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Draft Animals in the Past, Present and Future

HESSEN

Acknowledgments

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Claus Kropp

Welcoming words

With this conference volume, the second special edition of the research magazine "Laureshamensia" at the UNESCO World Heritage Site Lorsch Abbey after 2020 is now being published. We, the State Administration of Palaces and Gardens in Hesse, are pleased that despite the difficult conditions caused by the pandemic, with this new edition we have been able to make another impressive contribution towards international networking in the fields of history, archaeology, ethnology and museum studies, but above all also in the thematic fields of sustainability and sustainable development. The fact that this volume, in addition to the printed version, is also made available as an open-source online resource is of particular concern to us and emphasizes our self-understanding and sense of responsibility in this regard.

Kirsten Worms

Director of the State Palaces and Gardens of Hesse

Prologue

The presented conference proceedings, which were prepared as a result of the 2021 digital world congress "Draft Animals in the Past, Present and Future" fits excellently into the further efforts of the State Castles and Gardens of Hesse to implement the sustainability strategy (Hessische Nachhaltigkeitsstrategie) defined by the State administration. Thus, not only educational approaches such as the newly implemented "Knowledge growing in the Garden" in Bad Homburg Castle Gardens as well as acquired third-party projects such as the competition "Landscape in Motion" awarded by the Rhine-Neckar metropolitan region are part of this, but also just such as the here presented publication projects. Once again, it becomes clear that our historical cultural monuments can also provide important impulses and contributions to discussions on current issues of sustainability, and that these are in fact desirable. In the special context of the UNESCO World Heritage Site Lorsch Abbey, the UNESCO Convention and the UN Sustainable Development Goals constantly are serving as important anchor points for reflecting on and following up on our own projects. The results of the conference dedicated to draft animals therefore also have to be seen as an outcome of that reflexion-process.

The conference proceedings impressively show that only the inclusion of historical dimensions allows for a complete coverage of the topic of "animal traction" and that the networking efforts undertaken by the Lauresham Open-Air Laboratory, which made the collaboration of this international body of authors possible in the first place, can certainly serve as a role model in any cultural context.

Hermann Schefers
Director of Lorsch Abbey

Editors' Preface

For millennia, draft animals played a key role in the survival of many cultures. Even today, draft animals still secure the livelihood of millions of people around the globe. Be it in transportation, agriculture or forestry: draft animals can offer sustainable, eco-friendly, and economically valuable ways of land use. Nevertheless, there are a lot of challenges, ranging from the pressure of high-profit markets or politics to animal welfare, breeding, and harnessing. The total number of draft animals is universally declining – in May 2021, our international conference 'Draft Animals in the Past, Present and Future' addressed these challenges. For the first time ever, more than 400 people from 18 countries came together virtually to discuss this topic and using a holistic approach: both scientists as well as practitioners, museum professionals, farmers, NGOs and associations took a deep look into past, present and future use of draft animals around the globe. This resulted in many different perspectives – all of which benefited from the mutual exchange of ideas and challenges.

Draft animals certainly deserve respect and recognition: Draft animal power helps to tackle the climate crisis by replacing fossil energy and by offering opportunities for sustainable, minimally invasive land use from which our ecosystems and biodiversity benefit. Moreover, the use of draft animals is by no means backward, but future-oriented, as the latest know-how and the further development of technologies and science are constantly being worked on – especially to ensure that the animals have a dignified life because they are not commodities, but valuable partners.

By teaching the broad public about the draft animal cause and promoting draft animal power, we are not only sharing and preserving traditional skills, we are also passing on how to handle and teach animals – in particular to a younger audience among whom we are raising awareness about responsibility for animals and our environment. This also contributes to a bottom-up approach, as draft animals are usually ignored in politics, but if the general public is educated about the positive asspects of draft animal power through workshops, shows, and educational work, this can shift perspectives on it up to the highest political levels and help to implement actual sustainability instead of mere words.

With these conference proceedings, we are trying to make a joint contribution to sustainable future development, the preservation of traditions and skills, as well as to cooperation and networking across regional and national borders. As we want to make it possible for everyone to have access to the information from the conference, and as we consider it important to spread the information about draft animals as widely as possible, we are providing the publication both in book-format as well as free of charge in an open-access digital format.

This can only be a first but nevertheless important and valuable step into a changing perception of draft animal use, but we are happy to have played and continue to play our part in that development.

Claus Kropp

Manager Lauresham Laboratory for Experimental Archaeology

UNESCO World Heritage Site Lorsch Abbey

Lena Zoll

Scientific Trainee at Lauresham Laboratory for Experimental Archaeology and UNESCO World Heritage Site Lorsch Abbey

Draft animals in the world

Paul Starkey and Bertha Mudamburi

Abstract

The paper, illustrated with photos, considers draft animals with worldwide geographical and historical perspectives and examples of the diverse operations undertaken. In various regions and at different times, domesticated animals such as cattle, buffaloes, yaks, horses, donkeys, elephants, camels, llamas, goats, reindeer and dogs have been used as transport animals (packing, pulling sledges or carts and/or riding). Draft animals have been important for soil tillage, and can be used for planting, harvesting and associated agricultural processes (irrigation, threshing, milling, logging). Some options for yoking, harnessing and combining work animals are reviewed. There have been major changes in animal power use in the past 150 years, with increasing motorization worldwide but also some expansion in the areas of draft animal use. Motors have a strong comparative advantage over animals for rotary movements (milling and irrigation), but less for steady pulling, intermittent short-distance transport and manoeuvrability in constrained or difficult environments. People continue to use or adopt animal power if they see benefits (including labour-saving, environmental and ethical advantages) and there is a supportive environment. They stop using draft animals if affordable motorized alternatives are available, they lack labour and/or the prevailing environment is unfavourable or lacking supporting service providers. There is need to overcome the common perception that draft animals are old-fashioned. This requires education and positive audio-visual and social media information. Heritage organizations could assist by combining retrospective information with modern, forward-looking examples of draft animals, and working with national and international networks of user-groups, researchers and concerned stakeholders.

Résumé

L'article, illustré de photos, examine les animaux de trait dans une perspective géographique et historique mondiale et donne des exemples des diverses opérations entreprises. Dans diverses régions et à différentes époques, les animaux domestiqués tels que les bovins, les buffles, les yaks, les chevaux, les ânes, les éléphants, les chameaux, les lamas, les chèvres, les rennes et les chiens ont été utilisés comme animaux de transport (pour le bât, tirer des traîneaux ou des charrettes et/ou monter). Les animaux de trait ont été importants pour le travail du sol et peuvent être utilisés pour la plantation, la récolte et lestravaux agricoles associés (irrigation, battage, mouture, abattage). Quelques options pour atteler, harnacher et associer les animaux de trait sont passées en revue. L'utilisation de la force animale a connu des changements majeurs au cours des 150 dernières années, avec une motorisation croissante dans le monde entier mais aussi une certaine expansion dans les domaines d'utilisation des animaux de trait. Les moteurs présentent un avantage comparatif important sur les animaux pour les mouvements rotatifs (fraisage et irrigation), mais moins pour la traction régulière, le transport intermittent sur de courtes distances et la maniabilité dans des environnements contraints ou difficiles. Les gens continuent d'utiliser ou d'adopter la traction animale s'ils y voient des avantages (notamment en termes d'économie de main-d'œuvre, d'environnement et d'éthique) et s'il existe un environnement favorable. Ils cessent d'utiliser les animaux de trait si des alternatives motorisées abordables sont disponibles, s'ils manquent de main-d'œuvre et/ou si l'environnement est défavorable ou s'il n'y a pas de prestataires de services. Il est nécessaire de surmonter la perception commune selon laquelle les animaux de trait sont démodés. Cela passe par l'éducation et par une information positive dans les médias audiovisuels et sociaux. Les organisations patrimoniales pourraient apporter leur aide en combinant des informations rétrospectives avec des exemples d'animaux de trait modernes et tournés vers l'avenir, et en travaillant avec des réseaux nationaux et internationaux de groupes d'utilisateurs, de chercheurs et de parties prenantes concernées.

Kurzfassung

Der mit Fotos illustrierte Beitrag befasst sich mit Zugtieren aus weltweiter geografischer und historischer Perspektive und zeigt Beispiele für ihre vielfältigen Einsatzmöglichkeiten. In verschiedenen Regionen und zu verschiedenen Zeiten wurden domestizierte Tiere wie Rinder, Büffel, Yaks, Pferde, Esel, Elefanten, Kamele, Lamas, Ziegen, Rentiere und Hunde als Transporttiere (zum Tragen, Ziehen von Schlitten oder Karren und/oder zum Reiten) eingesetzt. Zugtiere waren wichtig für die Bodenbearbeitung und können für die Aussaat, die Ernte und die damit verbundenen landwirtschaftlichen Prozesse (Bewässerung, Dreschen, Mahlen, Holzeinschlag) eingesetzt werden. Es werden einige Optionen für das Anspannen, Anschirren und Kombinieren von Arbeitstieren untersucht. In den letzten 150 Jahren hat sich die Nutzung der tierischen Arbeitskraft stark verändert, wobei die Motorisierung weltweit zugenommen hat, aber auch die Nutzung von Zugtieren zugenommen hat. Motoren haben einen starken komparativen Vorteil gegenüber Tieren bei rotierenden Bewegungen (Fräsen und Bewässerung), aber weniger bei gleichmäßigem Ziehen, intermittierendem Kurzstreckentransport und Manövrierfähigkeit in eingeschränkten oder schwierigen Umgebungen. Die Menschen nutzen weiterhin tierische Antriebskraft oder entscheiden sich für sie, wenn sie die Vorteile sehen (u. a. Arbeitsersparnis, ökologische und ethische Vorteile) und ein günstiges Umfeld vorhanden ist. Sie stellen die Nutzung von Zugtieren ein, wenn erschwingliche motorisierte Alternativen zur Verfügung stehen, es ihnen an Arbeitskräften mangelt und/oder das vorherrschende Umfeld ungünstig ist oder es an unterstützenden Dienstleister:innen fehlt. Es gilt, die weit verbreitete Meinung zu überwinden, dass Zugtiere altmodisch sind. Dies erfordert Aufklärung und positive audiovisuelle und in den sozialen Medien verbreitete Informationen. Heritage-Organisationen könnten dabei helfen, indem sie historische Informationen mit modernen, zukunftsorientierten Beispielen von Zugtieren kombinieren und mit nationalen und internationalen Netzwerken von Nutzer:innengruppen, Forscher:innen und Betroffenen zusammenarbeiten.

Resumen

El artículo con fotografías ilustrado examina animales de tiro desde una perspectiva geográfica-histórica global. En diversas regiones y épocas, animales domesticados como el ganado vacuno, búfalos, yaks, caballos, asnos, elefantes, camellos, llamas, cabras, renos y perros se han utilizado como animales de transporte (embalando, tirando de trineos o carros y/o montando). Los animales de tiro han sido importantes para el laboreo del suelo, y pueden utilizarse para la siembra, la cosecha, entre otros (riego, trilla, molienda, tala). En los últimos 150 años se han producido importantes cambios en el uso de fuerza animal, con una creciente motorización en todo el mundo, pero también una cierta expansión en las áreas de uso de los animales de tiro. Los motores tienen una gran ventaja comparativa sobre los animales para los movimientos rotativos (molienda y riego), pero menos para el arrastre constante, el transporte intermitente a corta distancia y la maniobrabilidad en entornos limitados o difíciles. Si los beneficios son visibles, existe una tendencia entre la población a utilizar o a adoptar la tracción animal en los trabajos agrícolas en los entornos que lo permiten. La tracción animal se ve sustituida por alternativas motorizadas en los entornos donde esta es más asequible o donde se carece de proveedores de servicios de apoyo. La percepción común sobre los animales de tiro, su relación con la era preindustrial y el uso de estos de forma anticuada es un imperativo de cambio. Para ello es necesario educar e informar de forma positiva a través de medios audiovisuales y sociales. Las organizaciones patrimoniales podrían ayudar combinando información retrospectiva con ejemplos modernos de animales de tiro con vistas al futuro, y trabajando con redes nacionales e internacionales de grupos de usuarios, investigadores y partes interesadas.

Introduction

This paper will endeavour to provide a concise overview of draft animals in the world, taking historical, geographical, technological and socio-economic perspectives. It is based on the authors' reading, personal observations in over a hundred countries and discussions with colleagues of various disciplines in numerous countries. It will start with an historical view and end with some current issues in the 21st century. It will briefly consider the various types of draft animals, and some of the equipment associated with the wide range of operations draft animals can perform. This overview, including the many photographs that illustrate it, is intended to introduce the subject and provide a basis for understanding the diversity and complexity of draft animal issues. It is intended to stimulate interest, discussion and encourage readers to delve deeper into the many multi-disciplinary issues being skimmed through. While taking a worldwide perspective, it is complemented by a companion overview paper by the same authors that concentrates on sub-Saharan Africa[1].

From the outset, it must be stressed that the authors are aware of the problems associated with such an overview and request a sympathetic understanding. It is necessary to simplify complex issues and provide generalizations that do not represent all situations and circumstances. For all the subjects and issues dealt with, there are other works that go deeper and provide more detailed, authoritative information. The authors encourage readers to look for more specialized expertise for understanding the different historical periods, the equipment used, the biology and welfare of the animals and the socio-economic issues of specific countries, communities and people of different status, wealth, age, gender, culture and ethnicity.

Historical, geographical and cultural perspective

The origins of draft animals

Exactly where and when the first animals were used for work is a source of archaeological conjecture and a continuing debate. Table 1 provides simplified, approximate timelines.

Many of the larger species of work animals may well have been initially kept for meat and milk and were subsequently trained for use in transport by carrying goods or dragging loads[3]. The use of simple ard ploughs has been associated with remains of early domesticated cattle and buffaloes, but the dates of the first uses of work cattle and buffaloes remain debateable.

The spread of draft animal technologies

Once animal species had been domesticated, and technologies to permit transport and/or tillage had been invented, the animals and the technologies gradually spread, through migration, trade and military campaigns.

- Between 5000 and 2000 years ago, the use of draft animals had spread throughout most of Asia, North and Northeast Africa and Europe
- Between 2000 and 500 years ago, pack and riding animals spread through the Sahel
- Europeans carried wheeled transport and tillage technologies to the Americas (about 500 years ago) and to West, Southern, East and Central Africa (about 350-150 years ago). The spread of draft animal technologies in Africa is discussed in the companion paper[4].

The value of animals to permit the movement of humans and goods, through riding, packing, sledges and wheeled transport is clearly highly beneficial, and draft animals can assist trade, military operations and governance. Their value for tillage depends on the agricultural systems in operation. The greatest benefit is likely to come on flood plains, where floods replenish soil nutrients, and it is possible to till the ground and grow crops every year. It is no coincidence that the development of some civilizations and the early use of ard ploughs appears to have occurred in flood-plain areas, including Mesopotamia, the Nile valley, the Indus valley and various significant water courses in South, Southeast and Eastern Asia.

Away from such sites, the predominant system of crop cultivation tends to involve shifting cultivation. Trees and shrubs are felled and burned, and crops are planted in the ash-enriched soil. After one or two years, the farmers move to a new site and the forest or woodland gradually grows back. Under this type of system, that has been widely used in the past century in parts of Africa, Asia and the Americas, the roots of trees and shrubs remain in the soil and tillage with animals is impracticable. Only when the stability of communities and the shortage of available land justify the effort of removing the roots from the soil, is it worth moving to animal-powered tillage

Animal type	Domestication (years ago)	Location	Initial work uses
Bos taurus cattle	10,000	Mesopotamia region	Transport and tillage
Bos indicus cattle	7,000	South Asia	Transport and tillage
Water buffaloes	6,000	South Asia and Southeast Asia	Transport and tillage
Donkeys	6,000	Egypt / Northeast Africa	Transport
Horses	5,500	Eurasian Steppes	Transport
Bactrian camels	5,000	Central Asia	Transport
Dromedaries	4,000	Northeast Africa/Arabian Peninsula	Transport
Llamas	4,000	Multiple Andean locations	Transport
Dogs	4,000	Artic circle (Asia/America)	Transport
Reindeer	2,000	Siberian arctic	Transport

Table 1 – Simplified timeline of the domestication of some draft animal species[2]

1 Mudamburi/Starkey 2022.
2 Based on many different sources.
3 Russell 2012.
4 Mudamburi/Starkey 2022.

and the use of natural or artificial fertilizers. This helps to explain why the use of draft animals for tillage did not spread rapidly in sub-Saharan Africa, and comparable farming systems in parts of Asia and the Americas. Another issue in sub-Saharan Africa was the stratification of some farming systems, with crop farmers keeping only small livestock and certain tribes maintaining cattle herds in itinerant systems that moved the animals in search of pasture.

Draft animals become an integral part of cultural heritage

As work animals are adopted within societies, they and their associated technologies become part of the prevailing culture. People identify strongly with their local animals, yokes, implement designs and methods. The animals and their technologies are included in local songs, festivals and works of art. The local yokes, harnesses and brassware are proudly reproduced and replicated, and may differ from those of neighbouring communities and countries. The detail included in the painting of carts, the carving of yokes and the decoration of harnesses and saddles is far more than is justified by their utilitarian uses. The effort and costs of such decoration are justified by cultural appreciation and proud tradition.

The cultural heritage of draft animal artifacts is appreciated and preserved by numerous museums around the world. The art of ancient Egypt is exceptional, with work animals (oxen, cows, donkeys, horses and, in the later periods, camels) proudly displayed in bas-reliefs, three-dimensional models included in burials and the artwork of papyrus paintings. In India, there are many local breeds of cattle developed in different areas as work animals, and numerous variations in cart design, specific to particular geographical areas. In Europe too, the animal-drawn cart designs are specific to particular regions. In the Museum of English Rural Life in UK, there is a large collection of cart and wagon designs, each associated with particular counties. The traditional designs of ploughs used for swamp rice cultivation vary throughout South and Southeast Asia as do the yokes. In France, withers yokes are traditional in many departments, while yokes tied to the horns may be used in neighbouring areas. There is no geographical logic to the distribution of these two very different types of yoke but farmers in all areas say that their yoking system is superior to that of their neighbours. In Portugal, heavy, elaborately carved and painted yokes are used, that are not ergonomically beneficial to the animals, but they give the animal owners cultural pride. Similarly, the colourfully painted ox carts of Costa Rica are a cultural heritage.

Different cultural traditions can develop over the centuries, but they can also arise very quickly. In some areas of sub-Saharan Africa, draft animals only spread widely from the 1950s, and in this time the design of yokes and the colour of carts has become 'traditional' in specific geographical areas. The painting all ox carts (made by different workshops) yellow, or blue or blue-and-black reflects a new local tradition, rather than the colour preferences of individual owners[5].

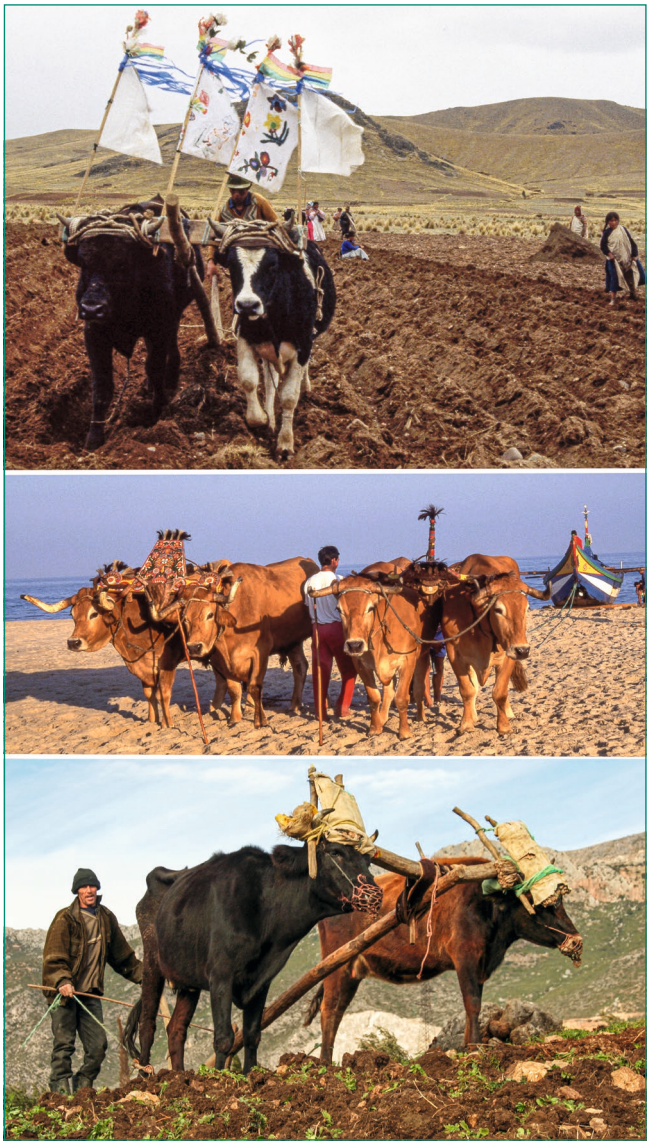

Figure 1 *– Cultural heritage reflected in ox yokes. Top: Flags on yoke celebrating potato planting in Bolivia. Middle: Heavy carved and painted yokes on fishermen's oxen in Portugal. Bottom: Yoke extensions to reduce fly nuisance on cows in Morocco*

Affordability, status and gender issues

In modern times, western media (fixated by motorization) has tended to portray work animals as a backward technology used by poor people. However, the poorest people do not, and never have, owned work animals. Modern-day owners of work animals may be poor relative to richer people owning tractors and trucks, but they are wealthy compared with many of their peers who cannot afford the cost of buying and maintaining work animals. A woman with a donkey to carry her sack is not as poor as her neighbour who must carry her sack herself. Hence, the expression in Ethiopia 'a woman without a donkey is a donkey'.

Work animals have always been expensive in terms of their purchase price (or their potential sale value if bred by the owner). In addition, there are the investments in time and resources in order to train the animals and care for them throughout the year, including in times of feed shortage (such as dry seasons or winters). Keeping animals close to the homestead may require storing and carrying feed resources. Allowing animals to graze freely

5 Starkey 2001.

may require herding supervision, fencing and/or risk of theft. One mitigating solution employed by resource-poor smallholder farmers in many countries throughout the world, has been to use cows for work. This removes the need to feed oxen during the lean months and increases the benefits as the working animals also provide milk and calves.

***Figure 2** – People pulling implements due to lack of animal power in Bolivia (top) and India (below)*

As with many technologies in the early years of adoption, only high-status people can afford to own working animals. Then as the technology spreads and becomes mainstreamed, others can invest in the benefits of working animals. Since their early domestication, horses have been considered as high-status animals, as have camels, in countries where these are important. In many cultures, men are considered as being of higher status than women, and to this day working horses, camels and oxen are usually owned and used by men. Donkeys, on the other hand, have often been considered as low status animals, and women have been responsible for them. While the 'low status' association of donkeys and women has been (and remains) unfortunate, women have been able to benefit from the load carrying capacity of donkeys. The recent high Chinese demand for *ejiao* (donkey gelatine) has led to the value of donkeys soaring and the consequent decimation of donkey populations[6]. Sadly, some men have sold donkeys that were greatly benefitting women.

6 Cheng 2018; Donkey Sanctuary 2019; Brooke 2019.

Diverse species and breeds

Diverse draft animals:

Around the world at least twenty types of animal have been used for work. The main draft animals have been bovids, including cattle (*Bos taurus* and *Bos indicus*) and water buffalo, the equids (horses, donkeys and mules) and the camelids (dromedary, Bactrian camels and llamas). Certain other species have filled important niche roles in particular environments. These include other bovids (yaks around the Himalayas, banteng in Indonesia and goats in many countries), Asian elephants, cervids (reindeer) and dogs. Other species (including moose, zebra. African buffalo and African elephants) have been trained successfully but were never widely used. Various animals also perform other work operations for humans, but these do not really come under the category of 'draft animals'. For example, sheep dogs and guide dogs are specialized working animals, donkeys can guard small livestock, messenger pigeons have been important for communications and rats have been used for bomb detection. While the local importance of all the work animals is acknowledged, this overview paper will concentrate on those animals that have been most widespread in the world and are still used in large numbers, especially the bovids and equids.

Bovids: *Bos taurus*, *Bos indicus* and water buffaloes

There are two main species of cattle (although whether they are species or subspecies is being debated). The humpless cattle (*Bos taurus*) have been used for millennia in the Middle East, North Africa and Europe. Humped cattle or zebus (*Bos indicus*) originated in South Asia and spread around Asia and into Africa in prehistoric times, where they have been bred to form a wide variety of indigenous zebu breeds. In the past 500 years humpless and humped cattle breeds have been exported to the Americas and throughout the world, leading to many crossbreds and some distinct breeds based on the hybrids. In West Africa, away from the Sahel, there are some dwarf cattle, notably the N'Dama, that are also humpless *Bos taurus* breeds. These evolved to become tolerant to the enzootic trypanosomiasis (sleeping sickness) and so they could inhabit the forest fringes that can still prove fatal to zebu cattle. Although they are small, N'Dama cattle have been successfully used for work since the 1920s[7].

There are many breeds of water buffalo, but two main types. Swamp buffaloes, with long, straight sweeping horns, have been bred mainly for meat and for work, notably for rice cultivation for which their large feet are well adapted. River buffaloes or dairy buffaloes, that typically have tightly curled horns, have been bred for milk production, although some (notably the surplus males) are used for work[8]. Swamp buffaloes are mainly used in rice farming systems in South and Southeast Asia (although in the region as a whole, far more oxen than buffaloes are used for rice cultivation). Dairy buffaloes are widely maintained on the Indian sub-continent and are also important in Egypt and some parts of southern Europe[9]. Although dairy buffaloes can be used for work, most working buf-

7 Starkey 1981.
8 FAO 1977.
9 Ibd.; Gilbert et al. 2018.

faloes are of the swamp type. The comparative advantages of buffaloes over cattle are that they can survive on low quality feed (including rice straw), they are individually strong (due to their weight) and they have large feet that allows them to walk easily in swamps. However, their thermoregulation through sweating is greatly inferior to cattle (hence their tendency to cool off in standing water) and so they can become heat stressed if worked hard. They are also slow at breeding and susceptible to some diseases to which zebu cattle are more resistant.

Figure 3 *– The two main types of buffalo. Top: Swamp buffalo with swept horns in the Philippines. Below: Dairy buffalo with curled horns in Pakistan*

An American academic team made an erroneous suggestion that the water buffalo could be an ideal animal for Sub-Saharan Africa[10] and this resulted in some failed attempts to introduce them as work animals. Their susceptibility to disease was problematic, they were expensive, and decades would be required to breed up a significant population. Moreover, local resistant zebu breeds were readily available and inexpensive, and a pair of zebus could achieve more in tillage in rice swamps or upland soils than a single buffalo[11].

Gender issues for 'oxen'

Throughout the world, oxen have been, and remain, the most used animals for soil tillage. In English (and many other languages) the word 'oxen' (or buey, bœuf, boi) means a work animal and/or a castrated male animal. The two meanings are overlapping because most working cattle have been castrated males. However, not all working cattle are castrated oxen. In some countries, including Chad, Nigeria and Mexico, intact bulls may be used for ploughing and even riding. Some 'work oxen' are cows and this is quite common in Southern Europe, Turkey, North Africa, Indonesia and the altiplano of Bolivia. Papyrus paintings from ancient Egypt clearly portray udders on some of the working animals. As has been noted, smallholder farmers with intermittent draft work may use cows that provide a better return on feed and labour resources, providing calves and milk as well as work, manure and meat. This switch from oxen to cows has been a farmer-led innovation, by farmers with modest work requirements and limited access to feed resources. Some professional researchers and agricultural extension workers had not noticed this trend, and only learned about this practice when they looked closely below the working animals or talked with the farmers. It is not uncommon to hear people concerned about the impact of the work on achieving and fulfilling pregnancy. However, provided there is adequate nutrition, cows (as with humans) are able to carry out a modest amount of physical work without interfering with successful reproduction. The comparative advantages of oxen and cows for work was well illustrated in Portugal in the last decades of the 20th century, by an example of 'the exception that proves the rule'. Almost all the smallholder farmers who had not mechanized, used cows intermittently for transport and a modest amount of tillage. Another use of working cattle in Portugal at this time was to launch fishing boats and pull in long fishing nets. All these working cattle were castrated oxen, as they were needed to work in teams at least twice a day on almost every day of the year. Oxen

10 BOSTID 1981.

11 Starkey 1990.

Figure 4 *– Two cows with head yoke ploughing in Spain*

were better for the commercial specialized application, while cows were more appropriate for the multipurpose requirements of smallholder farmers.

Equids: horses, donkeys, mules and hinneys

Horses

Historically, horses have tended to be high-status transport animals, used for riding (including racing) and pulling chariots, carts and wagons. They tended to have high purchase and maintenance costs, which contrasted with the cheaper, multipurpose and less risky cattle, that could be more easily afforded for farming and transport operations, and which could be converted into valuable meat if necessary. Over the years, breeding has led to the light, fast thoroughbred racing horses, the heavy, strong draft horses and the intermediate, strong but fast horses used for military purposes. All three types, as well as smaller ponies, can be used for work, depending on their availability, cost, maintenance needs and work requirements. In South Africa, horses rejected by the racing industry have been used to pull coal delivery carts and some have also been used by small-scale farmers for tillage.

Historically, and to this day, the main use of horses has been for transport which benefits from their important comparative advantage of speed. In industrialized countries, as motor power increasingly replaced working animals on farms and roads, urban collection and delivery services based on horse carts and wagons persisted for decades. This was because animal transport is well adapted to short distance travel and much waiting. This advantage, combined with the high-status image of horses, also makes horse carriages common around tourist locations in many countries in the modern world.

In Europe, between the 13th and 19th centuries, horses gradually replaced oxen as the main animals used to pull ploughs and other implements[12]. The slow transition was repeatedly interrupted by wars, that increased the demand by the military for horses. The development of more complex implements for seeding and harvesting accelerated the change, as the speed and acceleration of horses were well-adapted to pulling the new machines. Heavy horses were shipped around the world to the Americas (mainly to temperate and highland areas), South Africa and Australia. Equids seldom thrive in hot, humid conditions and the use of horses in Africa and other tropical areas is primarily in semi-arid and highland zones. Here they are mainly used for transport, with a relatively small number being used for tillage.

Donkeys

Donkeys are well adapted to arid environments, and they do not thrive in the humid tropics. They need less feed and attention than horses. They are mainly used as transport animals in semi-arid zones and mountainous regions, notably for packing and pulling carts. Larger types of donkeys can be ridden, and some of the larger breeds have been selected for a gait that provides a comfortable ride. Their ability to carry packs on narrow paths in mountainous environments, gives them a comparative advantage over most motorized transport. They also have the advantages of being cheap (relative to other work animals), of low risk of theft and able to survive on minimal feed resources. However, in the past decade, the high Chinese demand for *ejiao* (donkey gelatine) has greatly increased their value and thereby the theft risk. Donkeys are generally smaller than cattle and horses (although there are some very large breeds) and can only pull relatively small implements, unless they are harnessed in teams. Nevertheless, smallholder farmers who own donkeys may use them for light tillage operations, particularly if they have no alternative animals.

Mules and hinnies

Mules are crossbred animals made by crossing a female horse and a male donkey. Hinnies are made from crossing a male horse with a female donkey. The hinny cross is more difficult to produce, and hinnies are much less common. Both crosses combine the resilient sturdiness and sure-footedness of the donkey with the larger size of the horse, with mules generally being bigger and stronger than hinnies. Since mules and hinneys are sterile, there are no breeding populations and specialized mule breeders are able to charge high prices. Mules tend to be used as dedicated transport animals (packing or pulling carts or wagons), for example by full-time commercial transporters. They can be used for riding and for tillage but are this is less common. Their temperament and cost encourage owners to keep them employed throughout the year.

Figure 5 *– Top: Hinny used for pack transport in Nepal. Below: Large mule weeding maize in USA*

12 Collins 2010.

Camelids

The use of dromedaries (one hump camels), Bactrian camels (two humps) and llamas has been important in specific environments. Dromedaries evolved in arid, sandy environments and their heat tolerance, water conservation, large feet and long stride make them excellent for riding and pack transport in arid zones, notably the Middle East and the countries bordering the Sahara. They can also be used for pulling carts or wagons, including in northwest India and in Pakistan. Where they are owned and used for transport (their main role), they can be used for tillage, but their height does not make draft operations particularly easy. In some countries, camels have been used for irrigation and to turn mills to extract oil from seeds or olives[13].

Bactrian camels evolved in the Asian steppes and are adapted to cold weather and stony ground. They have mainly been used for riding and pack transport, with only limited examples of wheeled transport and tillage.

Llamas, and the much small alpaca, evolved in the Andes and have been used for centuries as pack animals. Their use for riding, wheeled transport and tillage has been minimal. While farmers who keep llamas for their meat and wool will sometimes use them for pack transport, most commercial transporters switched to donkeys and then, where roads were available, to motorized transport.

The use of camelids for transport continues in their various specialized zones, notably in circum-Saharan countries and India, but it has declined significantly due to motor transport.

Figure 6 – Women using pack llamas in Ecuador

Diverse harnessing systems

There is a huge range of saddles (for packing or riding) and harnessing systems for linking the animals to implements, carts or machines. The remains of ancient harnessing systems are quite rare (due to decay) but are part of the archaeological evidence of draft animal use.

Numerous designs of saddles, yokes, collars and harnesses have been developed over the years and have often become part of folk art and a cultural heritage. Aspects of their design are often robustly defended by their users, with equally vocal advocacy by the users of different designs in neighbouring areas.

Bovids

Yokes have been, and remain, the most common way of linking oxen, cows or buffaloes to the chains or beams used to pull implements, carts or wagons. There are two main types of yoke, that can be used with pairs of animals (most common) or single animals. Withers yokes rest at the base of the neck and the animal pushes with that part of its body (the withers). Head or horn yokes are tied to the horns and provide a more rigid attachment. This makes them particularly suitable for operations requiring the animal to brake the load being pulled (such as a cart or a log in forestry operations). Both types are widely used throughout the world, with withers yokes the most numerous as they are the dominant yokes in much of Asia and Africa. Head/horn yokes are particularly common in Latin America. While both types are widely defended by their owners, there appears to be no compelling evidence to show either type is particularly efficient or beneficial to the animals[14]. This is partly due to the huge variation of designs, so within-type variations make between-type comparisons difficult. However, badly made or badly fitted yokes of either type can cause problems, notably skin injuries.

Figure 7 – Top: Oxen with carved horn/head yoke in Mexico. Below: Oxen with pole-type withers yoke in India

Collars or breastbands are widely used with horses but are seldom used with bovids. There are historical examples of oxen working with collars, and in a small part of Europe (including parts of Germany and Switzerland) three-pad collars have been developed for use with single animals. However, despite some promotion attempts, such technologies have never become widespread, partly because yokes are effective and tend to be much cheaper and easier to fit.

13 Starkey 2000.

14 Id. 1989.

Equids

Equids are usually harnessed with breast bands or collars, although there are some historical and geographical examples of equids working with yokes. A well-fitted collar is considered the most comfortable and efficient means of harnessing a horse, mule or donkey for hard work, but it is also the most expensive and complicated means of doing so. In the tropics and subtropics, full collars are rarely employed. Throughout the world, breast band harnesses are widely used for light operations including carting. Carting operations generally require a small saddle on the back of the animal to take the downward load, and such saddles (as with pack saddles) have pads lying on each side of the vertebrae so that there is no direct pressure on the backbone[15].

The manufacture of leather harnesses is skilled work and good harnesses are expensive. This is particularly problematic for donkey users, as a good harness may cost more than the value of the animal itself. Therefore, low-income farmers and transporters often use cheaper materials, notably tyre rubber, webbing, sacking or ropes. These can damage the animals' skin particularly if joins are made using wire. In recent years some animal welfare charities have been promoting the local manufacture of equid harnesses from softer and less abrasive materials that are less expensive than leather.

Harnessing teams of animals

Most animals are worked singly (notably equids, water buffaloes and camelids) or in pairs (especially oxen). It is unusual for different types of animal to be worked together, although this sometimes happens when a farmer does not have a suitable pair of animals, and so substitutes an equid for a bovid. In North Africa, very different pairs of animals may be worked together, including cattle, equids and camels. This is made possible by each animal being fitted with a withers harness that connects with a beam (a 'belly yoke') running beneath the animals. With such a system, a donkey can plough with a camel, with the camel providing the strength and the donkey ensuring they walk in straight lines. However, linking different animals is always problematic for the animals as they have different strides and stepping rates.

Figure 8 *– Top: A camel and a mule fitted with withers bands and a 'belly' yoke ploughing together in Morocco*

15 Pearson et al. 2003.

Where two animals are insufficient for the power requirements, larger teams can be assembled. With oxen, this generally involves connecting pairs of animals in tandem with chains joining the various yokes. Teams of four or more animals can be used to pull wagons or implements, and this remains quite common in Southern Africa. Historically much larger teams were used for ploughing and pulling large wagons. The main streets of some towns in Africa, including Bulawayo, were made wide enough to allow wagons pulled by large spans of oxen to do a U-turn.

With equids, multiple pairs of animals can be harnessed in tandem with swingle trees behind the animals connected to eveners that connect with a chain to the next evener. For field operations, three or more equids, notably heavy horses, can be harnessed to work side-by-side, with a system of swingle trees and eveners to ensure the work is shared according to the strength of the various team members.

Large teams of draft animals allow one (or more) operator to control many animals, and so can be labour saving. However, large teams are slower and more complicated to harness, and require large fields in which to manoeuvre. In smaller fields, multiple teams of two animals pulling lighter equipment may be more appropriate, if sufficient labour is available.

Figure 9 *– A team of six donkeys pulling a three-furrow plough in South Africa*

Diversity of draft animal operations

Transport and soil tillage have been, and remain, the main uses of draft animals throughout the world, but work animals can also be used for many other more specialized operations including water-raising, crop processing and logging.

Riding and packing

One of the earliest uses of domesticated animals, notably equids and camelids, was getting them to carry people or goods. Millenia ago, horses became high-prestige animals allowing people (notably men) to travel fast and over long distances. This was very important for military purposes, and the use of cavalry in international warfare continued until the 20th century. Horse saddles and bridle systems were developed to improve the comfort and efficiency of riding. Camel saddles were also developed, and camels permitted both effective warfare and long-distance journeys and trading. Camels were also important for long-distance pack transport. Horses could also be used for packing, but their high status meant they tended to be used for riding and wheeled transport, allowing donkeys and mules to become the main pack animals.

Figure 10 *– Boy in Colombia riding to school on a donkey with a wooden saddle*

Donkeys have also been used for riding. Cattle have been used for riding (and warfare) and pack transport, but this has been, and remains, quite unusual.

In the 21st century, horses remain the main riding animal and are widely used in sport, recreation, ranching and for personal transport in remote areas. Donkeys and mules remain important pack animals in mountainous and remote areas, and still are available for use in military campaigns. Camels continue to be used for riding and packing in remote, arid areas as well as for prestigious sports.

Dragging and logging

Because dragging technology is so cheap and simple, it has been widely used with oxen in many countries and remains important for smallholder farmers in parts of Africa, Asia, Latin America, the Caribbean and Pacific. A simple V-shaped branch can act as the sledge, that is pulled by a chain attached to a yoke or harness. More complicated sledges can be used to move efficiently on snowy ground, and these can be pulled by dogs, equids or cervids. Training animals to drag loads, perhaps using simple wooden sledges to reduce the friction, probably happened early in domestication, preceding the wheel.

Figure 11 *– Pairs of oxen pulling sledges in Fiji (top) and Cuba (below)*

Logging uses similar principles, whether employed by a smallholder in North America dragging lumber or by a forestry enterprise extracting felled trees. Oxen, horses and mules tend to be the main animals used for logging, although the Asian elephant excelled at logging work. In addition to simple dragging with chains, friction can be reduced through the use of a simple sledge (to raise the leading end) or a sulky, a simple wheeled device that also raises the leading end to prevent it ploughing into the ground. With increasing concern for the environment, the benefits of animal logging over the use of heavy machinery are becoming more apparent. Some forestry enterprises in Europe are returning to animal-powered logging, to prevent the environmental destruction caused when forests have to be opened out to allow heavy machines to retrieve logs. Stratified systems are developed whereby animals (in Europe, mainly horses or mules) drag felled tree trunks to the tracks to which heavy machines are restricted.

Figure 12 *– Horse logging in Romania*

Carriages, carts and wagons

Various technologies involving draft animals pulling wheeled transport have been used for millennia. Until the 20th century, a high percentage of the world's land transport and trade depended on animal power. Two-wheel carts have been and remain the main wheeled transport pulled by bovids, equids and camelids, as they are relatively simple (and so cheap) as they do not require the two axles, four wheels and a steering mechanisms needed for carriages and wagons. However, animal-drawn carts with variable loads are not always well-balanced and tend to put some downward pressure on the animals. Four wheeled transport reduces the vertical load on the animals, makes loading and unloading easier (with or without animals in place) and allows much heavier loads to be drawn. So, carriages and wagons tend to be favoured by professional transporters and larger-scale farmers, while two-wheel carts are preferred by smallholder farmers and small-scale transport entrepreneurs.

In the 21st century, although the use of draft animals has declined, there are still tens of millions of ox carts in use worldwide, notably in India, as well as carts pulled by horses and donkeys, and to a lesser extent camels.

Figure 13 *– Top: Ox carts in Myanmar. Below: Horse pulling wagon of hay in Romania*

Ploughing, ridging and harrowing

The earliest ploughs were symmetrical ards with a wooden plough body attached to a long wooden beam that was pulled from the animals' yoke. From quite early times, the plough share became a metal chisel or spear that penetrated the earth. Such ploughs have remained in use for millennia, and many of the traditional ploughs used today in Asia, North Africa and Ethiopia (mainly pulled by oxen) conform to this pattern, albeit modified over the centuries of traditional use.

Figure 14 *– Farmer in Ecuador weeding with oxen using a traditional long-beamed ard plough*

Similar ards were introduced into Latin America by colonialists and have since become traditional. Ard ploughs perform tine tillage, which loosens the soil but does not invert it fully. A finer seedbed it made by a second pass, generally travelling in a different direction, and the loosened soil can be moved into ridges with the ard, if required.

Mouldboard ploughs were developed in Europe, to invert the turf or soil for weed control and in Asia to invert the soil in irrigated rice fields. With the industrial revolution, ploughs with wooden mouldboards were replaced by factory-made steel implements. Such ploughs were introduced around the world, including in sub-Saharan Africa. Despite the widespread availability of steel mouldboard ploughs for well over a century, ard ploughs generally remain important in the countries where they were (and are) widely used.

Symmetrical ploughs with two mouldboards are known as ridgers and these can be used for primary tillage, or for creating earthed up ridges from ploughed land. Ridging takes more effort and so is generally only done where there are benefits in water control or to maintain looser soil around the plant roots.

Figure 15 *– Pair of oxen in Cuba with a wide weeding yoke pulling a ridger to weed and earth up the crop*

Having broken the soil structure with a plough, larger clods can be broken down by passing with a harrow. This provides wide but shallow tillage using multiple tines. Ancient Egyptian harrows comprised a wooden frame and metal tines, and many traditional and modern harrows in use in the world today reflect this basic idea. With the industrial revolution came all-steel tine harrows and disc harrows (only suitable with strong animals). However, similar work can be achieved more cheaply by dragging branches of thorn-trees across ploughed land, and this has been used in some countries.

Puddling and levelling

Traditional ards or mouldboard ploughs can be used for primary tillage in rice production. However, irrigated rice requires the soil to be relatively impervious to water (to prevent it draining away) and for the field to be level, to ensure the water is of uniform depth and optimal for the rice plants. To achieve this puddling and levelling, animals (usually oxen) pull a plough around the flooded rice field, and through a combination of the implement and their footsteps, the soil is puddled so water is retained. Often at the same time, another pair of animals pulls a long horizontal bar across the field, moving soil from the higher ground to the lower areas. The weight of the operator standing on the leveller assists the process and the operator can stop and raise the implement to dump moved soil where it is needed. With multiple passes the field can be puddled and levelled and be ready for transplanting. Equids are seldom used in rice fields. Water buffaloes are very good at puddling and are the main draft animals in the Philippines and some other countries. Nevertheless, oxen puddle and level the majority of irrigated rice fields in the world that are cultivated using animal power.

Figure 16 *– Puddling and levelling rice fields using both oxen and tractors in Dominican Republic (top) and Nepal (below)*

Planting, weeding and spraying

Historically, and to the present day, most farming operations that use animal power involve primary and secondary tillage and transport. Planting has mainly been done by hand, as has weed control. This has been partly because planters require relatively complicated metering mechanisms to ensure appropriate seed spacing and without wide and uniform row spacing, weeding with animal power is difficult.

There is evidence of animal-pulled double-tube seed drills being used in China about two millennia ago and a similar design being patented in Italy in the 16th century. Single-tube planters dropping seeds behind an ard have been used in India. However, the initial development of the modern, multi-row seeder is generally attributed to Jethro Tull in the 18th century. Animal drawn seeders for small grain cereals gradually became widespread in the larger farms of Europe and North America and spread to other regions. Smaller scale farmers tended to continue with hand seeding and that remains common to this day. In West Africa, notably Senegal, the use of seeders for groundnuts, maize, beans and delinted cotton increased rapidly in the final decades of the 20th century, partly because some of the light, sandy soils allowed direct seeding without primary tillage. More recently, attention has been given to the use of heavier seeders and fertilizer applicators based on models currently in use in several

Latin American countries. These can allow direct seeding into the mulch remaining in conservation tillage systems and they have been recently trialled and promoted in parts of Africa and Latin America[16]. While initial research results appear favourable, the proof of the technology will be in sustained adoption.

Weeding with animal power is difficult with cereals that are closely planted, unless the crops are resistant to soil disturbance and trampling. In many traditional farming systems, plants were often multi-cropped and/or not in regular rows, so that weeding with animals was not practical without changing to line planting. However, perennial crops like vines could be weeded by simple animal-drawn tine tillage between the rows. Crops that are row-planted and widely spaced can be weeded with draft animals, whether working singly or in pairs. Animal-drawn weeding can save a great deal of manual hard work that is often performed by women. Single-row weeders can be a set of three or five tines or a ridging body that earths up the plants. Multi-row weeders are also available.

While animal-powered weeding can be beneficial in time saving and yields, it requires well-trained animals and fairly accurate row spacing, which are both investments in themselves. Hence weeding with draft animals is a more advanced technology that tends to be adopted some years after ploughing with animals has become a normal part of the farming system. Work animals can also be used to pull sprayers that distribute crop-protection chemicals, although this not a widely-used technology.

Figure 17 *– Weeding maize with animal power – Top: Ox in Myanmar Below: Horse in Portugal*

Harvest and post-harvest

Draft animals can be used for a wide range of harvest and post-harvest operations including, raising root crops, raising groundnuts, grain harvesting, grass cutting, threshing and various milling technologies. The oldest technologies, dating back several millennia, probably relate to threshing as animals can help remove grains from the seed ears by trampling or by pulling a simple threshing sledge over straw on a threshing floor. This technology is still used, notably in South Asia, Ethiopia and the Andes. Simple ards or ploughs or more specialized implements can be pulled through the soil to raise potatoes or crops like groundnuts. Such techniques remain common where such crops are grown in rows using draft animals (notably in Bolivia and the Sahel).

16 CIMMYT 2016; Chikulo 2019; FAO 2021.

Figure 18 *– Crop spraying with oxen in Cuba*

For most of human history, the cutting of grass and the harvesting of grain have been mainly manual operations, although there is continued research interest in the Gallo-Roman *vallus*, an animal-pushed implement that assisted the harvesting of grain[17]. Animal-drawn reapers and mowers were developed in the 19th century in Europe and North America and were mainly designed for the power and acceleration provided by two or more large horses. Adoption in those regions was quite rapid, but soon coincided with the development of traction engines and tractors. The technology remained in use in Eastern Europe until the end of the 20th century and also on the Amish farms in North America. While there was some spread to mainly horse-using farmers in Latin America, Southern Africa and Australia, there was little adoption by small-scale farmers in other regions, that generally relied on ox power.

***Figure 19** – Top: Shire horses pulling hay mower in UK. Below: Shire horse turning gear to power historic farm machinery in UK*

Using animals to process crops has had many long traditions, dating back millennia. Animals have been used to grind grains to flour, to extract oil from seeds or fruits, to pulp grapes or apples to make alcoholic drinks and to extract sugar from cane. The technologies generally involve an animal walking around in circles, pulling a beam that operates the mill. For crushing grains and fruits, the beam may connect to a stone wheel running in a channel containing the material to be crushed. Oil extraction may involve the beam being connected to a wooden pestle rotating in a mortar carved from a tree trunk. Sugar cane crushing involves a beam connected to geared vertical rollers that squeeze the juice out. This technology is only a few centuries old, but the traditional wooden *trapiche* for crushing sugarcane became widespread in parts of Latin America. Subsequently factory-made metal mills, using similar principles, became more common.

***Figure 20** – Oxen turning 'trapiche' mill to crush sugar cane in Honduras*

Animal powered mills have been used in most regions of the world, and many still exist. However, while animals are efficient at pulling loads in a straight line, they are less efficient at creating rotary movements, particularly as the equipment must be strong enough to remain intact should the animal's pull not correspond to the tangent of the circle. Small motors (petrol, diesel or electric) are able to produce high speed rotation that can be used for many milling operations. This partly explains why many animal-powered mills have been replaced, and animal powered milling technology is now quite rare.

Water raising

Using animals to raise water for household use, livestock or crop irrigation has also been a long-standing practice for millennia and has been used in most parts of the world. Simple mechanisms involve the animals walking away from a well, pulling a rope attached to the water container (such as a sheepskin bag) that needs to be raised. More complicated systems involve animals walking in circles to turn pumps. The ancient Egyptian *sakia* is a cleverly-designed spiral that draws up water from a shallow depth into an irrigation canal or other water receptacle[18]. While some similar designs of *sakia* are still in use today, the convenience of motor pumps has largely replaced animal-powered water raising throughout the world. Nevertheless, animal power is still used to raise water from some remote wells in circum-Saharan countries.

***Figure 21** – Raising irrigation water using a sakia in Egypt with a cow (left) and a donkey (right)*

17 Raepsaet 2002; AIMA 2017.

18 Löwe 1986.

Spread of motorization in the 20th century

For most of human history, there were no electric or fossil-fuel motors and most farming and land transport depended on draft animals and/or human labour. The situation changed in the 19th century with the development (with approximate dates) of steam locomotives (1802), traction engines (1859), tractors (1889), motor cars (1886), motorcycles (1894) and trucks (1896). While draft animals remained important in most regions of the world, throughout the 20th century, in the more industrialized countries cars, trucks and buses progressively replaced animal-drawn vehicles and tractors gradually replaced farm work animals. On a generational basis, the transition was gradual, but looking from the perspective of the millennium, the technological changes, and their socio-economic implications, were remarkably fast.

Investment in tractors can normally be justified by economies of scale, and so the processes of tractorization were generally associated with increases in farm sizes. Depending on the economic and land tenure situation of the country, farm size grew though the purchase of additional land, often the land of smaller farmers who had gone bankrupt. Where unused land was available, or it was controlled by authorities, farmers with tractors could be allocated additional land. Similar processes occurred as larger tractors and associated implements were developed. The tractors and machines were labour-saving, and the large farms no longer needed so many workers to tend the draft animals and perform manual work. So tractorization was associated with many smallholder farmers leaving farming and becoming employees in rural or urban areas, changing the socioeconomics of farming and rural economies as well as those of towns and cities.

Inevitably, richer farmers with larger holdings were among the early adopters of tractors, and those with smaller farms and less access to capital retained working animals. So, in Europe and North America, draft animals and tractors were both common until the 1950s. In the following 50 years, draft animals became increasingly uncommon. In low and middle-income countries, the process was much slower, and draft animals continued to be important for most of the 20th century.

There were numerous attempts to try to share the investment costs of tractor mechanization across multiple farms, through cooperatives or through public or private hire schemes[19]. The cooperatives and public schemes tended to have management problems, while the entrepreneurial schemes struggled to cope with high seasonal demand peaks. Success in serving rain-fed agricultural markets was very limited as everyone needed the tractors at the same time. Where there was widespread smallholder irrigation (as in the Punjab) the demand for tractors was much more uniform during the year, and this allowed some business models to work.

In low and middle-income countries, smallholder tractorization was uncommon for most of the 20th century. However, from the 1950s power tillers (2-wheel tractors) were increasingly adopted by smallholders in rice-farming systems in Asia and four-wheel tractors were increasingly available for hire in areas with much irrigated land.

19 Starkey et al. 1995.

Spread of draft animal technologies in 20th century

In parallel to the spread of tractors in the 20th century in industrialized countries (and in larger farms in other countries) animal traction was actually expanding in areas of Africa, Asia and Latin America. The areas of expanding use of draft animals were mainly in areas where farming had involved shifting cultivation using human labour. In such areas, farmers could often increase the land they cultivated annually, so justifying animal power through economies of scale.

In sub-Saharan Africa in the first half of the 20th century, animal power was introduced into farming systems and promoted by colonial authorities, often as part of schemes to increase the volume of export crops such as groundnuts and cotton. In the second half of the 20th century, independent governments, NGOs and development projects continued to promote and support an increasing use of animal power. This growth of animal traction in Africa is discussed further in the companion paper to this publication[20].

Throughout the 20th century and in the past two decades, religious groups (Amish and Mennonites) in north America have successfully continued to use animal power and steadily increased the total land area farmed by them[21]. Apart from their religious conviction, this has been helped by their lack of heavy debt (a bane for owners of expensive equipment) and their tendency to having large families and close cooperation.

***Figure 22** – Amish farmers in USA using a transport horse for light cultivation (top) and three heavy horses for ploughing (below)*

20 Mudamburi/Starkey 2022.
21 Starkey 2011.

In Europe, in the second half of the 20th century, animal power gradually decreased in the smallholder sector (accelerated by the end of the Soviet Union and the expansion of the European Union). One key factor causing people to give up draft animals was the lack of available family labour to assist with animal care. With smaller families, and spouses needing to work away from the farm to boost family income, labour was a key constraint. At the same time, labour rates were rising and machinery costs were falling relative to labour. Not only were the economic benefits of tractor use increasing, but also the support facilities for animal traction were decreasing, as local blacksmiths, harness-makers and farriers decreased due to the reduction in demand for their services. As animal traction users became fewer, there was no longer a critical mass of customers to allow the support services to thrive.

Nevertheless, the use of draft animals in Europe was both retained and newly adopted in particular niches where the environmental and socio-economic benefits of work animals outweighed the advantages of motorization. Some farmers continued to use animals because of their beliefs and preferences. This is sometimes dismissed as 'hobbyism' as the primary motivation is not economic necessity. However, draft animals still have a comparative advantage for certain operations, particularly if environmental impacts, sustainability, quality of life and organic agriculture premiums are fully acknowledged. The viable, beneficial uses of work animals in industrialized countries can including forestry logging, tillage between vines, farming on slopes and short distance transport with much waiting time (as in park maintenance). The scope of current use of horses in Europe is clearly shown on the social media sites of the Fédération Européenne du Cheval de Trait pour la promotion de son Utilisation (FECTU)[22].

Figure 23 *– Smallholder farmers in Norway who have chosen to use horses for environmental reasons. Top: Double row weeding Below: Turning hay with a motor-assisted tedder*

22 FECTU 2022.

Comparative advantages of animal power and motors

Draft animals and motors have both advantages and disadvantages, depending on the operations, the environment and the availability and cost of labour.

Motors have a strong comparative advantage over animals for rotary movements, and this explains why the longstanding and widespread use of animals for milling and pumping with animals is now uncommon.

Motor transport has great advantages for moving large quantities of people or goods for long distances at high speeds on good road infrastructure. This explains the great decline of animal caravans carrying produce over long distances.

Animal power can be advantageous for low-volume, intermittent, short-distance transport, for manoeuvrability in cramped locations and for deployment in difficult terrain. This helps to explain the continued (and sometime renewed) use of animals for on-farm transport, for deliveries, for tillage in small fields and for uses in remote areas including mountainous terrain.

In agriculture, the primary benefit of mechanization is to save labour, and allow one unit of labour to cultivate more land. This is true whether moving from hand cultivation to animal power or changing from animal traction to tractorization. Thus, mechanization allows extensification (provided land is available). It is a commonly believed myth that mechanization leads to higher yields, whereas mechanization generally leads to lower yields per unit area, for a comparable input of seeds and fertilizer. Intensive agriculture, often with multi-cropping, gives the higher yields per hectare. The highest yields (for a given quantity of compost, manure or fertilizer) are found in hand-prepared farms or vegetable gardens, whether in smallholder farming systems in the tropics or in urban gardens in industrialized countries. Mechanization, with animals or tractors, allows one person to cultivate more land, and so can be justified if more land is available to the farmer. With more land, the total farm yield will be higher, even if the yield per unit area is lower. Tractor-powered farms do not generally lead to higher yields per unit area or per unit of fertilizer, but those using tractors are more likely to have access to capital or credit to afford higher quantities of fertilizer, hence the widely held belief that tractorization increases crop yields.

There are a few circumstances where problematic soil structure, such as hard pans beneath the surface, can be improved by deep ploughing or ripping with a tractor[23]. In such cases, combining occasional tractor use and animal powered tillage can be advantageous[24]. However, in most cases, soil structures can be improved through conservation agriculture and high yields per unit areas can be achieved using animal traction and appropriate fertilization.

Animal traction has one other characteristic that can be an advantage or a disadvantage, particularly in more industrialized societies: animals need caring for throughout the year, and this is usually labour-intensive. The advantage of this is that people and families benefit from

23 Tebebu et al. 2020.
24 Mudamburi 2016.

close relationships with the animals. Many farmers feel close bonds with their working animals, and this is lost if the animals are replaced by a machine. Close associations with animals are now being encouraged in certain circumstances to improve people's mental health[25]. However, the need to feed, water, groom and care for work animals can be a serious disadvantage where the availability of family time or paid labour is problematic. In many countries, the fact that there are fewer children and that these need schooling and other activities, reduces the ability of small farms to use family labour to share the caring of work animals. In commercial or municipal enterprises, machinery can be parked at weekends without incurring labour costs. Where work animals are used, staff must be paid to look after them at weekends.

Current world trends on policy support to draft animals

Historically animal traction was developed and spread through most of the world because of private entrepreneurship and the traditional norms of societies. Within societies there have been some attempts at draft animal control or regulation by authorities, for example through taxes, tolls, restrictions on use in particular areas or on certain days, timeslots for particular operations, the requisition of animals by the military or for the welfare of animals. As has been discussed, in the 20th century there were efforts by some authorities (notably in sub-Saharan Africa, but also parts of Asia and Latin America) to actively promote the use of work animals to complement manual labour. There have also been growing numbers of restrictions designed to improve animal welfare and/or to keep draft animals away from fast traffic or congested urban areas.

Based on the situations and trends reported here, it is possible to make several generalizations relating to the adoption, continuation and abandonment of draft animals.

- People using human-powered tillage and transport will adopt draft animals when they are available, adapted to the environment, affordable, profitable and socially acceptable.
- People retain animal power when it is profitable, socially acceptable or ecologically appropriate and/or when there are no easy alternatives (provided there is a supportive environment).
- People stop using draft animals if affordable motorized alternatives are readily available, profitable and socially acceptable.
- Some people and organizations choose draft animals because it is environmentally, socially or culturally appropriate for sustainable farming and specialized applications.

Since the 50s, the mainstream media, including television and films, have generally portrayed draft animals as historic (old-fashioned) and/or associated with poverty and drudgery. Indeed, it is quite often stated that supporting draft animal technologies is like promoting a 'a U-turn back to the stone age'. However, it has been stressed that draft animals require resources, and the poorest people cannot afford them.

25 Portaro et al. 2020; Ratschen et al. 2020.

During the second half of the 20th century, there was not only promotion of draft animal technologies in parts of Africa, Asia and Latin America, there was also considerable national and international public sector investment in draft animal research, education and training. During the 80s, most of the international agricultural research centres had animal traction research programmes, as did several United Nations agencies including FAO and ILO. Also, at this time, several European countries (including France, UK and The Netherlands) funded research centres in their own countries to carry out international research relating to animal power. Other donor countries, including Australia, Germany, Sweden and USA, also funded international animal traction research and networking, often in collaboration with universities in their countries. At the same time, research institutes in many middle- and low-income countries also had significant animal traction research programmes, including in India, Pakistan, Bangladesh, Vietnam, Brazil, Mexico, Bolivia, Ethiopia, South Africa and Zimbabwe. Much of their research related to implements, operations and animal husbandry, and this was complemented by socioeconomic research in many universities throughout the world.

During the first two decades of the 21st century, such efforts at national and international promotion and research declined markedly and have practically stopped. Throughout the world, including high-, medium and low-income countries, very little public money is now being spent on draft animal issues. In most countries, animal traction is no longer part of the curricula of schools or universities. There are few research institutions or universities anywhere that are actively engaged in draft animal issues. Even in low-income countries where animal power is still important in smallholder farming systems, few agricultural ministries are actively engaging with draft animal issues. Globally, there is minimal investment in research about, or support for, draft animal technologies. One notable exception is the work of some animal welfare charities that are trying to improve the care of working animals, although their work is highly localized within certain countries. Their influence is likely to be increased through the formation of the Equid Power Network in collaboration with FECTU[26].

Requirements for successful animal traction

Considering the ancient and recent history of draft animal use and support in the world, it is possible to summarize the prerequisites needed to allow animal traction to thrive.

- An easily accessible supply of suitable and affordable animals
- Available and affordable labour to maintain and work with animals
- Knowledge of training and operational working practices
- Affordable and available animal nutrition and health care
- Available and affordable harnessing and equipment and its repairs (local artisans)
- A supportive environment without excessive fear of theft, obstruction or ridicule.

26 Equid Power Network 2022.

Where animal traction is increasing there is generally a positive spiral of all these prerequisites, making adoption and use increasingly easy. However, in an area where animal traction is decreasing, there is a vicious circle of a contracting market affecting the availability of inputs and support, making continued use increasingly difficult.

Strategy for a supportive environment for draft animals

A supportive environment to allow people to adopt or to continue using draft animals is one that helps to facilitate the various prerequisites listed that are required for successful animal traction use.

If the affordability of animals, implements and other inputs is a major issue, there may be a case to facilitate credit to the end users or to the supply chains serving them. In the case of zones of introduction, subsidies have been proved highly effective in stimulating the market demand required for a subsequent sustainable, unsubsidized upward spiral of increasing demand and therefore better supplies. Regulation may be required if the availability of animals is being constrained: for example, banning the trade in donkey gelatine or restricting the slaughter of healthy young oxen.

The aim should be sustainable private sector support services that can ensure the availability of appropriate animals, nutrition, animal health care, implements, harnessing, spare parts and repairs. NGOs and local associations of users and/or suppliers can assist by working with farmers and with service providers to identify problems and facilitate collaboration with the various stakeholders to find appropriate, acceptable solutions. Governments and authorities should provide an enabling environment to allow smallholder farmers, private sector suppliers and NGOs to jointly ensure the successful continuation or growth of draft animal use. However, currently the great majority of governments and authorities in the world do not have any positive policies or strategies designed to permit animal traction to thrive.

The priority for supporters of draft animal usage in the coming decade must be to inform, educate and influence existing policy makers, the media and entire populations to ensure authorities are facilitating the necessary enabling environment. Policy makers do not want to be seen by their peers and electorates as promoting a 'U-turn back to the stone age'. So, they and their relevant reference groups must all be influenced to understand that animal traction can be positive for the users, the environment and the local economies.

Influencing policy makers and populations will not be easy but it could be achieved through champions (individuals/organizations), media education and influence (audio-visual information and resources), research (to provide data and indicators to inform policy) and the national and international networking of users, activists and supporting organizations.

Local and international champions can be very influential. Nelson Mandela famously rode into a stadium on a donkey cart, and in 2020, social media in Namibia was excited to see video clips of the Mayor of Windhoek ploughing with oxen. Sympathetic social media influencers or international celebrities could play an important role in making the public more sympathetic to draft animal power.

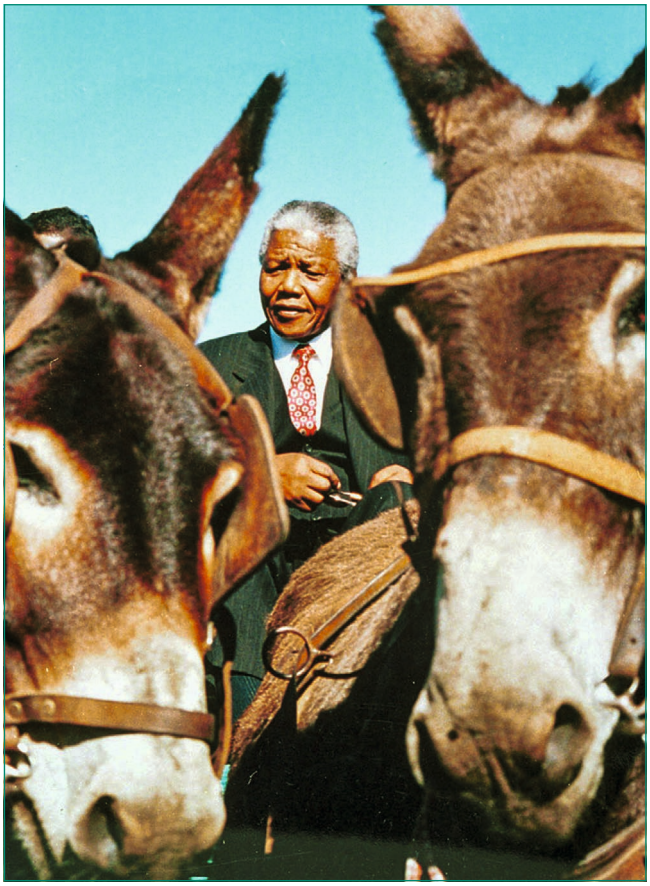

Figure 24 *– Nelson Mandela acting as a champion for donkey users as he entered the Upington Stadium on a donkey cart on South Africa's Freedom Day in 1977*

There is an urgent need for good videos and resource materials to educate school children, students, the public and policy makers. These need to be accessible in the growth area of social media, from where more people, notably the younger generations, gain their information and ideas. Research is needed to ensure that data and indicators are available on the level of use of animal power and the efficiency of local support systems. In the past, a great deal of time and money has been spent on top-down research inventing, reinventing and modifying implements (often without reviewing existing options in the world). Frequently these had minimal impact as equipment designs were not the limiting factor in that farming system or transport operation[27]. More attention needs to be paid to participatory research and understanding from the point of view of the draft animal users (or potential users) how animal power can best serve the farming or transport system and what are the key social, economic and technical constraints and how they can be alleviated. Where appropriate, such research should incorporate environmental issues notably climate change resilience and mitigation. The research should be highly gender sensitive, recognising the importance of animal traction for women and changing gender roles in the management, use and benefits of draft animals.

Heritage institutions such as living history farms and museums should proudly display (physically and digi-

27 Starkey 1988.

tally) the traditional uses of animal power, but also link this to modern applications whether national or international. Such retrospective and forward-looking displays and exhibitions would benefit from much more active networking between draft animal user groups, activists and researchers. Networks have proven highly successful in increasing information exchange, improving peer recognition and creating a critical mass for lobbying and action[28].

Through concerted efforts in and between the 'Global North' and the 'Global South', the historic importance of draft animals can be combined with a modern vision of the future, where the sustainable use of draft animals is recognized nationally and internationally as being beneficial to their owners, the environment and to the local economies.

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Author info
Paul Starkey

Museum of English Rural Life, University of Reading; Visiting Senior Research Fellow
Oxgate, 64 Northcourt Avenue, Reading RG2 7HQ

E-Mail: p.h.starkey@reading.ac.uk / p.h.starkey@gmail.com
Digital paper: https://youtu.be/W6InpESQyxQ

Author info
Bertha Mudamburi

University of Namibia; Lecturer
P Bag 5520, Oshakati, Namibia

E-Mail: bmudamburi@gmail.com
Digital paper: https://youtu.be/9wb-gb6EyTw

Draft animal issues, constraints and opportunities in Africa

Bertha Mudamburi and Paul Starkey

Abstract

Most African smallholders rely on manual labour or draft animals. Tractorization works for large-scale farms but is economically and logistically problematic for smallholders. Draft cattle and pack donkeys were employed in ancient Egypt 5000 years ago, and pack donkeys have long been used in the Horn of Africa and the circum-Saharan countries. In Ethiopia, the traditional maresha ox plough has been used for millennia, and still is. Elsewhere in sub-Saharan Africa, animal traction was introduced in colonial times, with ox ploughs and carts in many areas and donkeys and horses in drier and highland zones. Cattle are multipurpose providing work, milk, meat, hides, manure and lobola payments. From 1950-2000, the range of donkeys expanded, and they were increasingly used for transport and tillage, partly as their theft risk was low. This changed from 2000, when Chinese demand for ejiao (donkey gelatine) affected donkey values. Equid transport is increasingly replaced by motorcycles and three-wheelers. Through many influences (films, media, urbanization, modernization), animal traction has negative, backward connotations. Despite this, it is widely used and persistent although declining in some areas with diminishing support services, few political champions and minimal support from development agencies. Experience from Namibia suggests many university students see draft animals as relevant, available, affordable and sustainable. They improve smallholder farmers' timeliness and workloads through environmentally-friendly tillage and transport. Animal traction in Africa needs champions, policy support, relevant investment, good media coverage and appropriate networking to ensure its development and continuity, with a critical mass of users and support services.

Résumé

La plupart des petits exploitants africains ont recours au travail manuel ou aux animaux de trait. La tractorisation fonctionne pour les grandes exploitations, mais elle est économiquement et logistiquement problématique pour les petits exploitants. Les bovins de trait et les ânes de bât étaient employés dans l'Égypte ancienne il y a 5000 ans, et les ânes de bât sont utilisés depuis longtemps dans la corne de l'Afrique et les pays circum-sahariens. En Éthiopie, la charrue bovine traditionnelle, la „maresha" est utilisée depuis des millénaires et l'est toujours actuellement. Ailleurs en Afrique subsaharienne, la traction animale a été introduite à l'époque coloniale, avec des charrues et des charrettes à bœufs dans de nombreuses régions et des ânes et des chevaux dans les zones plus sèches et les hauts plateaux. Les bovins sont polyvalents et fournissent du travail, du lait, de la viande, des peaux, du fumier et des paiements de lobola (dot payée sous forme de bétail). De 1950 à 2000, la gamme des ânes s'est étendue et ils ont été de plus en plus utilisés pour le transport et le travail du sol, en partie parce que le risque de vol était faible. Cela a changé à partir de 2000, lorsque la demande chinoise d'ejiao (gélatine d'âne) a affecté la valeur des ânes. Le transport par les équidés est de plus en plus remplacé par des motos et des trois roues. Par de nombreuses influences (films, médias, urbanisation, modernisation), la traction animale a des connotations négatives et arriérées. Malgré cela, elle est largement utilisée et persistante, bien qu'en déclin dans certaines régions, avec des services d'appui en baisse, peu de champions politiques et un soutien minimal des agences de développement. L'expérience de la Namibie suggère que de nombreux étudiants universitaires considèrent les animaux de trait comme pertinents, disponibles, abordables et durables. Ils améliorent la rapidité et la charge de travail des petits exploitants agricoles grâce à un travail du sol et un transport respectueux de l'environnement. La traction animale en Afrique a besoin de champions, de soutien politique, d'investissements pertinents, d'une bonne couverture médiatique et d'un réseau approprié pour assurer son développement et sa continuité, avec une masse critique d'utilisateurs et de services de soutien.

Kurzfassung

Die meisten afrikanischen Kleinbäuer:innen sind auf Handarbeit oder Zugtiere angewiesen. Die Verwendung von Traktoren funktioniert in Großbetrieben, ist aber für Kleinbäuer:innen wirtschaftlich und logistisch problematisch. Zugrinder und Packesel wurden bereits vor 5000 Jahren im Alten Ägypten eingesetzt, und Packesel werden seit langem am Horn von Afrika und in den Ländern südlich der Sahara verwendet. In Äthiopien wird der traditionelle Maresha-Ochsenpflug seit Jahrtausenden verwendet, und das ist auch heute noch so. In anderen afrikanischen Ländern südlich der Sahara wurde die tierische Zugkraft in der Kolonialzeit eingeführt, mit Ochsenpflügen und -karren in vielen Gebieten und Eseln und Pferden in trockeneren und hochgelegenen Regionen. Rinder sind vielseitig einsetzbar und liefern Arbeitskraft, Milch, Fleisch, Häute, Dung und Lobola-Zahlungen. Von 1950 bis 2000 wurde das Angebot an Eseln vergrößert, und sie wurden zunehmend für den Transport und die Bodenbearbeitung eingesetzt, zum Teil auch, weil ihr Diebstahlrisiko gering war. Dies änderte sich ab 2000, als die Chinesische Nachfrage nach Ejiao (Eselgelatine) den Wert der Esel beeinflusste. Der Transport auf Pferden wird zunehmend durch Motorräder und Dreiräder abgelöst. Durch viele Einflüsse (Filme, Medien, Verstädterung, Modernisierung) hat die tierische Antriebskraft einen negativen, rückständigen Beigeschmack. Trotzdem ist sie weit verbreitet und hält sich beharrlich, auch wenn sie in einigen Gebieten mit abnehmenden Unterstützungsdienstleistungen, wenigen politischen Verfechter:innen und minimaler Unterstützung durch Entwicklungsorganisationen rückläufig ist. Erfahrungen aus Namibia zeigen, dass viele Studierende Zugtiere jedoch als relevant, verfügbar, erschwinglich und nachhaltig ansehen. Durch umweltfreundliche Bodenbearbeitung und Beförderung verbessern sie den Zeit- und Arbeitsaufwand der Kleinbäuer:innen. Die Zugtierhaltung in Afrika braucht Fürsprecher:innen, politische Unterstützung, entsprechende Investitionen, eine gute Medienberichterstattung und eine angemessene Vernetzung, um ihre Entwicklung und Kontinuität zu sichern sowie eine kritische Masse an Nutzer:innen und Unterstützungsangeboten.

Resumen

La mayoría de los pequeños agricultores africanos dependen del trabajo manual o de los animales de tiro. Aunque la tractorización funciona en grandes explotaciones, continua siendo económica y logísticamente problemática para los pequeños agricultores. Ganado de tiro y burros de carga eran ya empleados en el antiguo Egipto hace 5.000 años, los burros de carga incluso son utilizados desde hace tiempo en los países del cuerno de África y los alrededores del Sahara. En Etiopía, el tradicional arado con bueyes maresha se ha utilizado durante milenios, y sigue utilizándose en la actualidad. En el resto del África subsahariana, la tracción animal se introdujo en la época colonial, en muchas zonas con arados de bueyes y carretas, en las zonas más secas y tierras altas con burros y caballos. El ganado es muy heterogéneo proporcionando trabajo, alimentos, pieles, estiércol y pagos de lobola. Entre 1950 y 2000, la cría de burros aumentó, utilizándose cada vez más para el transporte y la labranza, en parte porque el riesgo de su robo era escaso. Esto cambió a partir del año 2000, cuando la demanda china de ejiao (gelatina de burro) afectó al valor de los burros. El transporte de cargas con burros se sustituyó cada vez más por motocicletas y vehículos de tres ruedas. Debido a numerosas influencias (películas, medios de comunicación, urbanización, modernización), el transporte con animales tiene connotaciones peyorativas de atraso, de ser anticuado. Aunque su uso es extendido y persiste en muchas zonas, su utilización está disminuyendo, debido al escaso apoyo político y la mínima ayuda de las agencias de desarrollo. La experiencia de Namibia muestra que muchos universitarios consideran a los animales de tiro como relevantes, disponibles, asequibles y sostenibles, agilizan la producción de los pequeños agricultores gracias a una labranza y un transporte respetuosos con el medio ambiente. La tracción animal en África necesita defensores, apoyo político, inversiones relevantes, buena cobertura mediática y la creación de redes adecuadas para garantizar su desarrollo y continuidad, con un cuerpo extenso de usuarios y servicios de apoyo.

Introduction

This paper provides an overview of the past and present status of draft animals in Africa. It is based on observations, literature review, research studies and networking exchanges. There is a lack of recent data and statistics on draft animal ownership and trends within countries[1]. Two studies on animal traction in Africa have concentrated on francophone West Africa[2]. The most recent comprehensive overviews on draft animals in Africa have been provided by Starkey[3] with Blench[4] adding some additional information. Many reports published in recent years do not give a realistic perspective of the overall situation in Africa, as they have been based on small-scale projects relating to agricultural technologies or the promotion of animal welfare. These have tended to be optimistic to justify their funding and effort and do not generally portray the overall regional trends.

Historical perspective

Origins of draft animal power in Africa

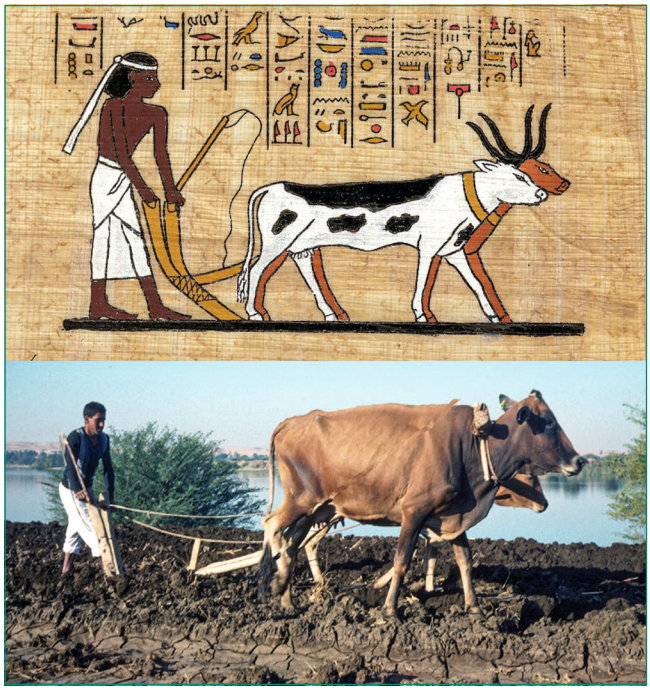

Figure 1 *– Replica papyrus illustration from an ancient Egyptian Book of the Dead showing cows ploughing (above) and modern use of very similar technologies, including use of cows (below)*

Animal power in Africa is recorded to have started about 6-5000 BP in Egypt with the first drawings of oxen and ard plows occurring in the III Dynasty[5]. These, together with the engravings of oxen and plows in early Mesopotamian civilisations, appear to constitute some of the earliest records of animal traction anywhere in the world. From Egypt and the Arabian Peninsula, draft animal technologies spread across North Africa and into Northeast Africa where they have been used for millennia[6]. In sub-Saharan Africa, pastoralists have also probably used cattle for pack transport for millennia. Transport animals such as horses, donkeys and camels spread through the Sahelian zone before the colonial era as did some milling technologies. Draft animals were systematically introduced into sub-Saharan Africa in colonial times, initially for transport around ports and subsequently for agriculture[7].

Draft animals in North Africa

The use of draft animal technologies spread from Egypt and the Middle East across North Africa, and animal power has been an integral part of farming and transportation systems for well over 2000 years[8]. A wide range of species and technologies are now used, with oxen, horses, mules, donkeys and camels used for transport, tillage, water-raising and milling[9]. Water buffaloes, of the dairy variety, were introduced to Egypt from Asia around 1300 years ago[10]. In addition to milk production some were (and still are) used to pull carts, turn irrigation equipment and sometimes pull a plough. Water buffaloes did not spread to sub-Saharan Africa and, despite efforts to promote them in the twentieth century[11], attempts to introduce them failed due to problems of heat tolerance (without standing water), susceptibility to trypanosomiasis and lack of relevant comparative advantages over cattle[12].

Figure 2 *– Imported water buffaloes ploughing in northern Senegal (top male, below female buffalo) – as with other water buffalo projects in sub-Saharan Africa, the trial was not a success*

Some of the technologies, particularly riding, pack transport and water-raising are likely to have been transmitted across the Sahara with the caravan trade. It is unclear whether the plough crossed the Sahara (although it

1 Starkey 2011; Blench 2015.
2 Le Thiec 1996; Lhoste et al. 2010.
3 Starkey 2000; Id. 2011.
4 Blench 2015.
5 Haudricourt/Delamarre 1955.
6 Starkey 2000; Blench 2015.
7 Starkey 2000.
8 Ibd.
9 Ibd; Id. 2011.
10 FAO 1977.
11 BOSTID 1981.
12 Starkey 1990.

Figure 3 *– Farmers in Ethiopia using pairs of oxen and the traditional maresha ard*

reached Sudan and Ethiopia millennia ago), but if it did, there appears to have been little or no uptake, which may be explained by the extensive nature of the predominant systems of shifting agricultural cultivation.

Draft animals in Ethiopia and the Horn of Africa

The *maresha* ard plough of Ethiopia is named after its blacksmith-made, spear-shape plough share[13]. It has been used in Ethiopia for several millennia, having been introduced either by Cushite-speaking peoples from Nubia (northeast Sudan) over 3000 years ago, or by Semitic-speaking peoples invading from South Arabia 2400-3000 years ago[14]. The use of the *maresha*, pulled by two oxen, is portrayed in illustrated manuscripts dating back many centuries. Similar implements are widely used today, despite many attempts over the years to introduce all-steel ploughs (which are heavier and more difficult to transport over the shoulder to the fields)[15].

Stationary applications of animal power in North and Northeast Africa and the Sahel

There are iconographic images in tomb-paintings, papyrus and bas-relief from Ancient Egypt of the use of animals for threshing, milling and irrigation. For millennia, such technologies have also been employed in North Africa, the Horn of Africa and in the Sahel. Threshing can simply involve animals trampling the harvested crop (as in current-day Ethiopia) but threshing sledges can be used and date back over 2000 years. Water raising from wells (or from rivers) is important to provide water for communities, for livestock and for crop irrigation. The simplest method of using leather bags, long ropes and an animal pulling (camel, horse, donkey or ox) has been used in circum-Sahara countries for millennia and is still used to this day in many countries. In Egypt, the traditional *sakia* wheels turned by a single animal have internal spirals, allowing them to efficiently raise water that is within two metres of the surface[16]. There is iconographic evidence that these were in use in Pharaonic times[17]. Their use continued into the twenty-first century, but they are now increasingly replaced by motorized pumps. This *sakia* technology does not appear to have spread far and this may be because it only works for irrigation in fields where the water table is very high.

Figure 4 *– Camel raising water from a well in Mauritania (Top left inset illustrates the depth of the well, the distance the pulling camel walks; Bottom right inset shows the leather bags and pulleys)*

Animal powered mills that extract oil are used in North Africa (including for olives) and are also found in countries stretching from Somalia to Chad where they may have been used for centuries[18]. Oilseeds such as sesame or groundnuts are placed in a large wooden mortar,

Figure 5 *– Single ox in Chad turning a pestle-and-mortar mill to extract seed oil (see photo inset) – the ancient technology had spread into Chad in pre-colonial times*

13 Goe 1987.
14 Ibd.
15 Ibd.; Starkey 1989.
16 Löwe 1986.
17 Stead 1986.
18 Starkey 2000.

carved out of the trunk of a large tree. A single animal walks around pulling a counter-balanced frame attached to a large wooden pestle. This grinds the seeds, extracting the oil. Very similar technologies are found in some countries around the Indian Ocean, including Yemen and Sri Lanka.

Introduction of draft animals in sub-Saharan Africa

In most sub-Saharan African countries (excluding Sudan, Ethiopia and the horn of Africa), animal traction for tillage and wheeled transport was introduced during the colonial period. However, before this time, in certain countries, horses, donkeys, camels and cattle had been used for riding and pack transport for centuries, if not millennia. There are historical observations from fifteenth century European seafarers concerning the Khoi-Khoi of South Africa. The Khoi-Khoi were pastoralists owning large herds of cattle, some of which they rode and used for pack transport. Some cattle had sharpened horns for offensive or defensive use in battles[19]. Certain pastoralist groups in the Sahel and East Africa currently ride cattle and use them as pack animals.

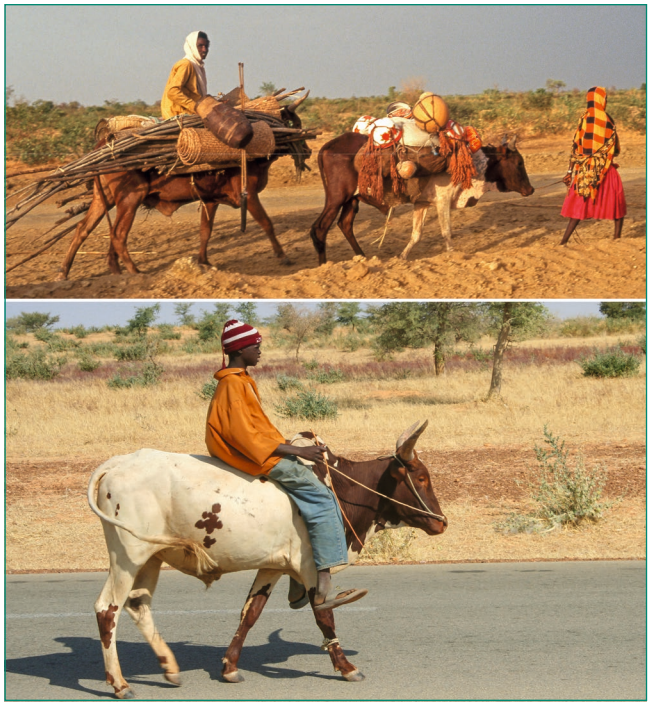

***Figure 6** – Top: Traditional pastoralists in Chad using cattle for riding and pack transport; Bottom: Modern continuation of the tradition of riding oxen in Niger*

In most sub-Saharan African countries, the use of draft animals started with animal-powered carts and wagons being used for transport operations around and beyond coastal and river ports in the seventeenth, eighteenth or nineteenth centuries[20]. In a few cases where social, economic and ecological conditions proved favourable, the use of animal-powered transport gradually spread from the coastal region, through the activities of traders, settlers, missionaries and the administering authorities. Animal-drawn cart technology spread inland in South Africa (and neighbouring territories), French West Africa (from Saint Louis) and in East Africa. In the South African Cape in 1657, white settlers were encouraged to use ploughs with teams of eight to twelve local oxen[21]. The settlers found that raising cattle and sheep and hunting were more profitable than crop production, and so the plough spread quite slowly through Southern Africa until the second half of the nineteenth century, by which time there were catalogues of available single and double mouldboard ploughs and other ox-drawn implements[22]. Also in the nineteenth century, some settlers and missionaries started to use ox-ploughs in several African countries, notably in East Africa and there was some transfer to the surrounding local farmers[23]. By the end of the nineteenth century, and in the early years of the twentieth century, draft animals played a crucial role in the agricultural, mining and transport sectors of the growing economy of South Africa and surrounding countries, and both large-scale and small-scale farmers used work animals for tillage and transport.

***Figure 7** – Team of eight Afrikander oxen pulling an example of a wagon that was used in the nineteenth century in South Africa*

Equids (horses, donkeys and mules) were used in Pharaonic Egypt and spread in the circum-Saharan coun-

***Figure 8** – Traders' wagons pulled by donkeys in Zimbabwe (then Rhodesia) in 1899*

19 Joubert 1995.
20 Law 1980.
21 Joubert 1995.
22 Ibd.
23 Starkey 2000.

tries for riding and pack transport. They were primarily used in arid, semi-arid or highland areas, due to health issues in the more humid areas. In East Africa, in pre-colonial days, donkeys were used by some pastoralists for pack transport. In South Africa, horses and donkeys were introduced to the Cape in the seventeenth century[24], and gradually spread to surrounding countries, with horses adopted for riding in Lesotho. By the end of the nineteenth century, donkeys were widely used for packing and cart transport on both large-scale and small-scale farms in Southern Africa, and large numbers of donkeys pulled wagons on trade routes, including in what is now Zimbabwe.

In several countries, attempts were made by settlers to domesticate wild indigenous animals for use as draft animals to avoid the health problems (such as African horse sickness) experienced by exotic animals. There were some short-term successes, for example, zebras pulled a stagecoach from Pietersburg into Botswana[25]. However, there was no sustained use of novel species.

Precisely when simple, wooden, triangular sledges started being used by smallholder farmers is not clear. Simple sledges (often made from V or Y shaped branches[26]) and some with basketwork superstructure are widely used for transport in Eastern and Southern Africa and Madagascar (but less so in West Africa)[27]. These were probably adopted after the start of the colonial period, as they are almost invariably pulled by one or two pairs of yoked oxen using a steel chain[28]. One example from north-eastern Zimbabwe appears to have been a farmer response to the banning of sledges by the colonial authorities (who feared that sledges accelerated erosion).

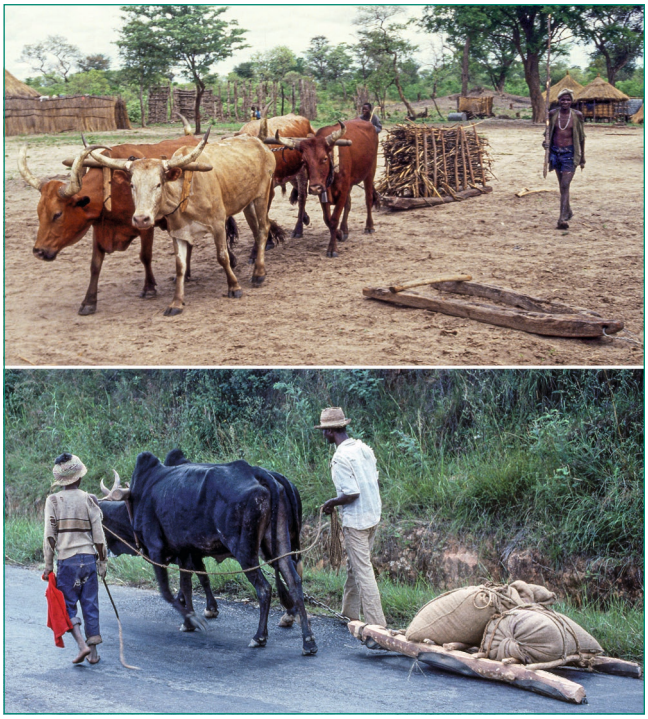

***Figure 9** – Ox-drawn sledges in Namibia (top) and Madagascar (bottom)*

24 Joubert 1995.
25 Ibd.
26 Müller 1986.
27 Starkey 2000.
28 Ibd.

Four-wheel, articulating carts were developed from Y-branch sledges using cross-sections of tree-trunks as wheels and simple wooden axles. Similar innovations have been seen in the Mbeya region of Tanzania.

By the start of the twentieth century, the use of animals for transport remained important for some pastoralists, and was becoming important for port cities, internal and international trade, and on the large-scale farms of settlers and some missionaries. However, the use of draft animals by smallholder farmers for soil tillage was minimal. This was partly due to the lack of promotion and that fact that most farming systems were based on shifting cultivation, meaning the soil remained full of woody roots, and so was difficult to plough. In Madagascar, cattle were used for rice cultivation by trampling and puddling the soil in paddy fields, a technique that is also seen in Indonesia which shares cultural and genetic traits with Malagasy people[29].

***Figure 10** – Cattle in Madagascar being used to puddle rice fields by trampling*

Promotion of draft animals in sub-Saharan Africa

Promotion of draft animals by colonial authorities

In the early twentieth century, some colonial authorities and companies growing export crops (cotton, groundnuts, rice) started to encourage local farmers to adopt the use of draft animals, notably oxen. In 1900, 1908 and 1913, farmers in three locations in German Togo were trained to use oxen to cultivate cotton, but uptake was not great[30]. Starting from 1914, small schemes were started in French Guinea and by 1929, 15,000 oxen had been trained[31]. The success of this reached neighbouring British Sierra Leone, and farmers were sent to Guinea to learn how to use oxen. The background and success of the Sierra Leone promotion was researched in the 1980s and it was found that farmers at that time not only remembered the training, but still used some French words to control their local N'Dama oxen[32]. Comparable schemes to promote the use of draft animals were carried out during the colonial period elsewhere in French West Africa (notably to increase the smallholder produc-

29 Ibd.
30 Westneat et al. 1988.
31 Bigot 1989.
32 Starkey 1981.

tion of the export crops of cotton and groundnuts in Senegal and Mali[33]), as well as in The Gambia, Kenya, Tanzania and Uganda[34]. By the 1950s, there had been modest take up of animal power by smallholder farmers in many countries in Africa, but still the majority of smallholder farmers used manual cultivation. The use of draft animals was mainly limited to transport and to ploughing (or ridging, notably in Nigeria), with some adoption of seeding and weeding technologies in Senegal and Mali. During the 50s, both the colonial authorities and the groundnut and cotton production companies were envisaging the increasing use of tractors, with tractor hire schemes to allow smallholders to benefit from tractorization.

***Figure 11** – Promotional exhibition and competition in Guinea demonstrating how to train N'Dama oxen to walk in rows to allow operational diversification to weeding with animal power*

Promotion of draft animals by authorities after independence

As most sub-Saharan African countries gained independence in the 60s, the national ministries and the export-orientated cotton and groundnut marketing authorities were hoping that there would be rapid modernization of smallholder farming through the use of mechanization. Smallholder tractor hire schemes were launched in most countries in sub-Saharan Africa, supported by donor agencies. However, none proved sustainable due to the highly seasonal nature of demand, the logistics of moving between different small farms and problems maintaining the tractors in remote rural areas. However, as one fleet of tractors died, another donor would support the drive to mechanization, so that in the yards of the agricultural mechanization authorities, graveyards of tractors developed, with identifiable strata with the particular colours and makes of the machines funded through the various donor agencies over the years. The sequential failures did not stop further tractorization initiatives, as these were popular with politicians and authorities, with photo opportunities with the new, modern tractors and, in some countries, possible benefits from the tractor contracts and the availability of subsidized tractors for the farms of the elites and their friends.

In the meantime, where implements and spares were available, animal traction was gradually spreading spontaneously, as farmers knew they could not rely on tractor mechanization at the time they would need it.

By the 70s and 80s, the problems of smallholder tractorization became more apparent, and so this became the heyday of donor-supported projects to promote and diversify the use of animal traction in sub-Saharan Africa. The idea of promoting draft animals was controversial, as politicians and urban elites often considered animal traction as backward and unworthy of promotion in independent countries striving for modernization. Nevertheless, it was national authorities that were responsible for the decisions to promote animal traction (although the offers of some donors at this time may have been explicitly to support smallholder farmer animal traction projects, rather than offers of funding with no conditions attached). In many countries, including Senegal, Mali, Burkina Faso, Niger, Togo, Guinea, Sierra Leone, Tanzania and Zambia, donor-support was provided to develop factories or workshops for the local production of animal-drawn implements and spare parts. In Francophone West Africa, the large increase in the use of draft animals was facilitated by parastatal crop export companies that provided credit and ensured implements (including seeders, weeders and carts) and spare parts were readily available[35]. In South Africa and Zimbabwe, the private sector had been producing ploughs for decades, and this continued, with some export orders to other African countries.

***Figure 12** – Stocks of Siscoma Houe Sine implements in Senegal*

The development of animal traction networks

In very many countries, projects were promoting the training of oxen (and in a few cases donkeys) and producing training manuals[36]. The West Africa Animal Traction Network was established to link the various francophone and anglophone initiatives. The network held four major international workshops (conducted in French and English), with published proceedings[37], and also promoted and facilitated study tour exchanges between different countries. The network did not itself receive funding, but its activities were funded by a range of donors and also supported by international research organisations and dissemination centres in Europe and USA. These included the International Livestock Centre for Africa (ILCA), International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Centre d'Etudes et d'Expérimentation du Machinisme Agricole Tropical (CEEMAT), Centre for Tropical Veterinary Medicine (CTVM), Institut d'Elevage

33 Havard et al. 2009.
34 Starkey 2000.
35 Havard et al. 2009.
36 CEEMAT 1971; Watson 1982; AETC 1986; Jones 1991; FAO 1994.
37 Poats et al. 1986; Starkey/Ndiamé 1988; Starkey/Faye 1990; Lawrence et al. 1993.

et de Médecine Vétérinaire des Pays Tropicaux (IEVMT), Instituut voor Mechanisatie, Arbeid en Gebouwen (IMAG), Silsoe Research Institute, Technical Centre for Agricultural and Rural Cooperation (CTA), Tillers International and Howell Farm.

The success of the West Africa Animal Traction Network, led to the formation of the Animal Traction Network for Eastern and Southern Africa (ATNESA). This also held three large international workshops with published proceedings[38], and several thematic workshops relating to donkeys[39], weeding technologies[40], gender issues[41] and conservation tillage[42]. National networks were also established, notably in Kenya, Tanzania, Zimbabwe, Namibia and South Africa. The South African Network for Animal Traction (SANAT) hosted some international and national workshops and produced a newsletter and a variety of publications[43].

The availably of donor funding not only allowed national animal traction research and development projects to be funded, but also enabled researchers in international centres (notably ILCA and ICRISAT) and European centres (Silsoe, CEEMAT, IEVMT, IMAG, CTVM, University of East Anglia, etc.) to carry out research relating to animal traction in Africa, including agricultural implements, animal nutrition, animal health and socio-economic issues. Most, but not all, of this research was carried out in collaboration with local projects, universities and/or ministries. The international and national networks assisted the rapid diffusion of ideas and technologies, and enabled national researchers to publish their findings, so rewarding their work in what was considered by some of their colleagues to be a 'backward technology'. The CTVM's 'Draught Animal News' (also donor funded) also assisted networking and the rapid publication of local research findings[44].

Some of the research on implements at this time was decidedly 'top-down' in its approach, with engineers developing implements on research stations without sufficient regard to the realities of smallholder farming needs and constraints. The classic example was the development of animal-drawn wheeled toolcarriers that were 'perfected' on research stations in Senegal, The Gambia and Mali and strongly promoted with stories of great success as to how one versatile implement could replace a plough, harrow, seeder, weeder and cart. However, from early on they were rejected by farmers as too expensive, too heavy for their cattle, insufficiently manoeuvrable for their small farms and of high risk, as one problem could make all operations impossible. Farmers preferred a range of lighter implements and a separate cart. It is estimated that over 40 million US dollars were spent by various development agencies on promoting this technology to smallholder farmers, before it was quietly forgotten[45].

Despite a few failures, the overall result of the research-development and extension projects was a gradual uptake and diversification of draft animal power, which continued into the twenty-first century[46].

***Figure 13** – Wheeled toolcarrier fitted with a motorised grass cutter on a research station in Zambia*

The increasing range and importance of donkeys

One of lessons shared through networking was the increasing importance of donkeys. Most of the draft animal promotion in the 70s and 80s was focussed on the importance of oxen for tillage and transport, with little attention given to the use of donkeys. However, while oxen remained the main draft animals, farmers in semi-arid areas were increasingly choosing to use donkeys for cart transport and light tillage. Donkey populations were generally increasing in the semi-arid and highland zones of Africa[47]. This was partly due to deforestation, as farmers cleared more and more land, and a drier environment that reduced the health threats of tsetse flies and parasites. In West Africa, the rainfall isohyets run more or less east-west, and so does a 'donkey line' that during the past fifty years has been steadily moving southwards[48]. North of the line donkeys are common, while south of the line they are seldom seen, and around the line there are villages where farmers have just started to use donkeys. For example, in the 60s the 'donkey line' ran north of The Gambia and donkeys were rarely used and in the 70s a development project promoted oxen. However, by the 80s many farmers had switched to donkeys.

***Figure 14** – Woman in Burkina Faso using a donkey cart to transport firewood*

38 Starkey et al. 1994; Starkey/Kaumbutho 1999; Kaumbutho et al. 1999.
39 Pearson et al. 2003; Fielding/Pearson 1991; Fielding/Starkey 2004.
40 Starkey/Simalenga 1998.
41 Sylwander/Mpande 1992.
42 Kaumbutho/Simalenga 1999.
43 Joubert 2002; Simalenga/Joubert 2004; Simalenga et al. 2007.
44 CTVM 1983-2009.
45 Starkey 1988.
46 Lhoste et al. 2010.
47 Starkey/Starkey 2000.
48 Starkey 1994.

Figure 15 – Women weeding with donkeys in Tanga Region, Tanzania

Similar situations were occurring in Guinea Bissau, Guinea, Mali, Burkina Faso and elsewhere in West Africa[49]. Donkeys were also increasing their range in Eastern and Southern Africa, although the donkey lines were not so obvious. The adoption of donkeys for tillage as well as transport was related to their low price (at that time): they were cheap and so the risk of theft was low. They could be left to forage by themselves without fear that they would be stolen. In most countries, there was little demand for donkey meat, whereas a stolen oxen could be rapidly converted into anonymous and expensive meat. Historically, donkeys were considered low status animals, and were often the responsibility of women. As donkeys became increasingly common, women had greater access to draft animal power. While the increasing adoption of donkeys was initially farmer-led, the draft animal projects and networks in the 80s and 90s paid increasing attention to donkey welfare, harnessing and low-draft tillage implements[50].

Current status and trends in sub-Saharan Africa

The great majority of all farmers in Africa still rely on manual labour or draft animals. Estimates that this could be 80-90 % of farmers continue to be cited[51], but such figures may be outdated. The use of tractors is steadily increasing, but in most sub-Saharan African countries only a minority of farmers have timely access to tractors. In Ethiopia, the *maresha* plough is still widely used with oxen, as are pack donkeys. In the semi-arid regions of West Africa, Central Africa, East and Southern Africa use of cattle and donkeys has become part of smallholder farming systems.

Cattle remain multipurpose animals, kept for milk, meat, hide, manure, the paying of lobola and for tillage and transport. Draft animals can also relieve the burden of women by contributing to the transport of water, wood, fertilizer, manure, seeds, tillage implements and produce, which would otherwise be head-loaded by women, reducing their availability for other tasks. During the twentieth century, draft cattle were used mainly for mouldboard ploughing and cart transport. However, the impact of the development projects in the final decades of that century led to a diversification, with more farmers using draft animals for tine tillage and seeding (particularly in Sahelian countries[52]), weeding and conservation tillage[53]. This was made possible by the availability of appropriate implements, spares and, in some cases, credit. The labour-saving and environmental benefits of animal power are likely to see continued diversification, provided the implements and spares remain available. In Tanzania, small-scale cotton farmers rely on rainfed production, use limited inputs, and plant the cotton crop by hand hoes and animal traction[54]. In South Africa, animal traction continues to be a major part of smallholder farming[55]. While there is likely to be a gradual increase in the use of tractor power for primary cultivation, there is little sign that tractor use is diversifying much. Therefore, operations such as seeding and weeding will continue to be carried out using hand or animal power. Whether or not farmers will continue to train and maintain draft animals only for secondary operations and transport will depend on many factors, including supply chains, support services and the prevailing environment of policies and attitudes.

Cattle are largely absent from the humid forest zones and equids do not thrive in such conditions, so that draft animals are rare. However, animal power for transport and tillage is gradually increasing at the margins, where

49 Ibd.
50 Fielding/Pearson, 1991; Le Thiec 1996; Hagmann 1998; Pearson et al. 2003; Fielding/Starkey 2004.
51 Daum 2020.
52 Lhoste et al. 2010.
53 Starkey 2011.
54 USDA 2020.
55 Manzana 2014; Zantsi/Bester 2019.

deforestation is creating savannah ecosystems, for example in parts of the Democratic Republic of Congo.

Light horses are mainly used for transport in highland plateau areas such as Ethiopia and Lesotho, temperate/sub-tropical areas (North Africa and South Africa) and the Sahelian region. Their continued use is being affected by the availability of motorcycles and three-wheelers and is declining in Ethiopia. The use of horses for peri-urban cart transport in Ethiopia and South Africa is also declining, partly due to regulatory requirements and enforcement.

In Kenya, it is estimated that 1.3 million donkeys are still widely used for transport and some tillage, while in Burkina Faso, the use of donkeys for transport and tillage also continues to have major socio-economic benefits for society[56]. KENDAT (a Kenyan NGO: the Kenya Network for Dissemination of Agricultural Technologies, formerly the Kenya Network for Draught Animal Technology) highlighted that the donkeys were critical to Kenyan households as a transport mode. One lady empowered by KENDAT reported that the donkey income had enabled her family to educate their children with ease. Because of the success of her donkey enterprise, she had also bought a parcel of land on which she planned to construct semi-permanent rental houses[57].

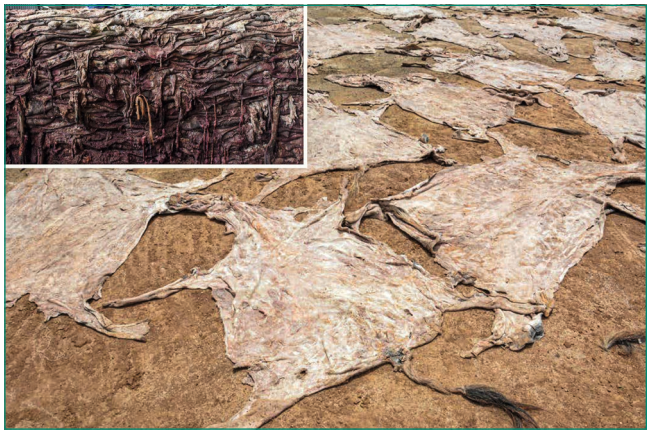

Figure 16 *– Drying donkey skins in Kenya destined for the ejiao market. Inset: warehouse with large stocks of donkey skins for export to China*

It has already been noted that the donkey population in Africa increased between 1950 and 2000, but since then their numbers have crashed due to their sale and slaughter for their skins. *Ejiao* is a traditional Chinese medicine made from donkey gelatine obtained by boiling donkey hides and has been used by Chinese people for more than 2,500 years. From 2000, Chinese demand for *ejiao* led to Chinese traders buying donkey hides in many African countries, and in some cases working with partners to establish slaughterhouses specifically for donkeys[58]. This led to greatly increased donkey values and led to a decimation of some donkey populations[59]. The high value of donkeys led to a rapid increase in donkey thefts. In some cases, men who learned of their high value, sold donkeys to traders, even though the donkeys were in regular use for transport by female family members. By 2019, fourteen African governments, including most Sahelian countries, had closed donkey slaughterhouses and/or banned the export of donkey skins, according to the UK-based animal welfare group the Donkey Sanctuary[60].

Challenges

Motorized transport

Cars and lorries have largely replaced long-distance transport of goods and humans using animals, although there are still some traders using camel trains in Ethiopia. Equid transport is increasingly replaced by motorcycles and three-wheelers in countries such as Ethiopia, Kenya, Nigeria and Uganda. Nevertheless, while motorized transport has increased greatly in the past 30 years, the use of animal power for local transport has not experienced a proportionate decline. Ox carts and donkey carts are still widely used for local transport, as are pack donkeys.

Figure 17 *– Motorised three-wheeler and donkeys travelling to market in Tanzania: there is a tendency to use motorcycles and three-wheelers instead of donkeys*

Tractors

Governments, donor agencies and people aspire to modern, tractor farming. Tractorization is economically viable for large-scale farms but is economically and logistically problematic for smallholder, rain-fed systems[61]. Two-wheel tractors or power tillers are widely used in Asian countries, primarily for irrigated rice cultivation, but also for tillage of rain-fed crops, farm transport and post-harvest operations[62]. Since the 1960s, there have been numerous attempts to promote two-wheel and other small-scale tractors, with many innovative designs as well as the importation of proven Asian technologies[63]. However, while there has been some adoption (primarily for transport and swamp rice production), small-scale tractors have yet to become a major part of smallholder farming in sub-Saharan Africa. Despite huge investment and subsidies for smallholder mechanization in the past 50 years, there are few examples of sustainable, unsubsidized smallholder tractor expansion in sub-Saharan

56 Mwita 2020; Brooke 2019; Id. 2020.
57 Mwita 2020.
58 Cheng 2018; Donkey Sanctuary 2019.
59 Star 2018.
60 Donkey Sanctuary 2019.
61 Starkey 2011.
62 Justice et al. 2016.
63 Holtkamp 1990; Grain de sel 2009; Daum/Birner 2020.

Africa entirely managed by the private sector[64]. This is in total contrast to animal traction, and to transport technologies such as motorcycles, three-wheelers, cars and minibuses.

Some researchers in Namibia cited two important lessons for smallholder farmers, based on a comparison of different draft power sources[65].

- For a large field (e.g. 10 ha and above), it is convenient and economical to use a tractor because of the amount of effort and time required if other power sources are used.
- For a typical, average-sized field (e.g. around 2 ha) it is economic and convenient to use draft animals, since they are affordable and fast enough to carry out the operations in good time.

Figure 18 shows one disadvantage of using a tractor-drawn disc harrow. The operation shows a cloud of dust from using the tractor disc harrow and this is detrimental to the environment and the operators.

Figure 18 *– Tractor harrowing in Namibia, showing dust cloud*

Draft animal use is almost entirely private sector, sustainable and unsubsidized. Yet governments, donor agencies and people want to see smallholder tractorization, and the authorities are often willing to subsidise this. There is likely to be a continued expansion of the use of tractor power for primary land preparation, but in the coming decade much of semi-arid West Africa, Ethiopia and the Eastern and Southern African regions will continue to be cultivated using hand and animal power[66].

In semi-arid areas, a delay of even one day in cultivation, weeding or planting after rain has fallen can reduce yields. Research conducted in Zimbabwe found that 5-10 % of cereal potential grain yield is lost for every week of delay in planting[67]. This is very important in semi-arid areas like Namibia and the Sahel, where the time of planting after the first rains is critical. In theory, greater timeliness can come from tractors, but in practice when it comes to tractor-hire tillage services this is only true for the first in the tractor queue. In contrast, when many smallholder farmers own animals, they can all plough their fields at the same optimum time, and this is still widely seen in Africa[68]. Assuming that everything else goes well, then farmers can expect good yields.

64 Starkey 2011; Mrema 2011.
65 Chigariro et al. 2008.
66 Starkey 2011.
67 Nyagumbo 2008.
68 Starkey 2011.

Draft animals and tractors are not necessarily alternatives: there can be systems where the different power sources complement each other, so benefiting from the comparative advantages of both power sources. Studies conducted in Namibia suggested that where possible and needed for land preparation, farmers should use tractor-drawn ripper furrowers to achieve maximum depths and widths, and then use animal-drawn ripper furrowers in subsequent years. This study also showed that in order to break the plough pan, for the first year a tractor ripper can be used and then in subsequent years animals can be used[69].

Image

A major constraint for animal traction is the negative connotation as people, particularly politicians and urban elites, view draft animals as backward. Through many influences such as films, media, urbanization and modernization, animal traction has negative, backward associations and the idea that the promotion of draft animals is a 'U-turn back to the stone age'. In South Africa for example the spread of modern mechanical power led to many perceiving animal power as backwards, irrelevant and less important. Despite the negative perceptions and neglect of animal traction, draft animals persist in smallholder farming systems and remain important to some farmers[70].

Animal welfare and care

Most working animals are well looked after and treated with respect by their owners. Nevertheless, there are examples of poor animal welfare and this can be a problem for the animals themselves, and for the image of draft animal power. Draft animals may work long hours in some situations. The welfare of transport equids can be particularly problematic, with heavy loads and poor harnessing systems. The problem can be particularly difficult for horses pulling carts and wagons if inappropriate harnessing systems are used, due to lack of understanding by operators and/or the lack of good quality harnesses that are affordable to the transporters who are probably struggling to make a livelihood. ***Figure 19*** shows an example of such problems.

Figure 19 *– Examples of harness sores from horse pulling a passenger 'gary' in Ethiopia (left) and a donkey pulling a freight cart in Senegal (right)*

69 Mudamburi 2016.
70 Zantsi/Bester 2019.

In most of the world, farmers use yokes for cattle and harnesses for equids. In Namibia and Zimbabwe, it is not uncommon for farmers to use yokes with donkeys, and yokes are more likely to cause problems than well-fitted harnesses[71]. ***Figure 20*** shows yokes on donkeys in Namibia.

Figure 20 *– Four donkeys, harnessed in pairs with yokes, pulling a donkey cart in Namibia*

Animal welfare organisations can be influential. The international ones tend to concentrate on the protection of equids, and tend to ignore working cattle. Some organisations have been promoting the appropriate use of working equids, including promoting the availability of good, low-cost harnesses[72]. Several national and international organisations have been campaigning against the trade in donkey skins[73]. However, some animal rights campaigners believe no animals should be used for work. Some animal welfare organisations encourage crackdowns against draft animal usage (such as tourist carriages), despite the socio-economic importance for their owners[74].

Institutional neglect

As has been noted, during the last three decades of the twentieth century, there were projects researching and promoting animal power in most sub-Saharan African countries. These were often funding by multilateral or bilateral aid agencies and technically supported, or influenced, by technical teams working in international research centres, United Nations agencies and several research centres and universities in Europe. In 2022, there is a totally different situation. There are very few projects or ministries promoting draft animals, and very few researchers in the world actively engaged with animal traction issues. In most countries, there is minimal support for draft animals from governments, political leaders and development agencies.

Problem of costs, theft and supplies

As the value of animals has increased, draft animals have become less affordable and more prone to theft. Stolen cattle can be quickly converted to meat and stolen donkeys can be stripped of their valuable hides, and better roads and easier access to transport, including motorcycles, make it easier to quickly remove and sell stolen animals, meat and hides. The high cost of animals and the risk of theft are now major constraints to farmers.

In the first half of the twentieth century, animal power was widely used by large and small farmers in South Africa, Zimbabwe and some neighbouring countries, and there were good commercial sector supply chains for implements and spares and the services needed to support the use of draft animals (blacksmiths, cart makers, farriers). In many other sub-Saharan African countries, during the later decades of the century projects supported the establishment of implement and cart workshops and the development of appropriate support services, including credit facilities. This created a critical mass of demand, and allowed the suppliers and support services to thrive, so facilitating a virtuous spiral of increasing adoption and the availability of services. However, as animal traction declines (due to tractorization, image, theft or other factors) fewer traders continue to stock draft animal implements and spares and fewer local artisans specialize in supporting the use of draft animals. A vicious circle or downwards spiral develops, where it becomes increasingly difficult for farmers to continue using draft animals, and for artisans or workshops to survive through animal traction. Many implement workshops started in the twentieth century have closed down or switched to more profitable products such as security bars, for which the market is growing.

Opportunities

Environmental issues and climate change

Draft animals are a renewable, ecologically sustainable resource that can improve resilience to climate change. With governments and donor agencies increasingly investing in ways to mitigate the effects of climate change, draft animals can contribute to rural resilience, the sustainable management of agricultural land, forests and environmentally sensitive zones and help to preserve biodiversity areas. With climate change increasing droughts and making feed resources less predictable, donkeys that require less grazing and water offer an alternative to oxen, provided the market distortion provided by the donkey skin trade is contained.

Conservation tillage and sustainable agriculture

Conservation tillage is environmentally friendly, with minimal soil disturbance, reduction in soil erosion, increased soil fertility, increased soil moisture and reduction in soil compaction. Conservation tillage helps reduce costs of production, saves time, increases yield through timelier planting, reduces diseases and pests through stimulation of biological diversity and reduces greenhouse gas emissions[75].

Conservation tillage can be beneficial using both tractor power, animal power or a combination of both. For smallholder farmers, it can be advantageous to move from hand labour to draft animals as this allows larger cultivation areas thereby increasing overall yields and incomes. Compared to hand labour, conservation tillage with draft animals can be economical and labour-sav-

71 Mudamburi/Keib 2007.
72 Pearson et al. 2003; Garrett undated.
73 Donkey Sanctuary 2018; Brooke 2019; Network for animals 2020.
74 World Animal Foundation 2021.
75 Hobbs 2006.

ing, which is important in view of the labour constrains caused by the HIV/AIDS prevalence.

Whilst using draft animals for conventional tillage can be slow, conservation tillage allows faster land preparation for smallholder farmers. Conservation tillage can use light implements making it easier for the animals and operators. A study conducted in northern Namibia showed conservation tillage using draft animals holds promise, is beneficial and has the potential to transform Namibian smallholder agriculture into a sustainable and productive crop production strategy[76].

Some farmers in Zimbabwe are using draft animals for conservation tillage. In Shamva District, farmers were introduced to an animal traction direct seeder which allows seeding and fertilizing directly into crop residues with minimum soil disturbance[77]. In the Sahel, much animal-drawn cultivation involves tine tillage and/or direct seeding.

Figure 21 *– Direct seeding with a horse in Senegal (top) and demonstrations of conservation tillage direct seeding in Zimbabwe (middle) and Uganda (bottom)*

Champions

With the problem of an old-fashioned image, animal traction needs champions to promote and identify with draft animals. A good example of this occurred in Namibia in 2020, when the Mayor of the City of Windhoek was seen and filmed ploughing in Zambezi Region. This was widely reported in the Namibian media and shared and discussed on Facebook[78]. This was an inspiration especially to young farmers who often see draft animals as backward. Of the more than 300 comments posted on the Facebook page, about 70 % were positive and in support of draft animals, but 30 % implied that this technology was taking Namibians 'back to the stone age'. Among the positive comments were:

- It saves costs and is effective.
- It is called the old way of ploughing but to me, it is the best way of doing it.
- It is not old, as we are still using it.

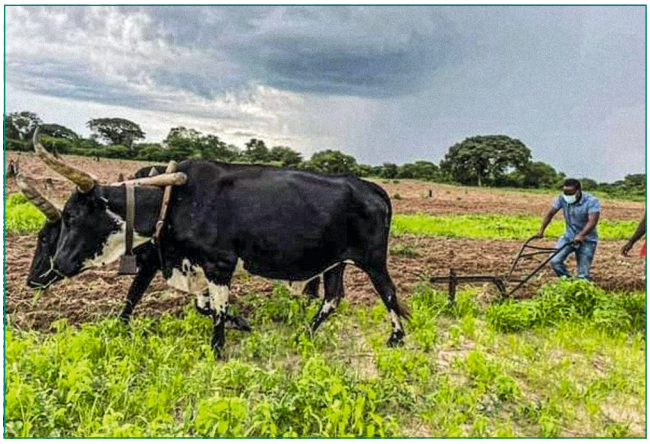

Figure 22 *– The Mayor of Windhoek ploughing with oxen in Zambezi Region of Namibia*

Networking and promotion

As noted, the international and national networks, including ATNESA, did much to improve information exchange and an understanding of the continuing importance of animal traction. They produced many resource publications that are still available online and widely used in Africa and elsewhere. Without funding, and with few researchers and projects working on draft animal issues, most networking activities have ceased.

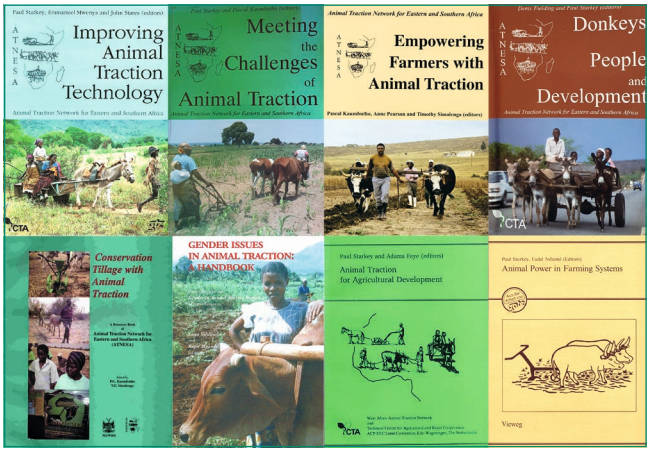

Figure 23 *– Examples of the many publications about draft animals available to download from the ATNESA website*

However, KENDAT, which established itself as an NGO able to receive funding for project implementation, continues to work on animal traction issues, and empow-

76 Mudamburi 2016.
77 CIMMYT 2016.
78 Entondo 2020.

ers communities in relation to the importance of donkeys in Kenya. The use of donkeys for transport has made a huge difference in some farmers' household incomes[79].

Apart from the continuing legacy of numerous resource publications, there are many lessons that can be drawn from the successful activities of the networks, and their importance in bringing stakeholders together to share lessons and to create a critical mass for influencing funding agencies, government authorities, public opinion and even smallholder farmers[80].

Students and young people

Experience from Namibia suggests that draft animals can improve smallholder farmers' timeliness and workload through environmentally friendly tillage and transport. Many students from the University of Namibia still view draft animals as available resources that are relevant to smallholder farmers. The students have argued:

- Draft animals are affordable, environmentally friendly and reduce the drudgery of farm tillage operations
- They enhance timeliness of operations and can be used with less soil disturbance than tractors
- Draft animals can also be used for rural transport (carting or packing) to carry water, produce and food
- For resource-poor farmers draft animals are better than manual tillage.

Recommendations

Africa needs leaders, political support and relevant investment to ensure the continuity and development of draft animal power with a critical mass of users and support services. National and international organisations could have a major impact by providing more information, educational materials and media resources explaining the benefits of animal traction in a modern world. Networks are highly effective for sharing information and providing the critical mass needed for influence, recognition and professional support.

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Author info
Bertha Mudamburi

University of Namibia; Lecturer
P Bag 5520, Oshakati, Namibia

E-Mail: bmudamburi@gmail.com
Digital paper: https://youtu.be/9wb-gb6EyTw

Author info
Paul Starkey

Museum of English Rural Life, University of Reading; Visiting Senior Research Fellow
Oxgate, 64 Northcourt Avenue, Reading RG2 7HQ

E-Mail: p.h.starkey@reading.ac.uk / p.h.starkey@gmail.com
Digital paper: https://youtu.be/9wb-gb6EyTw

Speeding up. Prehistoric animal traction and the revolute joint

Eva Rosenstock

Abstract

The use of animal in draft, particularly cattle, is likely as old as their domestication. However, due to high friction between sledges and sleighs and the ground or high work input implied by roller bearings, Neolithic and Copper Age animal traction was likely rather slow. Here, the revolute joint, an innovation of the late fourth and the early third millennia BCE, brought about wheelsets and wheels for carts and wagons along with other applications such as pivoted doors, the potter's wheel, and levers. As first automotoric machines in human history, wheelset and wheeled vehicles increased the work speed of draught cattle significantly and helped to shift prehistoric economies from being labour-limited to land-limited. Moreover, they enabled the use of horses as draught animals for Bronze Age chariots and Roman travel carts, resulting in an increase in travel speed. In terms of acceleration, these innovations were as significant as the acceleration period we currently encounter that started with industrialization.

Résumé

L'utilisation de la traction animale, en particulier les bovins, est probablement aussi ancienne que leur domestication. Cependant, en raison du frottement élevé entre les traîneaux et le sol ou de la charge de travail importante impliquée par les roulements à rouleaux, la traction animale du Néolithique et de l'Âge du Cuivre était probablement plutôt lente. Ici, l'articulation tournante, une innovation de la fin du quatrième et du début du troisième millénaire avant notre ère, a donné naissance aux essieux et aux roues des charrettes et des chariots, ainsi qu'à d'autres applications telles que les portes pivotantes, le tour du potier et les leviers. En tant que premières machines automotrices de l'histoire de l'humanité, les véhicules à ensembles de roues ou à roues ont considérablement augmenté la vitesse de travail des animaux de trait et ont contribué à faire passer les économies préhistoriques d'une situation où la main-d'œuvre était limitée à une situation où la terre était limitée. En outre, ils ont déclenché l'utilisation de chevaux comme animaux de trait pour les chars de l'Âge du Bronze et les voitures de voyage romaines, ce qui constitue une étape dans la réduction du temps de voyage dans la préhistoire. Ces innovations ont probablement été aussi importantes que la période d'accélération que nous connaissons actuellement et qui a débuté avec l'industrialisation.

Kurzfassung

Die Nutzung der Zugkraft von Tieren, insbesondere von Rindern, ist wahrscheinlich so alt wie ihre Domestikation. Aufgrund der hohen Reibung zwischen Schlitten und Boden oder des hohen Arbeitsaufwands, den Rollenlager mit sich bringen, ging die Zugtiernutzung im Neolithikum und in der Kupferzeit jedoch bestenfalls eher langsam vonstatten. Das Rotationsgelenk, eine Erfindung des späten vierten und frühen dritten Jahrtausends v. u. Z., führte zu Radsätzen und Rädern für Karren und Wagen sowie zu anderen Anwendungen wie Schwenktüren, der Töpferscheibe und Hebeln. Als erste automotorische Maschinen in der Geschichte der Menschheit steigerten Gefährte mit Radsätzen oder Rädern die Arbeitsgeschwindigkeit von Zugtieren erheblich und trugen dazu bei, dass die prähistorische Wirtschaft nicht mehr durch die verfügbare Arbeitskraft, sondern v.a. durch die verfügbaren Landflächen begrenzt war. Darüber hinaus lösten Radsatz und Rad die Verwendung von Pferden als Zugtiere für bronzezeitliche Streitwagen und römische Reisewagen als weiteren Beschleunigungssprung in der Vorgeschichte aus. Was die Beschleunigung anbetrifft, waren diese Innovationen wahrscheinlich ebenso bedeutsam wie jene, die seit der Industrialisierung die Beschleunigungsphase auslösten, die wir bis heute erleben.

Resumen

El uso de animales en el campo del cultivo, especialmente del ganado, es probablemente tan antiguo como su domesticación. Sin embargo, debido a la elevada fricción de los trineos o incluso el gran esfuerzo que suponían los rodamientos contra el suelo, la tracción animal en el Neolítico y la Edad de Cobre era probablemente bastante lenta. Es debido a esto que la innovadora pieza de ingeniera de finales del cuarto y principios del tercer milenio a.C. de la unta, trajo consigo numerosos juegos de ruedas tanto para carros y carretas, además de otras aplicaciones como puertas pivotantes, torno de alfarero y las palancas. Como primeras máquinas automotrices de la historia de la humanidad, los vehículos aumentaron considerablemente la velocidad de trabajo del ganado de tiro y contribuyeron a descentrar las economías prehistóricas limitadas a mano de obra con terrenos reducidos. En consecuencia, el uso de caballos como animal de tiro para carros se popularizó en la Edad de Bronce, reduciendo así los tiempo de trayecto. Estas innovaciones provocaron un periodo de aceleración, el cual se asemeja al proceso iniciado en la revolución Industrial, que continua desarrollándose exponencialmente hasta la actualidad.

Animal traction in prehistoric archaeology

Animal traction as a secondary product

Andrew Sherratt in 1981 put forward the idea that in the Neolithic and Chalcolithic, animals were only exploited for their primary products – products obtained by slaughtering an animal, such as meat, leather, and bone. Secondary products, i.e. products that can be "harvested" from living animals, such as milk, maybe blood, and wool as well as workforce, in contrast, were only exploited from the turn from the fourth to the third millennium BCE onwards, which marks – in broad terms - the turn to the Bronze Age. Further research into this topic over the last decades, however, has considerably reshaped this idea[1]. Rather than a "Secondary Products Revolution", the time around 3000 BCE is now perceived as a phase of rapid intensification of much older incipient secondary product use[2].

While wool production requires a particular genetic mutation in sheep that is currently assumed to have indeed happened in later prehistory[3], increasing evidence points to a Neolithic onset of animal milk and traction use. According to osteological hints, milking might be as early as the domestication of sheep, goat and cattle, and biochemical evidence demonstrates that milk was regularly processed in ceramic vessels from the seventh millennium BCE onwards[4]. Moreover, there is now increasing material evidence also for the Neolithic use of animal traction. From the late fourth millennium BCE onwards, however, evidence for animal traction use not only gets much more frequent, but also includes new species such as donkeys and horses. Admittedly, part of this increase in finds is a function of changed cultural practices and, hence, preservation conditions; but since this is true mainly for Europe, the situation in South-west Asia suggests that also animal traction witnessed an intensification from the fourth millennium BCE onwards.

Archaeological sources for animal traction

Except for northern latitudes where acidic soils prevent their preservation, animal bones are among the most frequent finds in most archaeological sites. Among the animal species traditionally used in traction, the dog is the oldest domesticate, as wolf husbandry started among later Palaeolithic hunters and gatherers from ca. 30000 BCE onwards[5]. Cattle were domesticated together with sheep and goat from ca. 9000 BCE onwards when farming developed in the early Neolithic after the end of the last ice age. Donkey and horses, however, were domesticated several thousand years later around 3000 BCE at the transition from the Neolithic or Chalcolithic to the Bronze Age[6]. Camels followed around 1000 BCE[7], and for the onset of reindeer domestication a wide date range between ca. 1500 BCE and 800 AD is debated[8].

1 Sherratt 1981.
2 Greenfield 2010.
3 Benecke et al. 2017.
4 Evershed et al. 2008; Hendy et al. 2018.
5 Bergström et al. 2020.
6 Librado et al. 2021.
7 Orlando 2016.
8 Pelletier et al. 2020.

However, as the presence of species potentially suited for traction work does not mean they were actually used in traction, zooarchaeologists look for signs of wear and tear on the bones: cattle traction use has been demonstrated to result in broadened surfaces in the distal phalangeal joints judging from a sample of slaughtered modern traction animals from rural Romania[9] and is a trait that can be distinguished also in archaeological material. In horses, in addition, bridling can lead to bit wear visible on the teeth in archaeological material[10].

Wood, bone and leather as the traditional materials for the manufacture of traction gear hardly survive in the archaeological record, so actual finds are limited to permafrost, arid or waterlogged conditions that are found in regions that have been settled later in the course of prehistory due to their adverse climatic conditions. The same is true for wooden road tracks built in marshy land. With the onset of the metal ages, highly strained construction parts such as bridles and wagon hubs have been increasingly replaced by metal, which can then be found in the archaeological record. However, the assumed high degree of metal recycling limits such finds mainly to grave goods in rich burials that may not always reflect standard work equipment but rather elitist items. Moreover, sledges and wagons as well as ards can leave traces in soft ground. However, such traces quickly erode unless they are buried under soil soon after, limiting their preservation to time periods when burial mounds were common.

Prequel: Mesolithic and Neolithic

Wooden runners found in Vis I in modern Russia dated to the seventh or sixth millennium BCE[11] suggested that Mesolithic hunter-gatherers used skis and sledges (**Figure 1**). While we cannot yet say for sure if humans or dogs pulled such vehicles[12], it is likely that contemporary Neolithic communities further south knew about sledges and travois-like devices, too, although interpretation of a wooden fragment from the Cardial site of La Draga (Banyoles, Espagne) in the 6th millennium BCE is questionable[13]. Hauling sledges is not only possible on snow cover or frozen ground, but also on dry soil if the load is not too heavy. Additionally, grass cover can lower friction considerably[14], similar to how threshing sledges traditionally used in arid regions like South-west Asia glide over cereal and pulse straw No actual prehistoric threshing sledge has survived, but at e. g. sixth millennium BCE Çatalhöyük West, squarish flint blades bearing a gloss characteristic for cutting plant material have been found[15]. Their resemblance to known insets into later prehistoric threshing sledges is so striking that a Neolithic use of threshing sledges should at the moment not be entirely excluded[16]. First ard marks and actual ard finds, in contrast, are only attested from ca. 3000 BCE onwards and – together with archaeobotanical evidence[17] – suggest that

9 D e Cupere et al. 2000
10 Greenfield et al. 2018.
11 Burov 1981.
12 Sinding et al. 2020.
13 Guilaine 2003, 147.
14 Atkinson 1956, 109.
15 Rosenstock et al. 2019a, 178.
16 Ostaptchouk 2016, 101, 119p; Kamjan et al. 2022.
17 Bogaard 2004, id. 2005.

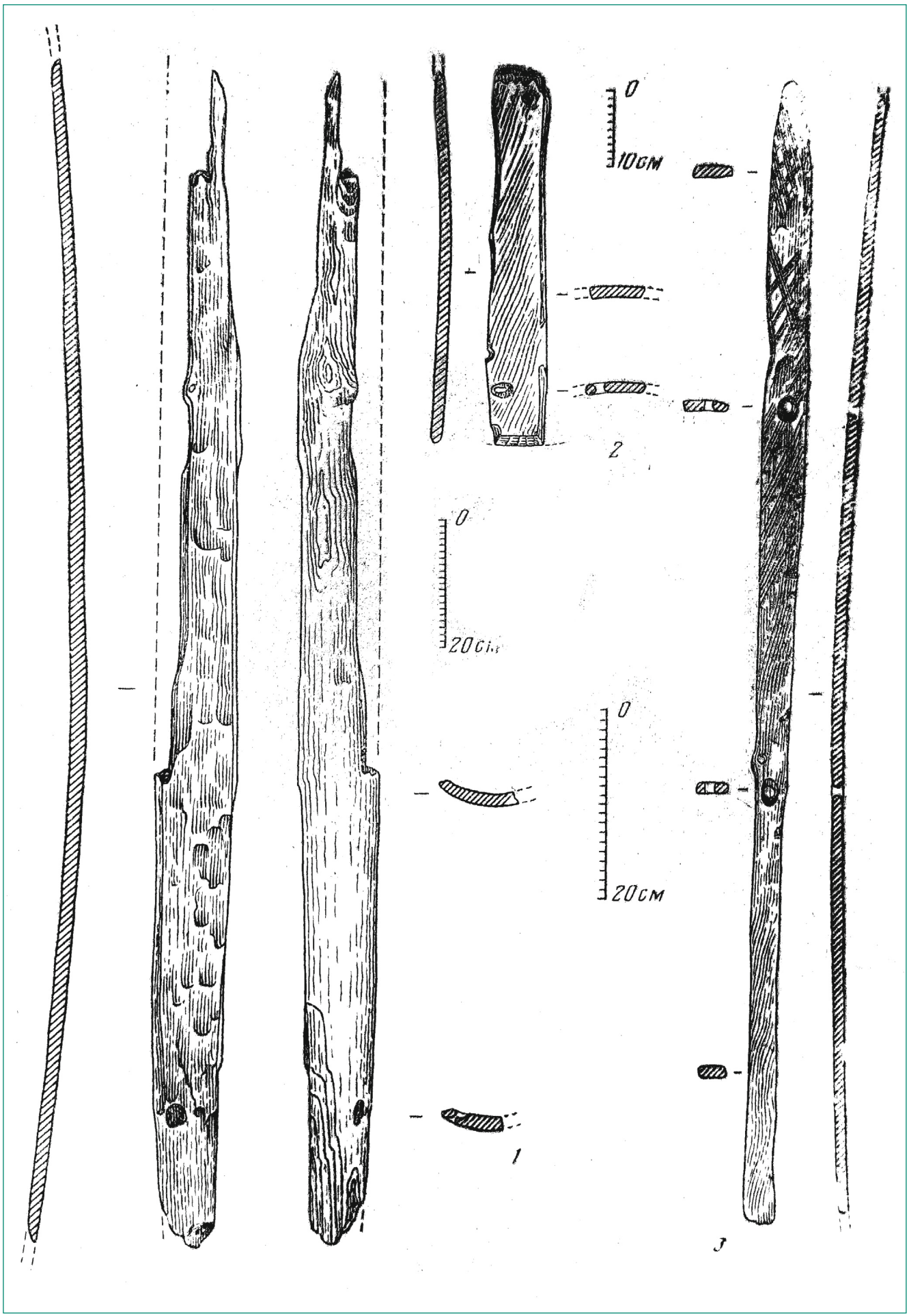

Figure 1 *– 7th or sixth millennium BCE sledge runners or skis from Mesolithic Vis*

Neolithic agriculture was hoe-based. However, this can only hold true if the absence of evidence for the ard is not only caused by preservation biases. Especially in the European Neolithic, when primeval forests had to be cleared to obtain agricultural land and timber-framed architecture, cattle draught force might have been welcome also for logging, a practice known today, too[18].

While all this merely hints at the possibility of early draught cattle, bones with broadened distal phalangeal joint surfaces observed at Early Neolithic sites in South-eastern Europe (***Figure 2***) confirm that cattle were at least occasionally used in draft tasks already in the Neolithic[19]. Such "ad hoc draft use" still – like milking – requires some training and hence a certain degree of familiarity between animals and humans. This demonstrates that people and their herds lived close together despite the lack of evidence for penning or even stabling of cattle close to the settlements in the Neolithic[20].

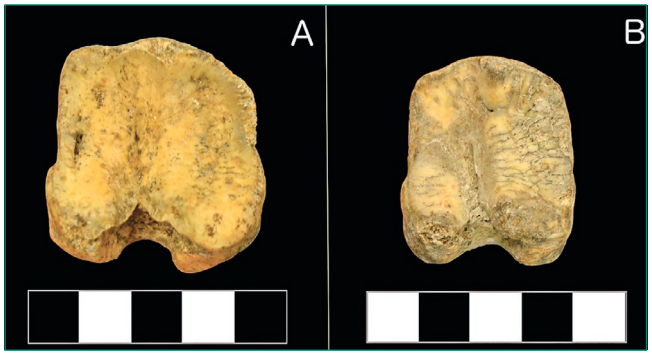

Figure 2 *– Broadened proximal articular surfaces of Bos taurus anterior second phalange from Foeni-Salaş (A) pointing to traction use in comparison to a specimen with the usual dimensions from Blagotin (B), both ca. 6000 BCE*

Chalcolithic and Early Bronze Age ca. 4000 – 2000 BCE

Ards and sledges

First evidence for ards is only known from around 3000 BCE onwards. Unlike later ploughs, ards do not turn the soil and do not distribute it on the field, but merely create furrows. Hence, fields of the Copper and Bronze Ages were ploughed in a criss-cross fashion. The soil under the mound of Jordehøj in Denmark dating from 3500 to 3300 BC has preserved one of the earliest examples of ard marks. Judging from rock carvings at Bagnolo and Borno 1 in Val Camonica/Italy probably also dating to the 2nd half of the 4th millennium BCE, ards were pulled by cattle teams of two[21]. The first preserved actual ards (***Figure 3***) such as the one from Walle near Aurich in Lower Saxony, Germany, however, date to the early 2nd millennium BCE[22] and are as simple wooden constructions as those observed in recent traditional contexts.

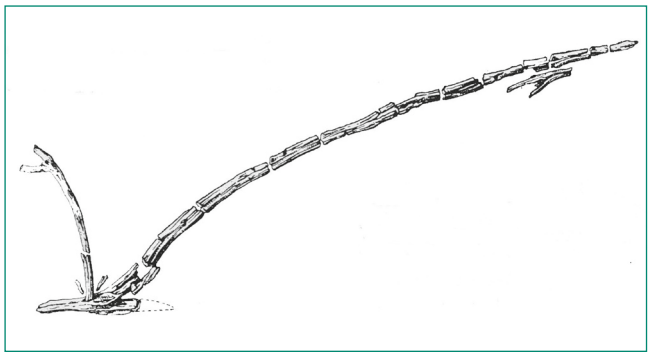

Figure 3 *– One of the first preserved ards from Walle – initially dated to the 3rd, now redated to the early 2nd millennium BCE*

Cylinder seals of the late Uruk period (ca. 3500-3100 BCE) of Mesopotamia, such as from Arslantepe (near Malatya, Turkey), show sledges with one seated person and another one standing on the sledge or next to it and controlling the single draught animal using a spike and a rein (***Figure 4***). The details of the harnessing are somewhat unclear, but the high friction of a sledge renders draw-

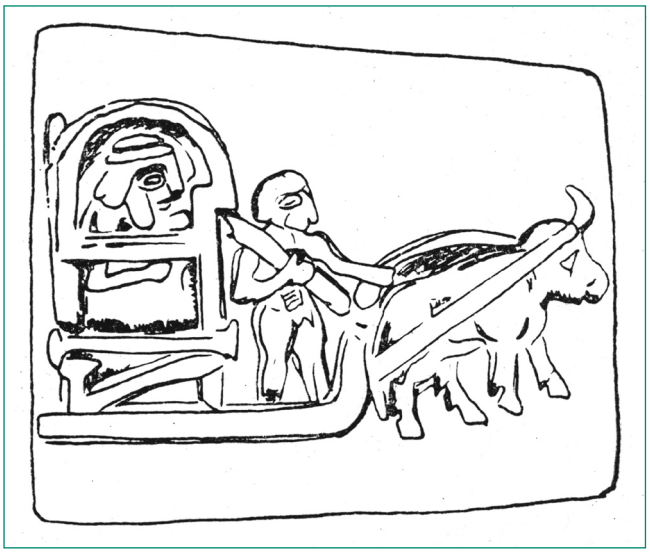

Figure 4 *– Late Chalcolithic steatite plaque showing a cattle-drawn sledge*

bars that enable the animal to brake the vehicle downhill unnecessary at least in flat terrain, so the connection between the animal's horn and the sledge shown likely represents some sort of traces. Remains of a sledge or wagon from the Early Dynastic period (ca. 2750-2350 BCE) and the skeletons of two bovids have been recovered from tomb RT 800 of the royal cemetery at Ur (Iraq)[23]. Details of the construction, including the attachment of the draught pole, however, remain unknown. Biblical passages such as 2 Kings 13:7, "For there was no more left of the people of Jehoahaz than fifty horsemen, ten chariots and ten thousand footmen. For the king of Syria had slain them, and made them as the dust of the threshing", could explain such sledges as symbolic attributes of high-ranking individuals derived from the threshing sledge. Threshing sledges are archaeologically attested by so-called Canaanite blades interpreted as lithic insets from the fourth millennium BCE onwards[24] and are traditional devices in arid regions like Southwest Asia.

18 Modern-day logging with draught cattle, URL: https://youtu.be/jDrAkIMF20I [23-06-22].
19 Gaastra et al. 2018.
20 Knipper 2011.
21 Anati 1975; Arcà 2003.
22 Geyh/Rasmussen 1998.
23 Littauer/Crouwel 1979; Piggott 1983.
24 Anderson et al. 2004.

Wheeled vehicles

One of the oldest examples among the variety of evidence for early vehicles[25] are the wheel and the axle from Stare Gmajne in Slovenia (***Figure 5***) ^{14}C-dated to 3350-3100 BCE[26]. The squarish axle hole of the tripartite disc wheel shows that the wheel was firmly attached to the rotating axle forming a wheelset[27] – a common trait in prehistoric vehicles around the Alps. Rock depictions from Val de Fontanalbe near Mont Bego, France, suggest that carts in this period and region were basically travois-like triangular devices with axles and wheels attached. A fragmentary object carved from a tree crotch found in Reute (Baden-Württemberg, Germany) and dendro-dated between 3709 und 3707 BCE[28] could be the front end of such a travois or triangular cart, whereas a complete specimen found at Chalain 19 in the French Jura (***Figure 6***) dated to 3015-2976 BCE bears use-wear traces at the ends of the two poles that suggest it was a travois[29]. Engravings from the megalithic tomb at Züschen (Hesse, Germany), in contrast, show two-wheeled vehicles with separate draught poles and cart bodies[30].

Figure 5 – *Wheelset from Stare Gmajne, Slowenia, late fourth millennium BCE*

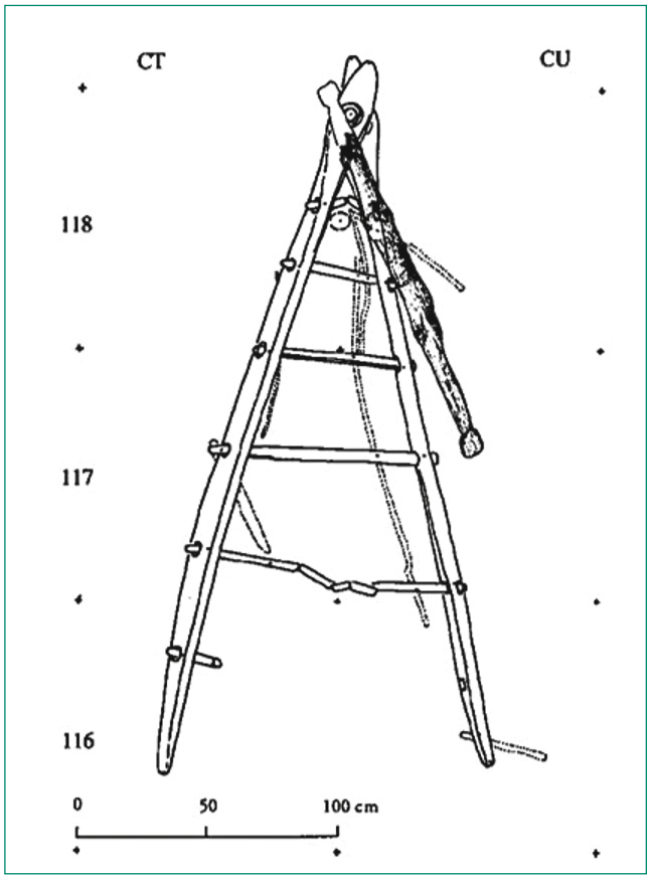

Figure 6 – *Travois and yoke found at Chalain, France*

Pictographs dated from ca. 3500-3350 BCE from Uruk (Iraq) show two round impressions under sledge symbols. If not counting marks[31], they could be interpreted as the earliest evidence for wheeled vehicles in Southwest Asia. Here, as well as in the Northern Pontic and in Northern Europe, wagons prevailed. With their four wheels turning independently on fixed axles by means of wheel hubs (***Figure 7***), they form a contrast to the wheelset carts of the alpine region. Early pictorial evidence from Europe, such as wagon-shaped ceramic cups of the Baden culture (ca. 3500-2800 BCE) or depictions on a Funnel Beaker culture vessel from Bronocice (second half of the fourth millennium BCE) complements actual wheels with hubs and axles with rounded ends including corresponding wear marks found in e.g. Gnarrenburg, mid-third millennium BCE, or the Meershusen bog, around 3000 BCE[32]. In the graves of the Yamnaya culture of the Northern Pontic steppes[33], there are also always four disc-wheels with hubs. But as with two-wheeled carts, cattle draught was paired, as copper figurines (***Figure 8***) and paired cattle burials from related cultures such as Funnel Beaker, Baden (e.g. from Alsónémedi) and Globular Amphora illustrate.

The spatial patterning of two- and four-wheeled vehicles can be explained as adaptations to hilly and flat terrain, respectively[34]. In the absence of separate brake mechanisms, the cattle team has to brake the vehicle downhill by means of the draught pole, which is much easier in a short and rigid cart construction. The different wheel principles are, in turn, likely connected to the number of axles. Wheels that rotate independently of each other enable easier cornering, as the outer wheel with the longer travel can turn faster than the inner wheel. This is true for single-axle carts, but it is more relevant for two-axle wagons. Their mass causes greater load on the individual wheel, and their wide axles cause greater difference in the travel of the wheels in the curve[35].

Cattle harness

The yoke found with the Chalain travois was only a roughly worked roundish piece of wood, so it is difficult to decide whether it was a horn or withers yoke[36], but at least one of the Val de Fontanalbe and all later depictions suggests the horn yoke as the regular yoke type in prehistory. In travoises as well as carts, a considerable

25 Burmeister 2017.
26 Velušček et al. 2009.
27 Bulliet 2016:80.
28 Mainberger 1997.
29 Pétrequin et al. 2002.
30 Kappel 1981; Hansen et al. 2021.
31 Burmeister 2004a.
32 Milisauskas/Kruk 1991; Burmeister 2017; Maran 2017.
33 Reinhold et al. 2017.
34 Sherratt 1986.
35 Bulliet 2016; Masson/Rosenstock 2011.
36 Pétrequin et al. 2002.

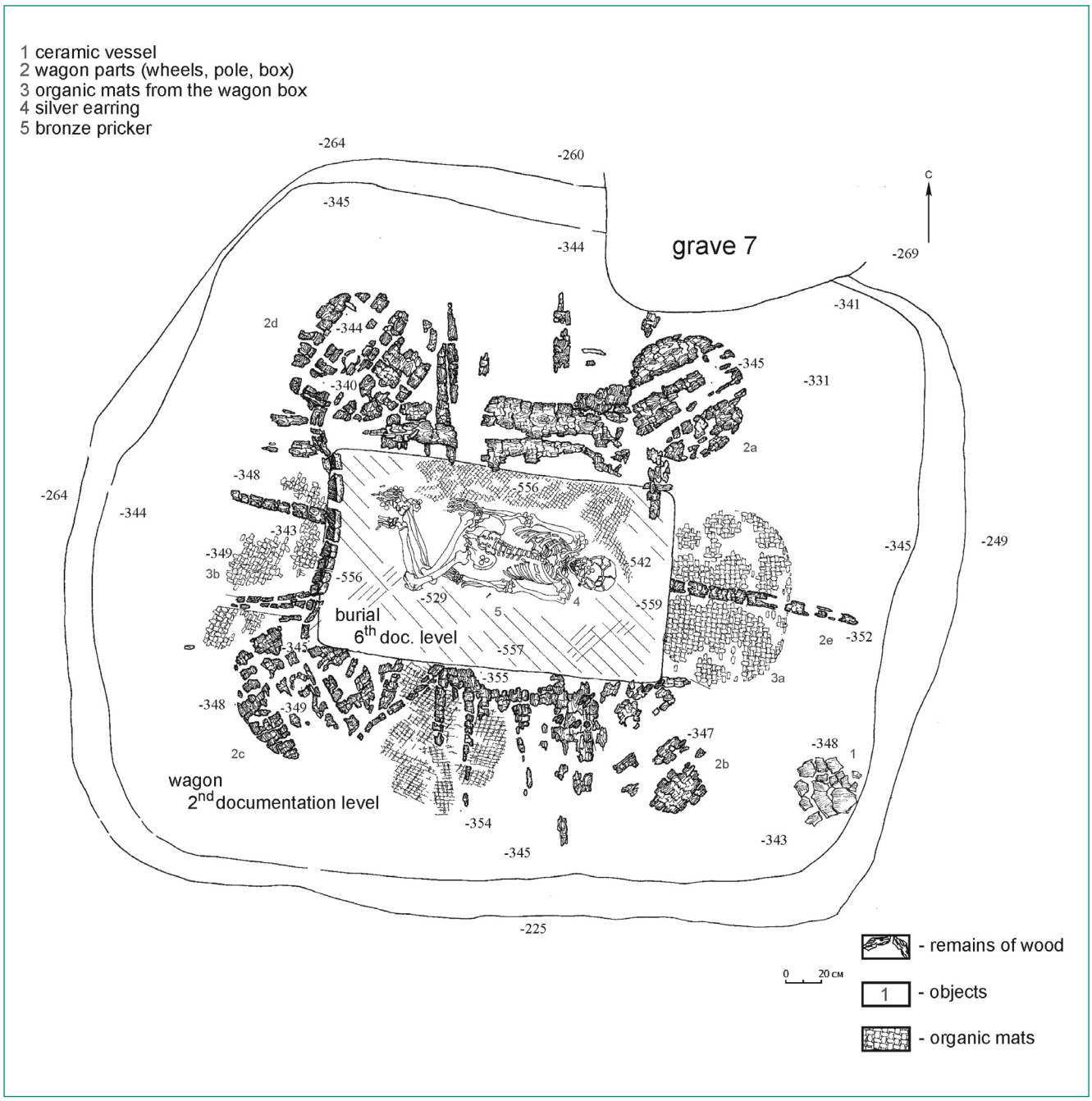

Figure 7 *– Yamnaya burial including a wagon with four wheels from Sharakhalsun 6 Kurgan 2, Russia*

Figure 8 *– Copper model of a cattle team from Bytyń, Poznań/Poland – probably late fourth millennium Funnel Beaker culture*

part of the load rests on the animals. A combination of horn yoke and cart is not uncommon[37], but puts extra strain on the animals in comparison to a cart with withers yoke or a four-wheeled wagon with horn yoke. While the fastening of front and neck yokes may result in chafing on the horn, the horn sheaves usually do not survive in the archaeological record. Hence, damaged horn cores such as in the find from Holubice (***Figure 9***) represent exceptional cases: either chafing was so severe that the bone underneath the horn was also affected or – more likely – the animal had lost the horn sheave by accident[38]. But in general, this find fits into a trend of increasing osteological evidence for physical strain on cattle from the

Figure 9 *– Worn horn core from Holubice, Bell beaker period, early third millennium BCE*

late fourth millennium BCE onwards[39]. Other yoke finds, such as from Arbon-Bleiche 3 (3384-3370 BCE), Vinelz (28th century BCE) and Chalain 2 (27th to 26th century BCE) have anatomically shaped recesses typical for withers yokes. With its comparatively small width of only ca. 1 m compared to 1.3 m to 1.7 m as in other finds, the yoke from Arbon-Bleiche[40] is too small to leave space for a draught pole between grown up animals, so it was either used for smaller animals such as goats or for training young cattle without a vehicle. The first known cases of genetic hornlessness, recognisable in cattle skulls by a characteristic cusp in the neck, appear in the fourth millennium BCE, too[41]. Given the spontaneous mutation rate of the underlying genes and their associated effects on other bodily traits such as eyelashes and genitals[42], their occurrence at a time when first dung finds (e.g. from Thayngen-Weier or Pestenacker) demonstrate livestock keeping close to the dwellings or even in stables appears[43] seems no coincidence: in crowded situations, hornless cattle are less likely to hurt each other, but they can – of course – not be harnessed with a horn yoke. As suggested by Yamnaya copper finds, cattle were steered using nose rings[44].

Hollow ways and wooden tracks

Often-used tracks would cause wheels to slide in the mud, especially in rainy weather. To prevent sliding and consequently uneven wearing of the wheels, felloes were frequently studded with metal nails in the third millennium BCE of South-west Asia[45]. In Europe, wooden tracks preserved in bogs likely served the same purpose. With widths between ca. 2,40 m and 4 m, they were broad enough for early wagons with their gauges between 1,2 m and 1,6 m, and the lack of curves suggests that early wagons had indeed no steerable front axle as suggested by traces of wear on preserved wagon parts[46]. Hence, draught poles were likely rather long to give more leverage facilitating the job of the cattle team if a wagon must go around a curve.

Later Bronze Age ca. 2000-1000 BCE

Equid domestication

Remains of domesticated African wild ass (*Equus asinus*) have been found in archaeological contexts in Northeast Africa from the fifth millennium BCE onwards; from the fourth millennium BCE onwards, they also appear in South-west Asia. Attempts at domesticating the Asiatic wild ass or Onager (*E. hemionus*) led to the first hybrid animals created by humans shortly before the domestication of the horse[47]. Several horse populations of Eurasia also including the Przewalsky's horse (*E. przewalsky*)[48] were intensively exploited from the fourth millennium BCE onwards[49]. Here, one population from the Volga-Don region has been determined as ancestral to the modern domestic horse (*E. caballus*) using genetic evidence. Selected traits in these early domestic horses included genes connected to greater docility and stress-resilience as well as better performance in running and weight bearing[50]. Such traits were highly desired if we look at the Kikkuli-text, a 2nd millennium BCE training instruction for chariot horses found in the Hittite capital in Central Anatolia[51]. It hence seems plausible that the development of a related technology for light-weight vehicles in the region accompanied the expansion of the horse into South-west Asia and Europe around 2000 BCE[52]. As, however, also in South-western Asia experiments with lighter equid draft were made since the third millennium BCE, the direction of influence is still a matter of debate[53].

37 Silvester 1980.
38 Peške 1985; Benecke 1994, 273.
39 Hüster Plogmann 2002; Johannsen 2006; Milisauskas/Kruk 1991.
40 Leuzinger 2002.
41 Benecke 1994, 273; Müller 1963.
42 Wiedemar et al. 2014.
43 Ebersbach 2002.
44 Reinhold et al. 2017.
45 Mühl 2014.
46 Burmeister 2004b, id. 2018.
47 Bennett et al. 2022; Grigson 2012; Milevski/Horwitz 2019; Mitchell 2018; Wang et al. 2020.
48 Gaunitz et al. 2018.
49 Anthony/Brown 2011; Outram et al. 2009.
50 Librado et al. 2021.
51 Raulwing 2005; Starke 1995.
52 Grigson 2012; Librado et al. 2021.
53 Burmeister/Raulwing 2012; Chechushkov/Epimakhov 2018.

Chariots and spoked wheels

Judging from pictorial evidence such as the so-called Standard of Ur (***Figure 10***), not only cattle, but also donkeys or onagers were harnessed in the early third millennium BCE in front of heavy four-wheeled wagons with a parapet. Moreover, models of so-called straddle-cars and carts with a platform for standing drivers were attempts at developing lighter two-wheeled vehicles pulled by up to four equids. While wheel construction in South-west Asia and Europe only experienced minor progress in later prehistory, mainly by reducing material needed by

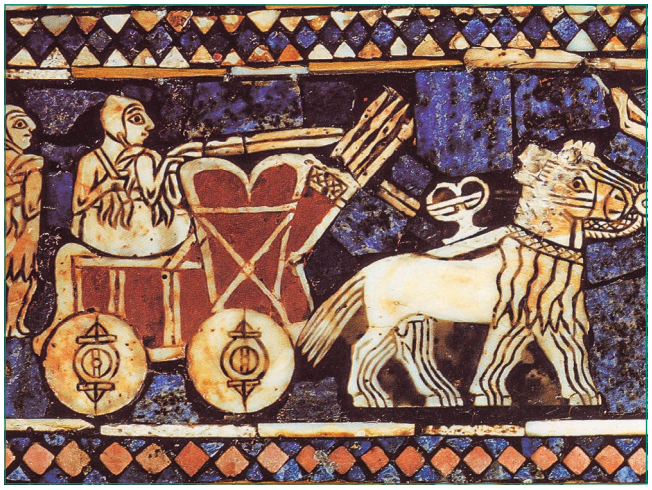

Figure 10 *– The Standard of Ur showing equids, likely onagers or hybrids between donkeys and onagers, pulling a four-wheeled wagon*

lunate openings[54], the oldest evidence for spoked wheels, a key trait of true light-weight vehicles, is associated with the horse in what today is Southern Russia. Here, carts buried at Sintashta (***Figure 11***) and related sites dating to the beginning of the second millennium BCE[55] had two wheels of approx. 1 m diameter. Judging from traces they left in the ground, the felloes and spokes were max. 4 to 4,5 cm thick[56], pointing to advanced woodworking techniques such as bending and the lathe. The association of the wheels with horses is clear from the deposition of horse skeletal remains as well as bridle cheek-pieces, but whether the vehicle bodies were made from massive wood or a frame with trellis or whether the body's opening was towards the rear or the front remains unknown. In somewhat later vehicles with similar multi-spoked wheels from late second millennium BCE Lchashen in Armenia, however, a light framework with interwoven leather straps has been preserved that opens to the front and suggests a seated driver. Chariots with front parapets and rear openings for standing drivers as in the older

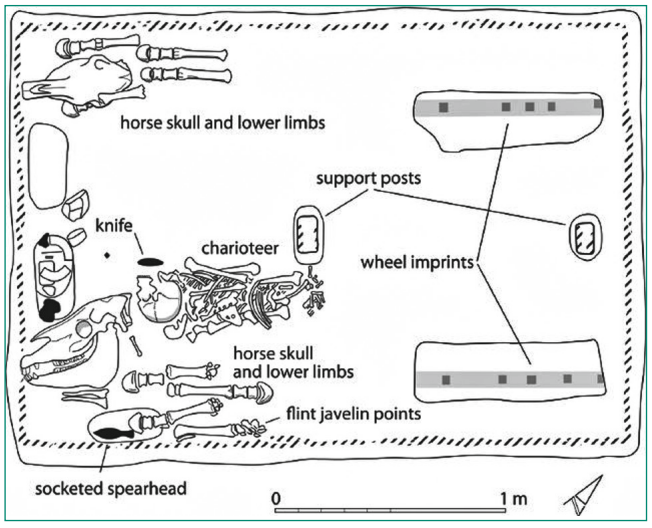

Figure 11 *– Remains of an early second millennium BCE burial of a male with remains of weapons, two horses and a two-wheeled vehicle from Sintashta Mogila Grave 30*

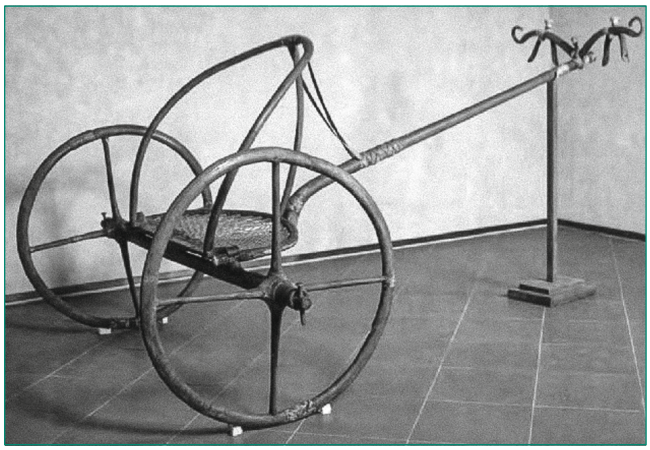

Figure 12 *– Egyptian wooden chariot, 18th Dynasty, currently in the Museum of Florence*

four-wheeled wagons, but with spoked wheels, however, do not predate depictions from the 18th/17th centuries BCE in South-west Asia and hence suggest a merging of pre-existing South-western Asian vehicle concepts with the horse and new wheelwright techniques as Eurasian innovations[57].

With only four spokes per wheel and ca. 25 kg total mass only, the developed Late Bronze chariot was extremely light and – consequently – did not require studded felloes[58]. By the second half of the second millennium BCE, such chariots (***Figure 12***) were used for cruising (***Figure 13***), hunting and warfare and formed an integral part of South-west Asian and Mediterranean and European elite lifestyle[59]; Egyptians perhaps lampooned people as only superficially integrated into Egyptian culture by showing their chariot as cattle-drawn[60], and an increasing symbolic charge of wheeled vehicles is visible in specimens like the Trundholm sun chariot (***Figure 14***). For a south-facing onlooker, the bright gilded side is visible when the vehicle is moved from East to West, while the return travel from West to East displays the dark side, mimicking the daily cycle of the sun's movement across the sky and reminding us of the ancient Greek mythological association of the sun god Helios with a chariot.

54 Piggott 1983; Lindner 2021.
55 Id. 2020.
56 Piggott 1983; Burmeister 2017; Lindner 2021.
57 Piggott 1983; Lindner 2021.
58 Mühl 2014.
59 Lindner 2021; Metzner-Nebelsick 2003; Pankau/Krause 2017.
60 Masson/Rosenstock 2011; Burmeister 2013.

Figure 13 *– Women driving a chariot. Reconstructed fresco from the palace at Tyrins/Greece, second millennium BCE*

Figure 14 – The so-called sun chariot from Trundholm/Denmark, ca. 1400 BCE

Yoke adaptations for equids

With their different physique, horses cannot be harnessed with a cattle yoke without specific adaptations. The archaeological record in the Bronze Age Eurasian steppes has not preserved remains of horse gear, but petroglyphs – that are, however, admittedly difficult to date – suggest yoke-like constructions[61] as in the early equid draft of South-west Asia[62]. Assuming that the blueprint for harnessing horses was the cattle horn yoke, depictions showing yokes close to the horses' nape of the neck do not seem entirely improbable as early stages of a technology transfer and have – moreover – proven functional in experiments[63]. Models and actual yokes such as found in Egyptian graves of the New Kingdom (*Figure 12*), however, show withers yokes additionally fastened by straps, often aided by a fork-like device to embrace the animal's lower neck. Suited mainly for light draught, this type of horse harness instigated a long-lasting division between heavy cattle draught for freight carts and wagons as well as the ard on the one and light horse draught for travel and race vehicles on the other hand.

Sequel: Iron Age and later periods

From ca. 1200 BCE onwards, the Iron Age in South-west Asia and the Eastern Mediterranean sees the transformation of the ultra-light chariot into a heavier, sturdier and more harnessed vehicle as described in Homer's Iliad that had, consequently also studded felloes[64]. In Europe, spoked-wheeled wagons appear as burial gifts. Judging from associated bridle finds, these wagons were likely horse-drawn, and in some of them a pivoted front axle is plausible[65]. Interpretations often revolve about the ceremonial use of such vehicles, but the four matching wheels from Stade (Germany) show that draught was heavy and frequent enough to require studded felloes[66]. In the later European Iron Age from ca. 400 BCE onwards, two-wheeled chariots are also known as grave goods[67]. How these Iron Age roots evolved into the known spectrum of Roman vehicles such as the four-wheeled *raeda* and the two-wheeled *cisium*, however, has not yet been the subject of targeted research[68] despite the important role roman technology had for the development of medieval animal draught technology[69]. Merowingian kings reported to travel their realms on cattle-driven wagons[70], however, are apparently a case of satire[71] similar to the Egyptian example mentioned above, as both medieval South-western Asia and Europe saw the rise of riding – on camels[72] or on equids – for personal transport and warfare until the resurge of wheeled travel with carriages from ca. 1400 CE onwards[73].

61 Chechushkov/Epimakhov 2018.
62 Littauer and Crouwel 1979.
63 Spruytte 1983.
64 Mühl 2014.
65 Koch 2006; Lindner 2021; Pare 1992; Piggott 1983, 138-194.
66 Mühl 2014.
67 Piggott 1983; Crouwel 1992; Id. 2012.

Animal traction and acceleration in prehistory

The revolute joint and the first machines

From the record outlined above, the appearance of what is colloquially called the "wheel" was key to the change in intensity in animal traction we observe around ca. 3000 BCE. However, the word "wheel" does not technically correspond to a technical or kinematic concept. Hence, the popular idea of the "invention of the wheel"[74] has prompted common misunderstandings in prehistoric research, as wheel-shaped objects such as spindle whorls and evidence for rotary motion predate wheeled vehicles by many millennia: judging from Middle Palaeolithic twisted threads[75], mankind has known how to use rotary motion since at least the time of the Neanderthals, and Neolithic fibre spinning by means of a spindle[76] is just an extension of this principle: ceramic spindle whorls are rare, but attested since the seventh millennium BCE[77]. However, despite the superficial resemblance of a spindle to a wheel attached to an axle[78], the rotary motion of a twisting spindle is not the pivoted motion that constitutes the kinematic pair of a wheel-and-axle. Rather, a spindle stick and a whorl form the spindle as a typical composite tool. Spindle and thread form what Miriam Haidle has termed a complementary toolset[79]. Here, like with bow and arrow, it is the constant control of the skilled human that keeps the active parts, i.e. the spindle and the thread, moving correctly. In contrast, in the respective machines, i.e. in the crossbow or the spinning wheel, the correct movement of the parts is ensured by joints in which the crossbow bolt or the spindle can move only in the desired direction. In that sense, the rotary motion of a roller bearing is only a complementary tool use, as the rollers must be steered by humans. Wheelsets (*Figure 15 left*), in contrast, do not require human interference due to pivoted motion in the revolute joint formed by the axle bearings. The same is true of wheels rotating around the axle (*Figure 15 right*), kinematically speaking levers that turn

68 Raepsaet 2009.
69 Holmes/Thomas (in this volume).
70 Masson/Rosenstock 2011; Murray 1998.
71 Kölzer 2004.
72 Bulliet 1990.
73 Id. 2016, 132.
74 Kaiser 2010.
75 Hardy et al. 2020.
76 Langgut et al. 2016.
77 Barber 1991; Çilingiroğlu 2009; Levy/Gilead 2013; Schoop 2014.
78 Klimscha 2017.
79 Haidle et al. 2015.

around a fulcrum[80]. After a long development of human tool use from basic to modular, composite and finally complementary use[81], the revolute joint around 3000 BCE constitutes the first attested moveable connection between components, and numerous applications of this new principle appear in the two millennia on either side of 3000 BCE[82].

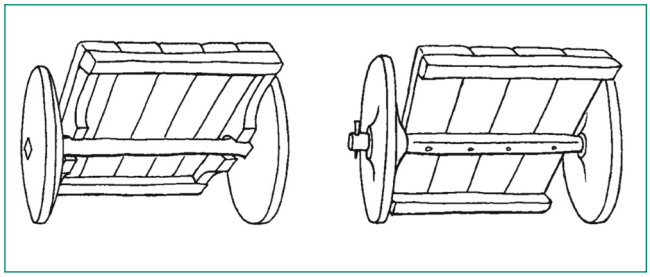

Figure 15 *– Andrew Sherratt's rotating axle principle (left) can be called a wheelset, a technical term actually derived from railroad vehicles, and is in kinematic a terms of a wheel-and-axle – rotating wheels (right), in contrast, are wheels in both technical and kinematic terms*

One of the oldest examples is the door from Robenhausen (Switzerland), the first pivoted door among other later specimens from both wood and stone[83]. With a date around 3700 BCE, the Robenhausen door supports the idea that animal figurines from the Northern Pontic Tripol'e culture that are somewhat unreliably dated to the first half of the fourth millennium BCE[84] might have held in their pierced legs revolving wheelsets predating actual wheeled transport (***Figure 16***) and raises the idea that the wheel-and-axle (or rotating axle, as Sherratt has put it) principle might somewhat predate the lever or fixed axle principle of wheeled vehicles[85]. Even though the two principles seemingly appear contemporaneously in the archaeological record[86], the kinematically entirely different mechanisms underlying the wheel-and-axle on the one and the lever on the other suggest that what is perceived as "the wheel" are in fact two separate innovations. Further applications of the wheel-and-axle are the potter's wheel and the lathe[87] – the latter in itself a prerequisite for

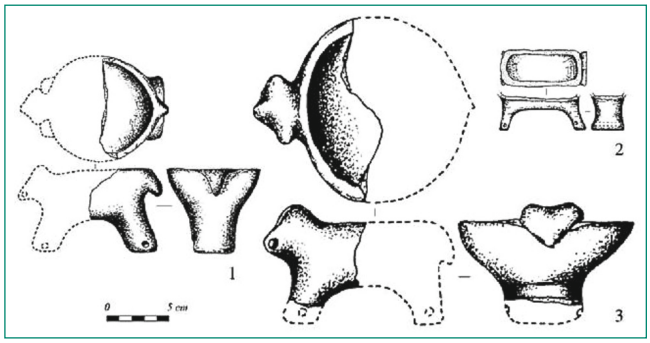

Figure 16 *– Chalcolithic animal figurines with pierced legs from sites of the Tripol'e B2 and C1 cultures, early fourth millennium BCE*

80 Reuleaux 1875.
81 Haidle et al. 2015.
82 Rosenstock 2020.
83 Altorfer 1999; Gauron/Massaud 1987; Klimscha 2017.
84 Burmeister 2004; Matuschik 2006, 281.
85 Bulliet 2016, 72. Chub, in prep.
86 Burmeister 2017; Maran 2017.
87 Cartwright 2005.

the construction of advanced vehicles , while the lever principle is used in well sweeps[88] and balance scales[89], innovations that are all first attested in the third millennium BCE. They all can be called the first machines in human history.

While a somewhat unprecise use of the term "machine" can be observed in ethnographic and prehistoric research[90], moveable connections are the defining criterion of the ISO 12100:2010 norm for the term machine as an "assembly, fitted with or intended to be fitted with a drive system consisting of linked parts or components, at least one of which moves, and which are joined together for a specific application". This machine definition is in line with 19th century CE approaches, such as by the engineer Franz Reuleaux[91] who still knew about the use of human, animal, wind and waterpower rather than only steam, combustion and electricity. However, it is not in line with the Machinery Directive of the European Union, which excludes directly applied human and animal power. But 2006/42/EU is inconsistent, as it tolerates human and animal power for some machines such as the block-and-tackle, and hence we can safely posit that the revolute joint constituted the first machines in the fourth millennium BCE. Likely initially merely manual machines – such as pivoted doors and perhaps wheeled toys of the fourth millennium BCE – soon were combined with pre-existing Neolithic knowledge of cattle traction to become automotoric.

Work speed and travel speed in early animal draft

Why carts and wagons were developed in the first place is an interesting question that has not yet been convincingly answered and may lie anywhere between ritual and utilitarian purposes[92]. Here, the hypothesis that Neolithic economy was in broad terms labour-limited, whereas only in later prehistory economy became land-limited[93] can be helpful to understand the – despite all symbolic meanings of wheeled vehicles – practical initial reasons for inventing carts and wagons and the apparent lack of ards before the end of the Neolithic. Although according to our definitions the ard is not an automotoric machine like carts and wagons, but an automotoric composite tool, its development appears connected to wheeled transport as another means of reducing the necessary input of manpower into production. The ard significantly increases the area that can be cultivated in comparison to hoe-based culture[94] and consequently the amount of harvest to be transported. The same applies to other bulk materials that are new in the Final Neolithic and Chalcolithic such as ore from extractive metallurgy[95] as well as soil, rubble and other material for monumental mounds[96]. Sledging and logging have high friction coefficients and, hence, Neolithic animal traction was likely rather slow. Roller bearings, albeit not attested in the archaeological record[97], can potentially reduce friction, as we demon-

88 Rost 2017.
89 Genz 2015.
90 Bleicher 2018; Gleser 2016; Leroi-Gourhan 1943; Id. 1945; Id. 1965.
91 Reuleaux 1875, 38.
92 Maran 2017.
93 Bogaard et al. 2019.
94 Kerig 2013a; Id. 2013b.
95 Bulliet 2016.
96 Müller 1990a; Id. 1990b; Rosenstock et al. 2019b.
97 Harris 2018.

strated during our trials at Domäne Dahlem in Berlin in 2016[98]. However, frequent breaks between hauling intervals are necessary in which a team of several people shifts the rollers and realigns the bearings, so roller bearings, if used at all in the Neolithic, caused an intermittent and consequently equally slow workflow. With a cart or wagon, in contrast, only one person is necessary to control the animals. Moreover, they can seamlessly pull for hours and for as long as the oxen can work – i.e. about half a day[99] – and, hence, helped to transform early economies from slow and labour- to fast and land-limited. Although soon to be complemented by the horse for fast draught, cattle traction continued into the modern era, as many contributions in this volume show.

Whether horses were even herded and let alone ridden in Eurasia before they were harnessed to two-wheeled vehicles in the early second millennium BCE remains an open question, as archaeochemical evidence for equid milk consumption and signs of bridling wear on equid teeth detected in fourth millennium BCE sites[100] have recently been challenged[101]. Goat and sheep have a strong herd instinct that makes them easy to shepherd, and cattle – like donkeys - tend to face potential threats. Horses, however, have a pronounced flight instinct that makes it virtually impossible to herd them as a pedestrian, and this may have been one of the reasons behind the desire of early Eurasian pastoralists to speed up – besides, of course, the joy the new velocity brought about. Whether early draft horses were mainly trotters or ran in full gallop as shown in later second millennium BCE chariot depictions from Egypt (***Figure 17***), or whether at least some of them had genes determining pacing that are currently first attested in the Medieval era[102] remains to be investigated; more knowledge about early horse gait may help to better understand the Kikkuli text[103] as well as rhythm perception of charioteers and – from at least the first millennium BCE onwards[104] – horse riders in the ancient world. Equids, hence, can be seen as a first attempt at finding other and faster motors than cattle. However, horses increased only the travel speed of prehistoric societies. And although this faster travel speed implies a wide range of potential and yet underexplored effects on realms like communication, migration, and warfare, work speed and therefore the pace of production remained determined by cattle until the horse collar enabled the use of the horse also in heavy traction in the Medieval[105].

Over time, not only every suitable large domesticate including camels[106] and reindeer[107] has been harnessed for traction. While sailing ships represent later prehistoric instances of the use of inanimate powers such as the wind, and water power has been known since at least the Roman era, vehicles have been driven by animals until the steam engine, an innovation that has been argued to be one of the drivers of the acceleration of life observed

98 Rosenstock et al. 2019b.
99 Masson 2015.
100 Anthony/Brown 2011; Outram et al. 2009.
101 Taylor/Barrón-Ortiz 2021; Wilkin et al. 2021.
102 Wutke et al. 2016.
103 Raulwing 2005; Starke 1995.
104 Littauer/Crouwel 1979.
105 Holmes/Thomas (in this volume).
106 Bulliet 1990.
107 Losey et al. 2021.

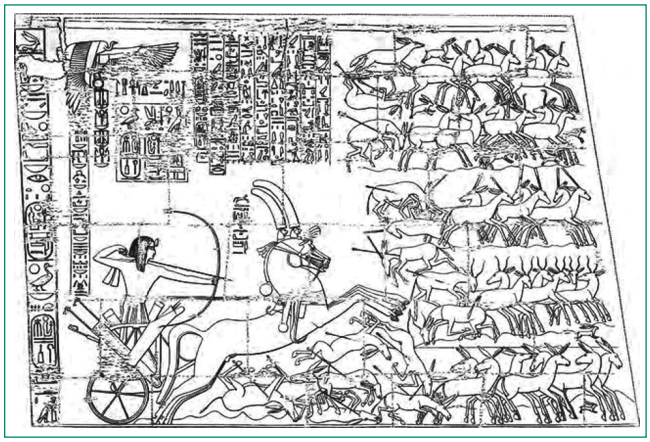

Figure 17 *– Pharaoh Ramesses III. hunting with bow and arrows and a chariot (Medinet Habu, 20th dynasty)*

by a number of philosophers and historians. Both, the invention of the revolute joint around ca. 3000 BCE and the harnessing of new motors around 2000 BCE, significantly accelerated work and travel speed of prehistoric societies. In a similar way, the industrial revolution around ca. 1800 AD and the subsequent rise of new motors such as the steam engine, combustion and electricity accelerated human life even further. Modern experiences of acceleration have been the subject of research by e.g. Paul Virilio, Reinhart Koselleck and Hartmut Rosa[108], and it can be fruitful to view prehistoric technical developments such as animal draft also from the angle of awareness of time in space and, hence, speed.

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108 Virilio 1989; Koselleck 2000; Rosa 2005.

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List of Figures

Title (Traditional equipment for cattle draught on display in the courtyard of the Selçuk caravanserai of Sultanhanı (Prov. Aksaray/Turkey): a döven (threshing sledge) with stone insets in the background, and a cart with solid wheels in the foreground (part of the drawbar apparently damaged and sawed off) – going back to at least the 4th millennium BCE, such implements have a deep history and significantly increased working speed in agricultural production) – E. Rosenstock.

Figure 1 – Burov 1981, fig. 1.

Figure 2 – Gaastra et al. 2018, fig. 5.

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Author info

Eva Rosenstock

Bonn Center for ArchaeoSciences
c/o Institut für Archäologie und Kulturanthropologie
Rheinische Friedrich-Wilhelms-Universität Bonn · Römerstraße 164 · 53117 Bonn

E-Mail: e.rosenstock@uni-bonn.de
Digital paper: https://youtu.be/6UqcpvKozzg

"…in winter, plough": Zooarchaeological evidence for the changing role of draught cattle and horses in medieval England AD 400-1400

Matilda Holmes and Richard Thomas

Abstract

Cattle were the tractors of medieval England and provided power essential for agricultural production, yet horses were not widely used for draught until after AD 1250. Evidence for the use of cattle and horses for draught purposes in England between AD 400 and 1400 is presented. Findings are based on zooarchaeological analysis of the animal economy and pathological and sub-pathological changes to cattle feet, alongside documentary evidence for the use of cattle and horses for traction. The use of draught cattle varies depending on social structure and economic pressures, and the effect of the increasing use of horses on a decline in the use of cattle in some areas can be observed.

Résumé

Les bovins étaient les tracteurs de l'Angleterre médiévale et fournissaient une puissance essentielle à la production agricole, mais les chevaux n'ont été largement utilisés pour le trait qu'après 1250. Cet article présente les preuves de l'utilisation de bovins et de chevaux à des fins de traction en Angleterre entre 400 et 1400. Les conclusions sont basées sur une analyse zooarchéologique de l'économie animale et des changements pathologiques et sub-pathologiques des pieds des bovins, ainsi que sur des preuves documentaires de l'utilisation des bovins et des chevaux pour la traction. L'utilisation du bétail de trait varie selon la structure sociale et les pressions économiques, et l'on peut observer l'effet de l'utilisation croissante des chevaux sur le déclin de l'utilisation du bétail dans certaines régions.

Kurzfassung

Rinder waren die Zugmaschinen des mittelalterlichen Englands und lieferten die für die landwirtschaftliche Produktion unerlässliche Kraft, während Pferde erst nach 1250 n. Chr. in großem Umfang als Zugtiere eingesetzt wurden. Im Artikel werden Belege für den Einsatz von Rindern und Pferden als Zugtiere in England zwischen 400 und 1400 n. Chr. vorgestellt. Die Ergebnisse basieren auf zooarchäologischen Analysen der Viehwirtschaft und pathologischen und subpathologischen Veränderungen an Rinderfüßen sowie auf urkundlichen Belegen für den Einsatz von Rindern und Pferden als Zugtiere. Der Einsatz von Zugvieh variiert je nach sozialer Struktur und wirtschaftlichem Druck, und die Auswirkungen des zunehmenden Einsatzes von Pferden auf einen Rückgang des Einsatzes von Rindern in einigen Gebieten können beobachtet werden.

Resumen

Aunque se le puede considerar al ganado como análogo al “tractor” de la Inglaterra medieval y proporcionaba la energía esencial para la producción agrícola, los caballos no fueron utilizados ampliamente para el tiro hasta después de 1250. Se presentan pruebas del uso del ganado vacuno y de los caballos para el tiro en Inglaterra entre los años 400 y 1400. Las conclusiones se basan en el análisis zoo-arqueológico de la economía animal y en los cambios patológicos y subpatológicos de las patas del ganado, junto con las pruebas documentales del uso del ganado vacuno y del caballo para la tracción. El uso del ganado de tiro varía en función de la estructura social y de las presiones económicas, y se observa el efecto del uso creciente de los caballos sobre el descenso del uso del ganado en algunas zonas.

Introduction

In the medieval world cattle and horses were vital draught animals, providing much of the power required for arable cultivation as well as hauling and carting. This paper presents the results of a project (Feeding Anglo Saxon England) investigating changes in agriculture in England between AD 400 and 1400, which corresponds to the English medieval period[1]. This period witnessed substantial changes to both society and economy. At the beginning of the period there was a relatively small population of c.1.5-2 million people living in England, and nearly everyone would have been directly involved in farming. People throughout the country lived in extended family groups on isolated farmsteads, producing much of their food and raw materials from the surrounding land[2]. Cattle were a hugely important form of portable wealth and would have been used for light draught duties such as pulling an ard[3]. The documentary evidence suggests that until the eleventh century, heavy, wheeled ploughs with mouldboards or coulters were uncommon and ard cultivation would have predominated[4].

From the ninth century, a rising population combined with an increase in trading and urban settlements meant that people were not solely employed on the land but had non-agrarian jobs requiring agricultural produce to be available on the commercial market[5]. In many parts of England, social changes meant that large rural estates were owned by an elite, and the workforce was organised into villages where agricultural output was overseen by a lord[6]. Increased production required extensification, whereby larger fields were cultivated, and crop rotation was employed[7]. The expansion of arable production onto new land meant that in many areas heavier soils were brought into use, requiring new, heavier plough technology so that, by the eleventh century, pictorial evidence shows substantial ploughs with wheels, coulters and mouldboards[8].

When, where, and how this transformation of agriculture emerged, and whether it had a significant impact before the Norman Conquest in 1066, remain contentious issues, largely because scholars have been forced to rely on a limited range of indirect evidence, both written and archaeological. There has been a lack of direct, closely dated evidence for early medieval fields themselves and for the conditions in which crops were grown. The FeedSax project interrogated and combined information from pollen, plant remains, landscape archaeology, stable isotopes and animal bones[9]. The latter was used to reconstruct changes in animal husbandry, tracking the changing exploitation of livestock for primary (i.e. meat) and secondary products (e.g. wool, manure, and power).

This chapter draws on some of this new evidence, combining zooarchaeological and documentary evidence to track the changing use of cattle and horses for draught power in medieval England to better understand their role in the transformation of agricultural production.

Material and methods

Cattle did not evolve to pull ploughs and carts and the biomechanical stresses placed on their lower limb bones when undertaking such activities can ultimately result in adaptive remodelling that is visible macroscopically[10]. The zooarchaeological focus of the FeedSax project involved recording pathological and sub-pathological changes associated with draught use on cattle autopodia (metapodials/ cannon bones and phalanges/ pastern and hoof), some examples of which are illustrated in ***Figure 1***. Cattle autopodia from 20 archaeological sites in England (***Figure 2, Table 1***) were recorded using a widely used and tested method, to generate a modified Pathological Index (mPI) for the combined results from each site[11]. This index produces values on a scale of 0 to 1: with 0 indicating no adaptive remodelling and values approach 1 indicating the most pronounced changes, and the increased likely presence of draught cattle. Front and hind foot bones are separated as the fore legs naturally carry more body weight and are affected by loading to a greater extent than the hind legs, even in non-draught animals[12]. It is not possible to determine which specific activities cattle were used for (ploughing, carting, haulage) using this approach, and indeed it is likely that they were used for numerous draught purposes.

Figure 1 *– Examples of deformations to the foot bones of cattle that may be caused by excess or repeated loading. A: distal metapodials or cannon bones, normal (left) and exhibiting exostosis and broadening (right). B: first phalanx or pastern bone, normal (left) and examples of proximal lipping (middle) and proximal and distal exostosis (right)*

1 Hamerow et al. 2020; Id. 2019.
2 O'Connor 2014.
3 Holmes et al. 2021a.
4 Banham/Faith 2014, 44; Holmes forthcoming-a.
5 Dyer et al. 2018.
6 Campbell 2000.
7 Hamerow et al. 2019.
8 Banham/Faith 2014, 47.
9 Hamerow et al. 2020.
10 Thomas et al. 2021.
11 Bartosiewicz et al. 1997; Holmes et al. 2021b; Thomas et al. 2021.
12 Holmes et al. 2021b; Thomas et al. 2021.

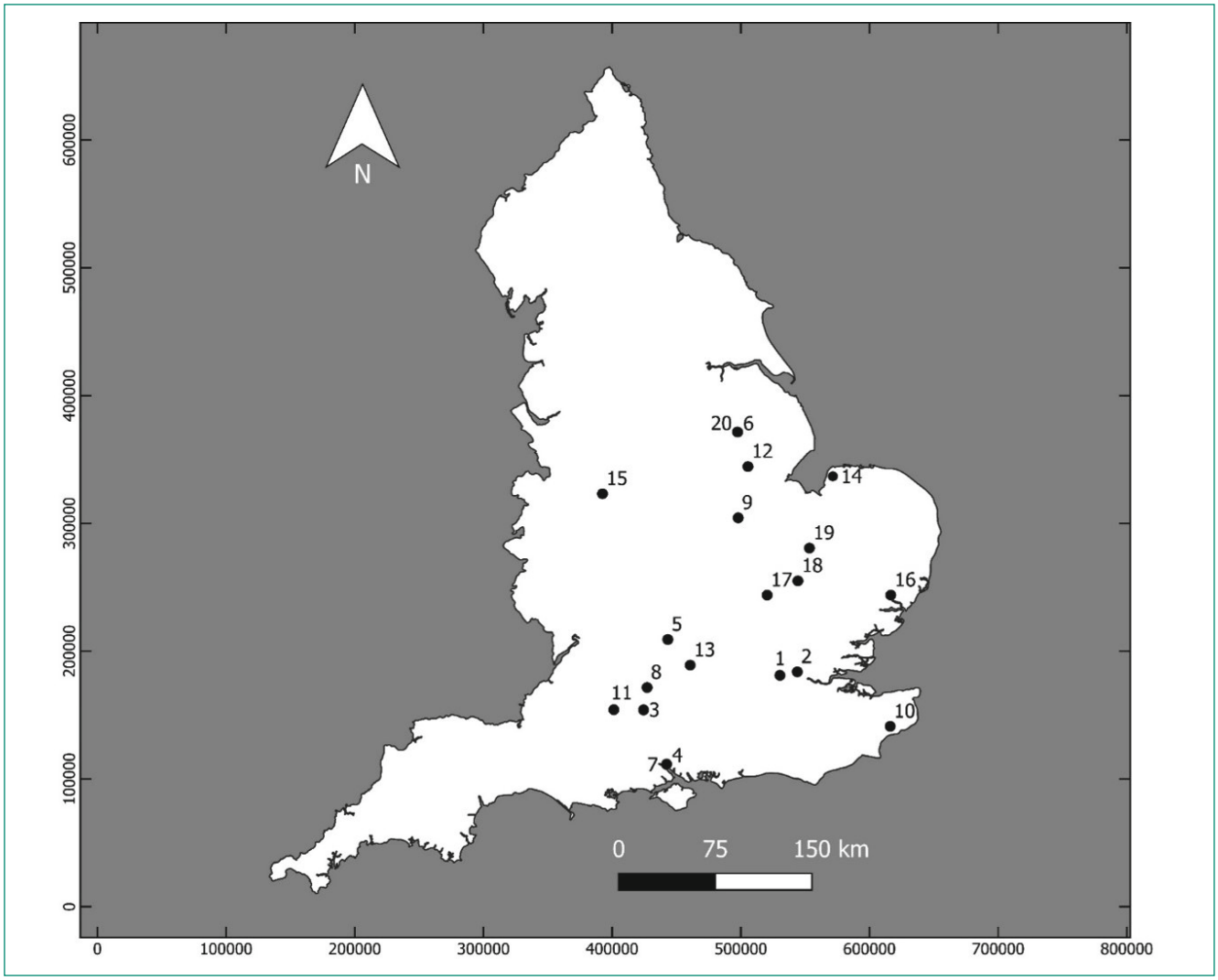

Figure 2 – Location of archaeological sites from which data were recorded (see Table 1 for site details)

Site	Map	Dates	County	Region[13]	Geology[14]	Elevation	Reference
Bow Street, London	1	600-750	Middlesex	South east	Valley terrace	19	Holmes 2019
Barking Abbey, London	2	500-1500	Middlesex	South east	Valley terrace	9	Holmes and Gordon 2020
Cadley rd, Collingbourne	3	700-900	Wiltshire	South east	Chalk	130	Hamilton-Dyer 2001
Cook Street, Southampton	4	650-875	Hampshire	South east	Valley terrace	2	Bourdillon 1993
Eynsham Abbey	5	500-1330	Oxfordshire	Central zone	Clay	74	Ayres et al 2003
Flaxengate, Lincoln	6	870-1400	Lincolnshire	Central zone	Clay	42	O'connor 1982
French Quarter, Southampton	7	900-1350	Hampshire	South east	Valley terrace	2	Bates and Nicholson 2011
High Street, Ramsbury	8	750-1300	Wiltshire	South east	Chalk	116	Coy 1980
Ketton	9	850-1066	Rutland	Central zone	Clay	51	Holmes 2018
Lyminge	10	400-1300	Kent	South east	Chalk	101	Thomas 2013
Market Lavington	11	400-1400	Wiltshire	Central zone	Clay	88	Bourdillon 2006
Quarrington	12	450-900	Lincolnshire	Central zone	Valley terrace	25	Rackham 2003
Reading Rd, Wallingford	13	900-1300	Oxfordshire	Central zone	Valley terrace	58	Holmes 2020
Sedgeford	14	650-1025	Norfolk	East Anglia	Chalk	36	unpublished
Stafford	15	900-1300	Staffordshire	Western lowlands	Valley terrace	77	Carver 2009
Stoke Quay, Ipswich	16	700-1500	Suffolk	East Anglia	Valley terrace	25	not published
Stratton	17	600-1350	Bedfordshire	Central zone	Valley terrace	41	Maltby forthcoming
Trumpington Meadows	18	600-1066	Cambridgeshire	South east	Clay	30	Rajkovaca 2018
West Fen Rd, Ely	19	700-1400	Cambridgeshire	East Anglia	Clay	22	Higbee 2005
West Parade, Lincoln	20	1050-1375	Lincolnshire	Central zone	Clay	18	Scott 1999

Table 1 – Case study site information (Map numbers relate to Figure 2, elevation in metres above ordnance datum)

13 Rippon et al 2013.
14 Lowerre 2010.

Results

Figure 3 illustrates the mean mPI scores for cattle from each site. The solid line indicates the average value for all sites and the broken line indicates the mean mPI values for the semi-feral herd at Chillingham, which were never used for ploughing or other draught use[15]. The fact that mPI values from medieval sites exceed the values of the semi-feral herd at Chillingham indicates that cattle were used for draught purposes at all sites to varying degrees. There are clearly a number of sites with notably high mPI mean values indicating more intensive use of cattle for ploughing. A full description of these data is provided elsewhere[16], but the key changes are highlighted here. Between AD 400 and 650 evidence for the intensive or repeated use of draught cattle is sporadic (***Figure 3***) and occurs alongside contemporary sites where mPI values are low (i.e. they are well below the mean value for all sites). From AD 650 a greater proportion of sites are recorded with higher values, suggesting that draught cattle became more widely (or intensively) used. Between AD 1025 and 1200, the presence of high mPI values at all sites suggests that the use of draught cattle was widespread and common. Eleventh and twelfth century sites that continue into the thirteenth century produced consistently lower mPI values, suggesting that the use of cattle for draught work diminished. Two sites occupied in the fourteenth century (Flaxengate and West Parade, both in Lincoln), once again produced high mPI values, which may be due to the provisioning of the town with older cattle at the end of their working lives.

Discussion

Cattle were the go-to tractors for much of the medieval period, reflected in their economic value[17] and evidence for their draught use in all periods. Horses were less abundant, were considered to be more expensive to feed and look after[18], and were not commonly eaten at the end of their working life, unlike cattle, making them less profitable to keep in large numbers. The animal economy in England in the post-Roman period (AD 400-650) centred on small, self-sufficient family farms that did not require extensive agricultural methods. The relatively small population at this time also meant that cultivation could take place on lighter soils suited to the use of ards, which were less taxing for draught cattle. This is reflected in the pathological index data for cattle, which implies that draught use was neither intensive nor protracted for most animals.

The increasing use of cattle for draught work observed from AD 650 coincides with an increase in the age of cattle[19] and the establishment of the first proto-urban trading centres, which housed a population of craft workers and merchants[20]. Feeding these communities required surplus production from the surrounding countryside, and cattle were increasingly vital to work the land and support the production and transportation of enough grain. The earliest material evidence for heavy plough technology also comes from this period, in the form of a seventh-century coulter, from the high-status site of Lyminge, Kent[21].

The eleventh century increase in cattle pathologies suggests that they were commonly used by all tiers of farming society for draught work, either intensively and/or for extended periods of time, enough to produce high mPI values at all sites in the data set (***Figure 3***). It coin-

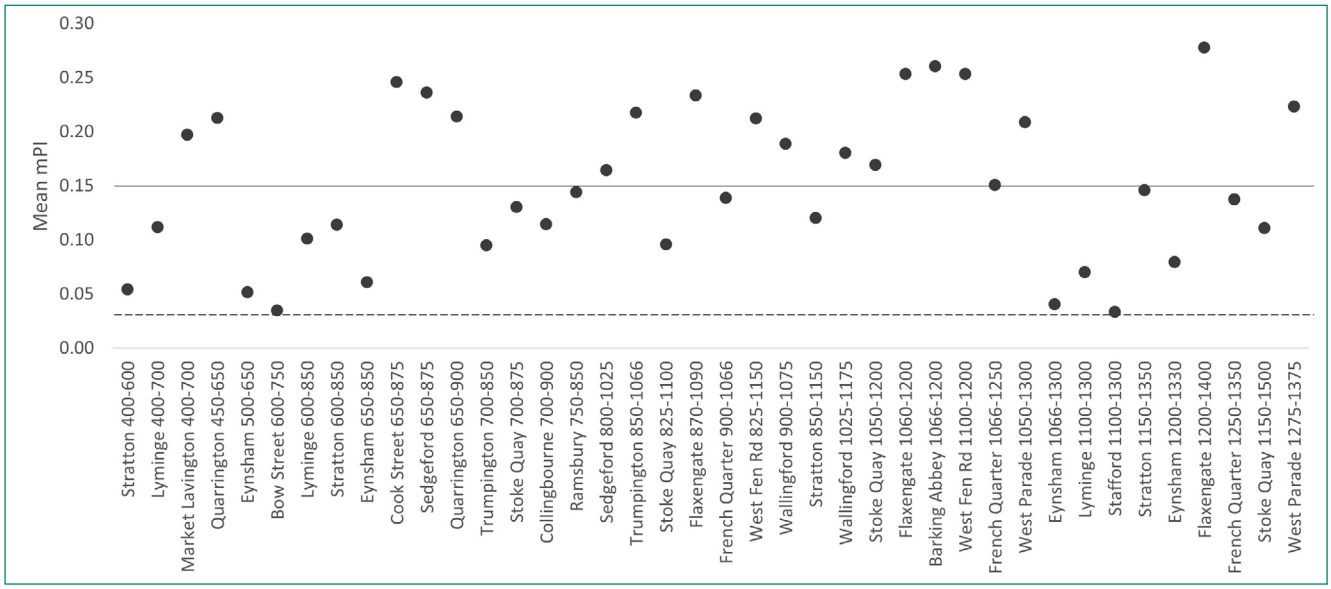

Figure 3 *– Mean modified Pathological Index (mPI) for posterior elements from all assemblages with ≥5 elements – in order of the mid-point of the date range of each assemblage (solid line describes the mean mPI from all assemblages, and the broken line is the mean of a semi-feral herd of modern cattle)*

15 Thomas et al. 2021.
16 Holmes forthcoming-a; Id. forthcoming-b.
17 Id. et al. 2021a.
18 Langdon 1986.
19 Holmes et al. forthcoming.
20 Crabtree 2018.
21 Thomas et al. 2016.

cides with another period of major growth brought about by the establishment of towns based on commercial markets and trade. Heavy ploughs are also portrayed in pictorial documents in this period, which further suggests they were common sights[22]. In summary, increased production required to feed a larger and non-farming population combined with a need to cultivate more fertile but heavier soils and a subsequent technological change to heavier ploughs is reflected in observations of an increase in draught cattle use in the archaeological record. This is consistent with Langdon's[23] work based on documentary sources that showed working horses were scarce in the eleventh century, and comprised between 1 and 10 % of the total number of working cattle and horses. At this point, cattle bore the burden of heavy draught work.

A decline in the widespread use of draught cattle from AD 1200 coincides with the increase in horse numbers relative to cattle as horses started to be more frequently used for carting and ploughing[24]. In some areas on light soils (notably Norfolk, the Chiltern Hills and parts of Kent) farms that used horses exclusively for draught work became increasingly common, and in other areas the use of mixed horse and cattle teams increased[25]. Cattle continued to be more commonly used for draught work on the heavy clay soils of the midlands and although horses were integrated into the agricultural regimes of farmers in the southern and eastern areas of the country, cattle held out in the north and west[26]. Another potential cause of the decline in draught cattle includes a fall in arable output that occurred from the mid-fourteenth century in response to the reduced population because of the Black Death[27], which would have required fewer draught animals. There is also evidence for an increase in the demand for beef cattle in this period[28], and the associated increase in younger animals would reduce the mean mPI of older draught cattle.

There is nothing to indicate that horses were directly involved in improving agricultural production, but they were able to reduce the costs associated with the farm and the increased use of horses came in response to several factors. They were faster and had greater endurance than cattle, being able to work more land per hour, and for more hours in the day[29]. This allowed a reduction in the number of animals required in a team, and the number of farmhands to work the team. Technological innovations such as harness improvements (e.g. the use of the padded collar) and shoeing, specific to horses were in place and available by the eleventh century[30]. Langdon further suggests that the most profound effect was the use of horses for carting, particularly in the twelfth and thirteenth centuries, coinciding with significant market growth. Horses were used for moving goods around by all sections of society: peasants and elites, rural and urban populations, and they not only moved goods faster, but also increased the distance covered in a day than was previously possible with cattle.

Conclusion

Figure 4 presents a summary of the data discussed here. Until the seventh century the English economy was based on small, self-sufficient farms where the ard was widely used and animals were not intensively worked. Cattle were a store of wealth, while horses were rare and expensive to keep. Increasing production began in the mid-seventh century as a surplus of grain was required to feed the labourers working in proto-urban trading centres, and this can be observed in an increase in cattle foot pathologies and the earliest physical evidence for plough technology.

From the eleventh century draught cattle were apparently widespread and common, which coincides with larger urban populations, heavier ploughs and the need for substantially increased arable production. Yet a decline in the use of cattle for traction occurs from the thirteenth century, partially at least, in response to the increased use of horses for carting, hauling and ploughing.

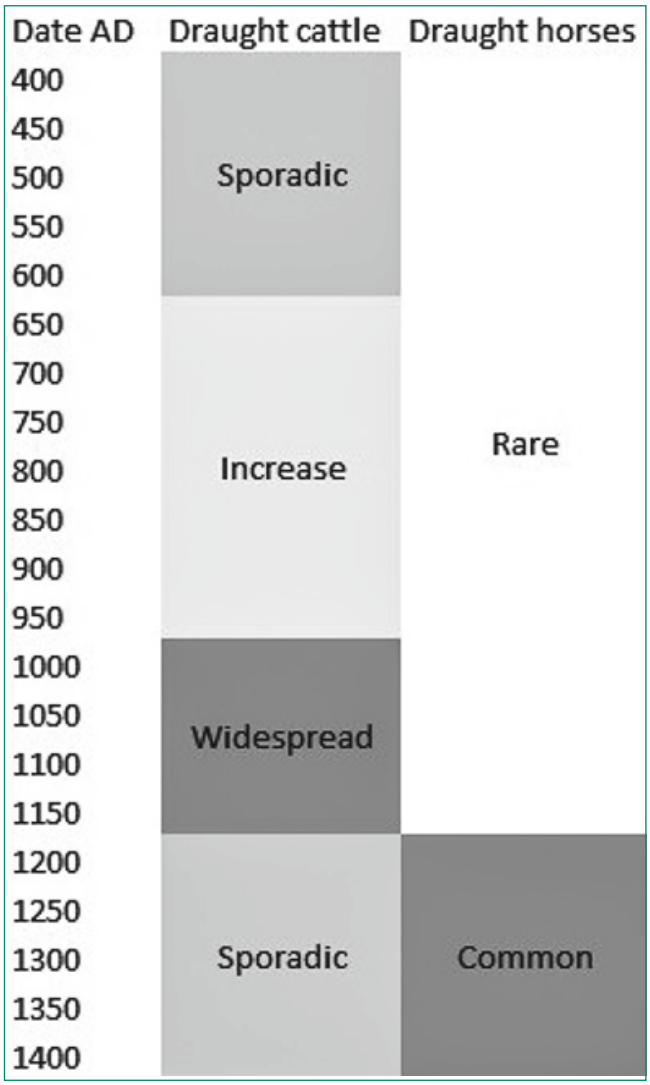

Figure 4 *– Summary of the evidence for draught cattle and horses*

22 Banham/Faith 2014, 47.
23 Langdon 1986.
24 Ibd., 99.
25 Ibd., 100.
26 Ibd., 159.
27 Ibd., 97.
28 Holmes et al. forthcoming.
29 Langdon 1986, 160.
30 Ibd., 20.

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Author info
Matilda Holmes
Consultant Archaeozoologist
45 Welland Rise, Sibbertoft, LEICS, LE16 9UD, United Kingdom
E-Mail: matty@archaeozoology.co.uk
Joint digital paper: https://youtu.be/FhFYw4c2Cuw

Author info
Richard Thomas
Professor of Archaeology, School of Archaeology and Ancient History
University of Leicester, University Road, LEICS, LE1 7RH, United Kingdom
E-Mail: rmt12@le.ac.uk
Joint digital paper: https://youtu.be/FhFYw4c2Cuw

Scottish Farm Horsemen's Society

Bob Powell

Abstract

This paper, presented as part of the 'DRAFT ANIMALS in the Past, Present and Future' 2021 virtual conference is an overview of the Scottish Horsemen's Society. Primarily associated with Scotland's principal arable areas, especially the north-east, this was a secretive, protectionist movement founded by the early 1800s. It was also associated with the cult of the Horseman's 'Word'.

Résumé

Cet article, présenté dans le cadre de la conférence virtuelle „Les animaux de trait, passé, présent et futur" 'DRAFT ANIMALS in the Past, Present and Future' en 2021, donne un aperçu de la „Société cavalière écossaise" („Scottish Horsemen's Society"). Initialement associée aux principales régions arables d'Écosse, notamment dans le nord-est du pays, il s'agissait d'un mouvement secret et protectionniste fondé au début des années 1800. Il était également associé au culte de la "parole du cavalier" (Horseman's Word).

Kurzfassung

Dieser Beitrag, der im Rahmen der virtuellen Konferenz 'DRAFT ANIMALS in the Past, Present and Future' 2021 präsentiert wurde, gibt einen Überblick über die Scottish Horsemen's Society. Es handelte sich dabei um eine geheime, protektionistische Bewegung, die Anfang des 19. Jahrhunderts gegründet wurde und in erster Linie mit den wichtigsten schottischen Ackerbauregionen, insbesondere dem Nordosten, verbunden war. Sie war auch mit dem Kult des "Horseman's Word" assoziiert.

Resumen

Esta ponencia, presentada en el marco de la conferencia virtual 'DRAFT ANIMALS in the Past, Present and Future' 2021, muestra una visión general de la Scottish Horsemen's Society. Establecida principalmente en las principales zonas de cultivo de Escocia, sobre todo del noreste, esta sociedad comenzó como un movimiento clandestino y proteccionista fundado a principios del siglo XIX. También es asociada con el culto del termino „jinete".

Figure 1 *– Past member of the Scottish Horsemen's Society and holder of 'The Word', the late 'Jock' Hepburn of Aberlour, Banffshire in circa 1930*

This paper, presented as part of the 'DRAFT ANIMALS in the Past, Present and Future' 2021 virtual conference is an overview of the Scottish Horsemen's Society. Primarily associated with Scotland's principal arable areas, especially the north-east, this was a secretive, protectionist movement founded by the early 1800s. It was also associated with the cult of the Horseman's 'Word'.

I, the author, was born in Ireland in 1953 and from the outset was obsessed with working horses. Both my maternal great-grandfather, who bred and showed Clydesdale horses, and my grandfather were horsemen, who my mother was convinced it was where my "in the blood" interest came from. As a young man, relocated to the English, East Anglian, Cambridgeshire "Fenlands", many of my friends and mentors were some of the best farm horsemen. It was by then that I had heard about the East Anglian farm horsemen's "magic" tradition of the toad's bone ritual that ostensibly gave the participant the means to have power over horses to ensure that they did their bidding. However, that is another subject.

By 1983 I had moved to Scotland for the first time, where my work as an agricultural curator gave me the opportunity to further develop my research on working horse culture. The material and non-material culture of Scotland was significantly different to that which I had been used to. One aspect, for which I was aware of, was that of the "secret" Scottish Horsemen's Society and the associated "Horseman's Word."

It was not until 1984 that I had a first-hand encounter with someone who had participated in the Horsemen's Society. I had gone to visit a retired farm horseman called John 'Jock' Hepburn (***Figure 1***), from Aberlour, Banffshire. We sat talking at Jock's fireplace, where the mantle had sitting on it, and favoured by Society farm horsemen, folk art cut out figures of harnessed "Clydesdale" horses. After a good time talking, Jock turned to me and said: "*Aye lad, ye've bin thro the chaff hoose door!*" As I will explain, this was an acknowledgement from a past member of the Horsemen's Society that I had some knowledge about farm horses, a comment for which I still feel honoured many years later.

The Horsemen's Society came about through major agricultural change and improvement in Scotland from the 1700s. The latter was primarily driven from 1784 by the establishment of the Highland and Agricultural Society, later the Royal Highland & Agricultural Society. There were numerous aspects that required improvement. For example, in the north-eastern county of Aberdeenshire, until the 1790s the inefficient and cumbersome "*Twal Owsen*" or twelve oxen plough predominated, requiring both a ploughman and an oxen "goadsman" to drive the beasts. Although published in 1877, the latter was well-illustrated (***Figure 2***) in William Alexander's 'Northern Rural Life in the Eighteenth Century'. Even where horses were used for agricultural work, they were invariably worked at length by two men as if they were oxen (***Figure 3***).

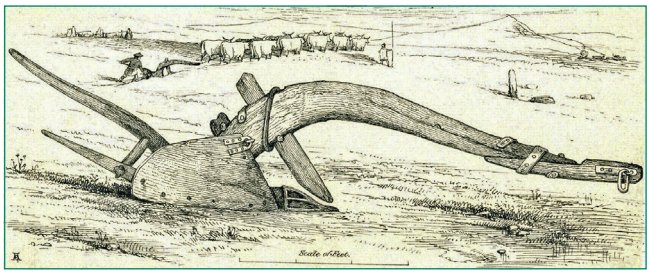

Figure 2 *– The cumbersome old Scots 'Twal Owsen' plough as illustrated in 1877 in William Alexander's 'Northern Rural Life in the Eighteenth Century'*

Figure 3 *– Driving horses at length as illustrated in a 1733 Scottish vignette from Hamilton's 'The Interest of Scotland Considered'*

Of the various factors affecting Scottish agricultural change that influenced the creation of the Horsemen's Society, two may be briefly considered. Firstly, and significantly in circa 1760 when Scots "plough-wright" James Small developed his improved plough with a true mouldboard that turned furrows. Initially Small's successful and influential plough was primarily wooden but by 1800 his all "iron plough" (***Figure 4***) was in production. With influences far beyond Scotland, Small's plough was a catalyst for one person simultaneously ploughing and driving a "pair", a team of horses (***Figure 5***) and subsequently the creation of the 'Farm Horseman' or "*Plooman*".

Secondly, by the end of the 1700s, land was increasingly being enclosed by landowners to create farms. Where there had been tenanted communities living in such as 'Townships' practising subsistence agriculture, they declined. Opportunities were consequently created for community dwellers to be formally employed as "Farm Servants." Thereby, as farms increasingly changed from oxen to horses, a new class of specialist farm servant, the 'Horseman' with different livestock management and working skills was created and sought. As such there was a new dawn, for the experienced horsemen realised that possessing these specialist skills and combining as a "Brotherhood" would give them a level of negotiation power with employers and selected approval over prospective horsemen.

However the brotherhood movement came about, and who the initial, unknown farm servant instigators were,

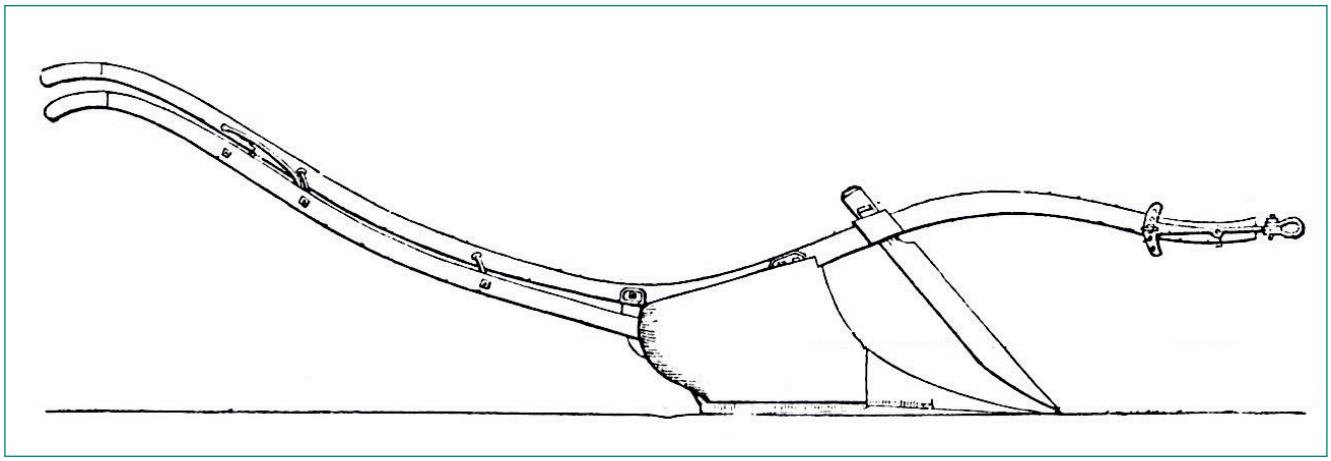

Figure 4 *– James Small's "Iron Plough" from Henry Stephen's 'Book of the Farm', 1842*

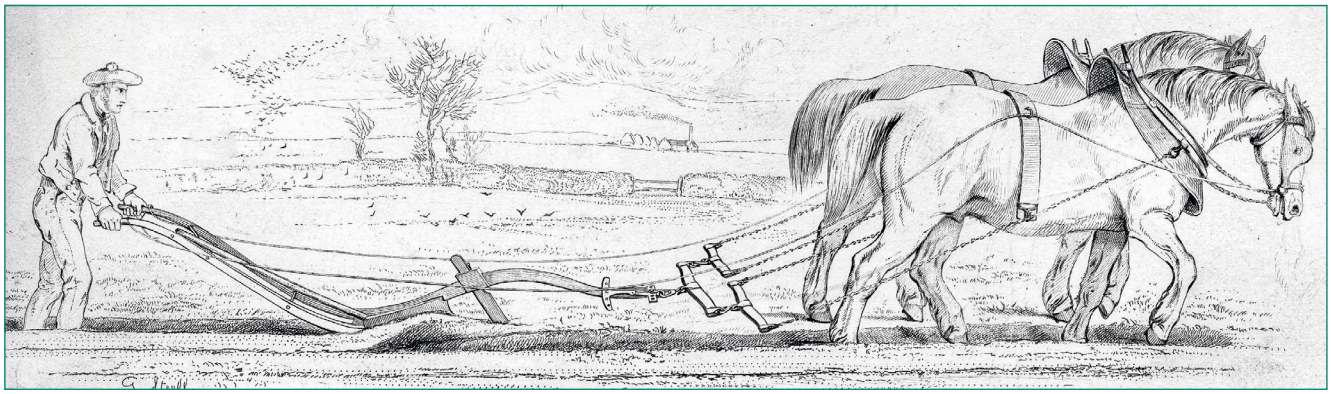

Figure 5 *– From the 1842, first edition of Henry Stephens' 'Book of the Farm', James Small's "Iron Plough" guided by one "plooman" driving his own "pair" of horses*

the culmination of this realisation was to look towards the models created by the established, once Medieval trades organisations, the "Worshipful Companies". The oldest of these being the Worshipful Company of Masons who oversaw their traditions, skills, training, and standards and from whom "The Masons" originated. These protective organizations by their nature were secretive but to the benefit of their accepted members and the people they served through the practice of their trade. Consequently, what the farm servant horsemen did first was adopt and adapt the brotherhood template developed by 'The the 'Masons', creating a protectionist, self-regulating 'closed shop'. It was tantamount to a trade union, becoming known as the 'Horsemen's Society'. However, secondly, they also embraced and adapted the deemed "secret" Masonic ritual practices as part of membership initiation which added to the mysteries, the "magic" of their trade.

It appears that by the early to mid-1800s that, what some consider a cult, the Horsemen's Society was well-established in Scotland particularly from the Glasgow-Edinburgh "central belt", up along the east-coast to Aberdeenshire, and extending further west towards Moray and Nairn. As stated, this coincided with the principal arable areas, where not only were the greatest number of horsemen employed, improved agricultural horses kept but where, on many farms, the "f'eed" (hired) six-month term at a time hired, unmarried and younger farm horsemen lived together in communal "bothies". A bothy was often a single room with a fireplace, attached to a farm building such as a stable, furnished with beds, a table, chairs and minimal cooking utensils, crockery, and cutlery. It engendered an environment where horse related culture could be shared, taught, and learned. It was from these bothies that the senior horsemen, either on the farm or in the local community, would select youths, known as "loons" in some areas, as prospective candidates to join the Society and take their first steps to becoming acknowledged by their peers as worthy of being considered a horseman.

For many "loons" as aspirational or prospective horsemen there was a hierarchy on the farms. The ultimate ambition would be the position of "First Horseman", with often the best team or "pair" of horses, and harness, on the farm. Depending on the size of the farm, for which some calculated one pair of horses for every 50 acres, there could be "Second", "Third", or more horsemen. However, for a youth, leaving school at the age of fourteen (Scotland from 1901), his initial position would probably be as an "Orra Loon", an odd or individual lad with an old single horse often undertaking tasks around the farm steading. Depending on his personal history, the lad may have had existing experience with, for example, his father, but his "orra loon" position was one for hands on learning, whilst being assessed by the established horsemen on his farm or in his community.

The progress from "Orra Loon" through, for example, "Third" to "First" horseman would be familiar to any aspirational horseman. In fact, the bothy accommodation system was a renowned source for "bothy ballads", songs often composed by the horsemen that reflected their lives as farm servants, both good and bad. One well known ballad was called "A Pair of Nicky Tams". The latter is the name given to the buckled straps that many of the horsemen wore around their trouser legs below the knees to keep the trouser leg bottoms out of the mud. Some horsemen even went to the extent of having buckles that matched those on their horses' harness.

In "A Pair of Nicky Tams", the ballad reflects on a loon's progress, from being hired as a Third man to becoming a member of the Horsemen's Society for which part of the process included the ritual to receive the Horseman's Word. Of course, it was possible for loons to join the Horsemen's Society if they were deemed good enough by their peers. However, many were at least sixteen before having the opportunity, which if having left school at fourteen would have given them two years' experience and time to be assessed as being worthy. The key aspect was that whether as a loon or a young lower rank horseman, they had a lot to learn before they could progress. However, that knowledge and assistance would not be forthcoming from the senior Horsemen's Society members until the horseman in need had been accepted and inducted into the Society. As stated before, it was a form of trade protection to ensure that the skills were only passed to those who needed to know.

Figure 6 *– A three pair farm: The second person from the right is probably the farm's "grieve" or foreman; next, the 'First Horseman' with the better horses and harness; then the 'Second' horseman and finally a young man, lower in the ranks as 'Third' horseman who may have aspired to, one day, being hired as a 'First' man*

First I got on for bailie loon (First I was hired as the farm loon)
Syne I got on for third (Then I was hired as Third horseman)
And syne of course I had to get (And then of course I had to get)
The Horseman's grippin' Word (The Horseman's gripping Word)
A loaf of breid to be ma' piece (A loaf of bread to be my food)
A bottle for drinkin' drams (A bottle of whisky for sharing "drams"/drinks)
Ye couldna get thru' the caffhoose door (However, you cannot pass through the chaff house door)
Without your Nicky Tams (Without your Nicky Tams)

The following is a version of the initiation ceremony or ritual that the aspirational member of the Horsemen's Society may have undergone. Initially the youth, who would have been partially aware of what he would have to do, may have been notified of his senior peer's intentions and invitation by, if he lived in a bothy, by a horse's hair being left in an envelope under his pillow. If his response to his fellow horsemen was deemed positive, he would be both tutored and guided by a senior Horseman.

***Figure 7** – A young horseman with his pair stood in front of arched cart sheds, above which is a loft, a "Hall", and where the Horsemen's Society may have held meetings*

Firstly, to enter the "Horsemen's Hall" to undergo the ceremony and receive the Horseman's Word, he would have to pass through the "Chaff Hoose Door". The latter meant passing through the door to the chaff *(Chaff ~ chopped hay or straw for feed)* house, a hay loft or other suitable hall-like space on a farm where the horsemen could meet to perform the ceremony. Consequently, the initiate would be instructed to be present at such as the chaff house or hay loft closed door at midnight and bring whisky and bread with him. There, outside, met by a senior Horseman, firstly he would be blindfolded and secondly, he would have to answer questions for which he would have been instructed.

For example:

Q: "Wha telt ye to come?"

A: "The Devil."

Q: "Which wey did ye come?"

A: "By the hooks and crooks of the road."

Q: "By which licht did ye come?"

A: "By the stars and licht of the moon."

Q: "Where were ye made a Horseman?"

A: "In a Horseman's Hall where the sun never shone, the wind never blew, the cock never crew. And the feet of a maiden never trod."

Such questions answered he would be led into the "Horseman's Hall"

***Figure 8** – Kneeling in front of the "alter" made from a grain measuring "bushel" upended over a sack of oats, while the lead senior horseman holds the Devil's hoof*

Inside the Hall, still blind folded, now stripped to the waist and unaware of who or what was there, the young initiate, sometimes already plied with whisky, was often nervous if not scared. Not that he could see it, but the initiate would be made to kneel before an altar, often made by a grain bushel measure upended over a sack of oats. From this point he would be made to both repeat and swear the Horsemen's "Oath" that would allow him to receive "The Word" which in turn would allow him to receive the knowledge, skills, and powers of horsemanship.

The following is extracted from 'The Oath'[1]:

"I of my own free will and accord solemnly vow and swear before God and all these witnesses that I will heal, conceal and never reveal any part of the true horsemanship which I am about to receive at this time…

… and if I fail to keep these promises may my flesh be torn to pieces with a wild horse and my heart cut through with a horseman's knife and my bones buried on the sands of the seashore where the tide ebbs and flows every twenty-four hours so that there may be no remembrance of me amongst lawful brethren so help me God to keep these promises. AMEN."

Finally, still blindfolded, the maybe slightly inebriated initiate would have to confirm his allegiance to the Brotherhood of the Horsemen by shaking hands with the "Auld Chiel", the Devil. The Devil was, as shown in ***Figure 9***, a pole covered with hide and a sewn-on hoof, although Jock Hepburn told me that they used to get a calf's leg with a real cloven hoof from the slaughterhouse! This really would have frightened many a God-fearing initiate and confirmed the seriousness of what he was undertaking. Nearing the end of the ceremony, the initiate would then be permitted to receive 'The Word', the never to be spoken, written, or otherwise revealed key and bond that joined the brotherhood of the Horsemen together.

Therefore, what is The Word? Yes, I know. It is out there to be found but never reveal! Without revealing it, the "Word" describes the mutual bond and empathy between man and horse.

This in essence was the end of the ceremony, after which the newly confirmed Horseman would share his

1 Printed Leaflet, National Museum of Scotland.

Figures 9 and 10 *– A horsehide covered pole with a created sewn on Devil's hoof for the initiate to shake hands with the "Auld Chiel". This pole came from Aberdeenshire and is in the collection of the Highland Folk Museum, Newtonmore, Inverness-shire*

whisky and bread with his fellow brethren. It was not though the end of the allegiance, for from that point forward, the new horseman was free to request assistance from his peers on issues such as training, working, or veterinary care for his horses.

In common myth or perception, being a member of the Horsemen's Society and having received 'The Word' was said to give the horseman power over horses. Some people claimed women too. To uninitiated outsiders it was often perceived as "magic". Commonly this was perpetuated by the horsemen doing tricks with their horses of which the most common was to have a horse or horses standing with their forefeet on the top of an upturned half barrel. It was not magic but a demonstration of trust between man and horse.

Figure 11 *– Getting a horse to stand on a half barrel was a common Horsemen's Society trick*

Away from the ritual and perceptions of the Society, there were benefits from being a member of the "Brotherhood." Firstly, knowing that you were approved by your peers and would have their support. Support that would include unity and strength in numbers for negotiations. Secondly, enjoying camaraderie that engendered pride in being a "Horseman", which for some top horsemen it gave them enhanced community respect and status. As implied for younger horsemen, access to mentoring and training, thereby gaining a peer lead informal qualification and a stepping-stone to improved employment positions. Finally, overall membership was intended to encourage best practice and maintain standards including through tradition and competition for horse and harness care

After over 100 year's existence, the second decade of the 20th century heralded the death knell for both the farm horse and the 'Horsemen's Society'. Firstly, there was the 1914-1918 First World War. It was a watershed. Previously the culture associated with both the horsemen and horses, the latter including the establishment of the horse breeds societies, had peaked. However, as both men and horses either went to War or were affected by it, change was inevitable. The men who went to war, came back with different attitudes to work and tradition. The latter became significantly less important. With emergency food cultivation and military needs, Scottish agricultural horse numbers slightly increased during the War but, thereafter, horse numbers dramatically decreased.

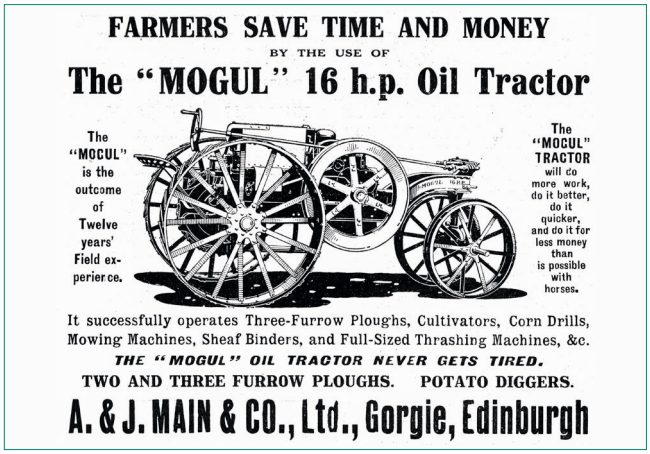

Figure 12 *– The onset of tractor mechanisation in 1915 (Image published in the Scottish Farmer, exact date unknown)*

Mechanization was a further major reason for the demise of both horses and the 'Horsemen's Society'. Tractors such as the International "Mogul" were introduced by 1915. In December 1917, the 'Fordson' was brought into production and by April 1918, six thousand had been supplied to Britain. During the War on the farms, the older resident horsemen were mainly averse to tractors. This gave women a role in driving them through such as the Women's Land Army. Coming back from the War, the

younger men especially were aware of the possibilities of mechanisation. Their inclination was more to crank a tractor engine rather than getting up early to feed, groom and harness a team of horses. There was no need for the Horsemen's Society.

A further reason for the Horsemen's Society's decline was an alternative, namely "The Scottish Farm Servants Union". Founded in 1887 the 'Union' had some similar aims to the 'Society' but as a formal Scottish national organization it was inclusive for all farm workers. By 1913 the Union had over 6,000 members and with united strength to negotiate for pay, working conditions and holidays the Horsemen's Society became increasingly irrelevant.

By the 1920s and onwards the changes were dramatic. There was a post-War agricultural depression. Wages fell and, if not leaving the land, farm workers were more concerned with their work conditions than tradition. In photos horsemen's clothing became more relaxed, their stance less depicting pride and the horses' harness less cared for. For committed horse breeders, many moved away from smaller working horses that suited the farm work in hand, to breeding larger animals to breed society standards whose conformation was more suited for show and making money.

Figure 13 – The badge of the Scottish Farm Servants Union

In simplistic terms such was the accelerating demise of both the Horsemen's Society and working farm horses. And the final nail in the coffin? … the 1946 'Freed from Bondage' introduction of the successful Ferguson TE-20 tractor that was compared to the detriment of remaining Scottish farm horses in economic, practical and farm worker terms. There really was little argument for final change!

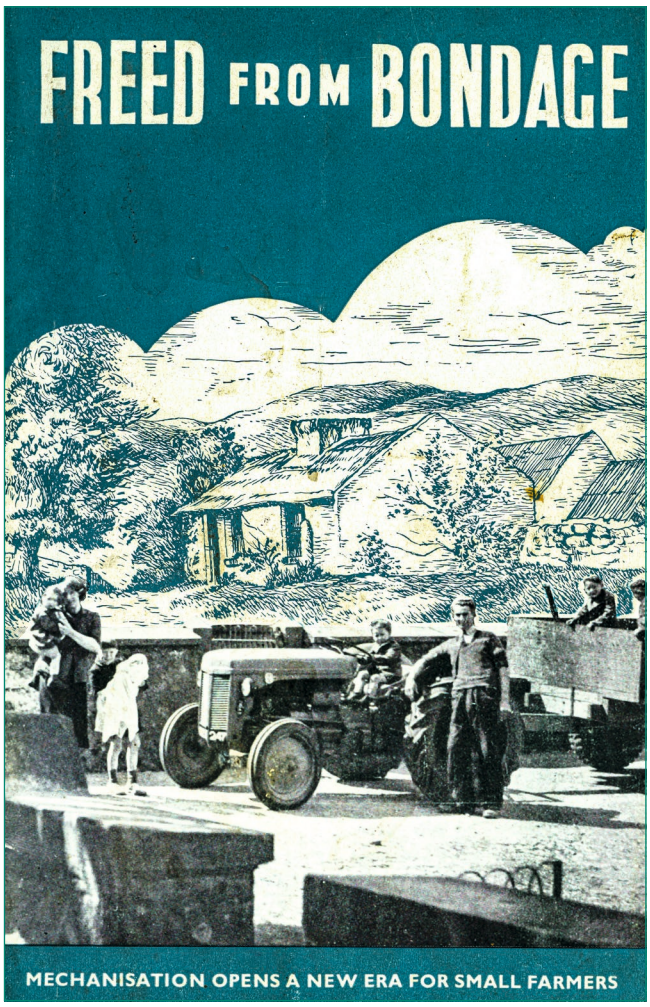

Figure 14 – The introduction in 1946 of the "Little Grey" Ferguson "TE" Tractor did more for the demise of the farm horse than possibly any other factor

Related Literature

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E. Taylor, Hooves Harness Hardwork, Ploughmen of Yesteryear (Finavon 1997).

List of Figures

Title (In this rare photograph probably from the north-east of Scotland, some Scottish farm horsemen having received the "Horsemen's Word", demonstrated their newly granted "power" by training their horses to do tricks. Commonly this was to get their horses to stand with their fore feet on a half barrel) – Bob Powell Archive.

Figure 1-14 – B. Powell.

Author info
Bob Powell

Working Horse & Farming Historian
Kingussie, Scotland

E-Mail: bob.powell53@btopenworld.com
Digital paper: https://youtu.be/8oURYAhcqQI

Eye-to-eye with animal draft in France – a case study in a broader ecosystem

Cozette Griffin-Kremer

Abstract

France is a country with a lively draft animal scene that includes use of animal power in real livelihoods such as farming, market gardening, transport, logging, the tourism industry and much more. There is also a global context, so we will look at how the very local fits into the wider picture with a sampling of the actors and the stakes involved, as well as the networking to bring draft animal users together, communicate with the public, recall the places they come to meet together, the historical background and strategies for the future, usually with an emphasis on working cattle. Animal draft supposes a whole matrix of skills, equipment, learning opportunities, organization and motivation. It survives and can even thrive in an ecosystem that recognizes its value and potential to help us keep our household, our global economy, within safe bounds.

Résumé

La France est un pays doté d'une scène animée d'animaux de trait qui comprend l'utilisation de l'énergie animale dans des moyens de subsistance réels tels que l'agriculture, le maraîchage, le transport, l'exploitation forestière, l'industrie du tourisme et bien plus encore. Il y a aussi un contexte mondial, nous allons donc examiner comment le niveau local s'inscrit dans un contexte plus large, avec un échantillon d'acteurs et d'enjeux, ainsi que le travail en réseau pour rassembler les utilisateurs d'animaux de trait, communiquer avec le public, rappeler les lieux où ils se réunissent, le contexte historique et les stratégies pour l'avenir, en mettant, en général, l'accent sur le bétail de trait. La traction animale suppose toute une matrice de compétences, d'équipements, de possibilités d'apprentissage, d'organisation et de motivation. Elle survit et peut même prospérer dans un écosystème qui reconnaît sa valeur et son potentiel pour nous aider à maintenir notre foyer et notre économie mondiale, dans des limites sûres.

Kurzfassung

Frankreich ist ein Land mit einer lebendigen Zugtierszene, in der die Kraft der Tiere in der Landwirtschaft, im Gemüseanbau, im Transportwesen, in der Forstwirtschaft, in der Tourismusbranche und in vielen anderen Bereichen eingesetzt wird. Es gibt außerdem auch einen globalen Kontext, daher werden wir uns ansehen, wie sich das sehr lokale in das größere Bild einfügt, mit einer Auswahl von Akteur:innen und Involvierter, sowie der Vernetzung, um die Nutzer:innen von Zugtieren zusammenzubringen, mit der Öffentlichkeit zu kommunizieren, die Orte, an denen sie sich treffen, den historischen Hintergrund und die Strategien für die Zukunft in Erinnerung zu rufen – üblicherweise mit dem Schwerpunkt auf Arbeitsvieh. Die Zugtierhaltung erfordert ein ganzes Geflecht von Fähigkeiten, Ausrüstung, Lernmöglichkeiten, Organisation und Motivation. Sie überlebt und kann in einem Ökosystem besonders gedeihen, das ihren Wert und ihr Potenzial anerkennt. Sie hilft uns dabei unseren Haushalt, unsere globale Wirtschaft, in sicheren Grenzen zu halten.

Resumen

Francia es un país con un concurrido panorama de animales de tiro y carga, el cual utiliza la fuerza animal en numerosas actividades agrícolas, en la horticultura, para el transporte, la explotación forestal, en la industria del turismo, etc. Partiendo desde una perspectiva global, veremos no solo cómo lo local encaja en el panorama más amplio de actores y sus intereses, sino la formación de redes usuarios de animales de tiro, su comunicación con el público y sus lugares de encuentro. Además se expondrán antecedentes históricos de estas actividades y las estrategias para el futuro. El trabajo con animales de tiro y carga supone toda una matriz de competencias, equipos, oportunidades de aprendizaje, organización y motivación. El reconocimiento de su valor en este ámbito ayudaría a mantener nuestros hogares, nuestra economía mundial, dentro de unos límites seguros.

Figure 1 *– Yana Houlier at Ferme de Méras 2013*

The "Draft Animals in the Past, Present and Future" congress[1] moved from very global to examples of the very local, as this article will do. It concentrates on networking to understand and promote the use of draft animals, especially cattle, in France, though there is much outreach to Europe and North America. This includes first and foremost the animals and their handlers, but also the groups that promote their training and work, as well as some examples of the events and places where you can see animal draft in everyday use and the ways in which information is communicated. Finally, it takes up two vital issues: the stakes involved today in our world to find a more reasonable relationship with the environment, that is, a proposal for *moving from one ecosystem to another*, and the equally vital transmission of know-how within its own broader "ecosystem" context, through the example of a particular animal draft expert.

Sometimes, the second task is possible, sometimes it is not, or is limited by a generational break in passing on knowledge and skills. There are good examples in France of present-day oxdrivers taking up older skills, either from traditional experts who were raised with them, or by sorting through the threads still left to re-establish good practice and go on to innovate. Some of the innovation in animal draft comes from fine-honing mechanization, thus avoiding or reducing the need for motorization. There is a multitude of busy movers and doers involved, so only a few will serve here to give an idea of what is going on.

1 Congress recording, URL: https://www.youtube.com/watch?v=TPbbu1XKvJg [10-02-2022].

Today, especially in France, animal power is being used successfully (and unsuccessfully) in many economic areas and at varying scales, although certainly never at the high-powered level perfected by Amish farmers to be seen in the Horse Progress Days[2] annual meetings that attract many of the essential actors – farmers, animal handlers, equipment-makers, researchers and a public intrigued by the question of whether it is really possible to do farming and food production in other ways than full-scale industrialization with the consequent inputs of synthetic fertilizers, and the pesticides that account for soil sterilization and have contributed to pollinator loss and ecosystem impoverishment more generally. The United States is also home to various groups that can undertake skills training on a simpler level, such as Tillers International[3] or even propose an undergraduate minor degree in draft animal power systems at Sterling College[4].

The environmental impacts associated with industrial-scale agriculture and stock raising are directly linked to an ecosystem in a broad economic sense, as Xenophon might have put it, how to run your global household. Might it be possible to shift towards a viable ecosystem combining many small-scale agricultural units that could be equally satisfactory with less impact on planetary health, as suggested by Marc Dufumier and Olivier Le Naire, Chris Smaje, Atelier Paysan[5] and others? One concept involving this process can be represented by a "doughnut" (a round pastry with a hole in the middle) that the economist Kate Raworth[6] proposes in order to keep the economy within well-defined social and planetary boundaries so we do not slip over the inside or outside

Figure 2 *– The concept at the heart of Doughnut Economics*

2 Horse Progress Days, URL: https://horseprogressdays.com/ [10-02-2022].
3 Tillers International, URL: https://www.tillersinternational.org/ [10-02-2022].
4 Sterling College, URL: https://www.sterlingcollege.edu/academics/draft-animal-management-minor/ [10-02-2022].
5 Dufumier/Le Naire 2019; Smaje 2020; Atelier Paysan 2021; Id., URL: https://www.latelierpaysan.org/ [10-02-2022].
6 Raworth 2017; DEAL, URL : https://doughnuteconomics.org/ [10-02-2022].

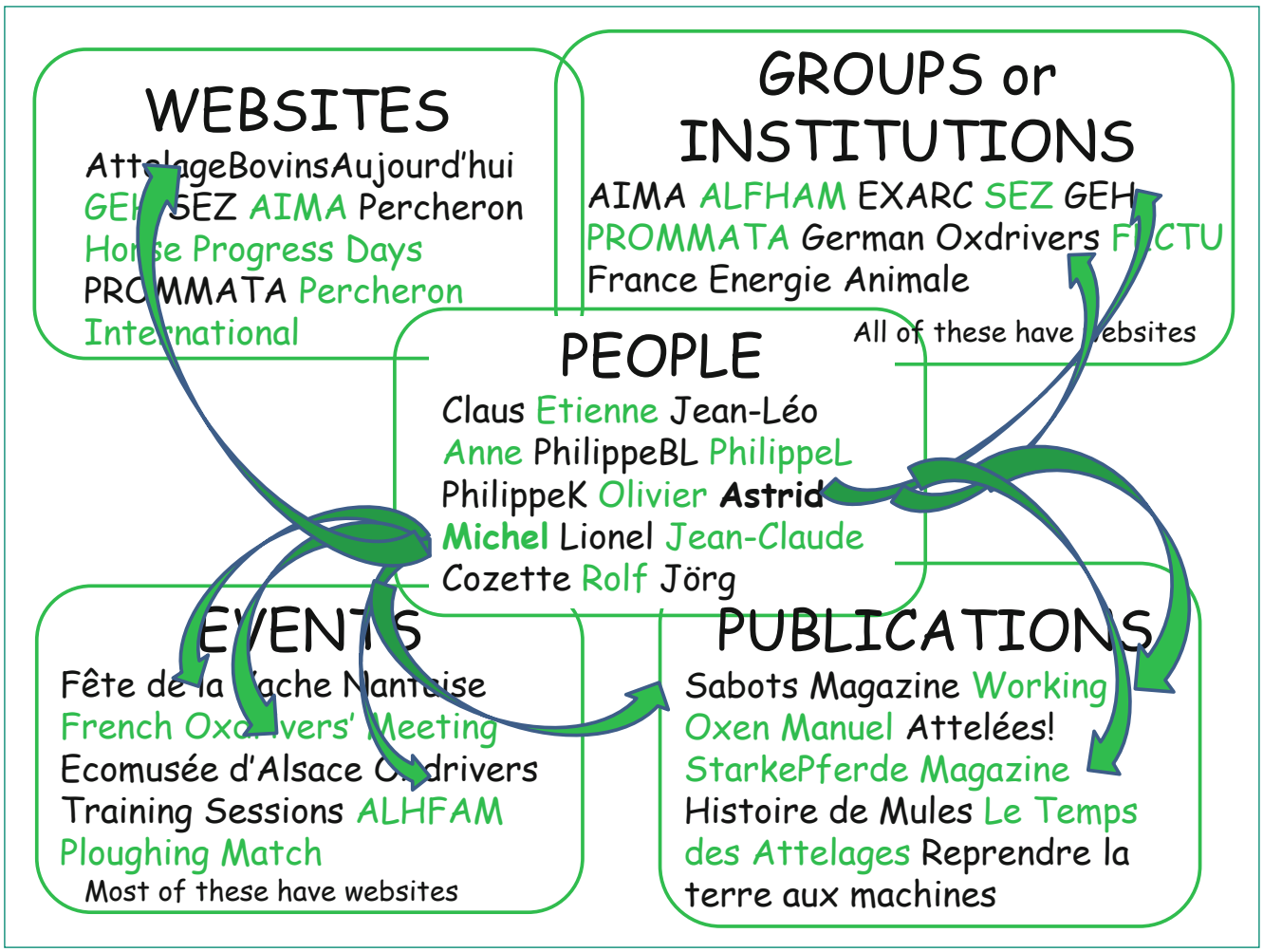

Figure 3 *– Sampling of interconnections in draft animal network*

edges towards socio-economic distress or ecological disaster. This is expressed in the graphic in ***Figure 2***.

Back to the doughnut[7] and the ideas in it later, as the first of two tasks here is to provide a quick portrait of some of the actors and events in the deeper network of animal draft, especially for working cattle. This can be represented in a graphic on networking with some recent examples (see ***Figure 3***).

Networks are made up of people. If we take only two of our sample people – Astrid and Michel – and begin connecting them with Internet or blog sites, groups or institutions and publications, it is easy to imagine the bigger picture of connections, all the more as so many of these people are in touch with one another. It would look like a totally entangled bush! Now, we can go on with that first task of highlighting a few examples of the connections. There is a list of the people, websites, groups or institutions, publications and events at the end of the paper, although this is a sampling only, that can be used by any reader.

We can take another of our people here to look at the crossing threads in networking – our host for the Draft Animals in the Past, Present and Future congress, Claus Kropp. He is a member of the AIMA[8] (International Association of Agricultural Museums), ALHFAM[9] (Association of Living History, Farming and Agriculture Museums), EXARC[10] (Experimental Archaeology Open-Air Museums), as well as of the German Oxdrivers' Working Group[11] (Arbeitsgruppe Rinderanspannung), and all these groups sent out the announcement of the congress through their websites, as did the French blogsite Attelages Bovins d'Aujourd'hui[12] (Working Cattle Today) piloted by Michel Nioulou. So did magazines such as the German *Starke Pferde*[13] (heavy horses), the British *Heavy Horse World*[14] and the French *Sabots*[15], followed up by post-congress reports in their pages or on their websites.

Taking these networking partners from the other end, the magazines, the German *Starke Pferde* devoted a section to draft cattle in its Summer 2021 issue, rather an exception to the mainly horses rule, stressing in its editorial by Erhard Schroll[16] that the magazine was dedicated to working horses, yes – but also other draft animals (in bold type!). This issue featured the first all-oxen cover, with Claus' and Lauresham's David and Darius to introduce

7 Doughnut Economics, URL: https://doughnuteconomics.org/tools-and-stories/11 [04-02-22].
8 AIMA, URL : https://www.agriculturalmuseums.org/ [10-02-2022].
9 ALHFAM, URL : https://alhfam.org/ [10-02-2022].
10 EXARC, URL : https://exarc.net/ [10-02-2022].
11 Arbeitsgruppe Rinderanspannung, URL : https://www.zugrinder.de/en/home.html [10-02-2022].
12 Attelages Bovins d'Aujourd'hui, URL: http://attelagesbovinsdaujourdhui.unblog.fr/ [10-02-2022].
13 Starke Pferde, URL : https://www.starke-pferde.com/ [10-02-2022].
14 Heavy Horse World, URL: https://www.heavyhorseworld.co.uk/ [10-02-2022].
15 Sabots, URL: https://www.sabots-magazine.com/accueil/accueil.php [10-02-2022].
16 Schroll 2021.

the article "Draft oxen in the service of archaeology"[17] at the heart of the 1:1 reconstitution of their 8th-9th-century site with central court buildings that include living and working spaces, as well as gardening, pasture and farming activities, their "open-air research laboratory". Among their objects of study is how cropping on ridge-and-furrow functioned, as it has been detected by LiDAR (airborne laser scanning) for many medieval sites. The experimental fields, with control fields nearby, are manured by the Lauresham livestock, and even the soil "climate" is analyzed. This provides a wealth of information, including a result quite pertinent for farming in today's highly variable climatic conditions: the difference between the high and low profiles of the furrows provides soil conditions that minimize risk and appear to give quite satisfactory average yields over time. Networking? Claus presented these results, not in the earlier *Starke Pferde* article, but in his PowerPoint for the July 2021 AIMA congress[18].

Staying with the same issue of *Starke Pferde* for the moment, the magazine featured a full-page announcement of Astrid Masson's *Working Oxen Manual*[19], which includes chapters by the cattle behavior specialist Anne Wiltafsky and by Rolf Minhorst[20], specialist on the German adjustable three-pad cow collar, amply illustrated in the Working Group website's photo library. *Starke Pferde* added an article by the group's photographer, Edwin Rotzal[21], on a truly emblematic farmer, Matthias Höwer and his draft cattle. Matthias remembers well that right into the 1960s, there were some thirty pairs of working cattle, usually cows, around his home in the Westerwald and he is today one of the champions of the old Rhineland-Pfalz Glanrind breed, as well as being a successful "modern" farmer.

In the usual international cooperation effort among magazines, British *Heavy Horse World* and French *Sabots* ran articles by Cozette[22] on Claus' draft animal congress with special emphasis on many of the points mentioned here and especially on promoting the positive image of animal draft. This has long been among the aims of both magazines, although HHW has often concentrated on coach transport and farming or market gardening, while *Sabots* has developed a broad approach facilitated by the great variety of activities involving especially working horses in France: logging, especially in "sensitive" environments, small-scale farming or market gardening using equipment like the *kassine* designed by PROMMATA[23] and the products of other harness- and implement-makers. Many environments are vulnerable to machine damage or simply inaccessible, such as riverbank, wetland and much forest maintenance – from light-touch transport to fern-bashing or broom-extraction in dune areas – not to mention the thriving work in French vineyards to avoid soil compaction or biodiversity loss. The human factor is much emphasized in *Sabots*, with "town horses" mobilized for "bussing" school children, waste pick-up, greenery-watering or tourism.

Sabots has a stable of regular authors like Jean-Léo Dugast, specialist on the Percheron horse[24] breed, the American Horse Progress Days and Amish farming, as well as nearly all the subjects mentioned above, or Etienne Petitclerc, who shares his rich historical document collection on draft animals, implements and vehicles. Jean-Léo authored the definitive *L'Age d'Or du Cheval Percheron* (Golden Age of the Percheron)[25] and Etienne the panoramic *Attelées!*[26], a "Tour de France" of animal draft, a worthy continuation of the earlier works by Phlippe Berte-Langereau that document ox draft and carting in the Morvan region[27]. *Sabots* likewise reports on festive activities of many kinds, among them the 25-year old mid-August event at the Perche Ecomuseum, the Percheron Horse Fête bringing together breeders, coach-users from France and Germany, the Republican Guard mounted corps in 2021, implement-makers, all wound up by a parade of the participating teams, including the riding and coach-racing specialists.

Jean-Léo Dugast's decades-long contributions to draft animal promotion were honored in another major event in 2018, the four-yearly Festival of the Nantaise Cattle Breed in Le Dresny, when all the high ground was given over to animal draft, from donkey to mule to horse to oxen. The highlight for the oxdrivers was the final "Grande Attelée" (Long Team), hitching five pairs of oxen to plough together. It was an event with a second special guest of honor, Laurent Avon[28], retired from the Breeds Institute, who devoted his spare time, also for decades, to the census of working oxen now continued by Michel Nioulou, Philippe Berte-Langereau, André Kammerer and his grandson Corentin Huber, volunteer oxdrivers for the events at the Ecomuseum of Alsace[29]. This is where the expert oxdriver Philippe Kuhlmann is the center of the (usually) annual meeting of Oxdrivers of Alsace and Beyond, as well as managing his highly popular twice-yearly training courses on working with cattle. The Alsace museum is another hot spot for exploration of the past in the present and future, with its "Theatre of Agriculture" that helps the public re-assess traditional farming practices and the traditional crops so often deeply matched with the region's soils, now widely replaced by maize.

These events, actors and museums are prime movers and bring us round to the second task proposed – of assessing the equally vital transmission of knowledge and skills within their broader "ecosystem" context. For harness, there is certainly the three-pad collar, as still made by saddlers such as Jean-Claude Mann[30] in Alsace or Hansrüdi Blaser[31] in Switzerland. Traditional wooden ox yokes are made by specialists like Lionel Rouanet[32], who "studied" with the master yoke-maker René Alibert,

17 Kropp 2021b.
18 Id. 2021a.
19 Masson 2015.
20 Minhorst 2007.
21 Rotzal 2021.
22 Griffin-Kremer 2021a; Id. 2021b.
23 PROMMATA, URL: https://assoprommata.org/?lang=en [10-02-2022].
24 Percheron International, URL : http://percheron-international.blogspot.com/ [10-02-2022].
25 Dugast 2019.
26 Petitclerc 2016.
27 Berte-Langereau 1996; Id. 2000.
28 Avon 2006.
29 Ecomusée d'Alsace, URL: https://www.ecomusee.alsace/fr/ [10-02-2022].
30 Jean-Claude Mann, URL: https://www.xn--tapissier-dcorateur-lzb.fr/mann-muhlbach-sur-munster/artisan/296/ [10-02-2022].
31 Hansrüdi Blaser, URL: https://www.blaser-sattlerei.ch/en/home [10-02-2022].
32 Lionel Rouanet, URL: http://attelagesbovinsdaujourdhui.unblog.fr/2013/05/06/geometrie-des-jougs-occitans-par-lionel-rouanet/ [10-02-2022].

or Michel Nioulou, the oxdrivers' information "hub" with his blog site. For the animal handling skills, the individuals mentioned, such as Philippe Kuhlmann in Alsace for cattle, who is compiling his own oxdrivers' manual[33], offer training courses. Hopefully, Philippe's manual will take up where the "grandfather" of ox-driving skills, François Juston, had to leave off with his *Quand la corne arrachait tout* (When horns tore it all away)[34]. There are several groups effectively coordinated by France Energie Animale[35] able to respond to the demand for training horse and donkey handlers, the large European Centre for Draft Animal Resources and Research[36] (CERRTA) or the FECTU[37] (European Federation for Draft Horse Use and Promotion). Authors like Jean-Léo Dugast, Etienne Petitclerc or Philippe Berte-Langereau have provided ample historical material. What is missing at times is local historical context and the big picture drawn from comparative observation, as so effectively carried out by François Juston. At least a small contribution to that can come from an inquiry carried out with the ox- and mule-driver, specialist in rare horse breeds like the Merens, Olivier Courthiade, in the Ariège area in southwest France.

Olivier has an exemplary collection of yokes – many in the Alzen Ecomuseum – as well as historical documents, including books, photographs, older postcards and models, not to mention a vast collection of harness. He also knew the elder statesmen in his area, the breeders and dealers (*maquignons*) who until the mid-twentieth century were at the heart of the great cattle and horse fairs, like "La Madeleine" in Montesquiou in the Gers *département* that brought together thousands of animals until it came to an end in the mid-1970s. "Statesmen", yes, but their wives and families were ever-present, beside them at work, during our visits in their homes and to see their recollections. They bear witness to decades of savvy dealing, rich storytelling, even of family tragedy during WWII, then the decline of an entire world of business in a single generation. They turned around quickly, as a rule, and became just as savvy larger-scale breeders attuned to markets and the latest machines, but they kept yokes, harness, tools, bells, fly masks, goads and other accessories on the walls alongside their award plaques.

During the interviews, with everyone bent over old photos, Olivier was careful to ask the same questions, so that their answers could be compared, often enlivened by clear disagreement about how an event really unfolded, and there was many a tale. In between visits, Olivier sat down at home to comment on his own collection, detailing many of the fine points the elder friends had evoked. One postcard spoke to him of the black smocks that the *maquignons* always wore and he read the postcard caption in Occitan, before pointing out that there are two Casta breed oxen in the throng of Gascon cattle, but all of them are "dressed" in their *mante* (mantle), because no owner would take an animal to the fair "naked". Another photo recalled the depth of expertise and grasp of the big picture possessed by François Juston, who understood the special *cuisine* – all the ingredients in their context, from breed to soil to land gradiant to weather – that once went into each micro-territory's traditions in oxdriving. Yet another picture was taken in the mid-1960s at the Montesquiou fair of a pair of Gascons with the ideal "cradle-shaped" horns (*en berceau*), known for their outstanding character, that is, they were the Harley Davidsons of oxen. A photo taken in the Aubrac region recalls two different ways of signaling to oxen to stand with the goad: leaning it upright against the yoke between them as in Ariège, but if they moved suddenly, the point might gouge out an eye, an argument for simply laying it across the back of their necks as in the Hautes Pyrenees – two different "codes" understood by human and animal. There, you have a small sample of the *cuisine* that made up cohesive, if deeply diverse systems of work, in a four-minute extract from one interview. Much of Olivier's own work with cattle and mules, as well as construction of the Landais yoke for the latter, has been documented by the film-maker Vasco de Lima[38] of the Association Le Trait.

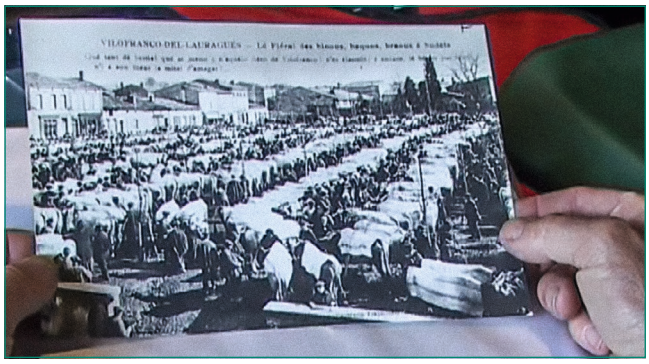

***Figure 4** – Olivier Courthiade explaining the cattle fair at Villefranche de Lauragais, Haute-Garonne Département*

Now, it is but a flea's hop from local cuisine to Kate Raworth's doughnut, from micro-ecosystems to a global goal. In the older ecosystem that used ox draft as the only energy available, at times right through the 1960s, all the components were still intact: know-how, vehicles, implements, tools, cattle, service providers, hubs of commerce, with all the choices available to make working with cattle efficient. That ecosystem disappeared almost overnight. The 2013 UNCTAD Report[39] with its promising title – *Wake up before it is too late / Make agriculture truly sustainable now for food security in a changing climate* – speaks of working animals only to mention rustling and the tragic theft of donkeys in Africa today to use their skins in traditional medicine. On top of that, the cover portrays a small farmer ploughing with two oxen… in an industrial-sized field, surely an unwitting fake. The UNCTAD 2021 Report[40] also calls for everyone to stop and think about other ways to produce food and run economies, featuring section titles such as "It's the end of the world as we know it". Out of 164 mentions of "energy", associated with "renewable", "transition", "efficiency", "clean" and "green" including wind, sun and water, there is none referring to animal power. ("Power" is limited to hydro- and political power.) To the UNCTAD Report's credit, there is ample discussion of fitting within boundaries, as in Raworth's

33 Kuhlmann 2022.
34 Juston 1996.
35 France Energie Animale, URL: https://www.energie-cheval.fr/menu-secondaire/france-energie-animale/ [10-02-2022].
36 CERRTA, URL: https://www.formationtractionanimale.com/ [10-02-2022].
37 FECTU, URL: https://www.fectu.org/ [10-02-2022].
38 Lima, URL: Trait https://www.youtube.com/channel/UC-U6Coqwo6kn4oPkwpdBODg/featured [10-02-2022].
39 UNCTAD 2013.
40 Id. 2021.

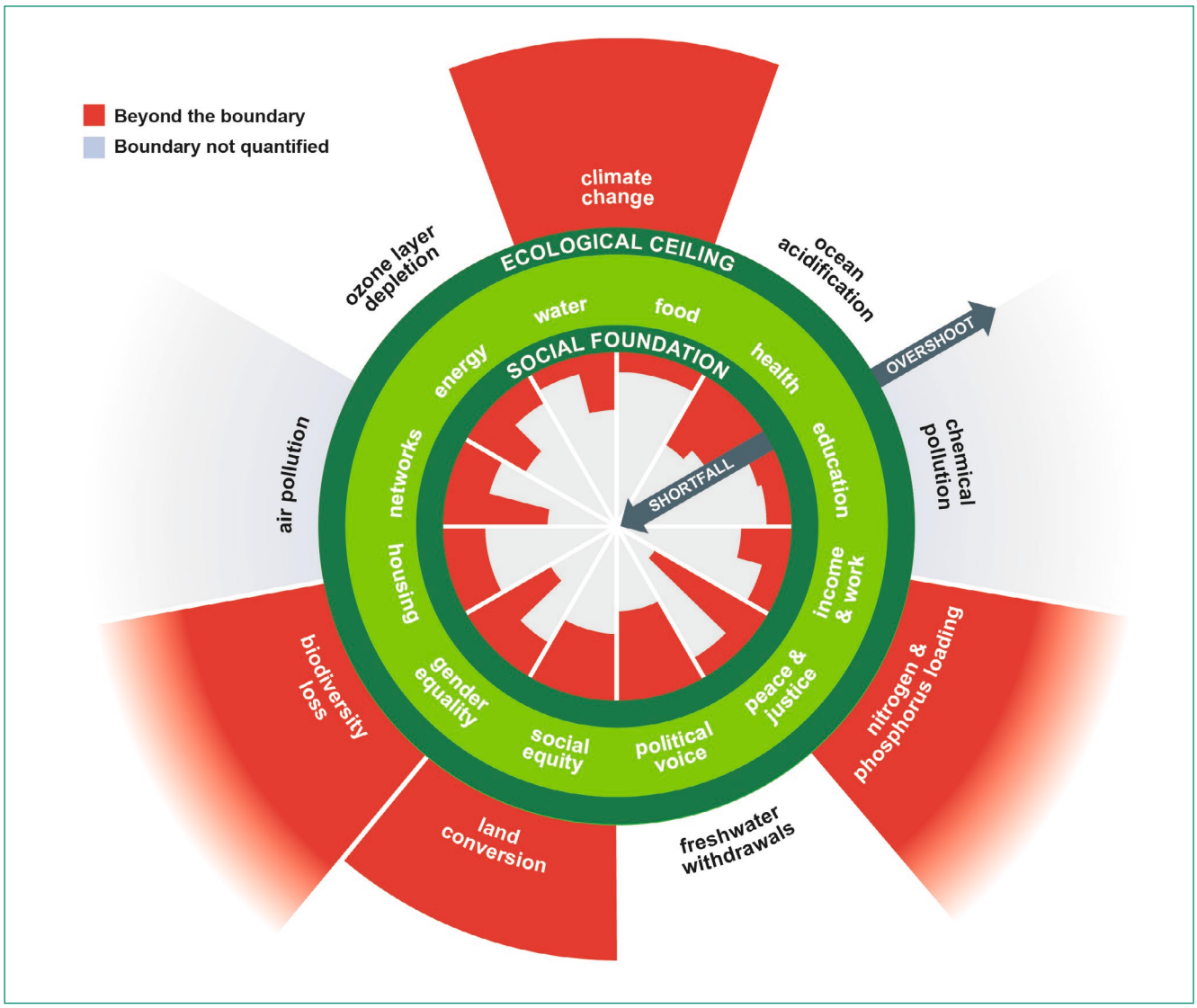

Figure 5 – Doughnut economics and planetary boundaries

doughnut. The doughnut graphic on overspill speaks for itself, with the planetary boundaries put forward by the Earth-system scientists led by Johan Rockström[41].

Obviously, economists and earth science teams are compatible co-workers, perhaps just as draft animals can work well with humans towards efficient food production and other activities that keep us within environmental boundaries. The networks you see only a glimpse of in the Draft Animals Congress are certainly important in bringing a diversity of actors together, but they are not sufficient. Using animal draft anywhere in the world requires generational transmission as well as vertical recognition running from agriculture ministries to unions, training institutions and on to farmers, market gardeners, stockbreeders and consumers, so that we could stop excessively extractive practices and get food systems back into the doughnut. Is it possible to take some of the earth back from machines, without renouncing mechanization, even with partial motorization? Can industrial agricultures be rethought into smaller units, as suggested by proponents of agroecology, agroforestry, permaculture & Co., most especially practices that regenerate the soil and avoid the pollution of water and air we are familiar with? Might we be on the cusp of new ecosystems that could involve animal draft, where it can be practiced efficiently enough to underwrite decent incomes for the people using it? The variety of thinkers and doers who participated in 'Draft Animals, Past, Present and Future' most certainly contribute to this!

41 Rockström, URL: https://www.stockholmresilience.org/research/planetary-boundaries.html [10-02-2022].

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Author info

Cozette Griffin-Kremer

Associate Researcher, CRBC (Centre de recherche bretonne et celtique), Brest
18 rue Gambetta, 78120 Rambouillet, France

E-Mail: griffin.kremer@wanadoo.fr
Digital paper: https://youtu.be/0flQm1mNwZQ

The introduction of draft donkey in Burkina Faso, West Africa

Marcel Scheidweiler

Abstract

By harnessing donkeys with self-made collars in 1959, Antoine Mailliet, a young farmer of Luxembourg, succeeded in changing the pack donkeys living in Burkina Faso (Upper Volta at that time) to draft animals. From 1959 to 1969, ten Luxembourgish volunteers together with state and clerical actors continued promoting the draft donkey.

Since 2003, the NGO *Luxembourg Young Farmers* started pairing the draft donkey with the multipurpose agricultural tool "kassine", designed by PROMMATA, France. In 2008, a training center was constructed in Imasgo, Boulkiemdé, where about 1,300 farmers learnt to use this new pairing and modern agricultural techniques in order to increase harvest yields.

In 2016, to promote the draft donkey on a larger scale, four local training facilities have been built in four villages belonging to different regions: Imasgo (Boulkiemdé), Tiogo (Sanguié), Sabouna (Yatenga) and Koalma (Sanmatenga). Four trainer teams, of five members each, have been teaching draft donkey usage to nearly 11,000 farmers. Through this, about 55,000 villagers benefited from increased food security.

Additionally, the training teams promote the creation of farmers' cooperatives to provide access to agricultural inputs and material as well as the building of management capacities.

The usage of draft animals is essential in light of the climate change; it is not only adapted to small scale farms, allowing to increase yield during extended draught seasons, but also an ecological way of tilling degraded soil to recover it. It contributes to reduce poverty for sub-Saharan rural families.

Résumé

En attelant des ânes avec des colliers simples, Antoine Mailliet, un jeune agriculteur luxembourgeois, réussissait en 1959 à transformer les ânes de bât du Burkina Faso (ancienne Haute-Volta) en animaux de trait. Entre 1959 et 1969, dix volontaires luxembourgeois, appuyés par des acteurs étatiques et religieux, continuèrent à promouvoir la traction asine.

Depuis 2003, l'ONG « *Lëtzebuerger Landjugend a Jongbaueren – Service Coopération a.s.b.l.* » fait la promotion de la traction asine et du porte-outil polyvalent « kassine », conçu par PROMMATA, France. En 2008, un centre de formation fut construit à Imasgo, Boulkiemdé, où environ 1 300 producteurs apprirent comment obtenir de meilleures récoltes en utilisant le duo âne-kassine et les méthodes agricoles modernes.

En 2016, quatre maisons relais furent construites dans quatre villages de régions différentes : Imasgo (Boulkiemdé), Tiogo (Sanguié), Sabouna (Yatenga), Koalma (Sanmatenga). Vingt formateurs enseignèrent les techniques de production en traction animale à presque 11 000 producteurs. Environ 55 000 villageois renforcèrent ainsi leur sécurité alimentaire.

Les équipes d'encadrement encouragèrent également la création de coopératives paysannes pour accéder aux intrants et matériels agricoles et consolidèrent les capacités de gestion des producteurs.

L'utilisation d'animaux de trait est essentielle face au changement climatique ; la traction animale est adaptée aux petites exploitations, permet d'augmenter les rendements durant les périodes de sécheresse prolongées et constitue un moyen écologique de labour et de récupération des sols dégradés. Elle contribue à réduire la pauvreté des familles rurales en zone subsaharienne.

Kurzfassung

Indem Antoine Mailliet, ein Luxemburger Landwirt, 1959 Esel mit einem selbstgemachten Kummet anspannte, wurden Zugtiere aus den in Burkina Faso (damals Ober-Volta) lebenden Packeseln. Von 1959 bis 1969 setzten sich zehn luxemburgische Freiwillige zusammen mit staatlichen und kirchlichen Akteuren für den Gebrauch des Eselsgespanns ein.

Seit 2003 fördert die ONG „Lëtzebuerger Landjugend a Jongbaueren – Service Coopération a.s.b.l." den Einsatz des Eselsgespanns mit dem von PROMMATA, Frankreich, entwickelten Mehrzweckgeräts „Kassin". Im Jahre 2008, wurde ein Ausbildungszentrum in Imasgo (Boulkiemdé) errichtet, wo 1.300 Landwirt:innen lernten, wie sie durch den Einsatz des Duos Esel/Kassin und moderner Arbeitsmethoden bei der Bewirtschaftung der Felder ihre Produktionskapazitäten steigern konnten.

Um das Eselsgespann in einem größeren Umfang zu fördern, wurden 2016 in verschiedenen Regionen vier lokale Trainingseinrichtungen in vier Dörfern gebaut: Imasgo (Boulkiemdé), Tiogo (Sanguié), Sabouna (Yatenga) und Koalma (Sanmatenga). Vier Trainerteams mit jeweils fünf Mitgliedern führten etwa 11.000 Produzenten in den Gebrauch des Eselsgespanns ein. Dadurch profitierten 55.000 Dorfbewohner von einer erhöhten Ernährungssicherheit.

Die lokalen Ausbildungsteams förderten die Gründung von Bauernvereinigungen, um den Zugang zu landwirtschaftlichen Betriebsmitteln und Materialien zu erleichtern, sowie die Schaffung von Verwaltungskapazitäten für Familienbetriebe.

Im Hinblick auf den Klimawandel hat der Einsatz von Zugtieren eine große Bedeutung. Er ist nicht nur für Familienbetriebe geeignet, die in längeren Dürreperioden ihren Ertrag steigern können, aber er ermöglicht auch eine ökologische Bodenbearbeitung, um degradierte Böden wieder fruchtbar zu machen. Er trägt dazu bei, die Armut von Familien in ländlichen Gebieten südlich der Sahara zu verringern.

Resumen

En 1959, Antoine Mailliet, un joven agricultor luxemburgués, consiguió adiestrar a los burros de carga que vivían en Burkina Faso (el Alto Volta en aquella época) para poder ser utilizados como animales de tiro. De 1959 a 1969, diez voluntarios luxemburgueses, junto con actores estatales y clericales, siguieron promoviendo el burro de tiro.

Desde 2003, la ONG Jóvenes Agricultores de Luxemburgo comenzó a emparejar el burro de tiro con la herramienta agrícola polivalente "kassine", diseñada por PROMMATA, Francia. En 2008, se construyó un centro de formación en Imasgo, Boulkiemdé, donde unos 1.300 agricultores aprendieron a utilizar esta nueva formación y otras técnicas agrícolas modernas para aumentar el rendimiento de las cosechas.

En 2016, para promover el burro de tiro a mayor escala, se construyeron cuatro centros de formación locales en cuatro pueblos pertenecientes a diferentes regiones: Imasgo (Boulkiemdé), Tiogo (Sanguié), Sabouna (Yatenga) y Koalma (Sanmatenga). Cuatro equipos de formadores de cinco miembros cada uno han enseñado el uso del burro de tiro a casi 11.000 agricultores. Gracias a ello, alrededor de 55.000 personas se han beneficiado de una mayor seguridad alimentaria.

Además, los equipos de formación promueven la creación de cooperativas de agricultores para acceder a insumos y materiales agrícolas, así como la creación de capacidades de gestión.

El uso de animales de tiro es esencial a la luz del cambio climático; no sólo se adapta a las explotaciones de pequeña escala, permitiendo aumentar el rendimiento durante las prolongadas temporadas de sequía, sino que también es una forma ecológica de labrar el suelo degradado para recuperarlo. Por último y no menos importante, el uso de animales de tiro contribuye a reducir el nivel de pobreza en familias de las zonas rurales del Africa subsahariana.

Burkina Faso, formerly called Upper Volta, is located in the West African Sahel zone. The country has no access to the sea. The borders are in the north and west Mali, in the south the Ivory Coast, Ghana, Togo and Benin, in the north-east Niger. The former French colony gained its independence in 1960. The name Burkina Faso was adopted in 1984 and means "The Land of the Incorruptible People". The capital Ouagadougou is 500 miles (about 800 km) from the Atlantic Ocean and is the center of the country[1].

Figure 1 – Map of West Africa

Figure 2 – Map of Burkina Faso

In the 50s the rain came very irregularly, and it rained a lot less than usual. One famine followed another, and many people died of starvation.

The farmers' traditional methods were not efficient to have enough to feed the families. Indeed, the farmers tilled their fields with the "daba", a short-handled hoe, they did not sow in lines and did not add any compost. The crops were not always sufficient for the family to survive.

Figure 3 – Before 1959, the soil was tilled with a small hoe, called 'daba'

Figure 4 – Three types of the "daba" hoe

The civil as well as the religious leaders tried to find solutions to this evil.

Monsignor Joseph Bretault, Bishop of Koudougou, asked Antoine Mailliet, a young Luxembourgish farmer, to come to his diocese to possibly find a solution to the problem of malnutrition in the population. Antoine Mailliet eventually succeeded. He harnessed donkeys with self-made collars. In this way, the donkey that usually transported big pieces of salt on its back from the Sahara to the South, became a draft animal.

1 Map, URL: http://www.transafrika.org/pages/laenderinfo-afrika/burkina-faso/geographie.php [09-02-2022].

Figure 5 – The smith of Lumbila (BF) still produced Antoine Mailliet's donkey collar in 2003

Figure 6 – 1960, two farmers in formation at Imasgo demonstrate how to plow with a donkey harnessed with a collar

Many old men were opposed to the innovation and did not want to change their traditional methods. The catechists and the technical agents of the Ministry of Agriculture as well as the ten Luxembourgish volunteers who worked from 1959 to 1969 with the financial and moral support of the Young Catholic Farmers and Winegrowers of Luxembourg under the leadership of Reverend Henry Spoden S. J., continued the promotion of the draft donkey. From 1963 to 1969, the organization "Secours Catholique", France (French Catholic Help) supported the project financially too[2].

Antoine Mailliet was stationed in Imasgo, where the National School for Catechists was established. He formed the catechists in draft donkey labor and the new agricultural methods. When the trained catechists were sent to different parts of the country, Monsignor Joseph Bretault provided them with a pair of donkeys with the necessary harness, a plow, and a donkey cart. The recipients had to pay back the cost of the equipment in three to five years. This was possible because the catechists harvested so much in their fields that they could sell part of the crops. In addition to their missionary work, they showed the local population the new farming methods with which they could fight the famine[3].

By becoming a draft animal, the donkey revolutionized the agricultural methods. The farmers ploughed their fields, sowed in lines, added compost to their fields and eliminated the weeds with a rake drawn by a donkey. The farmers' lives became easier, the crops grew, and the population had more to eat.

After 1959, the donkey, as a draft animal, became particularly important in transportation. As a donkey may easily pull a cart with 400 liters of water, the women and girls are relieved from bringing home the water on their heads. The harvests as well as all kind of material can be transported with the donkey carts – the everyday life of the people became easier[4].

Figure 7 – The draft donkey became an important help in transportation

The donkey is strong, undemanding and perfectly adapted to West Africa's climate. As the purchase cost is not too high, most families can own one or two donkeys.

The donkey collar made with the wood of the region and the materials available on site, can easily be produced by the blacksmiths of the village.

The "Manga Hoe", a multipurpose agricultural tool, invented by a missionary and a smith in the village of Manga, made many processes possible by using only one tool on which the implements could be changed.

2 Coopération au développement agricole en Haute-Volta.
3 Mailliet/Scheidweiler 1999.
4 Lëtzebuerger Jongbaueren a Jongwënzer – Service Coopération a.s.b.l 2010.

At the instigation of Mr. Jean Feyder, Director for Development Cooperation in the Luxembourg Foreign Ministry, an impact study was carried out in Burkina Faso in 2003.

- 'It was intended to give the public an insight into the socio-economic connections and effects of draft donkey in Burkina Faso, which was largely initiated by young Luxembourgish development workers. In addition to its summary results, the study concludes that the development aid that was applied 40 years ago (from 1959-2003) is still bearing its economic and social fruits today[5].

The following advantages of the donkey as a draft animal are particularly appreciated by the farmers:

- Ease of work
- Increases in income
- Expansion of the cultivation area
- Time savings in the cultivation work
- Sources of income through new services for third parties, e.g., transport and agricultural work[6]

Although many farmers considered the donkey as their "first son", they put an old tire around the donkey's neck, instead of using a collar to harness the animal. Often, they did not feed it properly and did not treat the animal well.

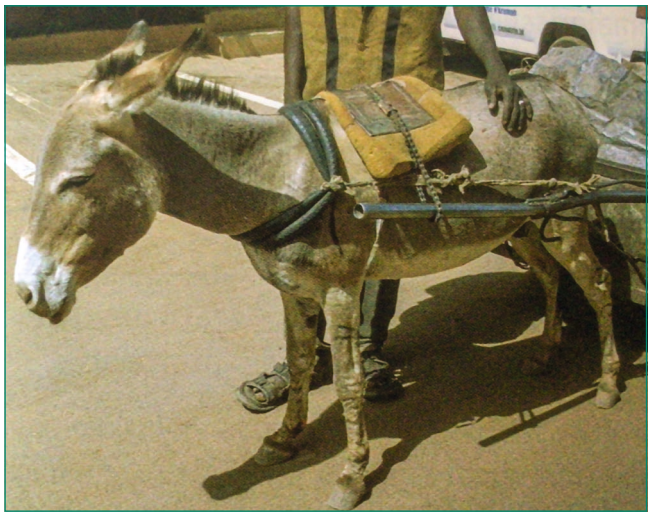

***Figure 8** – A donkey harnessed with an old tire*

To redress this deplorable situation, the young farmers in cooperation of the Ministry of Development of Luxembourg built a training center in Imasgo. From 2008 to 2016, over 1300 farmers learnt to work with the animal and how to treat it correctly. The kassine, a new modern multipurpose agricultural tool, was introduced and promoted at the same time[7].

***Figures 9-10** – Toilets and showers for farmers in formation / Stable for 20 donkeys*

Prommata was created in Ariège, France, in 1991, at the initiative of Jean Nolle (1918-1993) and a few farmers. Heirs to Jean Nolle's philosophy of versatility, Prommata designed the kassine in 1994, one year after the death of its honorary president and founding father[8].

Different accessories may be attached on the kassine without many difficulties.

- The farmer pulls a lever up to take the tool out
- Another tool is inserted into the frame of the kassine
- The lever is set down
- The tool is kept in the frame by the draft force
- There is no need to loosen a screw

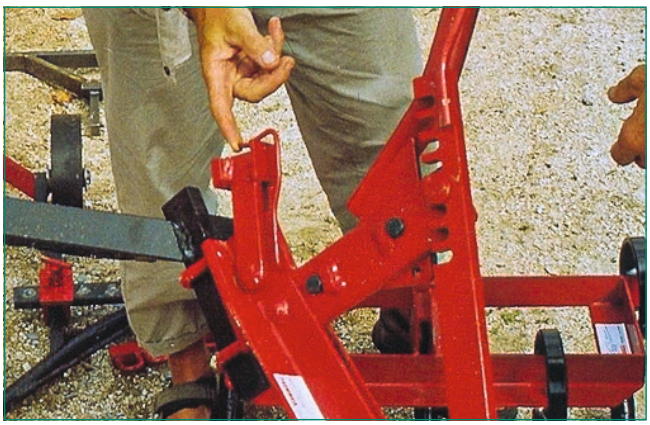

***Figure 11** – Process of changing a tool: Pull the lever up*

5 Feyder 2020.
6 Lëtzebuerger Jongbaueren a Jongwënzer Service Tiers-Monde a.s.b.l. 2004.
7 Id. 2016.
8 Jo Ballade 2021, oral statement.

***Figure 12** – Take out the tool*

***Figure 13** – Insert another tool, set down the lever*

***Figure 14** – The tool is kept in the frame by the draft force as shown by the demonstrator*

To promote the draft donkey on a larger scale, four local training facilities have been built in four villages belonging to different regions: Imasgo (Boulkiemdé), Tiogo (Sanguié), Sabouna (Yatenga) and Koalma (Sanmatenga). Four trainer teams of five members each are teaching draft donkey usage to nearly 11000 farmers in these areas counting 28 villages with a population of about 82000 inhabitants. The project began in 2018 and was closed in 2021. At the end of the project, about 55000 villagers benefited directly or indirectly from this project[9].

The kassine is excellent to prepare a field with the "zaï" method. The "zaï" consists in cutting the hard soil with a sort of knife attached to the kassine before the beginning of the rain season. The farmer draws a square pattern of lines on his ground. At the intersection point of two lines, they dig a hole wherein they put the seeds and the compost.

9 Monville 2018.

***Figures 15-16** – Mechanized "zaï" on a demonstration plot in Gomponsom (Passoré)*

To prepare a hectare without any draft animal, ten persons work for 300 hours to have the job done. With a kassine drawn by a couple of donkeys and two persons to lead them, the hard craft is finished within 40 hours.

The "zaï" method has the advantage that the water is recuperated and kept for a long time in the hollow dug by the farmer at the intersection of two lines. In this way, the plant has a better chance to survive and to grow, even if there is a lack of rain for a certain time[10].

The kassine is used with much benefit in transforming the so-called "zippélés" (areas of infertile soil) into fertile agricultural land by treating the soil with the "zaï" method.

***Figure 17** – Demonstration plot in an infertile area showing the best effects of the use of the kassine and the "zaï" method*

Furthermore, to stabilize the soil and to retain as much as possible of the rainwater, which is not so abundant, the farmers pile up stones in long lines that form terraces like small dams, called in French "diguettes" or "cordons pierreux".

***Figure 18** – Piled up stones form small dams to retain the rainwater – the picture was shot nearby Sabouna (Yatenga)*

Due to the high prices of the kassine and its accessories, the material is not accessible to everyone. Therefore, the creation of famers' cooperatives to access to agricultural inputs and material as well as the building of management capacities are essential. They are promoted by the training teams of the local training facilities.

The four training teams in the four training centers promote the idea of the usage of draft donkeys, the multiple use of the kassine and of compost, the method of "zaï", in setting up demonstration plots, in commenting the results and in broadcasting the efficient methods. They point out the donkey's behavior, its specifications, its needs, its food, and hygiene. They teach the correct treatment and education of the donkey, so that it becomes a reliable work companion. It is important to have the correct harness for the animal to do its work without being wounded by an inadequate gear. Furthermore, the teams introduce and train the farmers to act in cooperatives[11].

We are convinced that all these methods help fighting the famines and are guaranteeing a far better life to the farmers and to their families than in former times. The usage of draft animals has a future because it is an ecological way of tilling the soil, it is adapted to small-scale farms, and it gives best results[12].

10 Id. 2020.

11 Id. 2021.

12 Lhoste et al. 2011-2021.

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Author info

Marcel SCHEIDWEILER

Ex-development aid volunteer (1960-1961), project manager (2008-2012)
Lëtzebuerger Landjugend a Jongbaueren Service Coopération A S B L
9A, rue de Hosingen · L-9466 WEILER-PUTSCHEID
GRAND-DUCHÉ de LUXEMBOURG

E-Mail: marcelsr@pt.lu

Digital paper: https://youtu.be/l7BhhKi5aEM

Author info

Lëtzebuerger Landjugend a Jongbaueren Service Coopération A S B L:

Romain RICHER, president
Marie-Claude MARX, vice-president
Philippe MITSCH, vice-president
Jacqueline MONVILLE, project manager
François GLODT, secretary, ex-development aid volunteer
Marcel SCHEIDWEILER, ex-development aid volunteer, project manager (2008-2012

Draught animals in ancient Mesopotamia and today: the invaluable donkey

Jill Goulder

Abstract

Donkeys have commonly been undervalued in discussion of draught animals in antiquity, due partly to a traditional emphasis on oxen, but also a result of their general archaeological invisibility, with their remains only rarely found in food middens.

My work focuses on Mesopotamia in the 4th-3rd millennia BC. Donkeys, native to north-east Africa and brought as domesticates to Mesopotamia, were initially eclipsed in archaeological consideration by a powerful model of cattle traction proposed by Andrew Sherratt in his Secondary Products Revolution hypothesis. Cattle were indeed employed for traction in Mesopotamia from an early stage. Donkeys were acknowledged by commentators as long-distance pack animals, but recognition of their widespread use for traction from the 3rd millennium BC – as evidenced in cuneiform texts and depictions – is only now coalescing in archaeological discussion.

Modern development studies of working animal use, notably in sub-Saharan Africa, demonstrate the various virtues of working donkeys over cattle, for small farms in particular. While cattle have more tractive power for heavy soils, and can have value for milk and later meat, they require rich pasture and plentiful water. Donkeys are drought-tolerant and low-maintenance, requiring little herding and able to live on low-grade foraged materials; behaviourally, donkeys are far easier to train and handle. They are widely used for draught (ploughing and carting) in various regions, but working-animal use must be addressed holistically: donkeys are additionally invaluable for pack work, capable of carrying far more per live-weight than cattle.

Résumé

L'âne a souvent été sous-estimé dans les discussions sur les animaux de trait dans l'Antiquité, en partie à cause de l'accent traditionnel mis sur le bœuf, mais aussi à cause de son invisibilité archéologique générale, ses restes n'étant que rarement trouvés dans les dépôts de nourriture.

Mon travail se concentre sur la Mésopotamie du 4e au 3e millénaire avant Jésus-Christ. L'âne, originaire du nord-est de l'Afrique et domestiqué en Mésopotamie, a d'abord été éclipsé dans la considération archéologique par un puissant modèle de traction bovine proposé par Andrew Sherratt dans son hypothèse de révolution des produits secondaires. Le bétail a en effet été employé très tôt pour la traction en Mésopotamie. Les ânes étaient reconnus par les commentateurs comme des animaux de bât sur de longues distances, mais la reconnaissance de leur utilisation généralisée pour la traction à partir du 3e millénaire avant J.-C. – comme en témoignent les textes et les représentations cunéiformes – n'apparaît que maintenant dans les discussions archéologiques.

Les études modernes sur le développement de l'utilisation des animaux de trait, notamment en Afrique subsaharienne, démontrent les diverses vertus de l'âne par rapport au bétail, en particulier pour les petites exploitations. Si les bovins ont une plus grande force de traction pour les sols lourds, et peuvent avoir de la valeur pour le lait et plus tard la viande, ils ont besoin de pâturages riches et d'eau en abondance. Les ânes sont tolérants à la sécheresse et demandent peu d'entretien. Ils ne nécessitent que peu de gardiennage et sont capables de se nourrir de fourrages de qualité inférieure ; sur le plan comportemental, les ânes sont beaucoup plus faciles à dresser et à manipuler. Ils sont largement utilisés pour le travail de trait (labourage et transport) dans diverses régions, mais l'utilisation des animaux de trait doit être abordée de manière globale: les ânes sont en outre très précieux pour le travail de bât, car ils sont capables de porter beaucoup plus, pour un poids vif équivalent, que les bovins.

Kurzfassung

Esel wurden in der Diskussion über Zugtiere in der Vergangenheit häufig unterbewertet, was zum Teil auf die traditionelle Fokussierung auf Ochsen zurückzuführen ist, aber auch auf ihre allgemeine archäologische Unsichtbarkeit, da ihre Überreste nur selten in Speisegruben gefunden wurden.

Meine Arbeit konzentriert sich auf Mesopotamien im 4. bis 3. Jahrtausend vor Christus. Esel, die in Nordostafrika beheimatet waren und als Haustiere nach Mesopotamien gebracht wurden, wurden in der archäologischen Betrachtung zunächst von einem mächtigen Modell der Rinderzugkraft verdrängt, das Andrew Sherratt in seiner Hypothese der Secondary Products Revolution vorschlug. Tatsächlich wurden Rinder in Mesopotamien schon früh als Zugtiere eingesetzt. Esel wurden von Berichterstatter:innen als Langstreckentransporttiere angesehen, aber die Tatsache, dass sie seit dem 3. Jahrtausend v. Chr. in großem Umfang als Zugtiere eingesetzt wurden – wie dies in Keilschrifttexten und Darstellungen belegt ist – wird erst jetzt in der archäologischen Diskussion anerkannt.

Moderne Entwicklungsstudien über die Nutzung von Arbeitstieren, vor allem in Afrika südlich der Sahara, zeigen die verschiedenen Vorzüge von Eseln gegenüber Rindern, insbesondere für kleine Betriebe. Rinder haben zwar eine höhere Zugkraft für schwere Böden und können für Milch und später für Fleisch wertvoll sein, doch benötigen sie reichhaltiges Weideland und reichlich Wasser. Esel sind trockenheitstolerant und pflegeleicht, sie müssen nur wenig gehütet werden und können sich von minderwertigem Futter ernähren; außerdem sind sie viel leichter zu trainieren und zu handhaben. Sie werden in verschiedenen Regionen häufig als Zugtiere (zum Pflügen und für Fuhrwerke) eingesetzt, aber die Nutzung als Arbeitstiere muss ganzheitlich betrachtet werden: Esel sind außerdem von unschätzbarem Wert für die Arbeit als Lasttiere, da sie pro Lebendgewicht weit mehr transportieren können als Rinder.

Resumen

Los burros han comúnmente sido infravalorados en los debates sobre los animales de tiro en la antigüedad, debido en parte al énfasis tradicional en los bueyes, y por otra parte como resultado de su invisibilidad arqueológica general, con sus restos rara vez encontrados en basureros de comida.

Mi trabajo se centra en Mesopotamia de los milenios IV y III a.C. Los burros, nativos del noreste de África y llevados como animal domesticado a Mesopotamia, fueron inicialmente eclipsados en la consideración arqueológica por un poderoso modelo de tracción de ganado propuesto por Andrew Sherratt en su hipótesis de la revolución de los productos secundarios. De acuerdo que el ganado se empleó para la tracción en Mesopotamia desde una etapa temprana. Los burros fueron reconocidos por los comentaristas como animales de carga de larga distancia, pero no es hasta que la actualidad que el reconocimiento de su uso generalizado para la tracción a partir del tercer milenio a.C, como se evidencia en los textos cuneiformes y representaciones, solo ahora se está fusionando en la discusión arqueológica.

Estudios modernos sobre el desarrollo del uso de los animales de trabajo, sobre todo en el África subsahariana, demuestran las diversas virtudes de los burros en comparación con el ganado bovino, en particular para las pequeñas explotaciones. Aunque el ganado tiene más fuerza de tracción para los suelos pesados, y puede tener valor para la leche y más tarde para la carne, requiere ricos pastos y abundante agua. Los burros por el contrario son tolerantes a la sequía y requieren poco cuidados, ya que pueden vivir con materiales forrajeros de baja calidad; en cuanto a su comportamiento, son mucho más fáciles de entrenar y manejar. Se utilizan mucho para el tiro (arado y carreta) en varias regiones, pero el uso de los animales de trabajo debe abordarse de forma integral: los burros son además inestimables para el trabajo de carga, ya que son capaces de transportar mucho más por peso vivo que el ganado.

Introduction

This paper is less a setting-out of a hypothesis than an information piece offered to a draught-animal audience, bringing to notice the invaluable historic and present-day role of donkeys for ploughing and other traction, in antiquity and to the present day. For my doctoral thesis[1] and recent book[2] – 'Working Donkeys in 4th-3rd Millennium BC Mesopotamia: insights from modern development studies' – I have employed a novel interdisciplinary approach to examination of the day-to-day role and impact of working animals on communities in antiquity, through analogy with published studies of modern developing-world cultures using donkeys and cattle for work in circumstances bearing some relation to situations in antiquity. I focus on ethology (the study of innate animal behaviour) and animal physiology, placing the daily practicalities of the animals at the centre. I argue for modern analogical material, suitably used, forming a valuable guide to archaeological researchers through greater consciousness of the ubiquitous but often invisible presence of working animals from antiquity to today.

For my doctorate and book, I consulted several hundred published studies on modern use of working animals worldwide, for establishment of themes and analogy with the possible situation in antiquity. My research included brief study trips to Burkina Faso (2013) and Ethiopia (2014), less for the collection of significant original material than to gain understanding of the environment relating to the many studies which formed the data-set for my thesis and book.

I cite my open-access thesis[3] repeatedly in this paper as it contains the same material as my book[4] but is freely available online and provides a very large body of references to my subject-matter, without overly clogging this paper with references[5].

Draught animals in the Ancient Near East

Domestication of cattle and donkeys for work

The systematic adoption of animals for work constituted a new paradigm in human-animal relations, with a new focus on living individuals and the means of obtaining their cooperation[6], requiring entirely new skills in training and handling as well as of husbandry and maintenance. I describe below how in many discussions of early use of animals for traction in the Ancient Near East in particular, a Western-centric mindset has persisted in which ploughing and by extension all agricultural work is carried out with (male) cattle, applying mediaeval northern European (ox-ploughing) models to regions further East with very different soils, climates and available animals. This bias has contributed to the neglect until recently of study of the impact of both donkeys and (female) cows as plough animals in antiquity, despite the common worldwide use of both today for ploughing in arid, light soils in particular.

1 Goulder 2018.
2 Id. 2020.
3 Id. 2018.
4 Id. 2020.
5 Details of my other publications on this subject are given on my website, URL: https://jgoulder.com/archaeology/publications.html.
6 Meadow 1984, 310.

Sherratt's secondary products model

While donkeys were domesticated primarily for work, the majority (though not unchallenged) view is that cattle were initially domesticated for meat, in the 8th or even 9th millennium BC in the Ancient Near East[7]. Sherratt[8] took the view that although localised adoption of ploughing with cattle took place from perhaps the 6th millennium BC, with some possible earlier use for threshing, the systematic use of yoked oxen for ploughing in Mesopotamia emerged rapidly in the 4th millennium BC. This formed a central element of Sherratt's far-reaching Secondary Products model[9] concerning the exploitation of animal secondary products – labour, milk and wool.

He originally argued that these products were evolved or adopted as a package in the 4th millennium BC, including an ox-plough/cart 'traction complex, with its own technology, ideology, and attitude to domestic livestock'[10] (oxen being castrated male cattle), with a distinct but roughly contemporary enlistment of equids for long-distance pack transport[11] (***Figure 1***). Engels, Goody, Comaroff, Boserup[12] and others have also evolved high-level models of wealth disparity, social status, labour use, community and kinship interaction emerging from adoption of ox-ploughing, notably in relation to the role and status of women. It has become evident through my new research, though, that such approaches risk bypassing key findings, not least in relation to the use of donkeys and (female) cows for work.

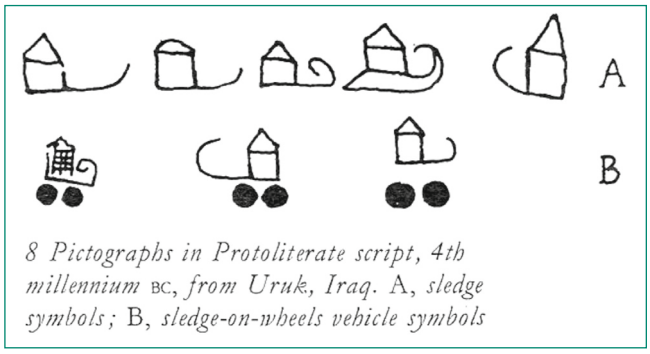
Figure 1 *– Sherratt's ox-centric view of early working animal use in 4th millennium BC Mesopotamia*

Original model and modifications

Sherratt's model focused on the transmission of specific hardware – the plough and the cart – between the Near East, Europe and the Central Asian steppe[13]. Sherratt initially included the horse in his model[14], suggesting a steppe 'package' of horse and ox-cart, and this may well have influenced Sherratt's relative neglect of pack-donkeys in Mesopotamia[15]. However, he later[16] withdrew horses from his scenario. Wheeled vehicles, as epitomised by the famous 4th-millennium BC Mesopotamian

7 Goulder 2018, 57.
8 e.g. Sherratt 1983, 98.
9 Id. 1981
10 Id. 1997a, 240.
11 Id. 1981, 295.
12 Boserup [1965] 2005; Comaroff 1985; Engels 1884; Goody 1976.
13 Sherratt 1981, 266, 288.
14 Ibd., 272pp.
15 Ibd., 295.
16 Id. 1997b, 31.

pictographs[17] (***Figure 2***), have been held up as an emblematic feature of the period; but Sherratt and others later concluded that wheeled vehicles at this early time were principally for ritual or prestige use.



8 Pictographs in Protoliterate script, 4th millennium BC, *from Uruk, Iraq.* A, *sledge symbols;* B, *sledge-on-wheels vehicle symbols*

***Figure 2** – Pictographs on clay tablets from Eanna IVa at Uruk-Warka, showing possible late 4th millennium BC sledges and wagons*

Archaeological thought now generally takes the view that there was not a moment of innovation or a package involving the close interrelation of several secondary products and traction modes diffusing as a unit. The preponderant use of oxen for early ploughing in Mesopotamia is also perhaps more assumed than indicated: Englund points out that in the earliest texts in the late 4th millennium BC

> *[o]nly several uncertain accounts register together the existence of both the plow represented by the sign APIN and oxen represented by the sign GU4. Whether oxen played a large role in field work in the Late Uruk period is thus a matter of conjecture.*[18]

A 4th millennium BC Mesopotamian cylinder seal illustration (***Figure 3***), of two men attempting to control a working bull, is much cited but may relate more to prestige than to mainstream farming practice.

***Figure 3** – Late 4th millennium BC seal showing two men controlling a working bull*

State-controlled working-animal activity in Mesopotamia in the 3rd millennium BC is meanwhile recorded in detail in the cuneiform texts, with increasing material being published on the use of donkeys for pulling ploughs and carts[19] (***Figure 4***). There is, too, growing archaeological evidence of small-scale independent farming in a region formerly thought of as fully under state control[20]; ample modern example indicates that a single animal (often a cow or a donkey) ploughing with a home-made ard or pulling a cart fulfils the subsistence needs of a small-scale farmer.

***Figure 4** – Impression of a cylinder seal, ED III (ca. 2400 BC). Upper register: equids (donkeys or hybrids) pulling a plough with a seed-funnel*

Invisible donkeys

Donkeys are native to north-east Africa, favouring rocky desert regions. Early *ad hoc* domestication of donkeys may have occurred there in the 5th millennium BC among mobile cattle-herding groups, for camp moves[21]. More intensive adoption may then have occurred where these mobile groups interacted with sedentary farmers, at the edge of the Nile valley[22]. Meanwhile, domesticated donkeys travelled from Egypt to the southern Levant, on the pack trail that famously became a vital artery for a time for supplies of wine and oil to Egypt[23].

The earliest potential indicators of use of donkeys for work in Mesopotamia, and indeed anywhere, are a depiction on a 5th millennium BC sherd from Fars in highland south-west Iran of a donkey with a possible blanket or pannier[24], and faunal remains from 4th millennium BC Tell Rubeidheh on the long-distance route east between southern Mesopotamia and the Zagros mountains[25]. While there is still debate on the presence of wild *Equus asinus* in Mesopotamia, working donkeys in this region are most likely to have been introduced as domesticates. In the 3rd millennium BC, faunal, textual and representational evidence of donkey use for ploughing and drawing carts has become common[26].

Detection of the presence of working donkeys in antiquity is considerably impeded by the low incidence of donkey skeletal remains. In the history of archaeology, most animal-bone finds come from food-refuse middens, often in urban environments. Such middens form for example a key source of evidence of working cattle, as the latter are almost universally used for meat at the end of their working lives, and their bones can be examined for work-related pathologies; but there is still a paucity of recognition of the different deposition processes that apply in the case of donkeys. In many regions through-

17 Piggott 1979, 5.
18 Englund 1995, 33.
19 e.g. Zarins 2014, 193-197.
20 Goulder 2018, 48-52.
21 Ibd., 58.
22 e.g. Zarins 2014, 109.
23 Goulder 2018, 59.
24 Potts 2011.
25 Payne 1988.
26 Goulder 2018, 60.

out history and to the present day, there is marked evidence of cultural (and practical) reluctance to eat working equids[27], with corresponding scarcity of bones in settlements. In addition to the issue of low incidence in food-middens, the remains of donkeys are unlikely to be found where they work (and die), as for practical reasons the carcasses may be dragged to unfrequented areas and their bones perhaps destroyed or scattered by predators. Archaeologically, the unique formation processes influencing deposition of donkey bones therefore result in a find-pattern that cannot be taken to reflect the living animals' incidence or distribution. The presence of animals used for work but not generally eaten can therefore be seriously underestimated, and one of my research aims has been to address this.

Draught animals today

Working animals are widely used in Africa and in much of Asia and Latin America, and still on a smaller scale in parts of Europe[28]. Use of working animals in sub-Saharan Africa has attracted particular promotional effort and study, and in this paper I focus on this region. The recent history and present-day usage of cattle and donkeys for traction in sub-Saharan Africa is authoritatively covered in this volume by Bertha Mudamburi and Paul Starkey's invaluable overview, 'Draft animal issues, constraints and opportunities in Africa'. As their paper describes, animal traction in sub-Saharan Africa featured very patchy adoption until the early 20th century AD, notably among small-scale farmers. While some pack donkeys had travelled through from north Africa, and although cattle were kept for meat, milk, blood and dung, there was very little use of working animals in many regions[29]. Commentators have put forward a range of reasons for this: the endemic animal disease in some regions, the persisting slave culture in many areas, the shifting hoe cultivation commonly used, and (though this is a debated issue) the wide physical and cultural separation between farmers and nomadic cattle-herders.

As Mudamburi and Starkey note, in the first half of the 20th century AD under various colonial and post-colonial official schemes, draught cattle were introduced into a number of regions, driven by a new emphasis on cash crops such as cotton and peanut[30]. Both early and later schemes often faltered or failed as a result of poor research, planning and cultural understanding: equipment was heavy and inappropriate, cattle died from the tsetse-transmitted disease trypanosomiasis, additional factors such as labour for other activities were not taken into account, too many changes were introduced at once, and adoption was hampered in some regions by heavy-handed regulation on local groups to protect the income of European settlers. Boserup[31] concurs that in many parts of the world colonial and independent governments drove overly towards commercial crops, but also blames the over-theoretical advice given and advisors often seeming 'to take it for granted that the cultivators have a preference for regular employment and are willing to give up seasonal leisure for a very modest compensation in additional output.'[32]

In some regions, these productivity-led initiatives then developed post-war into an emphasis on mechanisation, and this intensified in the post-colonial era as new governments worked to establish their modernising credentials[33]. Government authorities in various regions began reducing economic support for animal traction: Tibbs[34] alerts us to the attitude of organisations such as the World Bank, who in 1987 explicitly withheld research funding *'"[b]ecause of the simplicity of animal draft technology"'* which therefore was not perceived as requiring it. As Mudamburi and Starkey describe, this gap was filled by a series of major locally-generated research initiatives, international colloquia and expert consultations led instead by NGOs and the private sector[35]. The pioneering West Africa Animal Traction Network led on to the Animal Traction Network for Eastern and Southern Africa (ATNESA), which became an invaluable force for animal traction adoption in sub-Saharan Africa. By the start of the 21st century AD, hoe agriculture still predominated in sub-Saharan Africa but animal traction had become significantly more widely used than mechanical means[36].

The many studies published by ATNESA and others[37] highlight the complexity of farm and household systems which utilise working animals, and the central importance of their multifunctional role, of which ploughing is only a part. These studies chastise certain (urban) official bodies in Africa and elsewhere, who have often regarded donkeys as old-fashioned technology not in keeping with their modernising approach[38]. Traction with a pair of oxen was, though, a high-investment system, and some farmers turned to the lower-maintenance donkey, and to light tillage rather than heavy ploughing[39]. In heavy, damp soils as in northern Europe, soil inversion can be useful in killing off weeds and harmful insects; but in the light, arid soils common in the Near East and parts of Africa deep ploughing is increasingly considered to be damaging to soil structure and water content[40]. Meanwhile the donkey can off-duty be a far more flexible resource for pack and traction functions on and around small farms in particular.

Several commentators underline how adopters of working animals for ploughing may in practice take more interest in their use for farm transport or for income-earning transportation for others, particularly in the case of donkeys. Starkey[41] reports how some African farmers, having been encouraged to invest in animals for ploughing, return to manual cultivation and use their animals instead for profitable work transporting for others; in Zambia, Lubumbe[42] reports that farmers supplied with oxen on a loan basis for ploughing instead used them 'almost entirely for transportation in order to earn enough money to pay back their loans in the shortest possible

27 Ibd., 122-126.
28 e.g. Starkey 2011.
29 Ibd., 37,39pp.
30 Ibd., 39p.
31 Boserup [1965] 2005, 65.
32 Ibd., 66.
33 Goulder 2018, 40.
34 Tibbs 1989, 3.
35 Lhoste 2004, 128f.
36 e.g. Vall et al. 2002, 117.
37 Goulder 2018, 29,366-409.
38 Ibd., 29
39 Goulder 2018, 131.
40 Ibd.
41 Starkey 1994, 75.
42 Lubumbe 1994, 367.

time'. Authorities focusing on cash crops and a specific agricultural model made vain attempts to stem this shift: in Ivory Coast at one point ox-carts were even not issued to farmers because their use would divert cattle from use in cotton cultivation[43].

Hiring and sharing

This brings up a factor barely touched upon in studies of working-animal use in antiquity, of the very common practice in modern developing regions of sharing and hiring/renting of working animals[44], spreading the cost, responsibility and benefit. For working oxen, the economic importance of year-round utilisation levels is at least as much a driver for hiring out as is demand from non-owners, given the high investment/maintenance costs. This was an active process by at least the early 2nd millennium BC, with arrangements between owners and other users recorded in legal and commercial cuneiform texts.

Donkey hiring/sharing systems have a very different structure, given their much lower cost and maintenance needs, and relate more to their multi-purpose use for transportation, in a flourishing system of hiring, lending and communal ownership. This is a central part of the donkey-using industry, enabling wide access to donkey transport for low-income groups – notably for women.

The case of Ethiopia

A notable exception to the rarity of working animals in sub-Saharan Africa until recent times is Ethiopia. This large country has a growing human population of 80-100 million, 7-8 million oxen[45], and a growing donkey population of ca. 6.5 million[46]. Mechanisation of ploughing and transport activities is very low, and there is considerable NGO focus on working animals. The 'maresha' wooden ard-plough is thought to have been used here for at least 3,000 or even 5,000 years, possibly brought in from Egypt/Arabia or developed independently[47] (***Figure 5***).

Figure 5 *– Jill Goulder interviewing maresha ard-plough farmers in Western Ethiopia*

43 Landais/Lhoste 1990, 222.
44 Goulder 2016; Id. 2018, 172.
45 Starkey 2011, 12,33.
46 Donkey Sanctuary pers. comm. 2014.
47 Goulder 2018, 38.

Caveats for modern development studies

As Mudamburi and Starkey underline, the findings of modern studies should not of course be accepted unconditionally. Farnham[48] points out that African animal traction studies may range from anthropological modelling to accounts by agricultural engineers and agronomists, the latter sometimes based on trials at research stations rather than in the field; their agenda, often devised by urban-based official agents with little on-the-ground knowledge, is the promulgation of possibly isolated positive results in a drive to encourage local farmers to adopt new 'modern' agricultural systems. Meanwhile, NGO-commissioned studies of the use of working animals in developing regions specifically address social and economic aspects, but are likely to pitch their sampling and reporting in line with their worthy aim of improving conditions for animals and encouraging donations, with the potential result of polarising findings into pre-intervention (bad) and post-intervention (good)[49].

Working animals and women[50]

In many regions worldwide today, there are significant barriers to women ploughing with cattle[51] – though there is less of a taboo for use of female cows[52]. There is a large body of anthropological discussion on the exclusion of women from wealth and status through cultural barriers to their ownership and use of cattle, which I shall not go into here. Reports on agricultural studies of ploughing-animal use in sub-Saharan Africa and elsewhere commonly record entrenched local views that ploughs and cattle are too heavy and difficult for women[53] and that men consider it unsuitable for women to handle cattle; women themselves may feel culturally or physically deterred; there may of course be other factors such as the presence of young children.

Comaroff[54] underlines the long history of male ownership of 'prestige' cattle and argues the consequent ousting, though male plough use, of women from their traditional role as agriculturalists. Men may of course wish to ensure continuing labour for 'female' work such as transporting water and fuel and carrying out manual field tasks. Africa nevertheless has plentiful examples of female involvement in handling cattle, and women plough in parts of Botswana, Malawi, Tanzania, Zambia and Botswana[55]. Anthropologists hoping for overarching models are meanwhile defied by the intricate variations in sub-Saharan Africa in particular, where 'interdependent and complementary female and male farming systems exist alongside each other'[56].

In contrast to cattle, throughout history and to the present day donkeys are commonly despised – notably by non-users – and regarded as low-status. An FAO (Food and Agriculture Organization of the United Nations) working paper on animal traction worldwide notes that 'donkeys have fewer associations with masculine power

48 Farnham 1997, 29-34.
49 Goulder 2018, 34.
50 Id. 2016.
51 Id. 2018, 249-253.
52 Ibd., 81.
53 Ibd., 251.
54 Comaroff 1985.
55 Goulder 2018, 252.
56 Sylwander 1994, 261.

Figure 6 *– Woman transporting water, central Burkina Faso*

than most other work animals'[57]. This provides women with consequent (or possibly causative) freedom to employ donkeys without the cultural constraints attached to cattle (***Figure 6***).

Donkeys versus cattle for work: physiology

Donkeys and cattle often have complementary roles on the farm: donkeys for flexible use including pack, cattle for later meat value and (if female) milk. Oxen have greater absolute power (see table below) for heavy soils, but a higher purchase and maintenance cost, including the issue of theft due to their greater value. Donkeys are strong for their feed input (see table), low-maintenance and may have a longer working life; they are easy to train and handle and require little supervision.

Physiology

Oxen have powerful shoulders but a relatively weak chest, and a yoke is designed to be powered by the shoulders, with the yoke held forward by the ox's strong withers[58]. Donkeys have low, bony withers, with an equid's long slender thin-skinned neck and muscular concentration in the chest. Early depictions of state-controlled animal ploughing in Mesopotamia indicate that it was normally carried out with a pair of animals and a yoke, and this system persists in some regions to the present day; this militates against donkey use as the yoke is not suited to their body shape and restricts the power that they can deliver[59] (***Figure 7***).

Figure 7 *– Donkeys ploughing with an unsuitable yoke in Western Ethiopia*

Paired oxen are hard to turn as they are bulky and have relatively inflexible necks and insensitive hides; ploughing oxen generally therefore need to be led round turns, and the turning circles need to be large. In contrast, donkeys have a flexible neck designed for browsing and for watching for dangers while feeding; this, and their narrow bodies, allows them to turn sharply. Hagmann and Prasad[60] add that oxen, unlike donkeys, do not naturally tend to walk in straight lines.

Energy and work rates

Assessment of the relative benefits of using donkeys versus cattle in a farm environment is extremely complex[61]. Many published calculations, for example of hect-

57 Starkey 2011, 27.
58 Littauer [1968] 2002, 483.
59 Goulder 2018, 69.
60 Hagmann/Prasad 1995, 235.
61 Goulder 2018, 72.

ares cultivated per day, ignore a wide range of social and practical factors; but in practice, as is demonstrated daily in ancient and modern farm-based circumstances, farmers make rule-of-thumb decisions about the most suitable animal type and system to employ. *'A farmer will realise without any complex analysis whether using draught animals in a particular way (or at all) is profitable or not'*[62].

Calculating the comparative practical performance of working animals includes assessment of speed, force/output related to input in terms of investment, hours worked daily and coverage of the ground; this is influenced by particular empirical needs for the task in hand, such as a sustained hard pull, long hours, high speed, etc[63]. Figures are significantly affected by local situations and by the condition of the animals during the season, farmer skill, terrain and the work/rest cycle. Renger[64] concludes that in antiquity as now *'the human factor is decisive for increasing the effectiveness of animal power' in quality of 'training, guidance, feeding and care'*. Nevertheless, an attempt is made in the table below to provide comparative performance estimates and averages for ploughing donkeys and oxen from ethnographic and other information.

SPEED

- Ploughing speed (very contingent on local factors): oxen 2.3-2.5 km/hour, donkeys 2 km/hour[65]
- Balance to be struck between average speed, power output and number of hours of work (not a simple calculation although rules of thumb are habitually applied by users): *Equids are more suited to rapid low draught activities where their faster speed can be used to advantage. At higher draught forces, where speed is less important, the additional weight and power of cattle are an advantage*[66]
- Confusion in comparative accounts as donkeys (and female cows) generally plough more slowly than oxen but are faster for lighter work such as seeding and weeding[67], and for transporting items to and from the fields
- Oxen work slowly, at a single speed, but have greater endurance in heavy traction; donkeys have a wider range of speed, and better acceleration[68]
- The extent of rest periods, for the animals and the ploughing individuals, is a factor[69]
- In ploughing a key factor is the time that it takes to turn the animals (see above)
- Speed also decreases if the number of animals in a team is increased[70]: a trade-off is made between power and speed[71]

FORCE/OUTPUT

- Oxen are stronger for ploughing than donkeys in absolute terms[72] due to their extra weight
- Absolute weight can be better for tasks such as threshing
- However, the extra strength/weight is not necessarily required: farmers may shallow-plough, and the soil may be light and sandy[73], and not benefited by deep ploughing. Potts[74] notes that the 2nd-millennium BC Sumerian text *Farmer's Instructions*[75] recommends ploughing but is referring to a light ard, which would stir the earth to protect moisture but not dry out the ground as with a mouldboard plough
- Energy-rating studies conclude that donkeys can pull a larger percentage of liveweight than oxen[76]. Oxen are generally considered to be able to pull 10-12 % of their body-weight depending on breed and other factors such as harness and terrain; figures for donkey traction are rarer, but Prasad et al.[77] cite an FAO study stating that donkeys can pull 16-20% of their body-weight; Starkey[78] suggests a figure of 12-25 % of liveweight and up to 40% for short periods
- Unsuitable harness for donkeys (the yoke; see above) has a significant constricting effect

HOURS WORKED

- Oxen can typically plough for 4-5 hours/day, donkeys for 3-4 hours/day[79], though there are significant limiting factors including body condition
- The Prasad et al.[80] study cited above asserts that donkeys can only work for two hours before becoming exhausted, but as discussed this relates to unsuitably-harnessed animals. The authors themselves agree that it is very likely that use of a breastband would have increased the donkey hours worked, perhaps to equal those of cattle[81]
- Unlike cattle, donkeys do not require a rest period during the day for rumination; they graze more slowly than cattle, but graze at night

GROUND COVERAGE

- Accounts of ploughing with a pair of oxen and a simple plough indicate a normal coverage of c.0.2-0.4 hectares/day[82]
- Donkeys will cover less hectarage not only due to lower speed and possible earlier tiring, but because they can turn more sharply and so, crucially, plough more furrows per hectare[83]

***Table 1** – Energy and work-rate data for donkeys and cattle*[84]

62 Lawrence/Pearson 2002, 103.
63 Goulder 2018, 72.
64 Renger 1990, 275.
65 Goulder 2018, 537f.
66 Pearson/Vall 1998, 309.
67 Goulder 2018, 537.
68 Ibd.
69 Ibd., 424p.; Renger 1990, 269; Starkey 1989, 167.
70 Goulder 2018, 538.
71 Renger 1990, 271.
72 Goulder 2018, 475pp.
73 Ibd., 551pp.
74 Potts 1997, 73pp.
75 Black et al. 1998-2006.
76 Goulder 2018, 475pp.
77 Prasad et al. 1991, 237.
78 Starkey 1997, 193.
79 Goulder 2018, 475pp.
80 Prasad et al. 1991, 236.
81 Hagmann/Prasad 1995, 237; Prasad et al. 1991, 237.
82 Goulder 2018, 475-477.
83 Hagmann/Prasad 1995, 237.
84 Goulder 2018, 73p.

Feeding of working animals

A conundrum for keepers of working animals is how to allow them to graze for long enough (and on sufficient nutritious material) every day to replace weight lost through work effort[85]. A key differentiator between the husbandry methods appropriate for cattle and for donkeys is their physiology in relation to feed and water. Both cattle and equids process their food by fermentation; in cattle this occurs in the rumen, and in equids in the caecum – *'a blind sac at the junction of small and large intestines'*[86] – with an enlarged colon for storage. The rumen has limited capacity, and the rate of passage through the system is restricted by particle size, while the equid digestive system allows processing of bulky fibrous material: *'[d]onkeys' tough digestive system can break down near inedible vegetation and extract moisture from food more efficiently'*[87]. Donkeys, with their strong jaws, are more ready than cattle to browse on woody species, and there are accounts of donkeys surviving on bark, fish bones, kitchen waste, paper and equid manure[88].

> Left to their own devices, donkeys consume dry grass, bark, leaves, twigs and roots of preferred species of plants, even creosote bushes in desert areas – not because they are hungry, but because they like them. … Donkeys can become ill on rich food such as alfalfa/lucerne and lush spring grass.[89]

Jones[90] reports that while for (zebu) cattle almost half their intake must be high in carbohydrate and protein, for donkeys the figure drops to one-sixth, with much less need for total food and for high-nutrition food[91]. Barrett et al.[92] report from Burkina Faso that it costs four times more to feed oxen than donkeys.

Cattle graze by day, so the grazing area needs to be sufficiently near the working area and with access to plentiful water. Donkeys are slower feeders than cattle but habitually graze at night. Donkeys working today are commonly released after work and left to scavenge crop residue, dry grass and food waste[93]. Assessments of the length of time that cattle and donkeys can go without drinking are often speculative or anecdotal; both are said to survive at least 2-3 waterless days, but it is has been demonstrated by experiments that donkeys are significantly better able than cattle to withstand long periods between drinking without apparent stress or – importantly – loss of appetite, through a range of physiological and behavioural adaptations[94].

Practicalities of comparisons with antiquity

From earliest to modern times donkey-using cultures have encouraged free breeding with the wild and made little use of selective breeding[95]; unlike species kept for meat or milk, the size and vigour of wild donkeys were maintained during domestication as prized virtues, as were their low maintenance requirements. This gives grounds for confidence that the present-day standard medium-sized grey-brown donkey found worldwide bears performance comparison with those used in antiquity.

Concerning cattle, until the 4th millennium BC only *Bos taurus* was known in Mesopotamia. *Bos indicus* may have arrived at the eastern margins in the early 3rd millennium BC, and in southern Mesopotamia by the mid-3rd millennium BC. The reverse applies in Africa, where early domesticated cattle in Africa were taurines but from the 1st millennium AD these were increasingly hybridised with zebu (*Bos indicus*) stock from Asia. Zebu have various physiological advantages over taurines in hot, dry environments; but Galvin[96] notes that 100 % *Bos taurus* animals in modern Syria are fully heat-adapted, with convergence of characteristics with the zebu, and that *'genetic changes reflecting product specialization in bovids ... had taken place by at least 3000 BC'*[97] in Mesopotamia.

Donkeys versus cattle for work: behaviour

Donkeys are described by some as herd animals, but a better term is sociable: in the wild they form shifting associations with a small number of other individuals[98]; therefore, while they actively enjoy company, of their own or another species, and readily team up with other donkeys or humans, they also work well alone. In small groups as opposed to herds, signs of stress or pain are seen as indicative of dangerous weakness and the animal is excluded from the group, or if defending a territory is targeted for attack; in contrast in herds, reactions to threats alert the whole group so are seen as advantageous. The small-group characteristic translates into the well-known patience and stoicism of donkeys, as they are behaviourally adapted to showing few signs of pain. Unlike full herd animals, which have a strategy of fleeing from a threat (as predators should only catch the hindmost), donkeys become immobile or group and face a predator, as a good strategy in a small group under threat. They have a natural highly-developed sense of individual self-preservation, and their strategy is to 'freeze' and assess situations and obstacles cautiously before making a move, whether in dealing with a predator or if they do not understand what they are being asked to do or why[99]. This can be misunderstood in working situations as uncooperativeness or stupidity, and in the Western world and elsewhere donkeys are famously considered to be stubborn and difficult.

In studies of modern use in Africa and Asia, donkeys are widely agreed to be less demanding than oxen to control; they are not generally aggressive to humans and can be handled, harnessed and worked by a single individual, including women and children (***Figure 8***). Donkeys are also widely acknowledged to be quick to learn

85 Starkey 1989, 36.
86 Janis 1976, 759.
87 Yilmaz 2012, 17.
88 Goulder 2018, 169.
89 Yilmaz 2012, 69.
90 Jones 2008, 12
91 Yilmaz 2012, 35.
92 Barrett et al. 1982, 37.
93 Goulder 2018, 479-482.
94 Ibd., 171.
95 Ibd., 85p.
96 Galvin 1987, 123-126.
97 Ibd., 123.
98 Goulder 2018, 76.
99 Ibd., 76.

Figure 8 – Woman ploughing with a donkey in Ziniaré, Burkina Faso

from other donkeys and from humans, to remember their training longer than cattle[100] and to carry out tasks with minimal or no supervision[101].

Summing up

Working-animal practicalities

Robust ethnographic evidence demonstrates that key differences in maintenance needs between donkeys and cattle lead to very different trajectories as work animals, with implications from earliest use to today. The extra feeding and husbandry required by working cattle can provide eventual payback in terms of carcass value, but there has been a marked shift among farmers in parts of Africa to the lower-investment strategy of donkey power. Donkeys are physiologically more efficient than cattle at food and water processing and more behaviourally flexible in their feeding needs. Unless they are far from natural forage resources and engaged in full-time pack or vehicle work, they are often self-maintaining.

Accounts from throughout the African continent, of the expectations and actualities of adoption of working animals by farmers, give invaluable pointers to the learning curve experienced during their early systematic use in antiquity. The ethnographic evidence is that the drawbacks of adopting cattle for work (notably labour demands for foddering and penning) may have been outweighed by levelling factors such as hiring out. A different equation applies for the adoption of donkeys which, despite their more limited meat and milk potential, offer high work return on very low foddering and grazing outlay.

Working animals in ancient Mesopotamia

To date there has been very little archaeological focus on systematic use of working donkeys in late 4th and 3rd millennium BC Mesopotamia. A contribution to this lack of *'donkey-mindedness'* may be historical species availability, with donkeys not a feature of northern Europe, resulting in donkey-blind Western-centric models of early working-animal systems. There has also been undue reliance on elite-commissioned representations of oxen and ploughing in possibly ceremonial contexts. It is often insufficiently acknowledged that donkeys for traction appear in texts from the late 4th millennium BC and are commonly listed as employed in agricultural operations in the 3rd millennium BC. Their near-absence from the excavation record too readily results in their neglect in interpretation. Wider acknowledgement of the capabilities of working donkeys (and female cattle) opens a gate to better recognition of their likely role then and of the greater complexity of working-animal systems in antiquity than was envisaged in the early days of the Secondary Products model.

Working animals today

Initiatives by authorities in developing regions still tend to distort natural adoption and expansion of the most locally-suitable agricultural and rural transport systems, and to ignore established local practices such as use of donkeys. There has been a good deal of development literature recently about the complex and unexpected paths that working-animal use is taking now that the focus on imposition of Northern European models – with emphasis on investment in a pair of oxen – has lessened. Although in some areas a drive to modern mechanical options persists, with the more recent advent of flexible local systems[102] there has been a steady process in some regions of farmers switching from cattle to donkeys[103], preferring them for their low purchase and maintenance cost and greater suitability for the light ground preparation and

100 Kjaerby 1983, 159.
101 Goulder 2018, 77.
102 e.g. Barrett et al. 1982, 25,33.
103 Goulder 2018, 41.

general pack functions that form the basis of the African farmer's activities[104].

The use of data and observations from widely-available modern agricultural, social and economic development studies, in regions of significant working-animal use such as sub-Saharan Africa, is a largely-untapped resource for Ancient Near Eastern archaeologists. With suitable caveats it provides a means of rebooting archaeological thought and placing working animals within a newly-assessed social and economic framework focusing on practicalities and on household-level responses to change.

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104 e.g. Vall et al. 2002, 120.

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Author info
Jill Goulder
8 Wille Cottages, South St, Lewes BN7 2BX, United Kingdom
E-Mail: j.goulder@alumni.ucl.ac.uk
Web: www.jgoulder.com/archaeology

How museum collections tell us stories about draft animals

Barbara Sosič

Abstract

How museum collections tell us stories about draft animals

The museum's mission of collecting, interpreting and sharing knowledge of our ancestors' way of life is stored in a number of objects in agricultural and other collections, together with the stories they tell, field photos, field trip notes and footage, including of draft animals. Many of these materials can be seen in the museum's exhibitions, and on the website, which we find very important as draft animals disappeared from Slovenian fields, forests and roads about five or six decades ago.

Collections tell stories of the strong connections between men and draft animals, about their skills and interdependence. Slovenian farmers used to cultivate their fields and work in their woods with one pair of working oxen, from the 19th century on also with horses. In the museum, we are especially proud of the harnesses collection of yokes.

Collecting objects and other documents on draft animals is still going on. We see it as a bank of information for future generations, who we believe will find it interesting, inspiring and useful, despite the fact that the knowledge was not passed on directly, from generation to generation, inside of families or communities as it used to be.

Résumé

Comment les collections de musée nous racontent des histoires sur les animaux de trait

La mission de notre musée consiste à collecter, interpréter et partager les connaissances sur le mode de vie de nos ancêtres. Ces connaissances s'expriment à travers un certain nombre d'objets des collections agricoles et autres qui racontent des histoires par le biais de photos de terrain, de notes de voyage et de films, y compris sur des animaux de trait. Un grand nombre de ces documents sont accessibles au public directement dans les expositions ou sur le site Internet du musée. C'est d'autant plus important que les animaux de travail ont disparu des champs, des forêts et des routes de la Slovénie depuis cinquante à soixante ans.

Les collections témoignent des liens étroits entre les hommes et les animaux de trait, sur leurs compétences et leur interdépendance. Les agriculteurs slovènes avaient l'habitude de cultiver leurs champs et de travailler dans leurs forêts avec une paire de bœufs de trait, puis, à partir du 19e siècle, avec des chevaux. Au musée, nous sommes particulièrement fiers de notre riche collection de harnais et de jougs.

La collecte d'objets et d'autres documents sur les animaux de trait se poursuit actuellement. Nous la considérons comme une banque de données pour les générations futures qui, nous en sommes convaincus, les trouveront intéressantes, inspirantes et utiles, malgré le fait que ces connaissances ne sont plus transmises directement, de génération en génération, au sein des familles ou des communautés, comme c'était le cas auparavant.

Kurzfassung

Wie Museumssammlungen uns Geschichten über Zugtiere erzählen

Der Auftrag des Museums, Wissen über die Lebensweise unserer Vorfahren zu sammeln, zu interpretieren und weiterzugeben ist in einer Reihe von Objekten in landwirtschaftlichen und anderen Sammlungen verankert, zusammen mit den Geschichten, die sie Feldfotos, Aufzeichnungen von Exkursionen und Filmmaterial, einschließlich von Zugtieren. Viele dieser Materialien sind in den Ausstellungen des Museums und auf der Website zu sehen, was wir sehr wichtig finden, da Zugtiere vor etwa fünf oder sechs Jahrzehnten von den Slowenischen Feldern, Wäldern und Straßen verschwunden sind.

Die Sammlungen erzählen Geschichten über die enge Verbindung zwischen Menschen und Zugtieren, über ihre Fähigkeiten und ihre gegenseitige Abhängigkeit. Die slowenischen Bäuer:innen bestellten ihre Felder und arbeiteten in ihren Wäldern mit einem Gespann Arbeitsochsen, ab dem 19. Jahrhundert auch mit Pferden. Im Museum sind wir besonders stolz auf die Sammlung von Zugtiergeschirren und -jochen.

Das Sammeln von Gegenständen und anderen Dokumenten über Zugtiere ist immer noch im Gange. Wir sehen dies als einen Informationsspeicher für künftige Generationen, die es interessant, inspirierend und nützlich finden werden, auch wenn das Wissen nicht direkt von Generation zu Generation weitergegeben wurde, innerhalb von Familien oder Gemeinschaften - wie es früher der Fall war.

Resumen

Cómo las colecciones de los museos nos cuentan historias sobre los animales de tiro

En los objetos museales de las colecciones agrícolas se recogen como fue el modo de vida de nuestro antepasados. Muchos de estos materiales pueden verse en las exposiciones de los museos y páginas web. Esto es de gran importancia en el contexto de la Eslovenia actual, ya que los animales de tiro desaparecieron de los campos, bosques y carreteras de este país hace unas cinco o seis décadas.

Las colecciones del museo cuentan historias sobre los fuertes vínculos entre los hombres y los animales de tiro, sobre sus habilidades y la interdependencia. Los agricultores eslovenos solían cultivar sus campos y trabajar en sus bosques con una pareja de bueyes, a partir del siglo XIX también con caballos. El museo se siente especialmente orgulloso de la colección de arneses de yugo.

La recopilación de objetos y otros documentos sobre los animales de tiro continúa. Esto forma parte del banco de información museal, el cual favorecerá a las generaciones futuras, ya que el traspaso generacional interfamiliar de estos conocimientos es casi inexistente en la actualidad.

What is the role of museums, in particular of the Slovene ethnographic museum in researching, collecting and presenting materials connected to draft animals, knowing that draft animals disappeared from Slovenian fields, forests and roads about five or six decades ago? After the 1980s, an ox- or horse-drawn cart became a sign of social exclusion or poor adaptation, often connected with poverty.

As in many parts of Europe, after WW2 people were abandoning the peasant way of life. The share of the farming population dropped from the pre-war 70 % to a mere 20 % in the 1970s and to 8 % in 1991, when Slovenia gained independence. Since then, the share has continued to fall and is today estimated at 4 %.

The museum's mission of collecting, interpreting and sharing knowledge of our ancestors' way of life is stored in a number of objects in our agricultural and other collections, together with the stories they tell, field photos, field trip notes and footage, including of draft animals. This can be seen at our permanent exhibition entitled *Between Nature and Culture*, and much more in our storage depots, archives, articles and books. Many of these materials can be seen on the museum's website.

***Figure 1** – Yokes from the display case with implements used in harnessing, Slovene Ethnographic Museum, Ljubljana*

On the medium-heavy soil covering a great part of Slovenia, a small country in Central Europe, where we have steep Alps, the hilly Dolenjska region, the Pannonian plains and a Mediterranean area, the most common draft animals were oxen, in level areas also cows. The most numerous group in Slovenia – the medium-sized farms – cultivated their fields and worked in their woods with one pair of working oxen.

***Figure 2** – Work on the field, painted beehive front panel from 1897*

It was not until the end of 19th century that horses became important as draft animals. "*A small horse takes away a large fortune*", was a proverb saying that not every farmer could afford a horse.

***Figure 3** – Plouging with a pair of horses, around 1910*

In the Mediterranean area, donkeys were also used, mainly for transportation. Until the establishment of machines and transport vehicles in the second half of the 20th century, animals were used as draft or pack animals and for riding.

***Figure 4** – Istrian women farmers with their donkeys on the way from Trieste, where they used to sell milk, meat, vegetables and fruits, 1910*

In Slovene areas, livestock was harnessed into yokes or horse collars. Yokes were used for cattle; our ancestors were using them in the time of settlement of what is now Slovenian territory in the 6th century AD or even earlier. They were used for centuries whenever carting or ploughing was done using oxen or cows. Yokes were designed for either pulling with the head or with the neck. There were also Mediterranean yokes with *cambas* for harnessing one or two animals together, and we have Slovene yokes known as *telenge.* Yokes were most often made at home and were frequently decorated.

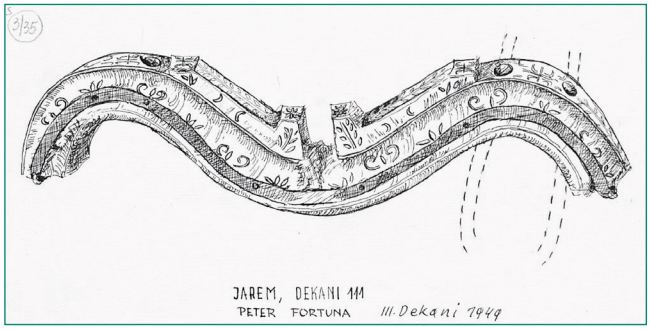

***Figure 5** – Yokes were most often made at home and were frequently decorated*

Horse collars were occasionally used for cattle or donkeys. They were made by saddlers from wood, covered in leather and had metal decorations. There were a number of local variants of the collar, but they differed generally between working and festive collars, and collars for pulling light or heavy weights. After WW2 horse collars started losing their original function and began being used as decoration, and were put on animals only on festive occasions.

As a curiosity, the Žiberna family, about 20 years ago, after three decades break, started raising a pair of oxen, but they use them only for festive occasions and public events. Such use of draft animals is referred to as *theatre of history.* Everywhere they go, they attract a lot of attention from people of all generations and can make especially the elderly, who still remember working with and driving oxen, quite emotional. To perform at a few events a year, they have to put a lot of work into caring for the animals and into demanding preparations.

Our museum has an interesting livestock collection from the 19th and 20th centuries, represented mainly by harnesses. In the 1950s-1960s, right at the time when extensive museum field research was being carried out in the Slovenian countryside, the use of draft animals was still an everyday phenomenon, and the museum is especially proud of the collection of ox yokes built during that time. Moreover, we have extensive documentation from that time: photos, drawings and field trip notes. For two decades now, my colleague Inja Smerdel has been researching and publishing articles on the relationship between human and ox, and the cultural aspects of working oxen in peasant civilization. She focuses on testimonies about oxen within the peasant family and the village community, about working companionship in some basic farm tasks – ploughing, harrowing, towing and driving, about castration, shoeing, feed and grazing, about naming oxen, about learning, harnessing and commands, about diseases and treatment, about choosing new and selling "used" oxen, and so on.

***Figure 6** – The Žiberna family with their two oxen, Nabrezina 2019*

***Figure 7** – This used to be our family, Dekani 2012*

Collecting objects and other documents on draft animals is still going on. We see it as a archive of information for future generations, who we believe will find it interesting, inspiring and useful, in spite of the fact that the knowledge was not passed on directly, from generation to generation, inside of families or communities as it used to be. Life has changed and we can never go back. Throughout history, people always found some new way forward, but by knowing our past, we can be wiser and more effective in the future.

***Figure 8** – Children used to work with draft animals and were very attached to them from an early age, Kal-Koritnica 1952*

Today, both individuals and families live a more or less self-contained life, relying on themselves, their employment possibilities, and various state and social institutions, but with this, they became very vulnerable. The uncertainty and fear, and the realization of our own limitations, brought on by the pandemic have only made it all the more urgent that we rethink our styles of life, our relationships, the organization of our societies and so on.

People, in general, are not very skilled at physical or farm work and have little knowledge of the environment and nature. They spend most of their working and free time indoors, but we all know that physical work regenerates, reinvigorates the mind, and it has always been the basis of human development.

The German political leader Konrad Adenauer's saying "*To look back into the past only makes sense if it serves the future*", is also true for museums. The motto of our museum is that we are a museum "about people, for people", a link between the past and the present, between traditional and modern culture, between the natural environment and civilization.

Now, more and more people feel that we live in a time of insecurity and those who know some history are aware that such crises might predict drastic changes for the future. Our generation depends on many networks and technologies, driven by systems that depend greatly on different energy sources, sometimes also with limited resources. What we observe in the museum is that even through new technologies, the knowledge and skills of our ancestors are becoming of increasing interest – from schoolchildren to elderly people and all ages in between – but especially to the latter, as they try to find relief from their stressful life in gardening or small-scale farming.

At our permanent exhibition, *Between Nature and Culture*, we present objects related to transport, growing and processing crops connected to draft animals in ways that have not been practiced for decades. Observing the visitors, we have noticed that in particular older people born in the countryside strongly relate to these collections, because they are associated with memories of their youth and work on the land. However, what can such objects tell today's urbanized people, who have never worked the land and have no experience with draft animals? We try to start from a personal experience and build on what a person knows and is familiar with. We have to be innovative to interpret to the visitors the former values defining the rural environment and the significance of draft animals in it. It is also necessary to explain that draft animals were regarded as means of subsistence. The attitude towards these animals was sometimes different than we might initially think – as was the general attitude towards animals. Over the last century, these values have greatly changed. Due to many cases of mistreatment, manuals and even decrees were passed as early as the mid-19th century to protect draft animals from neglect and cruelty.

***Figure 9** – Blacksmith shoes an Istrian ox, Krmci 1950*

We never idealize life in the past, we try to interpret it as realistically as possible. It was hard and people had to work hard, they had to be very skillful and persistent, to never give up, they had very complex knowledge of the care and use of draft animals, about the environment, which was built on from generation to generation.

We try to illustrate work with draft animals by including audio-visual material that illustrates the use and functions of the exhibited objects, but what fascinates visitors most is human's strong ties to the natural environment in the past, which actually enabled people to survive.

Knowing our heritage, we can be surer and more confident of a sustainable future, of the challenges and opportunities of safeguarding traditions in which draft animals might again play an important role. The knowledge incorporated in museum collections could be a good example of how to make the most of our history and the achievements of our ancestors for generations to come.

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Author info
Barbara Sosič
Slovenski etnografski muzej
Department of rural agriculture and transport
E-Mail: Barbara.Sosic@etno-muzej.si
Digital paper: https://youtu.be/Z8xb7Tc1esk

Draft animals in museum education at the National Museum of Agriculture and Agri-Food Industry in Szreniawa (Poland)

Witold Wołoszyński and Julia Hanulewicz

Abstract

The educational activity of the Museum is mainly for school children and adolescents. The Museum's live farm animals are very popular among visitors and we have 12 species of the most important livestock including several endangered native breeds of farm animals, with 4 oxen and 8 horses harnessed for fieldwork such as plowing, harrowing, as well as transport and the treadmill. Oxen have the main role in our educational activities, as well as in workshops, shows, events, and exhibitions (trade fairs).

Our educational activities with horses aim to show their historical significance with all the richness of material (e.g. various types of harnesses, vehicles, tools, etc.) and immaterial (gestures, vocabulary, customs, etc.) culture.

The use of horses in ecological farming, forestry, or agri-tourism is promoted during events organized by the Polish Association of Keepers and Friends of Workhorses hosted by the Museum in Szreniawa. The association is a member of the European Federation for the Promotion and Use of Workhorses (FECTU).

Our Museum has organized three international conferences (2013, 2016, and 2019) on issues that concern museum professionals related to animal breeding, and the educational and popularization work carried out here.

Résumé

L'activité éducative du musée s'adresse principalement aux écoliers et aux adolescents. Les animaux de ferme vivants du musée sont très appréciés des visiteurs. Nous possédons 12 espèces d'animaux d'élevage parmi les plus importantes, dont plusieurs races indigènes d'animaux de ferme en voie de disparition, ainsi que 4 bœufs et 8 chevaux attelés pour les travaux des champs tels que le labourage, le hersage, ainsi que le transport et le tapis roulant. Les bœufs jouent le rôle principal dans nos activités éducatives, ainsi que dans les ateliers, les spectacles, les événements et les expositions (foires commerciales).

Nos activités pédagogiques avec les chevaux visent à montrer leur importance historique avec toute la richesse de la culture matérielle (par exemple, divers types de harnais, de véhicules, d'outils, etc.) et immatérielle (gestes, vocabulaire, coutumes, etc.).

L'utilisation des chevaux dans le cadre de l'agriculture écologique, de la sylviculture ou de l'agrotourisme est promue lors d'événements organisés avec l'Association polonaise des gardiens et amis des chevaux de trait accueillie par le musée de Szreniawa. L'association est membre de la Fédération européenne pour la promotion et l'utilisation des chevaux de trait (FECTU).

Notre musée a organisé trois conférences internationales (2013, 2016 et 2019) sur des questions qui concernent les professionnels des musées en lien avec l'élevage, et le travail d'éducation et de vulgarisation réalisé ici.

Kurzfassung

Die pädagogische Tätigkeit des Museums richtet sich hauptsächlich an Schulkinder und Jugendliche. Die Nutztiere des Museums sind bei den Besucher:innen sehr beliebt. Wir halten 12 Arten der wichtigsten Nutztiere, darunter mehrere gefährdete einheimische Nutztierrassen, sowie 4 Ochsen und 8 Pferde, die für Feldarbeiten wie Pflügen und Eggen sowie für den Transport und die Tretmühle angeschirrt werden. Ochsen spielen die Hauptrolle bei unseren pädagogischen Aktivitäten sowie bei Workshops, Vorführungen, Veranstaltungen und Ausstellungen (Messen).

Unsere pädagogischen Aktivitäten mit Pferden zielen darauf ab, ihre historische Bedeutung mit dem ganzen Reichtum der materiellen (z. B. verschiedene Arten von Geschirren, Fahrzeugen, Werkzeugen usw.) und immateriellen (Gesten, Wortschatz, Bräuche usw.) Kultur zu zeigen.

Der Einsatz von Pferden in der ökologischen Landwirtschaft, in der Forstwirtschaft oder im Agrotourismus wird im Rahmen von Veranstaltungen des Polnischen Verbands der Züchter:innen und Liebhaber:innen von Arbeitspferden gefördert, die vom Museum in Szreniawa ausgerichtet werden. Der Verband ist Mitglied der Europäischen Föderation für die Förderung und Nutzung von Arbeitspferden (FECTU).

Unser Museum hat drei internationale Konferenzen (2013, 2016 und 2019) zu Themen organisiert, die Museumsfachleute im Zusammenhang mit der Tierzucht und der hier geleisteten Bildungs- und Öffentlichkeitsarbeit betreffen.

Resumen

Las actividades educativas en el Museo „" están dirigidas principalmente a escolares y adolescentes. Algunas de estas actividades son talleres, espectaculos, eventos y ferias con nuestros animales de granja - un total de 12 razas, en las que se incluyen algunas autoctonas y en peligro de extinción. Estas actividades y la visita a nuestros animales son muy populares y queridas entre nuestros visitantes

Nuestras actividades educativas con caballos pretenden mostrar tanto el papel histórico tan importante que jugaron estas criaturas, así como la cultura material (objetos de equitación, vehículos, herramientas…) e inmaterial (cambios en las convenciones y dinámicas sociales, estrategias en el campo de la equitación y doma de caballos…)

El uso de los caballos en la agricultura ecológica, la silvicultura o el agroturismo es promovido y organizado durante estos eventos por la Asociación Polaca de Guardianes y Amigos de los Caballos de Trabajo que acoge el Museo de Szreniawa, la cual es miembro de la Federación Europea para la Promoción y el Uso de los Caballos de Trabajo (FECTU).

Nuestro Museo ha organizado tres conferencias internacionales (2013, 2016 y 2019) para discutir diferentes temas que preocupan a los profesionales de los museos relacionados con la cría de animales y la labor educativa y de divulgación que aquí se realiza.

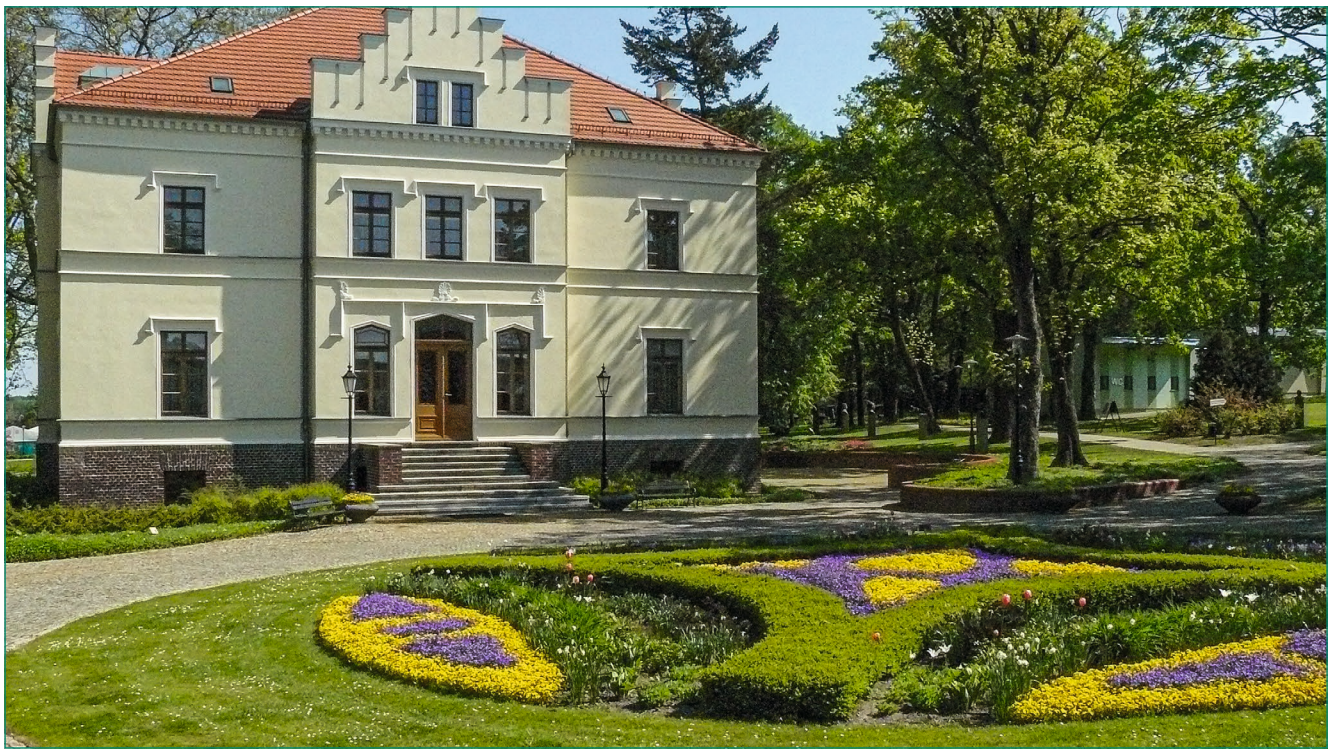

Figure 1 *– Palace from the mid-19th century*

The Museum of Agriculture and Agri-Food Industry in Szreniawa was established in 1964. In 1975 it was granted the status of a national institution. It is located on the premises of a 19th-century manor house, approximately 10 km from Poznań. The institution houses numerous exhibition pavilions, a palace with a park, a former manor yard which includes barns connected to a granary, a livestock building, and a historic distillery where the Szreniawa Brewery operates. About 11 of over 24 hectares of the Szreniawa Museum is devoted to an orchard of old varieties of fruit trees, an herb garden and a field where traditional garden and field crops are grown for demonstration purposes. For many years, the Museum has bred conservation livestock breeds. Animals and historic agricultural machines are displayed during numerous events, workshops and demonstrations held in the tourist season. The Museum borders on the Wielkopolski National Park. This unquestionable asset makes a visit to our institution a feast for technology and nature lovers alike.

Figure 2 *– Branch in Jaracz*

Apart from its main site, the Museum has 5 field branches within a 50 km radius: Museum of Milling and Aquatic Devices of Rural Industry in Jaracz, Museum of Wickerwork and Hop-Making in Nowy Tomyśl, Museum of Nature and Hunting in Uzarzewo, Professor Ryszard Kostecki Open Air Museum and Museum of Apiculture in Swarzędz, and Museum of Meat Economy in Sielinko.

Figure 3 *– Branch in Nowy Tomyśl*

Figure 4 *– Branch in Uzarzewo*

Figure 5 *– Branch in Swarzędz*

Figure 6 *– Branch in Sielinko*

The Department of Animal Husbandry and Plant Cultivation, one of the Museum's units, employs four staff members, including two specialists. The Department's personnel tend the livestock, cultivate the fields and hold demonstrations of animal use during museum shows and educational events: in the field, in the demonstration yard of the park, in a demonstration rural homestead, and in the livestock building. The last building houses an education hall with multimedia equipment which can seat around 40 viewers.

Figure 7 *– Educational room in the livestock building*

The Museum keeps 12 species of livestock, including a few conservation breeds of selected species. It has an open-air demonstration site of agricultural plants species and their variations. This "live museum" is a valuable addition to the extensive educational program of livestock husbandry and breeding and plant cultivation, on display at the following exhibits: "Livestock Husbandry and Breeding", "Veterinary Medicine", "Apiculture", "Rural Transport", "Salvaged Glamour of Carriages", "Plant Cultivation", "Horticulture", "Technical Progress in Agriculture – 19th and 20th century".

Figure 8 *– Veterinary Medicine*

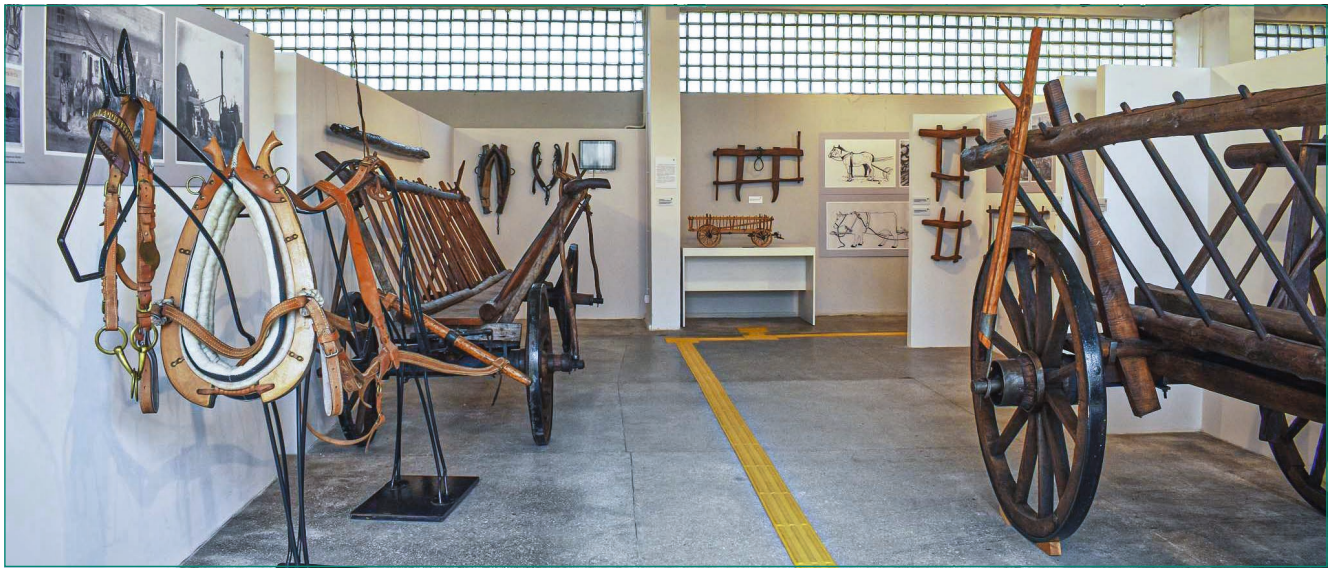

Figure 9 *– Rural Transport*

Appreciating the prominent role of the farm animals kept at the Museum in educational activities, in 2013 the Museum organised an international conference Live Animals in Museum Activities, an event that garnered widespread response among museum professionals. The substantial interest in the conference inspired the organisation of further events of this kind. The conferences held in 2016 and 2019 confirmed the relevance of keeping livestock in museums and reinforced the Museum specialists' conviction of the great importance of educational and promotional work involving farm animals.

The main issues discussed at the conference sessions included the presentation of animals to a museum audience in a way ensuring that the animals are not stressed and safe for the visitors. Ensuring animal welfare and compliance with legislation on work with traditional methods and tools using animals was an important issue in the discussions. Economic aspects of animal husbandry in museums and above all the use of live animals for education purposes were another important topic.

Figure 10-11 *– The 2013 conference*

The Museum's animals, especially cattle and horses, are one of the highlights of numerous events. All educational activities, such as demonstrations and workshops involving animals, are very popular with audiences of all ages. Direct contact with animals is an extremely valuable experience and is one of the main reasons for revisiting Szreniawa. The smell, movement, sound and sometimes the touch of the animal under the supervision of a carer enriches the cognitive process with a poly-sensory experience. This is an especially important aspect, as the educational activities of our institution consider the needs of persons with physical and intellectual disabilities and our events often have a therapeutic function.

The presence of cattle and horses is indispensable when recreating traditional farming; here the presence of human staff is of secondary importance. A live demonstration helps to quickly assimilate knowledge on the prominence of animal husbandry and breeding and the operation of basic farming tools and equipment. Direct

Figure 9 *– Rural Transport*

observation and sometimes personal participation in the demonstration is the best method of knowledge acquisition. Thanks to such activities, museums cease to be associated only with inaccessible objects and specialised, technical descriptions, and instead prove that they are for the public and respond to their needs.

The forms of educational activities carried out with the use of farm animals at the National Museum of Agriculture in Szreniawa are mainly museum classes, educational workshops, demonstrations, educational and recreational events, as well as exhibitions at trade fairs.

Museum classes

This part of the educational agenda is of primary importance in the Museum. It seems that this type of activities gives children and young people the best contact with the museum and its collections. The Szreniawa Museum offers lessons in the history of agricultural technology and livestock breeding for both primary and secondary school students. During these lessons, the audience are taught how traditional animal products are obtained. The activities include e.g. milking, butter and cheese making, sheep shearing, wool processing, and weaving. There are practical activities in the apiary, the feeding of animals in the past and today and the traditional use of farm animals: the harnessing of horses and oxen for transport and agricultural work in the field and farmstead.

One of the lessons on offer is "Traditional use of farm animals in the field". This activity aims to introduce traditional ways of employing animals. The highlight of the lesson is a demonstration of farm labour with draught animals. The participants also learn about the work of farm hands and grooms, professions which are closely related to the use of draught and working animals. Another lesson is entitled "On a wide road – the history of rural transport". The lesson indicates manual and horse-drawn means of transport, including various types of vehicles. Cattle and horses are the subject of other lessons, too: "In the homestead", "Farm animals", "Kindergarten students feed animals", and "Butter and cheese from a farm".

Figure 13 *– Lesson subject: "Farm animals"*

Education workshops and demonstrations

For several years now, the Museum has been running extensive one-day workshops taking place over a period of 3 or 4 weeks. The educational workshops are conducted for organised groups of school students, who are introduced to Polish Christmas customs and traditions involving animals. The knowledge offered at the stands is tailored to the age of the participants, ranging from pre-school children to secondary school pupils. Three themed workshops are the principal offer: "Christmas shows", "Easter shows" and the open-air show of autumn work "Autumn in the countryside". To illustrate the scale of the above projects, the Easter shows in 2017 attracted as many as 4,685 children and in 2018 were attended by 4,180 children.

Interactive themed events for families with children or individual visitors are held on weekends. There are also demonstrations for groups that can be held at any time on request, e.g. a demonstration of the work of oxen (in a treadmill or in a field), hiring a horse-drawn wagonette or carriage, and hiring a saddled pony.

Figure 14 *– Demonstration of oxen working a treadmill*

Figure 15 *– Renting a carriage*

Other forms of education

The Museum organizes one- or two-day weekend educational and recreational events for the general public and multi-generational families. There are around 10 such events per year.

The attractiveness of such events makes them very popular among visitors, and the turnout often exceeds several thousand people. They showcase the cyclical nature and rituals of fieldwork and festivals, such as the "Poznań potato", i.e. potato-digging demonstration, or the very spectacular "Whitsun Festival", recalling the festive decoration of oxen as a sign of the advent of spring. Horses and dogs are inseparable for disseminating knowledge on safety. This is especially prominent during the "Sunday at the Museum" event, held together with the Provincial Headquarters of the Police.

Figure 16 *– Poznań potato*

Figure 17 *– Whitsun Festival*

Figure 18 – Sunday at the Museum

During our events, animals become the main attraction in the following demonstrations:

- traditional field work with the use of old and modern agricultural machinery and tools (ploughing with a ploughshare, sokha and plough) cooperating with a team of horses in different types of harnesses, or in a team of oxen - in a yoke or collar,
- ploughing and logging competitions,
- driving and show jumping competitions,
- demonstrations of horse and dog agility,
- horseback and carriage rides.

The Museum gathers the main livestock species from our climate zone, i.e. cattle, sheep, goats, horses, poultry, and rabbits. Unfortunately, for sanitary reasons for the past 2 years we have not kept pigs. This is a measure to ensure the epizootic conditions of ASF (swine fever). Nevertheless, cattle and horses are of prime importance, both because of their leading role in meeting human needs (meat, milk, hides, work, safety) and because of the related rich tangible and intangible heritage. In particular, the use of the strength of these animals for agricultural work and transport, whether in peacetime or in wartime, has accounted for their prominent role in human history. The choice of animals for draught purposes largely depended on natural and geographical conditions and their domestication. Thus, on Polish soil mainly cattle and horses have been used for these purposes, for transport, tillage, and propelling various devices, especially agricultural ones.

Cattle

Since their domestication on Polish soil, i.e. around 5000 years B.C., cattle have played a prominent role among livestock, supplying humans with a variety of goods such as meat, milk, hides, fertiliser as well as being used in field work and for transport. Therefore, cattle also play a leading role during museum lessons and demonstrations.

Currently, the Museum owns a Polish Red x Jersey crossbred cow and a year-and-a-half old heifer, as well as two six-year-old oxen of the native Polish Red breed and two fifteen-year-old oxen, one of the White Back (also native) breed and the other of the Simmental breed. In the twenty-year history of the presentation of oxen in the Museum there have been mainly White Back and Simmental animals.

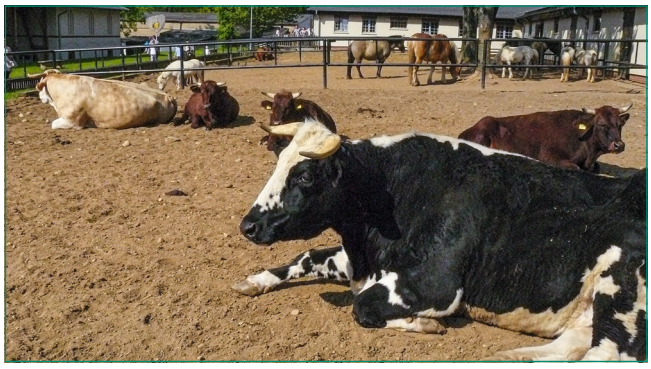

Figure 19 – Oxen in the paddock

Figure 20 *– A team of oxen in a double neck yoke*

During the interactive classes, viewers are introduced to manual milking, and the collected milk is used to make butter and cottage cheese by traditional methods. The activity ends with a tasting of the products made.

From the domestication of cattle until the third quarter of the 19th century, oxen were the common and principal means of locomotion and propulsion of agriculture. Although gradually replaced by horses, at the turn of the 20th century oxen still played a significant role on farmsteads. Until the Second World War, draught cattle continued to play a significant role in Eastern Poland, i.e. Polesie and Volhynia, on farms in Wielkopolska and in the foothills of the Carpathian Mountains. After the war, cattle harnessing persisted until the 1950s, mainly due to the lack of horses and tractors.

The neck yoke for a couple of animals was a common type of cattle harness in the Polish lands. The Museum collection houses 14 specimens of neck yokes of the throat type. A yoke for a single ox is half of the neck yoke for a pair of oxen. Such yokes were used only in the western part of the Carpathian foothills in poor households. The Museum owns 19 copies of single yokes. On the other hand, a horn yoke was put on the forehead of a cattle and tied to the horns. In the Polish lands this harness was used mainly in the territories of the Prussian partition, to a lesser extent than the neck yoke. In the second half of the 19th century, collars began to be used to harness oxen, modelled on horse collar harnesses. The Museum owns 12 specimens of bovine collars.

The harnesses we use on our oxen are faithful replicas of the originals. For about 10 years now, during our demonstrations we have put collar harnesses on the oxen, which is convenient for both the animals and the staff. When the Museum began its use of ox-drawn carts at the beginning of this century, the main difficulty was that there were no longer any working cattle in Poland and the farm hand profession was a thing of the past; only some place names related to this profession remained. Therefore, looking for someone capable of working oxen on a farm, we invited a specialist from Romania, thanks to whom in 2005 our Museum's team won first place in the First Brandenburg Ploughing Competition in Altranft in the cattle ploughing category.

Horses

The use of working horses in Poland, common until the 1970s, is rare today. After the ancient throat-girth harness, it was not until the Middle Ages that the primitive breast collar harness became popular, which at the turn of the 19th century was displaced by the collar harness. In all regions of the country, for heavy labour and in travelling harnesses, the collar or the breast-collar harnesses are used, the latter being more frequent. At present, the Museum keeps 8 horses and 1 donkey. These are 2 mares of the Polish horse breed and a gelding and a mare of the Polish cold-blooded horse breed, as well as 4 ponies. Many events are also held with horse-drawn carriages of members of the Working Horse Association.

Figure 21 – Horses in a paddock

The Museum in Szreniawa is the headquarters of the Prof. Ewald Sasimowski Polish Association of Draught Horse Users and Friends and Equine Organic Food Producers. Established in 2003, it is a member organisation of the European Draught Horse Federation (FECTU).

The live farm animals kept at the Museum make our educational agenda unique and distinguishable. Although over the course of nearly 60 years the Museum and its branches have collected over 31 000 artefacts, it is the animals that are our most treasured trademark, making us instantly recognisable throughout Poland.

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Author info
Witold Wołoszyński
National Museum of Agriculture and Agri-Food Industry Szreniawa, Specialist, Department of Animal Husbandry and Plant Cultivation

Author info
Julia Hanulewicz
National Museum of Agriculture and Agri-Food Industry Szreniawa, Curator, Department of Education and Publications
E-Mail: julia.hanulewicz@gmail.com
Digital paper: https://youtu.be/Py_7cjcGUdo

The role of draft cattle in (Archaeological) Open-Air Museums and Living History Farms – A personal Essay

Claus Kropp

Abstract

This paper explores the potential role of draft cattle usage in both Open-Air Museums as well as Living History Farms. As draft cattle can be interpreted as direct links to our agricultural past, they can be of great importance for educational programs on-site. Training classes in ox-driving, as well as the preservation of skills (e.g. animal-powered tillage implements), are both additional reasons why draft cattle usage is highly valuable and can create value for the wider sustainability discussion. Furthermore, the paper highlights what kind of challenges and limitations can be involved when using draft cattle in museum contexts, especially regarding of animal welfare vs authentic historical harnessing.

Résumé

Cet article explore le rôle potentiel de l'utilisation du bétail de trait dans les musées en plein air et les fermes d'histoire vivante. Comme les bovins de trait peuvent être interprétés comme des liens directs avec notre passé agricole, ils peuvent être d'une grande importance pour les programmes éducatifs sur place. Les cours de formation à la conduite des bœufs, ainsi que la préservation des compétences (par exemple, les outils de travail du sol à traction animale) sont deux raisons supplémentaires pour lesquelles l'utilisation des bovins de trait est très précieuse et peut créer de la valeur pour le débat plus large sur la durabilité. En outre, l'article met en évidence les défis et les limites de l'utilisation du bétail de trait dans les musées, notamment en ce qui concerne le bien-être des animaux et l'exploitation historique authentique.

Kurzfassung

In diesem Beitrag wird die potenzielle Bedeutung des Einsatzes von Zugrindern sowohl in Freilichtmuseen als auch Living History Farms beleuchtet. Da Zugtiere als direkte Verbindung zu unserer landwirtschaftlichen Vergangenheit interpretiert werden können, sind sie für Bildungsprogramme vor Ort von großer Bedeutung. Die Ausbildung im Umgang mit Zugtieren und die Bewahrung von Fertigkeiten (z.B. in Bezug auf Ackergeräte für den tierischen Zug) sind zwei weitere wichtige Gründe, warum die Nutzung von Zugtieren sehr wertvoll ist und einen Beitrag zur allgemeinen Nachhaltigkeitsdiskussion leisten kann. Darüber hinaus zeigt das Essay auf, welche Herausforderungen und Einschränkungen mit dem Einsatz von Zugrindern in musealen Kontexten verbunden sein können, insbesondere im Zusammenhang mit dem Tierschutz gegenüber einer authentischen historischen Nutzungsweise.

Resumen

Este artículo explora el papel potencial del uso del ganado de tiro tanto en los museos al aire libre como en las granjas de historia viva. Dado que el ganado de tiro puede formar un nexo directo con nuestro pasado agrícola, desempeñaría un papel de gran importancia en programas educativos in situ. Las clases de formación en la conducción de bueyes, así como la preservación de las habilidades, por ejemplo en el mantenimiento de aperos de labranza, son motivos adicionales por los que considerar el uso del ganado de tiro como una fuente inestimable de recursos educativos, creando así una base de debate más amplio sobre Ecologismo y Sostenibilidad. Sin embargo, una representación históricamente precisa del trato con los animales y respectivamente de su bienestar supone una clara limitación en la práctica museística. Estas barreras históricas y retos conceptuales serán más adelante desarrolladas.

Touching ground with draft cattle in museum contexts

My journey with draft cattle started in the year 2012 at an annual meeting of the German Ox Driver Working Group[1] in the Westerwald (Rhineland-Palatinate). I was overwhelmed back then with how much passion and persistence some people still use cattle for draft purposes. Although most of the people present there did so on a private basis, I also met quite a few which were using cattle in the context of Open-Air Museums. A very well example for that back then was – and still is – the so-called State Domain of Dahlem in Berlin, where Astrid Masson and her team are using draft cattle for various purposes – be it in front of the wagon, potato cultivation or vegetable growing[2]. Even more important in that respect: they also teach draft cattle classes on-site in Dahlem.

***Figure 1** – Training Class on Working Cattle at the "Domäne Dahlem"*

1 German Ox Driver Working Group, URL: www.zugrinder.de [26-04-22].
2 Domäne Dahlem - Landgut und Museum, URL: www.domaene-dahlem.de [27-06-22].

Before I started my job at the Lauresham Open-Air Laboratory, I already had the opportunity to take several training classes and courses, some of them in Dahlem, others at the farm of a fellow member of the Ox Driver working group, Gerhard Döring. We then started off on-site with a trained team of Raetian Grey cattle in 2013. In retrospect, I have to state that it probably took us at least five years, until we could consider ourselves as – at least to some extent – skilled ox drivers. In 2022, almost 10 years after my first encounter with draft cattle, I can with some pride state that we not only increased the number of animals to seven but also that we use them for all agricultural tasks on-site, for pulling the wagons as well as for haymaking and logging outside the museum limits. Every year, we train a group of four young adults to handle and train draft cattle as part of their Voluntary Ecological Year (FÖJ) on site.

My Ph.D. thesis on the use of draft cattle in Early Medieval agriculture[3], the fact that I am an active ox driver myself and my ongoing engagement within the ox driver communities and networks like AIMA[4], ALHFAM[5] or EXARC[6] finally brought me to a point at which I wanted to evaluate the current situation of draft cattle usage within Open-Air Museums, Living History Farms as well as Archaeological Open-Air Museums. Furthermore, I wanted to develop an international framework for the exchange of experience in that field. Finally, and most importantly, I wanted to promote the usage of draft cattle as part of a solution for a more sustainable, more local and eco-friendly future. Please understand this essay therefore as a conversation starter and as starting point for a larger project that I am pursuing.

3 Kropp (PhD-thesis, in preparation).
4 International Association of Agricultural Museums, URL: www.agriculturalmuseums.org [27-06-2022].
5 Association for Living History Farms and Agricultural Museums, URL: www.alhfam.org [27-06-2022].
6 EXARC, URL: www.exarc.net [27.06.2022].

***Figure 2** – Field Day in spring 2022 as part of the Annual Meeting of the German Working Cattle Group*

Asking the right questions

So let's first ask a set of questions that help us understand why draft cattle can be of a pivotal role in the context of Open-Air Museums and Living History Farms:

1) Why do we even keep draft cattle in Archaeological Open-Air Museums?

Most importantly, the presentation of draft cattle can, besides the agricultural implements themselves like ploughs or harrows, pose as one of the most direct links to our agricultural past. The use and even most of the techniques remained unchanged throughout the millennia and therefore draft cattle usage can open us windows into various periods, starting from the Neolithic up until the presentation of farm life in the first half of the 20th century. The use of draft cattle within museum contexts is also a good idea as it may function as a valuable and powerful way for the transmission of intangible heritage. To some extent, it is the museums, living history farms or organizations like Tillers International that find themselves in the role of preserving and teaching these fundamental techniques. Have a look at Howell's Living History Farm[7] in Mercer County (New Jersey, USA) for example, which provided training sessions for US Peace Corps volunteers, missionaries and others working in both international and local agricultural extensions. As another valuable example in that respect, the Ecomusée d´ Alsace in Ungersheim (France) with its by-annual draft cattle classes can be named.

7 Howell Living History Farm, URL: www.howellfarm.org/ [26-07-22].

Figure 3 *– Using Draft Cattle in an Iron Age context at Butser Ancient Farm (England)*

Using the cattle for agricultural purposes can in this context also be seen as a sort of an in vivo-conservation of old cultural techniques. Only by using these agricultural implements, be it authentic and restored originals or (re)constructions, we will be able to preserve the knowledge involved or to develop it further. When a fellow colleague and draft animal enthusiast Ed Schultz from Colonial Williamsburg[8] (Virginia, USA) states, that *"the skills of working draft animals have been declining throughout the developed world for many years. What took thousands of years to refine is very close to being lost*[9]", then we understand the true value of training and teaching draft cattle in museums contexts.

8 Colonial Williamsburg, URL: www.colonialwilliamsburg.org/ [26-07-22].
9 Schultz 2013, 86.

Figure 4 *– Course on Working Cattle at the Ecomusée d´ Alsace in Ungersheim (France)*

***Figure 5** – Plowing demonstration at Colonial Williamsburg (USA)*

There are also other quite clear advantages of keeping draft cattle: usually, they are easily becoming the stars of each museum, functioning as true "role models". Looking at the Open-Air Laboratory Lauresham for example, where our draft oxen David and Darius are by now available as stuffed miniature versions or at Archeon[10] (Netherlands) where the oxen Isaac and James even have their own Facebook page and fans of their own. The advantages of using these impressive animals as an integral part of the daily presentation in the museums become immanent. Starting from getting them yoked and harnessed as well as putting them to work can draw hours of visitors' attention.

Lastly there are clearly some functional and ecological benefits of keeping the draft animals in a museum context. When it comes to soil compression in the context of (re)constructing past agriculture for example, tractor-drawn implements can be of a clear disadvantage. The same can be said about specific field types like the so-called "ridge and furrows[11]", which can´t properly be worked with modern equipment. Additionally, museum fields are often rather small and draft animals are increasingly effective the smaller the plots get. Therefore, the choice to keep draft cattle can also be valuable for economic reasons.

2) What are the problems and limitations when using draft cattle in museum contexts?

In that respect, the historical setting respectively period in which cattle are to be implemented in the museum can cause massive challenges. Let´s take animal welfare issues as an example: we (taking German law as a baseline) are not allowed to replicate animal-keeping traditions or practices which are not in line with veterinary rules or laws. To some extent, this can also be said for some harnessing systems as not all known types of yokes can necessarily be considered very animal friendly. As a museum worker, you therefore always have to consider if it is necessary to break with the authentic setting for animal welfare reasons or if a compromise is possible. That very honest approach is usually then also a well-valued discussion starter with the visitors.

There is one more important thing that I want to talk about in that respect: skills – and I am not talking about the skills of the animals here but the skills of the handler. You can't just get a team of oxen or cows and start working with them; there is so much stuff than can go wrong, be it causing pathological problems for the animals due to overloading or getting into dangerous situations for the handler – and the public. I can only strongly advise everybody who is thinking about getting some draft cattle for their museums or archaeological opening museum to have skilled staff available or to get them properly educated. A museum site can over time develop into a training site itself. Nevertheless, a nationally or internationally used certification system is not developed yet.

Perspectives for the future

Let me in this last part of my essay come back to what I said in my introduction: I am in the process of evaluating who and where in museum contexts cattle are worked or trained. I want to find out for what purposes they are kept, be it just for show or actually working with them. I also want to gather information on how one copes with challenges that they experience and how to solve them. This could be a foundation of the deeper networking platform in which we as museum and draft animal professionals could combine forces in order to promote the topic on a larger scale. A first step in that direction was a survey I conducted with archaeological open-air museums and living history farms in Europe and North America. It was interesting to see that draft cattle are regularly seen as a key or prominent element of interpretation in the respective museums. Let me quote Ben Baumgartner, the leading agricultural interpreter from Barrington Plantation[12] (Texas, USA) here as he put it quite straight saying "*they [meaning the draft cattle] are in my opinion our best non-verbal interpretation we have. When visitors walk up and see the oxen work they are instantly transported to another time*"[13].

Another interesting comment came once more from Ed Schultz who referred to the fact that "*people today are in many respects far removed from agriculture*[14]". He also stated and I quote again "*working cattle do not get the credit they deserve and one way we can resolve that problem is to show them in our museum and teach our visitors about their importance in farming, commerce, moving of goods from ships to stores, logging, query work and construction*[15]".

Let me conclude with a call to action on a global scale: let's use the public attention open-air museums generate not only to reconnect people of the 21st century with draft animals and their use in historic context but also to serve as lighthouses for the training of draft cattle, to encourage their importance and relevance today and to play an active role for a more sustainable future!

10 Archeon, URL: www.archeon.nl/en/home.html [26-07-22].
11 Kropp 2022.
12 Barrington Plantation, URL: www.thc.texas.gov/historic-sites/barrington-plantation-state-historic-site [26-07-22].
13 Kropp 2020.
14 Ibd.
15 Ibd.

Figure 6 *– Ben Baumgartner (on the right) with a colleague and a team of oxen at Barrington Plantation (USA)*

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Figure 5 – Colonial Williamsburg/Ed Schultz.

Figure 6 – Barrington Plantation.

Author info

Claus Kropp

Manager Lauresham Laboratory for Experimental Archaeology
UNESCO World Heritage Site Lorsch Abbey

E-Mail: c.kropp@kloster-lorsch.de

Working animals – a historical approach

Peter Moser

Abstract

Working animals are often conceptualised as a phenomenon of the pre-industrial age. Historians regularly assume, that working animals became obsolete in the process of industrialisation. But a closer look at the development of the urban transport systems and the mechanisation of agricultural production in the 19th and 20th centuries illustrates, that working animals played a crucial role up to the middle of the 20th century. In other words, they were agents of modernisation and not, as often perceived, phenomena of a pre-industrial era. This article first gives an overview of the relevance and the variety of working animals and then focusses on the close interactions of men, women and children with their working companions. Although humans decided when the animals had to work, the work itself was always done in cooperation between human beings and animals. Work not only produced products, it also created ties. Work, therefore, was and remains profoundly ambivalent for men and animals: it can be a means of alienation, but it can also be an opportunity for emancipation.

Résumé

Les animaux de trait sont souvent considérés comme un phénomène de l'ère préindustrielle. Les historiens supposent habituellement que les animaux de trait sont devenus obsolètes au cours du processus d'industrialisation. Mais un examen plus attentif du développement des systèmes de transport urbain et de la mécanisation de la production agricole aux XIXe et XXe siècles montre que les animaux de trait ont joué un rôle crucial jusqu'au milieu du XXe siècle. C'est à dire, ils étaient des agents de la modernisation et non, comme on le croit souvent, des reliques d'une époque préindustrielle.

Cet article donne d'abord un aperçu de l'importance et de la variété des animaux de travail, pour se concentrer ensuite sur les interactions étroites des hommes, des femmes et des enfants avec leurs compagnons de travail. Certes, l'homme décidait du moment où les animaux devaient travailler, mais le travail lui-même était toujours effectué en coopération entre les êtres humains et les animaux. Donc, le travail ne générait pas seulement des produits, mais aussi des liens. C'est pourquoi le travail était et reste profondément ambivalent pour les hommes et les animaux : il peut être aliénant, mais il peut aussi fournir des occasions d'émancipation.

Kurzfassung

Arbeitstiere werden oft als Phänomen einer vorindustriellen Zeit wahrgenommen. Die Geschichtsschreibung geht in der Regel davon aus, dass sie im Zuge der Industrialisierung obsolet geworden seien. Doch ein genauer Blick auf die Entwicklung der städtischen Verkehrssysteme und die Mechanisierung der landwirtschaftlichen Produktion zeigt, dass Arbeitstiere bis zur Mitte des 20. Jahrhunderts eine wichtige Rolle spielten. Mit anderen Worten: Arbeitende Tiere waren Akteure der Modernisierung und nicht Phänomene einer vorindustriellen Zeit. Dieser Artikel gibt zunächst einen Überblick über die Vielfalt und Bedeutung der Arbeitstiere. Danach wird die enge Interaktion von Männern, Frauen und Kindern mit ihren tierlichen Arbeitskollegen thematisiert. Obwohl Menschen entschieden, wann Tiere zu arbeiten hatten, wurden die Arbeiten selbst immer in Kooperation zwischen Menschen und Tieren durchgeführt. Arbeit produzierte nicht nur Produkte, sondern auch Bindungen. Arbeit ist also zutiefst ambivalent: Sie kann ein Mittel zur Entfremdung sein, aber auch eine Chance zur Ermächtigung.

Resumen

Los animales de trabajo suelen considerarse un fenómeno de la era preindustrial. Los historiadores suelen suponer que los animales de trabajo quedaron obsoletos en el proceso de industrialización. Sin embargo, un análisis más detallado del desarrollo de los sistemas de transporte urbano y de la mecanización de la producción agrícola en los siglos XIX y XX demuestra que los animales de trabajo desempeñaron un papel crucial hasta mediados del siglo XX. En otras palabras, fueron agentes de la modernización y no, como se suele percibir, fenómenos de una época preindustrial.

Este artículo ofrece en primer lugar una visión general de la relevancia y la variedad entre los animales de trabajo. Más adelante se centra en las estrechas interacciones de hombres, mujeres y niños con sus compañeros de trabajo. Aunque los humanos decidían cuándo tenían que trabajar los animales, el trabajo en sí siempre se realizaba en cooperación entre los seres humanos y los animales. En otras palabras: El trabajo no sólo producía productos, también creaba vínculos. El trabajo, por tanto, era y sigue siendo profundamente ambivalente para los hombres y los animales: puede ser un medio de alienación, pero también una oportunidad de emancipación.

Introduction

Working animals are often conceptualised as a phenomenon of the pre-industrial age. Historians regularly assume, that working animals became obsolete in the process of industrialisation. But a closer look at the development of the urban transport systems and the mechanisation of agricultural production in the 19th and 20th centuries illustrates, that even in the Western world working animals played a crucial role up to the middle of the 20th century. In other words, they were agents of modernisation and not, as often perceived, phenomena of a pre-industrial era.[1]

This article first gives an overview of the relevance and the variety of working animals and then focuses on the close interactions of men, women and children with their working companions. Although humans decided when the animals had to work, the work itself was always done in cooperation between human beings and animals. Work not only produced products, but it also created ties. Work, therefore, was and remains profoundly ambivalent for men and animals: it can be a means of alienation, but it can also be an opportunity for emancipation.[2]

Horses, donkeys and mules

In the 19th century, most of the newly emerging urban transport systems were depending on horsepower. Cities often had a far higher horse density than rural areas. Since the cities could not produce the feed for the horses, their high demand for horses simultaneously shaped their rural surroundings. Not only the fodder for the horses was produced in the countryside, but also the horses themselves were reproduced here.[3]

Figure 1 – Even in North America mowing machines often were powered by oxen up to the First World War

In agricultural production, working horses remained indispensable up to the middle of the 20th century. Because the cultivation of plants depends on the weather, the topography and the soil structure, it took more than half a century to turn the strong, but clumsy and far too heavy steam-power machines of the 19th century into light, versatile, motor-driven machines, which were able to compete with animal power. In North America steam ploughs were successfully implemented for breaking

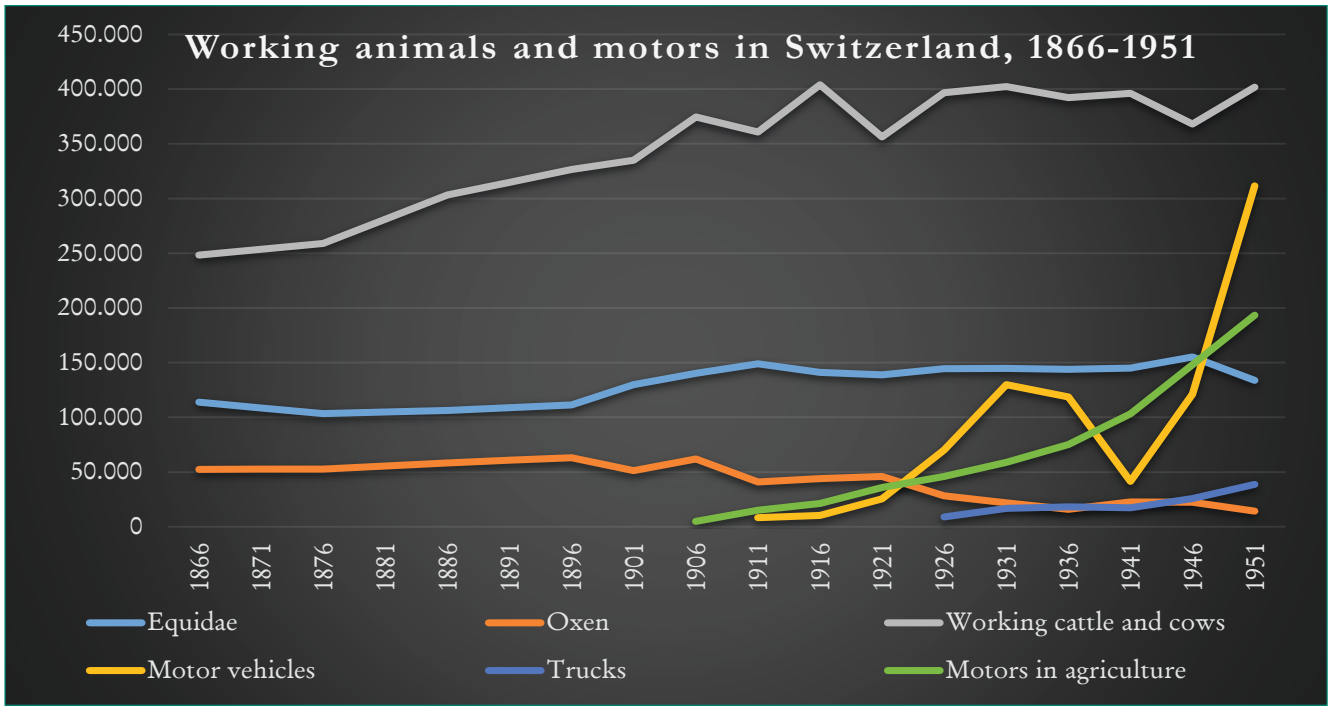

Table 1 – Working animals and motors in Switzerland, 1866-1951

1 Auderset/Schiedt 2021, 27-42.
2 Porcher/Estebanez 2019, 11-34.
3 Moser/Schiedt 2021.

up the prairies. But in cultivating the soil tractors only became an alternative to animal power during and after World War I. In Switzerland it was only after World War II when the number of tractors outnumbered the animal-driven machines.

Donkeys and mules were efficient, frugal and cheap working animals for many who couldn't afford horses. They served as riding, pack and draft animals. As so-called pack mules, they were able to carry heavier loads in relation to their weight than horses, cattle or camels. Donkeys were important and numerous around the Mediterranean, in northern Africa, in the Middle East, across Central Asia to China and in southern European countries such as Greece, Spain and Italy. In Europe, their distribution decreased from south to north. Deviating from this, in the first decades of the 19th century Ireland developed into a country whose density of donkeys per capita was roughly between that of Greece and Spain.

***Figure 2** – Mules were indispensable for carrying loads in mountain areas*

Oxen, cows and bulls

Animals were seldom categorised and counted as working animals in the official statistics. That is one of the main reasons why they have been overlooked as relevant actors for such a long time. While the number of horses, mules and oxen is relatively well documented in the official statistics, the number of working dogs, cows and bulls were seldom levied by the authorities. Their numerical relevance must, therefore, be reconstructed from other sources. The number of working cows, for example, can be calculated from scientific investigations that were undertaken into the working capacities of cows in the 1930s and 1940s when agronomists conducted scientific studies of the draft performance of cattle. These investigations enable us to reconstruct the number of cattle used for working purposes in the interwar period. In Switzerland, the statistically skilled agronomist Hans Wenger measured and analysed the work performed by cows on 375 carefully selected farms.[4] While the observed units mainly fell into the categories of small and medium farms, they nonetheless kept almost three-quarters of all cattle. In two-thirds of the surveyed farms, cows were kept by their owners as the main draft labour. They performed circa 90 percent of the drafting and hemming work. On half of the farms surveyed, cows were used to perform almost all draft work; on the other half, oxen and horses were deployed for particularly heavy draft work or work that had to be performed in very hot or cold conditions, such as, for example, hauling wood in the winter. But not only in Switzerland, in many other European regions too, cows were used in great numbers as draft animals on small and medium-sized farms.[5] To balance their milk

4 Wenger 1939.
5 Trossbach 2016, 215-244.

***Figure 3** – In many European regions, cows were the most numerous draft animals up to the middle of the 20th century*

***Figure 4** – Breeding bulls were used, often in cooperation with horses, oxen or cows, as draft animals too*

and draft performance, they normally were harnessed for a few hours per day only. And before and after giving birth to a calf they usually were spared from draft work altogether.

A today almost forgotten phenomenon is, that breeding bulls too were used as draft animals. Bulls were difficult to keep, their strength often made them dangerous for those who kept and fed them. But work was considered as easing their character. And there is clear evidence from written sources, that working bulls could be kept longer for breeding purposes than those who lived idle on farms.

Dogs

Dogs were not only used for protecting goods and herding cattle and sheep, they also played a crucial role in transporting goods to the markets or around the farms. But the dogs used for pulling were, similar to cows and breeding bulls, hardly ever recorded statistically. Numerous sources indicate, however, that working dogs were common and the number of dogs used for pulling increased in the second half of the 19th century. With the increasing production and consumption of milk, dogs became particularly relevant for delivering the milk from farms to the creameries and, within the towns, for distributing the milk to the consumers' homes. In addition to the farming population and the milkmen, smaller merchants, butchers, bakers, gardeners, and grocers too took advantage of the muscular strength, mental abilities, and docility of dogs.

The sources documenting this use of dogs almost always refer to local conditions. Towards the end of the 19th century, there were about 300 working dogs in the small town of Bern. In addition, practically all farms in the surrounding areas used their dogs for pulling purposes as well. One of the best experts on the question of working dogs was the famous geologist Albert Heim (1849-1937), who made a name for himself as a cynologist too.[6] Heim reminds us, that in the second half of the 19th century the dog carriage was as common as the ox, the horse or the donkey carriage.[7]

Another genre of sources documenting the work performed by dogs in cooperation with men are the sources created by the engagement of animal protection societies for a regulation or a total prohibition of the use of dogs as draft animals. The fight against the use of dogs for draft purposes was, however, not only motivated by animal protection motives. Equally important were the attempts to discredit and to displace the mobile, often sub-proletarian traders by the newly emerging class of stationary traders in towns and cities. Those people who used dogs as working animals argued, that they were capable to identify the needs of their working companions. Ernst Hess, a veterinarian at the University of Bern, furthermore pointed out that those who worked with animals and devoted a large part of their lives to feeding and caring for them, hardly ever were members of the emerging animal welfare associations. To their representatives, who usually came from a middle-class urban background and kept cats and pet birds in their homes, Hess pointed out, that working people were often depending in their surviving struggle on the cooperation of the "proletariat of working animals".

6 Schiedt 2022b.
7 Id. 2022a, 14pp.

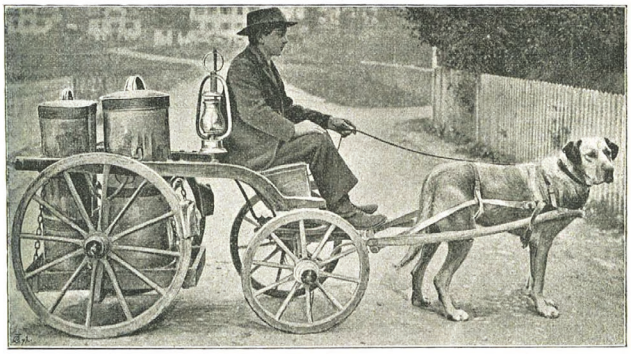
Fig. 28. Milchwagen für Hundebespannung.

Figure 5 – Dogs were indispensable for the distribution of milk in many European cities

In the long perspective, the attempts to prohibit the use of working dogs were successful – but not universally and only step by step in Western Europe. While in England a ban was implemented as early as 1854, in France this was only the case in 1925. In Belgium and the Netherlands, the prohibitionists were successful in certain areas in the 1950s and by the middle of the 1970s the use of dogs as draft animals was forbidden in both countries.[8] In Switzerland, where a strong tradition of keeping working dogs existed since the 19th century, they were, however, never fully banned.

But the attempts to ban working dogs contributed to the reduction of their numbers towards the end of the 19th century even in regions, where they were not banned. Some working dog owners replaced them with donkeys. Their number, therefore, rose towards the end of the 19th century for a short period – a phenomenon that even statisticians noticed when they argued, that the increase in donkeys in some areas had to be attributed to the efforts of charitable and animal welfare associations to prohibit or limit the number of dogs pulling milk trucks or vegetable carts.[9]

Interaction of working animals and men

Animals, like men, are not simply born to work. They have to learn it before they can perform it. The teaching techniques varied across cultures and times as much as the pulling harnesses for horses, cows and dogs. Foals, for example, usually were free to roam beside their working mothers in their first year. Then they were tied to a pulling adult to get adjusted to the working rhythm. Only if the horses were three or four years old, they were expected to work along with older companions.[10]

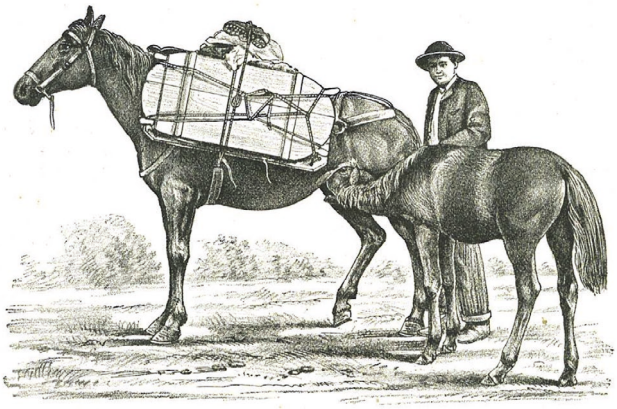
Fig. 42. Käsetransport im Binnthale.

Figure 6 – Learning by doing: animals had to learn to work just as well as men. Foals were free to roam beside their working mothers in the first year

8 Schmitz 2013, 289-299.

9 Moser 2021, 139-154.

10 This part of the paper is based on: Moser/Wigger 2022.

Figure 7 – Oxen and men could not work continuously, they had to rest, eat and drink periodically

***Figure 8** – Children and animals often worked together*

Recreation is another field where close interactions between men and animals can be observed. Both, men and animals get tired when they are working. Unlike motor-driven machines they are not able to work continually, without resting. As living resources, they have to eat and drink regularly. When men and animals were working together, they often rested, ate and drank together.

While the need for recreation, drinking and eating created bonds between men and their working animals, the inability to work continuously was crucial for the replacement of most, but not all, working animals by motor-driven machines once the latter became nearly as versatile as the working animals themselves.

Children, like men and women, were an integral part of the peasant economy up to the middle of the 20th century. While the burden of work was too heavy for young children, film sources now available from all over Europe indicate, that working with animals was an empowering experience for many of them too. An important aspect that becomes clear from the film sources is the close interaction of men, women and children with their working companions. Although men decided unilaterally when the animals had to work, the work itself was always done in cooperation between human beings and animals.

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Author info
Peter Moser

Archiv für Agrargeschichte - Archives de l'histoire rurale - Archives of rural history
Villettemattstrasse 9 · 3007 Bern, Switzerland

E-Mail: peter.moser@agrararchiv.ch
Digital paper: https://youtu.be/Hk3SHbUIAzY

Oxen: Status, Uses and Practices in the U.S.A., Encouraging a Historic Tradition to Thrive

Andrew B. Conroy

Abstract

Oxen in the United States of America have played an important role throughout its history. Unlike other countries,oxen were never completely given up for horses, mules, or tractors. Instead, the culture of keeping oxen has been maintained by a small group of teamsters in the Northeastern states collectively called New England. Their continued presence has been largely due to agricultural fairs and exhibitions where they have been used in competition for the last 200 years. Ox teamsters were surveyed in 2021via social media using Qualtrics. The 423 ox teamsters responding owned 1791 oxen in 39 states, with the majority of oxen and teamsters in Maine, New Hampshire, Vermont, Connecticut, Massachusetts and New York respectively. The gender breakdown of ox teamsters was 59 % men, 40 % women. Results showed 257 teamsters used their oxen for farm work, 213 for exhibitions and parades, 191 for logging, 173 for recreation, 165 for competition showing, 144 for competition pulling, 85 at living history farms and in historic settings, and 18 in television and movies. Teamsters worked oxen an average of 7 hours/week and 89 % train the oxen as calves. 289 people learned to train from friends, 211 from family, 202 from books, 158 from organizations related to oxen, 156 from the Internet, 152 in the 4-H program, 129 from videos, 94 at hands-on workshops, 54 from magazines and 42 from living history farms. More than 20 breeds of cattle were used as oxen with Milking Shorthorns (11.9 %), Holstein-Friesians (10.9 %), Chianina (9.6 %) and Brown Swiss (9.3 %) being the most numerous.

Résumé

Aux États-Unis d'Amérique, les bœufs ont joué un rôle important tout au long de l'histoire du pays. Contrairement à d'autres pays, les bœufs n'ont jamais été complètement abandonnés au profit des chevaux, des mules ou des tracteurs. Au contraire, la culture de l'utilisation des bœufs a été maintenue par un petit groupe d'utilisateurs dans les États du nord-est, collectivement appelés Nouvelle-Angleterre. Leur présence continue est due en grande partie aux foires et expositions agricoles où ils ont été utilisés en compétition au cours des 200 dernières années. Les conducteurs de bœufs ont été interrogés en 2021 par le biais des médias sociaux en utilisant Qualtrics. Les 423 meneurs de bœufs qui ont répondu possédaient 1791 bœufs dans 39 États, la majorité des bœufs et des utilisateurs se trouvant respectivement dans le Maine, le New Hampshire, le Vermont, le Connecticut, le Massachusetts et New York. La répartition par sexe des conducteurs de bœufs était de 59 % d'hommes et de 4 % de femmes. Les résultats ont montré que 257 meneurs utilisaient leurs bœufs pour les travaux agricoles, 213 pour les expositions et les parades, 191 pour l'exploitation forestière, 173 pour les loisirs, 165 pour les concours de présentation, 144 pour les concours de traction, 85 dans des fermes historiques et 18 pour la télévision et le cinéma. Les utilisateurs ont travaillé avec leurs bœufs en moyenne 7 heures par semaine et 89 % d'entre eux les ont dressés en tant que veaux. 289 personnes ont appris à dresser les bœufs auprès d'amis, 211 auprès de la famille, 202 dans des livres, 158 auprès d'organisations liées aux bœufs, 156 sur Internet, 152 dans le cadre du programme 4-H, 129 dans des vidéos, 94 lors d'ateliers pratiques, 54 dans des magazines et 42 dans des fermes d'histoire vivante. Plus de 20 races bovines ont été utilisées comme bœufs de trait, les plus nombreuses étant les Shorthorns laitiers (11,9 %), les Holstein-Friesians (10,9 %), les Chianina (9,6 %) et les Brown Swiss (9,3 %).

Kurzfassung

Ochsen haben in den Vereinigten Staaten von Amerika im Laufe ihrer Geschichte eine wichtige Rolle gespielt. Im Gegensatz zu anderen Ländern wurden Ochsen nie vollständig zugunsten von Pferden, Maultieren oder Traktoren aufgegeben. Stattdessen wurde die Kultur der Ochsenhaltung von einer kleinen Gruppe von Gespannfahrer:innen in den nordöstlichen Staaten, die unter dem Namen New England zusammengefasst sind, aufrechterhalten. Ihr Fortbestehen ist vor allem auf landwirtschaftliche Messen und Ausstellungen zurückzuführen, wo sie in den letzten 200 Jahren im Wettkampf eingesetzt wurden. Die Ochsenkutscher:innen wurden im Jahr 2021 über soziale Medien mit Hilfe von Qualtrics befragt. Die 423 befragten Gespannführer:innen besaßen 1791 Ochsen in 39 Bundesstaaten, wobei die meisten Ochsen und Gespannführer in Maine, New Hampshire, Vermont, Connecticut, Massachusetts und New York zu finden waren. Das Geschlecht der Gespannfahrer:innen setzte sich aus 59 % Männern und 40 % Frauen zusammen. Die Ergebnisse zeigen, dass 257 Gespanne ihre Ochsen für landwirtschaftliche Arbeiten, 213 für Ausstellungen und Paraden, 191 für Holzfällarbeiten, 173 zur Erholung, 165 für Vorführungen bei Wettbewerben, 144 für das Ziehen bei Wettbewerben, 85 auf historischen Bauernhöfen und 18 in Fernsehen und Film einsetzten. Die Fuhrmeister:innen arbeiteten im Durchschnitt 7 Stunden pro Woche mit Ochsen und 89 % trainierten die Ochsen bereits als Kälber. 289 Personen lernten das Training von Freund:innen, 211 von der Familie, 202 aus Büchern, 158 von Organisationen, die sich mit Ochsen beschäftigen, 156 aus dem Internet, 152 im 4-H-Programm, 129 aus Videos, 94 bei praktischen Workshops, 54 aus Zeitschriften und 42 auf historischen Höfen. Mehr als 20 Rinderrassen wurden als Arbeitstiere verwendet, wobei Milking Shorthorns (11,9 %), Holstein-Friesen (10,9 %), Chianina (9,6 %) und Braunvieh (9,3 %) am häufigsten vertreten waren.

Resumen

Los bueyes han desempeñado un papel importante a lo largo de la historia en los Estados Unidos de América (EEUU). A diferencia de otros países, los bueyes nunca fueron sustituidos por completo por caballos, mulas o tractores. Sin embargo, la cultura de cría de bueyes ha sido mantenida solo por un pequeño grupo de carreteros en los estados del noreste, llamados colectivamente Nueva Inglaterra. Su ininterrumpida presencia se debe en gran parte a las competiciones de bueyes en las ferias y exposiciones agrícolas de los últimos 200 años. En 2021 la empresa estadounidense Qualtrics realizó una encuesta entre jinetes de bueyes en los EEUU a través de las redes sociales. Los 423 criadores de bueyes que respondieron poseían 1791 y residían en 39 estados diferentes, la mayoría de ellos en Maine, New Hampshire, Vermont, Connecticut, Massachusetts y Nueva York respectivamente. El porcentaje de transportistas de bueyes era de un 59 % hombres y un 40 % mujeres. Los resultados de la encuesta mostraron que 257 jinetes utilizaron sus bueyes para el trabajo agrícola, 213 para exhibiciones y desfiles, 191 para la tala de árboles, 173 para el ocio, 165 para la competición, 144 para la competición de arrastre, 85 en granjas históricas vivientes y 18 en la televisión y el cine. Los jinetes trabajaron con bueyes una media de 7 horas semanales y el 89 % estos fueron entrenados desde becerros. 289 personas aprendieron a entrenar de amigos, 211 de la familia, 202 de libros, 158 de organizaciones relacionadas con los bueyes, 156 de Internet, 152 en el programa 4-H, 129 de vídeos, 94 en talleres prácticos, 54 de revistas y 42 de granjas históricas vivientes. Se utilizaron más de 20 razas vacunas, siendo las más numerosas la Shorthorns (11,9 %), la Holstein-Friesian (10,9 %), la Chianina (9,6 %) y la Brown Swiss o Parda suiza (9,3 %).

Review of Literature

History of Oxen in the U.S.A.

Robert Pike, in 'Tall Trees, Tough Men', stated the importance of the ox and the reasons why his presence always preceded other draught animals in almost every agricultural region in the world where horses might also be used. He was referring to the ox in a New England context, but his statement captures the essence of the ox in almost any region of the world. I will build on this quote to show how the ox in every way mentioned below found its place in North America and continues to be found in six Northeastern states, along the Atlantic coast, called New England.

"Before the horse there was the ox. The ox has many advantages: he is stronger than a horse; he is less apt to be scared; he is less inclined to flounder in snow and mud; he is not so given to sickness; he is less expensive to buy and keep; and if it becomes necessary; he is better to eat."[1]

Pike's statement above was accurate, and his words were also supported by earlier writers[2]. Yet, his statement about oxen being stronger than horses is not necessarily true today. In the mid-1800's oxen were indeed larger than horses in the Americas[3], but by the late 1800's as larger breeds of horses were imported, oxen were no longer necessarily stronger. A well harnessed and trained horse of the same weight as an ox will most often be able to pull larger loads or logs[4].

Oxen in North America

Shortly after their arrival in the New World, in what is now North and South America, the Spanish introduced their cattle and head yokes with which to work them[5]. Decades later the English brought their cattle and their neck yokes with which were familiar to Virginia and the New England colonies. While many European farmers were having great debates on the use of oxen versus horses at the end of the Middle Ages[6], the early American pioneers had no choice but to use oxen. Like their ancestors in Europe, manufactured resources were scarce. Good harnesses, well-built wagons and carts, grain for livestock and good roads were not available for decades. The early colonists recognized that cattle could survive under conditions that would have killed horses[7]. Cattle provided the power, leather, milk, meat and manure to build a new world[8]. Conditions were so difficult in the Northern settlements during the 1600's many cattle died due to the severe lack of winter feed[9]. Cattle that survived ate anything resembling roughage that they were given or allowed to find[10]. For the important spring plowing oxen were often in very poor condition, some barely able to perform in the yoke.

For the early cattle that survived the first winters in North America, their needs were few, but their jobs on a farm were many. Teams of oxen provided the draught power to tame the 'New World' and begin agricultural endeavors[11]. In the early colonies, the ox thrived where other draught animals failed[12]. Throughout colonial history oxen toiled under the yoke, ready for any task demanded of them. The ox was used first for logging in the vast forests of the colonies along the Atlantic coast[13]. By the mid to late 1600's teams of oxen were used to haul huge white pine logs strictly reserved for the British Navy's masts. This task required as many as 12-40 pairs of oxen to haul logs from the interior to the coast[14]. Many major roads through coastal towns in New England still bear the name Mast Road, due to the history of their location and use. This activity allowed New England ox teamsters to develop advanced skills in logging well before 1700[15].

Logging most took place in winter when the oxen could haul larger loads on frozen ground and roads[16]. In the spring season early farmers used oxen to pull tree stumps, later used to make stump fences and to remove boulders from recently cleared forests. These were used to make more permanent stonewalls that have lasted centuries[17]. Spring was time for plowing and harrowing fields, and later planting crops. Summer was a time for harvesting hay and other crops, excavating the land for building and making roads. Oxen hauled carts or wagons in summer and sleds in winter, which were filled with everything that the early colonists purchased, sold, or moved[18]. The work of the ox included pulling covered bridges into place, moving buildings, and moving everything from wood products to military armaments and supplies during the American Revolution[19]. As lands to the West of the early American colonies were opened up in the 1800's, farmers packed their belongings into wagons most often drawn by 6-8 teams of oxen and began the great westward expansion[20].

The ox continued to be a very important animal on the farm in the United States throughout the eighteenth and much of the nineteenth century. The presence and prominence of the ox can be seen in almost any photograph depicting the early settlements, agriculture and transportation in early America before 1900[21]. In time the horse replaced the ox in many midwestern and western areas, and the mule replaced oxen in many southern regions[22]. However, this was not until the ox had cleared the way for civilization[23]. Oxen were the primary draught animals to provide the power to clear the virgin forests of their enormous trees making way for the crops nec-

1 Pike 1967, 116.
2 Skinner 1844; Periam 1884; Meeker 1922; Marcy 2006.
3 Ibd.; Skinner 1844.
4 Conroy 2007, 149.
5 Dunmire 2013, Chapter 4; Id. 2021, 147.
6 Collins 2010; Liebowitz 1992.
7 Conroy 2007, 255.
8 Clater 1844, 151.
9 Smithcors 1958, 172.
10 Conroy 2007, 254.
11 Walden 1933, 112.
12 Conroy 2007.
13 Carlton 1939.
14 Cowan 2003, 21.
15 Ibd., 27.
16 Conroy 2007, 177.
17 Sloane 1962, 29.
18 Conroy 2007, 254.
19 Skinner 1844, 149p.
20 Marcy 2006; Ahmed 2016.
21 Conroy 2007, 254.
22 Kaufman/Liebowitz 1997, 18.
23 Skinner 1844, 151.

***Figure 1** – Oxen pulling freight wagons in the Black Hills, South Dakota, 1891*

essary for human survival. They were the first animals to plow tough prairie sods[24], and to build the trails, roads and bridges necessary to bring people to the newly settled areas of the American West. The plodding, patient beasts with simple wooden yokes forded rivers, crossed the hot plains, deserts, tallgrass prairies and even the great swamps of the Southeast[25].

On the Oregon Trail and earlier treks westward, the ox was preferred over the horse or mule because he was much cheaper to buy[26], was less likely to be stolen by Native Americans[27], was easier to capture on horseback[28], and in deep mud and water was easier to control than mules and horses[29]. In the case of injury or death, oxen were also better to eat[30]. They were thought to be easier to control for teamsters unfamiliar with draught animals[31]. The greatest attribute of the ox was its ability to do well on coarse roughage[32]. Being ruminant animals with four stomach compartments the oxen could graze at night, gorging on local forages in a few short hours, later chewing their cud and more effectively processing the roughage than the horse or mule. Oxen were slower moving than a well-fed horse or mule, with the U.S. Cavalry estimating the speed of the horse at 3 miles per hour, mules at 2.5 miles per hour and oxen at 2 miles per hour on a good road pulling a light load[33]. Oxen could be persuaded to move faster achieving 3-4 miles an hour in an emergency if they were in good condition[34]. Staying in better condition and setting a slower steady pace, an ox could equal the performance of both the horse and mule on long, difficult trails with poor grazing[35]. On good days oxen could average 16-18 miles by traveling in the cool of the morning, resting in the midday sun, and resuming the trek in the afternoon[36].

As trails became roads, farmland was settled and tough sods were opened in the tall and short grass prairies with oxen[37], the demise of the ox soon followed. Ample amounts of good feed, especially grains to supplement the native grasses[38], lighter plowing, and larger farms gave the faster horses and mules the advantage[39]. Thereby, the ox lost his prominence in much of the Western U.S.A.. By 1890 the ox had disappeared from the majority of the American landscape[40]. In New England, the states of Maine, New Hampshire, Vermont, and especially Connecticut maintained the highest proportion of oxen to total draught animals in the Northeast in the 1890's.

24 Liebowitz 1992, 32.
25 Meeker 1922; Gregg 1954, 73.
26 Marcy 2006, 29.
27 Ahmed 2016, 21; Gregg 1954, 73.
28 Marcy 2006, 29.
29 Gregg 1954, 46; Meeker 1922, 23.
30 Marcy 2006, 28.
31 Ahmed 2016, 21.
32 Kauffman/Liebowitz 1997, 14.
33 Cecil 2020, 69.
34 Marcy 2006, 29.
35 Kauffman/Liebowitz 1997, 18.
36 Marcy 2006, 29.
37 Kauffman/Liebowitz 1997, 20.
38 Periam 1884, 661.
39 Danhof 1969, 143.
40 Liebowitz 1992, 35.

The mid-Atlantic state of North Carolina actually showed an increase in the percentage of oxen between 1850 and 1890[41]. Similarly, Alabama, and Florida increased their percentage of oxen, largely due to logging in difficult areas in the late 1800's[42]. The last stand for the ox, outside of New England was in the great forests of northern California, Oregon and Washington in the late 1800's and early 1900's[43].

Oxen in New England

The ox was a draught animal that symbolized New England's history, and much like the mule in the Southern U.S.A. and the horse in the Western U.S.A[44]. The presence of the ox became intertwined with the New England region's rural culture and folklore[45], as oxen were the most important draught animal to the region's early development[46].

To some, the ox symbolized backwardness or farmers who were cash strapped and unwilling to change[47]. However, for New England farmers, the ox was well suited to their needs[48]. His slow pace and patient manner made him much less likely to break the farm implements pulled through the rocky hillside fields[49]. Preferring cool weather and having no fear of water the ox was comfortable working in winter, or in the wet soils and swamps commonly found in New England. Conversely, horses and mules struggle in the wet ground where their hooves can get stuck, and often become frantic when they have to pull in deep snow[50].

On the small farms in New England, the ox found work throughout the year[51]. They were used for logging in winter[52] and for hauling the sap from maple trees in early spring[53]. They would then be used for spreading manure, plowing, harrowing fields and planting crops such as wheat, rye and corn. In the warm weather of summer, oxen could be found working in hay fields and harvesting other crops. In much of New England, there were always stones to be removed from the fields and stumps to be pulled from new ground. By the late 1600's they could be found in every New England community where soil had to be tilled and materials moved on land, which often included moving buildings[54]. Their work was much like the work done by the truck or tractor today. They were not the fastest mode of transportation, but they were dependable, cost-effective, and readily available, especially for small-scale farmers[55]. Finally, when not at work, oxen were active capital for a small farmer, whereby the farmer could realize his full investment in an ox at the hands of the nearest butcher in the case of an accident or injury[56].

41 Ibd., 32; Garrett 1998, 236.
42 Liebowitz 1992, 32; Martin 1998, 230.
43 Andrews 1997.
44 Welsch 1994.
45 Welsch 1988; Id. 1993; Id. 1994.
46 Conroy 2007, 254.
47 Liebowitz 1992, 32; American Agriculturist 1872.
48 Hubka 2004, 62.
49 Conroy 2007, 149, 255.
50 Meeker 1922, 23; Martin 1998, 231.
51 Dangerfield 1821, 1; Skinner 1844, 149; Meeker 1922.
52 Liebowitz 1997, 34; Pike 1967, 117; Cowan 2003, 9.
53 French 1911, 42.
54 American Agriculturist 1873, 1; Hubka 2004, 140, 172.
55 Danof 1969, 143.
56 American Agriculturist 1872.

History of Ox Training

As early as the 1700's the ox teamsters in New England had gained notoriety for their work with draught cattle. William Strickland, an Englishman passing through Springfield, Massachusetts in 1794 commented,

> *"Stout able bodied oxen are everywhere, used for the purposes of husbandry. Hardly a horse is kept upon a farm: two or four go on a plough, a waine or waggon; they all work with common yokes, and are more tractable and better broke than I ever saw in England; it is not uncommon in this country for a boy to begin working a pair in a very light carriage, when they are little more than calves, which it may be intended for him to drive many years afterwards, by which means they become so habituated to him that they will follow him about like a dog."*

Beyond the above quote, there is ample evidence that children "played with" and trained bull calves to be oxen in New England and other regions[57]. In the book *Yankee Drover*, based on the autobiography of an early American farmer named Asa Sheldon, he wrote at length about his work with livestock and in particular oxen. As early as age 8, Asa was employed by farmers to plough with oxen, "*…a work that pleased me – at a shilling per day…*" and at age 9 was employed by his father to log with oxen in Massachusetts in 1797[58]. Jochen Welsch cites a publication called *The Cultivator* in 1844, where an 8-year-old Elijah Carpenter exhibited his 6-month calves at the Worcester County Cattle Show[59]. The fact that children frequently trained oxen in New England has been a long-standing tradition that likely resulted in better-trained oxen when the animals mature. Training oxen as calves allowed them to be more calm, docile and easily put to work[60]. Being that cattle are more patient and forgiving than horses or mules, the job of training the calves was often as much recreation for the hard-working children of early America[61], as it was essential an essential component of having a constant supply of well-trained animals. Early writers, especially those from New England encouraged training the animals young and doing so in a manner that used patience and firmness, rather than anger, force and profanity[62].

Organized agricultural shows in New England seemed to have appeared in the early 1800's, with farmers being encouraged to attend and compete as a method to transfer new agricultural practices. The oldest continuous agricultural fair in the U.S.A. is the Brooklyn Fair in Connecticut, which started in this way in 1809[63]. Historian Jochen Welsch explored this phenomenon and attributes much of the idea of cattle shows to the "progressive farmers"[64]. As early as 1811 in Massachusetts there were efforts to inspire the less progressive farmers to adopt new ideas[65]. Thereafter, in the 1800's it became more common for articles to appear in agricultural papers and newsletters

57 Meeker 1922, 9.
58 Sheldon 1988, 11.
59 Welsch 1994, 41.
60 Skinner 1844, 156; Periam 1864, 66; Walden 1933, 117.
61 Sloane 1962; Meeker 1922.
62 Skinner 1844, 156; Manning 1882, 653; Periam 1884, 661.
63 Windham County Agricultural Society 2012.
64 Welsch 1994, 23.
65 Id. 1988; Id. 1993; Id. 1994, 23.

***Figure 2** – Ox Show at the Cheshire Fair in New Hampshire late 1800's*

about the New England ox at fairs and shows[66]. Improved ideas about their use, yokes and even shaping horns to make teams more attractive also appeared in the press[67].

As oxen began to disappear from even New England farms in the late 1800's the number working in the forests also dwindled. Robert Pike said, "*by 1890, there were a few old timers swore by them ... but the beasts had generally been replaced by horses in the New England lumbering woods.*"[68]

Ezra Meeker in his autobiography and return to the Oregon Trail in 1906 said "*the time of the ox had passed*"[69]. However, one place from which oxen never completely disappeared was the agricultural fairs common throughout New England. Many of these fairs have been held continuously for over 150 years. The events, especially ox pulling, to the disappointment of the progressive farmers, became more popular for the entertainment of the less progressive farmers and rural citizens

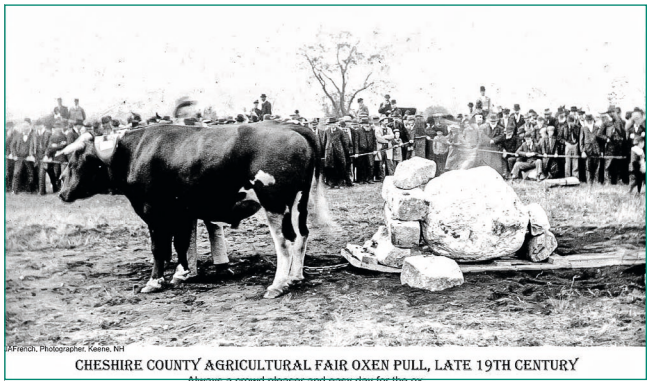

***Figure 3** – Ox Pulling competitions began by teamsters walking their oxen from their farms and coming together to determine who had the strongest oxen as a form of entertainment at the fairs*

than did plowing contests or events related to improved practices[70]. However, ox pulling provided the impetus for New England farmers to keep oxen to this day[71].

Similar to early agricultural shows, hands-on learning began to encourage children to consider new agricultural ideas beginning in the late 1800's. In the states of Minnesota and Ohio rural youth programs started in 1902. These were considered the predecessors to the national 4-H program. By 1912 the rural youth clubs were called 4-H clubs. A four-leaf clover with the letter H on each leaf represented promoting positive ideas for the Head, Heart, Hands, and Health. In 1914 the program was adopted by the Cooperative Extension System within the United States Department of Agriculture to promote youth development outside of public schools[72]. This program continues to this day and includes agricultural and non-agricultural activities. In 4-H youth to learn about domestic animals, in part by exhibiting their livestock at agricultural shows, fairs and other events. 4-H clubs and programs today can be found in all 50 states.

With a long history of children training and even showing oxen, the state of Maine was the first state to initiate a 4-H Working Steer program. The idea was developed in the early 1960's in Franklin County, Maine[73]. It allowed children who were interested in oxen to be trained in how to work with and care for oxen in a club environment. They were also encouraged to demonstrate what they learned in shows exclusively for children through the 4-H

***Figure 4** – The 4-H Working Steer (ox) Program started in the early 1960's in Maine and spread to other New England States in the 1970's; the program has taught hundreds of interested children how to train and care for oxen*

program. This 4-H Working Steer program later spread to other counties in Maine and in 1970 to New Hampshire[74]. In recent decades the 4-H working steer program enrolled 20-50 youth each year throughout New England[75].

New England, has for the last 100 years been the only region in the United States that boasts hundreds of teams of oxen and even more teamsters[76]. The farmers in New England maintained their use of oxen after much of America had given up on them, although even there the numbers dropped after the American Civil War in the 1860's[77]. After almost 400 years, the ox still can be found at work in the fields and the forests of New England. His presence today may seem unimportant, but it is unique. The skills of the teamsters who drive oxen can be attributed to their stubborn forefathers, who refused to give up the ox that had served them so well. Most importantly competitive events encouraged people to keep the tradition of working oxen tradition alive. Oxen can be seen

66 American Agriculturist 1871, 1.
67 Id. 1855; Id. 1872; Id. 1873; Id. 1874; Id. 1881.
68 Pike 1967, 117.
69 Meeker 1922.
70 Welsch 1994, 75.
71 Ibd., 52.
72 4-H 2021.
73 Winslow 2021.
74 Courser 2021.
75 Conroy 1986; Id. 1995b; Id.1996; Id. 2003; Id. 2007.
76 Id. 2015.
77 Kauffman/Liebowitz 1997,16.

Figure 5 *– Ox pulling competitions have been held in New England for over 200 years*

most often at country fairs, in parades or historic events in rural communities[78]. Teamsters range in age from small children driving calf teams in 4-H events to adults competing in log skidding or plowing competitions and pulling contests with some animals exceeding 3000 pounds each[79]. People from around the nation and the world have been found at such events trying to glean from these teamsters and their animals the skills that have long been lost in other regions.

In 2021, the New England states of Maine, New Hampshire, Vermont, Massachusetts, Connecticut, and Rhode Island hosted at least 70 ox pulling events where ox teamsters competed to see who had the strongest oxen by pulling sleds (called stoneboats) loaded with concrete blocks. Winning teams pulled as much as 3 times the ox team's combined weight in 2-meter bursts, called elimination pulls. In Maine the most common contest is to pull a heavily loaded stoneboat as far as possible in either 3 or 5 minutes. This is called a distance pull and can occasionally be found in other New England states. In addition to pulling, there were at least 49 shows in the region where ox teamsters competed with their animals based either on training, the animal's response to the teamsters, the conformation of the animals and/or how well they were matched in color and size.

Methods and Materials

The internet and social networks such as Facebook has encouraged interested parties to create networks or groups related to personal interests. There were many state and regional Facebook groups related to oxen in the United States, which provided an opportunity to connect with the teamsters through electronic means[80]. A short electronic survey developed using a software program called Qualtrics[81] was employed as a simple way to gather data. Known owners of oxen who were not using social media were contacted through email or other electronic means so that the anonymous survey could be passed onto them. The subjects were not compensated in any way and the study was approved by the University of New Hampshire's Institutional Review Board for the Protection of Human Subjects. The research subjects, all owners of oxen in the U.S.A. were asked to review a consent form online before taking the survey. They had the opportunity to decline to participate in the study. The ox owners were then asked to participate in a 10-minute survey about the use and status of oxen on their farms. The survey was available online from February 3, 2021, through March 12, 2021.

The questions posed to them were used to evaluate:

1) The geographic distribution of oxen in the United States
2) The current or intended uses of oxen
3) How many oxen or cattle being trained for work the participant owned in the last 12 months
4) The years of experience the participant had working with oxen
5) The age at which the oxen are trained
6) The hours the oxen were trained or worked per week
7) Where and/or how the participants learned to work oxen
8) Where the participants acquired the equipment they needed to work with oxen
9) The breeds the participants used as oxen
10) The gender of the participant

The data gathered through the survey were transferred to an Excel spreadsheet. They were analyzed using simple quantitative measures, such as the sum and average score of responses to the research questions. These data were then viewed in various forms of figures and tables, organized by geographic location, gender, and other data gathered. Any participants not from the U.S.A. or those who did not own or keep oxen were deleted from the data set.

78 Bryant 2010, 364.
79 Conroy 1995a; Id. 1996; Id. 2007.
80 Salmons 2016.
81 Qualtrics 2021.

The results reflect willing participants in this survey. It cannot be assumed this survey included all of the ox teamsters or oxen in the U.S.A.. There were people known who would not participate and others who may not have heard about or found this survey in the 5 weeks it was available in 2021. Therefore, this was not a census or a statistical estimate. It was a snapshot at one point in time with a group of willing and able participants who owned oxen in the U.S.A. in 2020-2021.

Results and Discussion

The geographic distribution of oxen in the United States

There were 423 participants who collectively kept 1791 oxen in 39 of the 50 states in the U.S.A. The eleven states where oxen were not reported were Hawaii, Nevada, Utah, Arizona, New Mexico, Iowa, Arkansas, Louisiana, Alabama, Florida and Delaware. Geographically the places not reporting any oxen were primarily from hot arid areas of the Southwest and hot humid states of the Southeast. Historically the American Southwest, which was a former Spanish colony was the first place oxen were used in North America and some Southeastern states were the last places outside New England where oxen were kept primarily for logging in the early 1900's[82]. In recent years oxen have been observed by the author on farms in Hawaii and Iowa, but there were no such participants in this survey.

The areas with the most oxen were, as expected in New England. Maine led the nation with 86 participants responding with 491 oxen. New Hampshire was ranked second with 65 teamsters who responded who kept a total of 253 oxen. Vermont ranked 3rd in the survey with 46 teamsters responding to the survey and 209 oxen. Fourth place was Connecticut with 38 teamsters responding and 194 oxen. Massachusetts ranked fifth with 30 teamsters responding owning 187 oxen, and the final state in New England, Rhode Island ranked 6th with 8 teamsters responding with a total of 24 oxen. Therefore, 273 teamsters responded to the survey from New England who owned collectively 1358 of the oxen counted in this survey. This represented 75.8 % of all of the oxen counted in the United States. The oxen and teamsters from New York state, adjacent to New England and frequent participants in New England ox events added 25 more teamsters and 76 more oxen. Together New York and New England accounted for 70 % of the ox teamsters and 80 % of the oxen counted in this survey. The notable areas with oxen outside the Northeastern U.S.A. were Virginia with 15 teamsters keeping 38 oxen and Michigan with 12 teamsters and 37 oxen.

What were the current or intended uses of oxen?

Farm work with oxen in the United States was ranked highest in response to this question. Teamsters responding to this survey[83] were allowed to choose numerous possible answers in the survey and 254 of the 423 or 60 % of the participants chose farm work. This represented 19.71 % of all responses to the question. This result may be surprising, as most of the oxen in the U.S.A. have been seen primarily at public events and in competitions. The answer lies largely in the fact that a teamster needs to find work for their oxen. Real work helps keep the oxen fit and responsive in the yoke. As it takes at least a small farm to support and keep oxen, they have been used for work such as spreading their own manure,

82 Garrett 1998.

83 In the digital paper presentation (link at the end of this paper), the uses of oxen in the U.S.A. was expressed as a percentage of all responses. Teamsters were given the opportunity to choose multiple uses of oxen and there was a total 1307 responses to this question.

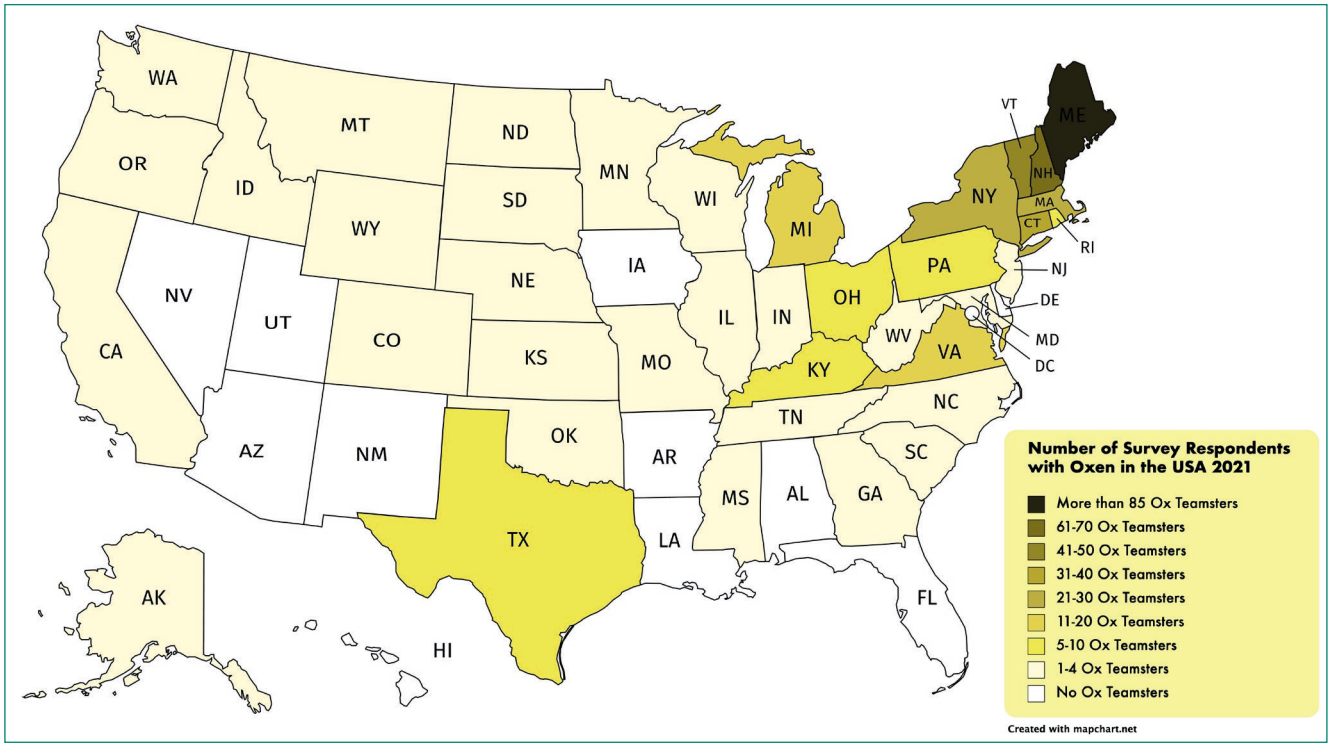

Figure 6 – United States Geographic Distribution of Ox Teamsters and Oxen in 2021, based on survey data

moving hay or other feed, and transporting things on a farm that might otherwise be done with a tractor. Some farmers also used oxen for fieldwork such as plowing, harrowing, and mowing hay.

Figure 7 *– Farm work with oxen ranked as the most common activity for all teamsters in the survey, in part as a result of teamsters who compete with oxen also using them for real work as part of training and conditioning the animals for work*

The second most common use for oxen was in exhibitions and parades, with 212/423 participants or 50 % of the teamsters in this survey choosing this activity. Oxen have been sought after for historic events, demonstrations and for holiday parades. Some teamsters may have chosen this answer instead of showing, as ox shows were also considered exhibitions. People who were not in the New England region take oxen out in the public even if they did not participate in formal competitions at agricultural fairs.

The third highest ranked activity or use of oxen was logging, with 188/423 participants accounting for 44 % of all responses from the ox teamsters. Logging has historically been a common use for oxen. The animal's power, speed and calm nature often made this an enjoyable activity. Similar to farm work, logging was an activity for training young cattle, keeping oxen fit, and providing real work for the animals. New England is a heavily forested region and logging has provided way to use the animals and reap some benefit. Oxen used in competition pulling, as well as showing, benefit from time in the forest. The ox teamster has a simple and enjoyable way of harvesting firewood, which has been a common supplemental heat source in many homes in the region. Lastly, a few ox teamsters have earned income from logging small forest plots, as well as removing salable lumber harvested on their own property.

Figure 8 *– Demonstrations to the public were considered by some ox teamsters to be exhibitions of the animals and their abilities to do many kinds of work*

Figure 9 *– Logging with oxen ranked as the third most common activity with oxen in the U.S.A. – most of the oxen in the U.S.A. are found in New England, a heavily forested region*

The fourth-ranked activity chosen by ox teamsters was recreation with 172/423 teamsters or 40.6 % of participants choosing this as a current or intended use of their oxen. For most ox teamsters in the U.S.A. oxen have become an optional animal on a farm over the last century. People choose to raise oxen; they do not need them. They are most often kept oxen for reasons other than making a living or providing the primary work necessary for agriculture. Recreational activities with oxen included creating trails in forests or fields, giving people rides in their wagons, sleds or carts, or simply having oxen in their fields and on their farm.

Figure 10 *– Recreation with oxen ranked #4 and included enjoying the animals with friends and family, in New Hampshire 2019*

The fifth-ranked activity with oxen was competition showing, with 164/423 ox teamsters or 38.7 % of participants showing their oxen at agricultural fairs and specialty events. This accounted for 12.72 % of all responses to this question. Ox showing has been going on as long as there have been agricultural fairs and field days in New England. The focus of an ox show has generally been for teamsters to demonstrate good animal training, handling, feeding and care. The animals have been exhibited similar to beef or dairy cattle where they are presented clean, with their hair-clipped and horns polished. They were shown at any age and were also judged by an individual who also evaluated the conformation of the oxen as draught animals.

Figure 11 *– Ox showing competitions can be found at agricultural fairs throughout New England – open shows were designed for both children and adults*

The sixth-ranked activity or use of oxen was competition pulling, with 143/423 ox teamsters or 34 % of participants in the survey using their oxen in pulling contests. These numbers were lower than the author expected. This could be due to many people having no chance to compete in pulling contests due to their geographic location outside of New England. The low count could have also been due to people who pulled oxen not responding to the survey. Finally, it may have been due to ox teamsters who chose other activities in addition to this competition pulling, thereby logging and farm work had a greater total number of responses.

Figure 12 *– At least 70 ox pulling competitions were held in New England in 2021; Two types of contests exist – one called a distance pull has the animals pull at least 125 %-200 % of their combined bodyweight as far as possible in 3 or 5 minutes; the second type of contest is considered an elimination contest where weight is added until the animals can no longer pull the sled 2 meters in one continuous motion*

The activity that ranked seventh was Living History Farms or Reenactments, with 83/423 or 20 % of participants responding to this question. In other more developed countries without such a vibrant ox culture, it might seem that the only place people see or use oxen would be at living history farms. Yet, in the U.S. A. it was often ox teamsters raising oxen privately who were invited to living history farms to demonstrate their skills in handling and working the animals. These same ox teamsters often sold their well-trained teams to living history farms to be used in education and historic farm work.

The eighth-ranked use of oxen was "Other Uses", with 55/423 or 13 % of participants choosing this option. This would include using oxen for any activity not previously listed. Some oxen can be ridden, other known ox teamsters used the oxen in animal therapy with adults or children, or they could just be kept to graze fields and keep them open. Finally, some teamsters train young oxen to sell as work animals, while others raise and work them for a few years and sell them for meat.

The ninth-ranked activity was using oxen in movies and television, with 18/423 or 4 % of participants choosing this as a way they have used oxen. Keeping historic animals and maintaining historic skills provided ox teamsters and their animals with unique opportunities, especially if the oxen were well trained and were the correct breed for the period the film or show was portraying.

Figure 13 – Working with oxen in movies provided a glimpse into the past on the Oregon Trail in Manhattan, Kansas – for Author Andrew Conroy 1994

Years of Experience the Participant had Working with Oxen

The years of experience each participant had was an excellent indicator that working with oxen was not only older teamsters clutching to a cultural practice that was disappearing. Rather it showed that there has been sustainability and interest in maintaining the skills needed for working with oxen in the U.S.A.. It also indicated that people were being encouraged to learn how to work oxen across all age groups and experience levels. Finally, the data showed that there are as many people just beginning to use oxen as there are people with many years of experience.

Figure 14 – Ox Teamsters varied in age, the only requirement being mobile and committed to working the oxen

Years of Experience	Percentage of Total
0-1	12.79
1-5	18.72
5-10	15.53
10-15	13.70
15-20	9.13
20-30	12.33
30-40	7.31
More than 40 years	10.50

Table 1 – The years of experience the participant had working with oxen

Where and/or how Ox Teamsters Learned to Work Oxen

Ox Teamsters were asked to answer all the ways they learned to work with oxen. Some teamsters learn to work with the animals using a variety of resources. Teamsters training oxen in regions outside New England any often lack mentors, or nearby teamsters. These teamsters had to rely on sources such as books, videos and the internet. The training of oxen by those who were from families who have had oxen, or who were located in a region with oxen and attend events, learn primarily from family and friends. In the 4-H youth working steer program many young people, even if they were from a family or region with oxen, learned to work oxen from adult leaders. Peers their own age encouraged and competed with them at their level. The 4-H program has been designed to allow youth to show based on both their age and skill level. For example, first-year youth competed only against others with the same skill set. While competition can discourage some youth, it also set a standard of achievement and training with adults guiding and encouraging the children in a formal setting[84].

84 Conroy 1986; Id. 2007.

Figure 15 – Learning to train oxen has for generations often been a family affair, passed down through the family

Where and/or How did Ox Teamsters Learn to Train and Work Oxen	Percentage of Total Responses
Family	13.87
Friends or Acquaintances	18.98
4-H	9.89
Association or Organizations related to Oxen	10.42
Living History Farms	2.65
Hands-on Workshops	6.10
Videos	8.49
Books	13.27
Magazines	3.58
Internet	10.22
Other	2.52

Table 2 – Where and/or how the participants learned to work oxen

Where Ox Teamsters Get Equipment to Work with Oxen

Almost 50 % of ox teamsters either made their own yoke or found someone to make one for them. This has been a common practice in New England. Friends with oxen or family members passed yokes on or sold them when they decided they were not going to keep oxen. Ox yokes can last for decades and the neck yoke can be cared for and be used in teams of the same size for multiple generations.

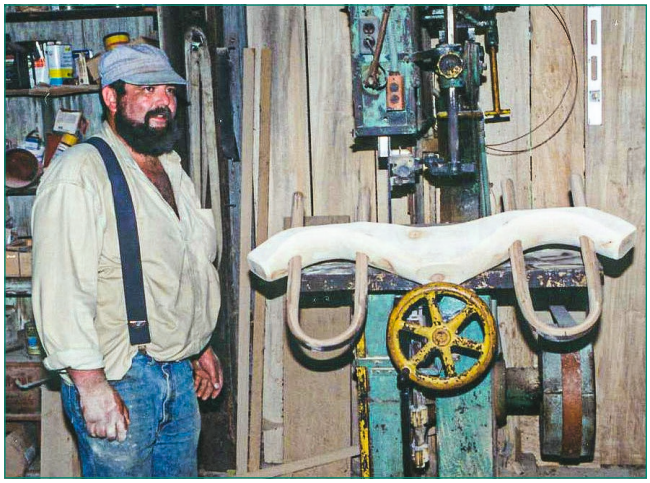

Figure 16 – Making ox yokes by teamsters such as Bud Kluchnik from Maine required a passion for oxen and the wood working tools and skills necessary to create a desirable yoke

Many yoke makers were also ox teamsters with the skills to make yokes as a part-time business. More recently a few craftsmen have realized there is a demand for ox yokes and related equipment outside of New England. These craftsmen have created specialized businesses that cater to buyers who need specific items and ship them across the country or even the world.

Where did Ox Teamsters Acquire Necessary and Related Equipment?	Percentage of Total Responses
Handed Down from Family	15.58
Friends or Acquaintances	17.61
Borrow Yokes and Related Equipment	5.87
Make their Own Yokes and Related Equipment	21.44
Buy Yokes and Equipment from Individual Craftsman	26.19
Purchase Yokes and Other Equipment from Specialized Businesses	4.97
Purchase Yokes and other Equipment from Antique Auctions and Estate Sales	5.53
Other	2.82

Table 3 – Where did ox teamsters get equipment to work with oxen

Age At Which Oxen Were Trained

As described in the early section on the history of oxen in New England, for hundreds of years ox teamsters have been encouraged to train oxen young. The result of acclimating young cattle to be handled, haltered, and lead reduces the stress on the animal during training. It also increases the ease with which they are trained. Cattle can be trained at any age, but the effort, skill and time required to train older animals are often discouraging, without the kind of opportunities many early teamsters had to tire them out on long treks or yoke them to older trained oxen. While training them at less than 2 months old seems extreme, much of this early training is desen-

Figure 17 – The vast majority of oxen in the U.S.A have been trained as calves, following a long tradition in New England which yielded calmer and easier animals to work with

Age oxen are trained	Percentage of Teamsters
Less than 2 months old	56.87
2-6 months old	32.77
6-12 months old	6.75
Over 12 months old	3.61

Table 4 – The ages the oxen are trained

sitizing the calves to things that might scare them and teaching them to follow and respect directions from humans. Finally, training calves has also been long known to be safer for the children who work with and train oxen.

Hours Oxen Were Trained or Worked per Week

This question was posed as the hours spent per week working when they are in use. This was because there are seasons of the year when the animals may not be used. For example, people who show or pull oxen spend less time in the winter working with oxen than they would during the other months of the year. This was largely due to oxen being a choice or hobby rather than a necessity. The amount of time oxen were worked in 2021 was far less than they would have been worked when their labor was historically required on a farm or on a cross-country trek. The more time oxen spend in the yoke, performing real work, the greater their responsiveness to their teamster. Both teamster and animal benefit from a relationship based on working together in a comfortable and productive environment. The teamsters with the higher number of hours of work per week were those who keep pulling oxen, as the animals need to be trained and conditioned like an athlete to pull heavy loads.

Hours worked per week	Percentage of Teamsters
Less than 1 hour	3.63
1-2 hours	13.80
2-4 hours	16.95
4-6 hours	19.61
6-8 hours	15.50
8-12 hours	14.53
12-15 hours	5.81
More than 15 hours	10.17

Table 5 *– Hours per week the ox teamster typically works the oxen*

Cattle Breeds used for Oxen

The breeds the participants used as oxen were many, with the Milking Shorthorn, Holstein, Chianina and Brown Swiss accounting for almost 42 % of all cattle in the survey. As noted below the Holstein and Chianina were also frequently used for crossbreeding. Holsteins are the most common dairy cattle in the U.S.A. Ox Teamsters have persuaded some dairy farmers to breed Holstein cows to other more desirable breeds for oxen such as the Chianina or Devon resulting in bull calves on a dairy farm that are destined to be oxen bringing a higher price.

Breed of Cattle used for Oxen	Percentage of Total Oxen in Survey
Milking Shorthorn	11.86
Holstein- (Friesian)	10.90
Chianina	9.56
Brown Swiss	9.32
Holstein crossbreed	6.30
Chianina crossbreed	6.17
American Milking Devon	5.08
Hereford crosses	4.72
Milking Shorthorn crosses	4.36
Jersey	3.87
Multiple Mixed Breeds	3.39
Hereford	2.91
Dexter	2.42
Dutch Belted	2.06
American Milking Devon crosses	1.94
Ayrshire	1.82
Normande	1.33
Texas Longhorn	1.21
Highland (Scottish Highland)	0.97
Kerry	0.61
Pineywoods	0.48
Brahman	0.36
Other	8.35

Table 6 *– The breeds of cattle used for oxen*

Figure 18 *– The Chianina breed has often been crossbred with Holstein cows yielding a large, all black, deeper bodied and calmer ox – both seen here at the Fryeburg Fair, in Maine 2017*

Figure 19 *– Any breed of cattle can compete in shows in New England.; these are organized into classes by age or weight, and they must have horns*

Many breeds are kept as oxen in the U.S.A. From the Chianina, one of the largest breeds in the world to the Dexter one of the smallest breeds, ox teamsters have a variety of reasons for keeping specific breeds. For example, the intended uses of the animals, the temperament of the breed, its size or its regional availability are all considered. One common trait among all the breeds listed would be that they have horns. Polled breeds can be worked as oxen, but they have not been allowed in the show or pulling competitions in New England. Only two breeds have been specifically selected for their draught characteristics. One was the American Milking Devon, which was historically known as the North Devon and long noted for their smaller size, speed and temperament. The Chianina is the second, which has been bred to keep the original form, size, and color of the Italian Chianina. The American version which is now polled, mostly black, shorter-legged and thicker as seen in the United States' beef cattle industry have been avoided.

Chianina oxen have dominated the ox pulling events and this has been a transformation over the last 20-30 years. The Chianina has become dominant not only due to the size of its frame size, but also its leaner more athletic build. These traits combined with the Chianina's temperament have given them an advantage in the pulling competition at any age or size. Milking Shorthorns continue to be the desired breed in the New England states in the showing and exhibition of oxen. The dairy breeds are often easy to find and relatively inexpensive, as the pure dairy bull calves have little value. Only Milking Shorthorn breeders and the farmers crossbreeding Holsteins find that the resulting male offspring sold to ox

Figure 20 *– Men outnumber women in total number of teamsters in the United States, however the gender representation has changed dramatically in the last 50 years; Men continue to be seen more commonly in pulling competitions, but women do compete and are almost equal in number in any other activity*

teamsters bring a higher return than selling them on the common market as days-old bull calves. The 8.35 % of teamsters who reported using breeds other than those listed reported they have kept breeds such as the Gelbvieh, Simmental, Charolais, Pineywoods, Guernsey, Randall Lineback, Pinzgauer and Gloucester type American Lineback. Many of the larger beef breeds have been most often used in crosses. The American and the Randall Lineback, as well as the Pineywoods have been the more commonly used "other" breeds that should have been included as a choice in the survey.

Gender of the Ox Teamsters

The genders of the ox teamsters were 59 % men and 40 % women, with 1 % reporting as other. In New England men have always been the dominant gender involved in ox pulling. Showing oxen competitively on the other hand, both in the youth or 4-H shows has had a more balanced proportion of men to women. A job historically linked to men, the ox teamsters in New England were in this survey well represented by almost equally by men and women.

State	% Women	% Men	% Other Choice
Maine	45	55	
New Hampshire	34	64.5	1.5
Vermont	50	50	
Connecticut	31.5	68.5	
Massachusetts	20	73	7
New York	28	72	
Virginia	47	53	
Michigan	33	59	8
Rhode Island	38	62	

***Table 7** – Gender breakdown by States with the highest number of ox teamsters*

Conclusion

Oxen can be found in every New England state and their current numbers have been holding steady or growing slightly each year[85]. With hands-on workshops, books, magazines, videos and the internet, sharing knowledge about training oxen has never been easier. To his followers, the ox has always been slow, strong, and dependable[86]. Teams in the United States continue to use the simple wooden neck yoke and are driven with a small stick called a goad or whip, as has been done for centuries[87]. The training techniques and commands used to control oxen have also remained unchanged for centuries. With the commands Get-up, Whoa, Gee, Haw, and Back the ox team can still be maneuvered anywhere their power is needed[88]. The ox teams found in the United States today are a stark reminder of the challenges faced by the early settlers of the United States. The tradition of working cattle, a distinctive part of New England's cultural past has been sustained. The skills that encompass training oxen appear likely to be passed along to other regions and generations for many years to come.

85 Conroy 1995a; Id. 1996; Id. 2005; Id. 2007.
86 Dangerfield 1821.
87 Skinner 1844, 164; Walden 1933, 116.
88 Skinner 1844, 161.

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Figure 4-20 – A. B. Conroy.

Author info

Andrew B. Conroy

Professor of Animal Science and Sustainable Agriculture
University of New Hampshire

E-Mail: oxwoodfarm@aol.com
Digital paper: https://youtu.be/Jr9c41YCck0

Amish Animal Traction

Dale K. Stoltzfus

Abstract

The Amish community of North America prefers to work with horses or mules to carry out all the work of daily life, such as transport or tilling their fields. The need for draft animal power led to a robust culture of animal traction farming equipment manufactured within the Amish community, resulting in jobs in the field, keeping money within the collective, but also strengthening social bonds between Amish families clustering near by and supporting each other in daily tasks. Moreover, the working animals provide a valuable resource in the form of manure for fertilizer and animal power is compatible with the natural environment. Besides, the Amish farming communities are also taking their place within the worldwide animal traction community and provide valuable insights into the viability of their way of life.

Résumé

La communauté Amish d'Amérique du Nord préfère travailler avec des chevaux ou des mules pour effectuer tous les travaux de la vie quotidienne, comme le transport ou le labourage de leurs champs. Le besoin d'utiliser l'énergie des animaux de trait a généré une solide culture axée sur des équipements agricoles pour la traction animale fabriqués au sein de la communauté amish, ce qui a permis de créer des emplois dans les champs, de conserver l'argent au sein de la collectivité, mais aussi de renforcer les liens sociaux entre les familles amishes s'installant à proximité et s'entraidant dans les tâches quotidiennes. De plus, les animaux de trait fournissent une ressource précieuse sous forme de fumier pour les engrais et l'énergie animale est compatible avec la sauvegarde de l'environnement naturel. Par ailleurs, les communautés agricoles amishes assument pleinement leur place au sein de la communauté mondiale de la traction animale et témoignent efficacement de la viabilité de leur mode de vie.

Kurzfassung

Die Amischen in Nordamerika ziehen es vor, mit Pferden oder Maultieren zu arbeiten, um alle Arbeiten des täglichen Lebens zu erledigen, wie beispielsweise den Transport oder das Bestellen ihrer Felder. Der Bedarf an Zugtieren führte zu einer ausgeprägten Kultur der Herstellung von landwirtschaftlichen Geräten für die tierische Antriebskraft innerhalb der Amish-Gemeinschaft, was zu Arbeitsplätzen vor Ort führt, das Geld in der Gemeinde hält, aber auch die sozialen Bindungen zwischen den Amish-Familien stärkt, die sich in nächster Nähe ansiedeln und sich gegenseitig bei den täglichen Aufgaben unterstützen. Außerdem stellen die Arbeitstiere eine wertvolle Ressource in Form von Dünger dar, und die tierische Antriebskraft ist mit der Umwelt verträglich. Außerdem nehmen die amischen Gemeinden ihren Platz in der weltweiten Gemeinschaft der Zugtierhaltenden ein und bieten wertvolle Einblicke in die Existenzfähigkeit ihrer Lebensweise

Resumen

Entre las comunidades amish de Norteamérica es muy popular el trabajo con caballos o mulas para realizar todas las labores de la vida cotidiana, como el transporte o el laboreo de los campos de cultivo. La necesidad de contar con la fuerza de los animales de tiro ha dado lugar a una sólida cultura de equipos agrícolas de tracción animal fabricados en el seno de la comunidad amish, lo que se traduce en puestos de trabajo en el campo, manteniendo el dinero dentro del colectivo, pero también reforzando los lazos sociales entre las familias amish que se agrupan cerca y se apoyan mutuamente en las tareas diarias. Además, los animales de trabajo proporcionan un valioso recurso en forma de estiércol para el abono y la energía animal es compatible con el entorno natural. Por otra parte, las comunidades agrícolas amish también ocupan su lugar dentro de la comunidad mundial de la tracción animal y aportan valiosas ideas sobre la viabilidad de su modo de vida.

Figure 1 *– Three American Belgians pulling a White Horse Equipment plow at Horse Progress Days*

The choice of equines for the Amish community

The Amish of North America are a group of Christian religionists who have agreed among themselves that included in their faith practices shall be the use of horses and mules for farm work and transportation. They now number about 300.000 souls. For those who wish to stay a part of the community the use of equine power is arbitrary. The rigid stubbornness of the Amish communities to practice horse farming has persisted in the face of a conventional race to modernity that has gripped the rest of the world. The paternalistic relationship of humans to animals often results in deeply felt respectful and loving relationships between the two.

Does it work?

The Amish people's use of horses and mules for farming has led to a robust culture of animal traction farming equipment manufactured from within. While the initial decision taken in the early part of the 19th century to farm with equine power was made apart from economically beneficial considerations, the economic power that has developed in the community in the present day displays unexpectedly welcome residual results. Manufacturing activities within the community provide jobs. There, the commercial exchange of goods within small clustered Amish communities, keeps money circulating within them, rather than having it lost to distant places.

Cultural benefits of limitations

Limiting farming practices to the use of animal traction limits the size of a farm to one that is more manageable for a nuclear family. Using horses for transportation keeps Amish communities in small clusters. These factors lead to neighbors and family members living in close proximity to one another making help and support of one another an almost involuntary reflex like breathing.

Figure 2 *– Two North American Spotted heavy horses pulling a Pioneer forecart hooked to a Pequea manure spreader*

Are there economic benefits to limitations?

The amount of capital needed to invest in a small animal traction farm in North America is much less than for a modern tractor farm. Smaller farms are much more intensely managed than large mega farms, consistently resulting in better profit margins without government intervention or support. The use of animals for farming utilizes a form of power that can replace itself in the form of offspring. Animals provide a valuable resource in the form of manure for fertilizer. Moreover, animal power is compatible with the natural environment.

Figure 3 – Two spans of American Belgians pulling hay mowing machines at Horse Progress Days

The gift of Amish ingenuity to the larger community

The present Amish communities in North America are large enough to be economically sustainable but small enough to mandate the self-manufacture of much of the equipment they need to farm. The results of this are a gift to the broader domestic and international community of animal traction enthusiasts and practitioners, who are able to avail themselves of it. These gifts are on display annually at a U.S. event called "Horse Progress Days", where they are demonstrated in actual field conditions powered by real animals, handled by practicing farmers. Many interested people from every worldwide continent have at various times been part of the 20.000 to 30.000 in people attendance to "Horse Progress Days".

Within the worldwide animal traction community, the Amish farming communities take their place as a microcosm to the worldwide animal traction community. The decision of the North American Amish community to farm with horses is carried out against the prevailing practice of fully mechanized conventional farming and is built solely on religious practices, that nevertheless result in economic viability. Thereby, this unique community takes its place in the worldwide animal traction communities of the world and in solidarity with them.

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Author info

Dale K. Stoltzfus

E-Mail: logcab7@ptd.net

Digital paper: https://youtu.be/D1t-Nnx1qOA

The article is a transcript of the digital paper.

Horsepower – Innovation in small-scale agriculture and gardening

Paul Schmit

Abstract

Currently, a transnational LEADER project called “Horsepower - Innovation in small-scale agriculture and gardening” is being planned. The aim of the project, with partners from Luxembourg and Sweden, is to support smallholders and vegetable growers in their technological development and to study their social environment.

According to the current CAP (common agricultural policy) regulations in the two EU-countries involved, the project is to start in 2023 and run until 2025.

With bottom-up participation of farmers and gardeners, new horse-drawn machinery will be co-designed and tested in so-called field laboratories. During the developing process and field testing, advanced computer aided design and electronic test equipment will be used. During the project preparation, a preliminary study on these technologies was successfully carried out, using the example of a horse-drawn mechanical and selective weed cutter for grassland.

For improving the eco-balance and restoring agrarian landscapes, the focus will lie on new tillage technologies for animal traction as well as closed nutrient and energy cycles in low-input and Agroforestry farming systems.

By networking and cross-border cooperation, the information collected will be spread as widely as possible. Therefore, public outreach with field days, online symposiums, public participation in a so-called crowdsourced science and open access publication on an innovation platform in the internet will mark the project.

Résumé

Actuellement, un projet LEADER transnational intitulé „Horsepower - Innovation in small-scale agriculture and gardening“ est en cours de planification. L‘objectif du projet, avec des partenaires du Luxembourg et de la Suède, est de soutenir les petits exploitants et les maraîchers dans leur développement technologique et d‘étudier leur environnement social.

Conformément aux règlements actuels de la PAC (politique agricole commune) dans les deux pays de l‘UE concernés, le projet doit démarrer en 2023 et se poursuivre jusqu‘en 2025.

Avec la participation ascendante des agriculteurs et des jardiniers, de nouvelles machines tirées par des chevaux seront conçues et testées dans des laboratoires en champs. Au cours du processus de développement et des essais sur le terrain, des équipements avancés de conception assistée par ordinateur et de test électronique seront utilisés. Au cours de la préparation du projet, une étude préliminaire sur ces technologies a été réalisée avec succès, en utilisant l‘exemple d‘un désherbeur mécanique et sélectif tiré par des chevaux pour les prairies.

Pour améliorer l‘éco-équilibre et restaurer les paysages agricoles, l‘accent sera mis sur les nouvelles technologies de travail du sol pour la traction animale ainsi que sur les cycles fermés de nutriments et d‘énergie dans les systèmes agricoles à faibles intrants et agroforestiers.

Grâce à la mise en réseau et à la coopération transfrontalière, les informations recueillies seront diffusées aussi largement que possible. Par conséquent, le projet sera marqué par une sensibilisation du public avec des journées pratiques, des symposiums en ligne, la participation du public à une science dite „crowdsourcée“ et une publication en libre accès sur une plateforme d‘innovation sur Internet.

Kurzfassung

Derzeit ist ein transnationales LEADER-Projekt mit dem Titel “Horsepower - Innovation in small-scale agriculture and gardening“ in Planung. Ziel des Projekts mit Partnern aus Luxemburg und Schweden ist es, Kleinbauern und Gemüsebauern in ihrer technologischen Entwicklung zu unterstützen und ihr soziales Umfeld zu untersuchen.

Gemäß den aktuellen GAP-Verordnungen (Gemeinsame Agrarpolitik) in den beiden beteiligten EU-Ländern soll das Projekt im Jahr 2023 beginnen und bis 2025 laufen.

Unter Beteiligung von Landwirten und Gärtnern werden neue pferdegezogene Maschinen mitentwickelt und in sogenannten Feldlabors getestet. Während des Entwicklungsprozesses und der Feldtests werden fortschrittliche computergestützte Design- und elektronische Testgeräte zum Einsatz kommen. Während der Projektvorbereitung wurde eine Vorstudie zu diesen Technologien am Beispiel eines pferdegezogenen mechanischen und selektiven Unkrautschneiders für Grünland erfolgreich durchgeführt.

Zur Verbesserung der Ökobilanz und zur Wiederherstellung von Agrarlandschaften werden neue Bodenbearbeitungstechnologien für die Tieranspannung sowie geschlossene Nährstoff- und Energiekreisläufe in Low-Input- und Agroforstsystemen im Mittelpunkt stehen.

Durch Vernetzung und grenzüberschreitende Zusammenarbeit sollen die gesammelten Informationen so weit wie möglich verbreitet werden. Daher wird das Projekt durch Feldtage, Online-Symposien, öffentliche Beteiligung an einer so genannten Crowdsourced Science und Open-Access-Veröffentlichungen auf einer Innovationsplattform im Internet gekennzeichnet sein.

Resumen

Actualmente, se está planificando un proyecto transnacional, con socios de Luxemburgo y Suecia, denominado “Horsepower – Innovation in small-scale gricultura and gardening”. El objetivo del proyecto conocido como LEADER es apoyar a los pequeños agricultores y hortelanos en su desarrollo tecnológico y estudiar su entorno social.

De acuerdo con la actual normativa de la PAC (Política Agrícola Común) en los dos países de la UE implicados, el proyecto se iniciará en 2023 y se prolongará hasta 2025.

Con la participación ascendente de los agricultores y hortelanos, se diseñará una nueva maquinaria de tracción animal probándola más tarde en los llamados laboratorios de campo. Durante el proceso de desarrollo y las pruebas sobre el terreno se utilizarán equipos avanzados de diseño asistido por ordenador y de pruebas electrónicas. Durante la preparación del proyecto, fue preciso un estudio preliminar sobre estas tecnologías, utilizando el ejemplo de una desbrozadora mecánica y selectiva para praderas tirada por caballos.

Para mejorar el equilibrio ecológico y restaurar los paisajes agrarios, la atención se centrará en las nuevas tecnologías de labranza para la tracción animal, así como en los ciclos cerrados de nutrientes y energía en los sistemas de cultivo de bajos insumos y agroforestales.

Mediante la creación de redes y la cooperación transfronteriza, la información recogida se difundirá lo más ampliamente posible. Por lo tanto, la difusión pública con días de campo, simposios en línea, la participación pública en la llamada ciencia crowdsourced y la publicación de acceso abierto en una plataforma de innovación en Internet marcarán el proyecto.

Locally led rural development in Europe

In December 2020, the LEADER Local Action Group LËTZEBUERG WEST, regrouping seven municipalities and eighteen associations from Western Luxembourg as well as Luxembourg's Chamber of Agriculture, and the LEADER LAG PH, regrouping the communities of Perstorp and Hässleholm in Sweden's southernmost province Skåne, agreed to carry out together an EU-funded trans-national LEADER project called "Horsepower - Innovation in small-scale agriculture and gardening".

The project aims to support European smallholders and market gardeners in their efforts to maintain sustainable food production and to study the social impact and technological feasibility of modern horse-powered agriculture.

The project initiator is the European network SCHAFF MAT PÄERD (SmP), an NGO based in Tuntange/Luxembourg, which supports the use of draught horses in modern-day small-scale farming. The main partner of the project is HÄLDE HÄSTKRAFT, a full-time horse entrepreneur company from Vittsjö in Sweden. Synergies have been established with the Department of Earth Sciences - Natural Resources and Sustainable Development of UPPSALA UNIVERSITY in Sweden[1] (***Figure 1***).

The LEADER program has been implemented in the European Union since 1991 by around 2800 LAG's covering 61 % of the rural population in the EU bringing together public, private, and civil-society stakeholders in a particular area for locally led development. LEADER stands for the French acronym "Liaison Entre Actions de Développement de l´Economie Rurale" meaning "Links between actions for the development of the rural economy"[2].

LEADER projects are carried out under the national and regional Rural Development Programmes (RPDs) of each EU Member State and are co-financed by the European Agricultural Fund for Rural Development (EAFRD). Fundamental to the LEADER method is that there are residents and operators in an area that drive and influence the development. Characteristics for the LEADER method are:

- Bottom-up perspective
- Local knowledge
- Cooperation
- Tripartite partnership
- Innovation
- Locally made decisions[2]

After a project preparation phase from 2021 to 2022 for building up the international network, visiting and analyzing the individual regions, as well as drawing up an action plan, the project is planned to start in 2023 with the implementation of the reformed Common Agricultural Policy in all EU countries.

For the project that follows, the main objectives are developing, manufacturing, and field-testing state-of-the-

1 Junge 2021.

2 LEADER/CLLD 2018.

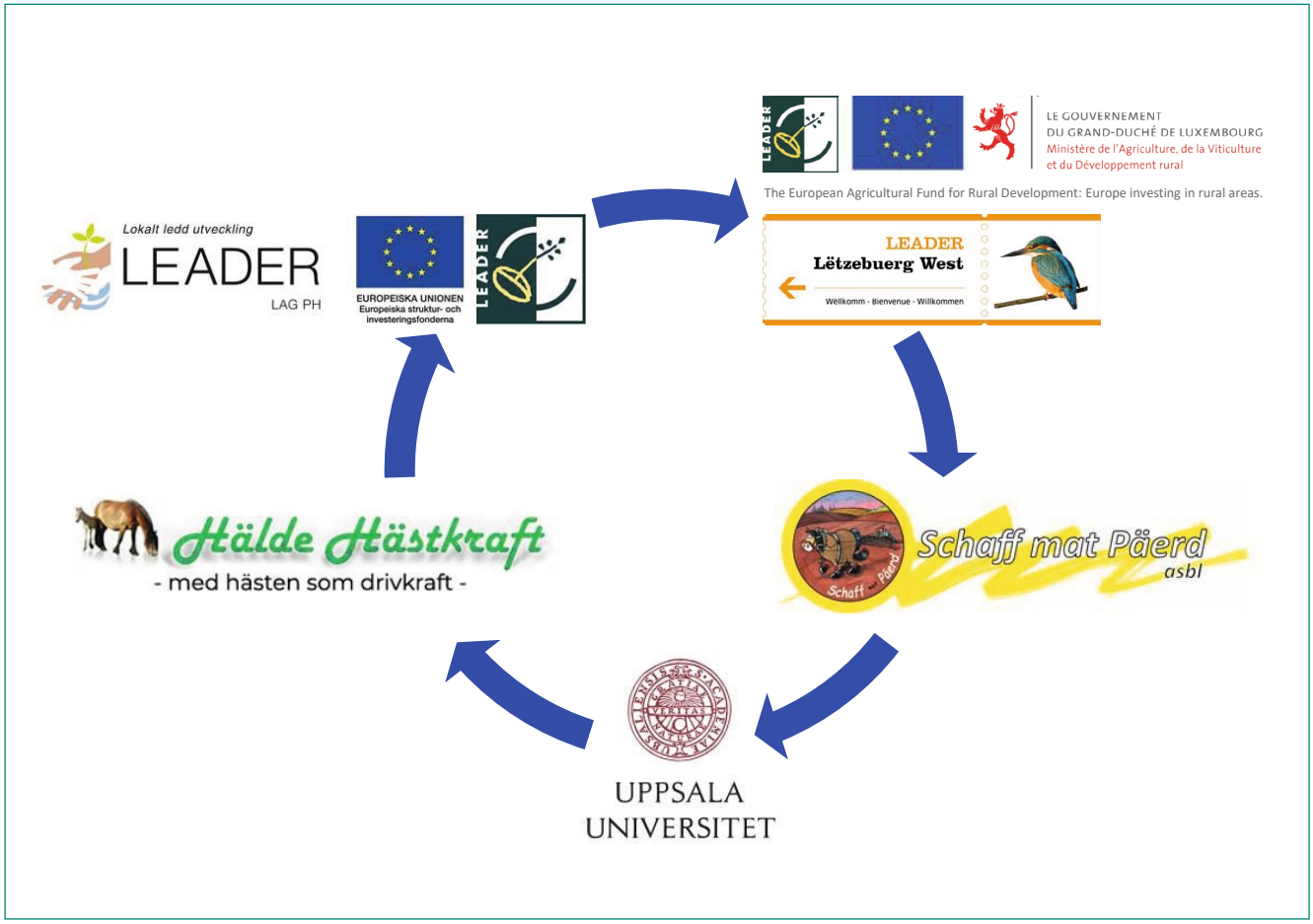

Figure 1 – *The project partners*

Figure 2 – *The hand operated Bolin's dandelion comb from 1924*

art horse-drawn equipment for small-scale agriculture and gardening, as well as public outreach with field days and open access publication of the findings.

The horse-drawn machinery will be selected and co-designed with bottom-up participation of farmers and gardeners in field laboratories. The main objectives are optimizing animal-powered tillage for regenerative farming, managing on-farm nutrients under various pedo-climatic conditions, improving the eco-balance by using completely renewable energy sources and restoring of agrarian landscapes to reach Sustainable Development Goals.

Besides the above criteria, the horse-drawn implements will be tested for their optimal working comfort for the draught horse(s) as well as their potential for self-maintenance and adaptation to European on-farm conditions[3].

Conception of a horse drawn CombCut

The above-mentioned actions across both European regions during the project preparation phase are currently supported by a study on the implementation of computer-aided design (CAD) and testing in equipment development, using the example of a horse-drawn version of the mechanical and selective weed cutter CombCut for grassland.

In organic farming, weed control is, besides closed nutrient cycles and soil conditioning, of essential importance. For selectively reducing weed in various established crops, the CombCut implement was invented in 2008 on an organic smallholding near Karlskrona, in the South-East of Sweden. By using the physical difference between the plants at the right growing stage, just the weeds are cut, and the crop is spared by a very simple mechanical system of motionless tilted razor-sharp knives.

The principle of weed cutters is not new. In its summer issue 2016, the British Heavy Horse World magazine published an article about horse-drawn mechanical thistle-cutters which were manufactured on either side of the eastern Scotland-England border in the beginning of the 20th century[4].

Another example of this technology can be found at the Åker exhibition of the Julita Gård open air museum, which is part of the Nordic Museum (Swedish: Nordiska museet) in Sweden. Here, a hand operated dandelion cutter is on display, which was invented by the Swedish agronomist Pehr Bolin in 1924 and sold at that time for 125 Swedish kronor under the name Bolin's dandelion comb (Swedish: Bolins Maskroskam)[5].

Unfortunately, as many great inventions of the horse and human powered farming era, this technology got somewhat forgotten in the past hundred years. But today,

3 Schmit 2020.

4 Powell 2016.

5 Blomquist 1995.

the rising interest in sustainable farming methods, led the CombCut to be patented and commercialized all over the world. Formerly known as Just Common Sense, the company has grown into the Lyckegård AB Group with a wide-ranging portfolio of implements for weed control, including machinery concepts from Sweden and Finland.

The fact that other European agricultural implement manufacturers have followed by developing similar concepts, proves that the path was well chosen. A newer implement from the German Zürn Harvesting company not only cuts the weed flowers but collects the clippings for reducing the seed potential on the treated area. However, because of the high complexity of their drivetrains, and finally also the price, these implements are out of the question for most farms using animal traction[6].

Another– not to be underestimated – reason, for selecting the CombCut for a conversion into animal traction was that the Lyckegård company had supported this idea from the beginning. Advice and assistance were provided during the whole design process, including the complete CAD drawings of the original tractor implement, which enabled enormous time savings in the conception of the horse-drawn version.

After two meetings in May and August 2016 for discussing the technical feasibility, SmP was supplied in December 2016 with a side section of the initially hydraulic operated CombCut implement for tractor use, which is currently available in 6 and 9 m width. The working width of the ground-drive implement for horse use was defined at 1,6 m. From this unit, only the knife bar with its three-dimensional knife angle adjustments and the brush comb were maintained.

The implement's new tubular frame with spring loaded suspension of the cutting unit, as well as the whole lifting device and drivetrain, had to be redesigned. The double-sided toothed belt drive has a transmission ratio of 1:5,09 to achieve a sufficient rotational speed on the brush comb, which cleans the blades from the cut material. Finger-type freewheel hubs on both ends of the comb shaft regulate the torque transmission. These parts, which are hard to find in Western Europe, because of the near extinction of ground-driven implements, were kindly supplied by the Mainardi company of Abbiategrasso in Northern Italy. This company still manufactures side-delivery hay rakes with ground drive for the European and South-American market. A plunger-type clutch, integrated into the assembly of the freewheel and secondary toothed belt pulley, allows the brush comb to be disengaged during transport.

In 2018, the complete design was advertised as a master-thesis at the Polytechnic University of Turin (Italian: Politecnico di Torino). However, even though animal traction is having a renaissance in Northern Italy, mainly by young people rediscovering the self-sufficient farms of their ancestors, linguistic barriers apparently prevented this master-thesis from getting realized[7].

With the now developing LEADER project, the realization came true. Furthermore, from September 2020 to April 2021, a part of the development of the horse-drawn CombCut was carried out as a teacher-supervised project in the section of environmental sciences, ending with a technical baccalaureate, at a public secondary school in Luxembourg. Here, the student's work consisted of computer drawings of basic implement parts and mainly in the mathematical dimensioning of the drivetrain components and the lifting mechanism for the cutting unit as well as strength calculations for the frame. Moreover, in a written project documentation, the pros and cons of the CombCut vs. other mechanical and chemical weed control methods were analyzed. Herein, the later use of the implement was limited to regulating docks, thistles and nettles on grassland.

All in all, 108 working hours were spent in the 3D-CAD drawing and about the same amount of time into the

6 Innovation award 2021.

7 Thesis proposals 2018.

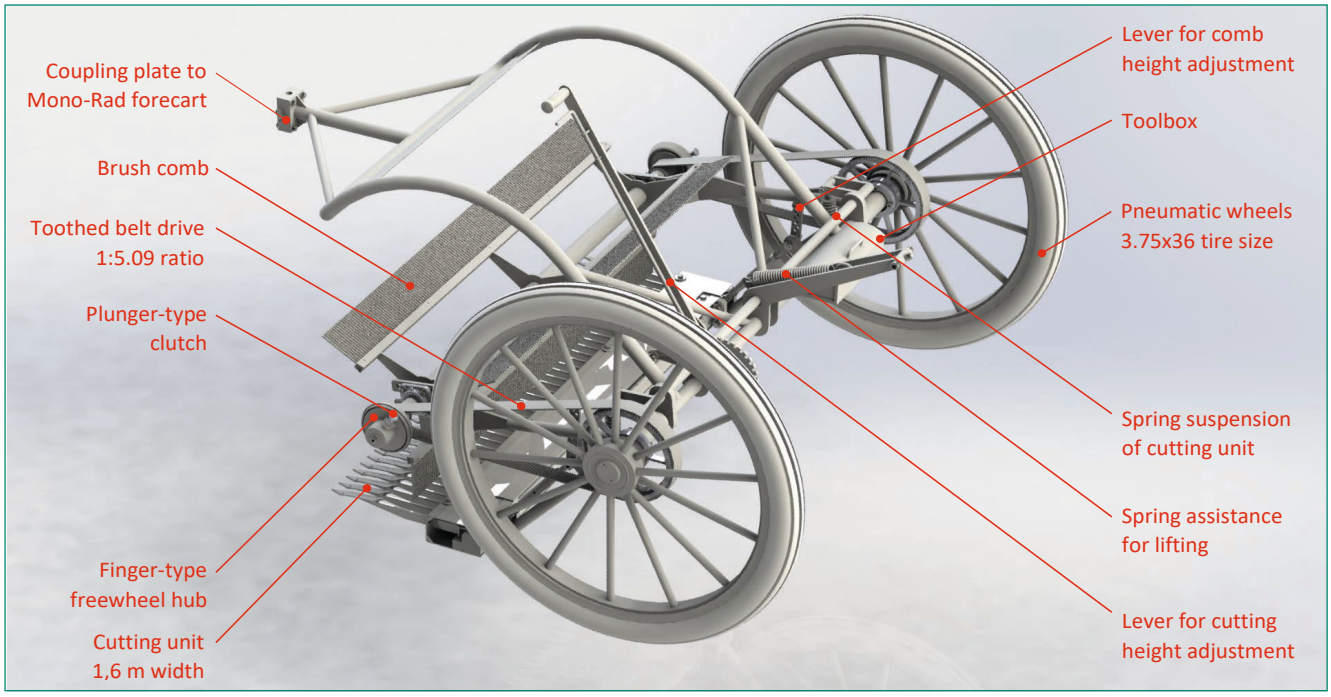

Figure 3 – *Overall view with component designation of the horse drawn CombCut*

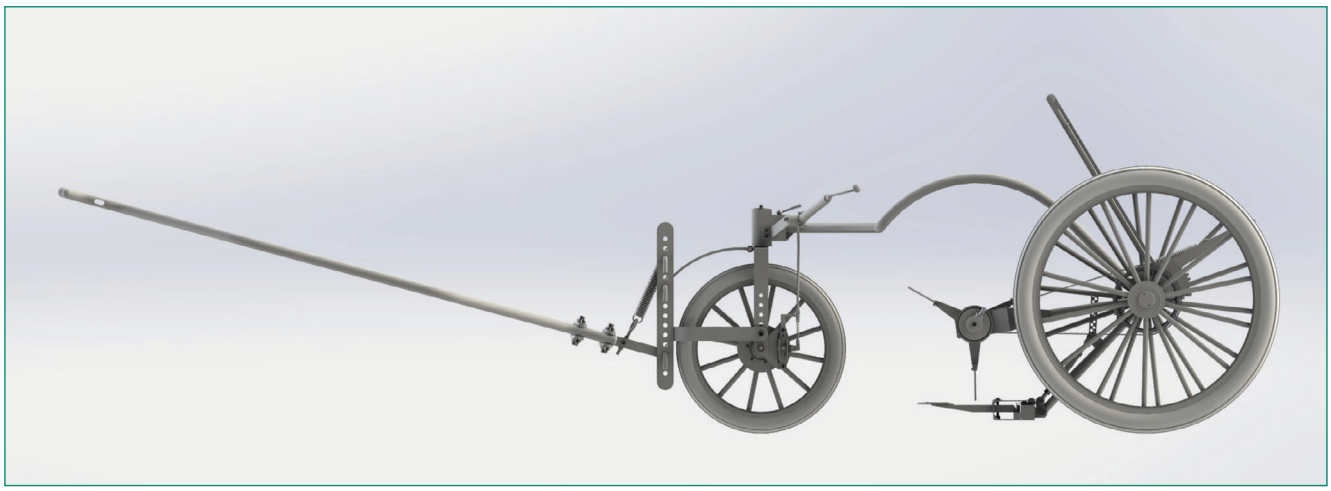

Figure 4 *– Side view of the horse drawn CombCut coupled to the forecart*

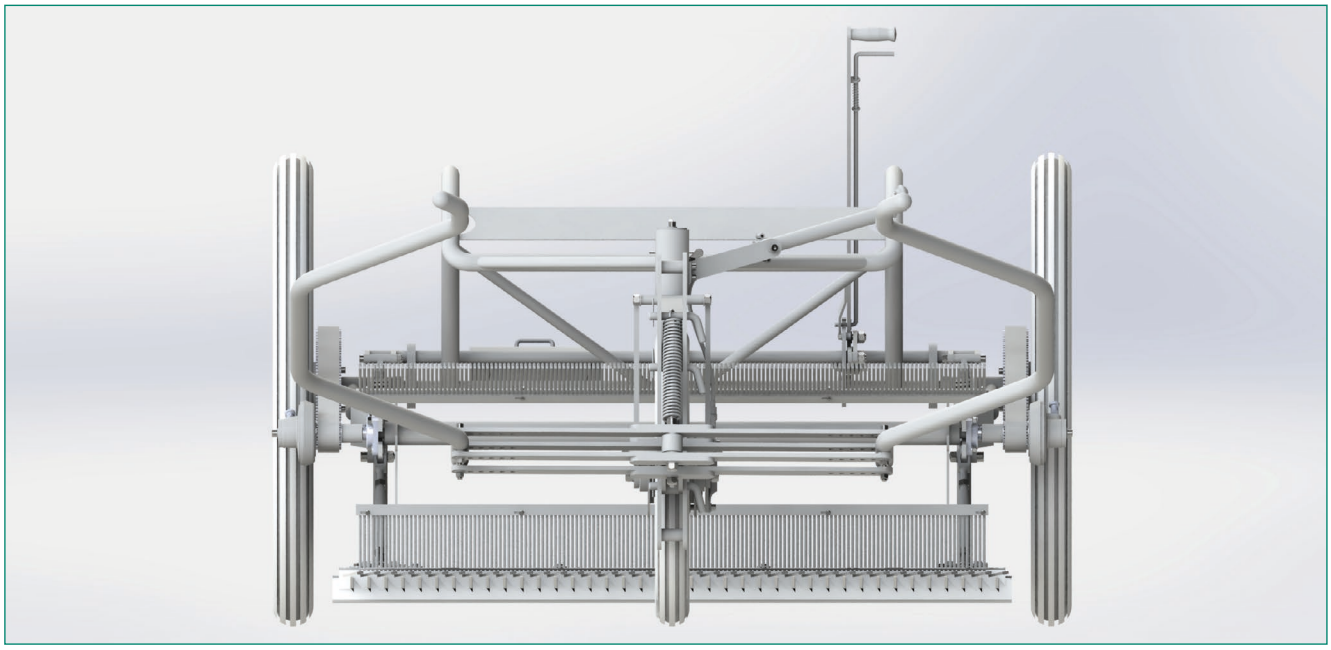

Figure 5 *– Front view of the horse drawn CombCut coupled to the forecart*

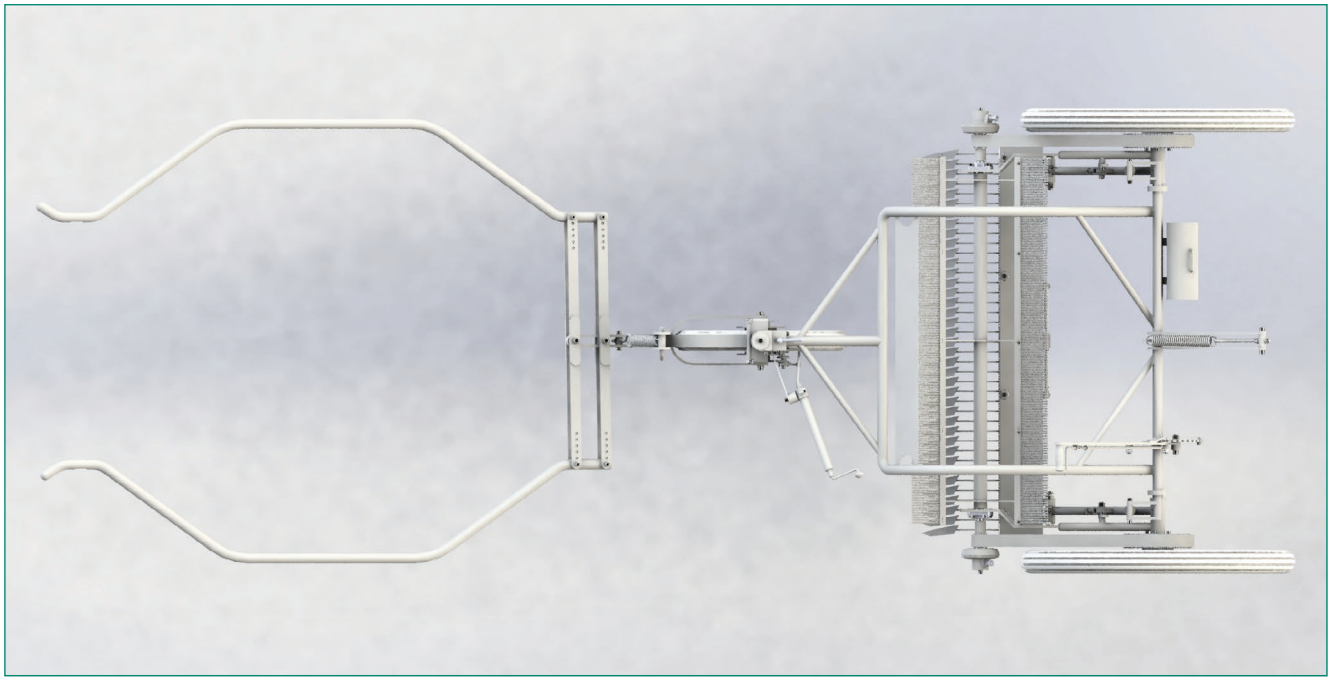

Figure 6 *– Top view of the horse drawn CombCut coupled to the forecart*

manufacturing of most of the implement parts and the final assembly in the workshop of the SmP association in Tuntange. Since all parts are available now as computer files, some of the more complex parts of the lifting mechanism were laser cut by a metal-working company in Luxembourg. In addition to the high precision of the manufactured parts, this also enabled a lot of manual labor to be saved, which more than outweighs the working time on the computer. In addition, the three-dimensional representation of individual parts and the entire assembly simplified the technical communication between all people involved and allows in a further stage to manufacture market-ready high-quality implements at a competitive price.

The drivetrain components were supplied by the large-scale manufacturer Mädler from Stuttgart in Germany and the wheels were ordered from Dominiak, a carriage manufacturer from Piaski in Poland. The tubular frame is hand- and homemade of thin-walled structural steel. The machine is designed for coupling to the braked SmP Mono-Rad Concept 1.3 single-wheel forecart. An optimum working comfort is guaranteed with the fully adjustable and spring-suspended traction shafts, as well as the forecart's central wheel, which runs in the longitudinal axis of the horse thus eliminating lateral forces. The total budget, excluding the working hours, of the first prototype adds up to € 5.000,- which was co-financed by the LEADER LAG LËTZEBUERG WEST.

As mentioned before, within the LEADER project, the conception of this newly developed implement is part of a preliminary study, analyzing the benefits of computer aided design during the development process. The next step consists of field trials in Luxembourg and Sweden. Besides the design process, the testing will also be computer-assisted, using multiple sensors like draft force, torque and movement gauges, offering the possibility to analyze the required tractive effort, the drivetrain efficiency and the horse's working comfort. As part of another school project, the effectiveness of the CombCut system for grassland maintenance is to be analyzed through targeted assessments. Here a cooperation with Sweden's workhorse driver education at the National Horse Center in Wången is envisaged. A joint-venture which could be financially supported by ERASMUS+, another EU-program in the educational sector.

***Figure 7** – Minimum tillage seeding of perennial rye in a silvorarable agroforestry plot*

Shaping the future together

Detailed information about the whole design process and the testing will be published on the project's webpage www.drafthorses.eu. With this networking and cross-border cooperation, the aim is to contribute to the further development of modern farming and gardening technology.

An international symposium is planned for November 2022 in the LEADER region Luxembourg-West. Keeping with the times, it will be an online event with specialist lectures and farm presentations. Thanks to a synergy with the Lauresham Open-Air Laboratory from Lorsch in Germany, this symposium will be a follow-up event of the very successful virtual conference "Draft animals in the Past, Present and Future", which was organized in the beginning of May 2021 with participants from 30 countries worldwide.

For two days, the contemporary use of draft animals in eco-friendly and low-input vegetable growing and agroforestry, will be discussed. Possible future strategies will be worked out with practitioners and experts in soil science, alternative cultivation methods and landscape design.

Low Input Farming Systems (LIFS) seek to optimize the management and use of on-farm resources and to minimize the use of production inputs as off-farm resources, such as purchased fossil fuels, chemical fertilizers, and pesticides. Long-term sustainable solutions need renewability, this in a holistically approach, closing on-farm cycles again in climate-friendly and regenerative agriculture[8].

According to the "European Climate Law", which was negotiated between the EU's 27 member countries and the European Parliament and adopted in April 2021 within the "European Green Deal", the EU is to become CO2-neutral by 2050. Carbon-dioxide is the most significant long-lived greenhouse gas in the Earth's atmosphere since the Industrial Revolution, resulting as anthropogenic emission caused by the mankind, primarily from the use of fossil fuels and deforestation[9].

Getting carbon-neutral requires a 'reverse' carbon footprint, which means that at least as much carbon is sequestered above and below ground as is emitted. You may see this as unrealistic, but you can also see it as a chance, an opportunity to sustainably change our society, including our food production. Here, we should acknowledge that there is still, in the 21st century, no other emission-free and low-cost power source than the work horse, which can even reproduce itself, and on a local level.

Agroforestry systems (AFS), a combination of woody plants and grass or arable crops on the same field, will be the second main subject of the first symposium within this LEADER project. Restoring a structurally rich landscape, and habitat diversity, offers high value creation potential. Reducing wind and water erosion, nitrate leaching, and temperature fluctuations can help to reach a more climate-resilient agriculture. Furthermore, with a suitable selection of trees and shrubs, natural nectar,

8 Low input farming systems 2007.
9 2050 long-term strategy 2021.

honeydew, and pollen sources are created, which contributes to better biodiversity protection[10].

In order to make European smallholdings relying on animal traction fit for the 21st century, not only the challenges of the future have to be faced, especially climate change, but the current social changes as well. The LEADER project is thus linked to a study, as a master thesis at STOCKHOLM UNIVERSITY, on the contemporary use of workhorses in Sweden, Luxembourg and Italy, which will also be carried out in 2022.

Furthermore, both project parts, the LIFS as well as the AFS are planned to be realized as so-called citizen science (CS), also known as crowd-sourced science. Herein a part of the research and data collection is planned to be conducted with a public participation under the direction of professional scientists. This monitoring will be based on an initiative for AFS of the University of Münster in Germany, an approach that fits perfectly into the philosophy of the LEADER projects[11].

Co-designing new farming systems is a multi-dimensional and complex process, in which changes in knowledge and technologies must take place. For these reasons, it is necessary to use a participatory approach, which is the basic LEADER philosophy. Exploration of the initial situation, which identifies local stakeholders potentially interested in being involved in the process, existing farming, and gardening systems, as well as their specific constraints, will be the first step within this project. Creation of an innovation platform, as a core of this process for generating a broad knowledge on viable small scale farming practices, will follow. Watch out for more information on www.drafthorses.eu!

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Figure 7 – C. Laroche.

Author info
Schaff mat Päerd asbl
Paul Schmit
27, rue de Brouch
L-7481 TUNTANGE
E-Mail: schaffmatpaerd@pt.lu
Web: www.schaffmatpaerd.com
Digital paper: https://www.youtube.com/watch?v=_aJ1dzoq8AA

Animal Drawn BioMechanical System (ADBIS) for Tillage in Colombia

Hugo Samuel Sanhueza Leal, Oscar Leonardo García Navarrete and Hugo A. González Sánchez

Abstract

The feasibility of using draft horses in the Andean (oriental) region of Colombia, was determined from an agricultural, socio-economic, energy and environmental perspective. A mechanical prototype named Animal Drawn Biomechanical System (ADBIS), composed of a hitch-cart/work-cart, two draft horses and a chisel plow were used for the study. To register and measure the draft force and working depth, an electronic measuring system (datalogger) was designed and built for this study, based on Arduino 1 card complemented by a Polar M400 sport watch with equine heart rate monitor band, to measure heart rate and animal speed during tillage. The tests were conducted in five experimental units, under different soil conditions and altitudes (a.s.l.), on-farm soil sampling was taken to determine the percentage of soil humidity and, a non-standard soil shear resistance rod (vane shear tool) to determine soil compaction to evaluate animal draft performance and tillage tool efficiency/efficacy. The ADBIS, could effectively performed in heavy soils and altitudes between 2560 and 3400 meters (a.s.l.), demonstrating its capacity to till in highly compacted and shear resistance soils in the Andean region at a depth of 15 cm. The ADBIS' lighter weight reduces soil compaction and allows for the employment of soil conservation practices. In conclusion, the use of systems like ADBIS are a reliable and economical source of animal energy to perform multiple agricultural tasks with a minimal environmental impact and for use by small and medium size farmers in the Andean region of Colombia.

Résumé

La faisabilité de l'utilisation de chevaux de trait dans la région andine (orientale) de la Colombie a été déterminée d'un point de vue agronomique, socio-économique, énergétique et environnemental. Le système de travail du sol biomécanique à traction animale (SIBIOTA), composé de deux chevaux de trait, d'un chariot d'attelage et d'une charrue à chisel (outil de travail du sol) a été utilisé pour l'étude. Pour les enregistrements et les mesures des forces de traction et de la profondeur de travail, un système de mesure électronique en temps réel (datalogger) a été conçu, composé d'une carte Arduino 1 et complété par une montre de sport POLAR M400 avec une sangle équine, pour mesurer la vitesse de travail et la fréquence cardiaque des animaux pendant le travail du sol. Les tests ont été réalisés dans 5 unités expérimentales (UE) dans des conditions de sol et d'altitude (masl) différentes, où des échantillons de sol ont été prélevés pour déterminer les pourcentages d'humidité et une tige non standardisée (9 mm X 1000 mm) a été utilisée pour évaluer la compaction du sol et la résistance potentielle au cisaillement afin de la mettre en relation avec la performance des animaux et l'efficacité et l'efficience de l'outil de travail du sol. Le SIBIOTA s'est montré efficace dans des sols lourds et à des altitudes comprises entre 2560 et 3400 mètres au-dessus du niveau de la mer, démontrant ainsi sa capacité à travailler des sols à forte résistance à la pénétration/coupe à une profondeur de 15 cm dans la région andine. Le poids léger du SIBIOTA réduit le compactage et facilite l'utilisation des pratiques de conservation du sol. En conclusion, l'utilisation de systèmes tels que le SIBIOTA, sont une source fiable et économique de puissance animale pour effectuer de multiples tâches agricoles avec un impact environnemental minimal et à la portée des petits et moyens producteurs de la région andine de Colombie.

Kurzfassung

Die Durchführbarkeit des Einsatzes von Zugpferden in der (östlichen) Andenregion Kolumbiens wurde aus agronomischer, sozioökonomischer, energetischer und ökologischer Sicht untersucht. Für die Studie wurde das biomechanische, von Tieren gezogene Bodenbearbeitungssystem (SIBIOTA) eingesetzt, das aus zwei Zugpferden, einem Anhängewagen und einem Meißelpflug (Bodenbearbeitungsgerät) besteht. Für die Aufzeichnungen und Messungen der Zugkräfte und der Arbeitstiefe wurde ein elektronisches Echtzeit-Messsystem (Datalogger) entwickelt, bestehend aus: einem Arduino 1 Board und ergänzt durch eine POLAR M400 Sportuhr mit Pferdegurt, um die Arbeitsgeschwindigkeit und die Herzfrequenz der Tiere während des Pflügens zu messen. Die Versuche wurden in 5 Versuchseinheiten (UE) unter verschiedenen Bodenbedingungen und Höhenlagen (m ü.d.M.) durchgeführt. Dabei wurden Bodenproben entnommen, um den Feuchtigkeitsgehalt zu bestimmen, und eine nicht genormte Stange (9 mm x 1000 mm) verwendet, um die Bodenverdichtung und die potenzielle Scherfestigkeit zu bewerten und sie mit der Leistung der Tiere sowie der Effizienz und Wirksamkeit des Bodenbearbeitungsgeräts in Beziehung zu setzen. Der SIBIOTA war in der Lage, in schweren Böden und in Höhen zwischen 2560 und 3400 Metern über dem Meeresspiegel effektiv zu arbeiten. Er bewies damit seine Fähigkeit, Böden mit hohem Eindring-/Schneidewiderstand in einer Tiefe von 15 cm in der Andenregion zu bearbeiten. Das geringe Gewicht des SIBIOTA verringert die Verdichtung und erleichtert die Anwendung konservierender Bodenbearbeitungsmethoden. Zusammenfassend lässt sich sagen, dass der Einsatz von Systemen wie dem SIBIOTA eine zuverlässige und wirtschaftliche Quelle für tierische Energie ist, um verschiedene landwirtschaftliche Aufgaben mit minimalen Auswirkungen auf die Umwelt und in Reichweite kleiner und mittlerer Erzeuger:innen in der kolumbianischen Andenregion zu erfüllen.

Resumen

Los resultados de este estudio determinan que la utilización de caballos de tiro en la región (oriental) andina de Colombia, desde una perspectiva agronómica, socioeconómica, energética y ambiental son totalmente viables y productivos. El Sistema Biomecánico de Labranza a Tracción Animal (SIBIOTA), compuesta por dos caballos de tiro, un carro de enganche y un arado de cincel (herramienta de labranza) fue utilizado en este estudio. Para los registros y mediciones de las fuerzas de tiro y profundidad de trabajo, se diseñó un sistema de medición electrónica en tiempo real (datalogger), compuesto por una tarjeta Arduino 1, complementado con un reloj deportivo POLAR M400 con cinta equina. Este convulo permite medir la velocidad de trabajo y ritmo cardiaco de los animales durante la labranza. Las pruebas se realizaron en 5 unidades experimentales (UE) bajo diferentes condiciones de suelo y altitudes (msnm). Además, se tomaron muestras de suelo para determinar porcentajes de humedad, utilizando una varilla no-normalizada (9 mm X 1000 mm) para evaluar la compactación del suelo y la potencial resistencia al corte, lo que permite relacionarlo con el rendimiento de los animales y la eficiencia de la herramienta de labranza. El SIBIOTA, pudo desempeñarse eficazmente en suelos pesados y en altitudes entre 2560 a 3400 msnm, demostrando su capacidad para labrar suelos, con alta resistencia a la penetración/corte a profundidades de 15 cm, en la región andina. El peso liviano del SIBIOTA reduce la compactación y facilita el empleo de prácticas de labranza de conservación. En conclusión, el uso de sistemas como el SIBIOTA, son una fuente confiable y económica de energía animal para desempeñar múltiples tareas agrícolas con mínimo impacto ambiental y al alcance del pequeño y mediano productor de la región andina de Colombia

Introduction

The use of draft horses is becoming more appropriate in the context of sustainable agriculture development and means a responsible interaction with the environment. Given the growing need for producing more and higher quality foods, it is necessary to consider alternative sources of energy whose capacity should be based on the efficient use of local renewable resources. Incorporating the use of animal traction with equines in local and national level agriculture can generate opportunities for sustainable development at a lesser cost, reduced fuel consumption and the fostering of employment opportunities for the non-qualified (traditional) rural labor force.

Small family farming in the Andean Cundiboyacense region of Colombia, is described as very traditional and utilizes minimal, modern technologies that allow them to complete their fieldworks in an opportune and efficient manner. It is characterized by smallholdings with a high dependency on the use of hand labor with limited education and training and a strong rooted ancestral knowledge. The most utilized productive systems are: potatoes and double-purpose livestock.

The small size of their landholdings in actual terms are considered an obstacle to development opportunities since they do not facilitate the employment of modern schemes of production systems and limit the adoption of modern technologies in agricultural mechanization[1].

Small and mid-size farmers and farmhands, show low productive efficiency due to a lack of mechanization technologies that allow for a multifunctional role in crop, forage and vegetable production and the employment of conservation techniques to counter the growing physical deterioration of Andean soils.

Nowadays, the application of animal traction for tillage, pasture and crops seeding is limited to the use of oxen and to a certain extent to the use of workhorses. In a much larger scope, regional agriculture is highly dependent in the use of non-qualified labor force, which uses traditional farm hand tools. A growing concern is the exodus of the younger generation towards urban centers in search of employment opportunities and better quality of life. The animal traction technology has the potential for creating employment opportunities in the local rural sector to minimize or reduce the abandonment of rural communities. Similarly, it also offers training opportunities in the area of agricultural mechanization with draft animals, updating anrefreshingsh technical knowledge and know-how in sustainable agriculture.

Materials and Methods

Location

The five experimental units were located in the municipalities of: Guasca, Mosquera and Zipaquirá – in altitudes between 2560 to 3400 meters (a.s.l.), in variable soil, topography and thermic floors, in parcels considered apt for beef and milk cattle, intensive and semi-intensive crop and vegetable production (vegetables, grain and fruits) and forestry.

Components

1) The Electronic Measuring System in Real-Time (EMSRT) was designed for measuring and storage of draft force, work speed, tool depth and animal heart rate information in field conditions[2]). The EMSRT was built with the following components: an Arduino 1 card with microcontroller (MCU) ATMEGA328P; datalogger module shield V1 with RTC; SD card for data storage in plain text, type .csv; display module (LCD) with 12C serial; Sharp GP2Y0A21 (IR) distance sensor, to measure the tool's working depth; a load cell, S-type with 1000 kg capacity and a 150 % safety overload to measure draft forces. The integration of all the elements was energized with a 12v car battery.

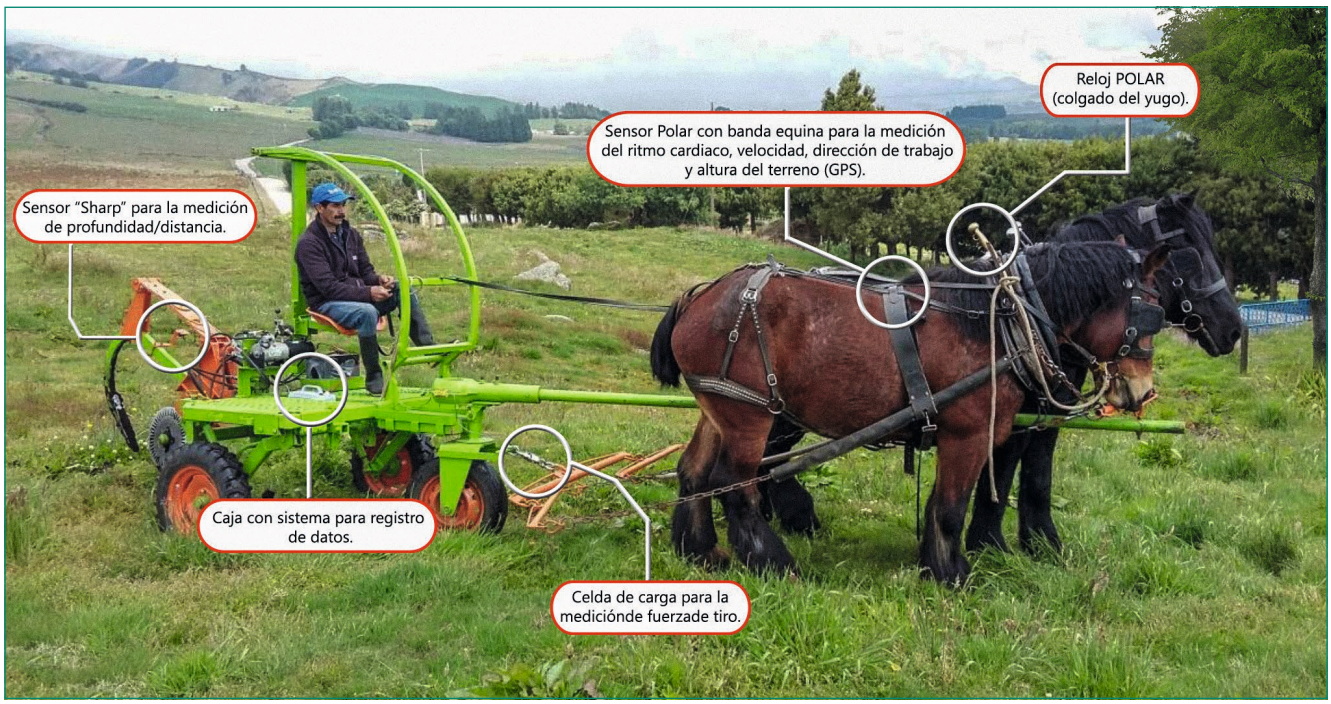

Figure 1 – The EMSRT Electronic Measuring System installed in the ADBIS

1 Cruz León 1997; IGAC 2005, 39.

2 Caballero et al. 2018; Venturelli et al. 2009.

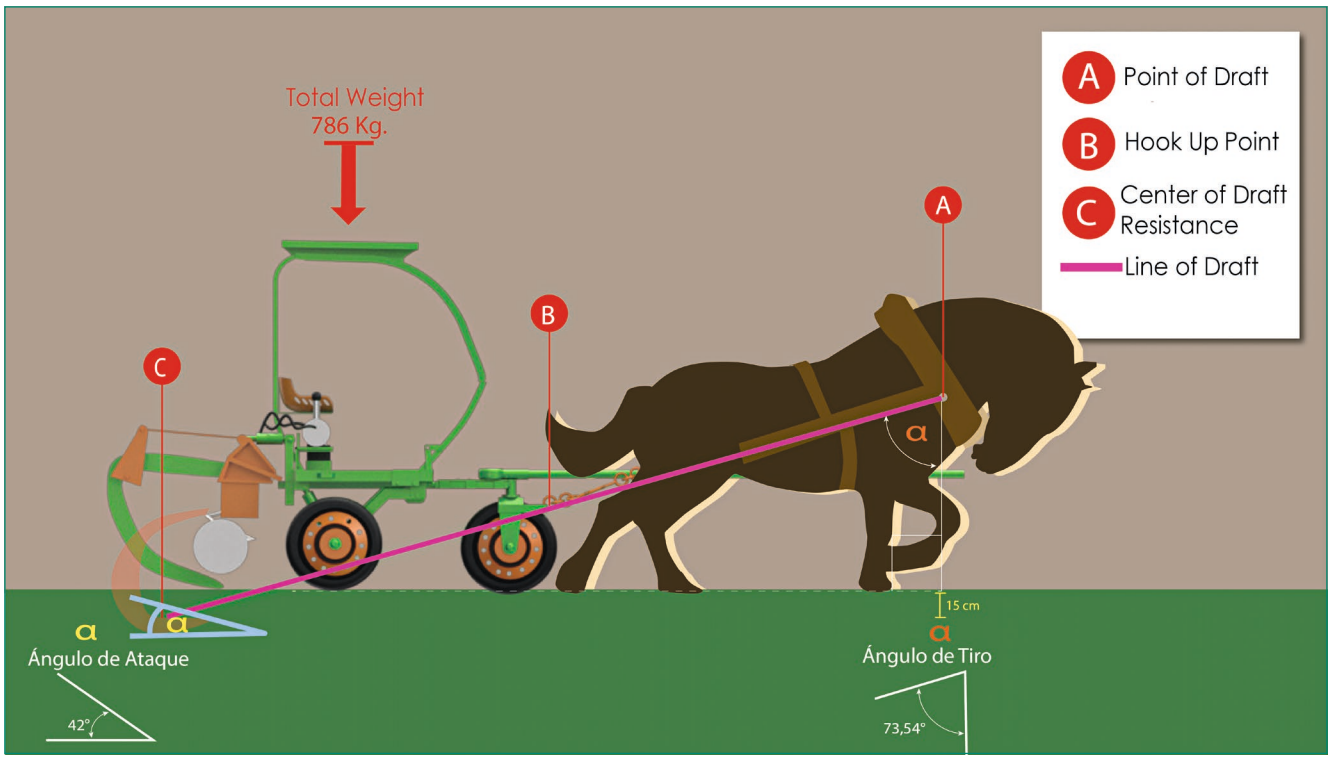

Figure 2 – Main forces that impact on the animals' draft force

2) A Polar 400 sports watch with an equine belt was used to measure, heart rate, work speed, time and traveled distance through an integrated GPS. The equine belt had two sensors (+/-) and a cardiac frequency sensor Polar H10 connected via Bluetooth to the watch. The information was discharged and stored in the Polar Flow application. The EMSRT installed in the ADBIS is shown in *Figure 1*.

3) ADBIS – composed of: hitch cart, chisel plow (tillage tool), team harness and two draft horses.

- **Hitch cart:** A mechanical platform used for operating machinery and implements class I and II. Fossil fuel is not required to operate this machinery. It is characterized by its capacity to perform multiple functions, such as, tillage, seeding/planting, mechanical weeding, crops harvesting, transport, etc. It can operate with more than two horses, based on power requirements; adapts well to small fields; and causes minimal soil compaction. The hitch cart with the chisel plow, 12V battery; hydraulic system and operator, weighted 7639,38 N (779 kgf).
- **Chisel plow:** The "Tebben" chisel plow, with a 43.2 cm (17") coulter, flute type, was selected for the present study.
- **Work harness:** Amish style (imported), fabricated in a bioplastic material except for the collars, which are made of leather and barley straw filler. The locally produced harnesses are fabricated using strips of car tires of much lower cost but, unfortunately, these cause skin lacerations due to bad designs and the poor quality of materials.
- **Work horses:** Two young stallions of five and six-year-old and an eleven-year-old mare of the European Belgian breed (Brabant), with 1, 3 and 7 yr. work experience, respectively; The three equines showed their character and aptitude for tillage work, ratifying their genetic quality as draft animals; The combined weight of the two stallions was 1280 kg

Variables and Measuring Instruments

- **Shear resistance:** It was measured using a 0 - 250 kPa shear vane tool. Testing was performed at depths of: 0, 5, 10, 15 and 20 cm to determine the degree of soil's shear resistance in kilopascals (kPa)[3] .
- **Soil water content:** The "dry oven" technique was used to determine the percentage of humidity in the soil before starting the tillage[4]. The technique is based on drying the soil sample at 105 °C for 24-48 hours[5].

$$\%\ Soil\ Water = \frac{weight\ of\ wet\ soil\ (g) – weight\ of\ dry\ soil\ (g)}{weight\ of\ dry\ soil\ (g)} \times 100$$

- **Soil type and texture:** The tactile method was used to identify soil type and texture[6] .
- **Heart rate and work speed:** The Polar 400 sport watch with the equine belt was hung from the harness. The Polar Flow application stores and download the statistics of collected data. The equine belt was placed in the thorax section of the horse, based on manufacturer's instructions. The four categories of work intensity, based on the horses' cardiac frequency (bpm), are: low: <90; moderate: 90-110; intense: 110-150; highly intense: >1507 .
- **Draft force and working depth:** The EMSRT presented the draft force in Newton (N) and the working depth in centimeters (cm).

Just as *Figure 2*, indicates, the chisel plow is straight aligned between the draft point (A) and the center of draft (C) in a straight line and generating a draft angle of 73.54° (B) as the chisel plow penetrates the ground 15 cm.

3 Rivera 2018.
4 USDA 1999.
5 URL: https://labmodules.soilweb.ca/gravimetric-soil-water-content/ [28-03-22].
6 USDA 1999.
7 NRC 2007.

- **Quality of Tillage:** The evaluation was based on recommendations provided in FAO 1994 and 1995 manuals and field observations. Special attention was on the vertical axis of the cutting wheel and the transversal axis of the chisel plow. It was further observed the removed soil quantity and its distribution on the surface, the number of turf pieces lifted with the chisel, and the quality of the cut and the size of the rupture made with the chisel plow.

These procedures are repeated in each experimental unit and it is implemented in four stages: 1) field evaluation, 2) EMSRT functioning and validation, 3) tillage work and data collection, and 4) post analysis and evaluation.

Methodology

The experimental design, named "parcels divided in time", based on the methodology by Gomez[8], was used. The study took place in five experimental units of four productive systems. The field trials consisted in chiseling each experimental parcel, in Kikuyo (grass) and fallow, at 15 cm depth and 1-meter separation between rows.

Evaluations of Horsepower, Work Effectiveness, Field Efficiency and Technological Impact of ADBIS

- **Horsepower:** It was based on determining if the animals' generated "power" was sufficient to perform tillage work with ADBIS and the chisel plow under typical soil and high-altitude conditions.
- **Effectiveness and efficiency of ADBIS under field conditions:** It was based on the capacity of ADBIS to operate with a chisel plow and to integrate other agricultural machinery. It was assumed that the animals would generate enough power to remain in the field for 4 hours working with the chisel plow, without having their physical and physiological conditions deteriorate significatively. The effectiveness and efficiency of fieldwork were measured according to: FAO[9]; Riquelme et al.[10]; Usman et al.[11]
- **Technological impact:** The impact evaluation of the animal traction technology was assessed from the "source" of renewable energy perspective, compared to the automotive technology, and considering the following factors: a) agronomic, b) social, c) economic, d) energetic, and e) environmental.

ADBIS and components

- **Hitch cart (multiple):** The displacement in the fields was done without a hitch with low friction between the tires and the ground, and a third frontal tire that facilitated the turns of the hitch cart directed by the pole. The operator handled the animals and operated the chisel plow with ease and skill with a clear view over the animals´ heads which gave him an unobstructed vision which helped him avoid holes and obstacles and maintain a straight line and avoid steep curves.
- **Chisel plow with coulter:** The displacement in the ground and its own weight helped the tool penetrate and endure the resistance and cutting forces to remain at the programmed depth. The 17" (43,2 cm) coulter was mounted in front of the chisel for a clean cut of the Kikuyo's (grass) roots system at a standard depth of 8 cm. The use of the coulter helped reduce power requirements, avoid lifting big pieces of "carpet" (chunks of grass) and facilitated the chisel's penetration and displacement in the soil up to the desired working depth.
- **Chisel point:** The following was the size: 27,94 cm in length, 5,08 cm wide, and 0,79 cm in thickness. The chisel point allowed the chisel to break the ground up to 15 cm in depth, traveling at an approximate angle of 42° (α) in relation to the soil's horizontal profile (horizon).
- **Draft horses:** The animals were hooked to the hitch cart by means of their harness to a set of doubletrees. The distance between the animals and the hitch cart was adequate to allow for precision, security (positive control) and sufficient space in the turns to avoid the fences. The average rest time for the animals was registered (Polar) as around 3 to 4 minutes for each 15 to 20 minutes work segment. After 2 hours, the rest time was increased to approximately 10 minutes for runs greater than 100 metros. The two animals on average took 4 hours to complete one hectare working with the chisel plow, which was considered very reasonable.
- **Work harness:** They were used for hooking up the horses safely to the hitch cart. The 1,60 m height of the horses was not too high and allowed the operator to put the harness without difficulty.

Field Activities

The research activities started during the rainy season, in the months of December to April and September to October. Some of the experimental units experienced intensive rain augmenting excessively the water content in the soil, exceeding the field capacity level, causing some of the work to be postponed. But, in other places, the light rains and the lack of adequate moisture in the soil caused high degree of hardening (cementing) which was evident during the tillage with the work horses.

Statistical analysis

The SigmaPlot V11 program was used for creating Person´s correlation matrixes between variables for Heart Rate (bpm), Speed (km/h), Draft force (N) and Power (hp), for each experimental unit with grouped plots' boxes for each variable.

RESULTS AND DISCUSSION

Experimental units: Experimental works took place in five different units. Following, we will discuss the results of E.U. #2, only: **E.U. #2. Garda Farm (Brabant's Horse Breeding Farm)**

The ADBIS operated in two sub parcels (plots) with 8.014 m^2 total area and completed the assigned work in 2,45 hours (approx..). The fields (sub parcels) were located in a soft rolling hill with 7 to 12 % slope. The two sub parcels are dedicated to the production of forage with a mix of grasses like Kikuyo, red and white clover, ryegrass, native poa and oats. The plots were cleaned, and the grass was chopped up before the chisel plow was used, with a 1-meter separation between rows.

8 Gomez Lopez 1997.
9 FAO 1994.
10 Riquelme et al. 1991.
11 Usman et al. 2004.

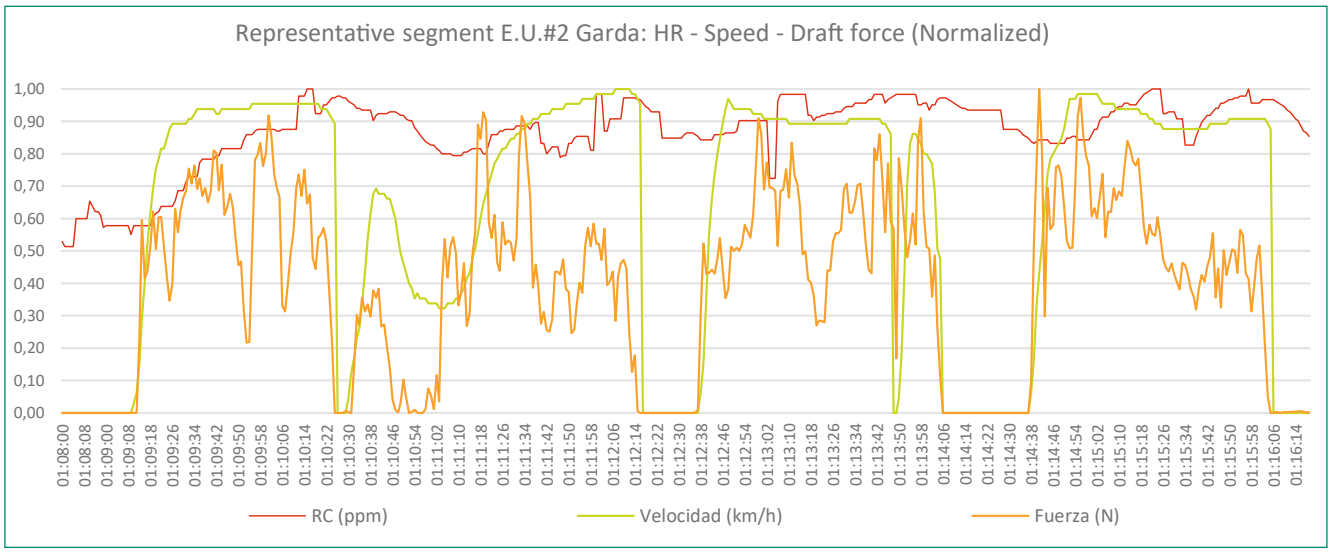

Figure 3 – Representative segment of a normal run, Garda farm

Animal performance: The animals worked comfortably during a cloudy and cool day with light rain. The horses showed a normal respiration rate during the duration of the exercise with regular periods of rest. The two horse's performance generated a force of 2260,1 N and power of 2519,4 W (3,5 HP).

Figure 3 shows a segment of a representative run with the following maximum values: HR: 185(bpm), Speed: 6,5 (km/h) and Draft force: 4359(N)

The variables of draft force and power represent a strong correlation (0,924), suggesting that "at a great generated force greater is the power of the animals. The velocity factor was relevant since indicated that "at a higher velocity greater is the generated force", therefore, greater is the power, see *Table 1*.

	HR (ppm)	Speed (km/h)	Force (N)	Power R. (HP)
HR (ppm)	1	0,208	-0,0679	0,0336
Speed (km/h)		1	0,503	0,743
Force (N)			1	0,924
Power R. (HP)				1

Table 1 – Pearson's Correlation for E.U. #2

In accordance with *Table 2*, the Experimental Unit #2 showed the soil´s lesser resistance and a medium humidity value that contributed to obtaining the highest velocity (5,4 km/h), resulting in a registered greater power value (3,5 HP) in comparison with the others E.Us

Soil Evaluation: The practice of aerating/chiseling the soil takes place twice a year (for the past three years) and it is combined with the spreading of (mature) horse manure mixed with lime, light commercial fertilizer and chicken manure.

Texture: Loamy Soil

It is considered a medium type of soil.

Water content: 50 %

The level of humidity was moderately high but demonstrated to be very appropriate for tillage, allowing the chisel plow´s forward displacement through the soil cutting with ease. It was observed that the soil was near the plastic state, it adhered easily to the tillage tool but it didn't burst (fragmentthe soil.

Shear resistance: 108 kPa.

This value is indicative of soil with a relatively low level of compaction, probably up to 15 cm deep.

Tool and accessory evaluation: The chisel plow, coulter and hydraulic system had no failures or accidents during the ground tillage and did not require of any sort of repairs or modifications to complete the job. The hydraulic system with a 1.5x10 inches cylinder/bottle had enough pressure to raise and lower the chisel. The charge of the 12v car battery lasted approximately four hours to complete the job.

Table 3 shows the results (average) of eleven variables of interest collected from all four participating farms in the study.

Analysis of Table 3

- **Shear resistance:** The greater resistance to soil´s shear resistance were the plots corresponding to E.U. #3 and #4B, which were characterized for having the lowest level of water content with respect to the other E.Us. Based on the obtained results, "at similar water content, greater is the power requirement for tilling a clay-loam versus a silt-loam soil. Due to conditions of low water content and a high degree of soil compaction (hardening), sudden changes in working depth and area of disturbed soil

Shear Resistance (kPa)	Humidity (%)	Working depth (m)	Heart Rate(ppm)	Speed (km/h)
108	50	0,15	127	5,4
Draft force (N/kgf)	Power (W)	Equivalency (HP)	Altitude (m.a.s.l.)	Temperature (°C)
2260,1/230,5	2519,4	3,4	2870	12-15

Table 2 – Power measurements (average) in E.U. #2

E.U.	Soil texture	Shear resistance (kPa)	Humidity (%)	Depth (m)	Heart rate	Speed (km/h)	Draft Force (N/kg)	Power (W)	Equiv. (HP)	Altitude (m.a.s.l.)	Temp. (°C)
1	Silt-loam	130,0	89	0,15	127	4,5	1781,3/181,6	1654,7	2,2	3400	8-11
2	Silt-loam	108,0	50	0,15	149	5,4	2260,1/230,5	2519,4	3,4	2870	12-15
3	Silt-loam	219,4	36	0,15	145	4,3	2722,6/277,6	2407,7	3,2	2850	10-12
4A	Clay-loam	176,0	47	0,15	139	4,8	1639,9/167,2	1620,8	2,2	2560	15-17
4B	Clay-loam	228,0	27	0,06 a 0,08	129	4,7	2086,9/212,8	2016,1	2,7	2560	14-16

Table 3 – Power Measurements (average) for a parabolic chisel plow with 2 draft horses of 640kg/ea

marked a significant difference in results of shear resistance and (draft) power. A similar situation is reported by Camacho and Rodriguez[12] in their research.

Based on the information presented in *Table 3*, can be inferred that when the soil presents major shear resistance the animals tends to slow their work speed.

- **Humidity content:** In 3 of 5 experimental units, the field trials took place under a high percentage of soil's humidity content. The greatest humidity level was registered in E.U. #1. The high level of humidity in the soil is considered too wet for efficient tillage since it is not near the point of plasticity. Similarly, it made the soil, in an aqueous state, stick to the chisel plow but, minimally affect the tool´s efficacy and increased in a way the animals´ draft force. The percentage which is closest to the optimum point of plasticity for effective tillage was registered in the E.U. #2 (50 %), facilitating the increase of work speed, generating greater power, therefore, resulting in mayor draft efficiency. The lowest percentage of humidity content shown by E.U. #4b compared to historical information of high compaction, also affected the higher demand for power. The soil's humidity content between the E.Us. ranged between 36 % and 89 % for light and heavy soils, respectively. The vane shear test registered shear resistance values of 108,0 to 219,4 kPa for medium-light soils and between 176,0 to 228,0 kPa in highly compacted soils.

The important "cultural" factor is highlighted, in the decision-making process about their agricultural practices. Both the farmer and the animals, perform tasks in the rain to take advantage of the rainwater to obtain a better harvest. We could say that the use of draft animals should be considered more acceptable in the cultural context of the Andean region than the tractor, in a sustainable agricultural context.

- **Soil type and texture:** The two types of soils identified in the samples taken in all participating E.Us. were silt-loam and clay-loam.
- **Working depth:** This was established at 15 cm deep with the purpose of exceeding the depth of the "Kikuyo" grass root system, which develops between 6 to 8 cm approximately, in this area. The exception to the established working depth was E.U. 4B, where the chisel plow was lifted off the ground surface due to the hardpan caused by heavy compaction of the soil. Small depth variations registered by the EMSRT were also caused by irregularities found in the ground; movements along the longitudinal axis of the hitchcart, and obstacles encountered by the chisel plow in the fields.

12 Camacho-Tamayo/Rodríguez 2007.

Analysis of Four Variables (Factors)

- **Draft Force (pull):** The two draft horses generated significant draft forces which oscillated between 1639,9 N and 2722,6 N, establishing a power range between 2,2 y 3,5 HP. The graph in *Figure 4* represents the *draft force* variable for the five experimental units. The most determining factor in the draft force variable was the soil water content, which represents a lesser dispersion with greater water content versus a mayor dispersion with less water content.

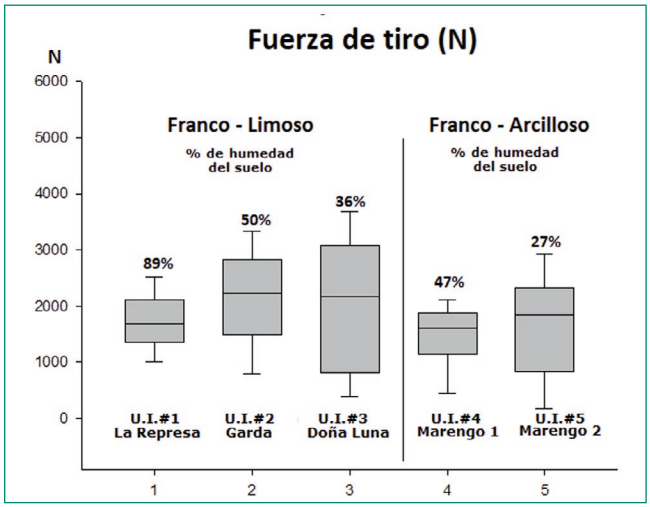

Figure 4 – Box plot for Draft Force (N) for all experimental units (E.U.'s)

- **Work Speed:** The majority of the velocities (km/h) were quite similar in range with the exception of E.U. #2, where the highest registered speed generated the biggest power. It is understood that average speed results were somewhat not normal given the possibility that in the soils with poor water content the chisel plow did not move softly and efficiently bursting the soil violently and irregularly with back-and-forth movements (accordion effect) between the horses and the hitch cart, due to a lack of elasticity of the hitching system when operates in the irregular ground. *Figure 5* represents the variable *speed* and it is observed a normal response to shear resistance and no significant differences were found between the treatments. The observed tendency was: "the greater the degree of compaction the lower the working speed" – see EU #3 and EU #4B.

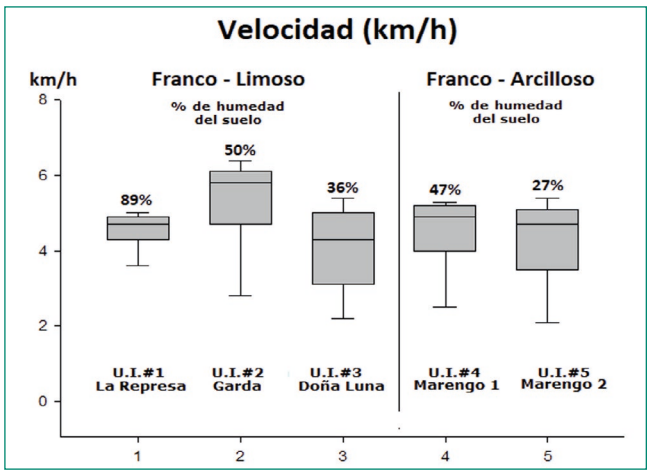

Figure 5 – Box plot for Speed (km/h) for all experimental units (E.U.s)

- **Heart Rate:** A significant HR difference between the E.Us. in relation to the varying altitudes (m.a.s.l.), could not be perceived. It cannot be concluded if a tendency in relation to the other variables exists, except that the physiological system in horses operated in a range of 127 to 149 bpm during the tillage with the chisel plow, of which it can be concluded that based on parameters established by the NCR[13], the work intensity in these trials can be classified from "moderate to intense". Based on the obtained results, it can be assumed that the heart rate was principally influenced by work speed and not by the Andean´s altitude as initially. Thereon, Nomura and Tominaga[14] from Tokyo University, reported that the relationship between heart rate and draft force was directly proportional and that the heart rate among trained (experienced) horses versus non-trained horses were lower[15].

The graphic in ***Figure 6*** shows the *heart rate* variable, where it is observed that the HR variable might have been affected by the type of work the animals performed but apparently, was not affected by the other variables. It should be noted that the altitude perhaps, did not affect the animals directly given the fact that both are considered "natives" (by birth) to the Cundiboyacense highlands and are well adapted to the local environmental conditions.

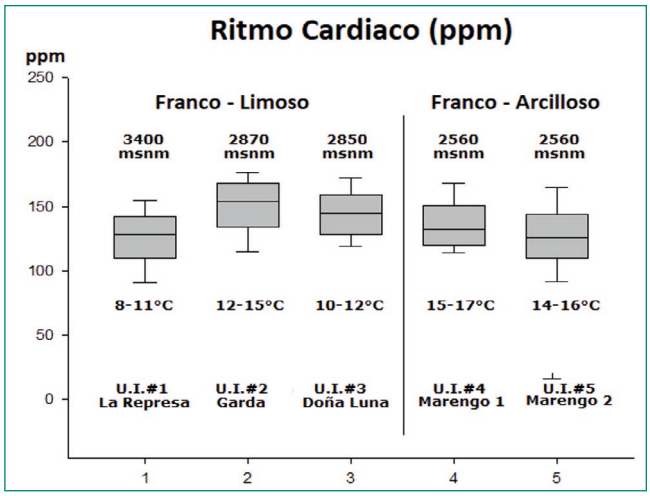

Figure 6 – Box plot for Heart Rate (ppm) for all experimental units (E.U.s)

13 NCR 2007.
14 Nomura/Tominaga 1960.
15 Hiraga/Sugano 2017.

The heart rate and the rest periods (recuperation) were closely monitored to avoid excessive fatigue and to protect the animals' well-being by avoiding dangerous or adverse physiological conditions. During work, it was observed that the heart rate remained at an adequate range and to maintain a good quality of (draft) force the rest periods were short but frequent. The physiological recuperation was quick making the horses' work capacity consistent and complementary. The draft horses demonstrated a great capacity for draft and work speed, under varied temperature conditions showing their adaptation to the changing climate of the highlands.

- **Power:** It is directly linked to the *draft power vs speed* relation. The greatest power (W) generated by the animals is registered in E.U. 2 where the high velocity (5,4 km/h) influenced a greater generation of draft power. This plot registered an intermedium level of water content and a lesser degree of compaction than the other E.Us. In the E.U. #1, for example, the two draft horses worked tilling a silty-loam type soil, the chisel plow operated at 15 cm depth, with 89% soil water content, work speed of 4,7 km/h at 3400 meters (a.s.l.), generating power of 1654,7 W (equivalent to 2,2 HP). However, in clay-loam-type soils, there were no conclusive results due to the limited available information (only two plots). The graphic in ***Figure 7***, shows the variable *Power* (kW), where it is observed that it was affected by the water content and in a similar way by the draft force in both types of soils, silty-loam, and clay-loam. Being the power a result of the conversion, it cannot be clear the source of the difference in the results between the two types of soils studied.

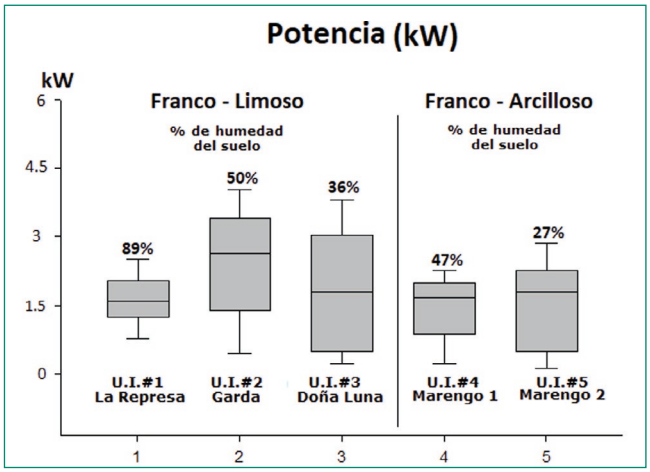

Figure 7 – Box plot for Power (kW) for all experimental units

Performance of the Hitch cart with the Chisel Plow

The use of the equipment in soils of identified hardiness, due to the high level of compaction, was effective and bear the forces and the impacts caused by the soils' shear resistance and other obstacles found in the field (fence post). The hitch cart and the horses left no marks of feet and tires on the ground. The (assumed) friction generated by the hitch cart with the chisel plow was identified as "displacement resistance" (or "rolling resistance", which is a term used to refer to automotive traction), where the rolling resistance is related to the machinery's/equipment's weight, type of soil and speed of work. The chisel plow's weight and the pressure exerted by the hydraulic servo were adequate/sufficient to assist the tool

to penetrate the soil to a depth of 15 cm, in plots where soil compaction was evident. The soil's shear resistance was determined between 108,0 to 228,0 kPa (***Table 3***). The chisel's point angle of attack was 42° and was set/determined manually[16].

Performance and Output of Draft Horses

The results of the study confirm the great performance and output of draft horses and were consistent with those obtained by Collins & Caine (1926). Based on the registered draft power values during the trials (***See Table 3***), the animals generated a draft force of 230 kgf, 17 % of the total force capacity of both animals, with a power equivalency of 2,9 HP to pull the chisel plow through a depth of 15 cm. Unlike the works of Collins & Caine (1926), the participating draft horses in this study operated satisfactorily in the high plains at altitudes between 2.560 m.a.s.l. and 3.400 m.a.s.l., showing normal fatigue, similar capacity to draft horses working in the lowlands (closer to sea level). The average work period to complete the assigned task of one hectare with regular rest periods was four hours with runs up to 120 meters and with an average speed of 4.5 km/hr and 50% humidity, without significantly affecting their performance and demonstrating their capacity and nobility to pull the agricultural tool.

In general, the literature on the subject indicates that the draft horse has the capacity for "pulling" (dragging) loads that represent between 10 % and 15 % of their body weight for approximately 8 hours/workday[17]. In their study, Collins/Caine used 14-inch plows (35,5 cm) with three horses to plow parcels with sudangrass in soils of medium texture, generating draft forces of approximately 227 kgf (500 lbf), at a depth of 15,24 cm (6 in), and generating power equivalence of 2,15 to 2,26 HP.

In principle, a 640 kg draft horse would produce enough power to energetically sustain between 0,5 to 3 hectares and two horses could easily provide the work power required for approximately 5 to 10 hectares of a diversified commercial farm. It appears, there is an acquired synergy when two or more horses are hitched together potentiating their work.

The monitoring of the heart rate (HR) and time of recuperation in working horses, is essential for determining their performance, draft power and physiological condition. The information can also be used as a tool for identifying and selecting good-quality horses for breeding[18]. During fieldwork, the animals exhibited a normal HR which oscillate between 127 bpm and 149 bpm, similar to values of those results reported by Nomura/Tominaga[19] and mentioned by Hiraga/Sugano[20].

The "negative power" caused by the resistance of the horses' displacement (traveling) was estimated at less than 7 % which is similar to the average value of the "rolling resistance" produced by the tires of an agricultural tractor.

Use of a non-standard rod: The non-standard rod, 3/8" diameter x 39.37 inches long, was fabricated in stainless steel. It was introduced into the ground up to 7.87 inches in depth, in order to, explore the approximate level of soil compaction. The greatest degree of compaction was found between 10 to 12 cm. from the ground's surface. This method resulted very practical and aided in developing a feel for the level of compaction and soil water content in the depths where these soil conditions can be found, useful information for designing, selecting, measuring and adjusting tillage tools to facilitate penetration and permanence at a designated working depth, especially in highly compacted soils.

Correlations between Speed – Draft Force and Power: While comparing the results of the Pearson's correlations between the variables of speed, draft force and power, a major correlation between draft force and power versus speed and power. The previous information indicates that an increment in draft force has a direct result in an increase in power but, it does not occur in the same proportion with (work) speed, possibly due to the animals' physiological factors.

Impact of the agricultural mechanization technology with animal traction: The areas of strategic interest for local and national agriculture its related to objective #3 of the main thesis, "evaluate the capacity, efficiency, and impact in the agronomic, social, economic, environmental, and technological, of the use of draft horses and agricultural machinery on the Andean soils of the Cundiboyacense region of Colombia. It is inferred that the use of work horses could have a renewed impact, wide and positive, in many farming activities and rural development. Through education and training, the use of AT technology and likewise, would incentive the younger generations to remain in the rural areas. The Andean regions of Colombia, such as: Cundinamarca, Boyacá, Antioquia y Nariño, where the tillage in hillsides is done by hand and minimum mechanization. The use of upgraded animal traction tools would improve human capacity for increasing production and efficiency. Farmers owning machinery and implements for use with animal traction could supplement their incomes by offering tillage services with their machinery and work horses to neighbors and members of the local community.

- **Agronomic impact:** The main objective of sustainable agriculture is to improve agricultural production with a minimum environmental impact. Agricultural mechanization with draft horses is a valid option for supporting farming activities in the three main productive systems with economic importance to the region: milk, potatoes, and vegetables.

  The draft horse has the capacity to work effectively and efficiently in < 20° slopes (when using a hitch cart) with modern, well-designed or modified tools and fabricated with high-quality materials to supply the needs of local farming. In principle, initial results on the power (energy) generated by this size of draft horse, indicate that it should be enough to mechanize family and commercial farming in Colombia.

  The chisel plow used was selected for its symmetry, facilitating the harmonious work with the horses, improving their performance. The weight facilitated its penetration in the soil, opening narrow gaps to aerate, decompaction and improve water infiltration, controlling runoff and erosion. Additionally, it did not alter significantly the surface relief with the formation of "sod". Additional accessories can be added

16 Makudiuh 2016.
17 Collins/Caine 1926; Miller 2004.
18 Hiraga/Sugano 2017.
19 Nomura/Tominaga 1960.
20 Hiraga/Sugano 2017.

to the chisel plow, such as a ridger or a single row planter, making it a multifunctional tool.

The ADBIS uses a complementary 12 volts, electrical hydraulic pump to operate the hydraulic system, to control the working depth. The study was limited to the use of the Tebben chisel plow to perform subsoiling/aeration. No other tillage tools were used in this study.

- **Socioeconomic impact:** The transformation of agriculture in the Andean region, is very necessary to respond to the needs of rural communities, caused by latent endemic poverty, where specialized and better-paid jobs are needed. Transformed agriculture with renewed rural and socio-cultural values, techno-scientific know-how, and an improved rural economy with opportunities for all would facilitate consensus to foster changes based on new sustainable farming technics among the farmers and the hand labor force. Studies conducted outside Latin America; report of important benefits obtained by small farmers with the use of draft horses[21]. The costs of investments and operation of work horses versus tractor mechanization are very reasonable. Horse farming directly promotes a circular economy where limited locally produced resources are utilized, recycled, and reinvested in the local community for the prosperity of all.

  The Amish concept of traditional farming[22] is a valuable example of a successful family/commercial farming experience, worth studying and adapting. The Amish model of association and interdependence foster the participation of the entire community and takes the form of a circular rural economy. The participation of all family members in the activities of the farm including the handling of the horses in field operations, as a source of less expensive renewable power, are some of its important features. The main point to rescue is the Amish family's capacity to live modestly in relative prosperity. Fundamentally, the Amish concept is a system of self-sufficiency, sustainability and highly productive in comparison to conventional agriculture.

- **Environmental impact:** The use of work horses is very appropriate in the context of sustainable, biodynamical and conservation agriculture. The negative environmental impact is considered much less damaging than those caused by the use of tractor technology and associated machinery. Tillage practices with draft animals affect the environment to a lesser degree, due to the design, weight, and geometry of the tools. The lesser weight of the work horses and their smaller and lighter tools can contribute to reducing the soil compaction and help control the erosion in the hillsides.

  The agricultural mechanization with draft horses would allow for conservation practices aiming to reduce CO2 production and demotivate the burning of post-harvest stubble. The great uncertainty associated with climate change is how this could affect the agricultural calendar of planting and harvesting and plants' adaptability to the solar intensity and the availability and frequency of the rains. Animal traction would allow a great number of farmers access to a source of less expensive energy (power) to mechanize their farming operation in an opportune way amidst climate change.

- **Energy impact:** Small producers seldom use fossil fuel in their farming activities, because these are manually accomplished. The animal traction technology has the capacity to use locally produced forages and grains, and animal feed, which later converts into useful energy for tillage and manufacturing of machinery, implements, harnesses, horseshoes, animal feeds, drugs, fertilizers, etc. The animal traction technology proportionally consumes less energy than the energy used by the agricultural automotive industry[23].

  The need to reduce fuel consumption positions the use of working animals as the appropriate technological choice to achieve an important level of "energetic autonomy". The use of diesel fuel represents between 40 % to 50 % of the total hourly cost of the tractor operation[24], hence the necessity to employ other options or sources of less expensive energy, as is the case of the animal traction technology. The results of a comparative study by Huerga et. al.[25], indicated that the automotive power produced 8,2 MJ/ha, a generated power of 2,26 K, and consumed 102,6 MJ/ha, by contrast, two work horses produced 8,2 MJ/ha, generated power of 0,98 KW and consumed 90,77 MJ/ha creating a saving of 12 MJ/ha of energy, approximately.

  The E.U. 2 also uses a 25 HP motorized hitch cart with a hydraulic system to operate a mower, a mini round baler and a rotary tiller. The fuel consumption is "in demand" as the engine is started up when there is a need to operate the selected machinery. The transport to and from the fields is done with the horses.

- **Technological impact:** Given the simplicity of the animal traction technology, producers, and farm workers can operate agricultural tools with minimum difficulties. A limiting factor to the employment of work horses on steep hillsides is the larger size of their hooves and a higher gravity center (GC), in comparison to mules, oxen and donkeys and this could cause draft horses to lose their footing. The maintenance, repair and fabrication of less sophisticated machinery and implements can be done easily and less costly and can be accomplished in local shops. Harness fabrication and repair are possible, and they can be done with national and imported materials resources in saddle shops located in cities and rural communities.

  The successful transfer of concepts like ADBIS necessarily must be contingent on the training of the operators, so that farmers and laborers have the opportunity to learn and acquire new abilities, to handle animals and equipment, in a safe, effective and efficient manner and where the animal´s welfare becomes paramount. ADBIS can function as a didactic platform for the development of abilities and newer concepts in tillage techniques, safety, and animal traction technology in general.

Conclusion

The animal traction technology (ATT) with draft horses is an excellent alternative to the automotive technology because it uses other sources of fuels like greens (forages and grains), oils, etc., and provides an energy that exponentially increases available power per hectare, a lot more than rural hand labor can. It can make work compatible with the environment and it reproduces itself with

21 Rydberg et.al. 2002; James 2003; Kendall 2005; Nordell/Nordell 2012.
22 James 2003.
23 Rydberg/Jansen 2002.
24 Hetz/Reina 2013.
25 Huerga et al. 2011.

local resources. Also, the animal traction technology can foster and function in a circular economy where goods and services are sold and purchased within the local economy and for the benefit of all the community.

The hitch cart proved to be a highly efficient and multifunctional tool, comfortable, balanced and of good visibility. The hydraulic system was of great utility to handle the working depth of the chisel plow (also, to operate with other implements, such as furrower, seeders/planters, sprayers, etc.). The relation draft force/live weight of the animals was in the order of 17 % which is considered reasonable, where the weight was supported by the rubber tires. The chisel plow proved to be less damaging (on the hillsides) than the rotary tiller and the disc plow since it did expose the worked soil to displacement of the soil by erosion or washed by the rains.

The Electronic Measuring System in Real-Time (EMS-RT) functioned adequately in field conditions. The sensors used produced readings within trustworthy ranges. The use of Polar 400 watch to monitor the animals´ heart rate was useful to report on their critical physical and physiological parameters, recovery and rest periods during tillage. This accessory can also be employed to identify and select breeding stock with greater draft qualities for work in the hillsides of the Andean region and for monitoring adequately their well-being.

The three draft horses used in the study, demonstrated unequivocally to possess the (draft) power and the necessary nobility to work with the chisel plow efficiently and a reasonable time.

The Kikuyo grass facilitated the horses' work in those soils that exceeded their humidity field capacity (fc). Kikuyo's root system and its' stolon, weave with each other to form a "green carpet" which supports both the weight of the animals and the associated draft animals' agricultural machinery, facilitating traffic through the fields and pastures in high humidity conditions. A phenomenon that does not occur when operating with a tractor, is where the tires skid on the surface of the grass to the point of making deep ditches to the point of getting the tractor stuck in the mud. Additionally, the animals and the animal traction machinery operated efficiently in soils with a high percentage of humidity, facilitating drainage and the infiltration of rainwater. According to field observations, the work horses do not appear to be affected by the Andean altitude (2500m.a.s.l. to 3400 m.a.s.l.)

The economic impact of ADBIS to the local rural economy can be meaningful since it resolves the need for increased production efficiency, reduction in soil compaction and erosion, fostering rural employment, reduction of fuel consumption and includes sustainable agriculture practices and self-sufficiency in food production. ADBIS uses in a complementary manner, electrical engines to operate a hydraulic system, power take-off and control the tool's working depth.

The chisel plow efficiently cut through the soil leaving narrow furrows to allow for better aeration and decompaction of soil for improving infiltration of rainwater and diminishing water run-off and erosion. Additionally, it does not significatively alter the pasture's surface with the formation of "grass turf".

RECOMMENDATIONS

- Draw up government policy (law) to promote research, development, and extension of the animal-drawn technology with the rural communities and renewable technology in agricultural mechanization and source of clean and less costly energy.
- Foster coordinated efforts with alike institutions in the animal-drawn theme.
- Establish a Center of Excellence for Andean Agricultural Mechanization for R+D+E, to include the study of mixed mechanization with automotive technology.
- Establish a draft horse (and mule) breeding programs with imported breeding stock to promote the genetic improvement of local horses to promote ag. mechanization with the use of draft animals.
- Promote the use of draft horses as an excellent energy source with alike development programs.
- Include the animal traction technology as a vital component of the national agricultural development strategy and link it with programs of alternative sources of energy and conservation tillage[26].
- Promote animal traction as a complement to the available rural hand labor.
- Set up educational and training programs in ag mechanization with draft horses (or draft animals).
- Foster semi-industrial and cottage industries for the fabrication of machinery and implements for use with draft animals.

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Author info
Hugo Samuel Sanhueza Leal

Magister en Ingeniería Agrícola, Universidad Nacional de Colombia, Facultad de Ingeniería, Departamento de Ingeniería Civil y Agrícola, Bogotá, Colombia

E-Mail: hssanhuezal@unal.edu.co
Digital paper: https://youtu.be/YPzdUpjaFrE

Author info
Oscar Leonardo García Navarrete

Ingeniero Agrícola, MSc., Universidad Nacional de Colombia, Facultad de Ingeniería, Departamento de Ingeniería Civil y Agrícola, Bogotá, Colombia

E-Mail: olgarcian@unal.edu.co

Author info
Hugo A. González Sánchez

Ingeniero Agrícola, MSc, Ph.D, Universidad Nacional de Colombia, Facultad de Ciencias Agrarias, Departamento de Ingeniería Agrícola y Alimentos, Medellín, Colombia

E-Mail: hagonzal@unal.edu.co

Modernizing mechanization in draft animal use for a sustainable peasant agriculture

Philippe Lhoste

Abstract

Prommata International Association was founded by a “peasant-engineer-technician” and great humanist, Jean Nolle (1918-1993). His work aims at improving the efficiency of agricultural work of small farmers in developing countries, by modernizing their draft animal implements. In order to achieve this, farming equipment and draft animal use should be enhanced through agro-ecological practice to improve their living conditions and make their work more efficient. This results in less hardship, faster implementation and a better quality of agricultural work (sowing, weeding, ridging, etc.). Since the people involved are the poorest farmers, draft animals will often be donkeys which are the most affordable choice. As for the implement: the modern tool-carrier, the Kassine, which has proven its value in many countries where it is locally made, has the advantage of being highly flexible, adapted to all kinds of animals (donkeys, horses, cattle) and easy to use for all members of a peasant family. To ensure this, blacksmiths, the southern partners of the association, are trained to make the Kassine according to precise instructions, then the farmers and technicians in their organizations are trained in how to use the new equipment. This training goes well beyond simply using the tool, because it fits into a plan for agro-ecological production that ensures the sustainability of agricultural production. The use of a particular tillage practice in Burkina, “mechanized zai” with draft animals, provides an example of how to work with a Kassine. The ultimate goal is improving working conditions, income and food security for peasant families.

Résumé

L’association Prommata International a été créée par un « paysan-ingénieur-technicien », grand humaniste, Jean Nolle (1918-1993). Ses actions visent à améliorer l’efficacité du travail agricole des petits paysans des pays en développement, grâce à la modernisation de leurs outils en traction animale. Pour y parvenir, il s’agit d’améliorer l’équipement agricole et l’utilisation des animaux de trait dans des pratiques agroécologiques pour améliorer les conditions et l’efficacité du travail de ces paysans. Il en résulte une moindre pénibilité du travail humain, une rapidité d’intervention accrue et une meilleure qualité du travail agricole (semis, sarclages, buttages, etc.). S’agissant des paysans les plus nécessiteux, l’action portera souvent sur l’espèce asine qui reste la plus accessible pour les plus démunis. Concernant l’équipement : la promotion d’un porte-outil moderne, la Kassine, qui a fait ses preuves dans de nombreux pays, où il est fabriqué sur place, présente l’avantage de sa polyvalence, de son adaptation à tous les attelages (ânes, chevaux, bovins) et de son utilisation facile par tous les membres de la famille paysanne. Pour cela, les forgerons, partenaires du Sud de l’association, sont formés à la fabrication de cette Kassine selon un cahier des charges précis qui leur est donné. Les paysans et les techniciens de leurs organisations sont formés à l’utilisation de ce nouveau matériel. Ces formations dépassent la simple utilisation du matériel car elles s’inscrivent dans un schéma de production agroécologique pour assurer la durabilité de la production agricole. La diffusion d’une pratique particulière de préparation du sol, le « Zaï mécanisé » en traction animale, au Burkina, illustre un exemple d’utilisation de la Kassine. C’est en définitive l’amélioration des conditions de travail, des revenus et de la sécurité alimentaire des familles paysannes qui est visée.

Kurzfassung

Die internationale Vereinigung Prommata wurde von einem "Bauern-Ingenieur-Techniker" und großen Humanisten, Jean Nolle (1918-1993), gegründet. Seine Arbeit zielt darauf ab, die Effizienz der landwirtschaftlichen Arbeit von Kleinbäuer:innen in Entwicklungsländern zu verbessern, indem ihre Zugtiergeräte modernisiert werden. Um dies zu erreichen, sollten die landwirtschaftlichen Geräte und der Einsatz von Zugtieren durch agrarökologische Praktiken verbessert werden, um ihre Lebensbedingungen zu verbessern und ihre Arbeit effizienter zu gestalten. Dies führt zu weniger Entbehrungen, einer schnelleren Umsetzung und einer besseren Qualität der landwirtschaftlichen Arbeit (Aussaat, Unkrautjäten, Eggen, usw.). Da es sich bei den Betroffenen um die ärmsten Landwirt:innen handelt, werden als Zugtiere häufig Esel eingesetzt, die die kostengünstigste Wahl darstellen. Was die Arbeitsgeräte betrifft, so hat der moderne Werkzeugträger, die Kassine, die sich in vielen Ländern, in denen sie vor Ort hergestellt wird, bewährt hat, den Vorteil, dass sie sehr flexibel ist, sich an alle Arten von Tieren (Esel, Pferde, Rinder) anpassen lässt und von allen Mitgliedern einer Bauernfamilie leicht benutzt werden kann. Um dies zu gewährleisten, werden die Schmied:innen, die südlichen Partner:innen des Vereins, darin geschult, die Kassine nach genauen Anweisungen herzustellen, und anschließend werden die Landwirt:innen und Techniker:innen in ihren Verbänden in der Verwendung der neuen Ausrüstung geschult. Diese Schulung geht weit über die bloße Nutzung des Geräts hinaus, denn sie fügt sich in ein agrarökologisches Produktionskonzept ein, das die Nachhaltigkeit der landwirtschaftlichen Produktion gewährleistet. Die Anwendung einer bestimmten Bodenbearbeitungsmethode in Burkina, des "mechanisierten Zai" mit Zugtieren, ist ein Beispiel dafür, wie man mit einer Kassine arbeitet. Ziel ist es, die Arbeitsbedingungen, das Einkommen und die Ernährungssicherheit der Bauernfamilien zu verbessern.

Resumen

La Asociación Internacional Prommata fue fundada por un "campesino-ingeniero-técnico" y gran humanista, Jean Nolle (1918-1993). Su trabajo tiene como objetivo mejorar la eficacia del trabajo agrícola de los pequeños agricultores de los países en desarrollo, mediante la modernización de sus aperos de tiro. Para ello, es preciso mejorar el equipamiento agrícola y potenciar el uso de los animales de tiro mediante prácticas agroecológicas para mejorar sus condiciones de vida y hacer más eficiente su trabajo. De este modo, se reducen las dificultades, se acelera la ejecución y se mejora la calidad de las labores agrícolas (siembra, escarda, aporque, etc.). Dado que se trata de los agricultores más pobres, los animales de tiro suelen ser burros, que son la opción más asequible. En cuanto al apero, el moderno portaherramientas, el Kassine, que ha demostrado su valor en muchos países donde se fabrica localmente, tiene la ventaja de ser muy flexible, adaptarse a todo tipo de animales (burros, caballos, ganado) y ser fácil de usar para todos los miembros de una familia de agricultores. Para ello, los herreros socios de la asociación, reciben formación para fabricar el Kassine según instrucciones precisas, y después se forma a los agricultores y técnicos de sus organizaciones para que sepan utilizar el nuevo equipo. Esta formación va mucho más allá del simple uso de la herramienta, ya que se inscribe en un plan de producción agroecológica que garantiza la sostenibilidad de la producción agrícola. El uso de una práctica de labranza particular en Burkina, el "zai mecanizado" con animales de tiro, proporciona un ejemplo de cómo trabajar con un Kassine. El objetivo final es mejorar las condiciones de trabajo, los ingresos y la seguridad alimentaria de las familias campesinas.

The international solidarity association, Prommata International (P.I.), founded at the end of the twentieth century by Jean Nolle (1918-1993), endeavors to promote modern animal draft as a means to support and develop ecological, farmer-based and sustainable agriculture around the world. Jean Nolle, a "farmer-engineer-technician", who was also a humanist visionary, worked to make animal draft a way for small farmers to be independent, especially by designing "modern", innovative and highly flexible agricultural implements[1] that have spread to many countries.

Relaunched in the twenty-first century, our association seeks to pursue the work begun by Jean Nolle and provide small farmers with a response using animal draft and an implement adapted to their needs: a realistic, accessible solution for the poorest farmers that is respectful of people and the environment[2].

The interest in using animal power in agriculture[3]

Using animal power along with a tool kit adapted to agro-ecological cropping methods is a sustainable solution to improve the working efficiency of small farmers in agriculturally challenging areas. This approach enables small farming structures to benefit from equipment and techniques that improve the efficiency and productivity of the poorest farmers, resulting in better harvests, both in quality and quantity, and thus improved food security for their families.

We can also emphasize that this is equally applicable for some family farms in Europe, especially those dedicated to market gardening, tree farming and wine production[4].

Figure 1 *– Ridging potatoes with the Kassine, France*

Effective use of animal draft supposes being able to utilize a series of specific tools to carry out the main tasks of the agricultural cycle, from soil preparation to harvest. For example, this can involve sowing a field at the end of the dry season which requires people to do a lot of work, when it is done manually (as with the traditional practice of *zaï* in Burkina Faso, see below). When *zaï* is mechanized thanks to animal draft developed with the Kassine over recent years in Burkina Faso, field preparation before the rainy season is faster, more efficient and above all, requires less investment in human effort[5].

Figure 2 *– Working in a greenhouse with a Kassine*

The same is true of hand weeding of crops (often carried out by women) to aerate the earth so that it does not crust up and will retain moisture better… Without animal draft, this kind of work requires entire days of demanding manual labor that often has to be done in a very short time. Once again, using draft animals with appropriate implements makes it possible to weed and earth up crops faster and with less fatigue for the farmer.

The donkey, the working animal of the poor

Donkeys, those modest equids, are the most affordable draft animals for poor families and there are often many donkeys in the countryside in African countries like Burkina Faso and Mali.

Figure 3 *– Rudimentary homemade harness, Burkina*

1 Nolle 1986.
2 Prommata International, URL:https://www.prommata-international.fr [09-03-2022].
3 Lhoste et al. 2010; Id. 2013.
4 Prommata, URL: http://prommata.org/ [09-03-2022].
5 Barro et al. 2005.

Furthermore, donkeys are frequently used for draft transport and too rarely for working the soil, which remains mainly manual labor. These donkeys are all too often poorly cared for and trained ("trained with the stick"), poorly harnessed, overworked and frequently beaten, when they are such friendly animals that require so little and are very good workers.

The farming implements peasants have are often poorly adapted to these small animals and do not work well because they are poorly maintained.

In fact, simple and robust donkeys that are inexpensive and easy to care for seem to be the "draft animals of the poor" most adequate for modest families. They make work easier, most especially for women who handle transport (water, wood, etc.) and work in the fields. The work of Prommata International and its partners has demonstrated the interest in such improvements in several sub-Saharan African countries involving:

- Good stockbreeding practices, in training and handling donkeys to improve work
- Improving harness and equipment for tillage, especially using the simple and inexpensive collar made by local craft people to replace the unwieldy breast collar presently used
- Developing farming equipment appropriate for this modest draft animal

igure 4 – Donkey at work with a Kassine wearing an appropriate homemade collar, Burkina

Improving the equipment: promoting a modern tool-carrier, the Kassine

The Kassine is a flexible carriage inspired by the *kanol* and the *houe-sine* (*sine hoe*), two inventions made by Jean Nolle. The Kassine was designed and fine-honed by the Association Prommata and has been sold since 1994 to European market gardeners working with animal draft. The Kassine has also been adapted, introduced and tested in various countries of the South and, using diverse implements, makes it possible to do fieldwork. This poly-cultivator is made in Burkina by blacksmiths trained by Prommata.

Various tools can be made and used with the Kassine: subsoiler tine, moldboard plough, ridger, furrow opener, springy tines cultivator, etc.

- The simple way the Kassine is designed enables small workshops to make, maintain and repair it easily and locally
- Standardized design enables component and tool exchange among users and joint purchase by several families of some tools. For the workshops involved, standardization encourages joint ordering of raw materials, hence at the most competitive prices. Standardization is a guarantee of product quality and long-lasting implements
- Flexibility: in both North and South, farmers' tool needs are many, depending on the work to be done and the technical itineraries adopted. It is possible to add tools to the Kassine gradually and hence to improve equipment over several seasons. The most expensive tools can also be purchased and utilized by several families (for example, furrow opener disks…)

This kind of equipment is also appropriate for some family-run farms in Europe that usually work with equids, especially in market gardening.

Important advantages of the Kassine for developing countries

In small farms in the South, the Kassine can be used with various draft animals that farmers may have. It enables them to carry out most tillage work, formerly done by hand, with less fatigue and can be used by all the farming family.

Important progress can be made on small family farms, thanks to proper utilization of draft animals along with a flexible implement like the Kassine.

It has been introduced and tested in many countries in the South such as Algeria, Burkina Faso, Madagascar, Mali, Morocco, etc. In some countries like Burkina Faso, it is made locally by blacksmiths and is increasingly utilized and appreciated by small farmers, especially for its flexibility[6].

***Figure 5** – Tilling soil in Morocco*

6 Prommata International, URL: https://www.prommata-international.fr [09-03-2022].

The advantage of the implement is its being adapted to all kinds of animals (donkeys, horses, cattle) and is easy to use by all members of the farm family.

Designed to last for years, the Kassine is sufficiently robust to be pulled by powerful animals (such as a pair of oxen) for harder work. All draft animals can be hitched to it, providing the tools are adjusted to their draft power. A donkey alone can also do all the tasks involved in fieldwork, but the success and quality of work are linked to the choice of tool, appropriate adjustment of the handlebar and the notch bar, the pressure on the handlebar and good harness for the animal's comfort.

In the African Sudano-Sahel and Sahel regions, working animals are mainly zebus, donkeys and horses (particularly in Senegal). Purchasing a pair of cattle is an important investment and often out of reach for small farmers. Cattle also require more food than donkeys, which is a problem on small farms.

Farmers should choose the sex of their draft animals according to their objectives: female, male, gelded or ungelded. For cattle, oxen (castrated males) are often preferred, but using cows for light work has many advantages. For equids, especially donkeys, males are rarely gelded in Africa.

Cooperative partnership practices

Our partner blacksmiths in the South are trained to make the Kassine according to the precise specifications provided them.

Prommata International thus carries out know-how-sharing and training for partners so they can make the animal draft equipment locally that is aimed at farmers in these countries. Our training missions enable mechanic-solderers as well as future training staff to produce implements appropriate to their country's farmers.

Figure 6 *– Blacksmiths making a Kassine, Burkina*

Traceability and quality monitoring of Kassines made by the workshops are an essential aspect for success in promoting this tool-carrier.

Farmers and technicians in their organizations are trained to use this new material.

It is paramount to emphasize training the producers. With optimized use of animal draft thanks to an implement appropriate to users' needs, it is possible to reconcile increasing cultivated surfaces and decreasing working time.

Another important point is also improving animal harness and tillage equipment. The simple and inexpensive collar made by village craftsmen can replace the unwieldy breast-collar that is currently used.

Farmers, training agents in their organizations and agricultural technicians are also trained in agro-ecological practices founded on crop-livestock association, using animal draft as well as modern equipment appropriate to their needs, thus representing the following advantages:

- Reducing hardship involved in the manual work presently done (cropping activities, various transport tasks…)
- Speeding up some work such as sowing, weeding, ridging, transport, etc.
- Improving tillage practices (mechanized zaï, weeding, earthing up, etc.)
- Producing and using organic matter necessary to keep the soil fertile thanks to quality composts and manure

An example from Africa: "mechanized zaï" in Burkina Faso

The example of encouraging mechanized *zaï* using animal draft in Burkina Faso demonstrates the advantages of using the Kassine.

Traditional *zaï* is dibble tilling done by hand in Burkina Faso. This technique requires around 300 hours/hectare of work, that is, some 40 days of work during the hottest time of the year (at the end of the dry season)

Figure 7 *– The author trains the local population in the use of the equipment*

Equipping the animal-powered Kassine with a tine enables farmers to efficiently cross-mark the ground, a technique we call "mechanized *zaï*". When this is carried out on a larger surface, where power and endurance are required, the Kassine is only effective when pulled by a pair of donkeys.

This tillage method considerably improves much-needed water and soil conservation.

To conclude, several goals can be met using this modern tool-carrier, the Kassine:

- Firstly, improving working conditions of peasant farmers by replacing some manual work with draft animal power
- Further, enabling agro-ecological practices that improve soil life and structure to provide better harvests
- Finally, improving sustainability of agricultural production

This truly aims at improving working conditions, income and food security for peasant families.

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Author info
Philippe Lhoste

Association Prommata International (membre du conseil d'administration)
8, rue de la Source, 34830 Clapiers, France

E-Mail: lhosteph@orange.fr
Digital paper: https://youtu.be/DKylXR6WEnc

I would like to thank Cozette Griffin-Kremer very much for the English translation of this text and for her expert advice.

A homage to Jo Ballade

Philippe Lhoste

Georges Ballade, co-presenter at the Draft Animal Congress, known to many as Jo, passed away on the 8th of May 2022, surrounded by his family and following a long illness. In honor of his continuing work we want to share a Homage authored by his colleague and fellow co-presenter Philippe Lhoste:

Jo was a farmer and trainer in working with donkeys, the designer of the "Kassine" tool carrier together with the association Prommata. He was one of Jean Nolle's close friends when Prommata – the association "for the promotion of modern animal-drawn equipment" – was created at the end of the last century. Since that time, he worked very actively in promoting animal draft and in particular donkey draft in France and in developing countries. As President, he was especially dedicated to the Prommata International Association, which contributes to supporting and developing ecological, small-scale, and sustainable agriculture in the world, by encouraging small farmers to use draft animals equipped with suitable equipment (https://www.prommata-international.fr/).

Jo Ballade trained many young farmers in using donkey draft in France and in Africa (West Africa, North Africa, Madagascar), where he carried out numerous projects to assist farmers in working with adequate harnessing and blacksmiths in making the Kassine. Donkeys, in particular – the animals of the poorest farmers – were still too often used only for transport (packs and carts). In the countries concerned, Jo Ballade demonstrated, with conviction and competence, that donkeys, despite their modest size, could relieve peasant families of very tiring work, often carried out by women, in the fields; this is possible thanks to well-adapted equipment: the simple and versatile tool carrier called the Kassine. Jo was convinced that farmers could thus significantly improve their food production and living conditions.

A tireless promoter of the use of draft donkeys, the "Kassine" tool-carrier, and agro-ecological practices, Jo Ballade leaves behind many who are keen to follow in his footsteps; with his work, he enabled a large number of farmers and market gardeners to operate in a different way, by passing on the techniques and values of ecological, small-scale and sustainable agriculture.

We honor his memory and his commitment to the small farmers of the world, for whom he played an essential role in relieving them of exhausting manual labor.

A tool for the achievement of the Sustainable Development Goals set up by United Nations

Antonio Perrone

Abstract

In the rural villages of the developing world, several hundred million of working animals cooperate with farmers. When, instead of manual labor, the draft animal power is utilized by the farmers their productivity increases by three to five times. This makes it possible to get more food, more rural products to be sold on the market, and, on occasion, also more clean water. In several research centers, in Asia and in Europe, the generation of electric energy, through the rotary mode operation of an engine moved by a draft animal, has been successfully tested. If properly managed, this source of electric current can increase the light hours of the villages for schools and artisan shops, enhancing the education and the production of goods. The electricity can also contribute to easing the process of grain milling and lifting clean water.

Unfortunately, all these enormous benefits are either ignored or not properly considered by both the governmental and non-governmental organizations engaging in international cooperation.

The article emphasizes the necessity that an advocacy activity should be done to convince people of the need to support the draft animal power as a very efficient tool to stimulate development.

Résumé

Dans les villages ruraux du monde en développement, plusieurs centaines de millions d'animaux de trait coopèrent avec les agriculteurs. Lorsque les agriculteurs utilisent l'énergie des animaux de trait au lieu du travail manuel, leur productivité augmente de trois à cinq fois. Cela permet d'obtenir plus de nourriture, plus de produits agricoles à vendre sur le marché et, à l'occasion, plus d'eau potable. Dans plusieurs centres de recherche, en Asie et en Europe, la production d'énergie électrique, par le fonctionnement rotatif d'un moteur mû par un animal de trait, a été testée avec succès. Si elle est correctement gérée, cette source de courant électrique peut augmenter le temps d'éclairage des villages pour les écoles et les boutiques des artisans, améliorant ainsi l'éducation et la production de biens. L'électricité peut également contribuer à faciliter le processus de mouture des céréales et à fournir de l'eau potable.

Malheureusement, tous ces énormes avantages sont soit ignorés, soit mal pris en compte par les organisations gouvernementales et non gouvernementales engagées dans la coopération internationale.

L'article souligne la nécessité d'une activité de plaidoyer pour convaincre les gens de la nécessité de soutenir l'énergie animale comme un outil très efficace pour stimuler le développement.

Kurzfassung

In den ländlichen Dörfern der Schwellenländer arbeiten mehrere hundert Millionen Arbeitstiere mit den Bauern zusammen. Wenn die Landwirt:innen anstelle von Handarbeit die Kraft der Zugtiere nutzen, steigt ihre Produktivität um das Drei- bis Fünffache. Dadurch können mehr Nahrungsmittel, mehr landwirtschaftliche Erzeugnisse, die auf dem Markt verkauft werden können, und gelegentlich auch mehr Trinkwasser gewonnen werden. In mehreren Forschungszentren in Asien und Europa wurde die Erzeugung von elektrischer Energie durch den Rotationsbetrieb eines Motors, der von einem Zugtier angetrieben wird, erfolgreich getestet. Bei richtiger Handhabung kann diese Stromquelle die Beleuchtungsdauer von Schulen und Handwerksbetrieben in den Dörfern verlängern und so die Schulbildung und die Produktion von Waren fördern. Die Elektrizität kann auch dazu beitragen, den Prozess des Getreidemahlens und die Förderung von sauberem Wasser zu erleichtern.

Leider werden all diese enormen Vorteile von Regierungs- und Nichtregierungsorganisationen, die sich in der internationalen Zusammenarbeit engagieren, entweder ignoriert oder nicht richtig berücksichtigt.

Der Artikel unterstreicht die Notwendigkeit einer Lobbyarbeit, um die Menschen von der Notwendigkeit zu überzeugen, die Zugtierkraft als ein sehr effizientes Instrument zur Förderung der Entwicklung zu begreifen.

Resumen

En las zonas rurales de los países en vías de desarrollo, varios cientos de millones de animales participan en numerosas actividades laborales con los agricultores. Cuando, en lugar del trabajo manual, los agricultores utilizan la fuerza de los animales de tiro, su productividad aumenta entre tres y cinco veces. Esto permite obtener más alimentos y productos agricolas para vender en el mercado y, en ocasiones, hasta más agua limpia. En varios centros de investigación de Asia y Europa, se ha probado con éxito la generación de energía eléctrica mediante el funcionamiento de un motor en rotación movido por un animal de tiro. Si se gestionara adecuadamente, esta fuente de corriente eléctrica podría aumentar las horas de luz eléctrica en los pueblos para las escuelas y los comercios artesanales, potenciando así la educación y la producción de bienes. La electricidad además contribuiría a facilitar la molienda de grano y aumentaría en nivel de agua potable.

Desgraciadamente, todos estos enormes beneficios son ignorados o no se tienen debidamente en cuenta tanto por las organizaciones gubernamentales como por las no gubernamentales que participan en la cooperación internacional.

El artículo subraya la necesidad de realizar una actividad de promoción para convencer a la población de la necesidad de apoyar la energía/el trabajo de los animales de tiro como una herramienta muy eficaz para estimular el desarrollo.

Introduction

In the world, at least two hundred million animals support farmers in their everyday works[1].

The use of the draft animals increases the productivity of people engaging in agriculture by three to five times.

Several studies in Asia and in Europe have demonstrated the viability of the use of the draft animal power not only for transport and soil cultivation but also for the generation of the electric current. These studies are confirmed by various websites, patents and scientific papers[2].

Substantially the difficulties to multiply the slow gait of the draft animal, walking on the round path, in a sufficient number of rounds per minute, requested for the electric generation, seem to be solved[3].

These new acquisitions have widened the role of the draft animal power and have shown the capacity of this source of energy to support the achievement of the Sustainable Development Goals Goals as defined by the United Nations.

Figure 1 *– Cape Buffalo, Syncerus caffer species, it does not belong to the Bubalus species, but is called African buffalo, wild and aggressive, in a rare attempt at domestication by towing a wagon with a sturdy yoke*

Draft animal power and the Sustainable Development Goals set out by the United Nations

Some considerations on how the draft animal power can match the need of the people engaged in the pursuit of the Sustainable Development Goals are here exposed[4].

About the 'No poverty'-Goal we can say that the increase of productivity, due to the employment of the draft animal power, means more rural products, more grains and more fruits to put on the market. New forms of electricity generation could increase the availability of light hours in the workshops and then could increase the productivity of the artisans.

About the 'Zero Hunger'-Goal it is possible to say that, in the same way, the increase of productivity means more rural products and thus more food for local consumption and distribution.

About the 'Good Health and Wellbeing'-Goal – among many other examples – it is useful to remember that the application of certain hand equipment, such as the grain milling stones, frequently wounds the fingers of the farmers, almost always women, procuring them septicemia and at times, as a consequence, the death. This hand equipment could be substituted by draft animal powered equipment.

Furthermore, light hours due to the electric generation means more light hours in dispensaries and infirmaries and more electricity means better communication for possible telemedicine.

About the 'Quality Education'-Goal it is possible to say that a new form of electricity generation could increase the availability of light hours for classrooms and the households of students, hence increasing the possible study hours.

About the 'Gender Equality'-Goal we can say that the draft animals and the pack animals can move drinking water and fire wood saving a lot of work generally done, by walk, by women and children.

The lifting of the water from wells or river up to a piezometric tower could ease the distribution of the water in the villages. This will allow one or more water taps in every single house in the village, allowing access to clean water and better sanitation.

About the 'Affordable and Clean'-Energy goal, we can say that one of the most utilized lighting systems in households of remote villages is the kerosene lamps. Kerosene is a great pollutant. A few minutes of an animal walking on a round path can generate – through a dynamo or an alternator – sufficient electricity to charge batteries to light various lamps for several hours for multiple days.

Regarding the 'Climate Action'-Goal, it has been observed that the eventual substitution of animal work with engines would increase the presence of fossil CO_2 in the atmosphere and the consumption of fossil fuel in the dimension of a rough 5-6 per thousand[5].

While a significant consideration is that the energy developed by the working animals has a weight of 1.4 % with respect to all the renewable energies produced in the world.

The draft animal power and the cooperation to development

All the realities above described, even if well-known, have never exceeded the point of inertia because they have always been underestimated by the companies engaged in social responsibilities initiatives, by the charities and also by the people engaged in the international cooperation to development.

Several perplexities have also been expressed by some exponents of the Global South because they believe that supporting animal traction is condemning their countries to backwardness. But this is not true because by increasing the productivity of farmers, a state of well-being can be achieved even faster.

1 Perrone 2014, 1-6.
2 Lhoste et al. 2010; Fuller/Aye 2012, 326-332; Kienzle et al. 2013.
3 Chandraker et al. 2014; Jakhar et al. 2017.
4 United Nations, URL: https://sdgs.un.org/goals [14-12-21].
5 Perrone 2014, 1-6.

Figure 2 *– Costa Rica 2018*

The mentioned prejudices can be removed with the following considerations.

To generate a kilowatt hour of electricity, with a small generator, at least one liter of fuel is required and this has a cost of around one Euro. This means that in an isolated village it would take about four hundred euros a year to have one kilowatt hour of energy per day. This is an incredible figure for villages in countries where the average per capita income is around five or six hundred Euros a year.

By contrast, the working animals are present in rural villages in any case and their cost is already amortized by their use for transport and plowing. These processes involve the animals for no more than 120, 140 days per year. Considering this, there is a great deal of their unused time available for a possible electric generation process.

Working animals generally feed on poor pastures that are not otherwise usable for agriculture, so their nutrition is not a competitor of human nutrition but is synergistic with it.

As demonstrated, by several prototypes already made, it is now possible to replace mechanical devices operated by animal traction with electromechanical devices, however, operated by animal traction, but simpler and more efficient.

This allows to exploit deeper aquifers and therefore, more numerous than those currently used, and also enables access to water that is not polluted by trampling and animal waste.

Moreover, water pumped from deeper aquifers is less brackish, because it is not evaporated.

Making wells in tubular form eliminates the danger of collapsing walls and then the, now frequent, closing of the well.

Using the improved equipment moved by draft animal power to raise the water, costs several times less than the use of photovoltaic energy pumps or pumps driven by internal combustion engines.

Another positive note is that with draft animal power most of the expenses will be in local currency.

To raise the water with piezometric towers allows the creation of a village water network.

The grinding of grains and oilseeds with less dangerous equipment is another advantage of the system.

The potential of improved equipment must be commensurate with the number of isolated villages with predominantly rural economies and the number of working animals present in these villages. As stated before, we are talking about hundreds of millions of animals currently used in transport and tillage.

An advocacy activity

Draft animals are buffaloes, donkeys, horses, mules, yaks, camels, dromedaries, oxen, and zebus. The rural work is seasonal and then it is possible to consider that the animals are engaged approximately only 120 days per year for an average time of five hours. Michael R. Goe and Robert E. McDowell in the publication “Animal traction Guidelines for Utilization” in Table 16, propose the following data, evaluated for light and heavy animals: horses from 0.6 (light) to 1.3 Hp (heavy), mules from 0.3 to 0.9 Hp, asses from 0.3 to 0.4 Hp, ox from 0.3 to 1.3 Hp, cow from 0.2 to 0.6 Hp, buffalo from 0.5 to 1.1 Hp, camels from 0.5 to 0.9 Hp.

All the above consideration should convince that an advocacy activity should be started in several directions in order to divulgate the potential of the draft animal power for the development of the remote villages of the developing countries.

Figure 3 – Costa Rica 2018

Target of these advocacy campaigns should be, as above said, charities, companies engaged in social responsibility initiatives and NGOs engaged in the field of the cooperation to the development.

Draft animal power and educational farms

A study is in progress addressing the use of the animal power, in the information processes, in the educational farms.

The proposed project involves the creation and diffusion of training modules to be allocated to the said kind of farms.

The modules will be used to implement procedures (i) of environmental education, (ii) of creating awareness in the fields of energy and climate change, (iii) of diffusing knowledge on issues related to cooperation with the Global South.

The idea is inspired by some activities already carried out in various rural areas in France and the United

Figure 4 – Costa Rica 2018

States (Tillers International and Prommata) and in some research centers in India and South Africa.

The training modules will be carried out according to a linear path that shows the energy cycle through the following stages: solar radiation, chlorophyll photosynthesis, the creation of the vegetable mass, the cultivation of animal feed, the development of the muscular energy of the animals fed by fodder, the animal traction, the use of animal traction also for the generation of electric current and finally, the transformation of the electricity generated by the muscular energy of the animals into mechanical energy for lifting water and grinding grains.

The young people who attend the educational farms, where these training modules are introduced, will thus be able to understand, with easy examples, why almost all the energy used by a person, even fossil energy, derives from solar radiation. Young people will be given the opportunity to understand how the simple movement of a dynamo is able to produce electric current. This will happen thanks to the device moved by animal traction and everything will take place with the same ease and attractiveness of a real equestrian show, but realized with the utmost respect for animal welfare.

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Author info
Antonio Perrone

74023 Grottaglie TA, Italy
+39 3496934669

E-Mail: aperrone@wedap.eu
Web: www.masseriacoppola.it
Digital paper: https://youtu.be/mSgE1aQk-2Y

Sterling College degree program “Sustainable Agriculture and Draft Animal Power Systems”

Rick Thomas

Abstract

Agriculture education programming in higher education systems within the United States is functionally void of draft animal powered systems curriculum. Interested students seeking such knowledge are limited to an increasingly shrinking weekend workshop type experience or are lucky enough to be accepted into various short-long range apprenticeships at living history museums. Sterling College, Craftsbury, VT, has maintained a central focus on draft animal powered curriculum since its inception and continues to offer a two-year concentrated program of study leading to a minor in draft animal powered systems. In 2019, the College’s programming expanded into Kentucky and formed a partnership with The Berry Center in Henry County, KY; this two-year degree completion format has allowed the expansion of the draft animal powered systems minor as the program scales out its reach. One important feature of the programming is the incorporation of horses, mules, and draft cattle allowing students the opportunity to experience and compare multiple systems side-by-side. The curriculum balances background theory with authentic work experiences as students gain valuable hands-on training in aspects of draft animal powered farm planning, animal husbandry, draft animal powered farming and forestry systems, and the economics (both financial and social) of incorporating draft animals into one’s enterprise.

Résumé

La programmation de l'enseignement agricole dans les systèmes d'enseignement supérieur aux États-Unis est fonctionnellement dépourvue de programmes sur les systèmes de traction animale. Les étudiants intéressés qui cherchent à acquérir de telles connaissances sont limités à une expérience de type atelier de week-end de plus en plus réduite ou ont la chance d'être acceptés dans divers stages de courte ou longue durée dans des musées d'histoire vivante. Le Sterling College, Craftsbury, VT, a maintenu un accent central sur les études des systèmes de traction animale depuis sa création et continue à offrir un programme d'études concentré de deux ans menant à une spécialisation en systèmes de traction animale. En 2019, la programmation du collège s'est étendue au Kentucky et a formé un partenariat avec le Berry Center dans le comté de Henry, KY ; ce format d'obtention de diplôme en deux ans a permis l'expansion progressive de cette spécialisation sur les animaux de trait à . Une caractéristique importante du programme est l'incorporation de chevaux, de mules et de bovins de trait, ce qui permet aux étudiants d'expérimenter et de comparer plusieurs systèmes côte à côte. Le programme équilibre la théorie de base avec des expériences de travail authentiques, les étudiants acquérant une formation pratique précieuse sur la planification d'une exploitation agricole utilisant des animaux de trait, l'élevage, les systèmes agricoles et forestiers en traction animale, et l'économie (financière et sociale) de l'intégration des animaux de trait dans une entreprise.

Kurzfassung

Die Lehrpläne für die landwirtschaftliche Ausbildung an den Hochschulen in den Vereinigten Staaten enthalten praktisch keine Lehrinhalte über Zugtiersysteme. Interessierte Studierende, die solche Kenntnisse erwerben wollen, müssen sich auf eine immer kleiner werdende Zahl von Wochenend-Workshops beschränken oder haben das Glück, in verschiedenen kurz- und langfristigen Lehrgängen in Living History Museen aufgenommen zu werden. Das Sterling College in Craftsbury, VT, hat seit seiner Gründung einen Schwerpunkt auf den Unterricht in der Zugtierhaltung gelegt und bietet daneben ein zweijähriges konzentriertes Studienprogramm an, das zu einem Abschluss in der Zugtierhaltung führt. Im Jahr 2019 wurde das Programm des Colleges auf Kentucky ausgeweitet und eine Partnerschaft mit dem Berry Center in Henry County, Kentucky, geschlossen. Dieses zweijährige Studienformat hat die Ausweitung des Nebenfachs für Zugtiersysteme ermöglicht, da das Programm seine Reichweite vergrößert. Ein wichtiges Merkmal des Studiums ist die Einbeziehung von Pferden, Maultieren und Zugrindern, die den Studierenden die Möglichkeit geben, mehrere Konzepte Seite an Seite zu erleben und zu vergleichen. Der Lehrplan bietet ein ausgewogenes Verhältnis zwischen theoretischem Hintergrundwissen und authentischen Arbeitserfahrungen, wobei die Studierenden eine wertvolle praktische Ausbildung in Aspekten der Planung von landwirtschaftlichen Betrieben mit Zugtieren, der Tierhaltung, land- und forstwirtschaftlichen Anwendungen von Zugtieren und hinsichtlich der wirtschaftlichen (sowohl finanziellen als auch sozialen) Aspekte der Integration von Zugtieren in den eigenen Betrieb erhalten.

Resumen

El currículo de los estudios agrícolas los sistemas de enseñanza superior de Estados Unidos carece funcionalmente de planes de estudio sobre sistemas de tracción animal. Los cursos dedicados a estos temas y ofrecidos a los estudiantes se limitan por ejemplo a taller de fin de semana o cursos de corta y larga duración en museos vivos de historia. El Sterling College, en Craftsbury, VT, la tracción animal se ha ha mantenido como tema central en su plan de estudios desde su creación y sigue ofreciendo un programa de estudio concentrado de dos años que conduce a una especialización en sistemas de tracción animal. En 2019, los programas de la universidad se expandieron a Kentucky, formando una asociación con The Berry Center en el condado de Henry, KY. Este formato de finalización de grado de dos años ha permitido la expansión de los sistemas menores de tracción animal. Una característica importante del programa es la incorporación de caballos, mulas y ganado de tiro, lo que permite a los estudiantes la oportunidad de experimentar y comparar múltiples sistemas simultaneamente. El plan de estudios equilibra la teoría de fondo con experiencias de trabajo auténticas, ya que los estudiantes adquieren una valiosa formación práctica en la planificación de las explotaciones agrícolas con animales de tiro, la cría de animales, los sistemas agrícolas y forestales y prácticas en economía tanto social como empresarial.

Sterling College embraces the attributes that make it unique – small enrollment, rural location, field programs, and real work – and welcomes students to campus under a creative, multifaceted plan that values both the health and welfare of its students and the integrity and quality of the Sterling experience.

The “Sustainable Agriculture and Food Systems degree coupled with Draft Animal Power Systems minor” program is designed to introduce students to cattle, horses and mules in work environments. We start off with a breadth class that is focused strictly on driving principles.

Figure 1 *– Teaching teamster Rick Thomas of the Wendell Berry Farming Program in Port Royal, KY, USA with American Milking Devon calves Dan and Jessie; the pair will be used to teach students draft cattle management and usage on the farm and woodlands*

I'm currently located at our satellite campus in Henry County, Kentucky, where we are part of the Wendell Berry Farming Program. Here our stable consists of a team of mules, a workhorse, a team of oxen and a pair of working steers, so during that first course students are introduced to the driving principles associated with working cattle, working mules, working teams, working singles, working three abreast – all the different configurations that are going to be useful as we progress through our curriculum. I also enjoy having young animals in the stable, so that students can experience training and training systems.

Once that good foundation is built, we put students into context. Something I call "teaching in context" or using meaningful work to guide our curriculum and so during their second semester we'll begin to work in the forest, we'll begin to work in the fields, perhaps mowing and picking up hay and we'll work in the gardens.

As we progress into our third semester their skill set has improved to where they can do more difficult manoeuvres, more difficult tactics are needed so, for instance, we might be on a logging job, where the ground is very steep and so we need to introduce steep terrain logging strategies, as an example. We are very interested in applying as much non-chemical, no-till cultivation practices as possible in a market garden setting and so we are constantly trying to problem solve different ways that we can use our draft animals to maintain the soil health in our garden environment.

As we're out in the field, mowing hay or clipping pastures, being able to troubleshoot a faulty mowing machine is something that comes to mind as an advanced technique that these students need to master, if they're going to get involved in draft animal farming. These three classes are progressive in nature, they build upon skill sets, so that students are allowed to work through the program at their own pace, even though we move together as a group each student brings their own skill set and their own rate of learning and so being a small group and being involved in the type of education that Sterling is known for, which is very hands-on, very experiential – we can make those changes, so that those students can continue to move forward at a pace that's comfortable for themselves.

The driving principles class and the applied power systems classes are core, but happening around the edges of those three courses, are more specific classes in things like restorative forestry, crop production systems, holistic livestock husbandry, soil science – so this larger educational platform is happening around this core of power, which from my perspective is this amazing opportunity for them to really explore draft animals as a key component to modern farming and forestry systems.

Figure 2 *– Molly and Mindy, Belgian mules, guide students as they acquire the skills necessary to manage woodlands with draft animals*

Once students graduate, they find work as farriers. I'm a trained farrier and so I teach a farrier science class, so several students have gone on to pursue advanced work in farrier science and are now working as farriers. We have cattle hoof trimmers, we certainly have students who have graduated from the program who are working in the forest industry, we have farmers and we have many students who are employed at living history museums now.

I ask a question to the students at the beginning of the first semester, which goes something like:

"What is the role of draft animals in 21st century farming or forestry?" – something like that and they answer it from a position of newness – they don't have a lot of experience and so there's a lot of romance that comes into that essay at that time. I ask that very same question at the end of the two-year program and the answers are very refined, some of them look at draft animals and simply cannot imagine employing them on their farm, others look at draft animals and can't imagine not having them on their farm. So that is one of my favorite assignments, to be able to watch the progression of thought through the students’ mind as they've gained some experience. They've spent some time with these animals, they've learned what they can do and they've learned what they can't do and it all comes back around to this notion of scale I think that's something that we talk a lot about here in our classes.

Figure 3 *– Henry and Zeke, Brown Swiss steers, are being re-schooled into working cattle; training a community of teamsters is one of the primary goals of the Wendell Berry Farming Program, utilizing young stock creates a perfect learning environment*

When I'm talking about scale with students and this whole notion of right-sizing a farm, so that draft animals can work both efficiently and profitably, I can't help but talk about the notion of pace and what it is like working at a human pace.

Starting a farming career which is actually what many of our students are doing – they have no background in farming, they're new to every aspect, they may have grown a kitchen garden, they've not done anything at scale, or not done much at scale, they've not done too much with forestry and so this is all very early career. The whole notion of pace is something that they don't have a lot of experience with yet. I find that working with draft animals puts a constraint, a welcomed constraint, on how much work we can do in a day. It is those limits that I enjoy exploring in our discussions. Are those limits bad? What does an agricultural system or a forestry system without limits look like? Well, that's not hard to investigate since it's our current system here in the United States.

Currently, I’m teaching in Kentucky (USA) as part of the Wendell Berry Farming Program of Sterling College. Here, the Wendell Berry Farming Program of Sterling College offers a tuition-free junior and senior year farming curriculum focused on ecological management of livestock, pasture, and forestry using draft animals and other appropriately scaled mixed power systems. Inspired by the lifework of farmer and writer Wendell Berry, and designed in partnership with The Berry Center, in New Castle, Kentucky, the program serves undergraduate students from Kentucky and elsewhere who intend to farm. The curriculum is focused on the survival of small and mid-scale farms. We study how to be profitable within ecological bounds. We work to cultivate a culture that supports farming that is inclusive, equitable, parity-based, and resilient. Our goal is unique in agricultural education: to interweave a hands-on, liberal arts, farming curriculum with a diversified mid-scale livestock farm using appropriately scaled mixed power systems (i.e., draft and combustion power). Our approach to farming is modestly scaled, humble, and attuned to rural places. The land is ideally suited for grass farming and a diversity of livestock: beef cattle, sheep, draft animals, and pastured poultry, a combination that provides the most potential for farm income. The farm has 50 acres of woodland that benefit from a “worst-first” management plan, which will improve the health of the woods while providing lumber, a small income, and a classroom. The use of draft animals provides a low-cost source of power. The work of mules, oxen, and horses is combined with other forms of appropriately scaled combustion technology. The WBFP uses grass, livestock, and forest like three legs of a stool in a model that is biologically based and economically viable.

Something that strikes me every year, when we take a person who has no experience working in the forest, for instance, and we take in simple tools such as an axe and a cross-cut saw and a team of oxen and we then fell some trees – we do things with that wood, we work with those primary resources, we take those primary resources and we turn them into objects that we then use to make other things with. The process of creating and being able to think and hear one another work, the conversation that happens, the team, the sounds of the team, the yoke creaking, the chains dragging the saw – it's a

Figure 4 *– Part of our woodland management strategy is to utilize all the products we harvest; here, low grade red oak is being fashioned using simple hand tools into useful tools such as these shaving horses which will then be utilized to teach green woodworking*

harmony, it's a chorus of peacefulness in my mind that is something that I can't attain when I'm running powered machinery. Something that strikes me every single time is how students are able to hear the birds. They're able to observe nature. As we become more estranged from the natural world, it's these experiences which I think students are really, really hungry for and why a place like Sterling College is so important right now, a place where these ideas and these techniques and tactics are actually practiced and taken seriously!

Along with the mechanics of driving and learning how to work in the woods or work in the fields or in the garden in terms of machinery, hooking up to equipment, that sort of thing – it's something that's always going on is the husbandry side of our curriculum which is learning how to select stock, learning how to go to an auction and choose an animal that is sound. The husbandry skills associated with the stable management, the veterinary care that we can perform ourselves, all of that is a package that's happening around the ‘higher glamour’ of harnessing and

going into the woods and extracting logs. Well, there was a lot of work that had to be done to that horse before he was ready to go into that work – so understanding nutrition, understanding animal care, diagnosing issues with your animal around, uncomfortable yoke fit or a bow bunch that's beginning to develop, being able to observe your animals and know them so well that you can tell just simply by the way they came into the barn that they're not quite right today. This is the kind of work that students really latch on to, they enjoy going to the woods and felling trees and extracting them, but I find they also really enjoy the care of the animals. We speak about the word 'dignity' in at our stable. We talk about dignity for all who come within and it's this notion that our animals are our working partners, that they are important to us and if something is important to you, you want to spend time with it and if you spend time with something – well, you begin to show affection to it and I think understanding that these animals are working and they are working partners is one thing but, on the other hand, being able to have some compassion towards your animal, being able to understand that your animal has good days and bad days – these are all very important skills!

I think something I've seen over the last now 23 years has been this: The fact that the experiences that students have while they're in this program are truly transformative. They may never experience draft animals again in their lives and most won't, but during their time here, their identity was completely intertwined with the barn, they were completely aware that they had a badge that they wore that said: "I am a draft animal person, I smell like cattle. I have horse hair all over my body in the spring." It's important for young people to develop an identity and to experience something that's bigger than themselves and I have just stood back and watched people mature in front of my eyes as a function of working with these draft animals here at the college.

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Author info
Rick Thomas

Faculty in Sustainable Agriculture and Food Systems, Sterling College
Currently teaching at The Wendell Berry Farming Program in New Castle, KY
Systems: Teaching Teamster, Farrier, and Woodsman

E-Mail: rthomas@sterlingcollege.edu
Web: sterlingcollege.edu
Digital paper: https://youtu.be/zxItJ8f0Iss

Refining Animal Traction: Linking Physical and Social Processes

Timothy Harrigan

Abstract

Draft animals provide tractive power to till the soil, transport firewood and water, and move crops from field to market. They provide meat, hides, and other byproducts for household use and income on about 250 million ha of land in developing countries worldwide. In Burkina Faso in West Africa, farmers with access to oxen are 'privileged' farmers, and the 70 % using only hand tools aspire to access draft animals. Few farmers can use wheeled tractors profitably because farms are small, farmland for expansion is scarce, and farm labor is plentiful. Animal traction makes full use of locally available resources, enhancing their efficiency and the resilience of the farming system. In our work there improving conservation tillage tools, rather than importing expensive technologies, we worked alongside local artisans to enhance their knowledge, skills, and abilities to build and repair the equipment using locally available materials.

Because of growing interest in soil health, local foods, climate-smart agriculture, and ecologically sound farm management, animal traction is regaining popularity in the U.S.A. For many draft animal practitioners, draft animals have social and cultural significance and embody a sense of community. The skilled application of animal power brings responsive and appropriate scale technology to demanding tasks such as tillage, planting, weeding, logging, and transportation. Most farms use mixed-power sources, animal traction in fields and forests, and motorized power for material handling. A cross-cutting theme is that practitioners' lifestyles converge around lower material consumption and a desire for a higher personal level of global well-being.

Kurzfassung

Zugtiere liefern die notwendige Zugkraft, um den Boden zu bestellen, Brennholz und Wasser zu transportieren und die Ernte vom Feld zum Markt zu bringen. Sie liefern Fleisch, Häute und andere Nebenprodukte für den Hausgebrauch sowie das Einkommen auf etwa 250 Millionen Hektar Land in Schwellenländern weltweit. In Burkina Faso in Westafrika sind Landwirt:innen, die Zugang zu Ochsen haben, "privilegierte" Landwirt:innen, und die 70 %, die nur mit Handwerkzeugen arbeiten, streben den Zugang zu Zugtieren an. Nur wenige Landwirt:innen können Traktoren auf Rädern gewinnbringend einsetzen, weil die Betriebe klein sind, die Anbauflächen knapp und die Arbeitskräfte reichlich vorhanden sind. Durch den Einsatz von Zugtieren können die lokal verfügbaren Ressourcen voll genutzt werden, was ihre Effizienz und die Widerstandsfähigkeit des landwirtschaftlichen Systems erhöht. Bei der Verbesserung von Werkzeugen für die konservierende Bodenbearbeitung arbeiteten wir nicht mit dem Import teurer Technologien, sondern mit einheimischen Handwerker:innen zusammen, um deren Kenntnisse, Fähigkeiten und Fertigkeiten beim Bau und bei der Reparatur der Geräte mit lokal verfügbaren Materialien zu verbessern.

Aufgrund des wachsenden Interesses an der Bodengesundheit, an lokalen Lebensmitteln, an einer klimafreundlichen Landwirtschaft und an einer ökologisch sinnvollen Bewirtschaftung von landwirtschaftlichen Betrieben gewinnt die Zugtierhaltung in den USA wieder an Popularität. Für viele Zugtierhalter:innen haben ihre Tiere eine soziale und kulturelle Bedeutung und verkörpern einen Sinn für Gemeinschaft. Der geschickte Einsatz von Tierkraft ermöglicht es, anspruchsvolle Aufgaben wie Bodenbearbeitung, Aussaat, Unkrautbekämpfung, Holzeinschlag und Transport in angemessenem Umfang zu bewältigen. Die meisten landwirtschaftlichen Betriebe nutzen eine Mischung aus tierischer Zugkraft auf den Feldern und in den Wäldern und motorisierter Energie für den Materialtransport. Ein übergreifendes Thema ist, dass sich die Lebensstile der Anwender:innen auf einen geringeren Materialverbrauch und den Wunsch nach einem höheren persönlichen Niveau des globalen Wohlbefindens richten.

Résumé

Les animaux de trait fournissent la force de traction nécessaire pour labourer le sol, transporter le bois de chauffage et l'eau et acheminer les cultures du champ au marché. Ils fournissent de la viande, des peaux et d'autres sous-produits pour l'usage domestique et les revenus sur environ 250 millions d'hectares de terres dans les pays en développement du monde entier. Au Burkina Faso, en Afrique de l'Ouest, les agriculteurs qui ont accès à des bœufs sont des agriculteurs "privilégiés", et les 70 % qui n'utilisent que des outils manuels aspirent à avoir accès à des animaux de trait. Peu d'agriculteurs peuvent utiliser des tracteurs à roues de manière rentable, car les exploitations sont petites, les terres agricoles disponibles pour s'étendre sont rares et la main-d'œuvre agricole est abondante. La traction animale permet d'utiliser pleinement les ressources disponibles localement, améliorant ainsi leur efficacité et la résilience du système agricole. Dans notre travail d'amélioration des outils de labour de conservation du sol, plutôt que d'importer des technologies coûteuses, nous avons travaillé aux côtés d'artisans locaux pour améliorer leurs connaissances, leurs compétences et leurs capacités à construire et réparer l'équipement en utilisant des matériaux disponibles localement.

En raison de l'intérêt croissant pour la santé des sols, les aliments locaux, l'agriculture intelligente face au climat et la gestion agroécologique des fermes, la traction animale regagne en popularité aux États-Unis. Pour de nombreux praticiens, les animaux de trait ont une signification sociale et culturelle et incarnent un sens de la communauté. L'utilisation habile de la traction animale apporte une technologie réactive et à échelle appropriée pour des tâches exigeantes telles que le travail du sol, la plantation, le désherbage, l'abattage et le transport. La plupart des exploitations utilisent des sources d'énergie mixtes, la traction animale dans les champs et les forêts, et la motorisation pour la manutention. Un thème transversal est que les modes de vie des praticiens convergent vers une consommation matérielle moindre et un désir personnel d'un niveau plus élevé de bien-être global.

Resumen

Los animales de tiro proporcionan fuerza de tracción para labrar la tierra, transportar leña, agua y trasladar los cultivos del campo al mercado. Además proporcionan carne, pieles y otros subproductos para uso doméstico e ingresos en unos 250 millones de hectáreas de tierra en los países en desarrollo de todo el mundo. En Burkina Faso, en África Occidental, los agricultores que tienen acceso a los bueyes son agricultores "privilegiados", y el 70% que sólo utiliza herramientas manuales aspira a acceder a los animales de tiro. Pocos agricultores pueden utilizar tractores de ruedas de forma rentable porque las explotaciones son pequeñas, las tierras de cultivo para su expansión son escasas y la mano de obra agrícola es abundante. La tracción animal podría aprovechar al máximo los recursos disponibles localmente, mejorando su eficiencia y la resistencia del sistema agrícola. En nuestro trabajo en Burkina Faso trabajamos junto a los artesanos locales para mejorar las herramientas de labranza de conservación, en lugar de importar tecnologías costosas, a la vez favoreciendo la expansión de conocimientos, habilidades y destrezas de los artesanos en otros ambitos para construir y reparar el equipo utilizando materiales disponibles localmente.

Debido al creciente interés tanto por la salud del suelo como por la agricultura y la gestión ecológica de las explotaciones, la tracción animal está recuperando su popularidad en Estados Unidos. Para muchos profesionales de la tracción animal, los animales de tiro tienen un significado sociocultural y encarnan un sentido de comunidad. La aplicación hábil de la tracción animal aporta una tecnología sensible y de escala adecuada a tareas exigentes como la labranza, la siembra, la escarda, la tala y el transporte. La mayoría de las explotaciones agrícolas utilizan fuentes de energía mixtas, tracción animal en los campos y los bosques, y energía motorizada para la manipulación de materiales. Un tema transversal es que los estilos de vida de los practicantes convergen en torno a un menor consumo de materiales y un deseo de un mayor nivel personal de bienestar global.

Introduction

The inspiration for this paper was the interaction with attendees at the international conference, *the Global Draft animal Conference "Draft Animals in the Past, Present and Future",* held in May 2021 regarding the relevance and utility of animal traction. In the first part of the paper, I will share recent experience and observations in developing appropriate scale mechanization for animal traction for smallholder farmers in the West African nation of Burkina Faso. Here, animal traction is a luxury for those with access but remains an aspiration and is out of reach for most farmers. The second part of the paper focuses on draft animal use in the U.S.A. Tractorization has made draft animals nearly obsolete in the U.S.A. However, animal power is still an appropriate technology for many small-scale farmers. Five animal traction practitioners will explain why that is the case.

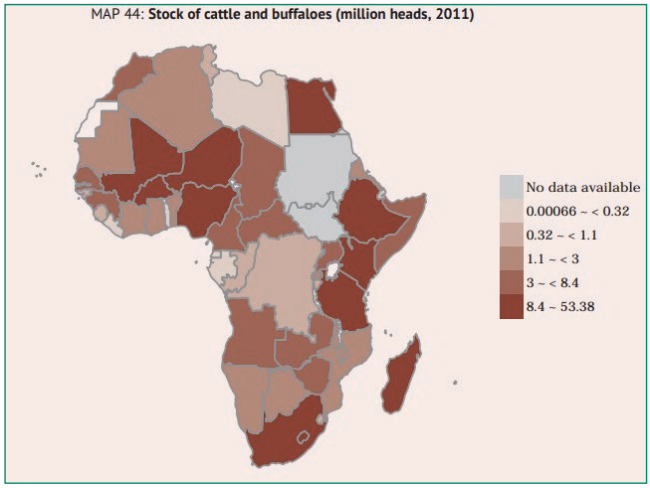

Figure 1 *– Distribution of cattle and buffalo in Africa in 2011*

Appropriate scale technology

Appropriate scale technology is the best fit or match-up between technology and the context of its use. Appropriate scale mechanization is technically, environmentally, economically, socially, and culturally correct for smallholder farmers. Worldwide, smallholder farmers strive to be financially sustainable and seek affordable technologies compatible with their economic and natural resource base. Animal power is relevant for many smallholder farmers because modern machinery is often inaccessible or unaffordable.

Draft animals provide tractive power to till the soil, transport firewood and water, and move crops from field to market. At the end of their lives, they provide meat, hides, and other byproducts for household use and income on about 250 million ha of land in developing countries worldwide. Hand labor is employed on about 125 million ha, while mechanized tractive power units cover nearly 104 million ha[1]. CIRAD[2] cites Jahnke[3], reporting about 170 million draft animals in Africa. About 86 % were cattle, along with donkeys, horses, mules, and camels. Figure one illustrates the stock of cattle and buffaloes.

1 L''Energie Cheval 2022.
2 CIRAD 1996.
3 Jahnke 1984.

Case study — Improving tools for animal traction in Burkina Faso

Figure 2 *– Young Burkinabé woman planting maize by hand with a 'daba'*

Our recent work in Burkina Faso, a small, landlocked country in West Africa, is an excellent example of where animal traction is the most appropriate technology. Ninety-two percent of the population of Burkina Faso is involved in agricultural pursuits[4]. Smallholder farmers typically work less than 3.5 hectares of land, mid-size farms are about 7 hectares, and large farms are 10 hectares. Forty-five percent of the farms have an income of less than $3 per day. Nearly the entire rural population relies on subsistence farming and lives in poverty.

Agricultural production is labor-intensive. Because the farms are small and farm income is low, animal traction and hand labor are widespread. Seventy percent of farmers do all fieldwork with hand tools. Nearly 29 % of smallholder farmers use oxen for tillage, yet planting and weeding are by hand. Farmers with access to oxen are 'privileged', and those using hand tools aspire to own or use draft animals. Animal traction is a significant technological advance for farmers accustomed to working solely with hand tools.

In the 1980s, Stuart Hill suggested three critical phases in the transition to sustainable agriculture 1) ef-

4 Beal et al. 2015.

ficiency, 2) substitution, and 3) redesign[5]. Efficiency is in targeted placement and tighter control of fertilizer and crop inputs to improve crop response. Substitution replaces existing technologies with more effective ones such as improved crop varieties or no-till cropping rather than inversion tillage. A redesign aims to deliver "*the optimum amount of ecosystem services to aid production while ensuring that agricultural production processes improve the ecosystem they depend on.*" A redesign can strengthen the agroecosystem by adding regenerative components.

Figure 3 *– Interaction and collaboration with local farmers is essential in understanding opportunities to redesign local farming systems*

Sustainable agriculture is not a specific technology; it is fundamentally a process of observing, learning, experimentation, and innovation. The redesign process develops social and human capital in deploying knowledge and the capacity for innovation to tackle landscape-scale problems. Interaction with local farmers and community members is essential in understanding opportunities to redesign local farming systems. Shared goals, values, and collaboration are critical in the redesign process. Farmers will fail to adopt even technically efficient and well-designed tools and implements if they are a poor match to local conditions[6].

At the outset of our work, we engaged farmers and other interested stakeholders in group settings to help us understand their resource constraints, needs, challenges, and opportunities. We challenged them with open-ended questions such as:

1) What is the local vision of smallholder farming systems that integrates all aspects of sustainability?
2) What forces (physical, biological, cultural, etc.) diminish the sustainability of local farming systems, and how can we offset them?
3) Which aspects of the local farming systems are most important to retain if the overall objective is a sustainable balance of environmental, economic, and social issues?
4) How can animal traction benefit local farming systems and balance sustainability and social and gender equity?

The farm community's highest priorities for innovation were improved tools and implements for alleviating the physical and time burden of 1) land preparation, 2) planting, and 3) weed control.

Appropriate scale technologies must be accessible to smallholder farmers. Mechanization and mechanical skills are insufficient at the farm and village levels. The supply chain and infrastructure for timely access to replacement parts, services, and repairs for imported equipment is generally nonexistent. There is a need to develop the mechanical skills of farmers and local artisans to efficiently use animal power. Worldwide, where mechanization took hold, the process has been stepwise and incremental, resulting in less labor-intensive farming systems. In our experience, improving tools for animal traction is one of the best ways to improve the lives of poor farmers while sustaining the natural resource base.

Figure 4 *– Local artisans developed skills in building and repairing planters and other implements with local materials*

Mechanization substitutes capital for labor. Mechanization must be affordable and have clear benefits in the cropping system to compete with low-cost hand labor on small farms. The purchase of a new machine or implement represents a significant investment. Even small, locally produced implements costing under $500 are substantial investments beyond the reach of many farmers. As sources of tractive power, wheeled tractors and draft animals are largely interchangeable because farmers can quickly adapt implements like planters and cultivators to either power source. Unless a wheeled tractor brings new ground into cultivation that hand labor or animal power cannot, simply replacing animal power with a wheeled tractor on a fixed land area rarely produces a larger production volume.

Animal traction — the most appropriate technology

There are many benefits of animal traction. Using mixed or diverse power sources on the same farm is quite common. Donkeys are mainly for material transport, but small utility vehicles are common near urban areas. Oxen do most of the primary tillage. Even when oxen or a tractor tills the soil, planting and weeding are hand tasks. Farmers' hand-harvest maize, and custom threshers shell it in return for a percentage of the crop. Women mill and process millet by hand to satisfy texture and taste preferences for family consumption.

5 Pretty/Pervez Bharucha 2018.
6 Starkey 1988.

Figure 5 – Mixed power sources on the same farm are common. Women process millet by hand to satisfy texture and taste preferences

Most smallholder farmers suffer from chronic low income. Few farmers can use wheeled tractors profitably because farms are small, farmland for expansion is scarce, and farm labor is readily available. In many areas, roads resemble little more than wide footpaths. Access for wheeled vehicles is challenging and, at times, impossible. Even in adverse weather, draft animals can navigate narrow trails and rugged terrain. In wet fields, draft animals are less damaging to soil than wheeled tractors.

Cattle for draft work are plentiful. Cattle reproduce. Little cash outlay is needed to replace an ox if it becomes disabled. Motorized tractors depreciate and lose value as they age, and modern farm equipment requires significant repair and maintenance costs. Fuel is expensive and subject to unpredictable swings in price. Reliance on mechanized power increases on-farm risk because farming communities lack the mechanical skills and support infrastructure to access replacement parts, repair breakdowns, and ensure timely field operations.

Animal traction makes full use of locally available resources, enhancing their efficiency and the resilience of the farming system. The value of an ox appreciates as it grows and matures, so farmers can sell an ox for more than they paid for it. The training of young draft animals receive increases their value, and draft animals increase in value as they mature and gain weight. The sale of mature cattle is an essential source of farm income that mitigates economic risk for the farm family.

A production system, not a simple technology

Figure 6 – Local artisans are collaborators actively involved in setting priorities, evaluating alternatives, and sharing work results

Figure 7 – Rather than importing expensive technologies, we worked alongside local artisans to enhance their knowledge, skills, and abilities to build and repair equipment using locally available materials

Figure 8 *– Strip-tillage builds soil health by conserving soil moisture, reducing tillage intensity, and retaining a protective crop residue on the soil surface*

Our approach to redesign farming systems is agro-ecological – a production system, not a simple technology. Machines and draft animals are part of a broader system where ecological and social benefits are valued and sought after. Our goal is to offer flexible options compatible with the local economic, social, and environmental conditions and enhance the farming system's efficiency and resilience. Our approach is participatory. Local farmers and artisans are collaborators actively involved in setting priorities, evaluating alternatives, and sharing the work results. Participatory development enhances farmers' capacity to learn about farms and resources.

Over-cultivation and over-grazing have degraded soils in Burkina Faso. Crop yield response to inorganic, commercial fertilizers is diminishing, and research has shown substantial yield benefits from combining inorganic fertilizers with organic nutrient sources such as manure and compost. Reclaiming and building soil fertility is a concern widely shared by smallholder farmers. Integrating crops and livestock on the farm returns organic matter to the soil and cycles crop nutrients through cropping.

Re-integrating crop and livestock systems is an opportunity to restore degraded soil and reclaim soil health. Livestock-based cropping systems improve soil fertility and crop yield by cycling nutrients from manure, compost, and cover crops. Forage crops extend the crop rotation and provide a vegetative cover to prevent soil loss. A 450 kg ox produces about 25 kg of manure per day—more than 270 kg of nitrogen and 180kg of phosphorus and other essential crop nutrients annually. Sustainable cropping practices minimize soil disturbance, maintain a protective vegetative or residue cover on the soil surface, and add organic inputs from manure, compost, and cover crops.

Local artisans, local materials, local solutions

There is a lack of affordable and accessible animal-drawn conservation tillage tools in Burkina Faso. The tools and implements need to be inexpensive, rugged, and functional, and built and repaired with local knowledge and

materials. The scope of our conservation tillage work encompassed the cropping system: an animal-drawn in-line ripper to reduce tillage intensity, improve water infiltration, and conserve protective crop residues; a planter to reduce the drudgery of hand planting; and a low-crown, low-pitch sweep cultivator to improve weed control. Rather than importing expensive technologies, we worked alongside local artisans to enhance their knowledge, skills, and abilities to build and repair the equipment using locally available materials. Local artisans and blacksmiths live among the farmers, understand their needs, and have the skills to develop and improve their tools.

In an adaptive management process, we built and evaluated a set of technologies compatible with the local economic, social, and environmental conditions. We redesigned an animal-drawn planter introduced decades earlier but widely rejected by local farmers because of the high cost and poor performance. We reduced the cost of the planter by 50 % by replacing an expensive imported spiral bevel gear drive with an open spur gear drive built on-site by local blacksmiths. We had made mold-injected seed plates for maize, sorghum, millet, and cowpea and an innovative furrow opener to place the seed at the correct depth. Locally built, concave discs well suited for clearing crop residue without plugging replaced the high crown furrow closers on the old-style planter. Finally, we reduced the press-wheel width by 50% to provide localized pressure to firm the soil in the narrow seedbed created by the in-line ripper. The refined planter's average implement draft was 20 kilogram-force (kgf), a manageable load for even a single donkey.

Figure 9 *– The implement draft dropped from 90 kgf with the moldboard plough to 45 kgf with the strip tiller, easing the burden on the local small-framed oxen*

Strip tillage builds soil health by conserving soil moisture, reducing tillage intensity, and retaining a protective crop residue on the soil surface. The strip-tiller tilled a narrow band of soil about 20 cm wide and 15 cm deep. It reduced the need for intensive full-width plowing or disking. We designed an open web steel truss to replace an expensive cast iron main beam, built a novel packer/crumbler to level, and firm the seedbed (***Figure 8***). The implement draft dropped from 90 kgf with a moldboard plow to less than 45 kgf with a strip-tiller, easing the burden on the local small-framed oxen and replacing full-width tillage with strip-tillage reduced by half the time in the field to prepare the soil for planting. By building the local artisans' and blacksmiths' mechanical and technical capabilities, we guarantee that farmers have local access to skilled and cost-effective labor for repair, maintenance, and ongoing innovation.

A mechanical advantage enables a biological advantage

The mechanical advantage of the planter enabled a biological advantage for the maize crop. The planter placed the seeds at a constant depth and consistent spacing. Seeds germinated faster and emerged at a uniform rate. Additionally, there was little need to replant, often required when hand seeding because of a low emergence rate. Side-by-side grain yield comparisons in farmer fields revealed an advantage from machine planting ranging from 50 % to 150 % compared to hand planting. Much of the yield increase was due to reduced seed loss to birds. Birds can easily find and consume hand planted seed, but they could not steal the machine-planted seed because they could not find it!

Agroecological concepts ground our approach to farming systems redesign. Evaluation is technical but viewed in social, cultural, and economic contexts. After one or two seasons of use, a group of women commented on the time and laborsaving impact of the animal-drawn planter on their lives. They noted that a family of three with a team of oxen could accomplish the work of a hand-planting crew of 15-20 laborers. The women used the time saved with the planter to perform other domestic tasks such as cooking, fetching water, child-care, and going to the market[7]. They could divert time from subsistence farming and household chores to income-generating activities such as processing shea butter or cashew nuts. Income from their off-farm enterprise funded children's schooling, food, and clothing. In addition, they saved money for unexpected expenses such as medical care and other family emergencies.

Figure 10 *– Time saved with the planter allowed women to divert time from subsistence farming and household chores to income-generating activities such as processing shea butter or cashew nuts*

Animal traction makes full use of locally available resources and enhances their efficiency and the resilience of the farming system. The benefits of animal traction and appropriate scale mechanization and the social process-

7 Harrigan/Jones 2020.

es that give rise to them are linked. Animal-drawn planter design benefits include efficient and effective planting with improved grain yield and farm income. The process benefits include greater affordability, accessibility, and repairability. Importantly, gender benefits accrue to the household through time and labor savings for women farmers and enhance entrepreneurial skills.

In recent years, the Food and Agriculture Organization of the United Nations (F.A.O.) has revisited the importance of working animals on the health and well-being of households in developing nations, particularly in the realms of agriculture, gender, food security, and rural development[8]. Working animals improve farm productivity by providing draft and transport power, milk, meat, hides, and other byproducts. Many smallholder farmers do not have access to mechanized power, so draft animals are central to their daily lives. There is a growing awareness of the need to raise the status and well-being of working animals worldwide, particularly in developing countries. Areas of concern include better veterinary care, animal nutrition and welfare, a need to reclaim skills in training draft animals, and the importance of indigenous knowledge in developing appropriate scale mechanization. There is a need to create and promote networking opportunities to nurture discussion and exchange of technical knowledge, engage a broader scope of stakeholders, and develop guidelines for best practices.

Draft animal power in the U.S.A.

Compared to Africa, where farm income was constrained because land for expansion was scarce and labor was abundant, the conditions in the U.S.A. were very different. In the 1800s, mechanization and technological change progressed in the context of limited labor and plentiful land[9]. With ample land for expansion, the lack of available labor limited farm production. Motorized tractors displaced nearly all working draft animals in the first half of the twentieth century. The transition from animal power to wheeled tractors and other agricultural machinery allowed farmers to increase the land area under production and produce a greater crop volume. Farm machinery investments steadily increased as the yields and profitability of farming increased due to these new mechanized technologies. The new machines allowed farmers to save time and labor, producing a greater volume of crops on a larger land area. The laborsaving devices developed as U.S. farms grew in size "*were typically built by local blacksmiths who lived among farm people, understood their needs, repaired their hand tools, and loved to tinker with tools, equipment, and machines*"[10].)

In many areas of the U.S., farms are small, and land for expansion is scarce or unaffordable. With the growing interest in sustainable development, soil health, local foods, mitigating climate change, protecting the environment, and ecologically sound farm management, animal traction is gaining popularity. Motorized draft power is locally available to these farms but not preferred for many tasks. Most farms use mixed-power sources; animal traction for field and forest and motorized power for material handling. A skilled application of animal power brings responsive and appropriate scale technology to demanding tasks such as tillage, planting, weeding, logging, transportation, and other chores. For many draft animal practitioners, draft animals have social and cultural significance and embody a sense of community. The animals are well integrated within the agricultural system and used efficiently and effectively within the local context.

The inspiration and rationale for applying animal power on farms in the U.S.A. vary from tasks and geographic location. I have invited five draft animal practitioners to explain how animal power contributes to their work and social environment. Long-term impacts will result from nurturing the social process whereby farmers take ownership of their development and the deliberate application of a living power source. A cross-cutting theme is that their lifestyles converge around lower material consumption, natural resource regeneration, and desire for a higher personal level of global well-being.

Carl Russell, Earthwise Farm and Forest, Bethel, Vermont, U.S.A.

Carl B. Russell and his wife, Lisa McCrory, own and operate Earthwise Farm and Forest in Bethel, VT. They raise organic vegetables and grass-fed livestock, use draft animals for logging and fieldwork, and offer workshops on skills for sustainable livelihoods.

Figure 11 *– Draft animal power is well integrated into the farming system at Earthwise Farm and Forest*

In 1986, at age 26, I bought a workhorse and started logging in our woods and for other landowners as part of my forestry business. There were several motivating factors behind this decision. Ecologically, draft animals reduced reliance on petroleum; economically, it reduced the costs of equipment purchase and maintenance. I valued the relationship with the animal through husbandry and work performance.

Over the last 36 years, I have worked horses and oxen in the woods and on the small farm built by my wife and me. The use of draft animals is a primary principle on our farm, using them for work in gardens, hayfields, and forests.

8 FAO 2014.
9 Cochrane 1993.
10 Ibd.

Working animals' performance rate often does not yield large financial gains because it takes a lot of work to work with animals.

From training/conditioning animals to repairing/building equipment, preparing the work site, felling trees, organizing gardens, and attaining related skills, once the animals are applied to a task, one has put in many hours and spent a lot of personal energy. While these realities can easily be seen as costly, they are also the source of significant personal reward – the aspect of working animals that substantiates the craft.

One of my strategies for using draft animals most effectively in our operations has been to engineer the scale of work to reduce their role to the most appropriate tasks. Our land-use systems that require motive power are purposefully limited to a scale that fits our animals' time and energy constraints and capabilities and affordable associated equipment.

Figure 12 *– Carl maximizes profit by keeping costs within the capabilities of animal-based production rather than through increased mechanical production to cover higher costs*

Farming system examples include; rotational grazing, feeding livestock outdoors during winter, and reducing the need to store, manage, and spread manure by orchestrating pasture systems that deposit nutrients as an ongoing process. We garden with semi-permanent raised beds within the scale and scope of animal power and human labor. With draft animal power, equipment and machinery costs are minimal, reducing the need for high volume production to support high fixed and operating costs.

We maximize profit by keeping costs within the capabilities of animal-based production rather than through increased mechanical production to cover higher costs. These basic principles allow for a greater personal reward through quality craft and husbandry, augmenting the admittedly lower overall income. This qualitative approach to personal compensation provides a level of profitability that justifies our reliance on living power that machinery cannot deliver.

Stephen Leslie, Cedar Mountain Farm, Hartland, Vermont, U.S.A.

Stephen Leslie is a co-owner of Cedar Mountain Farm and Cobb Hill Cheese, located in Hartland, VT. The farm produces milk, beef, mixed vegetables, and compost.

Figure 13 *– Cultivating garlic with a team of Fjords at Cedar Mountain Farm*

Over the last two decades at *Cedar Mountain Farm,* we developed systems for growing vegetables based on the methods we learned as apprentices on a biodynamic farm. The difference is we weaned ourselves off the wheeled tractor and achieved the goal of doing all the fieldwork, cultivation, and harvesting with our two teams of draft horses. Our dairy operation still relies on tractors; we feel that incorporating living horsepower into our vegetable production is a positive redundancy. They provide a truly "renewable" energy source and a regenerative component of the farming system.

Figure 14 *– Fjord power is the best fit for the farm, woodlot, and other tasks on Stephen Leslie's farm*

Economically, you would not purchase a 35 kW tractor to accomplish the workload of a 15 kW tractor. We chose to work with Norwegian Fjord horses because a full-sized

team of heavy draft horses would be overkill for the market garden scale we envisioned. The Fjord horse ranges in height from 13 to 15HH and typically weighs between 360 and 500 kg.

Before the last century, the Belgian and Percheron horses imported here were often crossed to lighter horses to produce a general-purpose farm horse. This suggests that the vintage equipment of that era is quite suitable for the smaller draft types such as the Fjord, Haflinger, Morgan, and drafts crossed with saddle horses. We have found the Fjords to be highly intelligent and trainable, nimble and careful with their steps, and possess great endurance and "try."

One of the compelling reasons for crossing the draft types to lighter horses was the economy of feeding the workhorse. A Belgian horse will require a bale of hay and some grain supplement in proportion to its daily workload. The typical Fjord is about half the size of a Belgian but only requires about one-quarter of the feed.

Our Fjord horses are the tractive power in our two-hectare market garden. Except for Amish-built forecarts and a plow, most of the equipment we use in the market garden is vintage early-to-mid-20th century horse-drawn implements. We use a 35 cm bottom walking plow, a 30 cm bottom riding plow, a 1.8-meter single-action disc, a three cubic meter single-axle ground-driven manure spreader, two sections of flex (pasture) harrow, a spring-tooth harrow, a riding cultivator, a 2.4-meter cultipacker, and a box-type lime spreader. We pull the spreaders, disc, and other harrows behind a standard Pioneer forecart (with the tongue length reduced from 3.9 to 3.0 meters). Come haying time, the Fjords also pull a no. 6 mower with a 1.5-meter bar, a Grimm tedder, and a New Holland side-delivery rake. A team of Fjords working within the scale of a two-ha garden can manage these implements without a problem.

The versatile Fjords also work well in the woodlot and make for a good riding horse, providing the farm family with a form of homegrown recreation and valuable for such farm tasks as checking fence lines or moving livestock groups.

Melvin Stoltzfus, Chestnut Feedery & Pet Store, Bradford, Pennsylvania, U.S.A.

Melvin L. Stoltzfus owns and operates a feed and pet store in Bradford, PA. He grew up on a farm in the middle of Pennsylvania and rubbed shoulders with the Amish as they were a primary customer base for his father's organic hay and grain. In the past, he sold portable Amish barns in his area and has used these connections to continue building relationships with them.

When the words 'Amish' and 'horse' come together, two pictures come to mind. One is a farmer in the field or woods using a draft horse. The other picture is a buggy going down the road with a smartly trotting horse in front. It is challenging to imagine the Amish people without horses and a slower way of life. Horses and the lack of motorized vehicles help keep the community close and significantly shape the Amish culture. They tend to set a slower pace and have a more deliberate and hands-on approach. The emphasis on farming and related craftsmanship gives their children something to do, responsibility, and a place in their culture.

This is not to say that farming with horses is a life of idyllic

Figure 15 *– An Amish-owned team of horses waits patiently while the logging crew breaks for lunch*

ease and a gentle pace; no, it is a physically demanding endeavor and requires situational awareness and common sense. Someone who can competently handle a young, energetic team of horses while spreading manure or mowing hay can rightfully feel a sense of accomplishment. Horses are used in any application that most people would use a car, tractor, or four-wheeler. Recently my father saw a young man riding a horse up a trail to an Amish barn. He was coming to help on the farm that day and took a back route to get there.

A question arises –are Amish farmers consummate horsemen and incredibly gifted people? I would say that, on average, this is not the case; they are aware of how to train their young people in this work and have a culture of learning on the job. There are common sense guides that they are careful to follow; for instance, you don't put your 11-year-old boy on a sulky plow with the new young team of Belgians. Youngsters train with older, more experienced teams on simple tasks. As the young man learns more about handling horses, he can graduate to handling less well-trained horses. If he is a gifted horse trainer and enjoys the work, he may even develop a sideline business of buying young horses in need of training, working them for a few years, and selling them for a profit after using them.

The horse has one more valuable deposit to make to the bottom line at the end of the day. His manure is used in the garden to grow excellent vegetables — a truly regenerative and multi-purposed creature.

Jim Slining, Director of Historical Collections and Exhibits, Tillers International, Scotts, Michigan U.S.A.

Jim is a lifelong student of historical technology. He combines experience with hand-tool technology and draft animal use with information revealed in historical artifacts to discover the context and circumstances optimal to their use.

***Figure 16** – Field-testing a three-row, ox-drawn planter at Tillers International*

Tillers International facilitates food security worldwide by helping smallholder farmers identify labor bottlenecks and design and initiate appropriate scale solutions to current challenges. Tillers International draws on historical examples of functional farming tools and systems and curates a collection of historic farm implements. In practice, we help communities locally produce affordable tools. Historically, human or animal-powered devices – simple though sophisticated – are easy to replicate without a significant investment in manufacturing facilities. Repair parts can be fashioned affordably by local artisans ensuring availability when the growing season demands.

***Figure 17** – Tillers International draws on historical examples of functional farming tools and implements to help local communities produce affordable tools*

In the 19th- and early 20th-century, when draft animals and hand tool labor were widespread, American farm tool designers were mindful of energy conservation. The physical architecture of tools from this era is instructive: lightweight yet durable, the weight placed to be an asset (over the bull/drive wheel, for instance); shape/size/angle of plow bottoms and tillage tools to match local soils, drive trains and bushings designed to minimize friction and energy use. Many clever design features are unnoticed when excess (machine) power is available. Existing wear marks tell the story of the tool's use and age. Perhaps how the device intersected with the soil or crop, evidence of operator (or draft animal) interaction, or lubrication use (or lack of). Repairs and redesign are evidence of on-the-job learning and a practical demonstration of physics principles. Such tangible evidence alludes to an intangible tool knowledge: the skills and abilities embodied in their use and application.

The work at Tillers International requires viewing history in context. We ask, "Under what social, economic, cultural, and natural environment was this ideal of agriculture accepted as best for that place and time"? Such awareness (which reveals opportunities for novel solutions) requires that reproduced tools of historical design (often paired with draft animal power) engage in real, physical work. Disuse safely preserves historical tools. Still, only the hands-on application of those tools maintains the skills to use them and appreciate their innate utility. We struggle to appreciate and understand the full context of past farming tasks without the skills and abilities forged in use. Tillers International and many other living history sites are uniquely capable of carrying out that mission.

As farm power and mechanization advanced in the U.S., agriculture established an efficient application of farm power that distributed limited physical and human

Figure 18 *– Kevin Cunningham uses oxen as the primary draft power source for his integrated crop and livestock farm*

resources evenly throughout the year. The need to conserve draft animals' energy reveals these systems' reality. Historical examples of these functional systems are crucial! One thread running through the *international conference 'Draft Animals in the Past, Present and Future'* was the widespread interest in adopting the West's "conventional" agriculture. Perhaps the most meaningful action would be to modernize the sophisticated historical farming systems and aptly apply them appropriately in our own back forty.

Kevin Cunningham, Shakefork Community Farm, Humbolt County, California, U.S.A.

Kevin Cunningham works 34 hectares along the Van Duzen River in Humboldt County, California, with his wife Melanie and son Clyde. They use draft oxen power on the 2.5 ha mixed vegetable garden and for moving a portable milking parlor and mobile chicken coops producing eggs and broiler chickens in the pastures. They integrate draft animal power into almost every part of the farm, including teaching farmer interns about regenerative agriculture.

We started in community farming as apprentices on a tractor-powered farm on the oxen-poor west coast of the U.S. My initial interest was in small grain production. Still, an assessment of the best use of the resource base made it clear that the most appropriate power source would be ox power. Most farm ground is rocky, unsuitable for cropping, but perfect for pasture. About 2.5 ha is suitable for cropping. We struck a deal with a local dairy farmer – four frozen chickens traded in exchange for four bull calves. After a few years of training the calves based on trial and error and with help from online networks such as the DAP-net Forum, we farm successfully with oxen – the primary draft power source for our market garden.

We transitioned from tractor to ox power, from conventional intensive tillage (plow, disk, fit, plant) to draft animal-appropriate, reduced tillage, raised beds. Most vegetable gardens in the region are smaller (one-quarter hectare or less) than our 2.5 ha plot. Ox power gives us longer and stronger arms--a level of tractive efficiency greater than human power or two-wheel tillers, but right-sized for our time and land base. Most of the implements used in the garden are modern, multi-purpose or vintage tools modified to achieve specific tasks. The goal is to have a one-person operation for the fieldwork.

Figure 19 *– The 2.5 ha tillable tract of mixed vegetables matches human and animal work and time constraints. Two covered greenhouses extend the growing season to a year-round operation*

We have a small cow-calf herd of Dexter cattle that we sell as grass-fed beef at the local farmers' market. We milk a few cows once per day for family and intern consumption and butter churning, with excess milk fed to pigs. The 2.5 ha tillable tract of mixed vegetables matches our human and animal working capabilities. Two covered greenhouses extend the growing season and supply the C.S.A. and local farmers' market year-round.

We have a mixed power-source farm. A small tractor is primarily for loader work--compost turning and materials handling. Two teams of oxen reside in a covered shelter. This assures frequent interaction for continuous ox training, and the manure and bedding collected in the shelter supply sufficient compost to feed the vegetable crops. The oxen have both physical and social roles on the farm. They are a unique attraction here in oxen-poor California, of great interest to farm visitors and at on-farm public engagement activities. The relationship and emotional connection with oxen are valued and have spillover effects on schoolchildren, visitors, customers, and social media. Many internship candidates are attracted to the unique opportunity to work with oxen, and they help draw a larger pool of candidates. At *Shakefork Community Farm*, oxen contribute to developing physical, human, and social capital and an integrated farming system with impacts that ripple at a landscape scale.

Draft animals have been rarely seen in the U.S.A. for almost seventy years. Yet the number of draft animal practitioners has increased as the interest in sustainable development, soil health, local foods, climate change mitigation, protecting the environment, and ecologically sound farm management gained popularity. For these draft animal practitioners, the intentional application of animal power is the most appropriate technology for their scale of farming. In working conditions, bystanders are often distracted from the work at hand by the power and elegance of working animals. However, for most agriculture, transport, and logging work, draft animals are simply the tractive unit providing motive power. The modern relevance is in the skillful application of living power to accomplish the tasks of tillage, planting, weeding, logging, etc.

Summary and Conclusions

In much of the developing world, on-farm mechanization is low. Draft animals provide tractive power to till the soil, transport firewood and water, and move crops from field to market. At the end of their lives, they provide meat, hides, and other byproducts for household use and income on about 250 million ha of land. Appropriate scale technology is the best fit, or match-up, between technology and the context in which it is used. Animal power is relevant for many smallholder farmers because modern machinery is often inaccessible or unaffordable. Animal traction is the most appropriate technology in Burkina Faso because farm income is low, labor is available, landholdings are small, and farmland is scarce for expansion. Mechanization must be affordable and have clear benefits in the cropping system to compete with low-cost hand labor on small farms. As sources of tractive power, wheeled tractors and draft animals are largely interchangeable because farmers can quickly adapt to implements like planters and cultivators to either power source. Few farmers can use wheeled tractors profitably because farms are small, farmland for expansion is scarce, and farm labor is readily available.

Largely replaced by tractors in the first half of the 20th century, draft animals have been rare in the U.S.A. for seventy years. Yet, farms are small in many areas, and land for expansion is scarce or unaffordable. Appropriate scale technology is the best fit or match-up between technology and the context in which it is used. With growing interest in sustainable development, soil health, local foods, climate change mitigation, environmental protection, and ecologically sound farm management, animal traction is gaining popularity. In working conditions, many observers are distracted from animal power work by the animals' novelty and elegance. Draft animals are simply providing motive power. Animal power brings responsive and appropriate scale technology to demanding tasks in agriculture, logging, transportation, and other jobs. The modern relevance is in the skillful application of animal power to accomplish demanding tasks with precision and efficiency.

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Author info
Timothy Harrigan
Department of Biosystems and Agricultural Engineering
Michigan State University · East Lansing, MI 48824
E-Mail: harriga1@msu.edu

Animal traction in Europe in the XXI century: challenges, threats and opportunities

João B. Rodrigues and Pit Schlechter

Abstract

The use of draft animals is manifold today. Animal traction power can be used in various fields such as forestry management, agriculture, which includes viticulture, urban management and tourism. Despite the many advantages, working with draft animals also presents many challenges. Especially as animal traction is still often seen as backward and unfashionable. It is also problematic that draft animal power does not fit into the current economic system, based on large-scale, fossil-fuel-powered machinery, and the dependency of the customers.

There is also a lack of professional manufacturers for the equipment needed for the use of draft animals, as well as instructors for the training of the animals.

FECTU (Fédération Européenne du Cheval de Trait pour la promotion de son Utilisation) works on different levels and together with other organisations to meet the challenges and to show that animal traction is a future-oriented and promising way of working - for people and animals.

Résumé

L'utilisation des animaux de trait est aujourd'hui multiple. La traction animale peut être utilisée dans divers domaines tels que la gestion forestière, l'agriculture, y compris la viticulture, la gestion urbaine et le tourisme. Malgré ses nombreux avantages, le travail avec des animaux de trait présente également de nombreux défis. D'autant plus que la traction animale est encore souvent considérée comme arriérée et démodée. Il est également problématique que la traction animale ne s'intègre pas dans le système économique actuel, basé sur des machines à grande échelle, alimentées par des combustibles fossiles, et sur la dépendance des clients.

Il y a également un manque de fabricants professionnels pour le matériel nécessaire à l'utilisation des animaux de trait, ainsi que d'instructeurs pour le dressage des animaux.

La FECTU (Fédération Européenne du Cheval de Trait pour la promotion de son Utilisation) travaille à différents niveaux et avec d'autres organisations pour relever les défis et montrer que la traction animale est une méthode de travail tournée vers l'avenir et prometteuse - pour les hommes et les animaux.

Kurzfassung

Der Einsatz von Zugtieren ist heute sehr vielfältig. Die Antriebskraft von Tieren kann in verschiedenen Bereichen eingesetzt werden, z. B. in der Forstwirtschaft, in der Landwirtschaft (einschließlich Weinbau), in der Stadtbewirtschaftung und im Tourismus. Trotz der vielen Vorteile ist die Arbeit mit Zugtieren auch mit vielen Herausforderungen verbunden. Zumal die tierische Zugkraft oft noch als rückständig und unmodern angesehen wird. Problematisch ist auch, dass die Arbeit mit Zugtieren nicht in das aktuelle Wirtschaftssystem passt, das auf großen, mit fossilen Brennstoffen betriebenen Maschinen und der Abhängigkeit der Kund:innen basiert.

Außerdem fehlt es an professionellen Hersteller:innen der für den Einsatz von Zugtieren erforderlichen Ausrüstung sowie an Ausbilder:innen für das Training der Tiere.

FECTU (Fédération Européenne du Cheval de Trait pour la promotion de son Utilisation) arbeitet auf verschiedenen Ebenen und gemeinsam mit anderen Organisationen daran, den Herausforderungen zu begegnen und zu zeigen, dass die Anwendung von Zugtieren eine zukunftsorientierte und vielversprechende Arbeitsweise ist - für Mensch und Tier.

Resumen

Los usos de animales de tiro hoy en día son muy diversos dependiendo del campo en los que se aplique. La fuerza de tracción animal puede utilizarse tanto en el sector forestal, de agricultura, viticultura, como en el sector urbana y turístico. A pesar de las muchas ventajas, el trabajo con animales de tiro también presenta muchos retos. Uno de ellos es la concepción errónea de la relación entre tracción animal y retraso, no apto para el sistema económico actual. Además existe una escasez entre los profesionales fabricantes de los equipos necesarios para el uso de animales de tiro, así como instructores cualificados para el entrenamiento de los animales.

La FECTU (Fédération Européenne du Cheval de Trait pour la promotion de son Utilisation) trabaja a diferentes niveles y junto con otras organizaciones para hacer frente a los retos y demostrar que la tracción animal es una forma de trabajo orientada al futuro y prometedora, tanto para las personas como para los animales.

FECTU Introduction

FECTU stands for Fédération Européenne du Cheval de Trait pour la promotion de son Utilisation – in its original French name and was established in 2003 when seven organizations met for the first time in Luxembourg and created this umbrella organization. Today FECTU – 18 years later – represents the animal traction sector in Europe and has 23 active members from 15 European countries representing more than 35.000 individuals from the membership lists of member associations.

Animal traction in Europe

When we talk about animal traction in Europe, we need to talk about forestry management, agriculture which includes viticulture – the production of wine –, urban management, and tourism.

In terms of forestry, it's important to note that we all observe a growing concern about nature conservation, preservation of the soil, or low impact management methods, especially in protected areas and these concerns somehow boosted the use of animal traction in many different parts of Europe. Moreover, it's important to mention that the work done in the forest sector is not limited to traditional logging but also often relies on combined techniques and newly developed equipment.

An example is the use of animal traction to manage a riverbank – riverbanks are very delicate, fragile ecosystems, and bringing heavy machinery into such an environment can cause massive problems, so animal traction in this case is being used as a very interesting alternative. Another example of draft horses being used is to manage sand dunes. These are also very sensitive ecosystems, so once again bringing heavy machinery should not be an option, so animals are being used with excellent results.

Draft animals can pull objects directly, but often various implements – motorised or non-motorised – are hitched in between to carry out different activities. This includes agricultural work such as ploughing on fields or in vineyards, but also the transport of logs.

In the case of logging work, for example, it is possible to use a forecart and a series of logging arches to make it easier. The good thing about this technology is that the same animal can carry bigger logs without exerting a higher effort which is important from the animal welfare point of view. Furthermore, even smaller equids such as donkeys can use similar technology to be able to work in a proper way, in an efficient way without overloading the animals or disrespecting their dignity or physical limits, and this is something very important!

Another instance of the use of draft animals, usually working equids, is market gardening – small-scale agriculture and horticulture. Here a big challenge links with the fact that most of these small-scale farmers using animal traction also need to be the sellers of their own products, usually in local markets, based on a relationship of trust between them and the consumers.

Over the last years, we saw draft animal-themed books appearing, such as the interesting book written by Clémentine Bonnin, Pascal Sachot, and Philipe Rocher, back in 2019 – *L'Âne Maraîcher* (the use of donkeys for gardening) showing that there is an increased interest in the topic!

The use of draft animals in viticulture is another growing reality, and recent studies show that the use of animal traction has a very positive impact in terms of soil conservation, not compacting the soil and with much better results when compared with tractors. Additionally, the same studies also show that the plants started to produce earlier, so we have not only a better wine or/and grapes quality but also productions that start earlier.

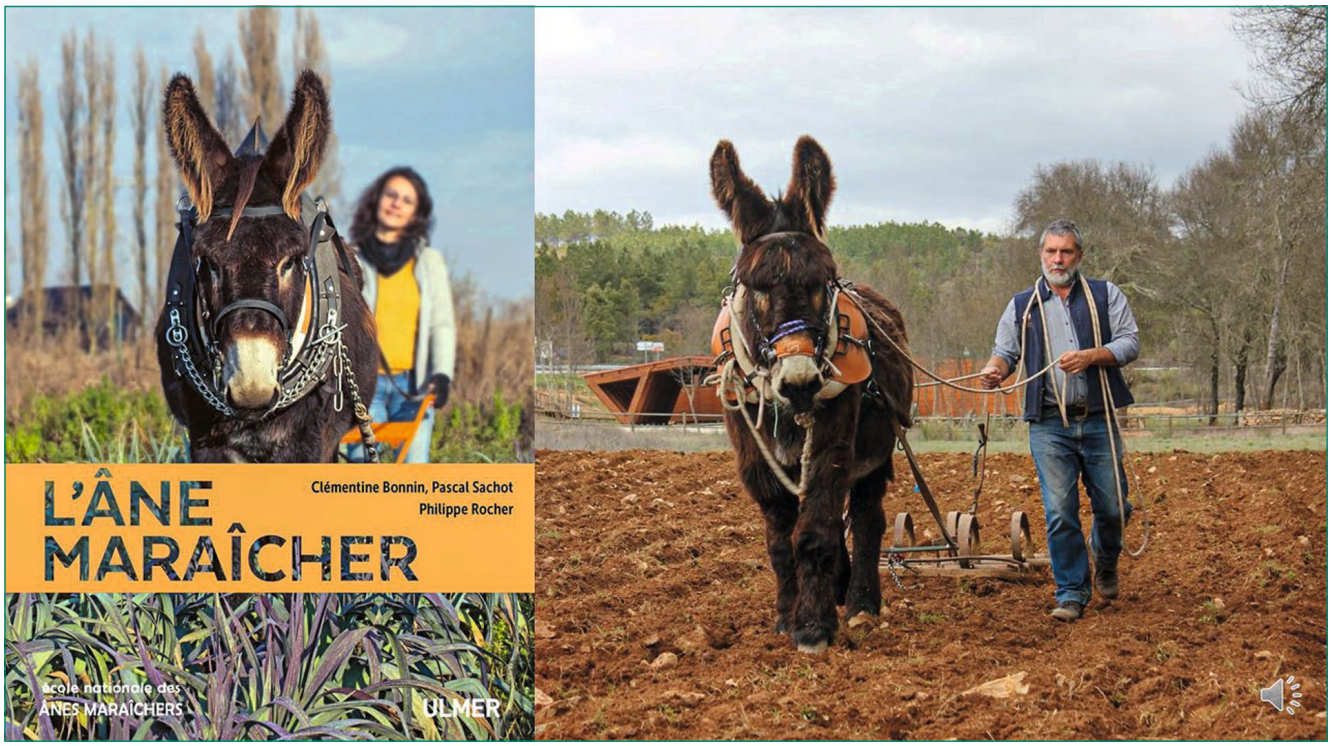

Figure 1 *– Large European donkeys being used for small-scale agriculture: on the left, the cover of the book L'Âne Maraîcher shows a Poitou donkey, and on the right a Zamorano-Leonês donkey working with a spring harrow, during a training course in Portugal*

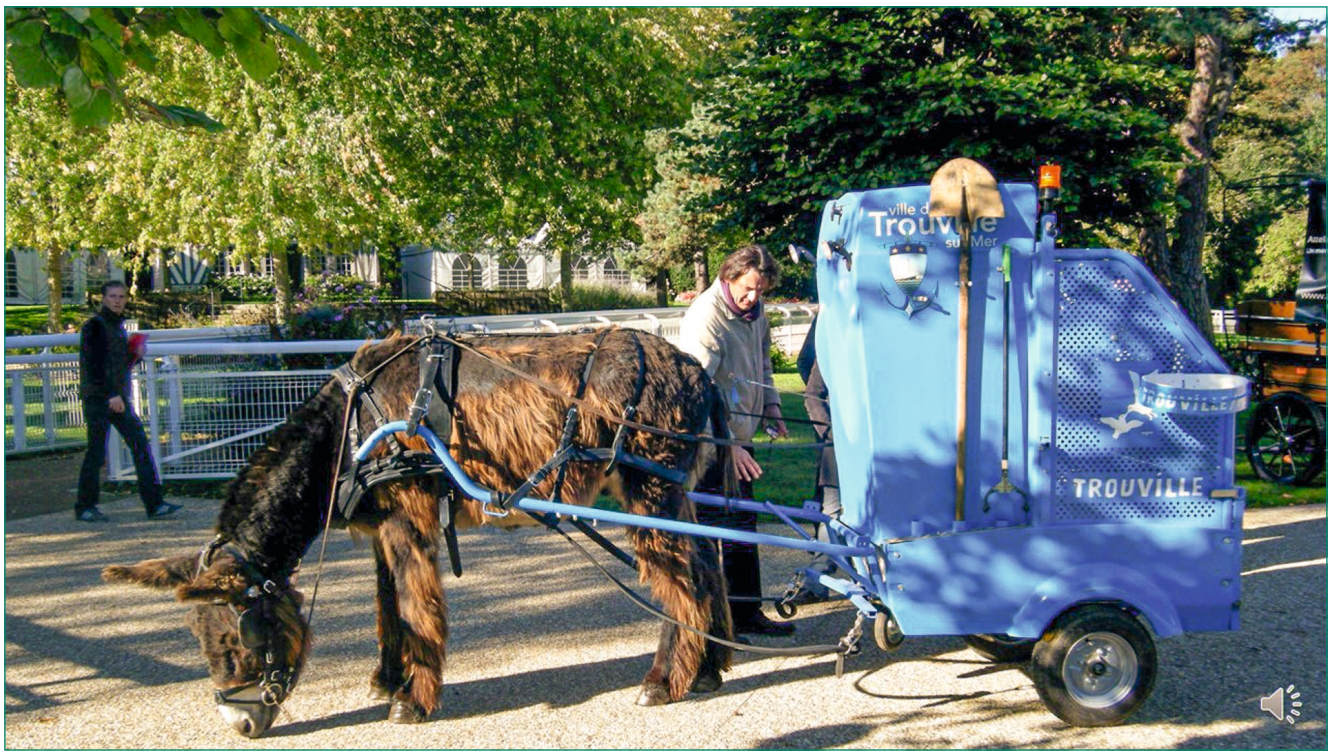

Figure 2 *– Poitou donkey working in a public park, in Trouville-Sur-Mer, a city in French Normandie – France created a national network called Cheval Territorial, where more than 300 cities and towns who use draft animals for urban management came together*

Moreover, the management of urban surroundings is also another interesting field for animal traction! We can see animals being used in collecting glass, litter, or paper. We can see animals being used in park management and in the transport of school children, too.

Draft animal power is also used in tourism. We know that there is a huge tradition in many different towns and cities of Europe that use animals to pull carriages, but what we've been generally observing is the use of animal traction mainly in sustainable tourism in mountain areas and this has actually been a potential asset to allow local people to remain in these low-density areas while having a decent job.

Challenges of animal traction in Europe

It is important to keep in mind that the overall perception of animal traction has very slowly changed over the last 30 years in Europe. Working with animals is still considered by many as something nostalgic, inefficient static, or even obsolete. In some respects, on the opposite side, people also consider draft animal power as a modern, eco-friendly, and sustainable option. Nevertheless, improving the profile of working with animals is still a big challenge nowadays!

Probably the biggest challenge that can easily become a threat is the fact that animal traction does not fit in the current economic system, based on large-scale, fossil-fuel-powered machinery, and the dependency of the customers. There is absolutely no doubt that animal energy is a renewable source of energy, but a drawback is that it currently cannot be transformed in a way that it could be stored, distributed, or sold out with the help of the existing technical system.

Another challenge for the draft animal users is the capacity to have access to professional manufacturers – both implements and harnesses – as manufacturers usually sell on a local scale, with limited distribution capacity, so it can be difficult to find a professional manufacturer if you are in a country in Europe where there are none.

Another difficulty is related to training, and for years it was hard for new users to find places where to receive proper training. Over the last 10 to 15 years, there was an increased offer in terms of training, mainly delivered by FECTU members, with some agricultural schools and institutions also providing training, mainly in collaboration with NGOs representing the animal traction sector.

Finding well-trained animals is also another difficulty. We need to keep in mind that training an animal is a complex and sometimes time-consuming process, especially for beginners, who need to rely on professionals to get trustful animals. Another important aspect to keep in mind is that the selection in the breeding process (in those breeds historically used to work) was mainly determined by meat production over a long time. Therefore, important characteristics such as conformation or the attitude towards the work were neglected.

The need to find a strategy to see animal traction included in national and international development strategies is another challenge. FECTU is working on this but has very limited funds and very limited human resources, so FECTU is always looking for partnerships and trying to find creative solutions. There are some good examples of the use of animal traction as part of national development strategies. You can see some really interesting documents published by the government of Luxembourg and Germany, in 2005 and 2009, focused on sustainable forest management. However, these are rather isolated initiatives, and a lot of work still has to be done to achieve

more usage of draft animal power on a European level. This challenge also takes another dimension if you look in detail: we have two different realities inside Europe and for which Romania is taken as an example of what is happening in the East: Romania is a country with probably the highest number of working equids in Europe, with official numbers pointing to 700.000 working horses, but local authorities are not supportive at all the use of working animals. This, of course, increases the challenges that must be faced while trying to adapt animal traction as part of national and international development strategies.

Another important aspect to mention is the increasing social movement with more radical positions, such as the ones assumed by animal rights activists asking to totally ban the use of working equids. Dialogue is not always easy or possible, despite the use of the arguments mentioned in this document regarding the benefits and the opportunities of the use of modern animal traction, and this is another challenge to keep in mind.

Equid Power Network

FECTU together with two UK charities, the Donkey Sanctuary and World Horse Welfare, started a project that is called "Equid Power Network" – www.equidpower.org. One of the main tasks of this Network is to create a comprehensive database that brings together all manufacturers from all over the world. Although this is a work in progress, the manufacturers' section of the webpage has a list with more than 130 manufacturers from more than 20 different countries. This is an excellent resource for professional draft animal users, but also new people who want to look at what is available on the market, and a good example where a challenge became an opportunity and not a threat!

Opportunities

The upcoming scientific interest that we observed over the years is, of course, an incredible opportunity for animal traction. You can see technically skilled individuals, draft animal associations, welfare charities as well as technical institutions or agricultural departments of universities showing a (re)new(ed) interest in research on issues linked to the use of working equids.

Apart from the scientific interest and the creation of partnerships, FECTU sees cooperation as an excellent opportunity for reaching our common goals. FECTU recently also joined the "Working Animal Alliance, which is a very interesting project (www.workinganimalsalliance.org). The idea of this Alliance is no more than a strategic coalition of stakeholders seeking to raise awareness of the contribution working animals make towards achieving the United Nations sustainable development goals, which is an excellent opportunity to bring working equids into the international agenda and show their importance to reach what the United Nations assume to be the most important goals until 2030 – the UN sustainable development goals. It is an excellent opportunity for us all together to promote and to show the importance of working equids, not only in Europe but worldwide!

Prospect

Looking into the future – still, in the 21st century – we believe there is a growing general awareness for energy issues, renewables, and ecological alternatives, but traditional options are also getting more attention, and this is a social context that in some respects is favorable to enhance the reputation of animal traction. And on the other page, we can also see small farming being recognized! Once it was part of the problem and today it is being

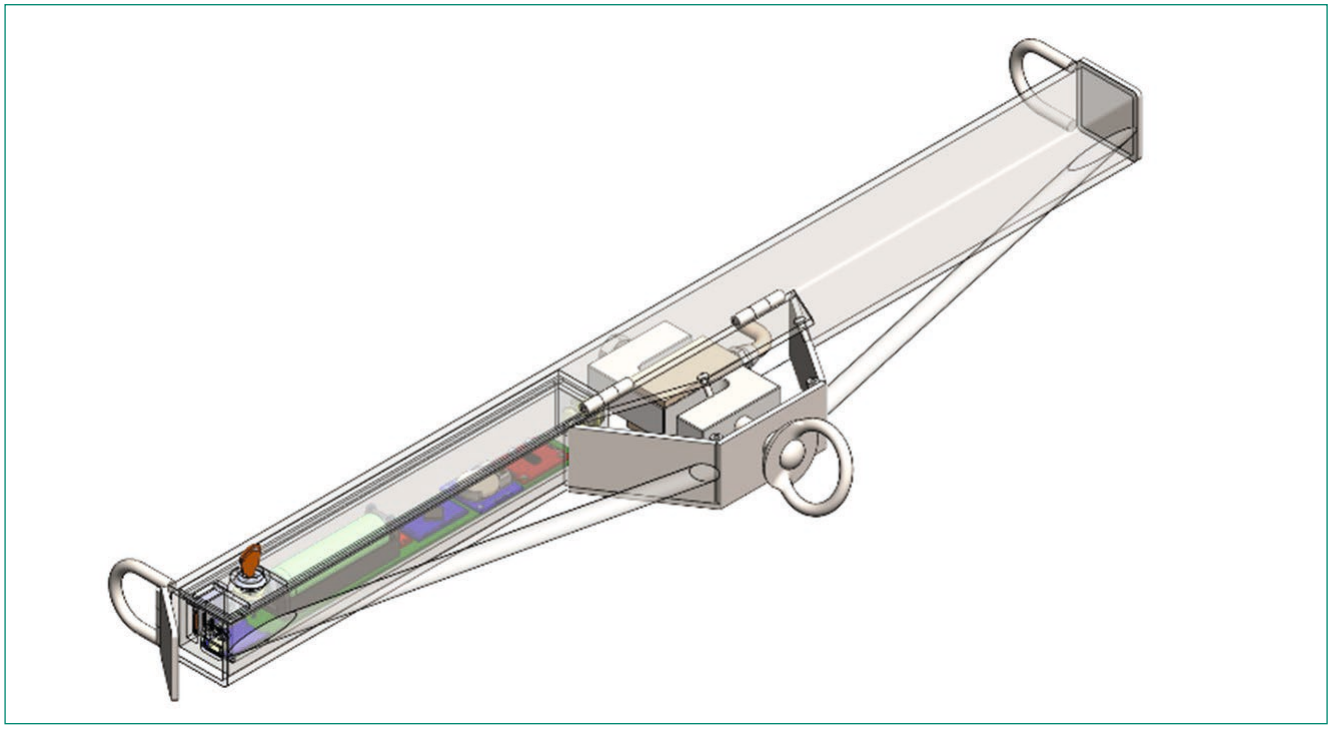

Figure 3 *– Swingle tree developed by researchers of The Donkey Sanctuary and the Polytechnic Institute of Bragança, as part of a research project to measure the force exerted by the animals during work. The load cell and the data logger were embedded in the swingle tree, not interfering with the action of the animals and allowing data collection for 8 hours*

recognized as a fundamental contribution to feeding the world – especially in combination with draft animal power that proves how viable animal traction is in market gardening, in the vineyards but also in the forest and in the urban surroundings. We believe that this development might bring a bright future for animal attraction in Europe!

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Title (Conservation work in a protected forest using draft horses) – J. P. Marnoto.

Figure 1-3 – J. B. Rodrigues/FECTU.

Author info
João B. Rodrigues
Chairman of the FECTU (European Draft Horse Federation)
E-Mail: joaobrandaorodrigues@gmail.com
Web: https://www.fectu.org/
Digital paper: https://www.youtube.com/watch?v=XJumPkTY-n0
The article is a transcript of the digital paper.

Author info
Pit Schlechter
Vice-President of the FECTU (European Draft Horse Federation)
E-Mail: pit.schlechter@fectu.org

Epilogue

Astrid Masson

For the first time, several hundred people from all over the world met to discuss the topic of working animals. These participants contributed and discussed a broad spectrum of the diverse uses of draft animals. There were impressive pictures of cattle, various equines, reindeer, camels and dogs. These working animals helped with transport, soil cultivation, sowing and harvesting, threshing, haymaking, forestry work and viticulture. The animals were used as pack or draft for fetching water, for municipal refuse collection and also for hobby purposes. Historians and archaeologists provided information on the past, practitioners on the present, and not only the concluding discussion focused on the future of working animals.

***Figure 1** – Hay transport using oxen in rural Romania*

The exchange brought us a big step forward. Apart from getting to know each other and encouraging each other, the following important realizations for future work emerged from the conference:

1. The use of working animals is very sustainable in relation to working with machines, in more ways than one. They are cultural techniques that meet many of the UN Sustainable Development Goals - both environmental & climate, social and economic.
2. Although working animals play an important role worldwide, they are not valued or even noticed. They are often seen as antiquated. At best there is a romanticized image, at worst the image is of poverty and hardship for both humans and animals. In any case, the above-mentioned advantages are not recognized.
3. People whose prosperity does not depend on working animals, who have chosen to do so voluntarily and frequently as a result of working with machines, almost always cultivate very high regard for the labor and their animals. People who depend on draft or pack animals, and often work in traditional ways, sometimes perceive their work itself as inferior and backward. The lack of appreciation can have a negative impact on animal welfare, too.
4. There is a lack of development of modern equipment and harnesses.

One of the most important tasks is to correct the negative image of working animals worldwide; only when positive images are seen, will draft animal power to be given the appreciation it deserves. It is only when there is positive impressions are introduced will the above-mentioned advantages become more evident. In the final session, Timothy Harrigan, therefore, recommended shifting the focus away from the animals and more towards the highly contemporary ecological and social aspects that underpin our work.

***Figure 2** – Plowing with a team of draft horses on a research field for animal traction in Lorsch*

During the conference, many of these aspects were listed, some of which are reflected in the UN Sustainable Development Goals:

Ecological aspects of using working animals compared to using machines: Biodiversity, species and climate protection, clean energy.

- Draft animals compact the soil less than machines, both in forestry and on arable land and grassland.
- Draft animal handlers tend to manage smaller farms; this creates or maintains smaller landscape structures that also increase biodiversity.
- Many working animals belong to endangered, native livestock breeds - their conservation contributes to biodiversity.
- Unlike tractors, working animals reproduce themselves.
- Almost all working animals are grazers; instead of fossil fuels, they use renewable raw materials as their fuel.
- Fodder plants can be obtained from grazing areas such as steppes, slopes, or marshes, where no food for humans can be grown. Pasture is an effective CO2 sink, and keeping the land open promotes biodiversity. Alternatively, they utilize green manure or forage, which contributes to more diverse crop rotations and higher soil fertility.
- Draft animals create valuable “fertilizer” (manure). This fertilizer also adds to greater biodiversity because, in addition to our crops, it nourishes soil life and other organisms.

- Unlike mineral fertilizer, manure enriches the soil with organic matter. This builds up humus and stores carbon in the soil, which is good for the climate.
- Because the soil is usually worked more gently, there is less soil erosion and less disturbance of soil life.
- With admittedly higher labor input, working animals create a high added value with relatively little input.

Social aspects of using working animals: Poverty and hunger alleviation, less gender inequality, independence, affordable clean energy, decent work, health.

- In many regions, fetching water is the exclusive task of women and children. Donkeys can support them in this hard work. Therefore, owning a donkey empowers women.
- Fieldwork in the Global South is often done by women using only a hand hoe. Donkeys or even oxen, which do the heavy lifting for them, can make the difference between poverty and modest prosperity.
- With a draft animal, a larger area can be cultivated than by hand. Surpluses can be sold on the market. Increased food security and better health have been repeatedly demonstrated by this larger area cultivation.
- Working animals can be maintained with local resources, unlike machinery. Independence from industrial markets such as fuel, expensive machinery and spare parts also contributes to higher food security.
- Draft animal workers become more familiar with their own soil qualities and topographic issues because they experience every meter (or foot) of their land.
- Draft animal workers become very aware of the tractive force(s) exerted, which raises energy awareness.
- Many people who work with draft animals find the work with the animals physically and psychologically enriching and valuable. Instead of sitting on a noisy tractor emitting pollution, one moves in the fresh air doing a meaningful activity.

But how do we get out of the role of backward exotics?

The topic of working animals may seem rather out of touch for anyone not directly involved in it. Many of us know the phenomenon of "feeling like an alien in the room" (quoting João Rodrigues) when talking about the draft or pack animals - even in ecologically thinking and working groups.

We need a comprehensive outreach strategy to discuss all the elements discussed above.

To outreach to the wider world, we need intensified communication and better exchange among ourselves. This conference was an important step towards reaching this goal.

Through presentations and courses with draft and pack animals, many people can be reached on a regional level. Articles, social media posts, books and other publications on the topic can reach additional interested people. Conferences, fairs and other events can also communicate to politicians and other decision-makers a regional, national and international levels.

We could potentially develop an international certification “logo” or mark for food produced with working animals. Having a logo mark could increase appreciation of sustainably-farmed food products. This logo could combine with Claus Kropp's idea to apply for draft animal work as a UN World Heritage Site.

Last but not least, we need to work on animal welfare and the development of modern equipment. Tillers International in the USA and Prommata in France, which collaborate with small-scale farmers in developing countries to improve food security concerns in their communities, and Paul Schmit (Schaff mat Päerd) in Luxembourg who develops tools for draught animals for small-scale farmers are already doing pioneering work in research, development and training.

When it comes to animal welfare, caring for people, animals and the environment should be considered jointly. Organizations like "The Brooke East Africa" have already recognized a connection between these elements and are helping with veterinary services in a bundle with counseling for humans and animals.

So there is a lot to do!

Our cattle, horses and other working animals have been drivers of progress for thousands of years. Perhaps our draft animals can once again support us in the fulfillment of modern-day progress with their beauty, wisdom and strength.

After this conference, we have a new feeling of solidarity within the working animals' community - and we have growing anticipation for the next conference.

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Figure 2 – Staatl. Schlösser und Gärten Hessen.

Author info
Astrid Masson
Head of Agriculture Domäne Dahlem
E-Mail: masson@unisoftware.de

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Editors
Claus Kropp M. A.
Lena Zoll M. A.

Layout Design
Michael C. Thumm
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P. Starkey

Order
Staatliche Schlösser und Gärten Hessen
Schloss, D-61348 Bad Homburg v. d. Höhe
info@kloster-lorsch.de

Contact
UNESCO Welterbe Kloster Lorsch
Nibelungenstraße 32
64653 Lorsch
Tel: +49 (0)62 51-86 92 00
Fax +49 (0)62 51-86 920 29
info@kloster-lorsch.de

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Draft Animals in the Past, Present and Future

For millennia, draft animals played a key role in the survival of many cultures. Even today, draft animals still secure the livelihood of millions of people around the globe. Be it in transportation, agriculture, or forestry: draft animals can offer sustainable, ecofriendly and economically valuable ways of land use. Nevertheless, there are a lot of challenges, be it the pressure of high-profit markets or politics, in animal welfare, breeding and harnessing. Furthermore, the total number of draft animals is declining. In 2021, an international and virtual conference has addressed these challenges. Participants from more than 20 countries around the world discussed the history, preservation, education and future of draft animals. The conference proceedings presented here represent a comprehensive result of these efforts.

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