3. Common harnessing systems

3.1 Harnesses and yokes: clarification of definitions

In both English and French, the word harness (*harnais*) has been predominantly used in the relatively narrow sense of the straps and fittings used for hitching and controlling horses or donkeys, and dictionaries in both languages generally define harness with reference to horses. For working oxen, the hitching together has generally involved a rigid yoke (*"joug"* in French), and historically the word "yoke" could also be used to describe a team of oxen. The French word *"attelage"* has no single word equivalent in current English usage but refers to the system of hitching animals together whether it be the yoking of oxen or the harnessing of horses. (*La culture attelée* is often used in the same sense as the English phrase *draft animal power*.) As with the word yoke, *"attelage"* can also be applied to the teams of animals themselves.

In three influential books published by FAO the word *harnessing* was used in a more general sense to cover the yoking of oxen as well as the harnessing of horses and donkeys (Hopfen and Biesalski, 1953; Hopfen, 1969; FAO/CEEMAT, 1972). This more general use of the word harnessing to cover all the elements involved in the "transmission" system linking the animals to their working implements (plows, carts etc.) was maintained in the reviews of Barwell and Ayre (1982) and Viebig (1982). The main CEEMAT publication on animal traction in Africa (CEEMAT, 1971) used the French word *"harnais"* in the restricted sense; however in his comprehensive monograph on the subject Duchenne (1984) opted for the broader definition. These recent precedents will be followed and in this section harnessing will also be used in the broad sense of systems for linking animals to their workloads and, where applicable, to the person controlling them.

The introductory definition and etymological discussion is not merely to clarify some obvious confusions arising from evolution in the meaning of words. It also illustrates an important generalization. For several hundred years most English and French words relating to the "transmission systems" of animal power in both agriculture and transport have clearly differentiated between the bovine (ox) and the equine (horse, mule and donkey) types. In general bovines are hitched with yokes while equines are harnessed with collars or straps. The distinction is not absolute, for there are examples of equines being yoked and bovines being worked with collars, but if one takes either an historical or a geographical perspective, it is clear that the generalization apparent in the etymology is almost a universal rule. Thus in this section the standard harnessing/yoking systems will be described first, and the exceptions will be discussed under non-conventional usages.

The wide range of yoking types falls into two main categories, those tied to the horns of the animal and those taking power mainly from the *withers*. The "withers" of an animal refers to the part of the back that is over the shoulders, directly above the first thoracic vertebra. In Zebu (*Bos indicus*) cattle the withers are immediately in front of the hump.

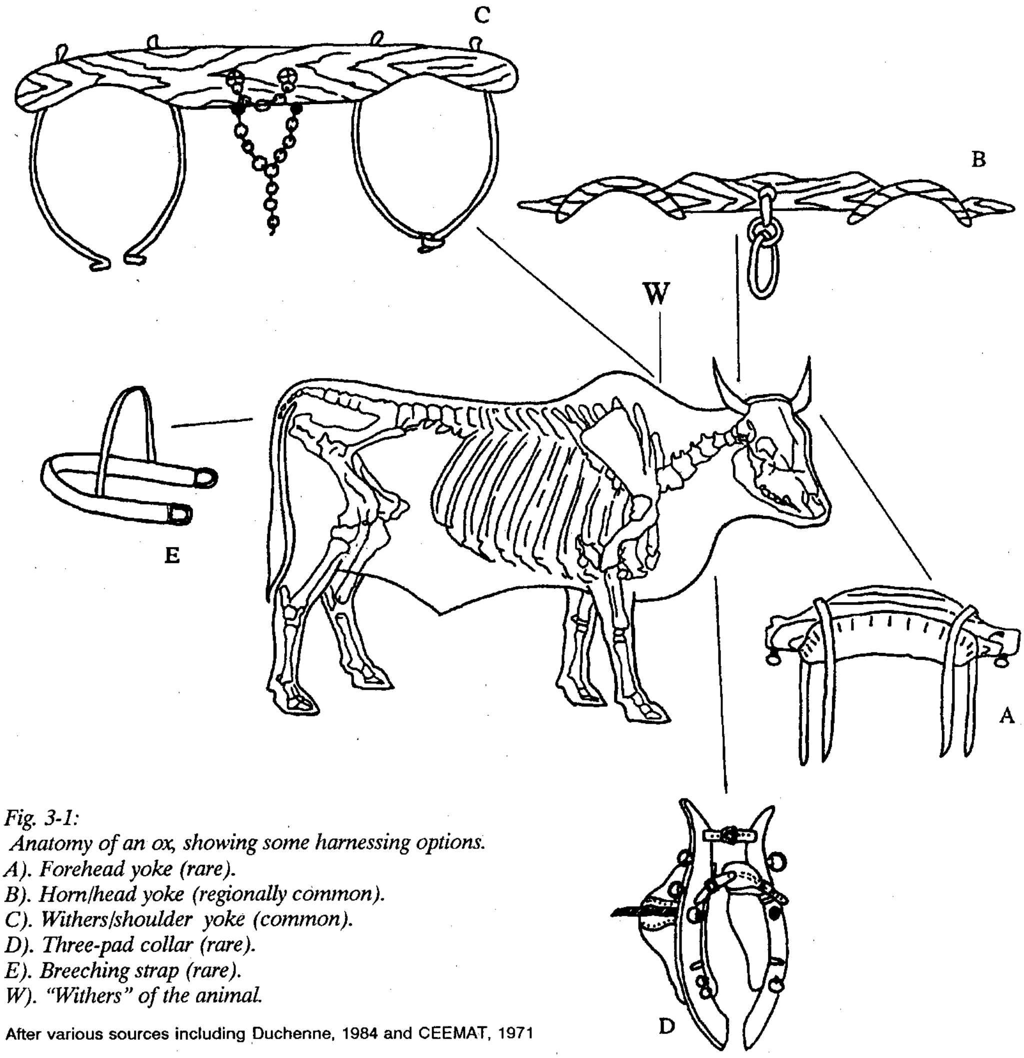


Fig. 3-1:
Anatomy of an ox, showing some harnessing options.
A). Forehead yoke (rare).
B). Horn/head yoke (regionally common).
C). Withers/shoulder yoke (common).
D). Three-pad collar (rare).
E). Breeching strap (rare).
W). "Withers" of the animal.

After various sources including Duchenne, 1984 and CEEMAT, 1971

In English historical studies on yoking types the terms "horn yoke" and "head yoke" have been used synonymously, as have the terms withers and shoulder yokes (Fenton, 1973). Technically the shoulders are below the withers, and there are good arguments for dropping the term shoulder yoke, as it misleadingly implies that the power is applied from the shoulders. However the actual meaning of *withers* is not widely understood so that the term shoulder yoke can be quite useful in distinguishing between different yoke types. In French the term *joug de garrot* is equivalent to withers yokes while *joug de corne* and *joug de tête* have both been used for horn/head yokes (Delamarre, 1969; Duchenne, 1984).

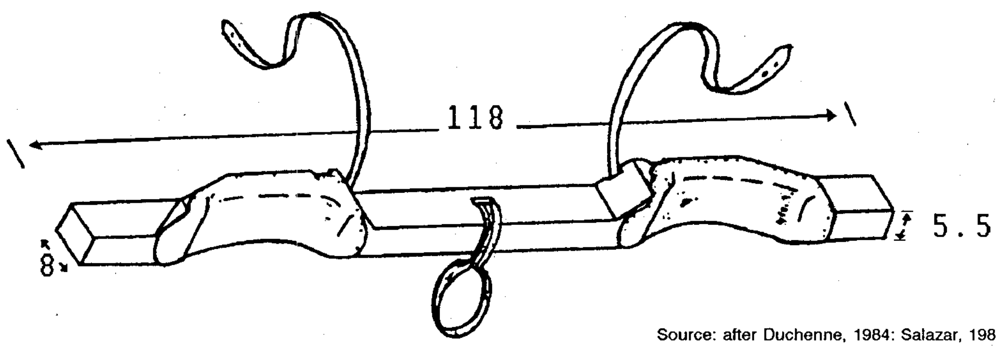
Horn/head yokes are occasionally used in front of the horns, where they are described as forehead yokes (*joug frontal*). More commonly they are fitted behind the horns, and in this position they have sometimes been called "neck yokes" (*joug de nuque*). However the use of the word "neck" has been the source of considerable confusion in the international literature. Hopfen (1960; 1969) classified yokes tied to the horns as head yokes and described yokes taking power from the withers as "neck yokes". Ramaswamy (1981) followed a similar convention. In contrast FAO/CEEMAT (1972) classified the yokes tied to the horns as "neck yokes", and those resting on the withers as shoulder yokes. Viebig (1982) used a similar classification, although he preferred the term withers yoke to shoulder yoke. Two recent specialist texts on yoking systems have followed the Hopfen definitions and used the term neck yoke to describe the withers/shoulder yoke (Devnani, 1981; Barwell and Ayre, 1982).

Thus although all texts agree that there are two very distinct categories of yoke, depending on the context and source, the words "neck yoke" can refer to either of these different types! Since the neck is defined as the part of the body between the head and the thoracic vertebrae, both yoke types can indeed be claimed to rest at one or other extreme of the neck. Of the two uses, the FAO/CEEMAT definition of neck yoke is to be preferred since it is a reasonable translation of *joug de nuque*, and there does not seem to be the same confusion in the French language. One of the authors responsible for revitalizing the "neck yoke = withers yoke" definition subsequently used the clearer and less controversial terms head yoke and shoulder yoke (Barwell and Hathway, 1986). This may imply that the withers application of the term neck yoke may be decreasing. However **it is recommended that to avoid further confusion over conflicting definitions, the use of the term "neck yoke" should be avoided.** Thus the major yoke types will be classified here as *horn/head* yokes (*joug de corne/tête*) for those tied to the horns, and *withers/shoulder* yokes (*joug de garrot*) for those taking power from the withers.

3.2 Horn/head yokes

There have been examples in Europe, Latin America and Africa of forehead yokes (*joug frontal*), tied in front of the horns. While single forehead harnesses (Fig. 3-1) have been used effectively in Germany, the use of double forehead yokes (Fig. 3-2) is very uncommon. In one controlled study in Bolivia, using a circular, experimental track, forehead yokes were found to allow greater maximal force and greater overall power over a six hour period than head yokes tied behind the horns, withers yokes or even three-pad collars (Salazar, 1981). It seems agreed that forehead yokes require more careful fitting and padding than other forms of head yoke, and that there may be greater risk of injury to the head if they are not correctly fitted. Most of the other characteristics of forehead yokes are similar to the more widespread designs of horn/head yokes which will be discussed in greater detail.

Fig. 3-2: Double forehead yoke of a design evaluated by researchers in Bolivia (dimensions in cm).



Source: after Duchenne, 1984: Salazar, 1981

Most head yokes are tied behind the horns (*joug de nuque*). Such yokes are commonly employed in West Africa, Latin America and Southern Europe, where they are used mainly on humpless (taurine) cattle. Simple uncarved wooden poles can be used as head yokes (Fig. 3-3), but these tend to rotate and slip and cannot be recommended. It is therefore usual to carve the yokes in such a way that they both fit the heads and also have grooves and protrusions to allow easy and firm attachment of the ropes or straps (Fig. 3-4). A wide variety of shapes is used and the carving of yokes has become part of the folk art in some countries (de Oliveira, Galhano and Pereira, 1973). There appears to be no evidence that the different designs of head yoke have a significant impact on working efficiency, provided they are properly secured. An example of a securing system for a horn yoke is shown in Fig. 3-5. Ropes or leather straps can be used for securing the head yokes, depending on local availability. Some light padding may be desirable, although a well fitting yoke of smooth wood may itself be less abrasive than rough material such as sacking.

A head yoke must be strong, but it should also be light for maximum comfort to the animals. In countries where such yokes are tradi-

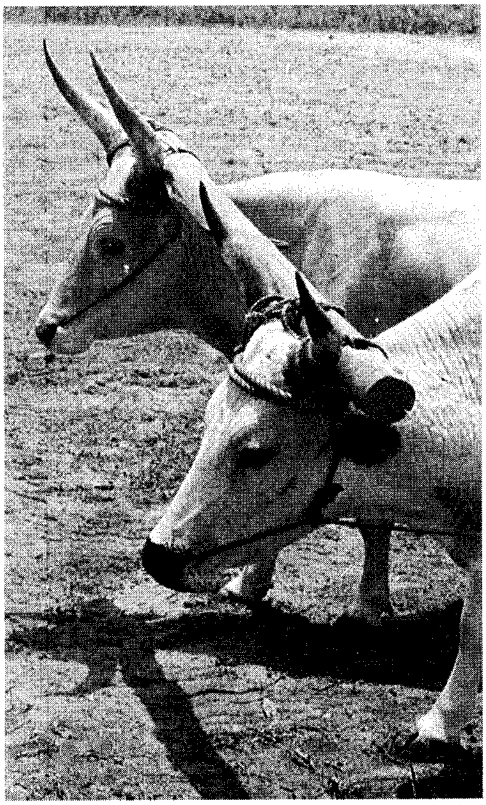
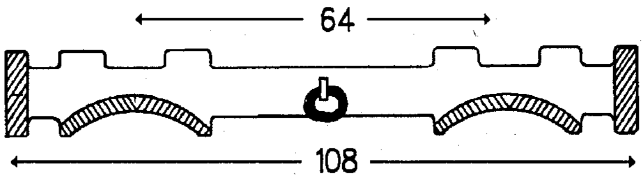
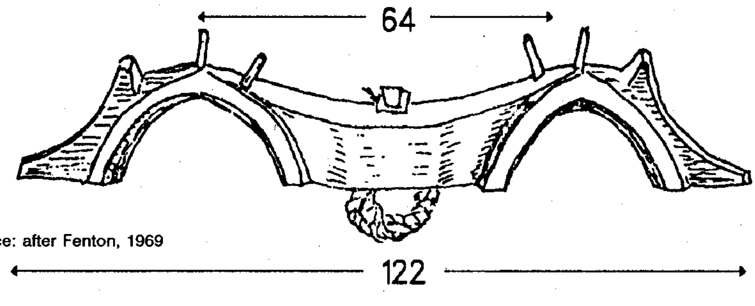


Photo: Paul Starkey

Fig. 3-3: Head yoke in The Gambia.
Simple uncarved head yokes such as this one are difficult to secure firmly and have a tendancy to slip. Note also the nose rein system.



Source: after Starkey, 1981



Source: after Fenton, 1969

Fig. 3-4:

Drawings of head yokes (dimensions in centimetres).

Top: *Head yoke used by Sierra Leone Work Oxen Programme.*

Below: *English head yoke of 18th century*

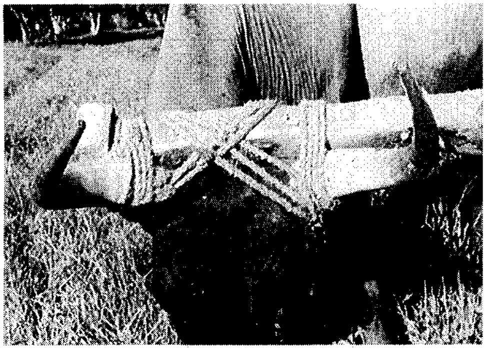


Photo: Paul Starkey

Fig. 3-5: Method of attaching head yoke to horns in Sierra Leone.

tional, there are favoured woods known to combine these features, and in countries where head yokes are being evaluated, local knowledge of tree species should be sought to identify suitable woods.

Horn/head yokes are most suitable on cattle with relatively short and strong necks. They require the presence of good horns to securely attach the yoke, and fixing the yoke is easier if the horns sweep forward and upward, rather than backwards or downwards. Since most draft animals come from cattle breeds with horns that are naturally long, the use of head yokes should not greatly affect the choice of animals, although polled (hornless) cattle or individuals with broken or weak horns will be unsuitable. Once a head yoke has been firmly tied to a pair of animals, they are less free to toss their heads and horns. This is often seen as an advantage, for it provides greater safety and confidence to inexperienced users, particularly if the animals are only partially trained. Similarly once the yoke is fitted, the animals cannot damage each other with their horns. However the loss of movement restricts the ability of the animals to ward off flies by tossing their heads, and some people consider the loss of free head movement causes the animal significant discomfort.

As head yokes are firmly attached to the horns, the yoke can be used to apply forces in several directions. For example, in forestry operations animals can lift the ends of logs by raising their heads, and they can apply powerful braking forces to restrain a tree trunk moving too quickly down a hill (Fig. 3-6). When implements and carts are pulled by a rigid drawbar rather than a traction chain, head yokes that are securely fastened to the animals can facilitate braking and reversing. In similar circumstances, withers yokes that are not rigidly attached to the animals may ride forward onto the heads of the animals (this can be prevented by transferring such forces to the rear of the animals through

Fig. 3-6: Oxen with head yoke logging in Malawi. Head yokes can be used for lifting, pulling and braking logs. Photo: Paul Starkey

Photo: Paul Starkey

Fig. 3-7: Example of poorly fitted head yoke on small, inexperienced animals in Sierra Leone.

breeching straps or by suitable bars fitted to a cart).

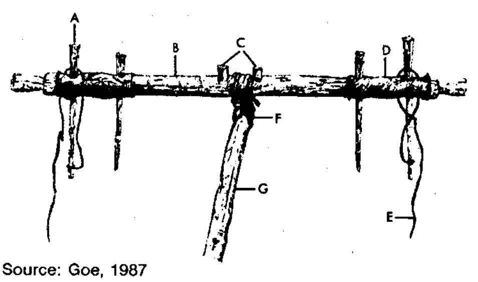
A well secured head yoke should not cause skin abrasions, since there should be little scope for movement and rubbing. However the vibrations of work are transmitted directly to the head, which may be a source of discomfort. In addition the lack of movement may mean that the neck or head is held in a twisted or otherwise uncomfortable position (Fig. 3-7). Nevertheless there seems no objective evidence to suggest that head yokes differ significantly from withers yokes in overall comfort, and suggestions of cruelty probably relate to occasions when yokes have been incorrectly fitted or used.

Head yokes have been successfully used in many parts of the world on both humped (zebu) animals and humpless (taurine) cattle. Although they have mainly been used with humpless cattle, they should not be regarded as limited to these animals.

3.3 Withers/shoulder yokes

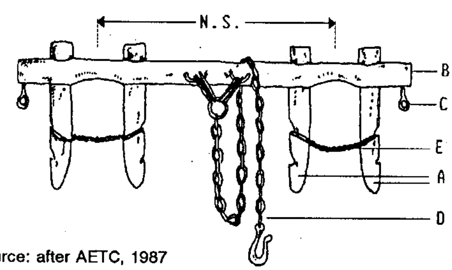
Withers yokes are numerically the most important system of harnessing in the world. They are almost universally used in Asia and Ethiopia, and are widely used in parts of western, eastern and southern Africa and areas of Europe and the Americas. They are almost always made of wood, although a few projects in Africa and Asia have made yokes from steel pipe. In their simplest form they are just wooden poles with small descending pegs (sticks) to restrict lateral movement. These pegs, also known as staves or skeis, may be joined by a loose rope, chain or strip of hide, but this has no draft function and does not (or should not) pull against the windpipe (Fig. 5-5). The wooden yokes may be shaped into double bows to more closely match the shape of the withers, thus giving a greater surface area of contact (Fig. 3-13). *Such simple shaping may well be the simplest and most cost-effective means of increasing the comfort and therefore the effectiveness of a wooden yoke.*

Fig. 3-8: Withers yoke used in Ethiopia A - wooden peg; B - yoke beam; C - wooden centre pegs; D - padding; E - leather neck strap; F - leather thong for tying plow beam (G).

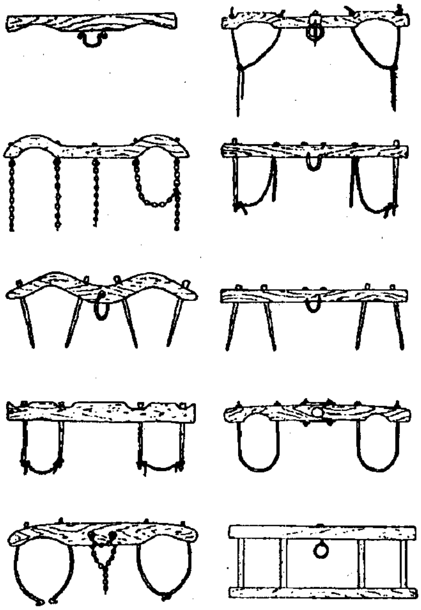


Source: Goe, 1987

Fig. 3-9: Withers yoke used in Zimbabwe. A - wooden pegs "skeis"; B - yoke beam; C - eyes for steering ropes; D - trek chain; E - leather thongs "strops". N.S. - Nominal size.

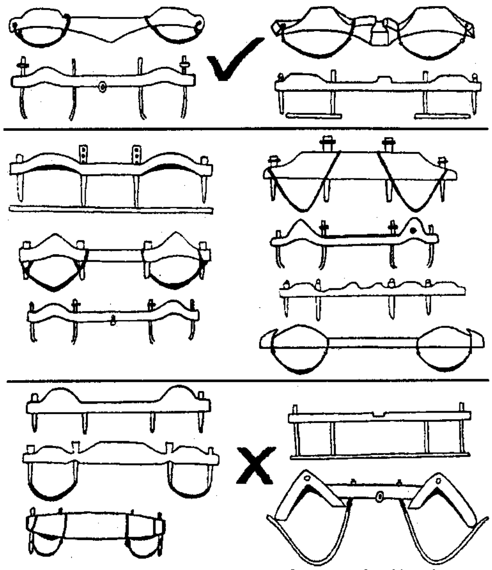


Source: after AETC, 1987



Source: after Viebig, 1982; Casse et al., 1965

Fig. 3-10:
Examples of withers yokes used in Africa.



Source: after Vaugh, 1947

Fig. 3-11: Withers yokes from different locations in India tested in 1944. Oxen gave significantly higher average dynamometer readings with the top four designs than the bottom five designs, although this was not clearly correlated with contact surface area, shape or weight. The yoke that performed worst in the test was the bottom right "improved" yoke.

Withers yokes can be lightly padded, and in Ethiopia the traditional yoke is padded with sheepskin or cloth covered with cowhide. Some designs of withers yokes can be seen in Figs 3-8 to 3-13. The ornamental carving or painting of withers yokes has developed into an artform in some countries.

The descending rods may be made of metal, and may join together and in some yokes they are in the form of a U that rises into the yoke beam during fitting. These are functionally equivalent to some traditional European and North-American yokes which had ascending bows made from wooden poles specially bent into the shape of a U. More rarely the descending rods are joined by a second horizontal pole to form a frame (Figs 3-10 and 3-11). The yokes that fully surround the neck with a frame or with U- or double-J-rods provide a greater sense of security for the operator, but are more difficult to remove quickly should one animal fall. It has been claimed that large bows, staves or rods may provide useful, additional surface area against which the shoulders of an animal can push (Kivikko and Rosenberg 1987). However while the main beam of a withers yoke is in more-or-less permanent contact with the animal, the movement of the shoulders means that the staves are only in contact some of the time so that they cannot be used like a yoke for sustained effort. In general, yoke staves are neither spaced nor shaped for work application. To attempt to develop them for such use and at the same time avoid rubbing is likely to lead to a variation of the three-pad or collar-type harnessing systems which, as will be discussed, have both advantages and disadvantages.

Withers yokes can be very simple and easily manufactured with little carving. Thus they can be cheap although this is not a simple rule as some designs in use are quite expens-

Photo: Paul Starkey

Fig. 3-12: Uncurved pole withers yoke in Tanzania with wooden descending rods,

Photo: FAO archives

Fig. 3-13: Curved withers yoke in Mali. There are no descending bars, the yoke being held in place by its curvature and lose rope ties.

ive and complicated to fit. They allow the animals to move their heads freely, and because they do not require horns, they can be used with polled cattle or even equines. As withers yokes are not attached securely they can move relative to the skin; unpleasant abrasions or yoke galls can develop when such movement is prolonged or excessive. Withers yokes are designed to transmit forces during forward motion only and they cannot easily be used for braking carts, or for reversing, unless a back *breeching* strap (or rope) is used to prevent the yoke moving forward. Such straps are seldom used, and the problem is partially overcome on carts in India by the fitting of a bar on the cart immediately behind the animals. When descending a hill, braking or reversing, this bar contacts the animals and takes the forces before the yoke is pushed onto the animals' heads.

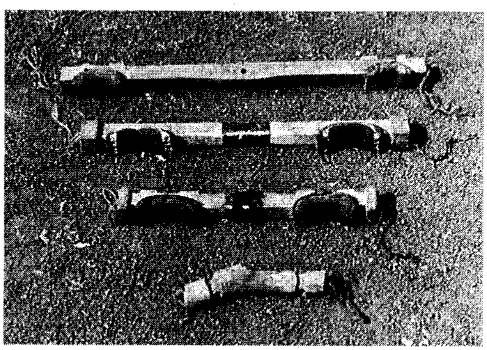
3.4 The length of yokes

The length of yoke can be important in ensuring the efficient management of draft animals, although it should not affect the actual draft power. The more widely spaced are the animals, the greater the potential leverage of one animal on the other, and the greater the risk of accidental damage due to yokes. Farmers in the central Ethiopian highlands prefer using a short yoke when plowing heavy soils as they believe it concentrates the forward pulling force of the team. Longer yokes are preferred on rough terrain because wider spacing between the oxen improves both animal stability and the ability of the farmer to manoeuvre the ard plow (Goe, 1987). In general for both plowing and transport it is recommended that animals be close together but without actually touching each other or the traction chain or shaft. The actual dimensions of a yoke should

Fig. 3-14: Selection of head yokes used at a university farm in Sierra Leone.

Top: Weeding yoke (nominal size 132 cm);
Middle: Ridging yoke (N.S. 90 cm);
Plowing yoke (N.S. 64 cm);
Bottom: Single yoke.

Photo: Paul Starkey



Source: after Starkey, 1981

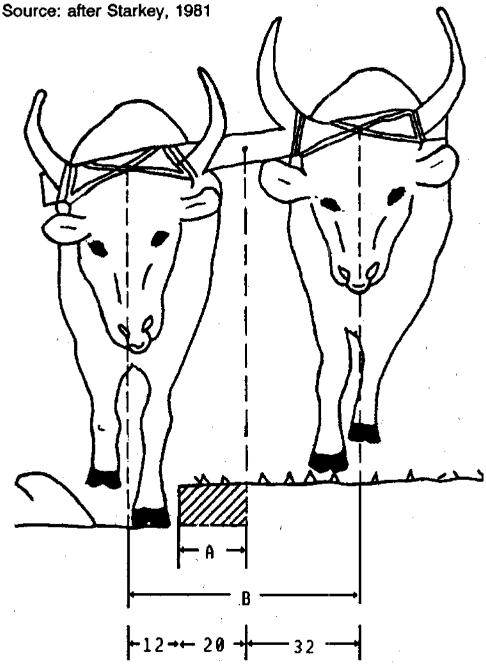


Fig. 3-15: Illustration of relationship between yoke size, share size and line of draft.
A - Nominal size of plow share.
B - Nominal size of yoke.
Figures (in centimetres) illustrate a 20 cm share being used with a 64 cm yoke. If other share sizes were used with this yoke, the horizontal regulator could be used to achieve the appropriate line of draft.

be determined by the breed/species of the animal and the operations to be performed. The nominal size of a yoke refers to the distance between the centres of each animal position (Fig. 3-9). For weeding, the nominal size must be a multiple of the row spacing. Thus for weeding 66 cm rows a yoke with an nominal size of 132 cm (2 x 66) is required and for weeding 90 cm rows a 180 cm yoke would be used.

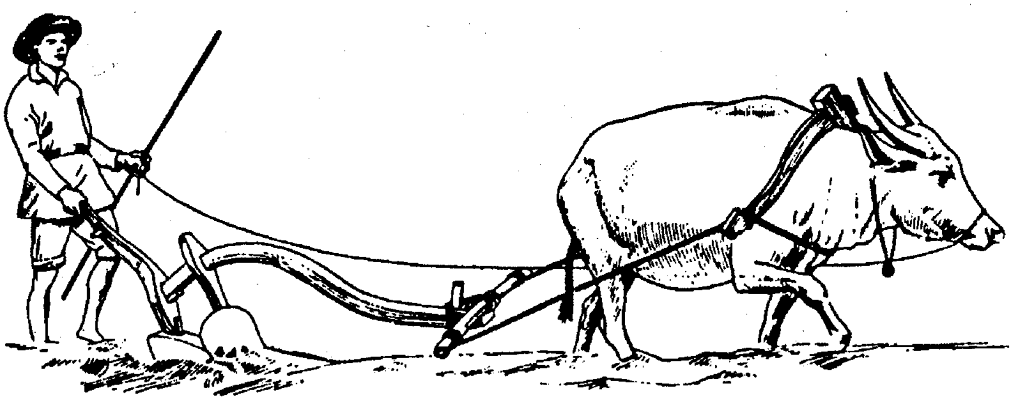
For plowing, it is best if the length of the yoke ensures that with one animal walking in the furrow, there is a direct line of draft to the plow (Fig. 3-15). Typical nominal sizes for plowing yokes are 64 cm for a head yoke for N'Dama in Sierra Leone, 75 cm for a withers yoke in Niger, 85 cm for a forehead yoke in Bolivia and 90 cm for a withers yoke in Zimbabwe. If one uses a plowing yoke for ridging, to obtain a direct line of draft the furrow animal must walk on the previous ridge. This can be avoided by using a longer yoke with a nominal size of twice the inter-ridge spacing to allow the furrow ox to walk in the inter-ridge furrow.

For transport use it may be advantageous if the nominal size of the yoke is equal to the wheel-track of the cart. This will mean that the animals walk directly in front of the wheels, and are therefore likely to avoid objects that might obstruct or puncture a tyre (AETC, 1986).

It was noted in Chapter 2, that a yoke can be considered as a lever, pivoting about the point of attachment of the chain or pole. With animals of similar strength the levers should be of equal length. However should one animal be significantly stronger than another, this can be compensated for by adjusting the relative lengths of the levers, by changing the point at which the chain or pole attaches to the yoke. Some North American yokes have special slide rings, to allow the driver to make small, rapid and precise changes in length of each lever (Conroy, 1988). Improvisation is more common, for example the draft chain may be wound round the yoke once, to the left or right of the central attachment position (although this may also cause the yoke to rotate). The weaker animal needs more leverage, and so is provided with a longer lever by moving the chain towards the stronger animal.

3.5 Single yokes

Both head yokes and withers yokes can be used with single cattle, but since *cattle* are seldom used singly for field operations, single yokes are relatively uncommon. In parts of China and southeast Asia single buffaloes are commonly worked with withers yokes in the form of an inverted V. In these same areas



Source: Hopfen, 1969

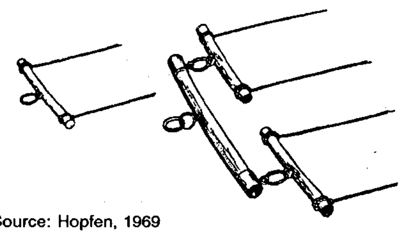
Fig. 3-16: Use of single withers yoke with water buffalo in China. The plow is attached directly to the swingle tree.

cattle are usually worked in pairs, although in parts of China single oxen may be worked with yokes similar to those used with buffaloes. It is not uncommon for single cattle to be yoked for transport, and a withers yoke may be permanently attached to the shafts of cart (Fig. 3-21). Single yokes are generally employed with relatively large animals.

While with double yokes the implement is attached to the centre of the yoke, with single yokes one attachment point is impractical. The force of the single animal must be transmitted from the yoke to traces or shafts attached to either end of the yoke and which pass back on either side of the animal. For transport purposes the shafts can attach directly to the frame of the cart and the yoke may even be permanently fixed to the shafts (Fig. 3-20). For crop cultivation the two traces are generally attached to either end of a small pole known as a *swingle tree*, and the work load is applied to the centre of this pole (Figs 3-16 and 3-17). One possible technical advantage of single yokes is that the attachment points of the shafts or traces are often (but not always) lower than they are on double yokes. Lower attachments should allow a lower angle of pull, so that less of the animal's power is used in "lifting" forces. However a single yoking system with side traces and swingle trees is generally more complicated to set up and work with than operations employing a double yoke. The two traces and swingle tree seem more liable to become caught up under the animal's feet during turning at the end of a row than one traction chain or beam. When using a single animal, the mutually reinforcing effect of two animals is lost.

A single animal can often achieve, in any one day, more than half of that which would have been achieved by a pair. This does not necessarily imply greater efficiency of the yoking system; if the animal achieves more it is because it is working harder. For very light operations (such as single-row seeding in light soil) yoked pairs do not have to work hard, so that if a single animal works twice as hard as a comparable animal in a pair, it can actually equal the work of a pair. The implications of such a situation for speed, draft and power output were discussed in Chapter 2, and illus-

Fig. 3-17: Swingle trees and evener for joining two swingle trees.



Source: Hopfen, 1969

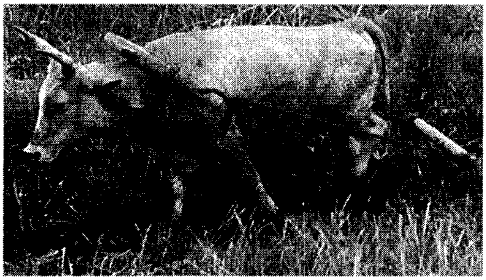


Photo: Paul Starkey

Fig. 3-18: Single withers yoke of Chinese design being tested in Sierra Leone. Note: in this test, the rope was tending to constrict the windpipe.

trated in a simplifed way in Fig. 2-4b. However it must be stressed that a single animal can only approach or match the daily performance of a pair for a few, light operations.

The extra work that a single animal has to perform, compared with one in a pair, is not "free", for it will require more energy from feed than when it is worked as part of a pair. A working single animal will not normally by itself require as much feed as two animals, and since there is only one basic maintenance requirement, that "marginal extra" amount of work can appear quite efficient in terms of energy. However the limitations imposed by both grazing time and the physical bulk of poor roughage makes it difficult for a single animal to eat enough during normal grazing to make up for the extra work. For a short time this may not matter (the animal will simply lose weight), but if animals are to be regularly worked as singles, the extra feed needed for the extra work may have to be supplied in a more concentrated form as a supplementary feed. The "marginal extra" feed can therefore be quite costly since concentrated feeds are more expensive than rough grazing. If supplements are required it may well cost more in monetary terms to feed a single animal than it does to feed a full working pair existing on grazing only. Naturally circumstances vary greatly, and there will be situations in which it is more appropriate or cost-effective to use single animals, and others when pairs will be preferable. It is however totally misleading to imply (as some people have done) that simply by using a single yoke, one animal can actually replace two animals.

In many African countries research and development workers have advocated the use of single oxen, particularly for light operations, such as sowing and weeding, but this has seldom been adopted (Matthews and Pullen, 1976; Starkey, 1981; Viebig, 1982). In the last few years research on the yoking or harnessing of single oxen (*"monobeouf"* in francophone countries) has increased substantially and in 1988 there were few countries in Africa without one or more programme investigating or advocating the use of single animals. Nevertheless this fashion has yet to be widely adopted by farmers.

Some of the enthusiasm for single yokes was stimulated by the International Livestock Centre for Africa (ILCA) which in 1983 reported "ILCA has found that a farmer does not need to have two oxen for cultivation" (ILCA, 1983a) for "the assumption that two oxen are needed for cultivation has hindered progress for centuries" (ILCA, 1983b). These

Fig. 3-19: Single ox with head yoke weeding on a university farm in Sierra Leone.

Photo: Paul Starkey

Photo: Paul Starkey

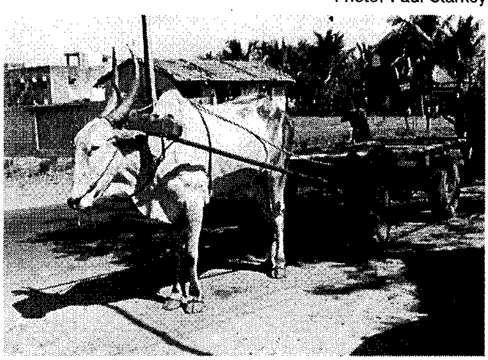
Fig. 3-20: Demonstration of a single withers yoke, swingle tree and modified maresha plow being used with a large ox at an ILCA Research Station in Ethiopia. In the background is an earth-moving scoop.

statements referred to research on the use of single withers yokes and shortened *maresha* ards for plowing in the Ethiopian highlands. The research itself was entirely valid but these quotations have been cited to illustrate that some of the resulting publicity was disproportionate. Although the research itself clearly referred to the highlands of Ethiopia, the subsequent simplification of the research results into generalized news items which diffused widely led to quite rampant misconceptions that ILCA was advocating a general use of single animals in Africa. In fact, ILCA scientists had simply been investigating one technology option for Ethiopian farmers who had only one animal (Gryseels *et al.*, 1984).

Much of the early optimism reported by ILCA staff had been based primarily on the initial on-station studies. However when ILCA scientists conducted larger scale on-farm "verification" studies, they identified several important disadvantages that tended to offset the well-publicized advantages. The traditional long-beamed *maresha* is normally attached directly to the double yoke, and this provides the Ethiopian farmers (who work their animals single-handedly) with good handling characteristics, and allows them to easily lift the plow when encountering a stone, or when turning. In contrast when a single yoke is used, the shortened maresha has to be attached to a trailed swingle tree and this arrangement, with much less rigidity, does not provide such stability and manoeuvrability (Jutzi and Goe, 1987). Moreover farmers found that with the single yoke, the mutually supporting effect of the two animals was lost. These reasons, together with cultural influences, and the structural problems encountered when replacing a long beam with a short

Fig. 3-21: Single withers yoke permanently attached to the shafts of a trailer in southern India.

Photo: Paul Starkey

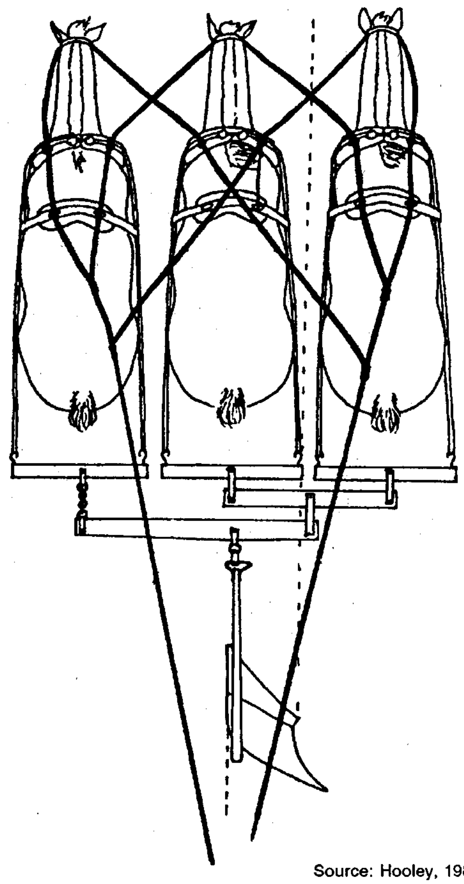


beam and skid, led the majority of farmers involved in the "verification" trials to revert to using double yokes. Indeed almost all the 1200 farmers participating in the trials yoked their one ox together with an ox of another farmer for the primary and secondary plowing, believing the power of two oxen was required for such tillage. While a few farmers used the single-yokes for subsequent lighter tillage, these represented fewer than 5% of the co-operating farmers. As a result it was concluded that while the single-ox plow might have some applications for secondary tillage under favourable conditions, it was unlikely to replace the use of paired oxen in primary land cultivation (Jutzi and Goe, 1987). Thus the traditional double yoke is likely to remain the harnessing system of choice in the Ethiopian highlands in the foreseeable future.

In conclusion, for many years development workers have felt that distinct benefits could be obtained from the selective use of single oxen. However few farmers in Africa have adopted these recommendations. In general the more widespread use of single animals is only likely to occur where standards of animal training are high, where single animals are sufficiently strong to perform the work easily and without the need for much encouragement and where there are strong economic or social reasons why teams of animals are impracticable or undesirable.

3.6 Multiple Hitching

Multiple hitching can be abreast or in tandem (one behind another). Animals harnessed with collars or breastbands are frequently hitched abreast, with their two swingle trees joined by an *evener* (Fig. 3-22). With equally matched animals the work can be applied to the centre of the evener, but the evener can be used to "even up" the work of animals of different strengths. The attachment point is moved away from the weaker animal to give it a longer lever on which to pull. With large teams of independently harnessed animals



Source: Hooley, 1984

Fig. 3-22: A suggested (but seldom practised) system for using three horses with two eveners in Bolivia.

several eveners can be used in a hierarchical pattern, but this is very uncommon in tropical countries. Through the use of eveners, young animals can assist with work during training and different breeds or species can be hitched together. However although intrinsically very simple, eveners contribute to the overall complexity of harnessing, and increase the time required to hitch up the harnesses and the potential for having the harness tangled or caught on an obstruction. When independently harnessed animals are joined with eveners, it is also usual to loosely link their heads or shoulders with *couplings*, cords run-

Photo: Paul Starkey

Fig. 3-23: Team of eight male and female animals being trained in Botswana. The withers pole yokes are linked with chains.

ning between their collars or bridles to ensure they move forward in a parallel manner.

The hitching of pairs or even single animals in tandem has been a common practice for both agriculture and transport in many regions. For multiple hitching of oxen, chains pass from yoke to yoke to link the animals, while with hitching of horses, donkeys or mules traces of the leading pair pass back to additional swingle trees in front of the second and subsequent pairs (Fig. 3-23). In Europe the employment of multiple teams of oxen became a standard practice in some areas. In Asia the use of pairs of animals for crop cultivation is the norm but farmers in the heavy black cotton soil (Vertisol) areas of India frequently hitch two or three pairs of oxen to a single mouldboard plow to achieve penetration in hard soils (Fig. 3-24). In Botswana the use of teams of at least three pairs of cattle is the normal practice, and teams can have as many as sixteen animals in eight pairs. In such large teams it is usual to include all available adult animals - oxen, bulls, cows and heifers. Interestingly farmers with fewer than six available animals consider plowing impracticable, yet there has been little acceptance of the "lower draft" farming techniques developed by researchers between 1970 and 1986. Elsewhere in southern and eastern Africa, including parts of Angola, Kenya, Mozambique, South Africa, Swaziland, Tanzania, Zambia and Zimbabwe there are certain areas where it is normal for four or six animals to be yoked for plowing. In other localities in the same countries it is usual to work only two animals at a

Fig. 3-24: Two pairs of oxen pulling a reversible plow in India.

Photo: Paul Starkey

Source: after FMDU-ATIP, 1987

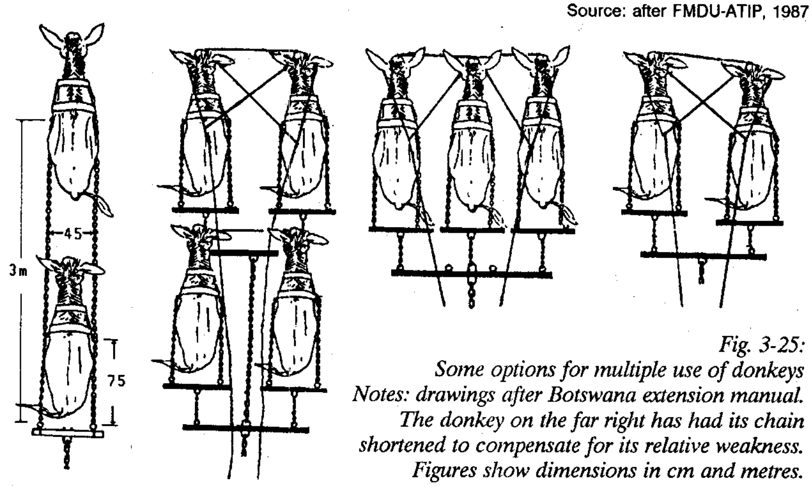


Fig. 3-25:
Some options for multiple use of donkeys
Notes: drawings after Botswana extension manual. The donkey on the far right has had its chain shortened to compensate for its relative weakness. Figures show dimensions in cm and metres.

time. The use of multiple teams in northern and western Africa is uncommon.

A less common practice is to work yoked pairs side by side by hitching both pairs to the same implement, usually a wide harrow or leveller. If the traction chains are attached to each end of the implement, eveners may not be necessary (Fig. 3-25). Such a system requires large fields if turning is not to be a major inconvenience.

Multiple hitching with *yokes* does not normally require much extra training, since the animals have fewer options for movement, and there is some mutual training between the animals themselves. If poorly trained animals are used with *independent hitching* there is considerable scope for reins and traces to become tangled.

Multiple hitching can be used by relatively wealthy farmers owning many animals or it may be organized on a community basis, with individuals contributing their own pairs. One obvious advantage is an increase in available power. This may allow the use of larger implements or deeper plowing. For example in Botswana, where large teams are worked, very broad 37 cm plows and some double mouldboard plows are often employed. Where animals plow in pairs, as in most of West Africa, 15-22 cm plows are more common. Multiple teams are only suitable for large fields, as the time and the space required to turn a big team is considerable. Inevitably with large numbers of animals, operations involving great precision are difficult.

Multiple teams with larger implements allow increased output per worker and per plow. Since teams of six to eight animals are typically controlled by two or three people, larger teams can lead to a lower ratio of workers to animals, which may be particularly advantageous in areas where animals are plentiful. Where soil conditions are not ex-

Fig. 3-26:
Use of two pairs of oxen abreast for field levelling in India.
Photo: Paul Starkey

treme and where human labour is not in short supply, the same number of animals could be yoked in pairs entirely independently, each pair drawing its own small implement. Similarly a given number of animals can either be hitched to one large cart or several small carts. The use of many small teams leads to greater manoeuvrability and organizational flexibility, but implies more workers and more equipment. Comparable arguments apply to the relative merits of using a few large animals or many smaller animals. The merits of these various options will depend mainly on whether one large, combined unit of power is actually necessary and whether animals are plentiful relative to humans.

It has been widely assumed that hitching animals in large teams leads to a decrease in overall efficiency, perhaps of the order of 7.5% per additional animal (CEEMAT, 1971; FAO/CEEMAT, 1972). Goe and McDowell (1980) quoted figures from the United States illustrating that achieved work rates with teams of 4-12 horses were not directly proportional to the numbers of horses used, and often the same amount of work could be achieved with five horses as with six. The relationship between animal numbers and work is discussed in Chapter 10.

In conclusion, the use of multiple teams of animals may be appropriate in areas with large fields where operations require high draft power and where animals are plentiful relative to labour and equipment.

Photo: Henk Dibbits

Fig. 3-27: A research-extension project in Kenya demonstrates the possibility of plowing with a team of donkeys.

3.7 Harnessing for donkeys and horses

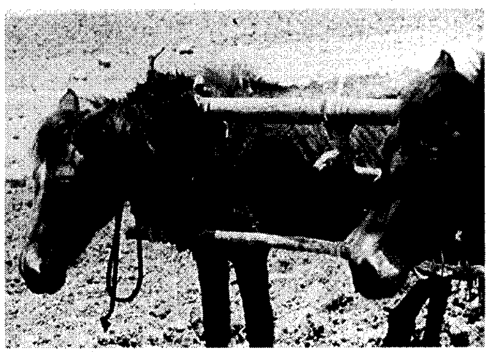
In a few areas of southern Africa, including parts of Malawi, Mozambique and Zimbabwe, donkeys are used with withers yokes, similar to those used for cattle (Fig. 3-28). Yoked donkeys, horses or mules are also sometimes used with padded withers yokes in North Africa, Ethiopia, Portugal and the Middle East (Fig. 3-29), One reason for yoking equines is simply for convenience and simplicity where withers yokes for oxen are already available, and where equine harnesses are not easily ob-

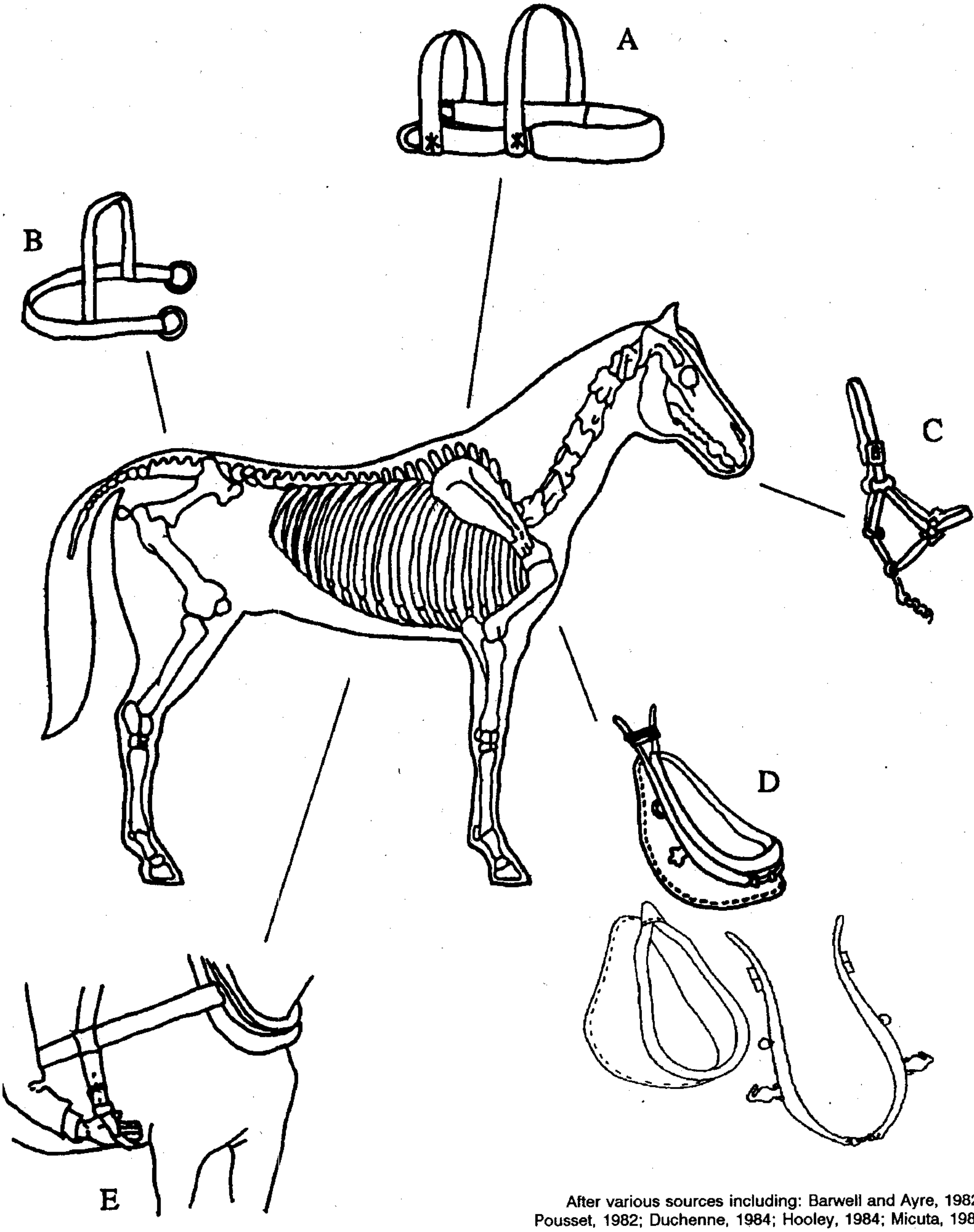
Fig. 3-28: Donkeys fitted with withers yoke for transport in Malawi. Yoking donkeys is rare.

Photo: Paul Starkey

Fig. 3-29: Horses fitted with withers yoke for plowing in Ethiopia. Yoking horses is rare.

Photo: Michael Goe





After various sources including: Barwell and Ayre, 1982; Pousset, 1982; Duchenne, 1984; Hooley, 1984; Micuta, 1985

Fig. 3-30: Anatomy of a horse showing some harnessing options.

A). Breastband harness (very commonly used for agriculture and transport).
B). Breeching strap (uncommon, but useful for slowing down equipment).
C). Bridle and bit (useful but not essential).
D). Full collar harness, showing its component collar and hames (rarely used in Africa).
E). Back strap and belly strap (useful if animal supporting weight of cart or if breeching strap fitted).

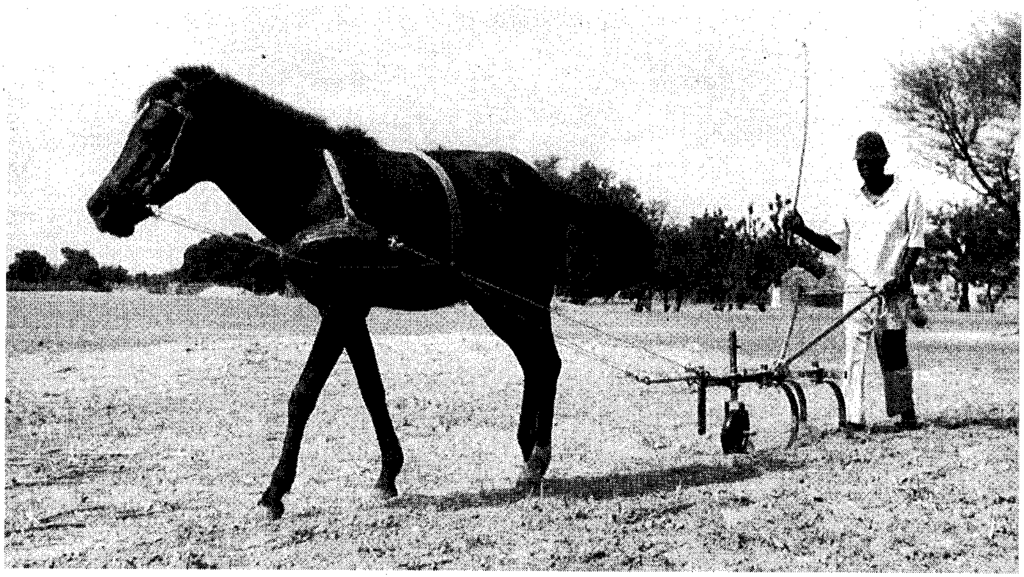


Photo: Paul Starkey

Fig. 3-31: Horse fitted with breastband harness, bridle and bit being used for tine tillage in Senegal.

tainable. In Europe there was a tendency to use head yokes in areas where cattle were predominantly used for work, breastbands and collars where horses were dominant, and interchangeable withers yokes in areas where both bovines and equines were used (Delamarre, 1969). A comparison of the anatomy of equines and cattle (Figs. 3-1 and 3-30) shows that equines are not as well suited to withers yokes as cattle. Equines, particularly horses, have relatively strong chests but they do not have pronounced withers to take the strain of a yoke. For this reason, when equines are yoked the descending bars become increasingly important for taking the strain, and there are examples of equine yokes fitted with collar-like structures to increase the comfort and efficiency of power transmission. Indeed it is speculated that independent equine collars were actually developed from the gradual augmentation of withers yokes. However it is generally agreed that yoking of equines is not

Fig. 3-32: Donkey fitted with collar made from a padded moped chain in Mali.

Photo: Paul Starkey

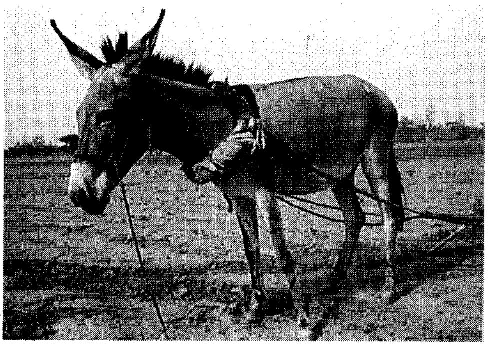
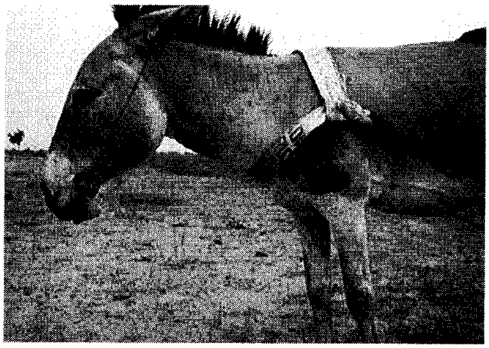


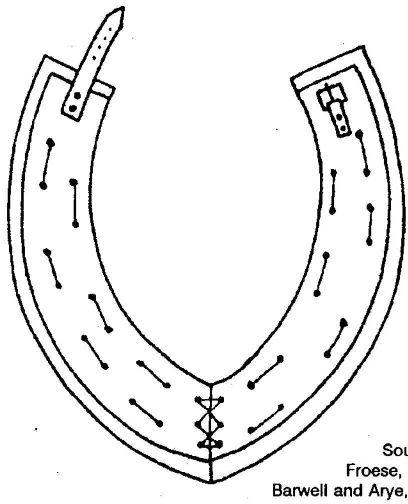
Fig. 3-33: Donkey fitted with breastband made from a synthetic sack in Senegal. (A skin abrasion from a previous harness is visible).

Photo: Paul Starkey



an efficient harnessing strategy, and breastbands or collars are the harnessing systems of choice for horses, mules and donkeys.

The breastband is the simpler and cheaper system for donkeys, mules and horses. The work force is primarily taken from a broad band of leather, rubber or strong canvas material across the animal's chest. Attached to either end of the breast band are the traces (ropes or chains) or shafts which pass back to the implement or swingle tree. The breast band is held in position by one or more straps. Usually there is a neck strap crossing the withers and a back strap across the middle of the back (Fig. 3-31). These straps not only maintain the position of the breast band, they also transmit the vertical component of the work, and they are often padded on the back and referred to as "saddles". The back straps may be adjustable or made to size. While leather is the traditional material for breastband and straps, rubber carefully cut from old lorry tyres is increasingly used and pieces are sewn together with wire. A study of several donkey harnesses in Botswana concluded that carefully made and padded breast harnesses made from either tyre rubber or from webbing could be both cheap and effective (Froese, 1980). The use of breastband harnesses made from padded rope has also been reported



Sources:
Froese, 1980;
Barwell and Arye, 1982

Fig. 3.34: Tyre collar harness. Developed in Botswana, the harness was found suitable only for donkeys undertaking light work. Lining material is stiched onto the old tyre walls.

(Barwell and Ayre, 1982) and in Senegal some breastbands are made from nylon rope surrounded by cloth, contained within an old inner tube.

Breastband harnesses are relatively simple to make, but are often of limited durability. There are examples of projects developing low cost harnesses, but later reverting to more expensive materials after frustration with breakages (McCutcheon, 1985). The skin of equines is sensitive to rubbing, and relatively soft materials or padding are advisable. Padding is particularly important if wire is used to join synthetic rubber or if abrasive ropes might rub against the skin.

Horse collars have been widely used in Europe and

Fig. 3-35: Full collar being used with horse on GRDR training farm in France.

Photo: Paul Starkey

Photo: Paul Starkey

Source: after Dibbits, 1985

Fig. 3-36: Prototype "Swiss-collar" harness at the University of Nairobi, Kenya.
Left: Donkeys fitted with harnesses give an on-station demonstration. Right: Drawing of collar harness

North America, particularly with larger animals. Horse collars are generally made of leather, supported by a wooden or metal frame usually in two pieces known as *hames*. The traditional European collar comprises two metal hames articulating at the bottom to form a U fitting over the leather collar and soft padding made to the size and shape of an individual horse. The load is applied to traces that pass back from rings attached to the hames. For certain operations such as harrowing there is no need for other harnessing, although a single back strap and saddle are often used in conjunction with a collar to take the vertical forces. For carting, or operations where braking is important a breeching strap is fitted around the rear of the animal and one or two saddles are used to support the vertical load on the shafts. In Europe horse harnessing was not only a highly skilled operation, it became a folk art.

Full collars based on the European style are seldom used in tropical countries. While collars are employed for heavy transport in North Africa, they are seen only rarely in Sahelian countries. In most African countries horses and donkeys are harnessed with breastbands for both transport and agriculture. There have been reports of collars made from the walls of cross-ply (*not radial*) car or motorcycle tyres (Fig. 3-34). While there have been some reports of such designs being appreciated by farmers (Froese, 1980, Lawrence, 1987) there does not seem to have been appreciable uptake of such collars for equines. One reported problem is that tyre harnesses distort as soon as a significant work load is applied and this together with broken wires from the tyre or the stitching can cause damaging skin abrasions (Barwell and Ayre, 1982).

Donkey collars made from two padded wooden hames linked with a leather hame strap and a chain have been developed, but these tend to be difficult to make (and therefore expensive) and are often more complicated to use than the simple breastband. It has been argued that the slanting breast of a donkey makes breastband harnesses only suitable for light work, and that to benefit from the strength of a donkey, power should be taken mainly from the shoulders. For this reason prototype "improved" donkey harnessing systems have been evaluated and promoted in

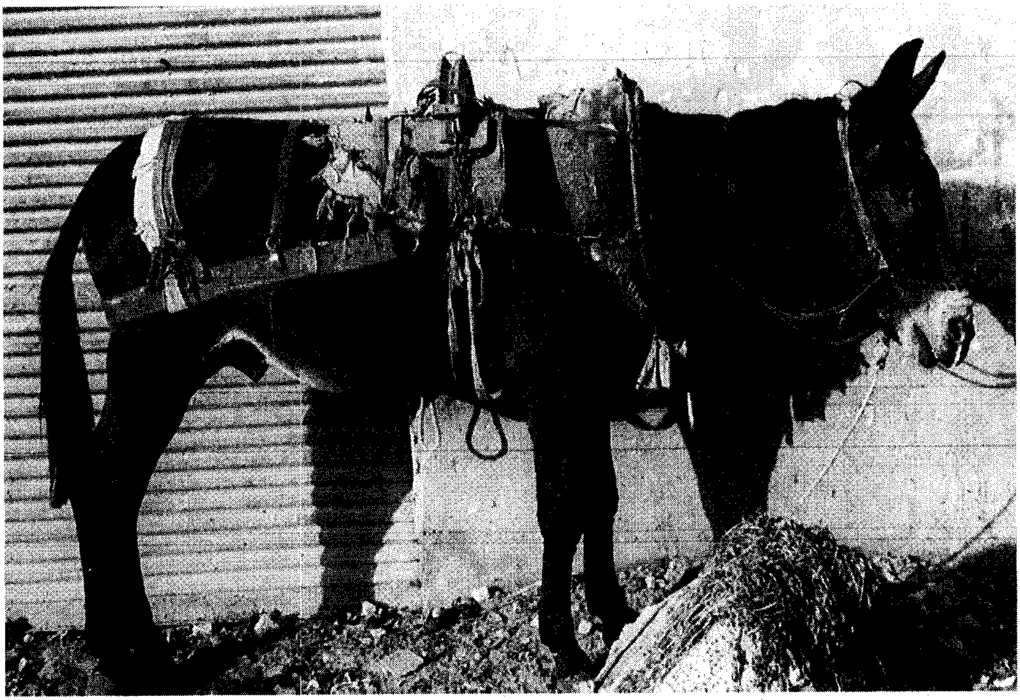
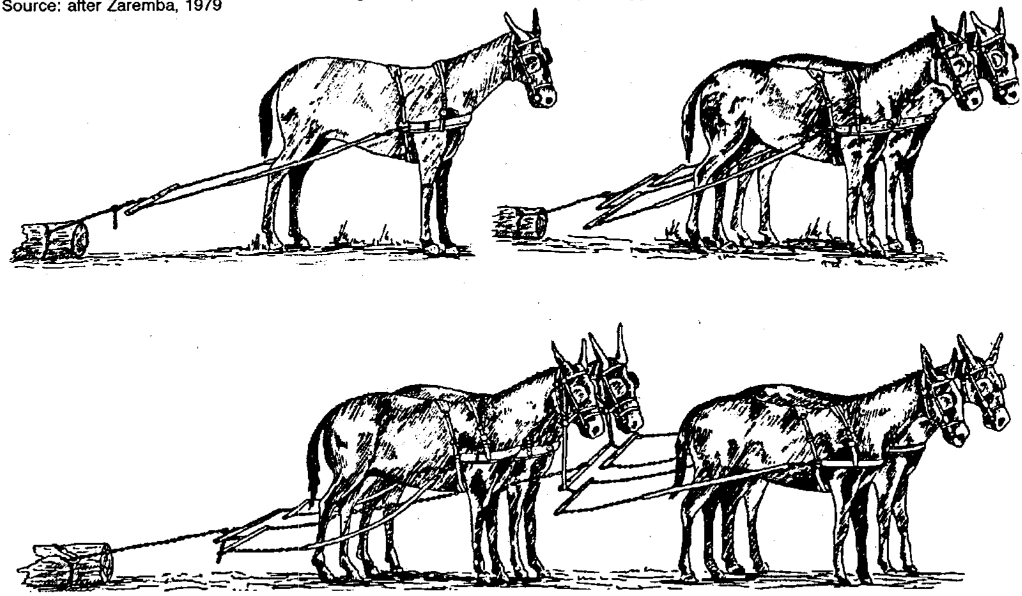


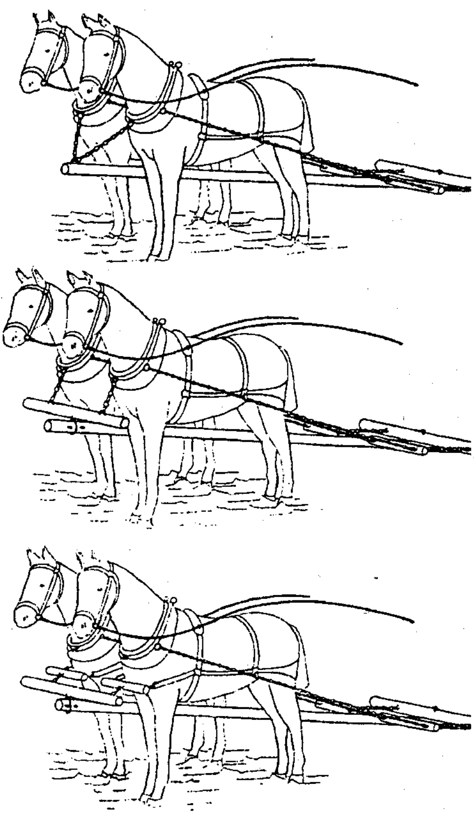
Photo: Paul Starkey

Fig. 3-37: Mule with full collar harness, breeching strap and cart saddle employed for transport in Egypt.

Fig. 3-37: Mule harnesses for logging.

Source: after Zaremba, 1979





Source: Barwell and Arye, 1982

Fig. 3-38: Some harnessing options for horse-drawn carts involving (bottom) the use of front swingle trees.

Kenya and Zambia (Dibbits, 1984, 1985, 1986; Fig. 3-36). Several artisans in Kenya and Zambia have been trained to make these harnesses but initial adoption rates by farmers have been slow, despite considerable publicity efforts. At the time of writing, these harnesses had not yet passed the test of long-term farmer acceptance and while it is too early to say whether significant numbers of farmers will go on to adopt these designs, it would seem prudent at this early stage to balance the reported optimism with a degree of caution.

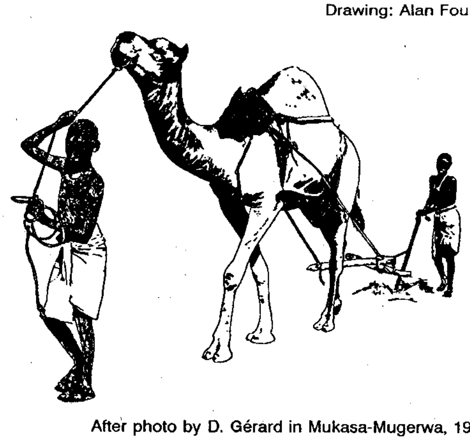
Donkeys and horses are the pack animals of choice in many parts of the world. Traditional saddles and panniers can be made of a variety of local materials, but generally incorporate a simple wooden frame to protect the spinal processes. This is secured by one or more girth straps, a breast band and a breeching strap or tail rope. Pack saddles and other transport issues are covered in Chapter 8.

3.8 Harnesses for camels

Camels are widely used for pack transport in arid areas and sometimes they are used to pull carts and power irrigation systems or grinding mills. The fact that camels have a high value for transport operations generally restricts their employment for agricultural operations. The long legs of camels allow them to cover ground quickly, but this height poses some problems for effective harnessing. Unless the traces of a camel harness are long (making turning difficult), the angle of pull is quite large, giving a significantly higher ratio of "lift" to "pull" than with less tall animals (see Chapter 2). Nevertheless it is not uncommon for camels to be used for crop cultivation in parts of North Africa, the Middle East, Pakistan and Rajasthan in India. In Sub-Saharan Africa the number of camels used for crop cultivation is very low, but it is reported that camels are being increasingly used for plowing

Fig. 3-39: Camel harnessed with withers harness made of leather being used to plow in Ethiopia.

Drawing: Alan Foulds



After photo by D. Gérard in Mukasa-Mugerwa, 1985

Photo: Jean-Louis Arrachart

Fig. 3-40: Camel pulling Arara plow in Niger. Note large angle of pull.

in parts of Sudan, Ethiopia, Mali, Niger and Nigeria. Although collars can be used with camels, simpler and cheaper systems are usual. A photograph and description of camel collars in Niger were provided by Fort (1973). These had padded wooden hames and were held in place by back and belly straps, but it was found that withers yokes were actually more appropriate for cultivation work. The single camel withers yokes used in Niger were made from old lorry springs, well padded and fitted with large rings at each end to take the traces. They were held in place by a belly band and also small saddle and neck bands (Fort, 1973).

In other countries, including Ethiopia, a broad piece of padded leather or webbing can act as a single withers yoke, with traces running from this harness to the implement or swingle tree. The harness may be held in place by a breast band and also by a strap or cord passing behind the hump (Mukasa-Mugerwa, 1985). Pathak (1984) provided a drawing of an Indian plowing harness made of rope passing over three pads to the front of the hump, under the chest and at the withers (Fig. 3-42). This apparently provides a large surface area of contact, but appears also to constrict the chest. Rathore (1986) provided a drawing of a plowing harness with traces attached directly to a saddle, itself held in place by a single

Fig: 3-41: Withers harnesses for camels.

Source: Duchenne, 1984
(after Ringlemann, 1905)

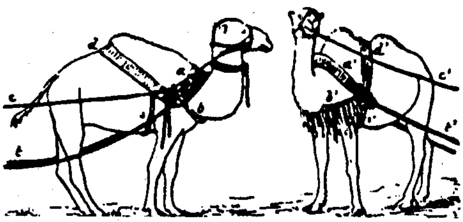
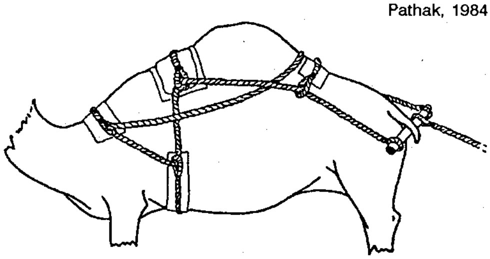
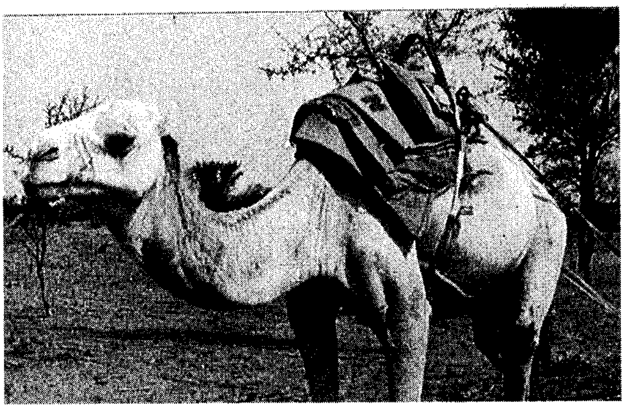


Fig. 3-42: Camel harness made of cord, as used in India.

Source:
Pathak, 1984





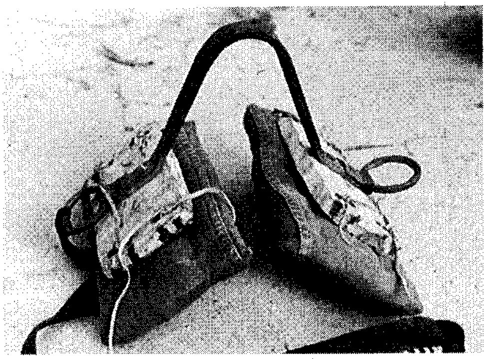
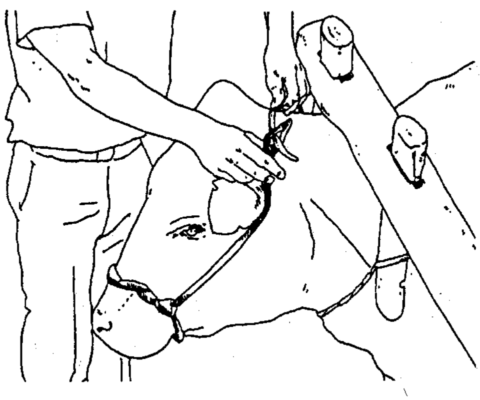


Fig. 3-43 a and b: Prototype hump harness based on traditional design and made by artisans in Niger.
Photos: Jean-Louis Arrachart

breastband. A similar system is used in Sudan (Wilson, 1984), and parts of Niger (Arrachart, 1988), and in both countries a child may ride the camel as the farmer plows (Fig. 3-40). One design of padded plowing saddle (or back yoke) from Niger that is made from old spring steel that fits over the camel's hump is shown in Fig. 3-43. The main disadvantage of back yokes on camels is that the attachment points for the traces are high on the animal, giving a large angle of draft.

Camels are used much more widely for transport than for pulling implements. Several illustrations of traditional pack saddles for camels were reproduced in the books of Wilson (1984) and Mukasa-Mugerwa (1985). For cart transport, a broad, padded withers harness is often used to provide the forward movement while a saddle over the hump takes much of the vertical load by supporting one or more straps, cords or even chains attached to the shafts.

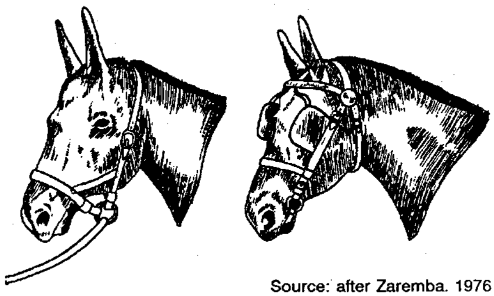
Fig. 3-44: Simple leather halter recommended for use in Zimbabwe.
Source: AETC, 1986



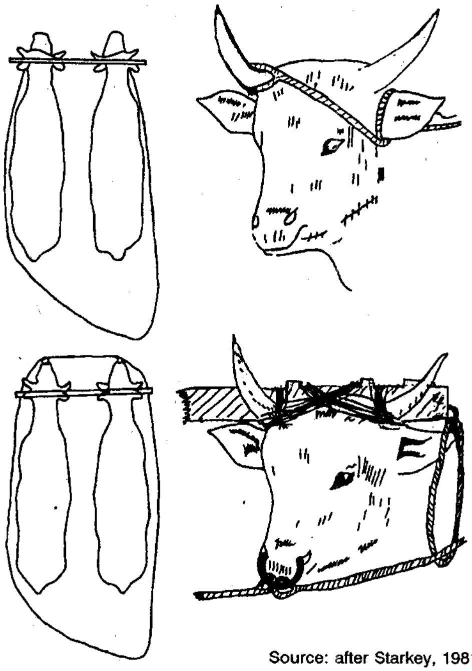
3.9 Reining systems

While traces are used to take the work load, reins are used to control the animals. Reins are not universal, and both bovines and equines can be trained to respond to voice commands. Steering reins are seldom used in conjunction with long-beam implements which can provide relatively direct contact between the operator and the animals. For reins

Fig. 3-45: Two rein attachment options for equines.
Left: halter (no mouth bit).
Right: bridle with mouth bit and blinkers.



Source: after Zaremba. 1976



Source: after Starkey, 1981

Fig: 3-46: Two reining options suggested for use in Sierra Leone.

to be effective they must be secured around the head of the animal. In cattle the attachment can be a nose ring, a nose rope or a rope around the horns. Nose rings lead to excellent control and are particularly useful for giving confidence to handlers unfamiliar with working animals. However they are relatively expensive, difficult to obtain and involve the piercing of the nasal septum. A cheaper system that also involves puncturing the septum uses rope in the form of a ring, or in a form of a halter running from horn to horn though the nose. A nose peg attached to a rope has a similar function. Unfortunately ropes made of natural fibre tend to rot, while synthetic ropes tend to slip. Ropes left on the head can become entangled in shrubs during grazing. Reins tied to the horns avoid some of these problems and risks but do not give such sensitive control.

For equines and sometimes for cattle a halter made of leather straps, ropes or rubber strips

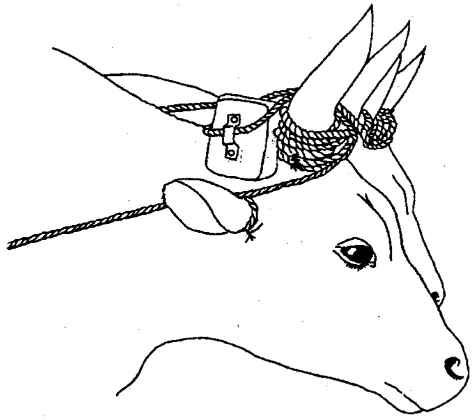


Fig. 3-47: A system of tying rein around ear.

that fits around the head of the animal can be used (Fig. 3-44). The use of a leather bridle that holds a metal bit behind the teeth of a horse, mule or donkey leads to particularly good control, but this is not always considered necessary (Fig. 3-45).

All animals may be led from the front by reins, but this is generally regarded as both unnecessary and undesirable for well-trained animals. Nevertheless in most African countries other than Ethiopia it is a common practice for one person to lead working animals, while a second person controls the implement. A third person often has the duty of encouraging the animals, making work with draft animals very labour intensive. Since it is an established fact that well-trained animals can be controlled by a single person, there would seem to be great potential savings if farmers were to invest in suitable reining systems and animal training. Indeed, investment in such training during a slack period of the farming year should release labour during the critical labour-bottlenecks during the cultivation season. If reining and training could achieve such benefits, it would seem to be a useful area for extension emphasis and therefore many programmes in Africa place much emphasis on “improved” systems of training and reining (Starkey, 1981; AETC, 1986; Mungroop, 1988). Nevertheless such obvious solutions are seldom as simple as they appear: firstly farmers argue that the animals are usually guided by children and youths, for whom the opportunity cost for alternative farm work may be low; secondly some farmers warn that well-trained animals represent a greater risk, since they are more easily stolen by strangers than are less docile animals; thirdly, some farmers argue, the animals are only used for a short period each year, and may be sold for meat after just a few seasons, making it difficult to justify the time needed to train animals and keep them in training.

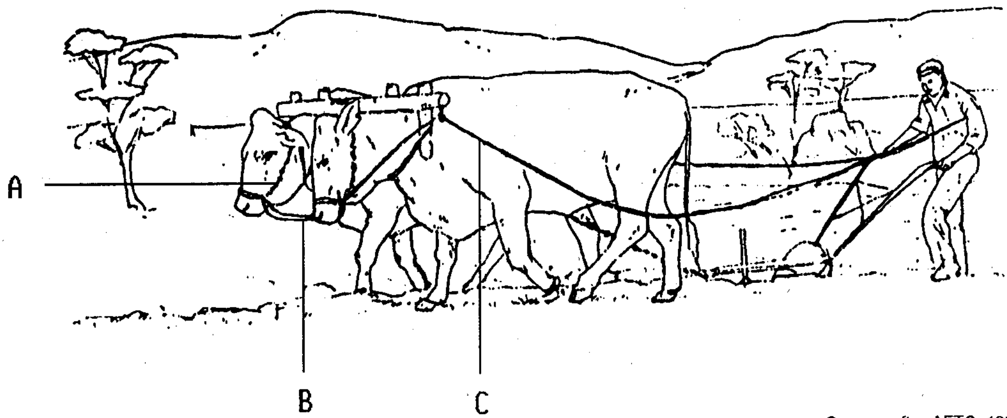
Reining systems recommended by extension programmes involve reins passing backwards from nose rings, halters or bridles to the operator. They are used, in conjunction with verbal commands, for steering and for stopping the animals. (Figs 3-48, 3-49) When two animals are used, one rope or strap joins the two nose rings or halters and one rein passes from the outer side of each animal. For improved control reins can loop round the ears of the animals (perhaps with some padding) (Fig. 3-47). It is evident that for the welfare of the animals, care should be taken when tugging at reins looped round ears or attached to nose rings.

Photo: Paul Starkey

Fig. 3-48: Nose-ring reining system for single ox, being used on-station in Sierra Leone.

Reins are useful in the early stages of working with draft animals, but they can often be dispensed with when animals are well trained, for they represent one more item to fit and one more possibility for entanglement.

Fig. 3-49: System of reins recommended for use in Zimbabwe. A - Halter; B - Coupling; C - Steering rope.



Source: after AETC, 1986