4. Less common harnessing systems

4.1 Full-collars and three-pad harnesses for cattle

Although it is common, perhaps almost conventional, for people to *advocate* that cattle should be harnessed with collars, harnessing collars are seldom actually *used* in Africa (outside the confines of research stations or small, charitable development projects). For this reason they are discussed here as *non-conventional* harnessing systems, in order to stress that, to date, they have not been widely adopted. In Europe, collars for horses spread rapidly after the eleventh century, and for several hundred years in Europe horses were harnessed with full collars for heavy work and with breast-bands for lighter work. As the horse collar spread, so collars were developed for use with oxen. Ox collars were adopted in some localities in Europe (Steinmetz, 1936), but they were never employed to the same extent that horse collars were used. In Europe head yokes, withers yokes, ox-collars and flexible harnesses coexisted for centuries without one clearly dominant oxen harnessing system emerging. More recently ox-yokes and collars coexisted in North America.

While wooden yokes for oxen appear to have had worldwide dominance on farms for cen-

Fig. 4-1: Full collar harness on a British ox. Collars and yokes co-existed in Britain for many years.

Photo: Archives of Institute of Agricultural History, Reading

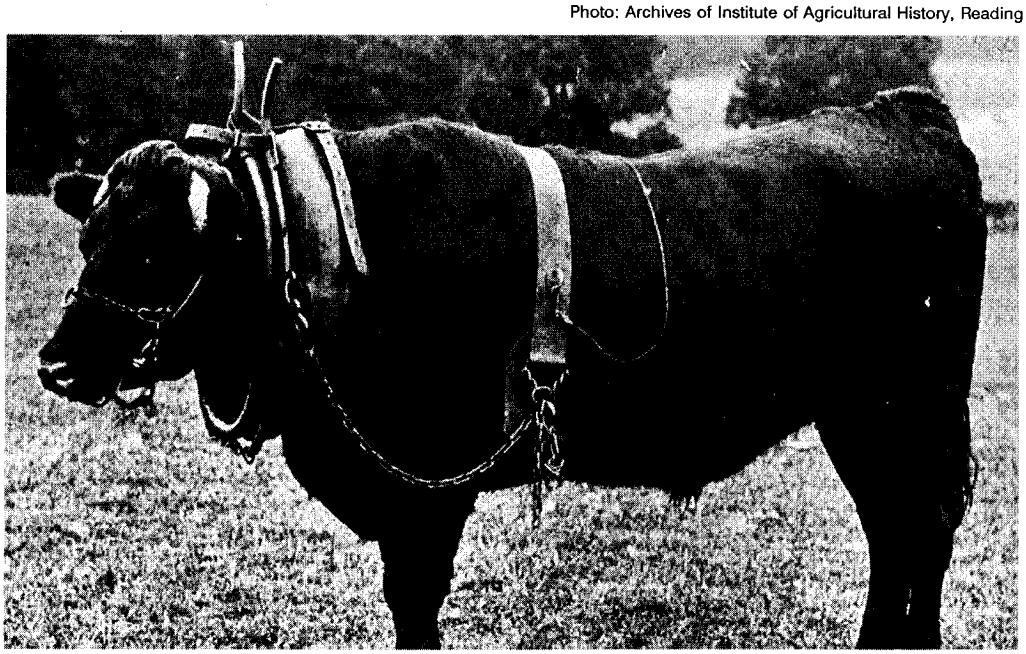


Photo:UEA/David Gibbon

Fig. 4-2: Three-pad collar harness being used at the University of East Anglia, UK.

turies, innovative farmers and researchers have repeatedly tried to develop more efficient and comfortable harnessing systems, and have several times developed different forms of bovine collar. The three-pad collar harness for oxen was one such innovation, developed in Europe this century. In response to a shortage of draft horses prior to and during the Second World War, farmers in Switzerland had to harness cattle for work. The full "Berne" ox-collar (Fig. 4-3c) was expensive and complicated to make, and a simpler derivative, the 3-pad collar was developed by the Féderation suisse d'élevage de la race tachetée rouge (FSERT) (Wenger, 1938; FSERT, undated; Micuta, 1985). The three-pad harness was apparently well received, spread quite rapidly in certain areas, and is still used to a very limited extent in parts of Switzerland and Germany. The harness comprises two wooden hames, hinged by leather straps at the top, and joined by a removable chain at the bottom (Fig. 4-3a). The hames are shaped to exactly match the contours of the animal. The shoulders of the animal are protected from direct contact with the hames

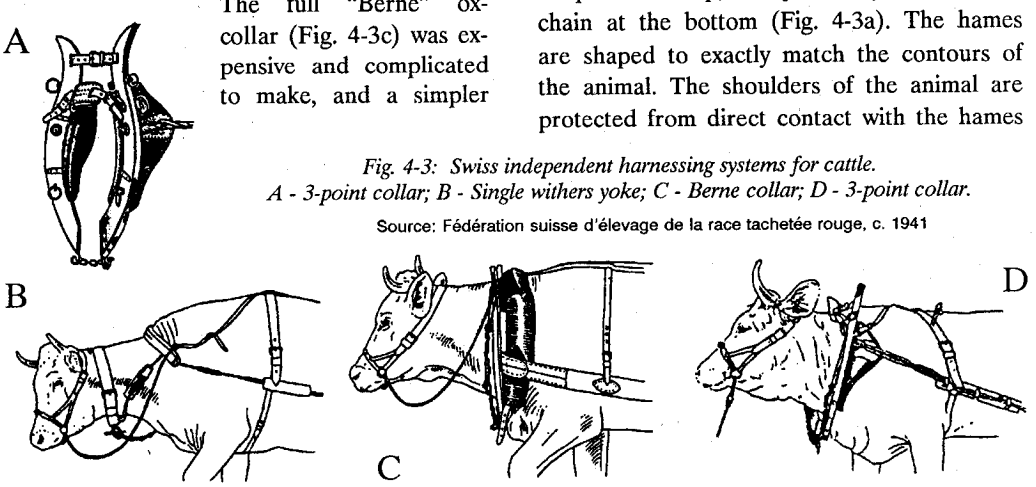


Fig. 4-3: Swiss independent harnessing systems for cattle.
A - 3-point collar; B - Single withers yoke; C - Berne collar; D - 3-point collar.

Source: Fédération suisse d'élevage de la race tachetée rouge, c. 1941

Photo: Paul Starkey

Fig. 4-4: Three-pad collar harness being demonstrated at the University of Nairobi, Kenya.

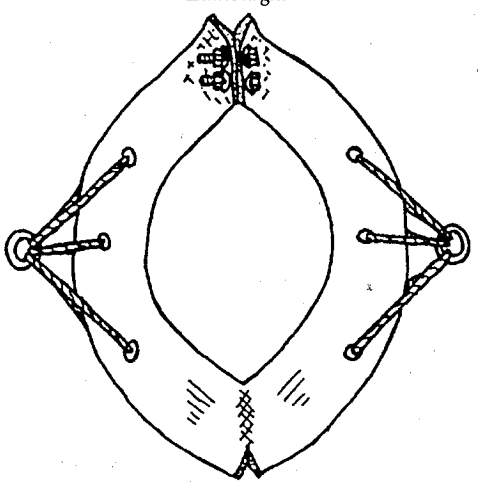
by two pads, traditionally made of leather stuffed with animal hair, but more recently made from canvas or sack cloth. The third pad is attached to the upper strap which rests on the withers.

Many authors have highlighted the advantages of the three pad harness in increasing the surface area of contact, lowering the angle of pull and increasing the comfort of the animal (Hopfen, 1969; Barton *et al.*, 1982; Micuta, 1985; Dibbits, 1986). However three-pad harnesses are much more expensive to make than yokes, and are more complicated to fit and use. Collars and three-pad harnesses have been assessed in many African countries, but have not been adopted by farmers to any significant extent. Recent artisanal training schemes in Kenya and Zambia have shown that it is feasible to make such harnesses at village level (Dibbits, 1985). However such initiatives have not yet demonstrated that the technology can be sustained by farmers purchasing the harnesses from the artisans.

4.2 Tyre collars and flexible harnesses

Full collars and three-pad harnesses are expensive to make, but collars for cattle and buffalo can also be made from old car or motorcycle tyres. These have been evaluated in Botswana (Froese, 1980), Scotland (Lawrence,

Fig. 4-5: Prototype tyre collar tested at CTVM, Edinburgh.



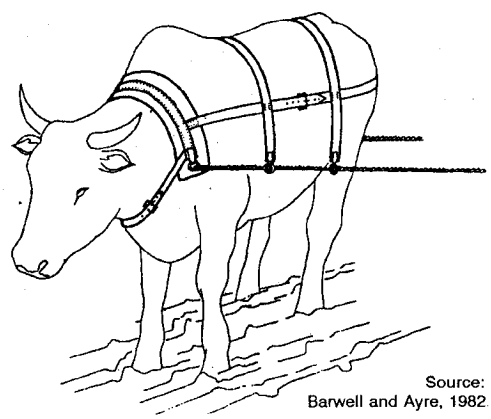
Source: Lawrence, 1987

Photo: Bob Munro/CTVM

Fig. 4-6: Tyre collar harness being tested on ergometer track at the Centre for Tropical Veterinary Medicine, University of Edinburgh.

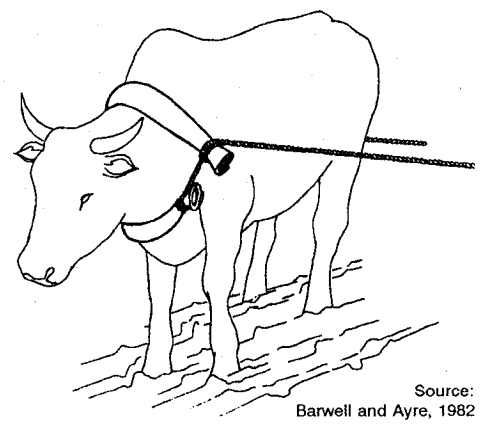
1983), Malaysia (Kehoe and Chan, 1987) and Thailand (Van Koeverden, 1987). Tyre-collars have some of the advantages of more conventional collars (low hitch point, large surface area for applying work) while being substantially cheaper. However since they have no wooden hames, they distort more easily than three-pad harnesses, causing the effective surface area to be reduced when the collar is under strain. There are also reports of discomfort caused by the attachment ropes and the materials used to join the tyre sections (wire or bolts). Kehoe and Chan (1987) found that tyre collars became uncomfortable to buffaloes if they became hot, and so they recommended they only be used in shaded conditions, such as beneath oilpalm trees. Although tyre collars have been found acceptable in on-station trials, there has been little adoption by farmers, and so, as with all non-conventional systems, the technology should be treated with some caution.

Fig. 4-7: European design of flexible withers yoke/harness made from leather. In operation it was similar to the Swiss withers yoke (Fig. 4-3).



Source: Barwell and Ayre, 1982

Fig. 4-8: Prototype flexible withers yoke made from sacking as tested in Zimbabwe.



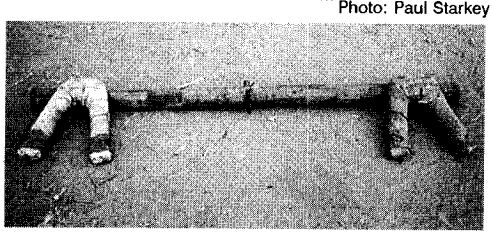
Source: Barwell and Ayre, 1982

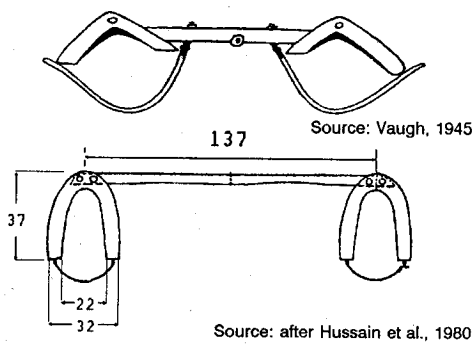
Another system designed for single, or independently hitched animals is the flexible harness. In its simplest form this operates like a single withers yoke made of flexible material such as leather, tyre rubber, sacking or webbing, to which the traces are attached. In order to prevent slippage and allow forces to be spread, a breast band may be attached, as may be a series of back straps and girth straps. Flexible harnesses held in place by a series of leather straps were used with cattle in Europe, and have been experimentally evaluated in Zimbabwe (Barwell and Ayre, 1982) and Malaysia (Kehoe and Chan, 1987). The flexible harness has some of the advantages of collars (low hitch point, large surface area) and also some of the disadvantages (more complicated to fit and use than a yoke). To date there has been no significant farmer adoption of such harnesses in Africa.

4.3 Collar-type yokes

In some Mediterranean countries equines have been yoked together with a traditional design of withers yoke that has padded descending processes, designed to allow the animals to push from their shoulders as well as their withers. Comparable collar-yokes designed for oxen have been developed in India (Vaugh, 1945, Varshney *et al*, 1982) and Bangladesh (Hussain *et al*, 1980) and many similar designs have been tested in Africa (Fig. 4-9). A similar concept was used in the development of the "Allahabad" yoke in India, which is not unlike a pair of three-pad harnesses linked with a metal yoke (Swamy-Rao, 1964; Ayre, 1982). Collar-type yokes combine some

Fig. 4-9: Prototype collar-type yoke being tested by a mission in Zambia. Photo: Paul Starkey





Source: Vaugh, 1945

Source: after Hussain et al., 1980

Fig. 4-10: Prototype collar-type yokes.
***Top:** Design tested on-station in India and found to be significantly inferior to traditional designs.*
***Below:** Design tested on-station in Bangladesh and found to be comparable to, or slightly better than, traditional yokes. Dimensions in centimetres.*

of the advantages and disadvantages of collars and yokes. Collar-yokes do not require independent hitching arrangements, which can be both beneficial (no need for traces and swingle trees) and disadvantageous (the rigidity of yokes is sometimes criticised for causing discomfort and restricting free movement). The hitching height of collar yokes is often intermediate between that of a traditional withers yoke and a full collar or three-pad harness.

Simple collar yokes appear to offer increased comfort through larger contact area and padding without a great increase in cost or complexity (although it should be noted that the Allahabad yoke was significantly more expensive and complicated than a traditional yoke). Some prototypes have performed very favourably in on-station trials, although it should be mentioned that in trials in India in the 1940s, an "improved" collar-type yoke performed significantly worse than all traditional yoking designs evaluated (Vaugh, 1945). Nevertheless recent farmer adoption of collar yokes has been minimal. Indeed some designs that were initially hailed as important breakthroughs in harnessing research (such as the Allahabad yoke) are actually no longer used even on the research stations where they were developed.

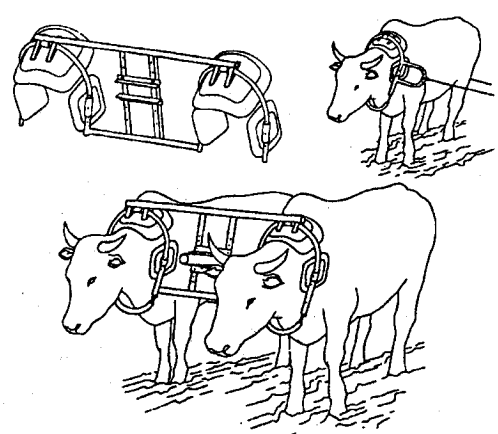
4.4 The merits and demerits of collars for oxen

Most of the criticisms of collars for oxen relate to their relative cost and complexity compared with simple yokes rather than their technical efficiency. However one ox team driver from the United States has recently argued (on the basis of observation and opinion rather than measurement) that collars are not technically appropriate for oxen (Conroy, 1988). Conroy (who by voice alone can encourage a yoked pair of oxen to pull over twice its weight on a flat sledge) argues that a well-fitted yoke is more effective, since collars tend to interfere with the animals' mobile and relatively pointed shoulders and slide out of position when the oxen lower their heads during work. The key words here may be "well-fitted", for any poorly fitted harnessing system is likely to be inferior to a well-fitted one.

Most of the arguments in favour of collars relate to claims that collars improve the power, work output or efficiency (seldom defined) of working cattle. In formulating recommendations for Botswana, Orev (1977) claimed "The horse collar harness has been found to increase the draught power 4-5 times, as compared with a yoke, therefore short of actual trials it is safe to assume that the 3-pad harness can double the draught power available in the country". Micuta (1985) observed "The significant advantages of using a collar harness rather than a yoke are universally recognised. In 1920 Ringlemann established that an ox equipped with a collar could accomplish the same amount of work as two oxen attached to a yoke". While this latter statement could be true for light work it is most unlikely to apply to heavy work. Such comparisons of yoked pairs and single harnesses tend to confuse the effects of single *versus* double harnessing with those of collar *versus* yoke.

Claims that collars *per se* increase power or efficiency by 48-70% compared with yokes should be treated with great caution and close attention to definitions. For example "Garner showed that the horsepower increased 70 percent when he replaced the yoke with a breast strap harness" (Vietmeyer, 1982) and "Garner demonstrated that a collar harness increased pulling force of buffaloes by 50%" (Micuta, 1985). These and several other authors have implied that the work of Jean Garner (1957) in Thailand had effectively proven the greater efficiency of bovine collars. Through citations such as those quoted, Garner's unpublished tests have acquired a totally unwarranted mystique of conclusive experimentation. In fact Garner had simply run a few tests in which a few buffaloes were harnessed with yokes, collars and breastbands and measurements were taken of the maximum sledge weight they would pull and the time required to pull a 340kg sledge along a 500m track. In the limited tests, the breastand performed best, followed by the collar and the yoke. No statistical analysis was performed, but percentage differences were presented. Based on the time required to pull the sledge, the computed power output was 390W with a single withers yoke, 580W with a collar and 660W with a breastband, representing *relative* percentage increases of 48% and 70% for the collar and

Fig. 4-11: These prototype "Allahabad" single and double harnesses performed well in some research studies, but they were not adopted by farmers.



Source: Ayre, 1981; Barwell and Ayre, 1982

breastband respectively. Although Garner was an enthusiastic advocate of bovine harnesses, immediately after presenting his data (in the very next sentence), he himself noted that his statistically unreplicated tests were "not assumed to be conclusive due to the limited trials", and he considered "more work should be done under actual field conditions". Unfortunately other writers have tended to ignore Garner's caution and have simply quoted percentages, giving them a spurious authority.

While Micuta (1985) referred to the original trials of Garner as evidence for the claims, some other authors have simply referred to Micuta's work. This is despite the fact that Micuta himself did not claim to have carried out objective experimental work. For example, de Vries (1986) stated "Dr. Micuta has tested the [Swiss] collar in Switzerland and Kenya. It can be adapted for use with oxen, donkeys and horses. Not only does it increase pulling power by 50-100%, but it also lengthens the useful working life of animals". Such reports in newsletters and magazines have given many people who do not have access to the primary sources the impression that the dramatic efficiency claims for bovine collars have been proven. However such objective experimental evidence as has been obtained is less convincing.

Swamy-Rao (1964) undertook more replicated research on harnessing on a research station in India. His trials involved the taking of 50,000 dynamometer readings and during the tests the pair of bullocks covered a total of 1,400 km under a variety of work schedules (Ayre, 1981 and 1982). Detailed comparisons were made of single or double bovine collars of the innovative but expensive "Allahabad" design (Fig. 4-10) with single back harnesses (Fig. 4-14) and traditional double withers yokes. During sledge-pulling and plowing trials, oxen harnessed with withers yokes worked at a rate of 570-1030W while similar oxen with the collar-type yoke had a power output of 670-1310W. Oxen harnessed with the back saddle had an output of 450-960W in comparison with 540-960W for the single collar-type yoke. Since the mean draft (implement resistance) was not constant within trials, it is difficult to make direct comparisons between these figures, but the higher work output was related to higher average walking speed. In some trials the back yoke out-performed the single collar-type yoke, but in all trials between the double-yoke systems the collar-type yoke appeared to give better results, and it was concluded that the "Allahabad" collar-type yoke resulted in 14% more power and allowed animals to work 30% longer without major power lose. Its estimated cost of about three times the price of the traditional yoke should have been recovered through increased farm income in two years on a holding of about 3.5 hectares (Ayre, 1981 and 1982). In more recent on-station trials, the "Allahabad" yoke was found to be inferior to two traditional yokes, and superior to two others. The basis for this selection was the degree of physiological stress (rise in temperature, pulse and respiration) suffered by the animals (Varshney *et al.*, 1982). However from the data presented, such "stress" may well have been associated with quicker walking speeds and faster rates of work.

In replicated experiments in a controlled but unnatural environment in Edinburgh, an ergometer and gas analyser were used to determine the ratio of work accomplished to energy expended for some buffaloes and Brahman cattle fitted with different harnessing systems (Lawrence, 1983). Buffaloes with withers yokes worked at 35.4% (±1.03) net efficiency, while those with collars worked at 38.8% (±1.30). Under similar conditions Brahman cattle with withers yokes worked at 28.9% (±0.68) efficiency, while those with collars worked at 31.1% (±0.89). This indicated that collars improved the net efficiency of work by about 3%, a figure that was just statistically significant ($p \approx 0.05$), (Lawrence, 1983). Clearly this figure of a 3% improvement in recorded net efficiency is well below

claims of high percentage improvements in efficiency made by authors working under less controlled conditions. One reason is that Lawrence's percentages refer to the calculated efficiencies of each yoking system (work done relative to actual energy expended over that normally dissipated when walking without a load). The 3% increase in the recorded net efficiency of the collars in comparision with withers yokes represented a 7-9% *relative* improvement of collars over yokes.

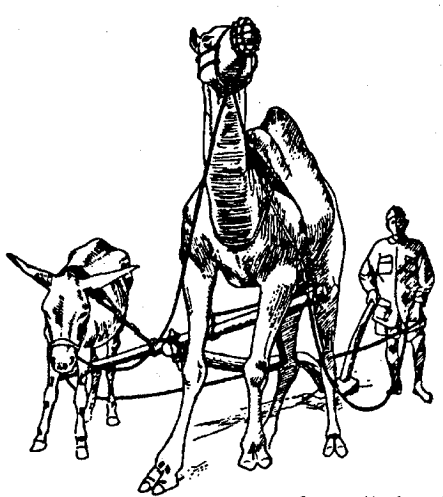
In field trials in Burundi comparable statistically significant increases in net efficiency of 1-2% were recorded (Barton, 1985). However Barton, who had previously advocated the use of three-pad harnesses (Barton *et al.*, 1982) concluded that bovine collars were unlikely to be adopted in developing countries as such modest increases were unlikely to justify their cost and complexity compared with yokes.

The experimental and anecdotal evidence does then suggest that bovine collars may well be intrinsically more efficient than head yokes, withers yokes and back yokes. However there seems no hard evidence to support the very dramatic claims often made for them. Bovine collars can be used singly or doubly but this should not be allowed to confuse the argument as both shoulder and withers yokes can be used singly and can also be used in independent hitching arrangements. If correctly matched and fitted, bovine collars may be more comfortable to the animal, but it is arguable that a poorly made collar is at least as uncomfortable as a poor yoke. While enthusiasts have developed bovine collars at research stations and in small projects in many countries in Africa, Asia and Latin America in the past thirty years (Garner, 1957; Barton, 1985; Dibbits, 1985; Heifer, 1985; Pragasam, 1987; Kehoe and Chan, 1987), there seem to be no reports of sustained farmer adoption following demonstrations. Perhaps farmers consider that the cost and complexity of collars for cattle outweigh their apparent advantages.

4.5 Harnesses for mixed teams

One interesting picture (Fig. 4-12) taken in Morocco of a camel hitched to a donkey using a double belly yoke has been reproduced in at least three publications (Hopfen, 1960; Goe, 1983; Duchenne, 1984). The belly yoke pole does not contact the bodies, but it is suspended under the animals by traces attached to single withers harnesses. The animals look uncomfortable and Hopfen described the yoke as inefficient and painful and capable of causing severe injury to the animals. This belly yoke appears to have arisen as a local solution to the technical problem of how to use animals of different sizes with a traditional long-beam plow. It is also designed to combine the inherent strength of the camel with the stability of a donkey, for a single camel appears less able to walk in a straight line than a donkey or mule. In several north African countries, it is not particularly uncommon to see different species worked together, whether they be donkeys, mules, oxen or camels. A photograph of a young

Fig. 4-12: Mixed camel and donkey harnessed with belly yoke. This seemingly inefficient and uncomfortable harness is still used on a small scale, perhaps because it allows the power of a camel, the discipline of a donkey and the simplicity of a traditional ard to be combined.



Source: Hopfen, 1969

camel and a bullock yoked together (apparently uncomfortably) with a withers yoke for plowing in Egypt was reproduced in the book of Wilson (1984) and although this combination is quite rare, it is not unusual for buffaloes and cattle to be yoked together in Egypt. In Sub-Saharan Africa there is unlikely to be a significant demand for harnessing different species together, although systems for hitching large and small animals of the same species together may have wider application. In either case, the use of independent hitching is advised, together with swingle trees and one or more eveners. With such a system the harnesses of the individual animals can be different (withers yokes, breastbands, camel harnesses etc.). However the advantages of being able to use different animals in this way are partially offset by increased complexity and the fact that long-beamed implements may need to be shortened. Research in Morocco has suggested that some animals may suffer additional stress if teamed with animals of a different species or markedly different size due to differences in normal walking speed and stepping rates (Bansal *et al.*, 1989).

Photo: Paul Starkey

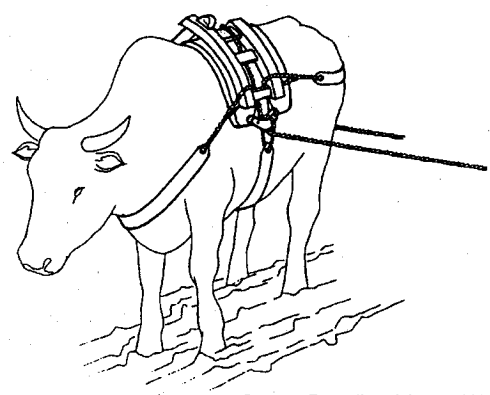
Fig. 4-13: Riding an ox in Mali.

4.6 Load saddles for oxen

Simple saddles can be padded wooden frames, broad straps or ropes over an animal's back which help bear vertical loads. These are widely used with horses, donkeys and camels that pull carts. Ramaswamy (1985) recommended that similar saddles should be used with bovines, to reduce the load on the necks. However, while agreeing with the principle, Barwell and Hathway (1986) suggested that many bovines will not accept a back load. Research at the University of Edinburgh demonstrated that the positioning of pack saddles on zebu cattle and buffaloes was critical. If the saddle was forward, over the shoulders, the animals accepted it more readily, and it required less energy to carry loads than if it was more central on the back (Stibbards, 1980). A saddle harness was widely used in Japan for cultivation and transport and in the 1960s it was found to be more efficient than withers yokes during on-station trials in India (Fig. 4-14; Barwell and Hathway, 1986).

Since the desirability of loading the backs of bovines seems somewhat controversial, it is interesting to note that while cattle can be successfully used for riding and pack purposes, there are few parts of the world where this is actually practised. Yaks are used as pack animals in some mountainous parts of Asia. Asian water buffaloes are occasionally

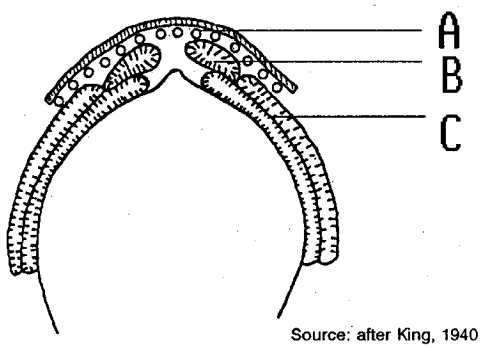
Fig. 4-14: Back harness that has been used in Japan.



Source: Barwell and Ayre, 1982

used to carry produce to and from the fields. In parts of Mali and Chad, farmers and children ride oxen without fitting saddles (Fig. 4-13). In several regions of Africa, including the Sahel and the rangelands of eastern Africa, pastoralists use simple basketwork panniers to enable cattle to carry household belongings when moving between sites (Fig. 4-15).

In the humid and semi-humid areas of Africa, disease generally prevents donkeys being used as pack animals and luxuriant vegetation and watercourses restrict the use of animal-drawn carts. In such circumstances farm produce and materials are generally head-loaded by women and men, and there would seem to be scope for using pack animals (Spencer, 1988). However such areas are generally those where cattle populations are low, people are unfamiliar with cattle husbandry and the presence of tree stumps makes it difficult to use draft animals for crop cultivation. Moreover the effort required to train, saddle, load and drive a pack ox, may well be greater than the transport value of relatively small quantities of materials. There have been several small-scale attempts to introduce the use of pack oxen. One systematic attempt in Tanzania was described by King (1940) who provided details of how to manufacture pack saddles and pannier baskets of a design similar to those used by pastoralists in northeast Africa. King considered that ox pack transport was "an essential prerequisite to the extension of mixed farming on account of the increased movement of crop residues, grass roughage and manure". However despite the apparent technical success of the panniers, the extension efforts and initial adoption by a few farmers, the technology does not appear to have spread. Other, smaller projects have had similar experiences. Thus it would seem that the use of bovine pack saddles is only likely to be worth investigating if transport is clearly a critical constraint and if it is impossible to use ox carts or pack donkeys.



Source: after King, 1940

Fig. 4-16:
Ox-saddle based on traditional Sudanese design. This pack saddle was developed for use in Tanzania, but was not adopted by farmers.
A -Wooden slats tied with baobab string; B - Bolsters for protecting spine, made from sacking densely packed with grass; C - Lightly stuffed sack.

Fig. 4-15: Pack saddle used by pastoralists in Somalia. Photo: GTZ archives