



Review Article

A Review on Draught Animal Research in India: Constraints and Future Thrust Areas

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ABSTRACT

Even though mechanization in agriculture caused a declining trend in the population of draught animals, they continued to be the major renewable and sustainable power source for Indian agriculture. Various researches have been carried out in different fields for the improvement of work efficiency of draught animals. It includes mainly characterization of draught breeds and their genetic improvement by breeding as well as molecular genetic tools, and studies on physiological, hematological and biochemical parameters. Improvements were also made in the design of equipments for the effective utilization of draught animal power in production and processing of various agriculture products as well as for transportation. In addition to these, various instruments also has been devised for the proper measurement of draught power. The important constraints in draught animal research include lack of a systematic and proper breeding programme for improvement of draught breeds, intense crossbreeding for high milk production, feed and fodder constraints as well as economics of rearing. Future draught animal research should be focused on the improvement of draught animal as such or improvement of equipments.

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INTRODUCTION

Livestock have been used in agriculture for thousands of years supplying energy for crop production in terms of draught power and organic manure. But due to mechanization in agriculture, the role of animals in crop production became less relevant. But in a country like India where 78% of farmers have less than 2 ha of area for cultivation, the question whether the use of tractors and tillers are economical put forward the importance of draught animals in agriculture. The use of animal power is inevitable in some conditions like slushy and water logged, hilly and narrow terraced fields, where tractors and tillers are not suitable. Animal drawn vehicle are suitable for rural areas under certain circumstances viz, uneven terrain, small loads for small distances where travel time is not important (Ramaswamy, 1985). In-spite of high urge for mechanization among farmers, the energy for ploughing two-thirds of the cultivated area and two-thirds of rural transport are coming from animals in India (GOI, 2008). So the role of animal traction is still proved to be vital for food security and economy of small holder farming systems in India.

Animal draught power was the first supplement to human energy inputs in agriculture. The draught power of an animal depends on the species, breed, sex, size, body weight, nutrition and health, environment, training for work and terrain conditions. Cattle and buffalo are the species predominantly used in agriculture operations to pull agricultural implements and devices, Equines, camels and elephants are also used to a certain extend. Draught animal power refers to the muscle power of draught animals used for the various tasks like pulling agricultural implements, hauling carts, giving motive power to devices such as water pumps, cane and seed crushers, and electricity generation equipment, carrying loads on the back, as

pack animals, handling, dragging and stacking timber logs in forests and hauling sledges in snow-covered regions (Ramasswamy, 1994).

Draught animal power is one of the 14 renewable sources of energy listed by United Nations Conference on New and Renewable sources of energy held in Nairobi in 1981, as it can be replaced by breeding and rearing in the required number. It is sustainable too, because the animals derive their energy for work from feed and fodder made available from agricultural products. Though mechanization helps to increase the agricultural production in an accelerated way, it is also associated with emission of greenhouse gases like carbon dioxide and other trace gases due to burning of fossil fuels. So on environmental view point, working animals saves natural resources, fossil fuels and prevents emission of greenhouse gases (Dikshit and Birthal, 2010).

The aim of this review is to provide an overview of the past researches done in the field of draught animal power especially in cattle and buffaloes over the past five decades. Furthermore, an earnest attempt has also been made to identify the constraints and future scope of draught animal research in India.

Population of Trend of Draught Animals in India

The population trend of working cattle and buffalo bullocks from 1972 to 2007 are presented in table and Fig 1. A sharp decline in the population of work animals was seen between 1972 and 1980. Between 1982 and 1992, even though there was a growing tendency, the trend again reversed in the following years. In the last few decades, population is seemed to be static. There was a decline of more than 20 million number of working animals at all-India level between 1972 and 2007. Reason was mainly by the rapid mechanization of agricultural operations

and the preference of small farmers to hire tractor as it is more economical.

Table 1: Population trend of working cattle and buffalo bullocks from 1972 to 2007

	1972	1982	1987	1992	1997	2003	2007
Cattle	73.2	61.1	63.6	70.3	55.8	54.3	53.3
Buffaloes	7.6	7.3	6.8	7.4	6.8	5.8	5.6
Total	80.8	68.4	70.4	77.7	62.6	60.2	59.0

Source: Livestock census 1972, 1982, 1987, 1992, 1997, 2003 and 2007.

The contribution of animal power to the total power availability to the agriculture in 1971, 1981 and 1991 were compared in Table 2. From the table it is clear that per cent contribution by draught animals is significantly reduced from 61 to 23 between 1971 and 1991. But the point to be noted that absolute contribution almost remained unchanged through these years, indicating the continued role of draught animals in Indian agriculture. It has been estimated that as a result of mechanisation, the share of agricultural workers continuously declined since 1981 and expected to be only 5.09 per cent by 2011-12 and that of draught animal power from 27.23 to 6.37 per cent in same period (Kulkarni, 2005).

Table 2: A comparison of contribution of Mechanical Power to agriculture from draught animal human and machines

Source of power	1971		1981		1991	
	Power (mw)	% in total	Power (mw)	% in total	Power (mw)	% in total
Human	8385	18.7	10951	12.4	12906	10.1
Draught animals	30426	60.5	31556	35.8	29840	23.3
Machines	10487	20.8	45699	51.8	85226	66.6

Source: Adapted from the Report of the Steering Group on National Livestock Policy Perspective, 1996, Department of Animal Husbandry, Ministry of Agriculture, Govt. of India

Characterization and Genetic Improvement of Draught Breeds

India is bestowed with rich genetic biodiversity of 37 cattle breeds, 10 buffaloes, 40 sheep breeds and 20 goat breeds. Mainly bovines in India are kept for the dual purpose of draught power and milk: mainly cattle for draught power and buffaloes for milk. Many Indian cattle breeds enter the draught category, because cattle development in India has principally based on production of bullock energy required for conventional agricultural operations and load pulling (Pandey *et al.*, 2006). These breeds yield very low milk as low as 0.5 to 1.5l per day per animal. The best Indian dairy, draught and dual-purpose cattle breeds are found mostly in the north-western region. Some good draught breeds also exist in southern peninsular region. Out of the 37 breeds of cattle in India, 22 were classified as draught breeds, 11 dual purpose and 4 milch breeds.

Performance evaluation, phenotypic and molecular characterization of draught breeds have been carried out independently by various researchers (Metta *et al.*, 2004, Pandey *et al.*, 2006a, Pandey *et al.*, 2006b, Karthickeyan *et al.*, 2006, Sharma *et al.*, 2006, Sodhi *et al.*, 2007, Karthickeyan *et al.*, 2007, Singh *et al.*, 2008, Gokhale *et al.*, 2008, Sharma *et al.*, 2008, Mukesh *et al.*, 2009, Thakur *et al.*, 2010, Sharma *et al.*, 2010, Thiagarajan and Thangaraju, 2011). Draught cattle breeds vary greatly in their body measurements, for example, Nagori, Khillari, Halliker, Amritmahal and Kangayem are tall and relatively large sized breeds where Umblachery, Punganur and Vechur are dwarf breeds (Joshi *et al.*, 2005).

So far no systematic and specific genetic improvement programme has been initiated exclusively for draught cattle.

Most of the breeding programmes are for improvement of milk production. Project Directorate on Cattle (PDC), Meerut has started an All India Co-ordinated Project (AICRP) on Cattle Indigenous breed Project, in which genetic improvement of Ongole and Hariana was initiated by establishing germplasm units and a number of associated herds (Annual Report, 2011-12). At a later stage Hariana breed was withdrawn. Besides performance evaluation, the Indigenous Breeds Project envisages progeny testing of bulls, their selection on the basis of progeny performance and production of superior germplasm for utilization in cattle development programs in the country. The quantification of the draft capacity of about 2 to 3 young bulls per sire was also done at the respective germplasm centers. So far 65 bulls in 8 sets of Ongole breed (Annual report, 2011-12) and 60 bulls in 7 sets of Hariana breed (Annual report, 2008-2009) were used under progeny testing programme and evaluated to find out the elite bulls which will be used for production of future breeding stock. Apart from these sires were evaluated and compared on the basis estimated breeding value of daughter's first lactation milk yield as well as male progeny's draughtability parameters in Hariana breed. The rank correlation between estimated breeding values was found to be -0.5 indicating these two traits (milk and draft) are of different nature (Annual report, 2008-09). The draft studies were also undertaken in Ongole breed, by using single harness plough with digital dynamometer. The draught power varied from 0.64 to 0.84 hp among the Ongole bulls.

Molecular marker studies on the draughtability of various breeds are very limited in India and abroad. Molecular investigation of glutathione peroxidase-1 (GPX-1) gene in Malvi and Nimari cattle (*Bos indicus*) for draught capacity have been carried out by Singh *et al.* (2011) and Jagtap and Singh (2012) and found out a polymorphism which had significant effect on draughtability of animals.

Performance Evaluation of Draught Animals

It is very much essential to assess the draft capacity of local bullocks for proper design and development of implements for their adoption by the farmers (Dhakane *et al.*, 2010). Various factors had influence on the draught performance of bullocks which include animal size, weight and conformation of the body, leg co-ordination, and body structure qualities. The amount of work, an animal or team of animals perform on sustainable basis is referred as work performance (draughtability) of animal. The work output of animal varied as per the draft, speed and duration of work. Therefore, draughtability assessment of animals is determined by recording the draft, speed and duration of work without being fatigued. The draught characteristics of animals are usually defined by the weight matrix of the animals. Generally this is 8-10% of the body weight in cattle and buffaloes. There is no comprehensive data on draught animals as per their body weight at national level. It is evident that 41% of the draught cattle population was small in size (with body weight group of 200-300 kg) and 44% in the medium range (body weight 300-400 kg). Only an estimated 11% were large (body weight 400-500 kg) and 4% heavy with body weight over 500 kg (Singh, 1999). Various studies have been done about the weight matrix of draught cattle on various conditions (Devadattam and Maurya (1978); Rautaray and Srivastava (1983).

Other important parameter to measure the performance of animal is based on the speed and it was observed that speed of the bullock declined linearly over passage of time. The working speed was determined by calculating the total distance covered during one hour of work. Singh *et al.* (1970), Roy *et al.* (1972), Acharya *et al.* (1979) had tried independently to estimate the average speed of both crossbred and indigenous bullocks. Devadattam and Maurya (1978) tried to estimate the optimum

speed of Haryana bullocks and it was found to be 3.8km/hr with draught of 60kg. Decrease of speed had been reported by, Upadhyay and Madan (1985) and Adkine *et al.* (1977), as the draught and duration increased. Another measurable parameter is power output which is a function of speed of bullocks.

Draught animal power can be measured in Horse power (hp) which is calculated by multiplying speed (in feet per second) by the force exerted (in pounds per second), and dividing the resultant by 550. A typical draught animal can exert a force of approximately 120 pounds per second while walking at 3 feet per second. Using this formula, the power of an average draught animal is approximately 0.66 hp.

Another important draughtability characteristic is animal fatigue parameters under load. Usually draughtability experiments are conducted by varying the draught loads on animals and studying their effect on speed and fatigue levels under continuous work. The 'fatigue levels' of the animals are quantifiable parameters based on body temperature, respiration rate, pulse rate and speed) It can be determined depending upon qualitative symptoms such as frothing, incoordination of legs, excitement, inhibition of progressive movements and tongue protrusion (Upadhyay and Madan, 1987). Based on physiological reactions, distress symptoms and behavioural manifestation, Upadhyay and Madan (1987) developed a fatigue score. For oxen and buffaloes the maximum points assigned were 40 and at 50% of the maximum score points animal is considered to be fatigued. Another factor which cause fatigue in animals is environmental stress (temperature and humidity) which further adds on stress to animals resulting in reduction in walking speed while working. In general the average speed of the animals during hot and humid season was lower compared to winter and summer (Singh, 1999).

Studies on Physiological Parameters, Hematological and Biochemical Parameters

Various researches have been carried out in draught cattle to find out the effect of working hours on the change in the physiological parameters of the animals (Mukherjee *et al.* (1961), Singh *et al.* (1968a), Rao and Upadhyay (1984), and Anil and Thomas (1996). It has been found that the age and weight groups of the bulls had significant influence on respiration rate (RR), pulse rate (PR) and rectal temperature (RT) before carting but the per cent increase in PR and RT after ploughing was significantly affected by the age of the bulls but not by the weight (Vinoos *et al.*, 2010). The relationship among the draught capability, and work output in relation to the age and body weight was studied for the Malvi and crossbred oxen (Singh and Singh, 2009) and identified a critical age group of 4.5 - 12 years to derive the maximum work output. It was observed that all the parameters like pulse rate, respiration rate and body temperature will increase with the period of work and the magnitude of change will be more during the initial periods when compared to the later. Increase in pulse rate and respiration with duration of work and draught were due to higher metabolic rate and thermal stress to supply more energy to muscles and dissipate the heat load. Vasodilatation of subcutaneous blood vessels during exercise causes increased blood flow through skin which was met by increasing cardiac output through increase in heart rate. The increase in body temperature with duration might be due to more heat produced on account of increased lactic acid production by the muscles and its removal by oxidative process. This is in agreement with the findings of Devadattam and Maurya (1978) and Chhikara and Singh (2000). The rise in temperature can be also accounted as a physiological necessity to increase the rate of chemical process to decrease internal friction resistance in muscles and to supply oxygen to the working muscles. Season

and atmospheric conditions also plays a significant role in the change in these parameters during work. The higher RR, BT and PR were observed during summer and lower during winter (Nagpul *et al.* (1984) and Rao and Upadhyay (1984) other factors like breed group, type of work and duration of work also had a significant role in physiological parameters. From various studies it is clearly concluded that crossbred bullocks are affected easily which is evidenced by higher physiological parameters and fatigue symptoms at an early stage when compared to indigenous cattle breeds (Maurya and Devadattam, 1986; Bhosrekar and Mangurkar (1989); Bijendrakumar *et al.*, 1996; Yawlikar *et al.* (2005).

It has been clearly proved by various researchers that there is significant variation in hematological and blood biochemical values during exercise as well as during working. Haemoglobin and other haematocrit values tend to be decreases after the performance of exercise (Singh *et al.* (1968b); Upadhyay and Madan (1988) and Chhikara and Singh (2000). The physical work causes a significant reduction in blood glucose level and elevation in blood lactic acid resulting in change in blood acid-base balance (Nangia *et al.* (1978) and Choudhary and Madan (1985). The rise in blood lactic acid concentration could be due to increased anaerobic muscular activity, greater activity being at higher intensity of loads. As in the case of physiological parameters, the indigenous breeds showed lower difference when compared to crossbreds, indicating their higher efficiency to be used as draught animals (Yawlikar *et al.* (2005).

Improvement in Design of Equipment

In most developing countries, animal-drawn implements, carts and devices are of crude, traditional design, with very little improvement having been made for centuries. Efforts have been made for improvement of yokes and harnesses, crop production equipment and agro-processing machinery. Improved crop production equipment have high area of coverage and lower cost of operation in comparison to existing size of implements with an increased power output of 30-70% (Singh, 1999). Bullock drawn sprayer has been devised and evaluated for application of chemicals in field (Singh *et al.*, 2009). With a view to increase the annual utilization and overall efficiency of draught animals, an ad-hoc project from Agricultural Produce fund in the name of "Coordinated Research Programme on Increased Utilization of Animal Energy with Enhanced System Efficiency" was started in January 1985 by the Indian Council of Agricultural Research (ICAR) at the Central Institute of Agricultural Engineering, Bhopal, India which was later converted into a regular all India coordinated research project from 1st July 1987. This project has undertaken various draughtability studies and developed various equipments for the effective utilization of draught animal power in production and processing of various agriculture products as well as for transportation. A prototype animal powered electricity generator, the "designed power mill" has also been proposed with negligible running cost (Paras *et al.*, 2012)

Instrumentation for Draught Animal Power Research

Measurement of the draughtability is one of the major limitations in draught animal research. All India Coordinated Research Projects on Utilization of Animal Energy in Agriculture has also undertaken this issue and various devices have been developed and used for measuring the draughtability of animals. Mainly loading devices, loading cars (Srivastava and Pandey (1992) and Singh and Singh, 2003) are used for this purpose. But, according to the load and tiredness the animal adjusts his speed and therefore onset of fatigue conditions get delayed and assessment of actual draughtability of animal at particular load and speed under sustained working conditions become difficult in loading devices and loading cars. To

overcome this limitation animal treadmill (Singh and Srivastava, 2006) has been devised which are portable and can be used for the laboratory studies on draughtability and fatigue of draught animals.

Constraints in Draught Animal Research

In spite of the recognition of the role of DAP in sustainable food production and income generation in rural areas, very limited research and development activities have been done in India. Even though majority of cattle breeds in India are developed over centuries as draught breeds, they have not given enough consideration and are being neglected due to various constraints. Most important among them is lack of organized herds for specific breeds. Performance evaluation and systematic recording of draught power of these animals cannot be done routinely as the parameters which are to be used are not easily measurable. Most of the bulls used for work in the field are castrated ones which restrict them from using breeding programme (Joshi *et al.*, 2005). So bringing about genetic improvement through a planned breeding programme is always limited by these factors.

The economics of rearing draught animals is one of the major constraints to rear these animals. Mechanization in agriculture and the availability of petrol based equipment along with declining trend in the population of draught animals became another important constraint in the research. A large proportion of these animals belong to farmers who have limited resources and cultivate small areas of land. They are mainly reared by waste residues. Insufficient feed and work often end up with various disease conditions and reduction in the performance of animals (Ramaswamy, 1994). Lack of infrastructural facilities like credit, insurance also does not motivate the maintenance of draught animals.

Due to the urbanization and high demand for milk, it became necessary to import high yielding dairy breeds like Brown Swiss, Jersey and Holstein Friesian for crossbreeding our indigenous cows to improve milk production. The males of the crossbred animals were not physically or economically efficient as the quality of indigenous draught breeds (Rajapurohit, 1979). It is already accepted that this movement of crossbreeding has resulted in the substantial improvement in the yield of cows, but with some unfortunate impacts like total negligence in the genetic improvement of draught animals. The fodder constraint caused further negative impact in the developmental programmes of these draught breeds.

Future Thrust Areas in Draught Power Research

Future research areas in draught power can be taken up by different agencies as the draught power can be improved either through animals as well as implements. Improvement of draught animals can be addressed through proper breeding, feeding and management of animals. Another strategy to increase the performance of animals by using improved agricultural implements. So the future research areas have to address either one of these two issues.

- Though India has many proven breeds of draught cattle, very little efforts have been taken up for their development. It is need of the hour to formulate specific breeding policy for draught animals and implement various genetic improvement programmes. Assessing the draughtability of various breeds also has to be undertaken as various breeds differ in their body measurements and their performance. Various molecular researches have to be carried out to identify the genes responsible for draughtability in animals. Association studies between molecular information and draughtability measures will surely open a new way for improvement of these animals.
- Poor feed and nutrition is one of the factors affecting the performance of draught animals. Draught animals are

usually fed with feed and fodder residues which will not meet their energy requirement. Studies have to be undertaken for assessing the energy expenditure and nutrient requirements of draught animals. Smallholder farmers who are the owners of majority of draught animals are generally reluctant to spend money feeds or feed supplements for draught animals. So the researches for a low cost feed which can meet the requirements of draught animals have to be taken up.

- The use and researches involving new reproductive technologies will help to conserve the rich biodiversity as well as rapid multiplication of elite animals. Various reproductive problems have to be addressed and proper management measures have to be undertaken.
- In the changing climatic scenario, researches related to the role of draught animals in climate resilient agriculture systems have to be carried out.
- The possibility of cow traction technologies in the field has to be explored wherever possible as only less than 2% of cows are used for work, and only in a few eastern and southern states such as Assam, West Bengal, Orissa, Bihar, Andhra Pradesh and Tamil Nadu (Singh, 1995). The use of dairy cows for traction could benefit total farm output and incomes through milk production, as well as by avoiding unnecessary feeding of draught bullock year-round.
- Socio-economic studies have to be undertaken for assessing the socioeconomic situation of farmers and their attitudes in utilizing draught animals. Economic evaluation of draught animal power utilization in comparison to mechanization also should be carried out.
- Standardization of measures of draught animal power is another prime area of importance of research.
- Enhancing power availability from draught animals through draughtability studies and scheduling proper work rest-cycles as well as by adoption of package of matching implements
- Evaluation of animal transport system for different regions and improvement in the design of animal carts for centralized manufacturing of critical components.
- Role of extension activities in the efficient technology transfer of draught animal power.

Conclusion and Way Forward

The mechanization in agriculture questioned the need for further research on improving animal power efficiency in the last few decades. But now, due to the recognition of benefits and importance of draught animal power in Indian agriculture, there is a rethinking on the development of these precious genetic resources. Therefore, a fresh look is needed from the policy point of view which will recognize the importance of draught breeds and put forward options for improvement of draught animal power. It is sure that draught animal power has been an integral part of traditional agricultural systems for thousands of years in India and will continue to in future years also.

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