DRAUGHT EFFICIENCY OF ASIAN ELEPHANTS *(Elephas maximus indicus)*

By

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THESIS

Submitted in partial fulfilment of the requirement for the degree

Master of Veterinary Science

Faculty of Veterinary and Animal Sciences

KERALA AGRICULTURAL UNIVERSITY

Department of Livestock Production Management

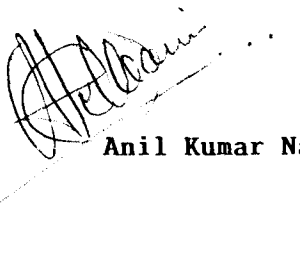
COLLEGE OF VETERINARY AND ANIMAL SCIENCES

MANNUTHY - THRISSUR

1996

DECLARATION

I hereby declare that this thesis entitled "**Draught efficiency of Asian Elephants (*Elephas maximus indicus*)**" bonafide record of research work done by me during the course of research and that this thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title of any other University or Society.



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Certified that this thesis entitled **"Draught efficiency of Asian Elephants (*Elephas maximus indicus*)"** is a record of research work done by **Sri. Anil Kumar Nair** under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to him.

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TO

MY LOVING PARENTS

ACKNOWLEDGEMENTS

I wish to express my heartfelt gratitude and indebtedness to **DR. P.C. SASEENDRAN**, *Associate Professor, Department of Livestock Production Management and Chairman of my Advisory Committee for his constant encouragement, valuable suggestions and critical advice throughout this work.*

I am indebted to **DR. T.G. RAJAGOPALAN**, *Professor and Head, Department of Livestock Production Management,* **DR. C.K. THOMAS**, *Professor, Department of Livestock Production Management and* **DR. M. NANDAKUMARAN**, *Associate Professor, Department of Animal Nutrition for their valuable advice, constant encouragement and timely help as members of the Advisory Committee throughout the course of this work.*

I express my sincere gratitude to the Kerala Forest Department for providing elephants for my experimental work. I am also thankful to Mr. Bharathi Balan of Kozhikode who in his personal interest had been very helpful to accord permission to utilize his elephants for this work.

I am grateful to Dr. K.C. George, Professor and Head, Ms. Santa Bai, Senior Programmer and Mr. K.V. Prasad, Junior Programmer, Department of Statistics for their help in the statistical analysis of the data.

Grateful acknowledgements are made to the staff of the Department of Livestock Production Management and Post-graduate students for the help rendered during the period of my study.

I am grateful to the help received from Dr. P.V. Raju, M.V.Sc. Veterinary Surgeon, Kodanadu; Dr. Vinodkumar, Veterinary Surgeon, Balussery; Ms. Shreeja, K.R., Research Associate, Department of Livestock Production Management for carrying out this work. I am gratefully indebted to the kind help.

My thanks are due to all the courageous and helpful mahouts of elephants of Kodanadu and Muthanga Forest Range with special appreciation to Mr. Radhakrishnan, Mr. Mohammed and Late Mr. Balan.

I am indebted to my family and Leena under their kind care and affection I could reach to this stage.

I am also thankful to the Dean, College of Veterinary and Animal Sciences, Mannuthy for providing the facilities to undertake the present study.

I would also like to express my sincere thanks to Dr. Anil, Dr. Biju, Dr. Kuruvilla, Dr. Tony, Dr. Ramakrishnan, Dr. Reny, Dr. Ralston, Dr. Manju,

Dr. Sandhya, Dr. Kumaravelu, Dr. Sudheer, Dr. Dinesh, Dr. Sulfikar, Dr. Sunil, Dr. Vidhyadharan, Dr. Nandakumar, Dr. George Varghese, Dr. Manoj, Dr. Sanjay, Dr. Vigil, Mr. Sudhakaran, Dr. Vyas and other friends for all the help and co-operations rendered from time to time.

I also thank Mr. R. Noel for his generous help in preparing the manuscript.

ANIL KUMAR NAIR

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INTRODUCTION

INTRODUCTION

The relationship between man and elephants has existed long before recorded history. Man has utilized this massive pachyderm as an instrument of war, a means of transportation, a hunter, a draught animal, parade animal and for display and entertainment. To manipulate an animal of such gigantic size requires special training of the animal and a close and supportive association between the elephants and its trainer.

The varied cultures of India used elephants as beasts of burden and draught animal. An abundant supply of elephants existed over much of Indian subcontinent. Drawings found on pottery uncovered in the Indus valley indicates that elephants were managed as work animals as early as 3500 BC.

As beasts of burden, elephants are still an integral part of the logging industry in south-east Asia. They can penetrate the teak forest where equipment cannot and the big tusked males can easily move logs.

The paradox of the Indian elephant, like its other Asian counterparts is that it is familiar in ceremony and mythology but endangered in the wild. The Asian elephants (Elephas maximus) numbers about 55,000 half of which live in India under a constant threat of habitat destruction.

Unlike the large herds of the African elephants (Loxondonta africana) which boasts a population of 600,000 supported by the vast savannah grasslands, the Asian elephants have been condemned by food scarcity to live in small groups which also makes it vulnerable to epidemics and the hazards of inbreeding.

There are about 6,000 captive elephants in India the bulk of them in national parks, sanctuaries and zoos. With reduction in timber felling, elephants owned by the forest and wild life departments were being diverted for ecotourism joy rides and patrolling. "A working elephant costs a state at least Rs.80,000 a year for food, veterinary care and mahout's pay. A captive elephant is given moderate work till the age of 25. Between 25 and 40 years, it does maximum work. After 40, its load is tapered off and it is retired at 60 (Krishnamurthy, V.).

Interestingly no fair or festivity, political or religious show, in Kerala is complete without a parade of elephants. The hire charges for an elephant is Rs.5,000/- a day, with food and medical care extra (Krishnamurthy, V.).

The market price of an elephant ranges from Rs. 3 lakhs to Rs. 6 lakhs making it a status symbol and a good investment rolled into one.

Absolute measurements of the work output of elephant is of little comparative value since their inefficiency is accepted as a necessary drawback to their use. Alternative sources of power in situations to which elephant are suited are expensive

and in many cases their use would be impractical. For example, access to mountainous forests for elephant is effected more easily than for mechanical equipment and the combined use of elephants for dragging log to rivers or roads where they are further transported by floatation or trucking may be most economic alternation in many cases. The elephant is therefore destined to play a continuing role as a working animal in the forests of developing countries like India.

Even so, no systematic study has been carried out to estimate the draught power of elephants for a scientific exploitation of draught potential of this species. The present work envisages to assess the draught potential and endurance of elephants to work with the following objectives:

i) To determine body weight, sex and age of elephants

ii) To estimate rectal temperature, respiration and pulse of the elephant during rest

iii) Weight of log and duration of hauling by each elephants during different schedules of work

iv) Recording RBC count, WBC count, Haemoglobin, ESR, PCV, MCH, MCHC, MCV during rest and immediately after each schedule of work

v) Rectal temperature, pulse and respiration after each schedule of work

vi) Signs of stress and fatigue after each schedule of work

vii) Estimation of relevant haematological parameters such as glucose, serum protein, serum creatinine and minerals like calcium and phosphorus

The knowledge gathered would be used as a yardstick to formulate the managemental measures to meet the higher body requirements of draught elephants. The information can also be used to make improvement on the hauling implements, so as to utilize elephants more effectively and efficiently without causing much injury to its body. In the absence of adequate knowledge of draught potential of the elephants, at present the elephants are being either underutilised or over exploited to the extent of causing fatigue and some times even death.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

Work Output

Work is done when there is transference of energy that is produced by the motion of the point of application of a force and is measured by multiplying the force and the displacement of its point of application in the line of action. Work in the strict sense of "Force exerted x distance through which the force is moved" is done by animals only under certain circumstances like (i) walking uphill and (ii) pulling against some external force. However, the term "work" has a more practical definition in the case of animal draught, it consists of "all activities which reduces an increase in energy expenditure".

Treadmills have been used traditionally for making simultaneous measurement of work output and energy expenditure for controlled experiments (Lawrence, 1985).

Work performance

Collins and Caine (1926) unlike automobiles, the efficiency of work production in horses was known to considerably vary with training, psychology of animal available foot hold and ability of the driver.

The work performance of animals can be measured by quantifying their capacity to generate power. The efficiency of work production in animals is closely related to the energy consumed, retained, energy expanded and environmental conditions (Broody, 1945).

Rai *et al.* (1982) Haulage capacity of he buffaloes is reported to the better than bullocks but it has not been accurately quantified.

Mack and coworkers (1987) reported that performance in relation to body weight was higher for the crossbreed than for the local purebreds.

Upadhyay and Madan (1987) indicated that the work efficiency of Hariana bullocks was higher than that of crossbreeds, however it reduced by continuous work.

As regards to draft potential of the animal in relation to body size, information available is meagre.

Literature available on the Indian elephants is confirmed mainly to its military use, ailments, anatomy, capture, reproduction in captivity, urinary, milk and blood constituents and diagnosis and treatment of parasitic infestations (Evans, 1901; Simon, 1961; Nirmalan *et al.*, 1967; Nirmalan and Nair, 1969).

For measuring of work performance in animals the following points had to be used as critesise such as the maximal load drawn by the animal (expressed as percentage of their body weight), time taken for performing a specified work, period of continuous working without break (endurance) and changes in the physiological responses (Mukherjee *et al.*, 1961; Swamy Rao, 1964; Singh *et al.*, 1968a; Singh *et al.*, 1970; Rao *et al.*, 1974; Acharya *et al.*, 197, Upadhyay, 1987).

Draft development

No references regarding draft generated by elephants can be traced out. However measurement of draft developed by cattle and buffaloes has been carried out by many scientists. According to Maurya and Devadattam (1982b) draught can be measured by:

$$\text{Draught} = \text{Load} \times \text{Cos}\theta$$

Singh *et al.* (1970) the application of draught from an animal for pulling a particular implement depends on several factors. The important factors are animal breed, health, bodyweight, method of harness, training and field working conditions.

Anon (1972) work animals can develop instantaneous draft more than their body weight. For paired donkeys it is 155% and for paired bullocks it varied between 104-115%.

Anon (1972) - The donkeys can develop a continuous draft of 15-20% of their body wight at speed varying from 2.5 to 2.8 km/h.

Maurya and Devadattam (1982a) conducted cart hauling experiments on two Jersey x Redsindhi bullocks to study their work performance using drafts between 11 to 18 per cent of their body weight. Significant difference in their power output was observed, similarly heavier draft resulted in increased power output.

Goe (1983) - For other work animals the draft capacity is not accurately known, but it is estimated to vary in case of mules it is 10 to 16 per cent, oxen it ranges from 10 to 14 per cent of their body weight and elephants 7 per cent of body weight.

Maurya (1985a) instantaneous drafts are not of much practical significance. The range of draft for continuous work was found to vary from 9.5 to 24.5. Percent of the body weight of bullocks with speed varying from 1.91 to 4.95 km/h.

Maurya and Devadattam (1982b) - Horses and mules can pack carry 12-15 per cent at their body weight while this range donkeys and camels is 27-40%.

Mack and coworkers (1987) found that Fresian crosses were superior to the Jersey crossbreds at all levels of draught power.

Agarwal and Agarwal (1992) studied the draught power of four Hariana steers and four Hariana x Jersey by making them pull a cart with different payload (0-2000). The result indicated that 1000 kg was the optimal payload for a single animal and that the crossbreds and Hariana did not differ in drought power.

Duration of work

Anon (1972) - Reported that in tropical climate the duration of work for animals is not likely to exceed 3-6 h without exhausting them. The draft bullocks

work for about 4-5 h a day in tropical Africa. The working hours for draft cattle may consists from 5 or 6 AM in the morning until 11 or mid day. While deciding the hours of work, unduly hot hours must be avoided.

Maurya and Devadattam (1982) tested two Jersey x Redsindhi bullocks individually for 6 hours per day for several days with draft varying from 11 to 18% of their body weight. Though no sign of permanent fatigue was noticed, excessive increase in some of the physiological parameters, particularly at higher draft was observed.

Rai and Hedge (1982) reported that individual he buffaloes can pull a load of 1 tonne at the rate of 3 km/h and easily cover a distance of 25 km/day. Further it is reported that a pair of he buffaloes can pull two tonnes of load for a distance of 30 km in a day. These findings suggest that buffaloes can work for about 8 hours in a day.

Singh and Verma (1987) reported that the camels can be employed for carting with optimum payloads for 6-8 hours with rest pause of 10-20 minutes.

Horse-power developed

The reports regarding the estimation of Horse-power developed by working elephants are very scanty. Therefore references on elephants regarding the generation of Horse-power could not be traced out.

According to Maurya and Devadattam (1982b) horse-power can be calculated by:

$$\text{Horse-power} = \frac{\text{Draught x Metre/sec (speed)}}{75}$$

Singh *et al.* (1970) studied the horse-power developed by sahiwal bullocks (6 to 10 years old) while using three agricultural implements and found out the horse-power developed viz., disc plough - 0.84 HP. Discharrow - 0.63 HP and with cultivator - 0.70 HP.

Maurya and Devadattam (1982a) - A draft of about 80 kg per bullock was found to be optimum to get a fairly uniform and maximum power output of 0.995 hp at maximum possible speed of 3.35 kg/h.

Agarwal and coworkers (1989) conducted studies with crossbred steers trained to pull a cart singly on uphill roads with varying loads of 350-800 kg. The horse-power developed ranged from 0.9 to 2.4 hp. The amount of work done increased with load on tar roads and was highest on uphill roads.

Speed of work

The work carried to ascertain the speed of work in elephants with load is scanty. Therefore references could not be traced. However the average speed of walking with out load in elephants has been estimated, which ranges from 3 to 3.5 km/h (Krishnamurthy, V., 1974).

Singh and coworkers (1970) observed the speed of walking in suluwal bullocks during disc ploughing, harrowing and tilling to be 2.21, 1.98 and 2.21 km/h respectively.

Work requiring high speed can be performed only for a short duration and that too at low draft. Speed have to be kept low if long duration work is required (Anon, 1972).

Upadhyay (1982) the studies revealed that speed of work limit the respiratory frequency hence ventilation volume. The speed has a negative co-relation with respiratory frequency in Zehu and crossbred.

Rao and Upadhyay (1984) used Jersey x Saluwal steers for pulling loads varying from 4, 6 and 8 quintals for 2-3 hours, the steers travelled at an average speed of 4.5, .3 and 3.9 km/hour.

Others investigated various factors such s season, loads pulled, type of work and nature of road surface on walking speed.

Agarwal and associates (1989) speed declined linearly with increased load. It ranged from 7.00±0.30 km/h on a tar road with 350 kg load. On a kutcha roads the speed ranged to 2.00±0.30 km/h with an 800 kg load.

Agarwal and Agarwal (1992) found that when Hariana crossbreds were used to pull a cart with different payloads (0-2000 kg), the speed declined from 9 km/hour for 0 kg payload to 4 km/hour for a payload of 2000 kg.

Sreekumar and Thomas (1990) observed that during dryland ploughing Kangayam bullocks walked at a speed of 1.24 m/sec compared to 1.05 m/sec by crossbreds.

Fatigue

Many workers have defined fatigue as a complex phenomenon. Intensity of work. proportionally loads cardiovascular, pulmonary and thermo regulatory system, which do not fully co-ordinated and as a result after 'chemical milieu' at the cellular level leading to a decreased work output. Various performance limiting factors contribute to fatigue but still do not know how critical these factors are (Srivastava and Ojha, 1987).

Anon (1972) - Fatigue is caused by two much work and results in lowering of physical resistance making the animal more susceptible to disease. Fatigue also has a direct effect on animals as it may cause loss of weight and weakness, which may lead to death from exhaustion.

Devdattam and Maurya, 1978; Acharya *et al.*, 1979; Rao and Upadhyay, 1984. Fatigue was mentioned as only a point based on personal experience and observations with no uniform pattern of evaluation in working bullocks.

In elephants not much work has been undertaken to predict the level of fatigue. The yardstick to formulate the level of fatigue in working elephants is very scanty. Therefore no relevant references could be found.

Upadhyay (1982) reported that during hot season, however crossbred bullocks manifested the signs of fatigue earlier than the indigenous ones and the signs of fatigue could be minimised by allowing intermittent rests.

Many workers have found out that, in addition, climatic factors namely atmospheric temperature and relative humidity also greatly influence the fatigue of animals. It is also reported that the combination of draft and duration of work causes the onset of fatigue in work animals.

Physiological changes

Thomas and Razdan (1973) - Orchatrated muscle contraction and relaxation involved in movement, pulling and bearing load require increased supply of nutrients, and oxygen to the tissues involved. The changes in the physiological reactions are partially a result of these. However while during work the animals are also

exposed to solar radiation and other climatic elements which influence their physiological reaction.

In general working increase rectal temperature at different hours in Hariana and crossbred bullock. The magnitude of rise being higher among crossbreds than Hariana bullocks (Devadattam and Maurya, 1978, Acharya *et al.*, 1979; Upadhyay and Rao, 1984; Upadhyay and Madan, 1985a,b).

Dukes (1977) - Exercise is known to enhance respiration rate (R.R), pulse rate (P.R.) and rectal temperature (R.T.).

Upadhyay and Madan (1985b) reported that rectal temperature rise of 2.5°C above pre-work, normal resting levels must be regarded intolerable and situation aheading towards higher temperature should be viewed in the light of the body's capacity to store heat.

An increase in body temperature of upto 3.5°C was observed in buffaloes while working (Rana *et al.*, 1978; Upadhyay and Rao, 1985; Peterson and Foulkes, 1988).

Pearson (1989b) reported that buffaloes could tolerate an increase in rectal temperature upto 40 to 40.3°C before rapid panting occurred at 41°C they became reluctant to work.

Almost all workers who made such investigations observed an increase in rectal temperature, pulse rate and respiration rate in cattle and buffaloes (Singh *et al.*, 1965a; Ray *et al.*, 1972; Maurya and Devadattam, 1982b; Thomas and Pearson, 1986; Pearson, 1989a and Sreekumar and Thomas, 1990b; Anil, 1994).

The rise in rectal temperature also occurs in buffaloes (Nangia *et al,* 1980; Upadhyay and Rao, 1985).

Rautaray (1987) studied the work output of crossbred, Malvi and local breeds. It was observed that the respiration rate, pulse rate, and body temperature of bullock increased with increase in working period. The variation in body temperature was not noticeable except at higher draft values during the last two hours of operations.

Singh and Verma (1987) - The physiological parameters of camel increases with the increase of payload and duration of work. The rate of increase is faster in the beginning of the work and the rate of increase is slow after two hours of operation. However after 3 hours operation, the pulse rate, respiration rate and body temperature become almost steady with insignificant increase at optimum load.

The excessive increase in the physiological parameters of Jersy x red sindhi (Maurya and Devadattam, 1982); Brown swizz x Saluwal bullocks (Georgie *et al.* 1970) and crossbred bullocks suggest that a rest pause after every 1.5 to 2 hours of work will be helpful.

Pearson (1989b) observed that body temperature started increasing as soon as the buffaloes started working. Upadhyay and Mdan (1985b) indicate that the rise in heart rate occur greater in zebu than crossbred which increase parallel with the rise in body temperature.

Bhosrekar and Momgurkoe (1989) observed that the rise in physiological reactions were higher in Holstein Friesien crossbreds than Jersey crossbreds.

There is progressive increase beyond normal limits in respiration rate, pulse rate and rectal temperature with advancement in hours of carting (Mukherjee *et al.*, 1967; Devadattam and Maurya, 1978; Maurya and Devadattam, 1982; Upadhyaya and Madan, 1984).

Mukherjee *et al.* (1961), Rautray, *et al.*(1982) have shown that the pulse rate, respiration rate and body temperature of draft animals changing with increase in working time at all levels of draft. However when the respiration rate and pulse rate were found to higher than 95 per minute. The animal showed interrupted and staggered walking with diminished response to even painful stimulies.

Adkine *et al.* (1976) reported that the pulse rate of all two breeds of bullocks (deons and red kandhari) tested was significantly higher in second working period than the first span.

Normal Haematological parameters of elephants

In elephants normal haematological parameters have been estimated by Simon (1961), Nirmalan and Nair (1971), Saseendran (1994). The observations on physical and haematological alteration during and after work on elephants are scanty. However the haematological changes due to stress associated with musth have been carried out, in which a significant higher serum creatinine level have been observed by Saseendran (1994).

Nirmalan, Nair and Simon (1967) reported that total erythrocyte count in the blood of elephants is very low compared to the values available for other mammals.

The physiology and biochemistry of elephants even during normal state was poorly understood (Niemuller *et al.*, 1990).

Erythrocyte sedimentation rate (ESR)

The erythrocyte sedimention rate observed in adult elephants were between 30.30 ± 2.90 mm for 30 minutes for 30 minutes (Simon, 1961); Pillai and Nair, 1994; Sreekumar, 1986 and Saseendran, 1944).

Hourly sedimentation rates observed were 29 mm per hour (Young and Lombard, 1967) and 34.6 mm per hour (Brown and White, 1980) in African elephants.

In Asian elephants the erythrocyte sedimention rate of 67.4±2.7 mm per hour in pregnant elephants and 64.5±0.5 mm per hour in lactating elephants (Niramlan, 1967 and Nirmalan *et al.*, 1967) and 51.67±2 mm per hour in baby elephants, 57.41±1.1 to 63.4±5.5 mm per hour in adult males (Nirmalan *et al.*, 1967 and Sreekumar, 1986) were reported.

Total Erythrocyte count

Erythrocyte count reported in elephants ranged from 2.40±0.05 x 10^{12} per 1 to 5.02 x 10^{12} per 1 which was reportedly not influenced by age or sex (Simon, 1961; Bartles *et al.*, 1963; Nirmalan *et al.*, 1967; Young and Lombard, 1967; Usani *et al.*, 1969; Andrewbutter, 1971; Jainudeen and Jayasinghe, 1971; Lewis, 1974; Jain, 1986; Niemuller *et al.*, 1990; Yathiraj *et al.*, 1992 and Saseendran, 1994).

Packed cell volume

The observed packed cell volume in elephants ranged from 33.25±0.46 to 54.8 per cent (Simon, 1961; Bartles *et al.*, 1963; Nirmalan *et al.*, 1967; Young and Lombard, 1967; Usami *et al.*, 1969; Jain, 1986; Niemuller *et al.* 1990; Yathiraj *et al.*, 1992 and Saseendran, 1994).

Haemoglobin

Haemoglobin value varied from 7.08±0.44 of per dl to 15.2 g per dl in elephants (Simon, 1961; Jainudeen and Jayasingh, 1971; Debbie and Clausen, 1975; Jain 1986; Niemuller *et al.*, 1990; Yathiraj, 1992 and Saseendran, 1994).

Total leukocytes count

The leukocyte count reported in elephants ranged from 6.4 to 20.85 x 9 per l (Simon, 1961; Schmitt, 1964; Jainudeen and Jaya Singh, 1971; Debhie and Clausen, 1975; Jain, 1986; Niemuller *et al.*, 1990; Yathiraj, *et al.*, 1992; Saseendran, 1992).

Minerals

i) **Calcium** - Calcium were estimated in the level of Asian elephants during normal state. The calcium level observed in elephants ranged from 8 to 12 mg/100 ml (Simon, 1961; Nirmalan, 1967; Nirmalan and Nair, 1969; Andrew Butter, 1971; Pillai, 1972; Ananthasubramaniam, 1979; Brown and White, 1980; Neimuller *et al.*, 1990; Saseendran, 1994).

ii) **Phosphorus** - Phosphorus were estimated in the Asian elephants during normal state and ranged from 3.00 to 6 mg% (Nirmalan, 1967), 1.63±0.16 (Niemuller *et al.*, 1990).

iii) **Creatinine** - Creatinine level were estimated in the elephants during normal state and ranged from 1.77 to 1.94 mg in 100 ml (Nirmalan, 1969; Nirmalan, *et al.*, 1969; Nirmalan and Nair, 1971; Saseendran, 1994).

iv) **Glucose** - Glucose level were estimated in the elephants at normal state and the level ranged from 52.86±13.91 to 67.47±15.25 mg per 110 ml (Nirmalan, 1967; Usani *et al.*, 1969; Saseendran, 1994).

v) **Total protein** - Total protein estimated in the serum of elephants at normal state ranged from 6.17±0.26 g per dl to 10.72±0.43 per dl (Giri *et al.*, 1958; Simon, 1961; Nirmalan and Nair, 1969; Moses and Gopalkrishnan, 1979; Sreekumar, 1986 and Saseendran, 1994).

Haematological variation due to work in animals

As work (exercise) involve greatly enhanced metabolic activity, it is but natural to expect haematological changes due to work. Many workers have therefore used investigations on the blood pictures as a means of assessing the effect of work on different type of animals.

Morehouse and Miller (1959) observed that the haematological changes in the bullocks seems to depend on the nature of exercise or work as in human beings light exercise increases while strenuous exercise decreases the total erythrocyte count.

Singh and associates (1968) observed that as a result of exercise there was a decrease in total erythrocyte, hematocit and in working bullocks.

Sastry *et al.* (1970) observed that the erythrocyte number and packed cell volume decreased in sahiwal bullocks and increased in crossbred bullocks during a sub maximal exercise of 2 hour duration.

Benjemin (1974) - A large reservoir of erythrocytes can be released to the circulation within minutes following excitement or strenuous exercise. The spleen is capable of supplying an erythrocyte volume equal to about 1/3 of circulator erythrocyte mass.

Nangia and associates (1980) reported an increase in haemoglobin content of blood after exercise in bullocks.

Bhattacharya (1984) studied the haematological changes in a group of untrained castrated goats carrying 40 kg weight load for a distance of 125 metre for half an hour and found an increase in RBC count and PCV values. Haemoglobin showed a significant drop and WBC significant rise.

Singh *et al.* (1986b) reported that total erythrocyte count, haematocrit value, decreased as a result of two hours exercise in Hariana bullocks.

Upadhyay (1987) reported that their is an increase in plasma volume, while performing heavy works at a higher speed. Some of the bullocks in beginning develop haemoconcentration but continuous work result in haemodilution. Most likely this occurs due to mobilizing their water content. The expansion of the plasma volume must be regarded as a homeostatic response. Expansion of plasma volume also help animals system to transport greater heat of work.

Upadhyay and Madan (1985) reported that continuous work caused a decline in venous haemoglobin and haematocrit and did not alter erythrocyte sedimentation rate. The decline in haemoglobin was more marked among Hariana bullocks.

Snow and associates (1988) studied the haematlogical and blood biochemical changes in nine camels after maximal exercise over 4 to 5 km. There was minimal increase in haemoglobin concentration and haematocrit.

Sreekumar and Thomas (1990a) observed a significant reduction in haemoglobin per cent, packed cell volume and of blood after work. Erythrocyte sedimentation rate showed a significant increase as a result of work. One hour of rest was not sufficient to bring these parameters to pre-exercise values.

Sreekumar and Thomas (1990b) reported decrease in PCV, which may be attributed to haemodilution and destruction of RBC during severe exercise. Similarly erythrocyte sedimentation rate increases after work, which may be due to RBC destruction during exercise.

Karanjkar and coworkers (1992) observed that values of blood glucose during harrowing did not vary between the Deoniaid crossbred bullocks significantly.

Karanjkar and coworkers (1992) compared the draft performance of Holstein Friesian x Deons (F_1) bullocks during ploughing and harrowing in terms of the

changes in haematological and biochemical parameters to that of Deoni bullocks significant increase in haemoglobin (Hb) and packed cell volume levels were observed in crossbreds during ploughing.

Fatigue score card

Upadhyay and Madan (1985) developed a fatigue score based on physiological reactions namely heart rate, respiration rate, and rectal temperature were scored on a five point basis. The fatigue score totalled 40 points, and animals attaining a score of 20 were declared fatigued. The assessment of fatigue on this basis has been done in Hariana, crossbreds and buffaloes performing light, moderate, submaximal and maximal load (Upadhyay, 1982; Upadhyay and Madan, 1987; Upadhyay and Rao, 1985).

MATERIALS AND METHODS

MATERIALS AND METHODS

The experiment was carried out from December 1994 to April 1996. The animals for the experiment were provided by the Forest Department of Kerala. Two elephants each were provided by Kodanad Forest range and Muthanga Forest range. Two elephants were provided by private elephant owners from Kozhikode. All the six elephants were trained and in the age group of 20 to 35 years. Details of elephants used for the study are given below:

Sl. No.	Elephant No.	Sex	Age	Body weight	Ownership
1	E_1	Male	23	2400	Department of Forest, Government of Kerala
2	E_2	Female	25	2600	"
3	E_3	Male	28	3000	"
4	E_4	Male	22	3200	"
5	E_5	Male	28	3300	Bharathi Balan, Kozhikode
6	E_6	Male	31	3350	"

The draught potential and efficiency of working elephants were assessed by qantifying the work output, speed of work, duration of work and monitoring the physiological parameters, haematological parameters and fatigue level.

A. Work output

a) **Estimation of body weight**

The body weight was estimated by weighing the animal on weigh bridge.

b) **Work performance**

The animal was made to haul a known weight of log. The weight of log was expressed as percentage to the body weight of the animal. The elephant was made to haul 3 hours from 7 AM to 10 AM followed by 1 hour rest and again 1 hour work from 11 AM to 12 Noon.

After completion of one hour work, all the physiological parameters like respiration, pulse and temperature were observed. Blood was collected for haematological examination. During different hours of operation, the animal was observed for exhibiting other behaviour indicative of fatigue during work viz. spraying of saliva from mouth, reluctance to move, tears from the eyes.

c) **Estimation of draught**

Draught = Load x $\cos\theta$ (Maurya and Devadattam (1982b).

Logs of known weights were used to carry out the experiments. The length of rope used by the elephants for dragging the log was measured with the help of

measuring tape. The rope was gripped by mouth of the elephant while hauling log. The distance between the mouth and ground level was measured by a measuring rod.

d) **Estimation of horse-power**

Horse-power developed by elephants were estimated by using the equation:

$$\text{Horse-power} = \frac{\text{Draft x speed/sec}}{75}$$ (Maurya and Devadattam (1982b)

B. Speed of walking

The walking speed without load were calculated by measuring the time taken to traverse a particular distance and the average was taken. The same method was also employed to determine the walking speed of elephants with load. The time taken was determined by a stop watch. The animal was made to walk on a distance measured tract.

C. Duration of work

Each animal was made to haul a particular load from 7 AM to 10 AM continuously with ten minutes break on completion of each hour. After working for 3 hours the animal was given one hour rest followed by 1 hour of work after the rest. In total the animal was made to work for 4 hours with one particular load for one day.

D. Observation of physiological parameters

Physiological changes:

Physiological changes in terms of respiration rate, pulse rate and rectal temperature were recorded before the start of the work, immediately after completion of each hour of work for 3 hours, followed by rest and 1 hour work after rest.

a) Respiration rate was ascertained by holding lower portion of the trunk and placing the palm of the hand close to the nostrils of the elephants and counting by feeling the number of times the elephant expires air through the nostrils. To countercheck the count, the movement of flank region was also noted and correlated.

b) **Pulse rate** was taken by placing the index finger on the ear artery at the base of the ear and by feeling the number of beats from ear artery with finger for one minute.

c) **Rectal temperature** of the elephant were taken by inserting full length of a clinical thermometer in the rectum and holding its bulb against the rectal mucous membrane for about one minute.

E. Haematological status

Blood was collected from the ear vein using ethylene diamine tetracetic acid (EDTA) as anticoagulant. The haemoglobin per cent (Schalm *et al.*, 1975) Erythrocyte sedimentation rate (Benjamin, 1974), packed cell volume volume (Benjamin, 1974). Mean corpuscular volume (Benjamin, 1974). Mean corpuscular haemoglobin concentration (Benjamin, 1974). Mean corpuscular haemoglobin (Benjamin, 1974). Total erythrocyte count and total leukocytes count (Benjamin, 1974) were estimated before the start of work and immediately after different hours of operation.

Serum glucose was estimated by ortho-toluidine method. Total serum protein was analysed by Biuret and BCG dye binding method. Serum creatinine was estimated by Alkaline picrate method. Serum calcium was estimated by orthocresopthalein complexion method. Serum phosphorus was estimated by modified Metol method. All the estimation were carried out before work and after completion of each hour of work.

F. Fatigue score card

A score chart has been prepared based on the physiological reactions namely pulse, respiration, rectal temperature and speed of walking during work. A score of 1 was given for every unit increase of pulse and respiration from the normal level at the end of each hour of work. In case of temperature a score of one was given for every 0.1 unit increase in rectal temperature from the normal level. With respect to speed for every unit of reduction of speed at the end of each hour of work from the normal level a score of 1 was allotted. Animals attaining a score of 15 were found fatigued. This fatigue score, accounts various easily measurable physiological parameters having direct implications and reflective of homeostatic mechanisms.

G. Statistical analysis

Mean and standard error were calculated with the data collected. Comparisons were made by using 't' test, detailed by Snedecor and Cochran (1967).

RESULTS

RESULTS

Respiration rate

The respiration rate of elephants before work were similar. At 10 per cent draft the respiration rate was increased from 8.83±0.30 to 12.66±0.49 per minute at the end of 3 hour of continuous work. The initial respiration rate and the rate at 3 hour of continuous work were 8.83±0.30 and 14.83±0.54 at 20 per cent draft and 8.83±0.30 and 17.16±0.30 at 30% draft (Table 1).

The difference between the initial and 3 hour readings were significant (Table 2).

The 1 hour rest after 3 hour of continuous work significantly ($P < 0.01$) reduced the respiration rate but the respiration rate after 1 hour rest continued to remain significantly ($P < 0.01$) higher than the initial level (Table 2) indicating the insufficient rest period.

No significant difference were observed between 1 hour work and 1 hour work after the rest at all draft. The respiration rate at the end of 3 hour of work were significantly ($P < 0.01$) higher than the respiration rate after 1 hour of rest at all draft.

Similarly the respiration rate after 3 hour of work were significantly ($P < 0.01$) higher than the respiration rate after 1 hour of work after the rest at all drafts.

Table 1 Mean respiration rate with standard errors of working elephants at different hours of operation at different draft (No/mt)

Draft per cent	Body weight of elephants (kg)	Before work	Immediately after work			Immediately after 1 hour rest	1 hour work after 1 hour rest
			1 hour	2 hour	3 hour		
10 %	2795 ± 160.07	8.83 ± 0.03	10.83 ± 0.47	11.66 ± 0.42	12.66 ± 0.49	9.83 ± 0.30	11.83 ± 0.30
20 %	2795 ± 160.07	8.83 ± 0.30	12.33 ± 0.33	13.60 ± 0.49	14.83 ± 0.54	10.16 ± 0.30	13.22 ± 0.34
30 %	2795 ± 160.07	8.83 ± 0.30	13.66 ± 0.33	15.66 ± 0.21	17.16 ± 0.30	10.16 ± 0.30	14.16 ± 0.40

Table 2 Comparison of respiration rate of working elephants at different hours of operation at different draft ('t' values)

Comparisons	10% draft	20% draft	30% draft
Before work Vs immediately after 1 hour work	7.7460**	15.6525**	29.000**
Before work Vs immediately after 3 hour work	12.4735**	16.4317**	25.000**
Before work Vs immediately after 1 hour rest	5.000**	6.3246**	6.3246**
Before work Vs 1 hour work after rest	17.000**	20.1246**	15.3265**
Immediately 1 hour work Vs 1 hour work after rest	1.7616	1.5962	1.5811
Immediately 3 hour work Vs immediately after 1 hour rest	8.2158**	11.0680**	15.6525**
Immediately 3 hour work Vs 1 hour work after rest	2.7386*	4.3916**	6.6351**

** Significant at 1% level * Significant at 5% level

Fig.1 compares the respiration rate of working elephants at different hours of operation with different draft.

Pulse rate

The elephants when put to work for 3 hour, there were significantly ($P < 0.01$) higher pulse rate than the initial reading at all levels of draft (Table 4). One hour rest after 3 hour of continuous work was sufficient to bring the pulse rate to the initial level as no significant difference in pulse rate were observed between before work and immediately after 1 hour rest (Table 3).

The pulse rate at 1 hour work were significantly lower than the pulse rate at the end of 1 hour work after the rest period. Similarly the pulse rate at the end of 3 hour work were significantly ($P < 0.01$) higher than the rate at end of 1 hour rest at all draft. Significantly ($P < 0.01$) higher pulse rate were also observed at the end of 3 hour of work when compared with 1 hour work after rest.

Fig.2 compares the pulse rate of working elephants at different hour of operation at different draft.

Rectal temperature

The mean rectal temperature with standard errors are presented in Table 5. Rectal temperature of elephant increased with duration of work at all draft. At 10 per cent draft the rectal temperature was increased from 36.06 ± 0.06 to 36.50 ± 0.08 °C at

Table 3 Mean pulse rate with standard errors of working elephants at different hours of operation at different draft (No/mt)

Draft per cent	Body weight of elephants (kg)	Before work	Immediately after work			Immediately after 1 hour rest	1 hour work after 1 hour rest
			1 hour	2 hour	3 hour		
10 %	2795 ± 160.07	29.80 ± 0.60	32.33 ± 0.42	34.16 ± 0.47	36.33 ± 0.42	30.16 ± 0.54	34.16 ± 0.47
20 %	2795 ± 160.07	29.83 ± 0.47	34.00 ± 0.57	37.00 ± 0.59	39.00 ± 0.44	29.83 ± 0.47	35.38 ± 0.33
30 %	2795 ± 160.07	30.00 ± 0.57	34.16 ± 0.70	39.00 ± 0.85	38.83 ± 0.79	30.33 ± 0.66	35.50 ± 0.56

Table 4 Comparison of pulse rate of working elephants at different hours of operation at different draft ('t' values)

Comparisons	10% draft	20% draft	30% draft
Before work Vs immediately after 1 hour work	11.1803**	13.5582**	25.000**
Before work Vs immediately after 3 hour work	15.1807**	19.2068**	18.5084**
Before work Vs immediately after 1 hour rest	1.5840	1.6272	1.8234
Before work Vs 1 hour work after rest	8.7646**	16.1024**	24.5967**
Immediately 1 hour work Vs 1 hour work after rest	4.5675**	2.6968*	6.3246**
Immediately 3 hour work Vs immediately after 1 hour rest	20.061**	19.2068**	17.000**
Immediately 3 hour work Vs 1 hour work after rest	7.0502**	11.0000**	7.9057**

* Significant at 5% level ** Significant at 1% level

the end of 3 hour of continuous work. The initial rectal temperature and the rectal temperature at 3 hour of continuous work were 36.13±0.08 and 36.81±0.07 °C at 20 per cent draft and 36.13±0.04 and 37.25±0.06 °C at 30 per cent draft. The rates were significantly different.

One hour rest after 3 hours of continuous work significantly ($P < 0.01$) reduced the rectal temperature but the rectal temperature after 1 hour rest continued to remain significantly ($P < 0.01$) higher than the initial level (Table 6) indicating the insufficient rest period.

The rectal temperature after 1 hour work were significantly higher than the initial reading at all draft. A significantly ($P < 0.010$) higher rectal temperature than the initial were observed after 1 hour work after 1 hour interim rest. Similarly rectal temperature at the end of 3 hour work were significantly ($P < 0.05$) higher at 10% and significantly ($P < 0.01$) higher at 20% and 30% draft than immediately after 1 hour rest.

Significant difference in rectal temperature were observed between 3 hours of work and 1 hour work after rest.

Fig.3 compares the rectal temperature of working elephants at different hours of operation at different draft.

Average speed

The mean with standard error of average speed of working elephants is presented in Table 7. The speed of operation decreased with duration of work at all draft.

The result of 't' tests carried out between the average speed at different hour of operation is presented in Table 8. The average speed significantly ($P < 0.01$) decreased after 3 hour of continuous work at all draft than that of initial speed. Similarly the average speed after 1 hour work were significantly ($P < 0.01$) lower than the initial speed.

The average speed at 1 hour work were significantly higher than the speed at 1 hour work after 1 hour rest. However no significant difference in speed were observed at 3 hour work and 1 hour work after rest.

Fig.4 compares the average speed of working by elephants at different hours of operation with different draft.

Haemoglobin

The mean haemoglobin percentage with standard error of working elephants are presented in Table 9. At 10% draft the haemoglobin content decreased from 10.16 ± 0.07 to 10.08 ± 0.08 mg% at the end of 3 hour continuous work. The initial

Table 5 Mean rectal temperature with standard errors of working elephants at different hours of operation at different draft (°C)

Draft per cent	Body weight of elephants (kg)	Before work	Immediately after work			Immediately after 1 hour rest	1 hour work after 1 hour rest
			1 hour	2 hour	3 hour		
10 %	2795 ± 160.07	36.06 ± 0.06	36.35 ± 0.08	36.50 ± 0.10	36.50 ± 0.08	36.31 ± 0.04	36.50 ± 0.03
20 %	2795 ± 160.07	36.10 ± 0.08	36.40 ± 0.09	36.61 ± 0.04	36.81 ± 0.07	36.35 ± 0.08	36.88 ± 0.23
30 %	2795 ± 160.07	36.13 ± 0.04	36.65 ± 0.04	36.98 ± 0.07	37.25 ± 0.06	36.50 ± 0.08	36.93 ± 0.06

Table 6 Comparison of rectal temperature of working elephants at different hours of operation at different draft ('t' values)

Comparisons	10% draft	20% draft	30% draft
Before work Vs immediately after 1 hour work	7.0589**	8.2158**	16.8121**
Before work Vs immediately after 3 hour work	5.8388**	21.999**	15.8804**
Before work Vs immediately after 1 hour rest	7.3193**	11.1803**	5.1175**
Before work Vs 1 hour work after rest	10.2773**	3.8097*	13.8564**
Immediately 1 hour work Vs 1 hour work after rest	2.6655*	2.6130*	4.7149**
Immediately 3 hour work Vs immediately after 1 hour rest	3.4780*	15.7275**	11.9312**
Immediately 3 hour work Vs 1 hour work after rest	10.9990**	2.6968*	10.3808**

* Significant at 5% level ** Significant at 1% level

Fig.1 VARIATION IN RESPIRATION RATE OF ELEPHANTS AT DRAFT OF 10%, 20% AND 30% OF THEIR BODY WEIGHT AT DIFFERENT HOURS OF OPERATION

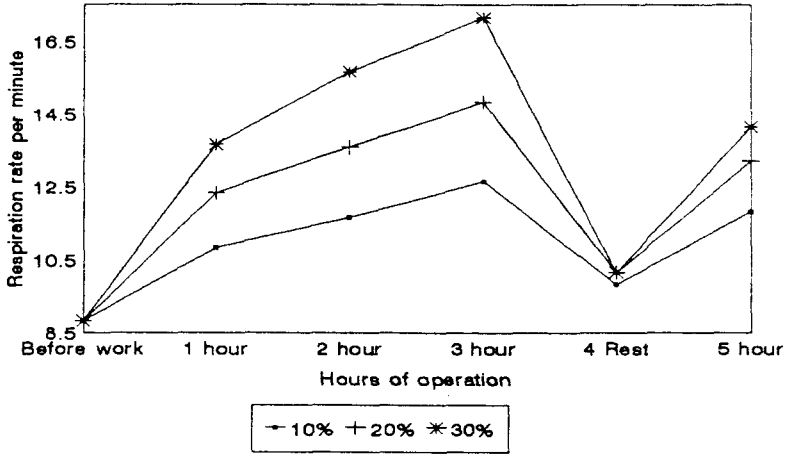


Fig.2 VARIATION IN PULSE RATE OF ELEPHANTS AT DRAFT OF 10%, 20% AND 30% OF THEIR BODY WEIGHT AT DIFFERENT HOURS OF OPERATION

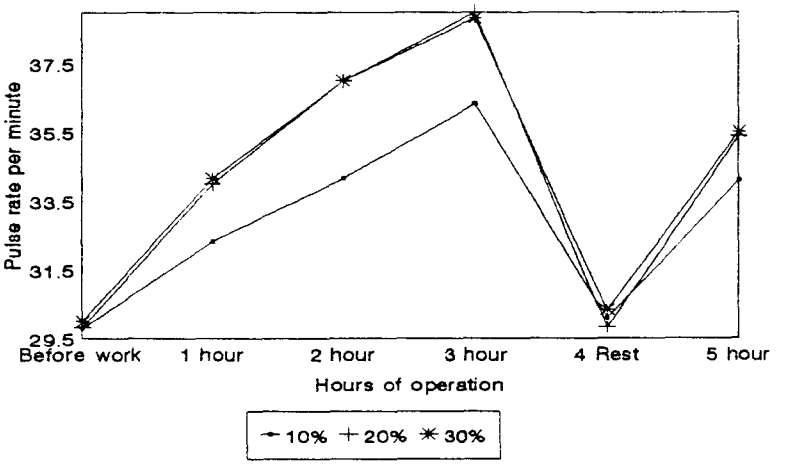
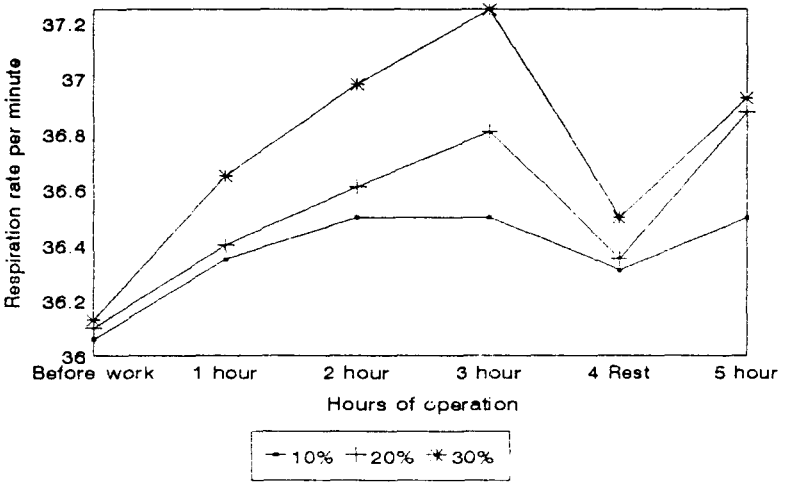


Fig3. VARIATION IN RECTAL TEMPERATURE OF ELEPHANTS AT DRAFT OF 10%, 20% AND 30% OF THEIR BODY WEIGHT AT DIFFERENT HOURS OF OPERATION



haemoglobin content and the Hb% at 3 hour of continuous work were 10.12±0.06 and 10.10±0.06 at 20% draft and 10.08±0.07 and 10.06±0.06 at 30% draft (Table 9).

The results of comparisons of average haemoglobin per cent by means of 't' tests is presented in Table 10. There were no significant difference in the haemoglobin content at any of the comparison at 10 per cent and 20 per cent draft. However significantly ($P < 0.05$) lower haemoglobin content than the initial reading were observed after 3 hour work at 30% draft. Similarly significant difference in haemoglobin content were observed immediately after 1 hour work than the initial level.

The haemoglobin content after 1 hour work after rest were significantly ($P < 0.01$) lower than the initial level at 30% draft. The haemoglobin content at the end of 1 hour work after 1 hour rest were significantly reduced than the first 1 hour work reading at 30 per cent draft. At 10 per cent and 20 per cent draft the difference was not significant. However no significant differences were observed in haemoglobin content between 3 hour work and immediately after 1 hour rest at any level of draft.

One hour work after 1 hour rest significantly ($P < 0.05$) reduced the haemoglobin content than 3 hour work at 30 per cent draft.

ble 7 Mean and standard errors of average speed of working elephants at different hours of operation at different draft (km/h)

Draft per cent	Body weight of elephants (kg)	Before work	Immediately after work			Immediately after 1 hour rest	1 hour work after 1 hour rest
			1 hour	2 hour	3 hour		
10 %	2795 ± 160.07	4.83 ± 0.11	4.40 ± 0.14	4.13 ± 0.13	3.68 ± 0.19	-	3.93 ± 0.21
20 %	2795 ± 160.07	4.41 ± 0.07	4.04 ± 0.04	3.81 ± 0.01	3.71 ± 0.36	-	3.53 ± 0.13
30 %	2795 ± 160.07	4.76 ± 0.10	4.15 ± 0.12	3.15 ± 0.04	2.35 ± 0.11	-	2.58 ± 0.07

Table 8 Comparison of average speed of working elephants at different hour of operation at different draft ('t' values)

Comparisons	10% draft	20% draft	30% draft
Before work Vs immediately after 1 hour work	13.0000**	5.9761**	4.5613**
Before work Vs immediately after 3 hour work	12.4166**	12.1300**	46.4758**
Before work Vs immediately after 1 hour rest	Rest	Rest	Rest
Before work Vs 1 hour work after rest	7.5709**	9.7088**	29.1471**
Immediately 1 hour work Vs 1 hour work after rest	4.0721*	5.9656**	14.9359**
Immediately 3 hour work Vs immediately after 1 hour rest	Rest	Rest	Rest
Immediately 3 hour work Vs 1 hour work after rest	1.3193	0.4514	1.9554

* Significant at 5% level ** Significant at 1% level

Fig.4 COMPARISON OF VARIATION IN AVERAGE SPEED OF ELEPHANTS AT DRAFT OF 10%, 20% AND 30% OF THEIR BODY WEIGHT AT DIFFERENT HOURS OF OPERATION

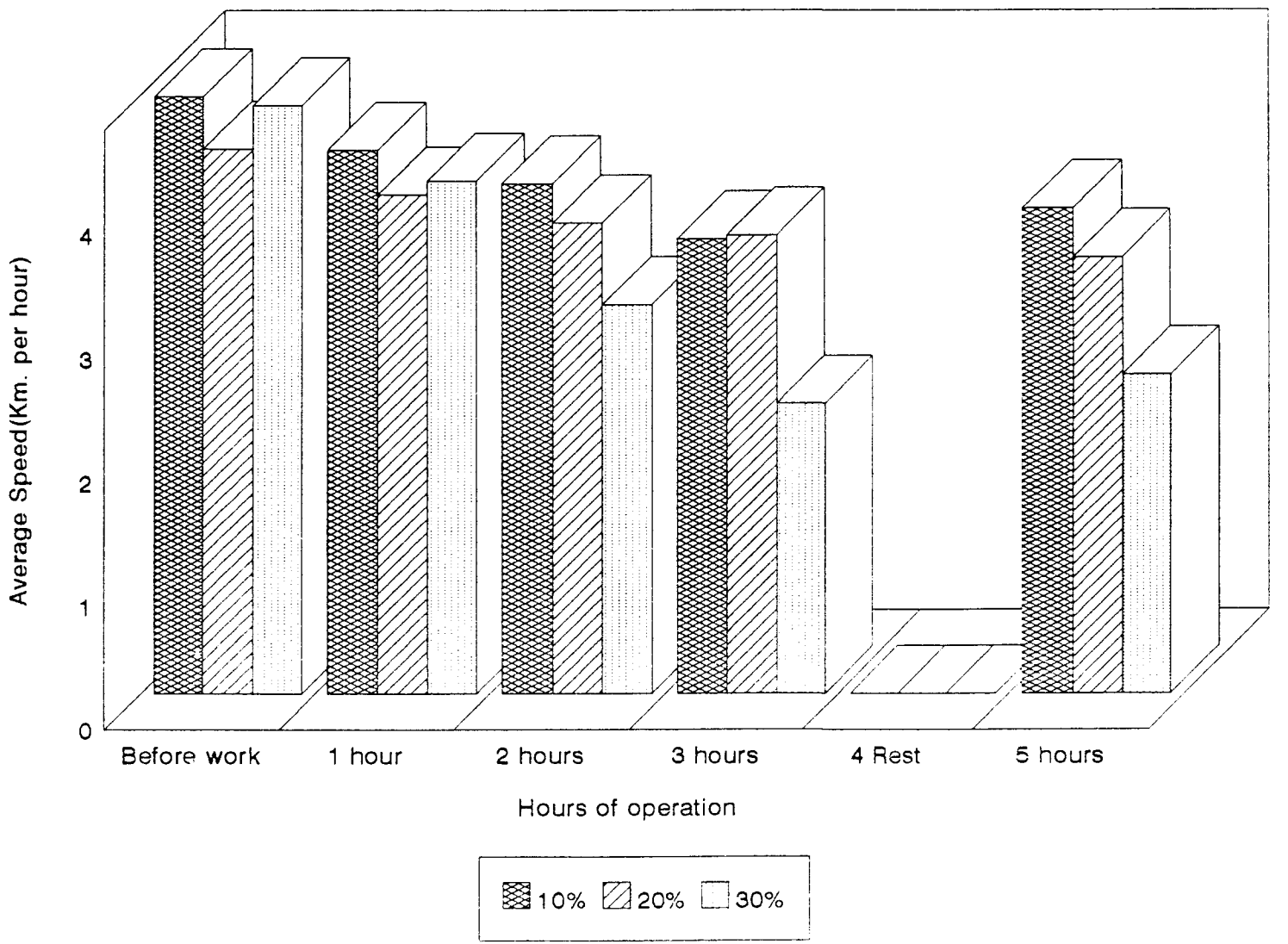


Table 9 Mean haemoglobin content with standard errors of working elephants at different hours of operation at different draft (g%)

Draft per cent	Body weight of elephants (kg)	Before work	Immediately after work			Immediately after 1 hour rest	1 hour work after 1 hour rest
			1 hour	2 hour	3 hour		
10 %	2795 ± 160.07	10.10± 0.06	10.16± 0.07	10.15± 0.06	10.08± 0.08	10.07± 0.06	9.98± 0.09
20 %	2795 ± 160.07	10.12± 0.06	10.24± 0.08	10.22± 0.06	10.10± 0.06	10.08± 0.07	10.03± 0.05
30 %	2795 ± 160.07	10.08± 0.07	10.18± 0.08	10.17± 0.08	10.06± 0.06	10.06± 0.05	9.92± 0.06

Table 10 Comparison of haemoglobin content of working elephants at different hours of operation at different draft ('t' values)

Comparisons	10% draft	20% draft	30% draft
Before work Vs immediately after 1 hour work	1.0272	1.5282	2.1329
Before work Vs immediately after 3 hour work	0.9818	0.5884	3.1148*
Before work Vs immediately after 1 hour rest	1.0048	0.5846	3.5412*
Before work Vs 1 hour work after rest	0.9422*	2.0656	7.5152**
Immediately 1 hour work Vs 1 hour work after rest	2.4383*	2.3191	6.1971**
Immediately 3 hour work Vs immediately after 1 hour rest	0.6852	0.3162	0.5431
Immediately 3 hour work Vs 1 hour work after rest	0.3567	1.6203	3.5880*

* Significant at 5% level ** Significant at 1% level

Packed cell volume (PCV)

The mean packed cell volume of elephants with standard errors are presented in Table 11. At 10 per cent draft the packed cell volume remained more or less constant. The packed cell volume just before the start of work and at 3 hour of continuous work were 19.00±0.31 and 18.80±0.62 at 20 per cent draft and 20.0±0.87 and 18.50±0.31 at 30 per cent draft (Table 11).

Comparison of packed cell volume between different hours of operation at different draft is presented in Table 12. There were no significant difference in any of the comparisons at 10 per cent and 20 per cent draft but significant ($P < 0.05$) decrease in packed cell volume were observed at 30% draft after 1 hour of work than the initial level. Packed cell volume remain significantly ($P < 0.05$) lower after 1 hour rest than the initial level. Similarly significantly ($P < 0.05$) lower PCV than the initial reading were observed after 3 hour of work at 30% draft.

No significant difference were observed between 3 hour work and immediately after 1 hour rest at any draft. However the packed cell volume after 1 hour rest continued to remain significantly ($P < 0.05$) lower than the initial level, indicating the insufficient rest period. The packed cell volume after 3 hour work were significantly ($P < 0.05$) higher than 1 hour work after 1 hour rest.

Fig.6 compares the packed cell volume of working elephants at different hours of operation with different draft.

Erythrocyte sedimentation rate (ESR)

The erythrocyte sedimentation rate of elephants before work were similar. Mean erythrocyte sedimentation rate with standard errors of working elephant are presented in Table 13. At 10 per cent draft the erythrocyte sedimentation rate decreased from 61.67±0.53 to 60.83±0.21 at the end of 3 hour continuous work. The initial erythrocyte sedimentation rate and the rate at 3 hour of continuous work were 61.35±0.64 to 60.75±0.37 at 20 per cent draft and 61.48±0.40 to 61.81±0.50 at 30 per cent draft (Table 13).

Comparison of erythrocyte sedimentation rate at different hours of operation with different draft is presented in Table 14. Significant ($P < 0.05$) increase in erythrocyte sedimentation rate were observed after 3 hours of work than the initial range at 30% draft. The erythrocyte sedimentation rate after 1 hour work after rest were significantly ($P < 0.05$) higher than the initial level at 30% draft. The value were not significant at 10 per cent and 20 per cent draft.

The erythrocyte sedimentation rate after 1 hour work were significantly ($P < 0.05$) lower than the initial value at 30% draft. Similarly erythrocyte sedimentation rate at 1 hour work after rest were found significantly ($P < 0.05$) higher than 1 hour work at 20 per cent and 30 per cent draft.

Fig.7 compares the erythrocyte sedimentation rate of working elephants at different hours of operation with different drafts.

Table 11 Mean packed cell volume with standard errors of working elephants at different hours of operation at different draft (%)

Draft per cent	Body weight of elephants (kg)	Before work	Immediately after work			Immediately after 1 hour rest	1 hour work after 1 hour rest
			1 hour	2 hour	3 hour		
10 %	2795 ± 160.07	18.07 ± 0.28	18.80 ± 0.32	18.80 ± 0.65	18.70 ± 0.27	18.70 ± 0.81	18.60 ± 0.42
20 %	2795 ± 160.07	19.00 ± 0.03	19.10 ± 0.81	18.90 ± 0.62	18.80 ± 0.62	18.80 ± 0.76	18.70 ± 0.31
30 %	2795 ± 160.07	20.00 ± 0.87	21.00 ± 0.42	18.50 ± 0.31	18.50 ± 0.31	18.50 ± 0.36	18.30 ± 0.38

Table 12 Comparison of packed cell volume of working elephants at different hours of operation at different draft ('t' values)

Comparisons	10% draft	20% draft	30% draft
Before work Vs immediately after 1 hour work	1.7055	1.8613	3.0984*
Before work Vs immediately after 3 hour work	2.1483	0.5022	2.8984*
Before work Vs immediately after 1 hour rest	1.0000	0.4510	2.5581*
Before work Vs 1 hour work after rest	0.5590	1.7082	3.2975*
Immediately 1 hour work Vs 1 hour work after rest	2.0232	2.4804	3.8473*
Immediately 3 hour work Vs immediately after 1 hour rest	1.6150	0.2548	0.2519
Immediately 3 hour work Vs 1 hour work after rest	1.6432	1.4513	2.6117*

* Significant at 5% level

Total leukocyte count

Mean leukocyte count with standard error of working elephants is presented in Table 17. At 10 per cent draft the total leukocyte count increased from 10.14±0.119 to 10.50±0.152 at the end of 3 hour continuous work. The initial total leukocyte and the rate at 3 hours of continuous work were 9.36±0.26 to 10.05±0.23 at 20 per cent draft and 9.72±0.28 to 10.33±0.39 at 30 per cent draft (Table 17).

The comparison of total leukocyte count between different hours of operation at different draft is presented in Table 18. There was no significant difference in total leukocyte count at any comparison at all the different draft but 't' tests indicated significant ($P < 0.05$) difference were observed between 1 hour work after rest than immediately 1 hour work after rest at 20% draft (Table 18). However no significant difference were observed in any of the other comparisons.

Fig.9 compares the total leukocyte count of working elephant at different hours of operation with different levels of draft.

Total erythrocyte count

Mean erythrocyte count with standard errors of working elephant are presented in Table 15. At 10 per cent the total. Erythrocyte count decreased from 2.36±0.40 million mm^3 to 2.32±0.076 million mm^3 at the end of 3 hours of continuous work. The initial respiration rate and the rate at 3 hours of continuous work

were 2.26±0.06 and 2.29±0.06 at 20 per cent draft and 2.29±0.04 and 2.20±0.06 at 30 per cent draft (Table 15).

Comparison of total erythrocyte count of working elephants between different hours of operation at different draft is presented in Table 16. No significant difference in total erythrocyte count were observed after 1 hour work than the initial level at all levels of draft. The total erythrocyte count after 3 hour work were significantly ($P < 0.01$) lower than the initial reading at 30 per cent draft, but no significant difference were observed at 10% and 20% draft. No significant difference in total erythrocyte count were observed after 1 hour rest than the initial levels at 10 and 20 per cent draft. However the difference were significant ($P < 0.01$) at 30% draft. Table 16 indicating the insufficient rest period.

Similarly the total erythrocyte count were significantly ($P < 0.05$) higher at 20% and significantly ($P < 0.01$) higher at 30% after 3 hour of continuous work than 1 hour work after rest. No significant difference were observed between 3 hour work and after 1 hour rest at all the draft.

Fig.7 compares the total erythrocyte count at different hours of operation at different draft.

Table 13 Mean erythrocyte sedimentation rate with standard errors of working elephants at different hours of operation at different draft (mm/h)

Draft per cent	Body weight of elephants (kg)	Before work	Immediately after work			Immediately after 1 hour rest	1 hour work after 1 hour rest
			1 hour	2 hour	3 hour		
10 %	2795 ± 160.07	61.67 ± 0.53	60.58 ± 0.38	60.55 ± 0.25	60.83 ± 0.21	61.16 ± 0.65	61.35 ± 0.80
20 %	2795 ± 160.07	61.35 ± 0.64	60.45 ± 0.43	61.02 ± 0.43	60.75 ± 0.37	61.56 ± 0.47	61.56 ± 0.47
30 %	2795 ± 160.07	61.48 ± 0.40	60.97 ± 0.37	61.25 ± 0.39	62.81 ± 0.50	62.01 ± 0.57	62.30 ± 0.41

Table 14 Comparison of erythrocyte sedimentation rate of working elephants at different hours of operation at different draft ('t' values)

Comparisons	10% draft	20% draft	30% draft
Before work Vs immediately after 1 hour work	2.2022	2.2822	2.6361
Before work Vs immediately after 3 hour work	2.2603	1.0758	3.0660*
Before work Vs immediately after 1 hour rest	1.1848	0.8632	2.3591
Before work Vs 1 hour work after rest	0.7317	0.7880	3.7428*
Immediately 1 hour work Vs 1 hour work after rest	0.6643	3.0210*	3.0295*
Immediately 3 hour work Vs immediately after 1 hour rest	0.5970	1.0321	1.6893
Immediately 3 hour work Vs 1 hour work after rest	0.5067	1.0968	2.9929*

* Significant at 5% level

Fig.5 COMPARISON OF HAEMOGLOBIN PERCENTAGE OF ELEPHANTS AT DRAFT 10%, 20% AND 30% OF THEIR BODY WEIGHT AT DIFFERENT HOURS OF OPERATION

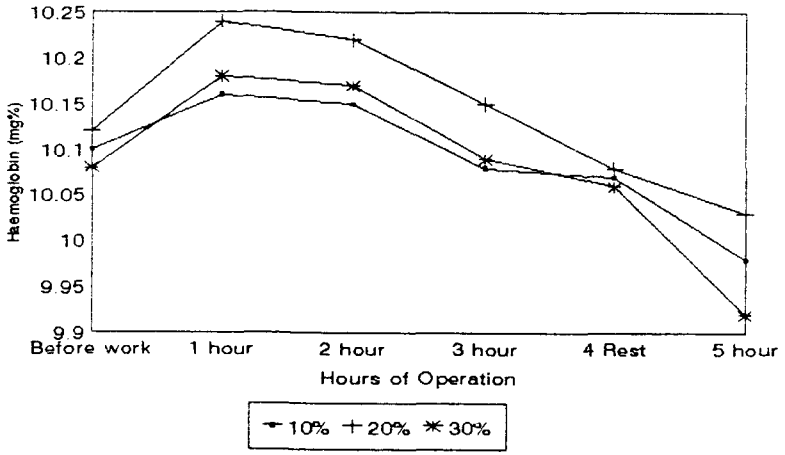


Fig.6 COMPARISON OF PACKED CELL VOLUME OF ELEPHANTS AT DRAFT 10%, 20% AND 30% OF THEIR BODY WEIGHT AT DIFFERENT HOURS OF OPERATION

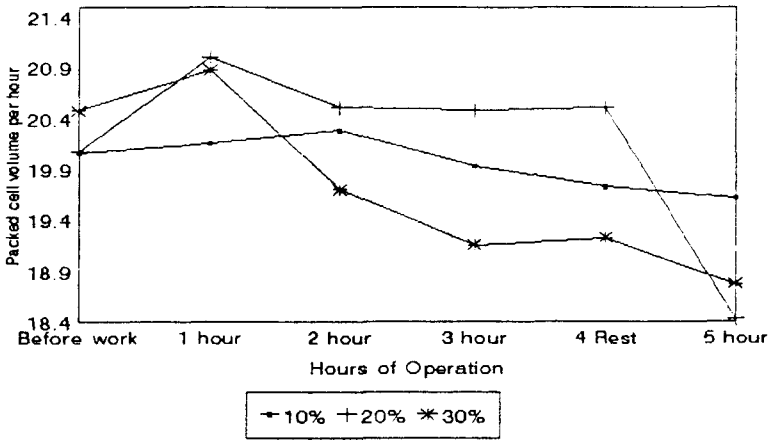


Fig.7 COMPARISON OF ERYTHORCYTE SEDIMENTATION RATE OF ELEPHANTS AT DRAFT 10%, 20% AND 30% OF THEIR BODY WEIGHT AT DIFFERENT HOURS OF OPERATION

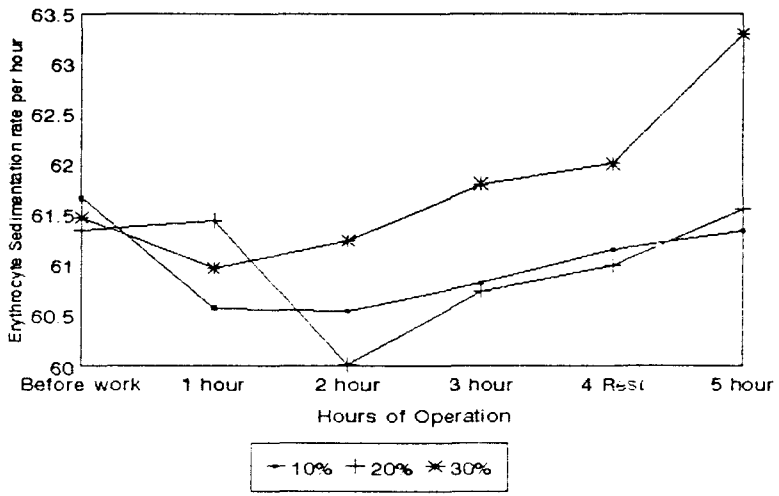


Table 15 Mean erythrocyte count (RBC) with standard errors of working elephants at different hours of operation at different draft (millions/microliter)

Draft per cent	Body weight of elephants (kg)	Before work	Immediately after work			Immediately after 1 hour rest	1 hour work after 1 hour rest
			1 hour	2 hour	3 hour		
10 %	2795 ± 160.07	2.36± 0.090	2.38± 0.094	2.34± 0.083	2.32± 0.076	2.32± 0.076	2.22± 0.049
20 %	2795 ± 160.07	2.26± 0.06	2.34± 0.06	2.31± 0.06	2.20± 0.06	2.20± 0.06	2.19± 0.04
30 %	2795 ± 160.07	2.29± 0.04	2.30± 0.06	2.21± 0.05	2.16± 0.05	2.14± 0.05	2.03± 0.04

Table 16 Comparison of total erythrocyte count of working elephants at different hours of operation at different draft ('t' values)

Comparisons	10% draft	20% draft	30% draft
Before work Vs immediately after 1 hour work	1.0842	1.4632	0.2104
Before work Vs immediately after 3 hour work	0.8586	0.9633	4.7364**
Before work Vs immediately after 1 hour rest	0.8674	0.4588	5.0366**
Before work Vs 1 hour work after rest	0.5357	0.1295	7.1726**
Immediately 1 hour work Vs 1 hour work after rest	2.1509	0.7420	8.1799**
Immediately 3 hour work Vs immediately after 1 hour rest	0.0824	0.9295	1.5301
Immediately 3 hour work Vs 1 hour work after rest	1.9604	3.1000*	5.8180**

* Significant at 5% level ** Significant at 1% level

Table 17 Mean leukocyte count (WBC) with standard errors of working elephants at different hours of operation at different draft (Thousands/mm^3)

Draft per cent	Body weight of elephants (kg)	Before work	Immediately after work			Immediately after 1 hour rest	1 hour work after 1 hour rest
			1 hour	2 hour	3 hour		
10 %	2795 ± 160.07	10.14 ± 0.1199	10.25 ± 0.09	10.44 ± 0.16	10.50 ± 0.152	10.47 ± 0.17	10.58 ± 0.175
20 %	2795 ± 160.07	9.36 ± 0.26	10.13 ± 0.29	10.19 ± 0.29	10.05 ± 0.23	10.03 ± 0.23	10.15 ± 0.25
30 %	2795 ± 160.07	9.728 ± 0.230	9.958 ± 0.305	10.07 ± 0.32	10.335 ± 0.390	10.12 ± 0.44	10.33 ± 0.46

Table 18 Comparison of leukocyte count of working elephants at different hours of operation at different draft ('t' values)

Comparisons	10% draft	20% draft	30% draft
Before work Vs immediately after 1 hour work	1.4175	1.7886	2.4344
Before work Vs immediately after 3 hour work	2.0720	1.6674	2.6226*
Before work Vs immediately after 1 hour rest	1.7682	1.2739	1.3750
Before work Vs 1 hour work after rest	1.4300	3.3050*	2.5429
Immediately 1 hour work Vs 1 hour work after rest	1.3752	0.1741	1.7820
Immediately 3 hour work Vs immediately after 1 hour rest	0.5029	1.1421	2.0548
Immediately 3 hour work Vs 1 hour work after rest	1.1927	1.4944	1.8000

* Significant at 5% level

Mean corpuscular volume (MCV)

Table 19 indicates the mean and standard error of mean corpuscular volume of working elephants. There was increase in corpuscular volume immediately after 1 hour work at 10% and 30% draft. However, there is decrease in mean corpuscular volume at 20% draft. It also indicates that 1 hour rest is not sufficient to bring the corpuscular volume to the pre-exercises level.

The results of comparisons of mean corpuscular volume between different hours of operation at different draft is presented in Table 29. The analysis also indicated that the difference were non-significant in all comparison between different hours of operation (Table 30).

Fig.10 compares the mean corpuscular volume of working elephants at different hours of operation with different draft.

Mean corpuscular haemoglobin concentration (MCHC)

Mean with standard errors of mean corpuscular haemoglobin concentration of working elephant is presented in Table 21.

Comparison of mean corpuscular haemoglobin concentration of working elephant between different hours of operation at different draft is presented in Table 22.

Fig.8 COMPARISON OF TOTAL ERYTHROCYTE COUNT OF ELEPHANTS AT DRAFT OF 10%, 20% AND 30% OF THEIR BODY WEIGHT AT DIFFERENT HOURS OF OPERATION

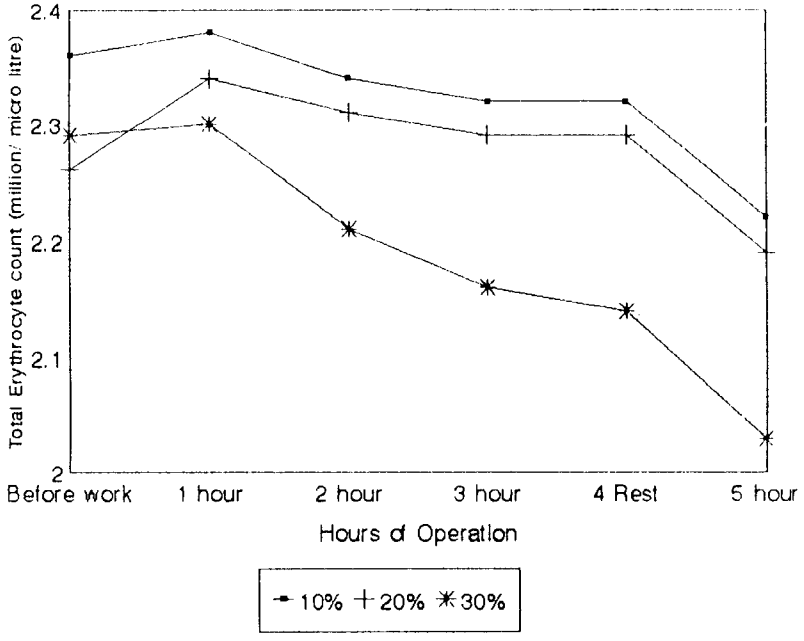
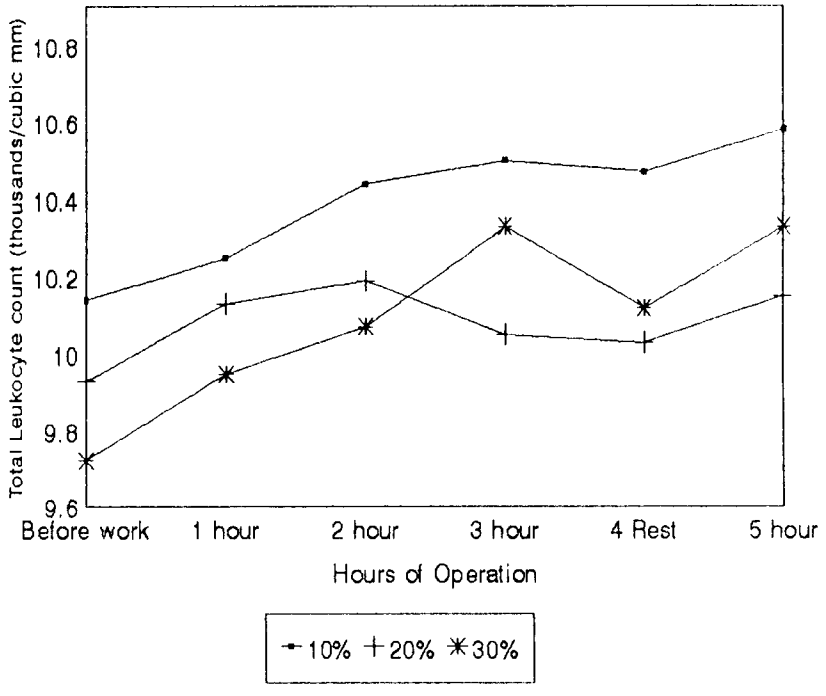


Fig.9 COMPARISON OF TOTAL LEUKOCYTES COUNT OF ELEPHANTS AT DRAFT OF 10%, 20% AND 30% OF THEIR BODY WEIGHT AT DIFFERENT HOURS OF OPERATION



The 't' test indicates no significant difference between 1 hour work and the initial mean corpuscular haemoglobin concentration at all the draft. Similarly mean corpuscular haemoglobin concentration at the end of 3 hour work were not significant than the initial mean corpuscular haemoglobin concentration. However mean corpuscular haemoglobin concentration were significantly ($P < 0.05$) higher after 1 hour of work after rest than the initial level at 20% draft. The mean corpuscular haemoglobin concentration after 1 hour work were significantly ($P < 0.05$) lower than 1 hour work after 1 hour rest at 30 per cent draft.

Fig.11 compares the mean corpuscular haemoglobin concentration at different hours of operation at different draft.

Mean corpuscular haemoglobin (MCH)

Mean with standard errors of mean corpuscular haemoglobin is represented in Table 23. At 10 per cent draft the mean corpuscular haemoglobin was increased from 42.5±1.52 to 43.61±1.32 at the end of 3 hours of continuous work. The initial mean corpuscular haemoglobin and the range at 3 hours of continuous work were 43.19±1.17 and 44.40±1.35 at 20 per cent draft and 43.82±1.30 and 46.75± 1.31 at 30 per cent draft (Table 23).

The result of the 't' test carried out between different hours of operation is presented in Table 24. There was no significant difference at any of the comparison

Table 19 Mean corpuscular volume (MCV) with standard errors of working elephants at different hours of operation at different draft (femtoliters)

Draft per cent	Body weight of elephants (kg)	Before work	Immediately after work			Immediately after 1 hour rest	1 hour work after 1 hour rest
			1 hour	2 hour	3 hour		
10 %	2795 ± 160.07	85.33 ± 4.765	87.50 ± 5.880	87.12 ± 3.97	86.43 ± 4.120	85.46 ± 4.11	88.17 ± 3.03
20 %	2795 ± 160.07	90.83 ± 3.97	89.95 ± 3.67	89.05 ± 4.25	89.60 ± 3.94	89.72 ± 4.24	90.00 ± 3.77
30 %	2795 ± 160.07	89.77 ± 3.65	90.99 ± 3.61	89.495 ± 3.84	88.83 ± 3.91	90.00 ± 3.86	91.83 ± 3.36

Table 20 Comparison of mean corpuscular volume of working elephants at different hours of operation at different draft ('t' values)

Comparisons	10% draft	20% draft	30% draft
Before work Vs immediately after 1 hour work	1.6028	0.5490	2.0074
Before work Vs immediately after 3 hour work	0.2812	0.4813	0.1094
Before work Vs immediately after 1 hour rest	0.2114	0.5972	0.3417
Before work Vs 1 hour work after rest	0.7713	0.7534	1.0238
Immediately 1 hour work Vs 1 hour work after rest	0.0528	0.1299	0.2865
Immediately 3 hour work Vs immediately after 1 hour rest	1.9784	0.1517	0.3833
Immediately 3 hour work Vs 1 hour work after rest	1.1296	0.0728	1.8235

Table 21 Mean and standard errors of mean corpuscular haemoglobin concentration (MCHC) of working elephants at different hours of operation at different draft

Draft per cent	Body weight of elephants (kg)	Before work	Immediately after work			Immediately after 1 hour rest	1 hour work after 1 hour rest
			1 hour	2 hour	3 hour		
10 %	2795 ± 160.07	56.66± 1.229	48.66± 1.819	49.88± 1.24	50.22± 1.14	50.83± 1.13	46.16± 5.35
20 %	2795 ± 160.07	48.66± 1.32	48.33± 1.08	49.50± 1.28	49.00± 1.41	51.00± 1.81	50.66± 1.30
30 %	2795 ± 160.07	49.16± 0.94	48.33± 0.17	51.33± 1.08	52.00± 1.09	51.66± 0.45	52.00± 0.96

Table 22 Comparison of mean corpuscular haemoglobin concentration of working elephants at different hours of operation at different draft ('t' values)

Comparisons	10% draft	20% draft	30% draft
Before work Vs immediately after 1 hour work	2.1126	0.3415	1.6981
Before work Vs immediately after 3 hour work	0.2236	0.7012	2.3530
Before work Vs immediately after 1 hour rest	0.2684	1.2642	2.3215
Before work Vs 1 hour work after rest	1.0323	2.5235*	2.2630
Immediately 1 hour work Vs 1 hour work after rest	0.6996	2.2712	2.9946*
Immediately 3 hour work Vs immediately after 1 hour rest	1.2846	1.1356	1.3592
Immediately 3 hour work Vs 1 hour work after rest	0.8492	1.5840	1.1171

* Significant at 5% level

Table 23 Mean with standard errors of mean corpuscular haemoglobin (MCH) of working elephants at different hours of operation at different draft (Picograms)

Draft per cent	Body weight of elephants (kg)	Before work	Immediately after work			Immediately after 1 hour rest	1 hour work after 1 hour rest
			1 hour	2 hour	3 hour		
10 %	2795 ± 160.07	42.50 ± 1.52	42.50 ± 1.66	43.54 ± 1.39	43.61 ± 1.32	43.51 ± 1.23	45.12 ± 0.65
20 %	2795 ± 160.07	43.19 ± 1.17	43.75 ± 1.42	43.83 ± 1.44	44.40 ± 1.32	43.90 ± 1.37	45.46 ± 3.65
30 %	2795 ± 160.07	43.82 ± 1.30	44.25 ± 1.40	45.90 ± 1.57	46.75 ± 1.31	46.20 ± 1.19	48.92 ± 1.02

Table 24 Comparison of mean corpuscular haemoglobin of working elephants at different hours of operation at different draft ('t' values)

Comparisons	10% draft	20% draft	30% draft
Before work Vs immediately after 1 hour work	1.1990	1.0155	0.5250
Before work Vs immediately after 3 hour work	0.7231	2.4416	4.6836**
Before work Vs immediately after 1 hour rest	0.7769	1.2272	4.5606**
Before work Vs 1 hour work after rest	1.3743	2.4099	6.6436**
Immediately 1 hour work Vs 1 hour work after rest	1.4071	1.9185	6.1173**
Immediately 3 hour work Vs immediately after 1 hour rest	0.2960	0.5293	0.6597
Immediately 3 hour work Vs 1 hour work after rest	1.3491	1.1675	3.4715*

* Significant at 5% level ** Significant at 1% level

Fig.10 COMPARISON OF MEAN CORPUSCULAR VOLUME OF ELEPHANTS AT DRAFT OF 10%, 20% AND 30% OF THEIR BODY WEIGHT AT DIFFERENT HOURS OF OPERATION

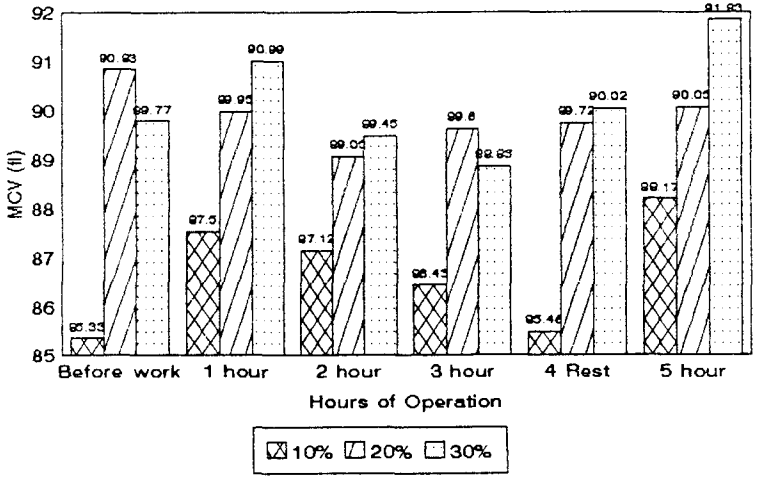


Fig.11 COMPARISON OF MEAN CORPUSCULAR HAEMOGLOBIN CONCENTRATION OF ELEPHANTS AT DRAFT OF 10%, 20% AND 30% OF THEIR BODY WEIGHT AT DIFFERENT HOURS OF OPERATION

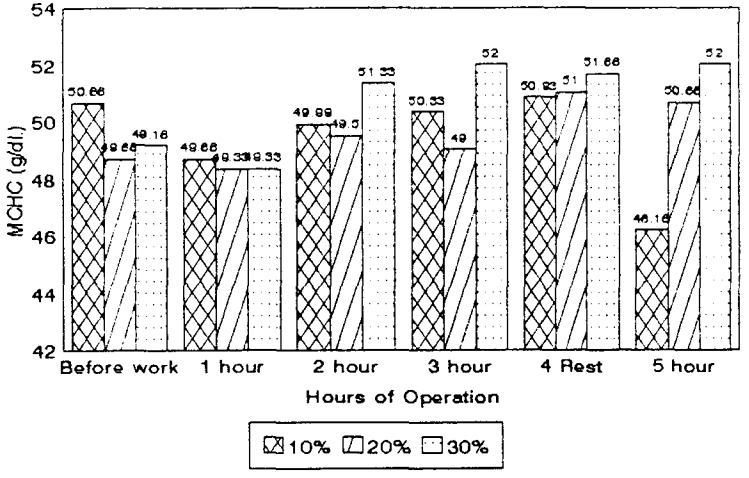
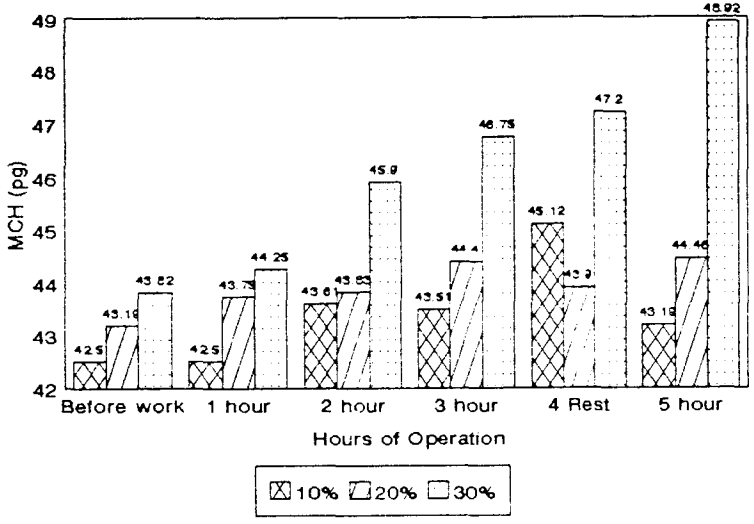


Fig.12 COMPARISON OF MEAN CORPUSCULAR HAEMOGLOBIN OF ELEPHANTS AT DRAFT OF 10%, 20% AND 30% OF THEIR BODY WEIGHT AT DIFFERENT HOURS OF OPERATION



at 10% and 20% draft. However, significant ($P < 0.01$) increase in mean corpuscular haemoglobin were observed after 3 hour of work than the initial level at 30 per cent draft. Similarly significant ($P < 0.01$) increase in mean corpuscular haemoglobin were observed after 1 hour rest than the initial range, indicating the insufficiency of 1 hour rest.

Fig.12 compares the mean corpuscular haemoglobin of working elephants at different hours of operation at different draft.

Glucose

Mean serum glucose percentage with standard errors of working elephants are presented in Table 25. The mean level of serum glucose percentage decreased immediately 1 hour after work at all draft. Similarly at 10 per cent draft the serum glucose level decreased from 69.87 ± 1.60 to 38.39 ± 2.17 at 3 hours of continuous work. The initial glucose percentage and the percentage at 3 hours of continuous work were 69.25 ± 1.93 and 39.43 ± 1.76 at 20 per cent draft and 68.11 ± 2.65 and 36.08 ± 2.06 at 30 per cent draft.

The result of the 't' test carried out between different hours of operation are presented in Table 26. The glucose percentage after 1 hour work, and 3 hour work were significantly ($P < 0.01$) lower than the initial level at all the draft. Similarly glucose percentage after 1 hour rest were significantly ($P < 0.01$) lower than the initial

level at all the draft indicating the insufficient rest period. No significant difference were observed in serum glucose percentage between 3 hour work and after 1 hour rest. Similarly serum glucose content after 3 hour work were not significant to that of 1 hour work after rest at all levels of draft.

Fig.13 compares the serum glucose percentage of working elephants at different hours of operation at different draft.

Serum total protein

The mean serum total protein with standard error are presented in Table 27. At 10 per cent draft the serum total protein decreased from 9.38±0.02 to 9.17±0.04 at the end of 3 hours of continuous work. The initial serum total protein and the serum total protein at 3 hours of continuous work were 9.33±0.05 and 9.11±0.14 at 20 per cent draft and 9.28±0.03 and 9.00±0.07 at 30 per cent draft (Table 27).

The results of the 't' test carried out between different hours of operation is presented in Table 28. No significant difference were observed in any of the comparison at 10 per cent draft and 20 per cent draft. However the serum total protein at the end of 3 hour work were significantly ($P < 0.05$) higher than the initial reading at 30 per cent draft.

The analysis also indicates that there is no significant difference in serum total protein at any other comparisons at 30 per cent draft.

Table 25 Mean glucose percentage with standard errors of working elephants at different hours of operation at different draft (mg%)

Draft per cent	Body weight of elephants (kg)	Before work	Immediately after work			Immediately after 1 hour rest	1 hour work after 1 hour rest
			1 hour	2 hour	3 hour		
10 %	2795 ± 160.07	69.87 ± 1.60	59.33 ± 2.49	46.98 ± 3.14	38.39 ± 2.17	41.32 ± 1.58	38.96 ± 1.62
20 %	2795 ± 160.07	69.25 ± 1.93	59.58 ± 1.87	49.89 ± 2.32	39.43 ± 1.76	42.06 ± 2.17	34.90 ± 2.55
30 %	2795 ± 160.07	68.115 ± 2.65	58.41 ± 2.58	47.24 ± 1.79	36.08 ± 2.06	36.95 ± 1.92	28.16 ± 3.00

Table 26 Comparison of serum glucose content of working elephants at different hours of operation at different draft ('t' values)

Comparisons	10% draft	20% draft	30% draft
Before work Vs immediately after 1 hour work	5.2760**	7.1820**	4.3580**
Before work Vs immediately after 3 hour work	9.6710**	13.8800**	7.5200**
Before work Vs immediately after 1 hour rest	14.4000**	16.9800**	7.2500**
Before work Vs 1 hour work after rest	10.6600**	14.0400**	15.2390**
Immediately 1 hour work Vs 1 hour work after rest	6.4690**	12.1910**	7.1410**
Immediately 3 hour work Vs immediately after 1 hour rest	2.5560	3.7614*	1.6230
Immediately 3 hour work Vs 1 hour work after rest	0.6925	1.3180	2.3490

* Significant at 5% level ** Significant at 1% level

Table 27 Mean total protein with standard errors of working elephants at different hours of operation at different draft (g%)

Draft per cent	Body weight of elephants (kg)	Before work	Immediately after work			Immediately after 1 hour rest	1 hour work after 1 hour rest
			1 hour	2 hour	3 hour		
10 %	2795 ± 160.07	9.38 ± 0.02	9.32 ± 0.05	9.31 ± 0.02	9.17 ± 0.04	9.22 ± 0.05	9.20 ± 0.04
20 %	2795 ± 160.07	9.33 ± 0.05	9.24 ± 0.03	9.25 ± 0.07	9.41 ± 0.05	9.11 ± 0.14	9.15 ± 0.09
30 %	2795 ± 160.07	9.28 ± 0.03	9.22 ± 0.05	9.10 ± 0.04	9.00 ± 0.07	9.07 ± 0.06	9.11 ± 0.05

Table 28 Comparison of serum total protein content of working elephants at different hours of operation at different draft ('t' values)

Comparisons	10% draft	20% draft	30% draft
Before work Vs immediately after 1 hour work	2.4880	2.3675	2.3250
Before work Vs immediately after 3 hour work	1.9590	2.4185	3.8990*
Before work Vs immediately after 1 hour rest	2.2960	2.114	2.4790
Before work Vs 1 hour work after rest	1.1630	1.7200	2.0330
Immediately 1 hour work Vs 1 hour work after rest	2.0990	1.4730	2.0320
Immediately 3 hour work Vs immediately after 1 hour rest	1.3780	0.3900	2.2081
Immediately 3 hour work Vs 1 hour work after rest	0.7220	0.9000	0.6660

* Significant at 5% level

Fig.13 COMPARISON OF GLUCOSE PERCENTAGE IN THE SERUM OF ELEPHANTS AT DRAFT OF 10%, 20% AND 30% OF THEIR BODY WEIGHT AT DIFFERENT HOURS OF OPERATION

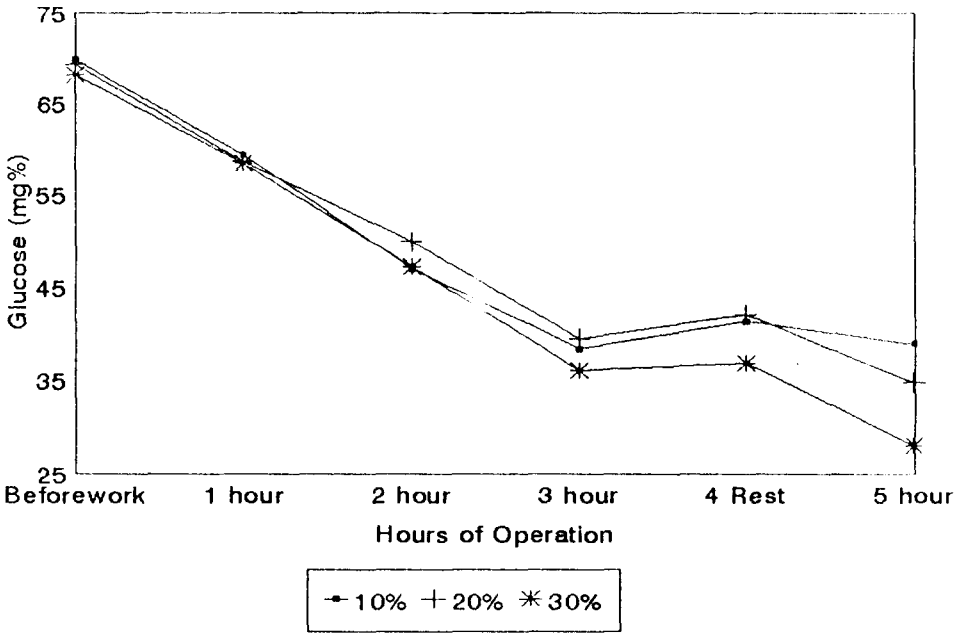


Fig.14 COMPARISON OF TOTAL PROTEIN IN THE SERUM OF ELEPHANTS AT DRAFT OF 10%, 20% AND 30% OF THEIR BODY WEIGHT AT DIFFERENT HOURS OF OPERATION

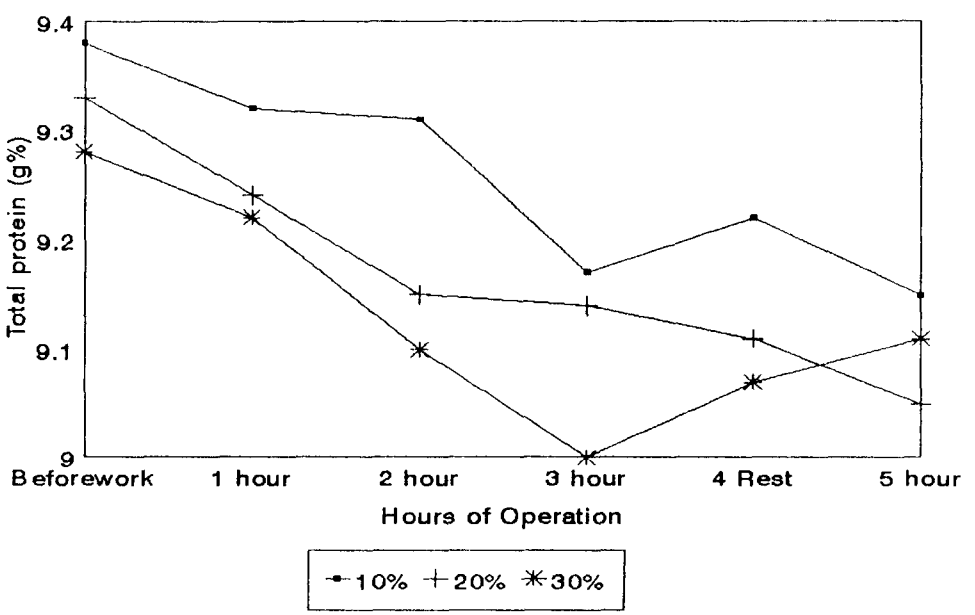


Fig.14 compares the serum total protein of working elephants at different hours of work with different draft.

Calcium

Mean with standard errors of calcium in the serum of working elephants are presented in Table 29. The results of 't' tests of calcium carried out between different hours of operation at different draft are presented in Table 30. No significant difference in serum calcium were observed between 1 hour work and the initial reading at all draft. However the calcium level after the end of 3 hour work were significantly ($P < 0.05$) lower than the initial reading at 30 per cent draft. The calcium level at the end of 1 hour rest were significantly ($P < 0.05$) lower than the initial level at 30 per cent draft. No significant difference were observed at any of the comparisons at 10 per cent and 20 per cent draft.

Fig.15 compares the serum calcium of working elephants at different hours of operation at different draft.

Phosphorus

Mean with standard errors of serum phosphorus percentage of working elephants are presented in Table 31. At 10 per cent draft the serum phosphorus decreased from 5.77 ± 0.46 to 5.62 ± 0.42 at the end of 3 hours of continuous work. The initial phosphorus content and the rate at 3 hours of continuous work were 5.73 ± 0.45 to 5.47 ± 0.39 at 20 per cent draft and 5.82 ± 0.41 to 5.54 ± 0.26 at 30 per cent draft.

The results of comparison of serum phosphorus percentage by means of 't' tests is presented in Table 32. The 1 hour rest after 3 hours of continuous work shows no significant difference from the initial level (Table 32). The serum phosphorus after 3 hour of work were significantly ($P < 0.05$) lower than the initial level. However no significant difference were seen at any other comparison at 10 per cent and 20 per cent draft. The phosphorus content at the end of 1 hour work after 1 hour interim rest were significantly ($P < 0.05$) lower than the initial level at 30 per cent draft.

Fig.16 compares the serum phosphorus of working elephants at different hours of operation at different draft.

Creatinine

Table 33 indicates the mean and standard errors of serum creatinine of working elephants at different hours of operation at different draft. At 10 per cent draft the creatinine level was increased from 1.79±0.04 to 1.80±0.02 at the end of 3 hours of continuous work. The initial creatinine level and at 3 hours of continuous work were 1.78±0.05 to 1.80±0.06 at 20 per cent draft and 1.79±0.02 and 1.81±0.03 at 30 per cent draft.

The creatinine level after 1 hour rest after 3 hours of continuous work significantly higher than the initial level of creatinine at 30 per cent draft (Table 34) indicating the insufficient rest period.

Table 29 Mean ± standard errors of calcium in the serum of working elephants at different hours of operation at different draft (mg%)

Draft per cent	Body weight of elephants (kg)	Before work	Immediately after work			Immediately after 1 hour rest	1 hour work after 1 hour rest
			1 hour	2 hour	3 hour		
10 %	2795 ± 160.07	10.73 ± 0.18	10.62 ± 0.17	10.53 ± 0.14	10.47 ± 0.16	10.41 ± 0.21	10.45 ± 0.19
20 %	2795 ± 160.07	10.05 ± 0.21	10.73 ± 0.25	10.88 ± 0.22	10.79 ± 0.19	10.74 ± 0.17	10.55 ± 0.26
30 %	2795 ± 160.07	10.88 ± 0.23	10.76 ± 0.18	10.67 ± 0.19	10.59 ± 0.21	10.52 ± 0.16	9.97 ± 0.51

Table 30 Comparison of serum calcium content of working elephants at different hours of operation at different draft ('t' values)

Comparisons	10% draft	20% draft	30% draft
Before work Vs immediately after 1 hour work	0.6520	2.0870	2.0270
Before work Vs immediately after 3 hour work	1.3840	2.6030	4.6960**
Before work Vs immediately after 1 hour rest	1.4310	2.3310	3.9410*
Before work Vs 1 hour work after rest	1.3420	3.5670	2.0770
Immediately 1 hour work Vs 1 hour work after rest	1.6530	0.8998	1.9800
Immediately 3 hour work Vs immediately after 1 hour rest	0.5330	1.4100	1.6980
Immediately 3 hour work Vs 1 hour work after rest	1.1780	2.4630	1.5380

* Significant at 5% level ** Significant at 1% level

Table 31 Mean and standard errors of phosphorus in the serum of working elephants at different hours of operation at different draft (mg%)

Draft per cent	Body weight of elephants (kg)	Before work	Immediately after work			Immediately after 1 hour rest	1 hour work after 1 hour rest
			1 hour	2 hour	3 hour		
10 %	2795 ± 160.07	5.77± 0.46	5.64± 0.44	5.62± 0.39	5.62± 0.42	5.64± 0.37	6.35± 0.36
20 %	2795 ± 160.07	5.73± 0.45	5.65± 0.44	5.69± 0.39	5.47± 0.39	5.46± 0.43	5.40± 0.31
30 %	2795 ± 160.07	5.82± 0.41	5.62± 0.39	5.66± 0.33	5.54± 0.26	5.59± 0.29	5.21± 0.32

Table 32 Comparison of serum phosphorus content of working elephants at different hours of operation at different draft ('t' values)

Comparisons	10% draft	20% draft	30% draft
Before work Vs immediately after 1 hour work	2.2840	2.2180	2.3125
Before work Vs immediately after 3 hour work	2.1440	2.2195	3.2380*
Before work Vs immediately after 1 hour rest	1.5050	1.7600	1.9500
Before work Vs 1 hour work after rest	1.5670	1.9920	3.0410*
Immediately 1 hour work Vs 1 hour work after rest	2.5760	2.2620	2.3070
Immediately 3 hour work Vs immediately after 1 hour rest	1.0490	1.2880	2.2300
Immediately 3 hour work Vs 1 hour work after rest	1.4480	1.7720	1.8754

* Significant at 5% level

Table 33 Mean and standard errors of creatinine in the serum of working elephants at different hours of operation at different draft (mg%)

Draft per cent	Body weight of elephants (kg)	Before work	Immediately after work			Immediately after 1 hour rest	1 hour work after 1 hour rest
			1 hour	2 hour	3 hour		
10 %	2795 ± 160.07	1.79± 0.04	1.79± 0.03	1.80± 0.04	1.80± 0.02	1.81± 0.04	1.81± 0.03
20 %	2795 ± 160.07	1.78± 0.05	1.78± 0.03	1.79± 0.03	1.80± 0.06	1.80± 0.05	1.80± 0.05
30 %	2795 ± 160.07	1.79± 0.02	1.80± 0.07	1.79± 0.06	1.81± 0.03	1.80± 0.02	1.81± 0.04

Table 34 Comparison of serum creatinine content of working elephants at different hours of operation at different draft ('t' values)

Comparisons	10% draft	20% draft	30% draft
Before work Vs immediately after 1 hour work	1.4640	1.5810	2.2360
Before work Vs immediately after 3 hour work	1.3950	2.3670	3.3250*
Before work Vs immediately after 1 hour rest	2.0500	1.8414	6.3250**
Before work Vs 1 hour work after rest	7.0000**	5.5340**	7.7460**
Immediately 1 hour work Vs 1 hour work after rest	1.8414	2.4770	6.7080**
Immediately 3 hour work Vs immediately after 1 hour rest	2.2361	1.0000	2.1620
Immediately 3 hour work Vs 1 hour work after rest	2.1620	2.4639	2.1620

* Significant at 5% level ** Significant at 1% level

Fig.15 COMPARISON OF CALCIUM PERCENTAGE IN THE SERUM OF ELEPHANTS AT DRAFT OF 10%, 20% AND 30% OF THEIR BODY WEIGHT AT DIFFERENT HOURS OF OPERATION

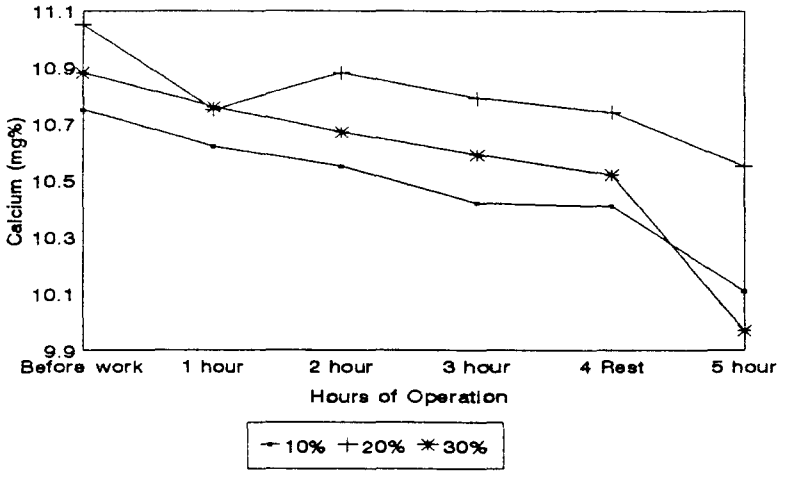


Fig.16 COMPARISON OF PHOSPHORUS PERCENTAGE IN THE SERUM OF ELEPHANTS AT DRAFT OF 10%, 20% AND 30% OF THEIR BODY WEIGHT AT DIFFERENT HOURS OF OPERATION

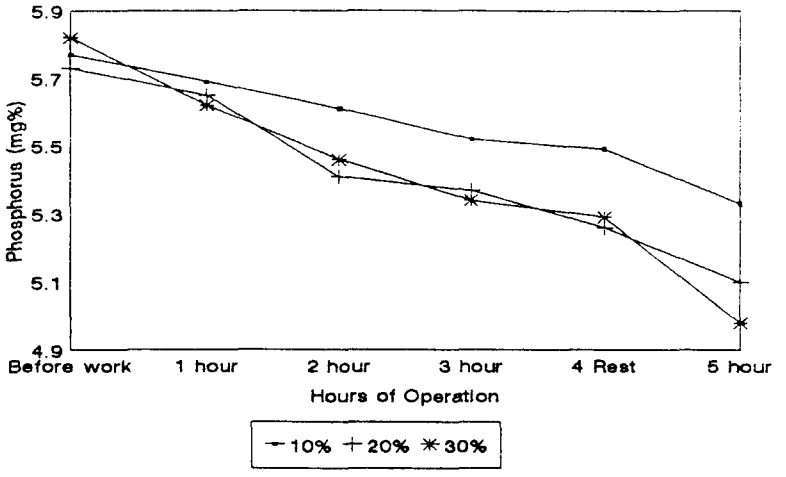
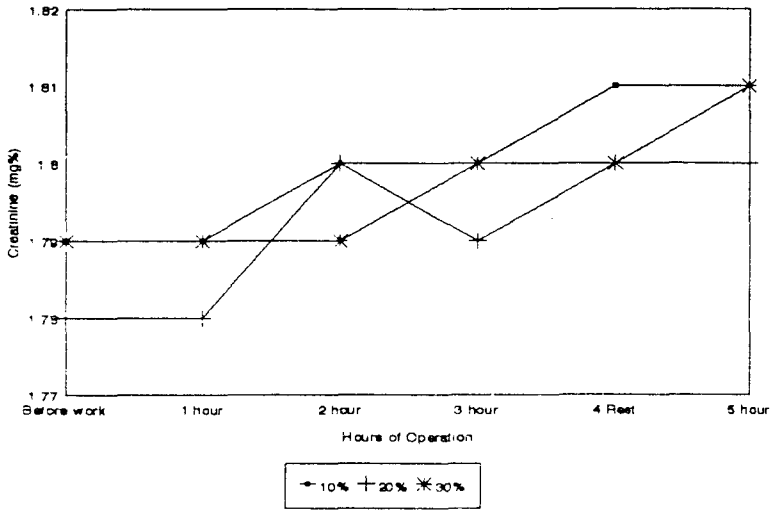


Fig.17 COMPARISON OF CREATININE PERCENTAGE IN THE SERUM OF ELEPHANTS AT DRAFT OF 10%, 20% AND 30% OF THEIR BODY WEIGHT AT DIFFERENT HOURS OF OPERATION



The creatinine level after 3 hour work were significantly ($P < 0.05$) higher than the initial level of 30 per cent draft. However the difference were non-significant at 10 per cent and 20 per cent draft.

A significant ($P < 0.01$) higher creatinine level than the initial reading were also observed at 1 hour work after 1 hour rest at 20 per cent and 30 per cent draft. Similarly creatinine level at 1 hour work after rest were significantly ($P < 0.01$) higher than 1 hour work at 30 per cent draft. Significant difference were not observed between 3 hour work and 1 hour work after rest.

Fig.17 compares the serum creatinine of working elephants at different hours of operation with different draft.

Fatigue score card

When fatigue level of elephant was quantified at work by using a score card (Table 35). At the end of 1 hour of operation the score were 5.2±0.43 at 10% level, 8.26±0.43 at 20% level and 10±0.19 at 30% draft. The observation of fatigue signs as given in Table 39 showed that during one hour of work at any level of draft, the elephants were not showing any sign of stress of fatigue. Similarly at 2 hour of work at 10% and 20% level was found to be non fatiguing on elephants as revealed by low score card but at 30% level the elephant was showing the signs of fatigue (Table 36) with a score card of 16.63±0.71. In the present study, the elephant attaining a score of 15 were declared fatigued.

The elephants have become fatigued at the end of third hour of work at 20% and 30% draft having a score of 17.16±0.74 and 20.65±0.70 respectively.

Even at 10 per cent level, 3 hour work was making the elephant nearer to fatigue level (Table 37).

Fig.18 compares the fatigue score card of working elephants at different hours of operation with different draft.

Signs of stress and fatigue in the form of physical response of working elephants during work at different draft are presented in Table 38.

Horse-power

Mean and standard error of horsepower developed by working elephants is presented in Table No.38. Maximum horsepower developed were 4.53±0.33 at 10% level, 8.36±0.55 at 20% level and 12.83±0.85 at 30 per cent level. As the duration of work increases the horsepower generated were found to have a gradual decline.

Fig.19 compares the horsepower generated by working elephants at different hour of operation with different draft.

Table 35 Mean and standard errors of fatigue score card at the end of first hour of operation at different draft

Draft per cent	Body weight of elephants (kg)	Speed	Pulse rate	Respiration	Rectal temperature	Total
10%	2795 ± 160.07	0.43±0.03	2.50±0.22	2.00±0.25	0.26±0.04	5.20±0.43
20%	2795 ± 160.07	0.44±0.06	4.16±0.30	3.50±0.22	0.30±0.03	8.26±0.43
30%	2795 ± 160.07	0.68±0.07	4.16±0.16	4.83±0.15	0.48±0.03	10.00±0.19

Table 36 Mean and standard errors of fatigue score card at the end of second hour of operation at different draft

Draft per cent	Body weight of elephants (kg)	Speed	Pulse rate	Respiration	Rectal temperature	Total
10%	2795 ± 160.07	0.71±0.07	3.85±0.49	2.85±0.16	0.43±0.06	8.35±0.45
20%	2795 ± 160.07	0.60±0.02	7.16±0.16	4.83±0.40	0.51±0.04	13.11±0.36
30%	2795 ± 160.07	1.61±0.10	7.00±0.44	6.83±0.30	0.85±0.05	16.63±0.71

Table 37 Mean and standard errors of fatigue score card at the end of third hour of operation at different draft

Draft per cent	Body weight of elephants (kg)	Speed	Pulse rate	Respiration	Rectal temperature	Total
10%	2795 ± 160.07	1.15±0.09	6.16±0.60	4.16±0.30	0.50±0.06	11.98±0.84
20%	2795 ± 160.07	1.26±0.11	9.16±0.47	6.00±0.36	0.73±0.03	17.16±0.74
30%	2795 ± 160.07	2.36±0.04	8.83±0.47	8.33±0.33	1.11±0.07	20.65±0.70

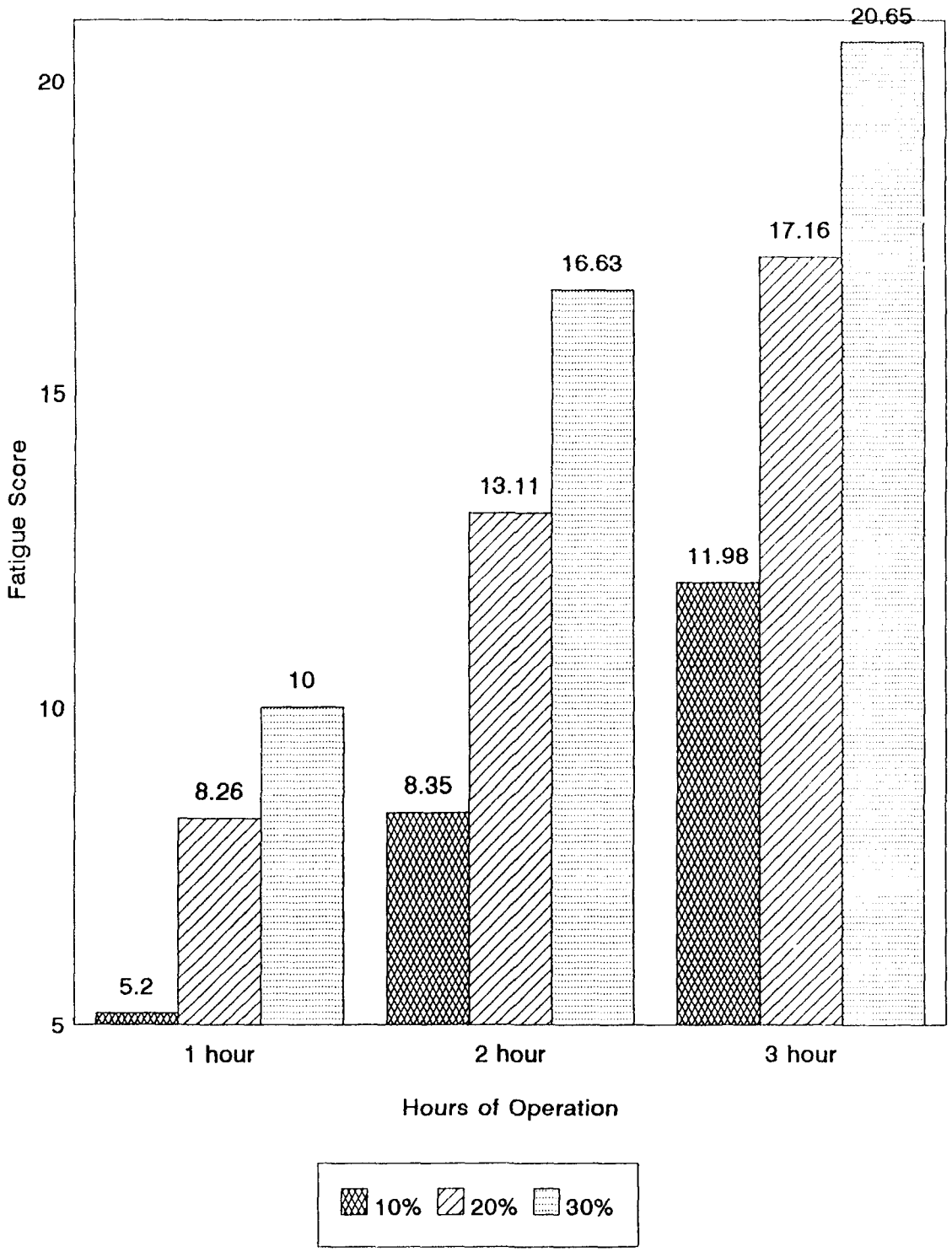
Table 38 Signs of stress and fatigue during work at different draft per cent

Draft per cent of body weight	Physical responses
10%	Reluctance to move was shown only once at 3rd hour work. Occasional spraying of saliva by trunk at 2nd and 3rd hour work. Occasional urination at 2 hour and thereafter. Occasional appearance of tears from the eyes.
20%	Reluctance to move was seen 6 to 10 times throughout the work. Frequent spraying of saliva by trunk on its body. Frequent urination. Slow walking and occasional dragging of feet in 3rd hour work. Frequent appearance of tears from the eyes.
30%	Frequency of spraying saliva by trunk to its body increases after second hour of operation. Reluctance and occasional refusal to walk at second and third hour work. Slow walking. No co-ordination between legs. Continuous flow of urine. Continuous appearance of tears from the eyes.

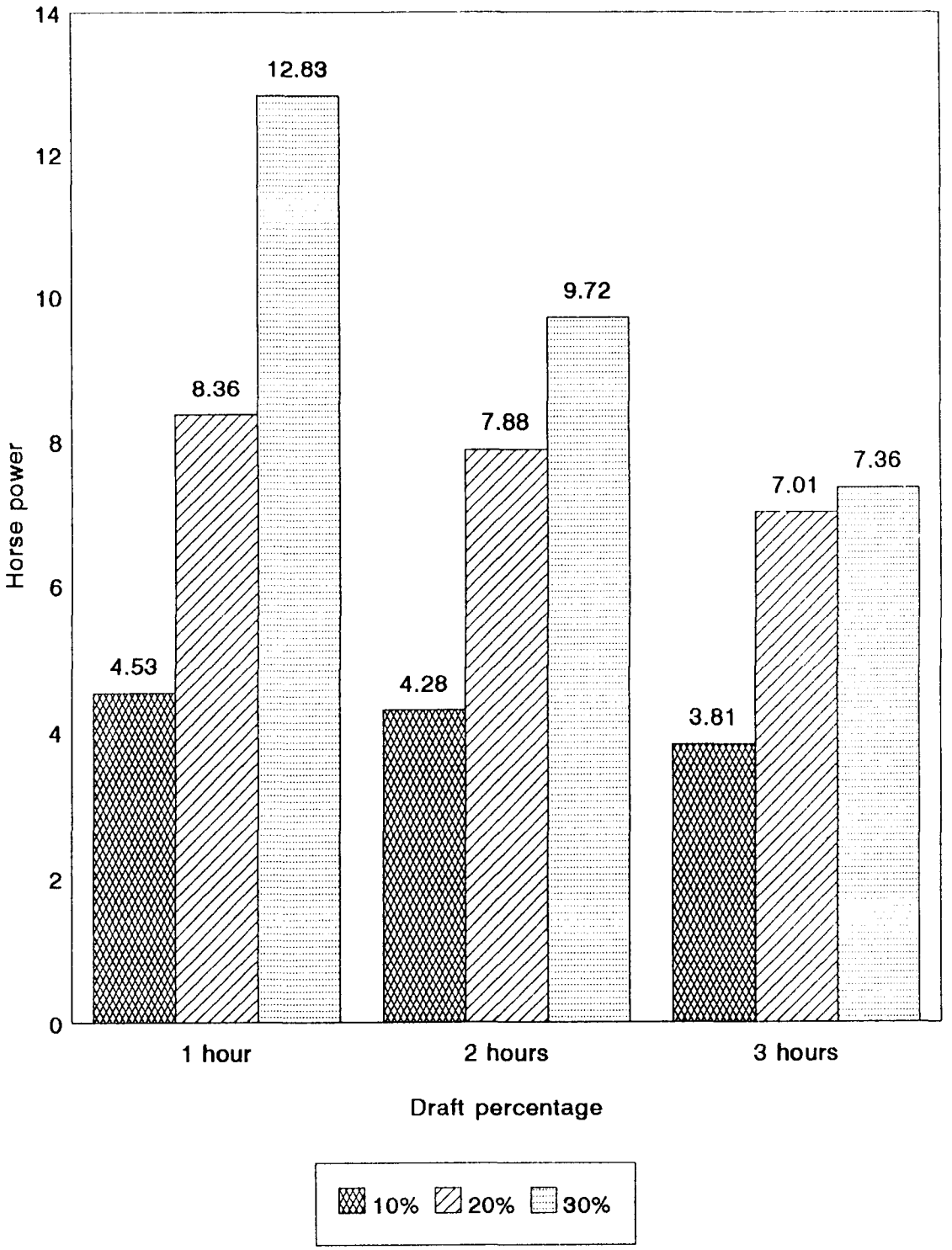
Table 39 Mean with standard errors of draft and horse-power developed by working elephants at different hours of operation

Draft per cent	Body weight of the elephants (kg)	Draft (kg)	Hours of operation - horse-power		
			I HP	II HP	III HP
10%	2795±160.07	277.50±13.60	4.53±0.33	4.28±0.33	3.81±0.36
20%	2795±160.07	555.80±26.20	8.36±0.55	7.88±0.56	7.01±0.58
30%	2795±160.07	833.66±39.39	12.83±0.85	9.72±0.50	7.36±0.67

Fig.18 FATIGUE SCORE CARD OF ELEPHANTS AT DRAFT OF 10%, 20% AND 30% OF THEIR BODY WEIGHT AT DIFFERENT HOURS OF OPERATION



g.19 COMPARISON OF HORSE POWER DEVELOPED BY ELELPHANTS AT DRAFT OF 10%, 20% AND 30% OF THEIR BODY WEIGHT AT DIFFERENT HOURS OF OPERATION



DISCUSSION

DISCUSSION

In the present study the elephants were made to work with a draft of 10 per cent, 20 per cent and 30 per cent of their body weight for a period of continuous three hour work followed by 1 hour of interim rest and 1 hour work after rest. The relationship between percentage of draft and duration of work were studied. The outcome of rest given after a period of 3 hours of continuous work on reducing the fatigue and ability to continue the work was estimated. The fatigue level of working elephants were evaluated on the basis of score card.

When the elephants were subjected to three hour of continuous work at 10 per cent, 20 per cent and 30 per cent draft. There were significant increase in respiration rate, pulse rate and rectal temperature than the reading at rest.

A. Assessment of fatigue

a) Respiration rate

Elephants showed a gradual rise in respiration rate as the duration of work increased. This is in agreement with the findings of previous investigators worked in cattle (Singh *et al.*, 1968a; Singh *et al.*, 1970; Devadattam and Maurya, 1978; Acharya *et al.*, 1979, Nangia *et al.*, 1980; Upadhyay and Madan, 1985; Thomas and Pearson, 1986; Sreekumar and Thomas, 1990a and Anil, 1994).

The respiratory rates did not return to pre-exercise values even after 1 hour of rest after the end of 3 hour work but there was a gradual decline in the rate of respiration during the rest period. This finding is similar to the observation made by Maurya and Devadattam (1982a). Sreekumar and Thomas (1990b); Anil (1994) in which a rest period of 1 hour was not sufficient to bring the increased respiration rates to the initial values.

At high environmental temperature and under exposure to solar radiation, wallowing and spraying with water reduce respiration rate in buffaloes (Chikamune *et al.*, 1987; Chikamune and Shimizu, 1983). While working the elephants were seen spraying saliva by the trunk on to its body.

b) Pulse rate

The present reports supports the fact as observed by almost all the previous workers irrespective of type of animals and nature of work, have noticed an enhancement of pulse rate due to exercise (Roy *et al.*, 1972; Devadattam and Maurya, 1978; Rana *et al.*, 1978; Maurya and Devadattam, 1982b; Thomas and Pearson, 1986; Sreekumar and Thomas, 1990 and Anil, 1994).

c) Rectal temperature

The increase in rectal temperature in bullocks due to exercise and work has been universally observed by almost all workers (Singh *et al.*, 1968a; Roy *et al.*, 1970;

Devadattam and Maurya, 1978; Rana *et al.*, 1978; Thomas and Pearson, 1986; Sreekumar and Thomas, 1990b and Anil, 1994).

One hour of rest after 3 hour of continuous work significantly ($P < 0.01$) reduced the rectal temperature at all draft but one hour of rest was inadequate to bring down the rectal temperature to pre-exercise values. The finding is similar to the observation made by (Sreekumar and Thomas, 1990b; Maurya and Devadattam, 1982 and Singh *et al.*, 1970).

It is universally understood that at high environmental temperatures buffaloes are able to dissipate the excess heat through evaporating ectosomatic water (Chikamune, 1987), wallowing (Chikamune and Shimizizu, 1983) and water spraying (Taneja and Bhatnagar, 1960) are known to lower rectal temperature in buffaloes under heat stress. Elephants while working were observed to splash saliva on to their body. This resulted in wetting of a large area of the skin and helped the elephants in thermolysis through evaporation of this ectosomatic water, preventing the excessive heat accumulation and rise of temperature in their body.

d) Average speed

The average speed of work has been reduced significantly ($P < 0.01$) at different levels of draft the finding from the present study confirms the earlier observation reported by Sreekumar and Thomas (1990b).

There were a significant increase in respiration rate, pulse rate, rectal temperature than the normal level at one hour work but there were no signs of fatigue at that stage. At 20 per cent and 30 per cent draft the elephants started showing fatigue sign like reluctance and refusal to walk, slow walking and incordination of legs at 3 hour of continuous work. The elephant was given one hour of interim rest after 3 hour of continuous work.

The quantification of fatigue level has given rise to a fatigue score of 17.16 and 20.65 at 20 per cent and 30 per cent draft at 3 hour of work. At 30 per cent draft, 2 hour work itself made the animal fatigued with a score of 16.63. In the present study it was observed that the elephant attained fatigue level early as the draft percentage increase (Fig.18).

At 10 per cent draft the fatigue score and reading at 1 hour, 2 hour and 3 hour continuous work were 5.2, 8.35 and 11.98 respectively. At 10 per cent draft the elephant has never reached the fatigue stage even after 3 hour of work, whereas at 20 per cent draft upto one hour work there was no sign of fatigue or tiredness in carrying out the work with a score of 8.26. However by 2 hour work the animal almost reached fatigue stage with a score of 13.1. At 30 per cent draft, even at one hour the animal was nearing fatigue stage and by second hour it has reached fatigue level with a score of 16.63. The result revealed that in elephants the ideal duration of continuous work seemed to be 3 hour at 20 per cent draft and 2 hour of work at 30 per cent draft.

Corresponding decrease in horsepower generated have been observed with increased draft and duration (Fig.19). This is in agreement with the findings of previous investigations worked in bullocks (Upadhyay, 1982; Anon, 1972; Singh *et al.*, 1970; Maurya and Devadattam, 1982a).

B. Haematological changes

Three hour of continuous work resulted in significant reduction in haemoglobin, packed cell volume and a significant increase in erythrocyte sedimentation rate at 30 per cent draft. At 10 and 20 per cent draft, there were no significant changes in these readings. The increase in draft caused more stress on elephants as evidenced by the change in haemoglobin, packed cell volume and erythrocyte sedimentation rate of the end of one hour of work itself.

Haemoglobin

Present study revealed that the haemoglobin content decreased immediately after 1 hour work at all levels of draft but only at 30 per cent draft the haemoglobin showed a significant ($P < 0.01$) decrease immediately after 1 hour work. This is in agreement with the findings of previous investigators. Thomas and Razdan (1973) reported an expansion of plasma volume and haemodilution due to heat stress. There were certain degree of red blood cell destruction during exercise (Rana *et al.*, 1977; Nangia *et al.*, 1978). This may also lead to a reduction in the haemoglobin per cent as a result of exercise. A decline in haemoglobin content after continuous

work in bullocks was also reported by (Upadhayay and Madan, 1988; Sreekumar and Thomas, 1990a).

Packed Cell Volume (PCV)

Packed Cell Volume value from 18.50±0.36 to 21.00±0.42 mm/hour noted in the present study in adult working elephants are in agreement with the values observed by Nirmalan *et al.*, 1967; Sreekumar, 1986; Young and Lombard, 1967; Usami *et al.*, 1969; Niemuller *et al.*, 1990 and Yathiraj *et al.*, 1992).

It was observed that the mean packed cell volume declined immediately after 3 hour of continuous work at all levels of draft. However significant ($P < 0.01$) reduction in packed cell volume was observed at the end of 3 hour work at 30 per cent draft. One hour of rest was found inadequate to bring the packed cell volume to the pre-exercise level. The decrease in packed cell volume after continuous work was in accordance with haemodilution and destruction of RBC during severe exercise. Similar reduction in the packed cell volume was observed by Singh *et al.*, 1980; Singh *et al.*, 1982; Upadhayay and Madan, 1982 as a result of different types of work in different classes of animals.

Erythrocyte sedimentation rate (ESR)

Elephants had a lower ESR value immediately after 1 hour work. However elephants had a higher ESR values after continuous work of 2 hour and 3 hour at all drafts. After one hour of rest the ESR value was higher than the initial ESR value.

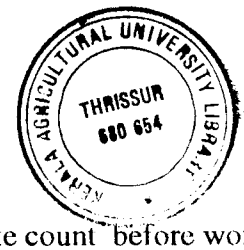
The higher value of ESR in case of elephants may be the rouleaux formation. This is a grouping of erythrocytes resembling a pile of coins and a normally found in the equine erythrocytes as well as erythrocytes of the buffalo. The degree of rouleaux formation in directly proportional to the erythrocyte sedimentation rate, because of this ESR is greatest in horses, buffaloes and elephants (Benjamin, 1974).

The values of ESR increased significantly in animals put to exercise and followed the inverse trend as that of PCV since, the number of erythrocytes per unit volume of blood has a marked effect on sedimentation rate. The speed of settling is inversely related to the number of red blood cells (Schalm, 1965). The increase in ESR may be partially due to red blood cell destruction during exercise. Continuous exercise seems to cause stress in elephants and rest seems to result in slow recovery.

Low PCV is associated with higher ESR (Nangia *et al.*, 1968). Similar increase in ESR was reported by Rana *et al.*, 1977 when buffalo calves were subjected to exercise.

Total Erythrocyte Count (TEC)

The low RBC count observed in the present study is in agreement with the reports of Simon (1961). Bartles *et al.* (1963), Nirmalan *et al.* (1967); Andrewbutter (1971), Jainudeen and Jayasinghe, 1971; Lewis, 1974; Jain, 1986 and Yathiraj, 1992.



There is no significant difference in total erythrocyte count before work to that of 1 hour work at any level of draft. However significant ($P < 0.01$) decrease in RBC were observed at 3 hours of continuous operation at 30 per cent draft. This is in agreement with the findings of previous investigator. Thomas and Razdan (1973) reported expansion of plasma volume and haemodilution due to exercise in bullocks. Also, there is a certain degree of red blood cell destruction during heavy exercise which is indicated by a high icteric index (Rana *et al.*, 1977; Nangia *et al.*, 1978; Sastry *et al.* (1970) observed that the erythrocyte number decreased in sahiwal bullocks during submaximal exercise of two hours duration.

Total Leukocyte count

The mean leukocyte count observed in this study ranged from 9.36±0.26 to 10.58±0.175 (thousands/mm^3). This is coming in the normal range of leukocyte count (8.78 to 11.90 x $10^3/mm^3$) reported by various workers (Simon, 1961; Schmitt, 1964; Jainudeen and Jaysinghe, 1971; Debbie and Clausen, 1975; Jain, 1986; Niemuller *et al.*, 1990; Yathiraj *et al.*, 1992 and Sassendran, 1994).

In the present study mean corpuscular volume (MCV) mean corpuscular haemoglobin (MCH) and mean corpuscular haemoglobin concentration (MCHC) were estimated. This was in agreement with the observation made by Jainudeen and Jayasinghe (1971); Lewis (1974); Jain (1986) and Yathiraj (1992).

Glucose

Present study revealed that there is significant ($P < 0.01$) decrease in serum glucose immediately after work at all levels of drafts. It was also observed that the level of glucose in the serum of working elephant decreases as the duration of work increases. The decreases glucose percentage in the serum of working elephants is due to breakdown of glucose to liberate ATP for energy carry out work.

Serum glucose level during medium musth stage is significantly lower ($P < 0.01$) than the value recorded during non musth stage. This low level might have obtained due to the reduction in food intake by the elephants during musth (Saseendran, 1994). However Niemiller *et al.* (1990) could not observe any change in blood glucose level during musth in elephants.

In very strenuous work, lasting 2.5 to 3 hour such as marathon running, exhaustion may result from serious depletion of carbohydrate reserve with a serious drop in blood sugar (Krough and Lindhrd, Christensen, Henchel *et al.*).

Total protein

In the present study, the total protein estimated in the serum of working elephants during different hour of operation at different draft ranged from 9.00 ± 0.07 to 9.38 ± 0.02 g%. This is in agreement with the findings of previous

investigators (Giri *et al.*, 1958; Simon, 1961; Nirmalan and Nair, 1969; Moses and Gopalakrishnan, 1979; Sreekumar, 1986 and Saseendran, 1994).

Minerals

Calcium - In the present study the calcium estimated in the serum of working elephants ranged from 9.97±0.31 to 10.73±0.18 mg percent. This is in agreement with the findings of previous investigators (Simon, 1961; Nirmalan, 1967; Nirmalan and Nair, 1969; Andrew Butter, 1971; Pillai, 1972; Ananthasubramanian, 1979; Brown and White, 1980; Neimullor *et al.*, 1990; Saseendran, 1994).

Phosphorus - In the present study the phosphorus estimated in the serum of working elephants ranged from 5.77±0.46 to 5.82±0.41 mg per cent. This was in agreement with the findings of previous investigators (Nirmalan, 1967; Niemuller, *et al.*, 1990).

Creatinine - In the present study significant increase ($P < 0.05$) in serum creatinine after work was observed. Since creatinine is a waste product of muscle tissue there may be some enhanced muscular activity during exercise. This is in agreement with the finding as reported by Chapple *et al.*, 1991; Niemuller *et al.*, 1991 and Saseendran, 1994).

SUMMARY

SUMMARY

The study was carried out to assess the draught potential of elephants. Four adult trained elephants in the age group of 25 to 35 from forest department and two elephants under private ownership from Kozhikode were utilized for the study. The elephants were put to work under 10 per cent, 20 per cent and 30 per cent draft for a period of 3 hour of continuous work followed by 1 hour rest and 1 hour work after rest. At the end of every hour of work, changes in respiration rate, pulse rate, rectal temperature speed of work and signs of fatigue were recorded and the same were employed for developing fatigue score card of elephants at work.

Physiological parameters such as respiration rate, pulse rate, rectal temperature and haematological parameters such as haemoglobin, packed cell volume, erythrocyte sedimentation rate, total erythrocyte count, total leukocyte count, mean corpuscular volume, mean corpuscular haemoglobin, mean corpuscular haemoglobin concentration, serum glucose, serum total protein, serum calcium, serum phosphorus, serum creatinine were estimated before work, immediately after 1 hour, 2 hour, 3 hour work followed by 1 hour rest and 1 hour work after rest. Other parameters like the average speed of working. Draft and horsepower developed during different hour of operation with different draft of 10 per cent, 20 per cent and 30 per cent were observed and compared.

When the elephants were subjected to three hour of continuous work, there were significant increase in respiration, rate, pulse rate and rectal temperature than the initial reading before the start of work. The respiration rate, pulse rate and rectal temperature in the elephants at 10 per cent draft increase after 3 hour of continuous work from 8.83 ± 0.03 to 12.66 ± 0.49/min. 29.08 ± 0.60 to 36.33 ± 0.42/min and 36.06 ± 0.06°C to 36.500 ± 0.08°C. The corresponding values at 20 per cent draft rose from 8.83 ± 0.30 to 10.16 ± 0.30/mt, 29.83 ± 0.47 to 39.00 ± 0.44/mt and 36.10 ± 0.08°C to 36.81 ± 0.07°C in case of 30 per cent draft. The comparative values significantly increased from 8.83 ± 0.03 to 17.16 ± 0.30, 30.00 ± 0.57 to 38.83 ± 0.79 and 36.13 ± 0.04°C to 37.25 ± 0.06°C.

After one hour rest the values dropped significantly, but did not reach the pre-exercise values indicating the insufficiency of 1 hour rest.

Similarly the speed of walking decreased as the duration and draft of work increased. The speed of walking at 3 hour of work decreased from 4.83 ± 0.11 to 3.68 ± 0.13 at 10% draft, 4.41 to 0.71 km/h to 3.71 ± 0.36 km/h at 20 per cent draft and 4.76 ± 0.10 km/h to 2.35 ± 0.11 km/h at 30 per cent draft.

The haemoglobin per cent of blood and packed cell volume decreased significantly as a result of work. The Hb% and PCV of elephant declined after 3 hour of work at 30% draft from 10.08 ± 0.07 to 10.06 ± 0.06 and 20.00 ± 0.87 mm/hour to 18.50 ± 0.31 mm/hour respectively. No significant difference were observed at 10 and 20 per cent draft for the same comparison.

The erythrocyte sedimentation rate were found to increase significantly after the end of 3 hour continuous work at 30 per cent draft. The value of ESR content increased from 61.48 ± 0.40 to 62.81 ± 0.50 mm/hour.

The mean erythrocyte count decreased from 2.29 ± 0.04 to 2.16 ± 0.05 at 3 hour of work at 30 per cent draft. Similarly mean leukocyte count significantly increased from 9.72 ± 0.23 to 10.335 ± 0.39 at 3 hour work at 30 per cent draft but no significant difference were observed at any other comparison.

No significant difference were observed in MCV, MCHC and MCH during different hours of operation with different draft.

Serum glucose level were significantly ($P < 0.01$) lower than the initial after 3 hours of work at 10, 20 and 30 draft. The serum glucose level decreased correspondingly from 69.87 ± 1.60 to 38.39 ± 1.58, 69.25 ± 1.93 to 39.43 ± 1.76 and 58.115 ± 2.65 to 36.08 ± 2.06 respectively.

There was significant difference in the serum protein, serum calcium and serum protein level after 3 hour of work at 30 per cent draft.

A significantly higher serum creatinine was observed after work than the initial level at 20 per cent and 30 per cent draft.

The corresponding fatigue score attained by the elephants after 3 hour of work at 10%, 20% and 30% draft were 10, 16.63, 20.65. The elephants attaining a score above 15 were found fatigued. At the end of 2nd hour work the corresponding fatigue score at 10, 20 and 30 per cent draft were 8.26, 13.11 and 17.16 respectively.

The horse-power developed by elephants at 3 hour of work at 10 per cent, 20 per cent and 30 per cent draft were 12.83, 9.72, 7.36 respectively.

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DRAUGHT EFFICIENCY OF ASIAN ELEPHANTS *(Elephas maximus indicus)*

By

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ABSTRACT OF A THESIS

Submitted in partial fulfilment of the
requirement for the degree

Master of Veterinary Science

Faculty of Veterinary and Animal Sciences

KERALA AGRICULTURAL UNIVERSITY

Department of Livestock Production Management

COLLEGE OF VETERINARY AND ANIMAL SCIENCES

MANNUTHY - THRISSUR

1996

ABSTRACT

The draught performance of elephants were assessed on the basis of the degree of variation from the normal physiological, haematological parameters during different hours of operation with different draft. The ability of the elephants to carry out work with different draft were observed on the basis of fatigue score card and distress signs exhibited by the animal during different hour of operation with different draft.

Six elephants were utilized for the study, the elephants were put to work for a period of 3 hour of continuous work from 7 AM to 10 AM, followed by 1 hour rest and 1 hour work after rest with different draft.

Physiological responses like respiratory rate, pulse rate, rectal temperature and haematological parameters like haemoglobin per cent, packed cell volume, erythrocyte sedimentation rate, total erythrocyte count, total leukocyte count, mean corpuscular volume, mean corpuscular haemoglobin, mean corpuscular haemoglobin concentration, serum glucose, serum protein, serum calcium, serum phosphorus, serum creatinine, were estimated before work, immediately after 1 hour, 2 hour, 3 hour followed by one hour rest and 1 hour work after rest. Other parameters like average speed of walking, draft and horsepower developed by elephants were also estimated.

As a result of work the physiological responses increased significantly. The physiological responses showed maximum increase at 3 hour of work at 30 per cent

draft indicative of distress. There were also other physical signs of distress like frequent spraying of saliva, refusal to work and dragging of feet. The physiological responses decreased but did not reach the pre-exercise values after one hour of rest.

The haemoglobin percent of blood, packed cell volume, total erythrocyte count decreased significantly after work. The erytrocyte sedimentation rate shows significant increase after work. The other parameters like average speed, decreased significantly as the duration work progressed. No significant difference were observed in mean corpuscular volume, mean corpuscular heamoglobin concentration and mean corpuscular haemoglobin. Serum glucose content decreased significantly after work serum creatinine significantly increased after work.

Overall, the results indicate that the elephants at 10 per cent draft can work for 3 hour continuously without showing any signs at distress, obtaining a comfortable fatigue score below 10. At 20 per cent draft animal starts showing the sign of distress at 3 hour of work with a fatigue score reaching upto 16.63. At 30 per cent draft the elephants starts exhibiting the signs of distress signs at the end of 2 hour of work itself and at 3 hour work the animal is highly fatigued with the fatigue score reaching 20.65. The elephants reaching fatigue score of above 15 were found fatigued.