of West and Central Africa, animal traction is still a current and future resource for durable development of family farming. However, over about 20 years, the decommitment of States from agro-industrial sectors has led to the dismantling of services supporting animal traction, which has in turn upset access conditions and possibilities for servicing draught teams and equipment. Today, producers and their organizations on the one side, public and private agricultural support services on the other are taking action to develop and coordinate their activities so as to rebuild a service system based on animal traction.

From 1999 to 2003, the CIRAD and its partners have carried out a multidisciplinary research project based on the renewal of producers' needs, the emerging systems to provide services and the adaptation of research practices in animal traction (Action Thematic Traction (Programmed Thematic Action) 'Animal Traction'[1]). This ATP provided the opportunity for a group of researchers from EMVT[2], TERA[3], CA[4] and ISRA[5] in Senegal, IRAD[6] and SADEL-GIE[7] in Cameroon and the Tin Tua Association[8] in Burkina Faso to discuss the adaptation of research methods and study a portfolio of proposed orientations for development actions concerning animal traction. Today, demand is growing with two trends: (i) the first, emerging trend, concerns new operations and the conditions for ensuring long-term services; (ii) the second concerns the renewal of producers' needs (financing animal traction, adapting techniques,

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[1]Complete title of the ATP: Animal traction; an essential part of producers' strategies in Western and Central Africa: what are the research practicies to be envisaged, in view of State decommitment? • [2]CIRAD Department of Tropical Veterinary Medicine and Stock raising • [3]CIRAD Land, Resources and Operators Department • [4]CIRAD Annual Crops Department • [5]Senegal Institute for Agroomic Research • [6]Institute of Agricultural Research for Development • [7]Local Development Support Service (design office) • [8]NGO/PO working in Gourmanché countries

agriculture-livestock raising, support/advice).

Problems

Over the past fifty years, through its multiple functions, animal traction has become a keystone of peasant strategy in this region (mechanisation of technical aspects, animal-drawn transport, diversification of household income, savings on the hoof...). The technical history is linked to the boom in industrial cultures (cotton, peanuts, rice) administered by regional bodies (companies, agencies, offices) to which the State delegated a rural development function. These bodies first used public funds to set up a set of coordinated services, destined to facilitate diffusion of the technique throughout the agricultural communities which very often did not raise stock. Gradually, the income from industrial agriculture was enough for peasants to afford animals and agricultural equipment and to develop mixed strategies based on agriculture and stock raising on their farms (capitalisation in the herd, diversification of crops for income and for food). However, over the past twenty years, with State decommitment, these support structures have experienced a steep decline in resources and have been gradually dismantled. In view of these developments, research relative to animal traction is questioned by producers and emerging service providers (financial services, veterinary surgeons, blacksmiths, support/advice services) on the following points:

1. What are the consequences of the reconstitution (break down?) of support services on animal traction services and producer strategies? How can producers continue to buy and keep their animals and tools in future? What are the technical adaptations to be linked with the changes in Sub-Saharan Africa?
2. Under what conditions will the new public or private service providers develop their activity and ensure its durability?
3. What are the current research and development priorities concerning animal traction? What are the research practices to be envisaged in view of this new information?

Main results

The results of the ATP were presented at the International exchange workshop on ‘Animal traction and operator strategies: what kind of research and services in view of State decommitment?’, held in Bobo-Dioulasso from 17 to 21 November 2003 under the Aegis of the CIRDES and with the financial backing of the CIRAD and CTA. At least sixty people concerned by animal traction attended, as well as various professions (in research and development) and different countries (Burkina, Cameroon, France, Great Britain, Guinea, Madagascar, Mali, Niger, Senegal, Chad). About 50% of the papers were also free contributions on the workshop theme. A certain number of conclusions were reached at the workshop, of which we shall note here a few updated observations and research themes.

The major disparities still existing in Sub-Saharan Africa relative to the use of animal energy, justify a sustained effort to help the least developed regions and poorest family farms to benefit (Figure 6). In Africa, this technology still plays a major role in reducing the drudgery of human labour, improving the productivity of agricultural production systems and alleviating poverty. The ATP gave the opportunity to determine the consequences of State decommitment with respect to animal traction and service development (Table 21).

Table 21: Comparison of the position of animal traction and support services relative to the level of State decommitment on 3 ATP areas

State decommitment Land	Total since 1980 Senegal peanut basin	In progress since 1992 North-Cameroon cotton basin	Forgotten region Eastern Burkina Faso
Pluviometry (mm/year) Population density (inhab/km²) Crops grown Percentage of house-holds with draught teams	400–600 > 80 Mil/Sorg/Peanuts 90 %	700–1200 10–50 (sud) 50 à 150 (nord) Sorg/Cotton (north) Peanuts/Cotton/Maize (south) 25–30 %	800–1100 20 à 50 Sorg/Peanuts (north) Sorg/Peanuts/Cotton (south) < 20%
Dominant draught species and career management	Horses and donkeys Long careers	Pairs of oxen (2/3) Donkeys (1/3) Oxen: 4–5 years Donkeys: long	Donkeys (dominant) Pairs of oxen Donkeys: long Oxen: ?
Animal-draught cultivation Animal-draught transport Evolution of equipment and itk	sowing/hoeing/lifting Carts (rural) Carriages (urbain) Highly developed Ageing seed drills Adaptation of hoes, lifters/craftsmen Seed deterioration	ploughing/hoeing/ earthing-up Ox-drawn carts Not very common Fewer heavy ploughs Adaptation of light ploughs/craftsmen Dvpt TCS and hoeing	Ploughing/(hoeing)/ earthing-up Donkey-drawn wagons Not very common Mainly manual work
Integration of agriculture and stock raising	SPAI access very difficult Recovery of straw and animal dung	SPAI access protected by Sodécoton Low recovery of animal dung	SPAI access very difficult Low recovery of animal dung
Financial services (credits MT) Agricultural equipment services Vet./zootechnical services Support/advice services Research	CNCA (inadequate) SISMAR (sale of seed drills) Blacksmiths (repairs, other equipment) Private (inadequate) ANCAR and CNCCR (OP) ISRA Bambey	Sodécoton (equipment) IMF (emerging) Manucycle (new) Blacksmiths (PR, ploughs) Sodécoton (good cover) Sodécoton IRAD Garoua	IMF (very inadequate) Blacksmiths and shopkeepers Private (inadequate) NGO and PO None in the East

Before, animal traction support services were provided by regional development organisations: distribution of equipment and sometimes trained animals, credits, health monitoring, input... With liberalisation, these services were taken over by private operators and producers' organisations and must fit into an economic logic. To rebuild a service system based on animal traction there are now three main aspects:

1. To draw up, for each service, content suited to the needs and constraints of its users (producers, craftsmen), particularly for intangible services (support/ advice, credits, veterinary surgeons) which find it difficult to meet demand and reach adequate technical and financial autonomy;
2. Create durable conditions (financial, organisational and social) for each service and the system of services based on animal traction, specifying who will pay? and who will provide quality control for the service?

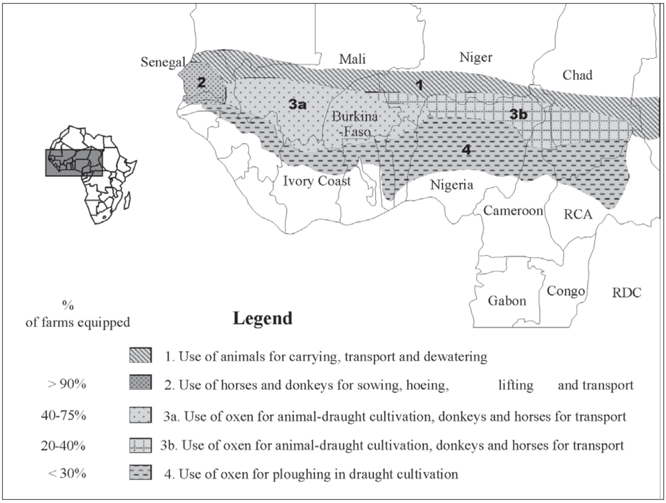


Figure 6: Zoning animal traction in West and Central Africa

3. Coordinate these services based on animal traction, encouraging the emergence of a contractualised consensus-building context in which to formalise this coordination and the instigation of a control and sanction body, provided by a local authority or the State as a last resort.

To support these processes, a system of strategic orientation, definition of a vision for agriculture, distribution of resources and stimulation must be developed: this is the part played by an agricultural policy. Animal traction will not develop without a deliberate agricultural policy in its favour.

At present, technical development is disturbed by this recomposition of socio-technical networks, but it is a period which is propitious for technical and organisational innovations. Where once it essentially involved developing equipment and technical standards, now the development of the context of operations and use of animal traction must be understood and a context of analysis and intervention must be drawn up. For this purpose, research must be transdisciplinary, managed in partnership and implement a proactive procedure for innovation, which we summarise in the idea of coupling research and innovation.

Research and application prospects

Consideration of producers requires research and development activities on the following points:

1. Techniques and equipment (adaptation of technical plans, innovation involving farmers and blacksmiths, adaptation of weedkilling tools, improve harnesses, seed drills and transport equipment).
2. Management of draught animals (management of animal careers, working cow management, equine nutrition, recovery of animal waste, multifunctionality of draught teams).

3. Management of natural resources and integration of farming and stock raising (impact of animal traction on the environment, animal traction and water management on plots of land and catchment basins, production of different sorts of fodder and communal management of plant biomasses).
4. Experimentation of research-action on recommending equipment for young farmers within a logical and 'contextualised' context, and discussion of other types of application of savings which is still, too often, in a rural environment, exclusively in the form of cattle… with the environmental consequences we are aware of in the event of overpasturing.

At the end of this workshop, everyone was also unanimous on the need to restart an animal traction network in French-speaking West and Central Africa (+ Madagascar), based on the CIRDES, a regional organisation which has many advantages. It was suggested that the network should be expanded on a theme of agriculture-stock raising synergy in mixed systems found in larger savannah zones, which may be better in terms of the development of durable agriculture.

Scientific publications and colloquia

Vall E., Lhoste P., Abakar O., Dongmo Ngoutsop A.L. (2003). La traction animale dans le contexte en mutation de l'Afrique subsaharienne : enjeux de développement et de recherche. *Cahiers Agricultures*, **12**(4): 219–226

Vall E., Lhoste Ph. (2003). Animal power in the West and Central Francophone zone of Africa in a renewed context: the issues for development and research achievements. In: Pearson R.A., Lhoste P., Saastamoinen M., Martin-Rosset W. (eds.) *Working Animals in Agriculture and Transport*, EAAP Technical Series N°6, Wageningen Academic Publishers, The Netherlands. pp. 13–25

Havard M., Njoya A., Pirot R., Vall E. and Wampfler B. (1999). Challenges of animal traction research and development in West and Central Africa on the eve of the 21st century. International Conference, Empowering farmers through animal traction into the 21st century, 20–24 September 1999, Loskop Dam Eco Resort, RSA, poster.

Sudan Equestrian Federation

Farriery Course - Khartoum - 2004

An ancient craft in modern times

The second course for trainee Sudanese farriers was held from 5–18 January, based at the Sudan Equestrian Federation (SEF) premises at Elgos, Khartoum. The first course was organised in February 2003, by the same sponsors, SPANA and TAWS in the UK and the SEF in Sudan.

The course leader in January 2004 was Mr David Symons, who is the Head Farrier at the Hereford School of Farriery in England. This was his first visit to Sudan but he has instructed previously on a similar course in Ethiopia and also has gained experience in Mexico and the Far East. Local planning was largely the responsibility of Dr Ayman Nahas, while Professor Ramsay Hovell provided liaison with the sponsoring organisations and equipment suppliers in UK.

This latest course aimed to build on the contents of the first one so that trainees under instruction previously will have reached a more advanced level by the recent closing date. The class consisted of some young practising farriers who are basically competent but also one or two others who up until now had received no formal training. In addition to assessing what trimming is necessary for the hooves of individual horses, according to their conformation and particular movement characteristics, which is termed balancing, shoeing and some metal forging techniques are being taught.

It is quite possible , for example, for some of the basic tools and equipment to be manufactured locally, mainly using blacksmith skills, so this has been organised. Items forged include ones important for removing shoes (buffer), for trimming (hoof pick, toeing knife and foot stand) and for shoeing and nailing (clench groover), as well of course as shoes themselves.

A lecture for owners and managers/trainers had been requested as had demonstrations for veterinary students. All of these training sessions were realised. Practical classes utilised police horses and draught animals, also sports horses of local breeds and thoroughbred type, for demonstration work. Students were individually assessed for aptitude and progress during the course.

30eme Journée de la Recherché Equine

The 30th Equine Research Day was held at the Maison Du Sport Francais Comite National Olympique Francais (CNOSF) on 3 March 2004 organised by les Haras Nationaux. More than 230 people attended the meeting to hear the important scientific results of various projects and courses of study.

The morning session was devoted to the new scientific findings in reproduction, sports aptitude and social sciences. In the afternoon ten presentations were given by international speakers and French researchers on the topics of locomotion and comportment, the wellbeing and the temperament of the horse and training. The meeting was well attended and everyone had ample opportunity to disucss the work inbetween the sessions and over lunch.

The proceedings and outcomes of the meeting are available at a cost of 57.50 Euros from: Service libraire, Les Haras Nationaux, Direction du Developpement, 16, rue Claude Bernard, 75231 Paris Cedex 05 (Phone: (33 1) 44 08 17 52 • Fax: (33 1) 44 08 18 00).

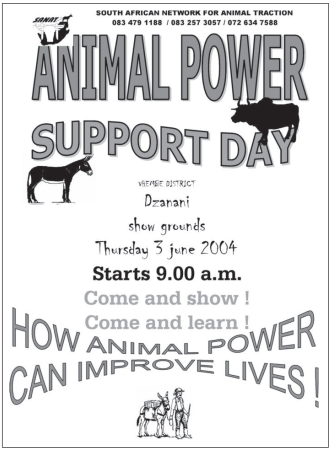
Animal power strongly supported

A report of the SANAT Limpopo Animal Power Support Day

Mashudu Jackson Maroge
Chairman, SANAT Provincial Committee
Tompi Seleka College of Agriculture, 072 634 7588

Thursday 4 June was a big day at the Dzanani Showground, in the Nzhelele valley, Vhembe District of Limpopo Province.

Nearly five hundred owners of working animals – some with their animals – came together at the invitation of SANAT, the South African Network for Animal Traction, to learn how to speak with a loud voice to make government listen to them. At the same time they learned about various people and institutions that could help them with training and skills to make their animals even more useful than they are already. SANAT's



research has already shown how much the use of working animals can improve household production, and how important they are to most smallholder farmers, but until now these farmers have received very little help or notice from government.

HÄSTT South Africa (a division of Steelnet Zimbabwe Ltd), makers of animal-drawn implements for cultivation, demonstrated some of their products, and promised to make them available through local outlets. The University of Venda was represented by Professor Timothy Simalenga, who emphasized that, in many parts of the world, cows (ie. female bovines) were routinely used for work due to the shortage of animals. From the Department of Agriculture was a warning lecture about the impact of HIV/AIDS on agriculture, which makes the role of animal labour all the more important. Professor Simalenga and his students also had a range of books and publications for sale. Most of the attention, however, centred on donkeys, and Donkey Power CC Facilitation and Consultancy demonstrated equipment, including harnesses, that donkey owners could make themselves, along with inexpensive health care products obtainable in most shops.

Posters illustrating the wide range of work done and equipment used by donkeys lined the walls of the hall where intense and participatory discussion took place. It emerged that animal owners were very anxious to have training, as well as access to health care for their animals, and wanted to know where they could access equipment like harnesses and carts. Names and numbers were exchanged, and it was decided that the way forward was to form Animal Power committees at various levels, to communicate with each other and with government.

Plate 13

A ripper planter being demonstrated at the Limpopo animal power day, S Africa (T. Simalenga).

People came from Soutpansberg and from further west from Bochum and Blouberg (Plate 13). A group of farmers and extension workers had come in from as far south as Sekhukhune District, from the northern part of the Drakensberg Mountains, and it was notable that so many mountain people found donkeys so useful. Dr Peta Jones of Donkey Power, who is on the national SANAT committee, also urged them to think of using their animals for tourism, because it is clear that animal power is not a thing of the past, but a thing of the future.

World Association for Transport Animal Welfare and Studies (TAWS)

Common ground: moving forward with animals

TAWS/TAA/BVA workshop held 15 April 2004, Silsoe Research Institute, UK

Workshop report by PH Starkey

The World Association for Transport Animal Welfare and Studies (TAWS) held its 2004 workshop on Thursday 15 April 2004. at the Silsoe Research Institute near Bedford, UK.

The workshop brought together about forty people concerned with working animals and their welfare, including agriculturalists, research staff, veterinarians, representatives of the major charities as well as interested supporters and students. It provided a stimulating and conducive environment to exchange ideas and information, and propose new initiatives and actions in this important field. This event was held in collaboration with the Overseas Group of the British Veterinary Association and the Tropical Agricultural Association. The presentations and papers presented at the meeting are available on the TAWS website: www.taws.org. Topics presented in the morning included: The importance of working animals in the world and the need to find common ground; Animal power for crop production: new tillage or no tillage?; Moving forward with animal power for transport; Collaboration with other organisations: practical and ethical considerations; Efficient yoking and harnessing of animals both oxen and donkeys; and Working cattle in Europe.

Practical demonstrations and posters

Following lunch there were practical demonstrations. After a brief display of donkey ploughing, attention switched to the specialised hitch cart developed by Charles Pinney of Carthorse Machinery. This has a 3-point linkage and a petrol motor to power auxiliary equipment such as manure spreaders. One advantage of this system is that the animals only have to pull the equipment and not power other moving parts from a ground wheel. Costing in the region of £4000–5000 (GBP), the equipment is intended primarily for the European market, although there may be applications in other parts of the world (Plate 14).

During the workshop there were demonstrations of equipment for farriers. TAWS, SPANA and the Overseas Group of the British Veterinary Association (BVA) provided information on their work. There were several posters relating to rural transport, animal welfare and simple animal-drawn carts. A range of publications, CDs, DVDs videos and other resource materials were on display (some available free and some for purchase).

Plate 14 Hitch cart being demonstrated at TAWS meeting, UK (P.H. Starkey).

Group discussions and concrete suggestions

At the start of the afternoon session, Tony Stevens gave a progress report relating to opportunities for students. He explained how the various objectives had been achieved and links created between veterinary colleges and the TAWS/BVA scheme to promote opportunities to get young people involved.

Three discussion groups were formed, to discuss issues relating to harnessing, transport and regulation and collaboration between agencies.

Workshop proceedings, outputs and further information

TAWS have published the papers presented and a summary of the discussions on its website – www.taws.org. Later in 2004, a printed volume of proceedings will be published. The TAWS Secretariat can be contacted at:

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Contact details for The 5th International Colloquium on Working Equines
(details next page)

Colloquium 2006, The Donkey Sanctuary, Sidmouth, Devon EX10 0NU, UK

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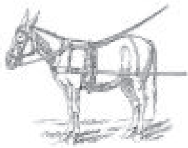
FORTHCOMING EVENTS



The Harness Development Agency

Dedicated to Harnessing the Energy of Working Equines

Working Donkey and Mule Awareness Weekend

With the kind permission and support of Shropshire County Council this event will take place at Acton Scott Working Farm Museum, Church Stretton, Shropshire, on 24th and 25th July 2004. Acton Scott has been established for some 30 years. It was the forerunner, and remains a leading light, in demonstrating farming methods of the late 19th century. Most of the work is undertaken using horsepower. There is on site, a permanent display of carts, wagons and horse drawn agricultural implements. For this reason it makes an ideal site for our proposed event.

We aim to demonstrate working methods and equipment that will enable equines to be used to better effect. This will include practical demonstrations of donkeys and mules in a working environment, ie. carting, carrying and, depending on climatic conditions at the time, ploughing, harrowing and cutting. Contemporary draught equipment suitable for use by donkeys will also be on display. Talks by experts on subjects such as Veterinary concerns, nutrition, foot care and harness provision, are also planned. For more information please contact

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FIRST ANNOUNCEMENT

The 5th International Colloquium on Working Equines

30th October – 2nd November 2006 • Ethiopia

The Future for Working Equines

The Donkey Sanctuary and the Faculty of Veterinary Medicine, Addis Ababa University, the host organisations, are proud to invite participants from all over the world to attend the Fifth International Colloquium on Working Equines, to be held in Ethiopia.

Theme: Sustainable methods of extension and education, welfare issues, animal legislation and environmental considerations.

Format: Three plenary sessions, workshops, demonstrations, field visits and poster sessions.

Host country: Elected as the site for the next colloquium, Ethiopia is a land of stunning natural beauty with a rich diversity of culture and geography that will captivate the visitor. The welcome that comes from the mosaic of a people with over 80 different languages and as many cultures is warm and spontaneous. Whether in the town or the countryside most of the estimated 8 million equines (donkeys, mules and horses) have a central place in Ethiopian life being used to transport produce and other agricultural goods.

Venue is to be confirmed • Registration fee is US$100 • Official language is English

The second announcement providing further details regarding the organisation of the colloquium and call for papers will be published in October 2004. Scholarships/sponsored places will be available. For more information contact the Organising Committee (see p. 58).

HARNESSING AND IMPLEMENTS

Power transmission unit for efficient utilisation of draught animal power in rotary mode of operation

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Introduction

India is endowed with a significant score of the world population of animals. Use of draught animals as source of energy is very dominant and will continue to be so for many more years (Srivastava, 2000). There are about 68 million draught animals in the country. These animals, cultivate about 60 to 65% of total cultivated area (approximate 85–93 million hectares). Rajasthan, the largest state of India (area 0.35 m sq. km) covers 11% of the total area and has 12% livestock population(3.01 m bullocks 0.7 m camels, and 1.3 m donkeys), that contributes to 19% of the total income of the state. The animals give stability to agriculture by subsidizing the income of the farmers.

Draught animals are used for tillage, sowing, interculture, threshing as well as rural transport. As these operations are seasonal, animals are used for 450–1500 hours (or 100–160 days) per year against the optimal utilisation of 2400–2700 hours. Therefore It is necessary to use this available resource in a more meaningful and judicious manner. This is possible through employing animal in the rotary mode of power to operate different agro processing machines (Srivastava, 1987).

Review of literature

Draught animals are traditionally used in rotary mode primarily to lift water from wells by peg gears meshing together (Persian wheel) and also to run the oil expeller (to extract oil from oilseeds) and Juice expeller (to extract sugarcane juice). In some places horizontal flour mills were also operated by animals. Animal powered gears are also used to lift water in remote parts of Africa.

A bullock power rotary complex operated chaff cutter was operated with a pair of Khillary bullock. (Hallikeri *et al.*,1995).An animal drawn reciprocating pump was developed that used two units of hand pumps and reported that the pump was capable of delivering water at rate of 7 lit/sec. at a head of 6 metre (Khepar *et al.,* 1975)

Power take off unit (speed ratio 1:28) was used for running a low head pump, grain cleaner, soyaflaking machine and a flour mill. Main problem in the developed power take off unit (PTU) was the frequent wearing of first stage bevel gear used for stepping up speed as the speed of the gear was low and consequently forces/ torque acting on the gear was very high for a given value of power transmitted, that resulted in excessive wear of the gear teeth (Anonymous, 1993).

In an experiment, on generation of electricity through rotary mode of operation, using a pair of buffalos, at an animal speed of 2.5 kilo metre per hour. The electricity generated was 0.8 kW at a shaft speed of 1300 rpm (Anonymous, 1993).

A power conversion unit that consists of an old gear box of Zetor tractor (speed ratio

1:10) was developed. The mechanical efficiency of the system was 78%. A chain sprocket (1:6) and belt pulley (1:4) were engaged to get speed ratio of 1:240 (Hallikeri, 1995)

The set up for power transmission unit consisted of a bull gear and a belt pulley. A wooden beam was used to operate the bull gear. The set up was used to operate a chaff cutter. They further reported that another power transmission unit consisted of bevel and spur gears, giving a step up of 1:34.3 with mechanical efficiency of 53% (Anonymous, 2000).

A 2 KVA electricity generator was operated by camels in rotary mode of operation. The draught developed was 125 kg (22% of body weight of camel) at a mean speed of 2.62 kmph and 1500 rpm. The generation was 800 watts(Anonymous, 2000).

Many bullocks work for less than 120 days in a year. In general a pair of bullock is required per 4 hectare of land (Bhaid, 1975).A survey in Tarai region of India indicated that average annual utilisation of buffalo was about 485 hours (Anonymous, 1995). Another survey in Bhopal (M.P., India) region indicated that only bullocks were used as draught animals. Their utilisation was very low 238, 285 and 319 hours per pair per year in three villages. The bullocks were used mainly for tillage (72%), sowing (19%) and transport (14%) (Anonymous, 2000).

It was found that 73% of the bullocks were used for less than 40%, only 3% were used for more than 60% of their capacity in the farm operations like blade harrowing, ploughing sowing, and interculture. April-May, July- August and October are busy months (82.15–101 hrs/month) and February is the leanest month (Anonymous, 2000).

Average annual use of bullocks and camels in Rewari region (Haryana, India) was 533 and 499 hours respectively. They suggested use of draught animals for 2500 hours. The use of bullocks consisted of tillage (67%) transport (13%) and sowing (20%) and 44, 37 and 18% for tillage, transport and sowing respectively for camels (Anonymous, 2000).

Plate 15 The power transmission unit developed in India (C.P. Doshi).

It is evident from above that different power transmission units designed and developed are neither popular nor easily available to the farmers. An attempt has been made to develop a power transmission system to overcome the short comings of available power transmission systems.

Developed power transmission unit

The developed power transmission unit is shown in Plate 15 and Figure 7. It consists of a set of crown & pinion and spur gears. The crown and pinion changes the direction of rotary motion of the draught animals and step up the speed in the ratio of 1:5.28. This set of gears supported by ball bearings is enclosed in a mild steel channel frame. The frame has been firmly fixed at the centre of circular track by cement concrete grouting. The output from the crown and pinion is further stepped up by two set of spur gears in the speed ratio of 1:120. A universal joint is used to link the output shaft, which also takes care of the lateral movements in the output of the second stage spur gears. A shaft (dia 25 mm and length 6000 mm) is used to transmit power out side the circular track. The shaft is encased in a hollow pipe (dia 100 mm) and supported at four places by ball bearings. The hollow pipe is firmly grouted to a depth of 300 mm under the soil and thus do not interfere in the walking of the animals. A 'V' belt pulley is attached to the out put shaft, which is utilised to operate agro processing machines.

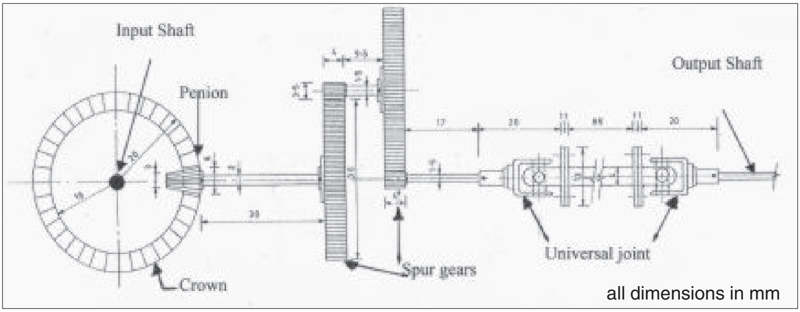

Figure 7: Schematic diagram of the power transmission unit

Animals are hitched to a telescopic beam, which in turn is connected to the input shaft of the power transmission system through a universal joint. This method of coupling eliminates the chances of overturning or any unwanted leverages generated by the animal on the power transmission unit. A ratchet is provided in between the universal joint and the input shaft of the gear system. The ratchet eliminates chances of hammering on the legs of animal by the inertia force of the beam. To further stabilize the operation of the beam a rubber wheel is provided at the outer end of the beam to eliminate the cantilever effect that also helps in reduction of vibration in the beam. At an average speed of 2–3.5 kilometre per hour of draught animals, under normal working radius of (3.5–4.5 metres), provides 2–3 rpm at the input shaft and is stepped up by the system in the range of 240 to 420 rpm at the output pulley. At this available rpm (240–420) different types of small agro processing machines can be operated.

References

Anonymous (1973). Cattle wealth of India. Information Unit, Director of Extension, Ministry of Agriculture, New Delhi.

Anonymous (1993). Annual report. AICRP on UAE with enhanced system efficiency. Coordinating Centre, Central Institute of Agricultural Engineering, Bhopal.

Anonymous (2000). Use of animals in rotary mode of operation a success story. Coordinating Centre, AICRP on UAE, , Central Institute of Agricultural Engineering, Bhopal

Anonymous (2000). Annual report AICRP on UAE with enhanced system efficiency. College of Technology, GBPUA&T Pantnagar, (Uttaranchal) April 10–11, 2000

Anonymous (2000). Bi-Annual report (1998–99), AICRP on UAE with enhanced system efficiency. Coordinating Centre, Central Institute of Agricultural Engineering, Bhopal.

Anonymous (2000). Research Digest of AICRP on UAE with enhanced system efficiency (1985–2000), Krishi Vigyan Kendra, Rampura, Rewari (Haryana).

Anonymous (2000). Survey of Indian Agriculture 2000, 'The Hindu'.

Hallikeri R.C.M., Nelkanthaya, A. and Kumathe, S (1995). Performance of a bullock power operated chaffcutter. Agricultural Engineering Today, **19**(3–4), 39–46.

Khepar, S.D. (1975). Development of animal drawn lift irrigation pump. *Journal of Agricultural Engineering*, **12**

Srivastava, N.S.L. (1987). Utilisation and economics of draught animal power. Technical Bulletin No. CIAE/87/51 Central Institute of Agricultural Engineering, Bhopal.

Srivastava, N.S.L. (1987.) Status of implement research for efficient draught animal power in Indian context. Seminar paper, National seminar on Status of Animal Energy Utilisation held at Central Institute of Agricultural Engineering, Bhopal. Jan. 24–25.

Srivastava, N.S.L. (2000). Animal energy in agriculture. *Agricultural Engineering Today*, **24**.

Rubber tyred carts and punctures

T B Muckle

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Introduction

Animal drawn carts are increasing in popularity on the African continent due to their ability to carry loads greater than those on a wheelbarrow or the human back. Pneumatic rubber tyred wheels and axles as used by motor vehicles are the preferred choice for users of animal carts in most areas of the world. They have many technical advantages over other types of wheel/axle particularly in off-the-road conditions where they play a major transport role. This popularity is partly due to their availability as used and worn components from the motor vehicle industry. Due to their used condition they are relatively low cost and can be recycled to the advantage of urban or rural transporters. Informal cart manufacturing industries, using these parts, are commonly found but recently, due to demand, the parts have become more difficult to locate and the onus to find them is moving to the potential buyer who is responsible for supplying them to the manufacturer.

To this day the pneumatic tyre remains the weakest and least reliable component of a motor vehicle, due to its susceptibility to punctures, and this despite more than 100 years of intensive and costly development. Thus a spare part, in the form of an extra wheel, is still supplied with every new vehicle and should always be carried by prudent motorists. For the owner of a typical animal drawn cart the puncture risk is compounded by the following factors:

- For cost reasons, worn tyres and tubes are mostly used and these have poor puncture resistance even on good road surfaces.
- Road or track surfaces, where carts are used, often have hazards such as sharp stones and thorns which increase the puncture risk.
- Under inflation, due to lack of knowledge and availability of tyre pump/pressure gauge, causes overheating of the side walls of the tyre which, apart from increasing the draft force, raises the puncture risk through tyre damage and by the lifting of poorly gummed patches.
- When a puncture occurs its repair becomes a major problem as no spare wheel is carried and the distance from a repair centre is often far.
- These problems can negate all the advantages of increased carrying capacity of a cart and account for their scarcity in many rural areas.

Punctures are more easily mended near motorised transport routes or where bicycles are popular as enterprising persons soon set up repair facilities due to the demand but the real difficulties occur when transporting to remote areas. In these thinly populated areas the demand for transport is limited and the ‘critical mass’ of carts to justify repair facilities cannot be reached.

Distances from vehicle transport routes can be considerable, up to 50 km in Kadjiado in Kenya for example. Transport of basic food to the interior is carried out by pack donkeys and some head loading but the quantities are limited and the resultant selling prices high. Donkey carts, as has been shown, can increase the amounts transported and reduce the costs to the buyer. However the environment is hostile and many punctures occur. Having a puncture under these conditions is a disaster for the owner(s) of the cart and its load. If tools are available to remove the wheel it must be carried to the nearest repair centre and returned and refitted in order to complete the journey. This can take days and the cart and its load must be guarded. More likely the owner just presses on with a flat tyre which, apart from overloading the animal, destroys the inner tube and perhaps the tyre. In this case the problem of punctures was so great that the carts were abandoned while other reports quote many cases of carts, even with new tyres, abandoned mainly due to punctures.

Puncture reduction options

The problem of punctures is not new and a range of measures has been developed to reduce or eliminate the problem but not all are practical or economic for the current situation.

The first is to fit a higher quality tyre, one with six or eight plies, or to provide a spare wheel. However these measures are costly and not affordable to the user. High capital cost equipment such as earthmovers, which must be operational for long periods without breakdown, have their tyres filled with two chemicals which react to form a spongy mass with similar shock absorbing qualities to air filled tyres thus making them puncture free. However the cost can only be justified for high input projects such as road and dam making. Liquids are available can be injected into the tube through the valve hole and they spread round the inner surfaces as the wheel rotates. They then automatically seal holes which appear in the tube but do not appear to have gained widespread acceptance. Former settlers have spoken of filling the tyre with grass as an emergency means of becoming mobile but on questioning agreed that while it got them home it generally destroyed the tyre.

Puncture free options

As the puncture problem is so great and a permanent limitation to the spread of rural transport to remote areas it is surely better to consider the possibility of making a puncture free tyre thus eliminating the problem completely.

Air, as the medium in a tyre, acts as a cushion to reduce shock loads from the surface undulations or pot holes being passed to the vehicle body and its contents. It is a very effective system for high speed vehicles but for cart speeds of a maximum of 10–12 km/h the impact loads are limited so less resilience in the tyre is needed to protect the cart body. Solid wheels of metal and metal/wood combinations do not provide this resilience and as a result the body must be stronger and more costly to resist the loads. Where a choice exists farmers prefer rubber tyred wheels. Tyres could be made puncture free if a filler medium with similar shock absorbing qualities to air could be identified and techniques developed to replace the air in the tyre.

This company has, over some years, experimented with different materials and means to produce a puncture free tyre and the experiences are described below.

Required characteristics of the filler material

- The material or medium used to fill the tyre must give a similar ride or shock absorbing qualities to that of air so that the user is unaware of any difference.
- It should preferably be a waste product and cheap to obtain especially in rural areas.
- It should be easy to load into the tyre.
- It must not leak out or change characteristics through use and time
- The increase in weight of the puncture free tyre should not be excessive.

Materials and techniques for filling

The objective was to modify a pair of wheels/tyres with some material to support a load of 500 kg without undue deformation. Deformation is the equivalent to running with low pressure which causes overheating and damage to the walls of the tyre.

Use of sawdust

This granular material is susceptible to compression and due to its availability was the first material to be tested in filling a conventional tyre/wheel combination.

Sawdust particles vary in size due to species of tree, method of sawing and moisture content. As it was not possible to get a homogenous sample the sawdust used was that which was available. It was sun dried by exposing a thin layer on a plastic sheet for two days and occasionally stirring it.

The technique developed for filling a standard tyre/wheel is as follows:

- Remove the tube from the rim and refit the tyre.
- Mark out and drill FIVE holes around the rim, the size of the valve hole but equally spaced round the rim. Plate16 shows the rim with the five extra holes. These were made by an arc electrode.
- Cut out a circular cardboard disk to lie on the rim to carry the sawdust and fill any other holes in the rim with cardboard.

Plate 16: A tyre rim showing the five extra holes. These were made by an arc electrode (B Muckle)

Plate 17: Pushing sawdust through the hole (B Muckle)

Plate18: The tyre is nearly filled – part of the tyre is not yet pushed into the well of the rim (B Muckle)

- Pour sawdust on the disk.
- One or more persons sitting round the rim, preferably under a tree, then push the sawdust into the holes using metal rods (Plate 17)
- As the tyre fills it will become more difficult to push in sawdust so use a hammer to compress it. An old engine valve is a useful tool to use as the valve head protects the hand from mis-hits!
- Gradually the tyre will expand in the rim while filling becomes more difficult but it must continue until the tyre is hard against the bead of the rim, as in an air filled tyre. In Plate 18 the tyre is nearly filled– part of the tyre is not yet pushed into the well of the rim)
- When no more sawdust can be added the holes should be blocked using tapered wooden plugs hammered into the holes and the tyre(s) refitted to the cart.
- Use the cart with half load for about one hour and observe the tyres. As the sawdust 'beds' down the walls may flex as with an under inflated tyre. If this occurs remove the plugs and add sawdust to all the holes and repeat the testing exercise.
- Repeat topping up and testing until the tyres no longer flex when under full load.
- The wooden plugs can be left in place, if a good fit, or the holes can be blocked by welding small metal plates.

Trials and results

Dry sawdust

(1) The trials were carried out on 14" rims with a 14 x 6.70 tyre and the weight of sawdust added was 8.5 kg/tyre. The cart, loaded with 500 kg, was pulled at

approximately 5.5km/h on a circular track and the inside tyre wall temperature measured at intervals until it reached a maximum. This was found to be 10 deg Celsius above ambient which was considered satisfactory for a 500 kg load. The temperature on the inside of the tyre wall was measured to avoid the direct heating effect of the sun. In long term trials some of the tyres became soft and investigation showed the sawdust had reduced to a fine powder. It was concluded that the sawdust had not been packed sufficiently tightly and had 'moved' due to the constant flexing of the tyre. It was decided to try wet sawdust as a filler.

Wet sawdust

(2) The sawdust was wetted and the surplus water squeezed out by hand. The filling technique was similar to that previously described. Trials showed that the addition of water made the tyre virtually solid and the cushioning of shock loads no longer occurred and the users were not willing to use carts with these tyres and the technique was abandoned.

Dry sawdust revisited

(3) It was clear that dry sawdust had the potential for cushioning the loads so further work was carried out on refining the filling techniques. This involved adding more sawdust and running longer periods to 'bed' it in then refilling so that the particles are locked together and cannot move against each other to create a powder.

Availability of sawdust

(4) Where sawmills exist the by product is generally available but due to excessive tree felling and changes in government policy on Conservation some of these mills have closed down and the previous mountains of sawdust have gone.

Other materials as fillers

Rubber grindings

(5) A search was made for other materials and an approach to a tyre retreading company indicated that prior to retreading the tyre is ground to have the required profile. The particles of rubber removed from the tyre are then thrown out as scrap so samples were used to fill the tyre. The same techniques were used and it was found that the grindings were easier to load into the tyre than sawdust especially the final topping up. The tyre had more bounce when dropped on the ground but the weight was greater by 4 kg. This was not considered to be a handicap. The supply of grindings decreased as other uses were found for it and while it was free there was a considerable transport cost from the capital city to the rural area. Not all countries have retreading factories so while this material makes a good filler its availability is limited.

Materials proposed but not tested

Rice husks

(6) Where rice is grown and milled there are often large amounts of husks available but they are of low density and may not be easy to load into the tyre.

Dry crop stalks

(7) If dry crop stalks such as maize or sorghum could be finely chopped up into small particles then these may be able to be loaded into tyres with sufficient density. Their availability would be good but the technique has not yet been tested.

Conclusion

The problem of punctures on animal drawn carts in remote rural is very real and limiting their use to the farmers detriment and development. Trials, spread over some years, have shown that the problem can be overcome by replacing the air with sawdust or rubber grindings but the availability of both these materials may be limiting. More work is needed to identify suitable materials which are readily available and low cost. Some have been proposed and the author would encourage staff and students of agricultural engineering institutions to take up the challenge of trying to identify which may be suitable and so produce simple techniques which could be applied to hundreds of thousands of animal carts in the world.

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