Using science to understand the biological constraints that limit work animal productivity

by

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Abstract

Research aimed at improving the efficiency of use of draft animals includes the study of animal nutrition, work output, animal fitness and training, equipment, breeding and disease control. Intake of poor quality foods is a major constraint to the effective use of draft animals, particularly when milking cows are used for draft purposes. Attempts to measure fitness for work and efficiency of training have not yet been successful and little is known about the effect of disease on draft animals. It is concluded that much research is still needed and could yield information of value to the small-scale farmer.

Introduction

The importance of work animals in many developing countries cannot be overestimated. They play a particularly important part in the livelihood of the poorer members of the agricultural communities in Africa, Latin America and Asia. Many outsiders have regarded the use of animals as somewhat antiquated and have assumed that they would be replaced by some form of mechanical power; in reality, this has always been an unlikely development because many of the farmers live at or near the subsistence level of production. Also modern machines need available spare parts, skilled labour and good communications if they are to be kept in working order. These factors have been forgotten by some involved in development projects and as a result there are many examples of agricultural machines ending up as so much scrap metal.

In contrast, the use of draft animals to provide farm power means that the animals' feed is derived from local resources, while the equipment can be made by the local blacksmith. Foreign exchange is not needed for such a system. Provided the animals can be fed on byproducts or on communal grazing there should be no serious competition for foodstuffs with the human population.

Thus it is unfortunate that until comparatively recently little or no research has been undertaken on this important area of production. Whereas over the last four decades much of the research effort in the West has been expended in increasing the productivity of dairy cows, laying birds, broilers and pigs, no similar research effort has been put into the improvement of draft animal use. In fact, because of the decline in importance of the draft animal in western countries, virtually all research in this area stopped in 1945.

Since 1977 the Centre for Tropical Veterinary Medicine (CTVM) in Edinburgh has been trying to rectify this situation by undertaking a programme of research with draft animals (Smith, 1981a). Other institutes such as the International Livestock Centre for Africa (ILCA) in Ethiopia and the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) in India are also now working in the same area. The current research work can be conveniently categorized under a number of headings.

Animal nutrition

Research in this area is important because draft animals consume large quantities of food whether they are being used or not. In

addition to the energy used for maintenance the animals need extra food for production. Work at the CTVM has indicated that with the best food and management draft animals will use an amount of energy equivalent to 1.7 times maintenance each day, whereas on poor quality food and indifferent management they will consume only 1.4 times maintenance (Lawrence and Smith, 1988). The amount of food an animal will eat is critical. Also, our results so far show that oxen cannot increase the consumption of poor quality roughage to match the energy they spend whilst working. In many parts of the tropics the quality of food is so low that, even when they are not working, oxen can only just maintain their body weight. When called upon to work, they lose weight and cannot compensate by eating more. They can only manage to eat more if the quality of the diet is improved which is not possible in many developing countries. The problem is even worse if cows are used for work instead of oxen, which is highly desirable in those Third World countries where both land and food are in short supply. The use of cows for work may mean feeding the animal at 2-2.2 times maintenance requirements if body weight is to be maintained and both work and milk output achieved (Lawrence and Smith, 1988). Such levels of intake entail the feeding of grain and competition for supplies of human food. An alternative strategy is to organize the work programme so that work does not correspond with the latter stages of pregnancy or peak lactation.

It is also important that available food resources should be used as efficiently as possible. Under all farming systems, work animals are used more intensively at some times of the year than at others. The most crucial time is during the season of land preparation and seeding. Unfortunately this is the very time of the year when animals are least likely to be in prime condition (Smith, 1981b).

Recent work (Peter Lawrence, personal communication) has shown that work increases the maintenance requirement of working animals and that this increased requirement continues for up to 16 hours after the animal has stopped working. This finding may influence our estimates of the true feed requirement of working animals.

Measuring work output

Most measurements of the amount of energy that animals use rely on the indirect method of measuring their consumption of oxygen and their production of carbon dioxide and methane. These measurements are made at the CTVM using an open circuit calorimeter. Since no truly portable apparatus exists for long-term (6-8 hours) measurements, Peter Lawrence at the CTVM is modifying a human "oxylog" for use with animals in the field.

The work achieved by animals both in the laboratory and in the field can be measured by an ergometer, also developed by Peter Lawrence, which measures work against distance and against time simultaneously. Work is the product of force and distance. For example, an ox that pulls with a force of 400 Newtons for 10 seconds at a speed of one metre per second, followed by 800 Newtons for 10 seconds at 0.5 metres per second exerts an average draft force of 600 Newtons over a distance of 15 metres and therefore apparently achieves 9,000 joules of work. In fact, research suggests that such an ox actually achieves 4,000 joules of work during each period of 10 seconds giving a total of 8,000 joules for a 20-second period (Lawrence and Smith, 1988). Thus the importance of measuring all three components is clear, especially with working animals whose speed and force exerted vary all the time that they are working.

Using equipment such as that described above, it has been estimated that oxen and buffaloes use an extra two joules of energy per metre travelled per kilogram of body weight on flat ground. This figure can be almost doubled if the animals are walking in mud (CTVM, 1987), a fact that is very important for animals working in paddy fields.

Using animals walking on treadmills it has been possible to measure the energy cost of carrying loads which is approximately 4 joules per kilogram carried per metre travelled. The energy cost varies according to where the load is placed: less energy is consumed when the load is over the front legs and more when over the middle of the animal's back (Lawrence, 1986).

Improved fitness and training

Lack of fitness during the period of cultivation could lead to delays in planting and sowing of crops which could lead in turn to reduced crop yields. At the present time there is no sure way to assess animal fitness. Work output, temperament and ability to work under hot conditions need to be measured. Changes in blood metabolites in exercising horses have also been measured by various workers including Revington (1983) but have not been shown to be clearly related to performance in horses. More recently, Pearson and Archibald (personal communication) have come to a similar conclusion with working cattle. Some measurement of fitness and training needs to be developed so that the effect of training can be measured and criteria developed for assessing "good" draft animals i.e. those that respond well to training. Such techniques would also be useful to establish how much time and effort is needed to train an animal at the beginning of the working season.

Improved equipment

In many cases the design of equipment for use by work animals in the Third World has not changed for centuries, and it is clear that much of it could be improved in a number of ways. The essential thing is to ensure that the method of harnessing is satisfactory (Garner, 1979). In Africa and Asia, where humped cattle are commonly used for draft purposes, simple shoulder yokes are used, while in Latin America, where the animals do not generally have humps, the yokes are fastened to their horns. Both systems of attaching the animals to the equipment are probably inferior to the collars which have been used for many years in parts of Europe and the USA, both for horses and cattle. Animals that are worked using well-shaped and padded yokes rather than rough ill-fitting ones will certainly achieve more work but the design of such yokes or collars is largely one of common sense rather than scientific experiment.

The need for cheap, efficient, well-designed equipment is no less important for animal-powered operations than for that driven by internal combustion engines, yet the resources that have been devoted to the two areas do not bear comparison. Better field equipment would mean that land could be cultivated in a shorter time with less effort, and crops sown earlier in the rainy season. Similarly, when animals are used for tasks such as water pumping, better pumps should result in fewer animals being needed. This might free some animals for other work or allow the farmer to keep fewer work animals.

Breeding

Only a limited amount of effort has been put into attempts to select better animals for draft purposes. In Sweden, various criteria have been defined to identify horses with superior pulling power: power tests have been devised using fixed or mobile ergometers, and draft aptitude tests in which horses show their natural aptitude to cope with pulling a load over varying terrain have also been developed (Dryendahl and Bengtsson, 1984).

In the UK and France, very large breeds of horses such as the Clydesdale, Shire, Suffolk Punch and Percheron, were developed for work purposes. These animals weigh 750-1,000 kg and they are capable of achieving more work than the smaller breeds used for riding purposes. Some European breeds of cattle, such as the Charolais and the Chiana-na, were also bred for use as draft animals and, as with horses, selection seems to have been for heavy body weight rather than for in-

creased power from animals of similar size. The same pattern seems to exist in the developing countries with the development of draft breeds of cattle such as the Hariana and the Kangayam in northern and southern India respectively.

Over the past 40 years, research workers have identified the characteristics needed in meat and milk animals and also the heritability of these traits. As a result of this work, considerable progress has been made in western countries in improving the efficiency of production of these animals. In contrast, very little is known about the selection of animals for work efficiency, and for this reason a research programme designed to identify the criteria for work capacity is being considered at CTVM.

Simple physiological or biochemical tests would help, but as yet we seem to be some way off obtaining simple criteria that could be used in the selection of draft animals, and still further from estimating the heritability of these characteristics. It is possible that progress could be made in the selection of draft animals once appropriate characteristics have been identified. These should obviously take into account pulling power and stamina, but should also include factors such as efficiency of food use, temperament, body heat production and the capacity for heat loss.

Disease control

Disease can pose considerable problems for the farmer. Plagues such as rinderpest can decimate cattle populations and it is important that draft animals be protected by vaccination. The loss of animals is often a disaster to the owner, especially if the loss occurs at the beginning of the plowing and planting season. Concentration of livestock is often greatest towards the end of the dry season and this facilitates the spread of diseases such as foot-and-mouth. Also, work may precipitate the effect of latent infection. Buffalo in Nepal that appeared normal but which, in fact, were heavily infected with liver flukes soon proved to be incapable of achieving any worthwhile work output (Anne Pearson, personal communication).

In areas where trypanosomiasis is endemic, the introduction of certain types of draft animal is difficult. The use of prophylactic drugs (Bourne and Scott, 1978) and trypanotolerant cattle may be the solution. The use of unusual species for draft such as the African buffalo and the eland is also a possibility. They may not, however, be acceptable to farmers and also they may succumb to trypanosomiasis when worked.

Conclusion

It is clear that draft animals are likely to remain the principal source of farm power in the majority of developing countries for many years to come. This being so, the investigation of possible ways of improving their use by farmers should be given a high priority - particularly as the subject has been neglected over the past 40 years. Improvements in harnessing techniques, nutrition, animal type and health, when implemented, are likely to have a greater impact on farmers in developing countries than are changes in other forms of livestock husbandry.

Résumé

Les travaux de recherche visant à améliorer l'efficacité des animaux de trait portent sur l'alimentation animale, la mesure des rendements physiques, l'amélioration du dressage et de la condition physique, l'élevage et le contrôle des maladies. Une alimentation qualitativement pauvre est l'une des principales contraintes au travail des animaux, en particulier dans le cas des vaches à lait utilisées pour le trait. A ce jour, que ce soit pour évaluer le dressage ou établir un critère de sélection, les tentatives de mesure de la condition physique des animaux n'apportent pas les résultats souhaités. L'effet des maladies sur les animaux de trait est mal connu. Des recherches importantes sont donc nécessaires si l'on souhaite apporter aux agriculteurs des informations utiles à leurs travaux.

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Title photograph (opposite)
In expectation of profitable animal traction: a farm family that had recently taken the decision to invest in animal traction in Sierra Leone
(Photo: Paul Starkey)