DRAUGHT POTENTIALITIES OF INDIGENOUS AND CROSS-BRED CATTLE

By

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THESIS

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DECLARATION

I hereby declare that this thesis entitled "Draught potentialities of indigenous and cross-bred cattle" is a bonafide record of research work done by me during the course of research and that the 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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CERTIFICATE

Certified that this thesis, entitled "Draught potentialities of indigenous and cross-bred cattle" is a record of research work done independently by Sri. D. Sreekumar, 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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Dedicated to my

beloved parents

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Introduction

INTRODUCTION

Use of draught animal power in developing countries is an excellent example of mass application of appropriate technology. About two billion people in the developing countries depend upon draught animal power for agricultural and allied operations, hauling vehicles, logging operations and carrying goods. Draught cattle and buffaloes produce anywhere between 0.4-0.8 horse power on a sustained basis. In India, there are more than 50 million small and marginal farms of less than three hectares. Bullock power is ideally suited for such small holdings because (1) the capital investment needed for the purchase of tractors is often beyond the capacity of such farmers and (2) the holdings are too small to put use the full capacity of these mechanical power sources.

Taking into consideration the power generated by draught animals in the country, it is assumed that five pairs of animals can be replaced by one tractor and about 30 million tillers and tractors will be required to replace the draught animals (Ramaswamy, 1983). Due to the fragmented and scattered land holdings, low economic levels, lack of adequate capital and abundance of man power, mechanisation is hindered in our country. Moreover, maintenance of an animal unit by the farmer is a traditional style and involves mostly family labour. Eight million work animals plough two-thirds of the land and carry two-thirds of the rural transportation. Apart from power the products like meat, skin, bone, hoof, horns, dung and numerous other by-products contribute to the economics of the country (Ramaswamy, 1983).

At present, in India, we have 70 million bullocks, 8 million buffaloes and one million each of horses, camels and donkeys. A majority of the well defined breeds of cattle in India are of the draught type. The males are good working animals and females poor milk producers. Practically all breeds of Indian cattle belong to the humped bovine. South India has some of the most important draught breeds of cattle namely Alambadi, Amrithmahal, Bargur, Hallikar, Kangayam and Khillari. All these animals are very hardy and suited for fast work. The Kangayam is one of the popular breeds of South India, mainly because they are economical to maintain.

The cross-breeding policy of our country has brought about an increase in the number of cross-bred bullocks which are mainly a by-product of this programme for increasing milk production. While the indigenous breeds are well recognised as ideal draught animals suitable for the harsh environmental conditions, the cross-breds are yet to prove their merit in this respect. There is considerable resistance on the part of farmers to accept cross-breds as work animals. Whether this is due to prejudice for something new or due to some genuine handicap on their part can only be assessed by careful experimentation. An answer to this question is vital as large number of cross-bred males are going to be produced in the country for which avenue as meat animals is limited.

The draught performance of cross-bred bullocks has not been much evaluated, especially so under our agro-climatic conditions. Moreover, comparison of the existing excellent native draught breeds with the above group is also meagre. The scanty data available at present is with Hariana (dual type cattle) and other minor draught breeds. Thorough investigation with the South Indian breeds and cross-breds available under the existing agro-climatic zone has not been done so far. Hence, this study is undertaken to compare the draught performance of a South Indian draught breed (Kangayam) with cross-bred draught bullocks.

Climate is one of the limiting factors in draught animal performance. According to ICAR (1977), the climate of Indian subcontinent is essentially tropical with three distinct seasons - winter (October-February), summer (March-June) and rainy (July-September). In Kerala, there is absence of seasonal rythm and little variation in day length (Nair, 1973). Somanathan and Rajagopalan (1983) after studying the climatic profile of Mannuthy, came to the conclusion that two distinct seasons (rainy and dry) prevail in this locality which is generally applicable to the plains of Kerala. The rainy season was again subdivided into cold-wet and warm-wet. Similarly, the dry season was subdivided into warm-dry and hot-dry. The draught animals are exposed to a persistent hot-humid climate and they are subjected to tremendous stress from the environment and from their system. The hot humid climate is imposing a direct and indirect influence on the draught animals. The heat generated from exercise and metabolic heat production are also adding upto the stress factors.

Low quality diets based on straw or very mature grasses are often the only food available for draught animals in the tropics. These diets add to the problems imposed by climate. On the one hand their high heat increment of feeding may add to the heat stress (Stott and Moody, 1960) and on the other they impose severe physiological limitations on their feed intake (Dinius and Baumgardt, 1970; Baile and Forbes, 1974). There is considerable evidence to suggest that cross-breds are less heat tolerant than the pure bred *Bos indicus* animals (Thomas and Razdan, 1973 and 1974; Amakiri and Funsho, 1979; Holmes *et al*., 1980). With the added heat production due to work, will the cross-bred bullock be able to perform efficiently and consume enough coarse feed to maintain itself and provide energy for work? On this will depend the future of *Bos indicus* x *Bos taurus* cross-bred bullocks as a draught animal for tropics. The present study aims at evaluating the draught potentialities of indigenous and cross-bred cattle under the agro-climatic zone of Kerala.

Review of Literature

REVIEW OF LITERATURE

2.1. Draughtability

Work is done when force is exerted to move an object over a distance. 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 (1) walking uphill and (2) 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 require an increase in energy expenditure".

For controlled experiments making simultaneous measurement of work-output and energy expenditure, traditionally treadmills have been used. The energy expenditure while working can conveniently be partitioned into that for walking unloaded, walking uphill, carrying loads and pulling loads. The net energy cost of walking unloaded has been estimated to be 2 joules/kg body weight/metre in cattle and buffaloes (Lawrence, 1985). Energy cost of walking uphill has been found to be 26.82 j/kg body weight/metre ascended (Thomas and Pearson, 1986) and 26.5 j/kg (Ribeiro et al., 1977). Cattle expended 3 joules and buffaloes 5 joules for carrying 1 kg load over 1 metre (Lawrence, 1985).

Brahman cattle had to spend 33 joules and swamp buffaloes 26 joules for pulling 1 kg/metre travelled (Lawrence, 1985).

Direct measurement of draughtability is generally inconvenient and difficult under field conditions because of lack of quantitative measure of draughtability. Unlike performance testing of milk, meat or wool producing animals, there is no simple objective criterion of the value of an animal for draught purpose (Lawrence and Pearson, 1985). Studies on developing a standard for measuring draughtability by correlating body measurements, body conformation and physiological reactions with work performed has been done by many workers.

The draught power exerted by animals is directly proportional to their body weight, though it is influenced to some extent by other factors like method of hitching the implements and the type of yoke used (Subramanian and Ryan, 1975). They reported that bullocks can exert roughly eight to twenty per cent of their body weight as draught.

Studies at the IVRI (Anon., 1960) to determine the maximum traction load which a bullock could carry for a long period without showing signs of distress or fatigue indicated that 58 per cent of the bullocks could draw cart loads upto 420 per cent of their body weight for six hours whereas four per cent of the animals could draw a load of only 300 per cent of their body weight for six hours.

Mukherjee and others (1961), reported that Hariana bullocks could draw a cart for six hours with maximum load of 310 to 540 per cent of body weight. They observed that the horse power developed in disc-ploughing, harrowing and cultivating was 0.80, 0.97 and 0.94 respectively for Hariana bullocks. Eight Hariana bullocks were used to study their draughtability while working with three common agricultural implements namely disc plough, harrow and cultivator (Singh et al., 1968). The pull was measured with a dynamometer and horse-power developed during these operations was calculated as 0.83, 0.97 and 0.74 respectively.

Singh et al. (1970) studied the horse-power developed by Sahiwal bullocks (6 to 10 years old) while working with disc-plough, disc-harrow and cultivator and compared it with that of Hariana bullocks. The horse-power developed by Sahiwal bullocks were 0.84, 0.63 and 0.70 respectively and were lower than that of Hariana.

The average sustained tractive force of draught animals depends on numerous factors of which body weight, speed and endurance are most important (Reh, 1982) and it has frequently been stated that a draught animal can sustain a tractive force equal to approximately 10 per cent of its body weight (FAO, 1972; Smith, 1981; Reh, 1982).

Gattewar (1983) compared the work performance of Hariana and Holstein x Hariana cross-breds by subjecting them to harrowing. The cross-breds had better draught capacity and higher power generation than Hariana. The Hariana bullocks exhibited more stamina to work slowly but steadily than cross-breds.

According to Goe (1983), the tractive force produced by oxen is largely dependent on body weight, especially the amount distributed over the front legs.

Draught performance and efficiency of work under hot dry, hot humid and cold dry climatic conditions for varying loads were evaluated among Hariana and Karanswiss bullocks using single-animal pneumatic tyred bullock cart. Hariana bullocks produced higher horse-power (0.57) than the Karanswiss cross-bred bullocks (0.44). At higher loads, Karanswiss bullocks generated more horse-power than Hariana in the cold season (Annual Report, 1985-86, ICAR).

Most of the above investigators have calculated 'work' done by taking a time average of the draught force as measured with a dynamometer times the total distance travelled (Goe and McDowell, 1980). However, Lawrence and Pearson (1985) are of the opinion that this approach is fundamentally wrong and can lead to errors.

For animals in the field, calculation of work-output and energy expenditure are more difficult. An animal working in the field experiences variations both in the applied load and in the speed at which it travels. Under these conditions, the correct way in which the work done can be measured is to integrate the force exerted by the animal with respect to distance travelled (Lawrence and Pearson, 1985).

2.2. Use of cross-bred animals for work

As a result of wide-spread cross-breeding of European (Bos taurus) and Zebu (Bos indicus) cattle to increase milk production, a large number of cross-bred males are produced.

These cross-bred males can be put to work in many parts where conditions are favourable (Pearson, 1985).

Cross-bred animals are usually heavier than pure-bred indigenous cattle and consequently should be able to generate more power (Anand and Sundaresan, 1974). They found that in heart girth measurements, which is a measure of stamina, the cross-bred bullocks are slightly better than Hariana. All the weight of the animals plus the load they carry is borne by the legs and hence the animals with thicker bones can manage heavier loads. In this respect also, they found cross-breds to be better than Zebu animals. But in height and length, two characteristics involved in speed, both cross-breds and Hariana were reported to be of the same capacity.

Roy *et al.* (1972) studied the ploughing activities of Hariana and Jersey-Hariana crosses under wet and dry soil conditions in West Bengal. Ploughing of wet land from 0800 hours to 1000 hours over a temperature range of 25 to 35°C resulted in the cross-breds ploughing a slightly larger area than the Hariana. Trials conducted on dry land, over the same period with a temperature range of 26-34°C caused a rise in temperature, pulse and respiratory rates of both the groups. Although, the cross-breds exhibited the largest increase in the above physiological reactions, equivalent amounts of land were ploughed by both the groups.

Rao *et al.* (1974), studied the work efficiency of cross-bred bullocks and concluded that during hot humid and winter months, the areas ploughed in unit time by cross-bred and Zebu bullocks were similar. They did not find any symptoms of distress during months even after continuous work for four hours. In a practical study consisting of ploughing and carting trials in Orissa, Acharya et al. (1979) reported that although cross-bred bullocks showed earlier manifestations of panting and salivary frothing accompanied by higher rates of pulse, respiration and temperature, they exhibited more stamina, higher speed and greater capacity for work than the non-descript indigenous bullocks.

Maurya and Devadattam (1982), tested Jersey x Red Sindhi bullocks by making them haul loaded carts to study the response of pulse, respiration and temperature under different draft and ambient conditions. There was significant increase in the above parameters and the study indicated that these bullocks were not very much heat sensitive as they continuously worked for six hours a day for 18-19 days at a stretch at drafts varying from 11-18 per cent of their body weight. Maximum power output was 0.99 horse-power at a speed of 3.35 kmph.

Gattewar (1983) compared the physiological responses of cross-bred (Holstein x Hariana) and Hariana bullocks as a result of harrowing during different seasons. The cross-bred bullocks had comparatively higher body temperature, pulse rate and respiratory rate than Hariana in all the seasons. Goe (1983), reported that when comparing the draught potentialities of indigenous to cross-bred cattle, consideration must be given to body weight. Since, the tractive effort produced by animals is largely dependent on body weight, especially the amount distributed over the front legs, cross-bred bullocks should be able to generate more power.

Rao and Upadhyay (1984) studied the work performance of Jersey x Sahiwal cross-bred bullocks by using them for ploughing and carting trials during different seasons. The areas ploughed in six hours by cross-breds in summer, hot humid and winter seasons were 2800, 2600 and 3100 sq.m. No distress symptoms were exhibited by the animals while ploughing for six hours and carting for two to three hours with 4, 6 and 8 quintal loads in a single animal pneumatic-tyred cart.

Nagpaul et al. (1984), reported that cross-bred bullocks performed as good as Zebu and buffalo bullocks during summer and winter seasons in carting and ploughing operations at village farms in India. The cross-breds did not have problems of excessive panting and other heat stress symptoms during summer months. The draught performance and efficiency of work under different seasons for varying loads was calculated among Hariana and cross-bred bullocks in a single animal pneumatic-tyred cart. With higher loads, there was no significant difference between Zebu and cross-bred bullocks, but with lower loads, Hariana animals travelled faster. Work producing efficiency of Hariana animals was found to be higher than that of cross-breds (Upadhyay and Madan, 1985).

Thomas and Pearson (1986), after studying the rectal temperature, sweating rate and respiratory rates suggested that cross-bred animals are less able to dissipate the heat associated with work than the pure-bred Zebu types, although all animals regardless of breed showed some increase in body temperature when working at high temperatures.

There has been little acceptance of cross-breds as draught animals because of the general opinion that the performance is inferior to that of indigenous cattle. It is said that they are difficult to harness as they lack the prominent hump of the pure Zebu. The absence of prominent hump in these animals should not be thought as a disadvantage (Pearson, 1986). Goe (1983) reported that F_1 cross-bred bullocks were less susceptible to yoke galls as a result of increased muscle development over the rhomboideus muscle and forward positioning of the reduced hump compared with pure-breds.

2.3. Feed intake

Although 300 million animals are used for draught purposes in developing countries, there had been very little research on the nutritional requirements of these animals. Most of the fragmentary information which is available is derived from investigations in a few centres in temperate countries. There is relatively little information on the physiological changes during work or exercise which might influence food intake. Also, very little information is available on the voluntary food intake of draught animals.

Apart from the native grasses, the staple diet of most of the draught cattle and buffaloes throughout the world is the fibrous crop residues remaining after the harvest. Therefore, for much of the year these animals are eating diets of a high fibre content which are usually low in crude protein and they are often unable to consume sufficient to meet their requirements particularly during work (Pearson, 1986). Low quality diets based on straw or very mature grasses are often the only food available to draught animals in the tropics and these diets add to the problems imposed by climate (Thomas and Pearson, 1986). There are many reports which indicate that Zebu type cattle are superior to European cattle in their capacity to utilize poor quality food particularly under heat stress (Phillips, 1961; Ashton, 1962).

It is well established that as diet quality declines, voluntary food intake is reduced (Dinius and Baumgardt, 1970). This is largely because the reduced rate of passage of food along the gut result in physiological limitation on the quantity of food which can be taken in unit time. A reduction in voluntary food intake is one of the first noticeable responses to thermal stress in most livestock (Thompson, 1973). An adequate energy intake is important if an animal is to carry out sustained work. Unless draught animals are allowed to overcome the nutritional limitation of food intake imposed by low quality diets and harsh physical environment, the response of draught cattle and buffaloes subsisting on such diets can only be a combination of reduced work rate and loss of body tissue.

The major limitation to work output by ruminants in developing countries is food intake. This may be due to a simple lack of available food, but also due to the poor quality of what is available which may impose severe physiological limitation on the nutrient intake. If working animals eat more food to meet increased demands of energy, then their intakes of protein will also increase. This is true for ruminant animals in which rumen microbial activity ensures that a balance is maintained between energy intake and the supplies of aminoacids and other nutrients to the tissues (ARC, 1980).

There is no evidence of specific requirement for mineral elements, vitamins or essential fatty acids for physical work and any extra food consumed to meet energy needs will supply the animal with additional other nutrients. Underwood (1981) noted that even the intense phosphorus metabolism which occurs during muscular activity does not raise phosphorus requirements because of the body's efficient conservation mechanisms.

Draught cattle and buffaloes are frequently poorly fed and appear to have reduced disease resistance (Reh, 1982; Coulomb, 1982). The combination of poor quality food and unhygienic surroundings lead many draught animals to suffer from chronic infections, not achieve physiologically sufficient food intake and remain less capable of sustained hard work.

Nutrient imbalances are frequently associated with reduced apetite. Correlation of the mineral and trace element deficiency and toxicities in local forages which are common in much of the tropics usually result in rapid increases in food intake and energy available for productive purposes. The low protein content of the poor diets on which most draught cattle in the tropics subsist might be a major factor limiting food intake (Moran et al., 1983) and therefore, the energy available for work. In such cases, higher protein intakes might have beneficial effects by stimulating apetite.

Upadhyay et al. (1983), in a study on the effect of nutrient intake upon the efficiency of work in young crossbred bullocks pulling carts over short distances found that work had no effect on food intake. Six Brown Swiss x Sahiwal bullocks of 2-3 years of age were used for the study. They were made to pull 400 and 650 kg of cart load for one hour on a metalled road.

The dry matter intake increased when cattle were maintained in a thermoneutral environment of 18.5°C for 10 days. But following exposure to heat, the intake gradually started declining, the gradient becoming steeper as the exposure period prolonged.

Lawrence and Campbell (1985), studied the effect of work on the voluntary drymatter intake of bullocks. Three pairs of bullocks were kept in metabolism crates except when working and fed on a diet consisting of either 11 g or 22 g of concentrate per kg live weight 0.75 per day plus a poor quality hay ad lib. Total voluntary drymatter intake was measured for each animal during weeks when they were working regularly everyday and during the weeks before and after. It was found that the average daily voluntary drymatter intake of bullocks eating the higher quality diet was generally more than those eating the lower quality and they maintained body weight. Animals which had the lower quality diet lost body weight. It was concluded that working bullocks were unable to supply their increased energy needs by eating more and therefore the quality of their diet must be increased if they are not to lose body weight.

Lawrence and Campbell (1985) found that work had no significant effect on the digestibility of organic matter of the diet. A supposition is that animals doing hard work such as ploughing use more energy during the day and hence need more and better quality food than animals doing light work such as pulling a cart. It has been found unreasonable to base the food requirements of working bullocks on the severity of the work they have to perform. On detailed study it was found that the energy expenditure of bullocks does not increase with the severity of work and that bullocks use more energy when doing light work than when they are doing hard work.

Lawrence (1985), in a study of the voluntary feed intake of oxen in Costa Rica, has found that work had little effect on apetite. Work which increased daily energy requirements to 1.4 to 1.5 times the maintenance was not associated with any increase in voluntary feed intake or digestibility of poor quality diet. There was some evidence of small increase in intake in the seven days immediately following work although this was not sufficient to compensate for the extra energy used during the working period. No effect of work on food intake has been observed in lactating cattle (Lawrence, 1985).

The voluntary drymatter intake on days of work under heat stress and days on which no work was done but animals remaining under heat stress was carried out on Brahman and Brahman x European cross-bred bullocks (Thomas and Pearson, 1986). There was no significant difference in intake between breeds. Animals when working at an ambient temperature of 33°C consumed significantly less food than they did on days on which no work was done and days on which they worked at 15°C. It was concluded that the reduced intake was more a reflection of the increased heat load on the days when work occurred.

In the absence of any stimulating effect of work on apetite, it must be assumed that voluntary food intake of high roughage diet is not likely to be sufficient to meet the extra energy required during work. Therefore, if an animal is required to work, the extra energy must be supplied by increasing the quality of the diet (Pearson, 1986).

2.4. Effect of thermal stress on animals with specific reference to draught animals

Ambient temperature, atmospheric humidity, solar radiation and wind velocity are the principal climatic factors determining stress to livestock due to physical environment and thus affect feed intake, production and efficiency of utilization of energy for production (McDowell et al., 1969). Animals used for draught purposes mostly work in environments where the ambient temperatures are high. The heat load on an animal is increased by the heat generated during physical work. The effects of solar radiation to which the animals in open fields are necessarily exposed and the metabolic heat produced by consuming coarse roughages further aggrevate the heat stress.

Breed differences exist in the adaptability of cattle to environmental thermal stress. There is considerable evidence to suggest that cross-bred animals are less heat tolerant than pure-bred Bos indicus animals (Thomas and Razdan, 1973 and 1974; Amakiri and Funsho, 1979; Holmes et al., 1980).

Moran (1973) studied the heat tolerance capacity of Brahman cross-breds, buffaloes, Banteng and shorthorn steers during exposure to sun and as a result of forced exercise lasting 45 minutes. The buffaloes were least heat tolerant in both the trials with the shorthorn coming next. The heat tolerance of Banteng and Brahman cross-breds differed little in the stationary trial but Bantengs were more stressed by forced exercise. Horst et al. (1975), worked out the Iberia heat tolerance coefficients (Rhoad, 1944) of Herefords, indigenous and cross-bred cattle as 78.0, 82.7 and 79.9 respectively showing that the indigenous cattle were more tolerant to heat than the Hereford but the differences were not significant.

Heat has been found to reduce work output because the working animal cannot lose heat to the environment sufficiently fast to prevent intolerable rises in body temperature (Ingram and Mount, 1975). The inability to dissipate the heat associated with work may limit the amount of work which an animal can undertake in a hot environment. The adverse effects of tropical environments may be minimised by working the animals in cooler early hours of the morning and again in the late afternoon as is traditional in some areas (Williamson and Payne, 1978).

Singh and Mishra (1980) studied the heat tolerance capacity of Holstein, Jersey cross-breds (Jersey x Hariana) and Hariana cows. They found that Holstein cows were most affected in hot humid environments. The cross-bred cows suffered from heat stress during summer whereas Hariana showed very little strain in any season. Ishaq et al. (1981) reported that observations on physiological reactions showed that although the cross-bred (Swedish Red and White x Sahiwal) heifers were more productive, they were significantly less adapted to heat stress than the native Sahiwal. Thomas and Pearson (1986) observed that immediately after exercise, cross-breds had significantly ($P < 0.05$) higher respiration rate than did Brahmans.

The capacity for work might be reduced as heat depresses appetite (Thompson, 1973; NRC, 1981; Thomas and Pearson, 1986). The main factors likely to influence work output by animals in the tropics are heat tolerance and ability of the animal to consume enough energy to replace that which is lost during work.

Thomas and Acharya (1981) calculated regression coefficients of milking averages of Holstein-Friesian and Jersey half breds on average daily maximum temperature, average vapour pressure, average THI and on number of months with average THSI above 75. All the regression coefficients were higher in Holstein-Friesian half-breds than in Jersey half-breds, indicating that Jersey crosses were affected to a lesser degree by environmental thermal stress than Holstein-Friesian cross-breds.

Evaluation of heat tolerance by means of three tolerance tests and of sweating rate in Holstein-Friesian, 3/4 Holstein-Friesian-1/2 Zebu and 5/8 Holstein-Friesian and 3/8 Zebu cattle showed significant differences between Holstein-Friesians and the cross-breds (Morais and Espinosa, 1982). It was found that the Holstein-Friesians were less heat tolerant than the cross-breds. Investigations of sweating rate also gave similar results.

Field and climatic chamber studies involving exercise (forced walking) in Hereford cattle with and without coat clipping revealed that walking elicited greater thermoregulatory stress than the possession of a wooly hair coat (Vajrabukka and Thawaites, 1984).

Physiological reactions like respiratory rate, pulse rate and rectal temperature have wide applicability in heat tolerance studies. Rectal temperature in animals can be taken as an index of body temperature because at this location a thermometer can be inserted into the body of the animal without exciting it. Findlay (1961) reported that for all practical purposes the rectal temperature appeared a very good measure of the temperature of the animal. Measurement of rectal temperature is highly relevant because it represents the overall heat balance. Increased respiratory rate is a means of thermolysis and is indicative of greater need for thermolysis. Exercise also enhances pulse rate as more energy and nutrients have to be transported to the muscles and metabolic residues and heat have to be removed from them at an increased rate.

Singh et al. (1968) studied the physiological reactions of Hariana bullocks while working with three common agricultural implements namely disc plough, harrow and cultivator while Singh et al. (1970) studied the physiological responses of Sahiwal and Hariana bullocks to exercise. In both studies significant rise in the physiological responses was observed. The respiratory rate came to normal within half an hour in all the bullocks. There was no fall in temperature after the first half hour, but later there was a gradual fall. The pulse rate showed a gradual fall after completion of the agricultural operations when the animals rested.

Increases in rectal temperature, respiration rate and pulse rate due to various types of exercises have been reported in Zebu cattle (Devadattam and Maurya, 1978; Gattewar, 1985; Upadhyay and Madan, 1985), European breeds (Moran, 1973; Yeates and Partridge, 1975; Garcia et al., 1978; Adeyemo et al., 1979), Bos taurus x Bos indicus cross-breds (Moran, 1973; Yeates and Partridge, 1975; Garcia et al., 1978; Maurya and Devadattam, 1982; Gattewar, 1985; Upadhyay and Madan, 1985) and water buffaloes (Moran, 1973; Rana et al., 1978; Nangia et al., 1980; Garg et al., 1981; Singh et al., 1982; Singh et al., 1983; Upadhyay and Rao, 1985).

Higher ambient temperature coupled with exercise produced greater stress. Exercise at 33°C resulted in significantly (P 0.05) higher rectal temperature than exercise at 15°C (Thomas and Pearson, 1986).

2.5. Haematological studies

Exercise has been found to decrease haemoglobin content and packed cell volume in male buffaloes (Rana et al., 1977; Singh et al., 1980; Singh et al., 1982). Gattewar (1983) on the other hand observed that exercise caused an increase in the blood haemoglobin content and packed cell volume in cross-bred bullocks whereas it decreased in Hariana bullocks.

Blood lactic acid content was observed to increase (Singh et al., 1980; Agarwal et al., 1983; Gattewar, 1983 and Upadhyay et al., 1983) due to exercise in male buffaloes and cross-bred and Hariana bullocks. Muscular activity is known to result in lactic acid production and increase blood lactic acid level (Harmansen and Vaage, 1977).

Most of the studies indicated a decrease in the blood bicarbonate level due to exercise (Garg et al., 1981; Aggarwal et al., 1983 and Gattewar, 1983). This is expected because exercise increases respiration rate resulting in hyper-ventillation and blowing off of carbondioxide from the lungs. To keep acid-base balance, the body excretes more bicarbonates, thus lowering the blood bicarbonate level. However, Nangia and associates (1980) and Singh et al. (1980) observed an increase in the blood bicarbonate level in male buffaloes due to exercise. They could not give a valid explanation for this.

The erythrocyte sedimentation rate has been found to increase due to exercise in male buffaloes and cross-bred bullocks (Rana et al., 1977; Singh et al., 1980; Singh et al., 1982 and Gattewar, 1983). On the other hand, exercise caused a decrease in erythrocyte sedimentation rate in Hariana bullocks (Singh et al., 1968 and Gattewar, 1983).

2.5. Area covered during ploughing

Roy and co-workers (1972) compared the ploughing abilities of Hariana bullocks and Jersey x Hariana cross-bred bullocks under wet and dry soil conditions in West Bengal. Ploughing of wet land from 0800 to 1000 hours resulted in the cross-breds ploughing a slightly greater area than Hariana. Trials conducted on dry land over the same time period showed that equivalent amounts of land were ploughed by both the groups. They found that when work commenced at 0600 hours and ended at 0800 hours, cross-breds were able to plough more land than Hariana and attempting to work the cross-breds after 10.00 hours was difficult.

Anand and Sundaresan (1974) found that cross-bred bullocks covered only less area while ploughing for six hours when compared to Hariana bullocks. The greatest difference was in humid summer when the total area ploughed by cross-breds was 17 per cent less than that ploughed by Hariana. In winter and summer seasons, the difference was only 10 per cent and 7 per cent respectively. Rao (1974) found that the area ploughed by Hariana bullocks in four hours was 9 and 11 per cent more than that ploughed by cross-breds during summer and winter months respectively and the difference increased to 17 per cent during hot humid period.

Nagpaul and associates (1984) used indigenous bullocks, cross-bred bullocks and buffalo bullocks for ploughing operations. They found that the cross-breds performed better as evidenced by maximum area ploughed in one hour in summer and winter and concluded cross-bred bullocks performed as good as Zebu and buffalo bullocks during summer and winter months in ploughing operations at village farms in India.

Rao and Upadhyay (1984) used two pairs of cross-bred bullocks for ploughing for six hours and found that the area ploughed in summer, hot-humid and winter seasons were 2800, 2600 and 3100 sq.m. respectively.

2.7. Speed of walking

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

Williamson and Payne (1975) observed that work ox has a rate of movement best suited to its gait and an average of 0.88 to 1.2 m/sec can be considered as the normal rate, whereas, the maximum speed that can be attained by buffaloes is on an average of 0.88 m/sec. The normal walking speed of cattle and buffaloes was estimated to be between 0.6 to 1.2 m/sec depending upon the type of job they are undertaking (Lawrence, 1985).

In a study on the draughtability of Swamp buffaloes and its crosses with Murrah, Garillo and co-workers (1987) found that swamp buffaloes had a speed of 0.599 m/sec in dryland ploughing and 0.555 m/sec in wet land ploughing, whereas swamp buffaloes x Murrah cross-breds walked at a speed of 0.501 m/sec in dry land and 0.539 m/sec in wet land. No significant difference was observed in the speed of walking.

Materials and Methods

MATERIALS AND METHODS

The experiment was conducted at Mannuthy, Trichur district, Kerala. Geographically, Mannuthy is situated at longitude 76°, 16°E at latitude 10°32°N and the altitude of place is 22.25 M above MSL.

3.1. Experimental animals

A batch of four adult cross-bred bullocks (Jersey x Red Sindhi) born and brought up in the University Livestock Farm, Kerala Agricultural University and four adult indigenous draught bullocks (Kangayam type) bought from local market were used for the study. The animals were already trained for ploughing and carting works. The two groups of animals were retained under identical experimental conditions in the farm. The animals were housed in well lighted and well ventillated conventional cattle sheds with concrete floor and tile roof. Individual feeding and watering arrangements were present.

The bullocks were fed a commercial concentrate mixture (pellets) and greengrass. The feed given throughout the entire period of study was more or less uniform. Measured quantities of concentrates according to their requirements were given. Roughage and water were offered *ad libitum*.

All animals were washed and scrubbed daily in the morning.

3.2. Observations

The meteorological data obtained from the Department of Agro Meteorology situated at an approximate distance of 2 km were utilized for the study. The climate was profiled with respect to ambient temperature, humidity and hours of bright sunshine. The daily recordings of maximum, minimum and daily mean temperatures, dry and wet bulb temperatures in the morning and evening every day and monthly total hours of bright sunshine for the whole year of 1986 were collected. They were averaged for each month and with these average values relative humidity, vapour pressure, temperature humidity index (THI) and temperature humidity sunshine index (THSI) (Thomas and Acharya, 1977) were estimated.

The animals were used for ploughing on dry land for 4 hours and 5 hours continuously on alternate days, on each day there being one pair of indigenous and one pair of cross-bred bullocks. The ploughers were switched over to avoid bias.

Physiological responses in terms of respiratory rate, pulse rate and rectal temperature were recorded immediately before the start of work, immediately after work and after 1 hour of rest after work.

Blood was collected using EDTA as anticoagulant. The haemoglobin per cent (Benjamin, 1974), erythrocyte sedimentation rate (Benjamin, 1974), packed cell volume (Benjamin, 1974), lactic acid content (Barker and Summerson, 1941) and plasma bicarbonate (Vanslyke, 1922) were estimated before the start of work, immediately after work and after 1 hour of rest after work. Blood was collected for the estimation of plasma bicarbonate as per the procedure described by Oser (1965) under inert mineral oil without contact with air.

In order to study the relative efficiency and speed of work, the indigenous bullocks and cross-bred bullocks were made to plough in uniform but separate fields. The area ploughed by each pair in one hour was measured and compared.

The walking speed of indigenous and cross-bred animals were calculated by measuring the time taken to traverse a particular distance and the averages taken and compared. This was repeated for 15 days.

The intake of concentrates and roughages of each animal was recorded at regular intervals and the dry matter intake was calculated. The body weight of animals were also recorded during the same periods and the dry matter intake per metabolic body size was estimated.

The water intakes of all animals were recorded at regular intervals and expressed as per cent of dry matter intake per metabolic body size.

The data were subjected to statistical analyses by paired 't' test. (Snedecor and Cochran, 1967)

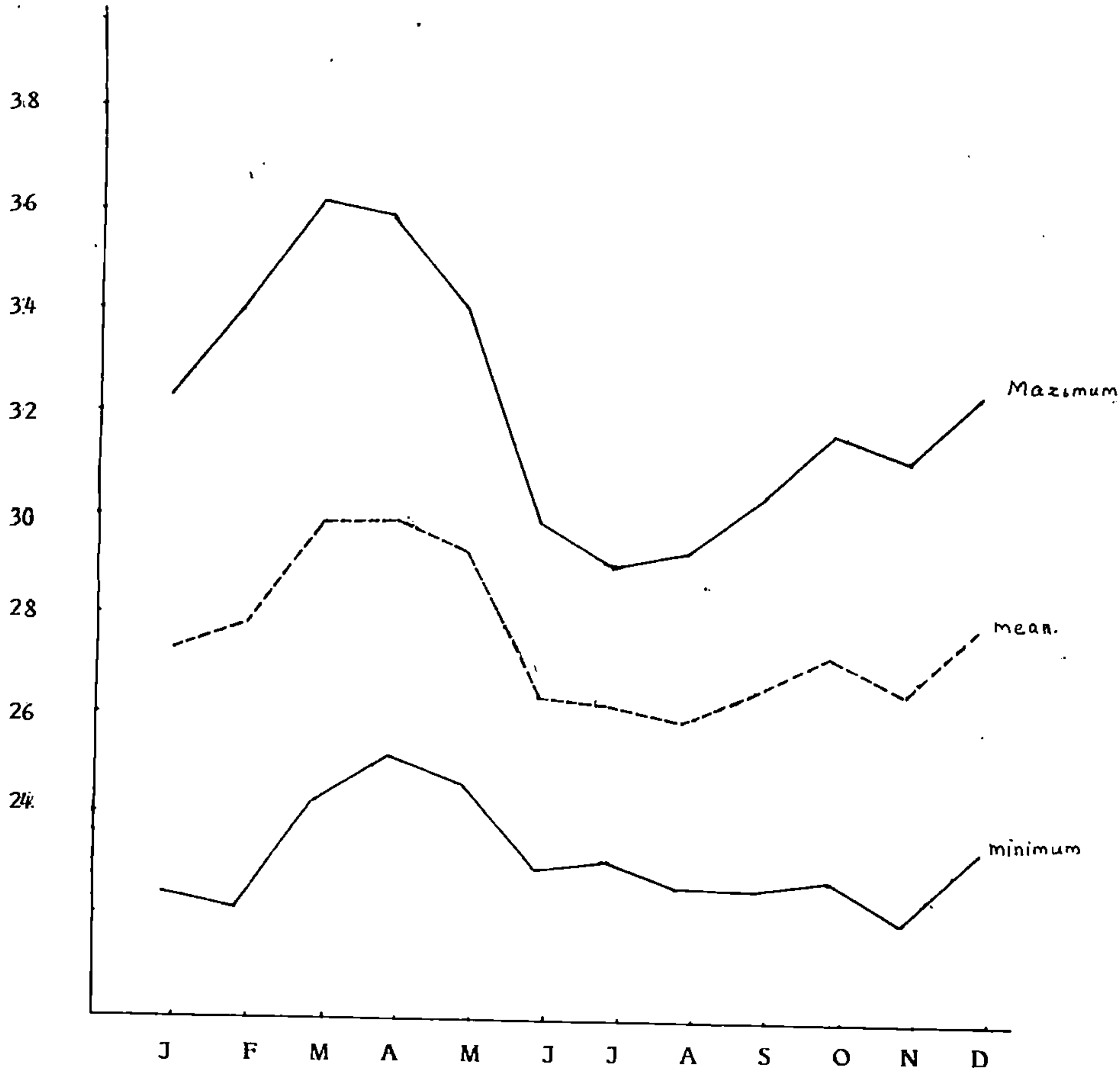
Results

RESULTS

The monthly average meteorological data of the experimental year 1986 with respect to maximum temperature, minimum temperature and daily mean temperature have been presented in figure 1. Figure 2 depicts the monthly averages of daily mean (of morning and evening) vapour pressure and relative humidity. The temperature humidity index (THI) values and temperature humidity sunshine index (THSI) values calculated from monthly average environmental variables have been presented in figure 3. The climograph of Mannuthy for the year 1986 is presented in figure 4.

Figures 5 and 6 present the means of respiratory rates of indigenous and cross-bred bullocks just before, immediately after and one hour after rest, after 4 hours and 5 hours of continuous periods of work. The respective mean values have been presented in table 1. These data were subjected to paired 't' test and the results of comparisons are presented in table 2.

Before the start of work, the cross-bred bullocks were found to have slightly higher respiratory rates; the differences being significant ($P < 0.05$). The respiratory rate showed a significant ($P < 0.05$) rise immediately after work in both indigenous and cross-bred bullocks while working for 4 hours and 5 hours continuously. After 1 hour of rest, the respiratory rate showed a significant ($P < 0.05$) decrease from


3.8
3.6
3.4
3.2
30
28
26
24
Mazimum
mean.
minimum
J
F
M
A
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J
A
S
O
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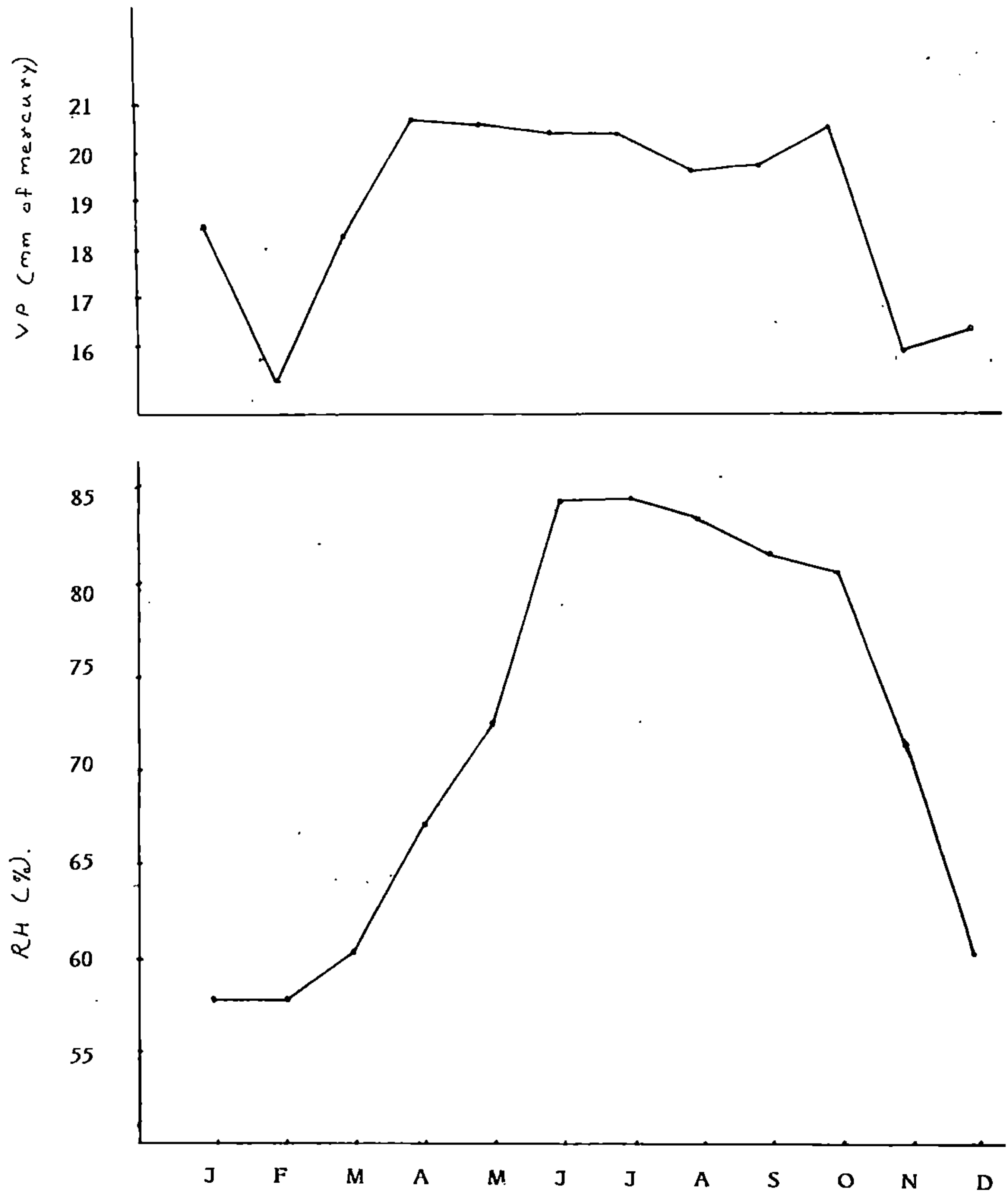
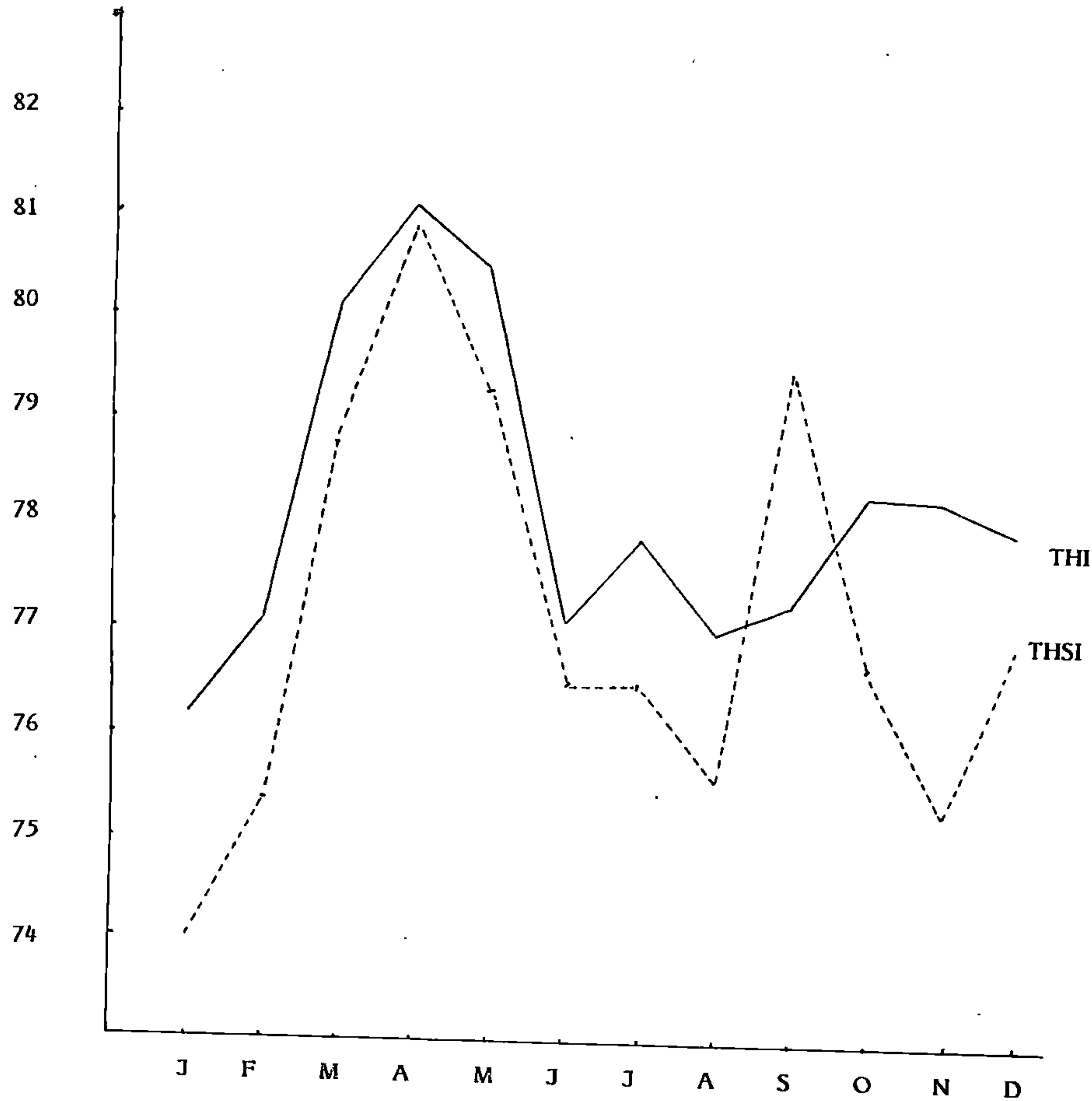
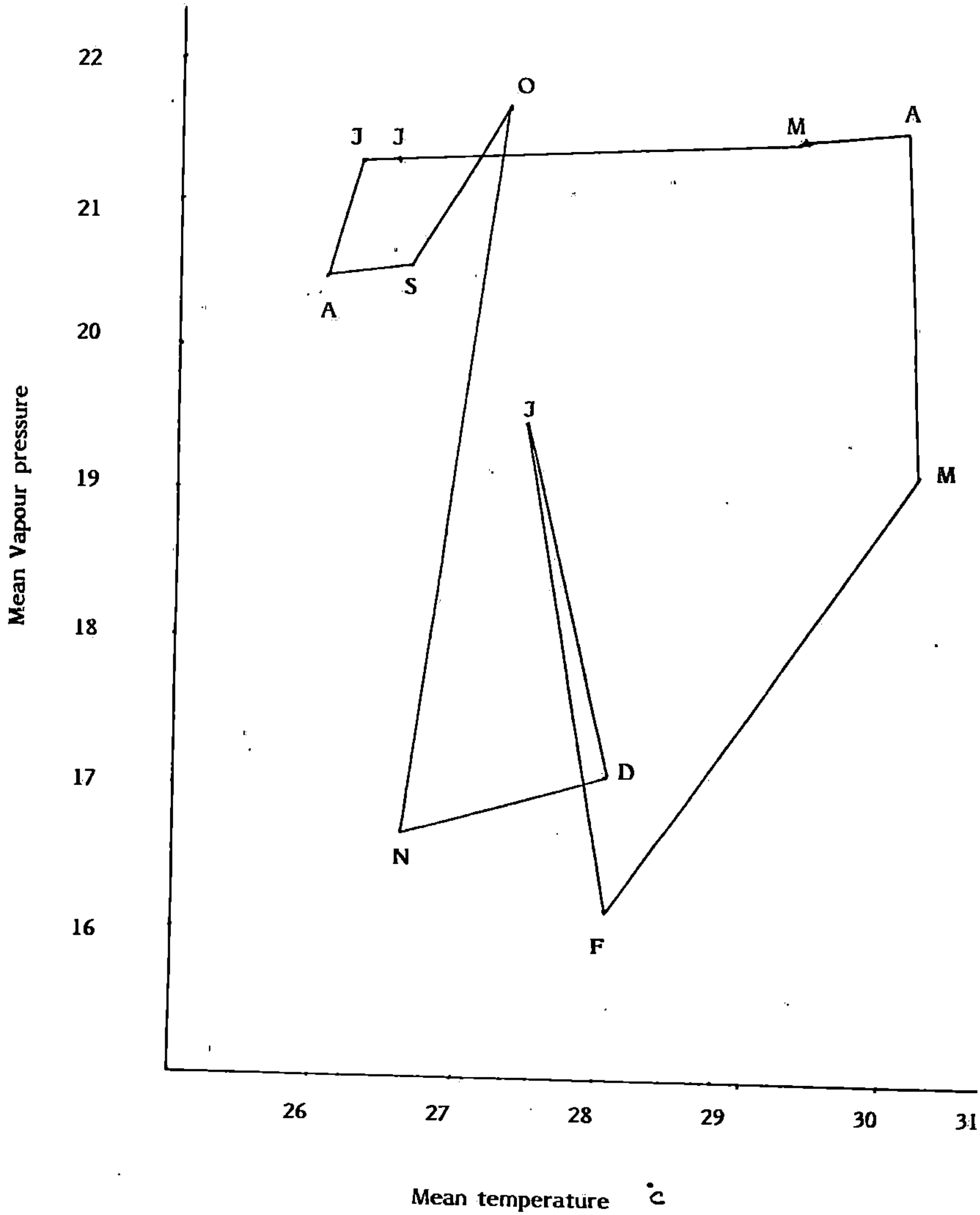
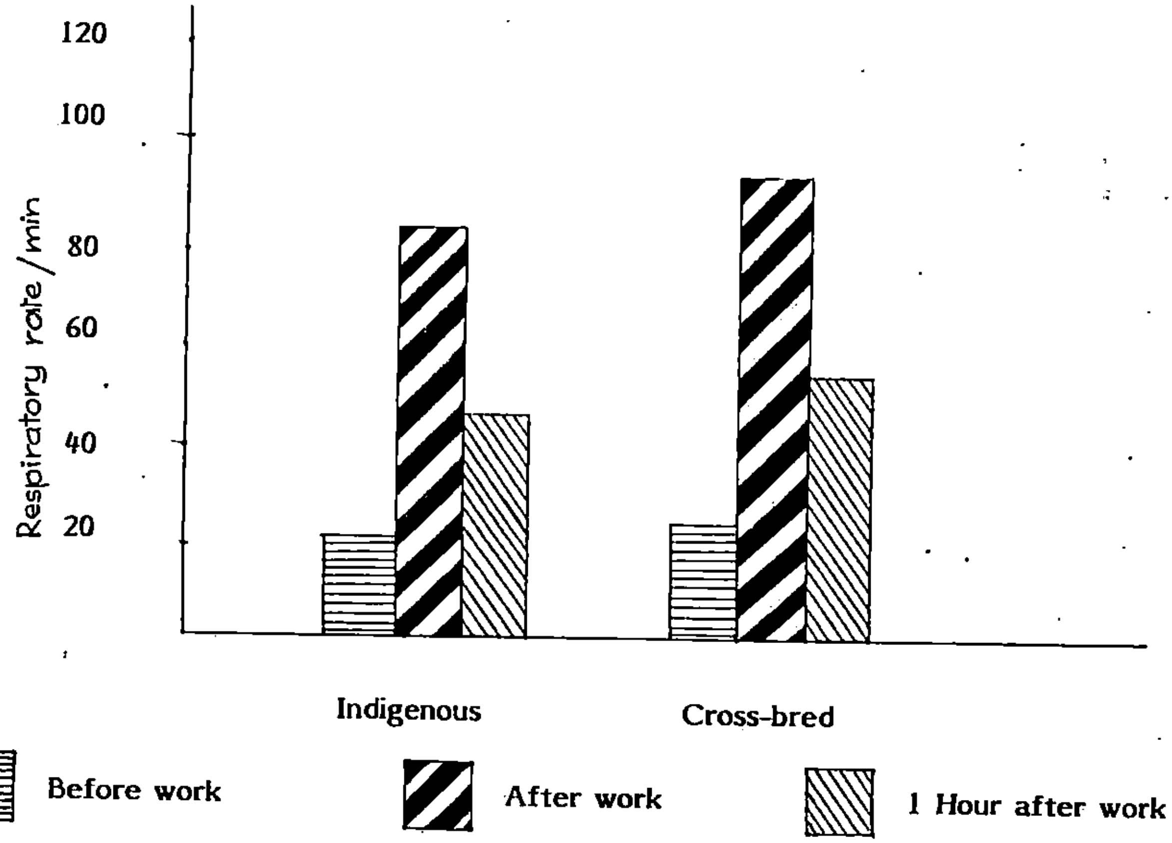
D


VP (mm of mercury)
21
20
19
18
17
16
RH (%).
85
80
75
70
65
60
55
J
F
M
A
M
J
J
A
S
O
N
D


82
81
80
79
78
77
76
75
74
J
F
M
A
M
J
J
A
S
O
N
D
THI
THSI


Mean Vapour pressure
22
21
20
19
18
17
16
O
J J
M
A
A
S
J
M
D
N
F
26
27
28
29
30
31
Mean temperature °c


Respiratory rate /min
120
100
80
60
40
20
Indigenous
Cross-bred
Before work
After work
1 Hour after work

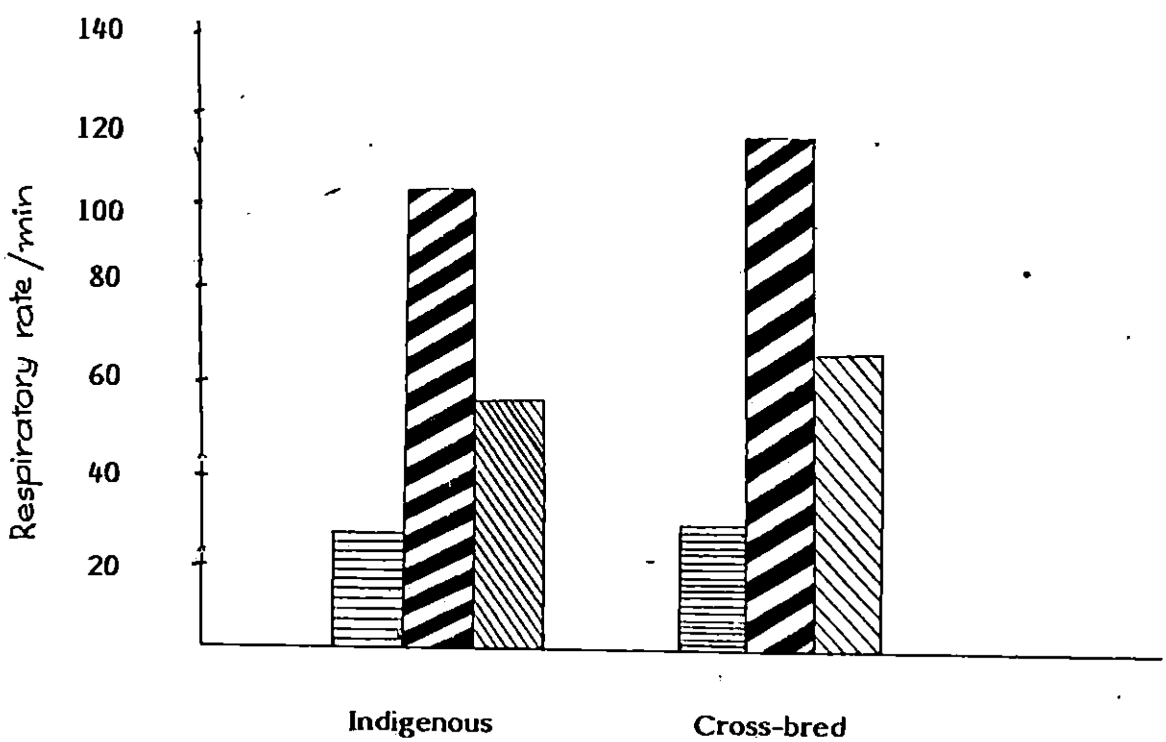

Respiratory rate /min
140
120
100
80
60
40
20
Indigenous
Cross-bred

Table 1. Mean respiratory rate of indigenous and cross-bred bullocks during 4 hours and 5 hours of work

	4 hours			5 hours		
	Before work	After work	1 hour after work	Before work	After work	1 hour after work
Indigenous	22.5185 ±0.1819	87.6852 ±0.5625	48.0741 ±0.4527	22.1250 ±1.0009	90.8333 ±0.8141	48.5416 ±0.5408
Cross-bred	24.7037 ±0.2299	97.4444 ±0.2976	57.2037 ±0.9894	25.0417 ±0.1532	102.4375 ±0.4705	56.1875 ±0.5548

Table 2. Comparison of respiratory rate (T values) between indigenous and cross-bred bullocks

	Before work	After work	1 hour after work
Indigenous x cross-bred 4 hours	12.61*	18.95*	11.36*
Indigenous x cross-bred 5 hours	20.82*	14.11*	16.77*

Comparison of respiratory rate (T values) just before work, immediately after work and after 1 hour of rest after work

	Before work x after work		Before work x 1 hour after work		After work x 1 hour after work	
	Indigenous	Cross-bred	Indigenous	Cross-bred	Indigenous	Cross-bred
4 hours	106.27*	172.59*	52.45*	30.62*	53.93*	41.81*
5 hours	83.97*	170.32*	49.29*	52.44*	63.49*	89.78*

Comparison of respiratory rate (T values) of indigenous and cross-bred bullocks between 4 hour and 5 hour work schedules

	Before work	After work	1 hour after work
Indigenous	1.83	3.24*	0.67
Cross-bred	1.19	9.18*	0.87

* Significant at 5 % level

the elevated rate in both the groups of animals. Also, there was significant ($P<0.05$) difference between the respiratory rates of animals before the start of work and after 1 hour of rest after work.

It was also noticed that on termination of work and also after one hour's rest, the respiratory rates in the cross-bred bullocks were significantly ($P<0.05$) higher than in indigenous bullocks in both 4 hour and 5 hour work regimes.

Comparing 4 hour and 5 hour working regimes to see whether length of work had any effect, showed that in both the genetic groups longer period of work resulted in significantly ($P<0.05$) higher rates of respiration. However, after one hour of rest this difference could not be observed.

Figures 7 and 8 present the means of pulse rate of indigenous and cross-bred bullocks before the start of work, immediately after work and after 1 hour of rest after work for 4 hours and 5 hours continuously. The mean values are presented in table 3 and the results of analyses by paired 't' test are presented in table 4.

It was found that there was a significant (P 0.05) difference in the pulse rate of indigenous and cross-bred bullocks before the start of work. In both the groups, the pulse rate increased significantly ($P<0.05$) immediately after working for 4 hours and 5 hours. The increase was more pronounced in cross-bred bullocks when compared to indigenous

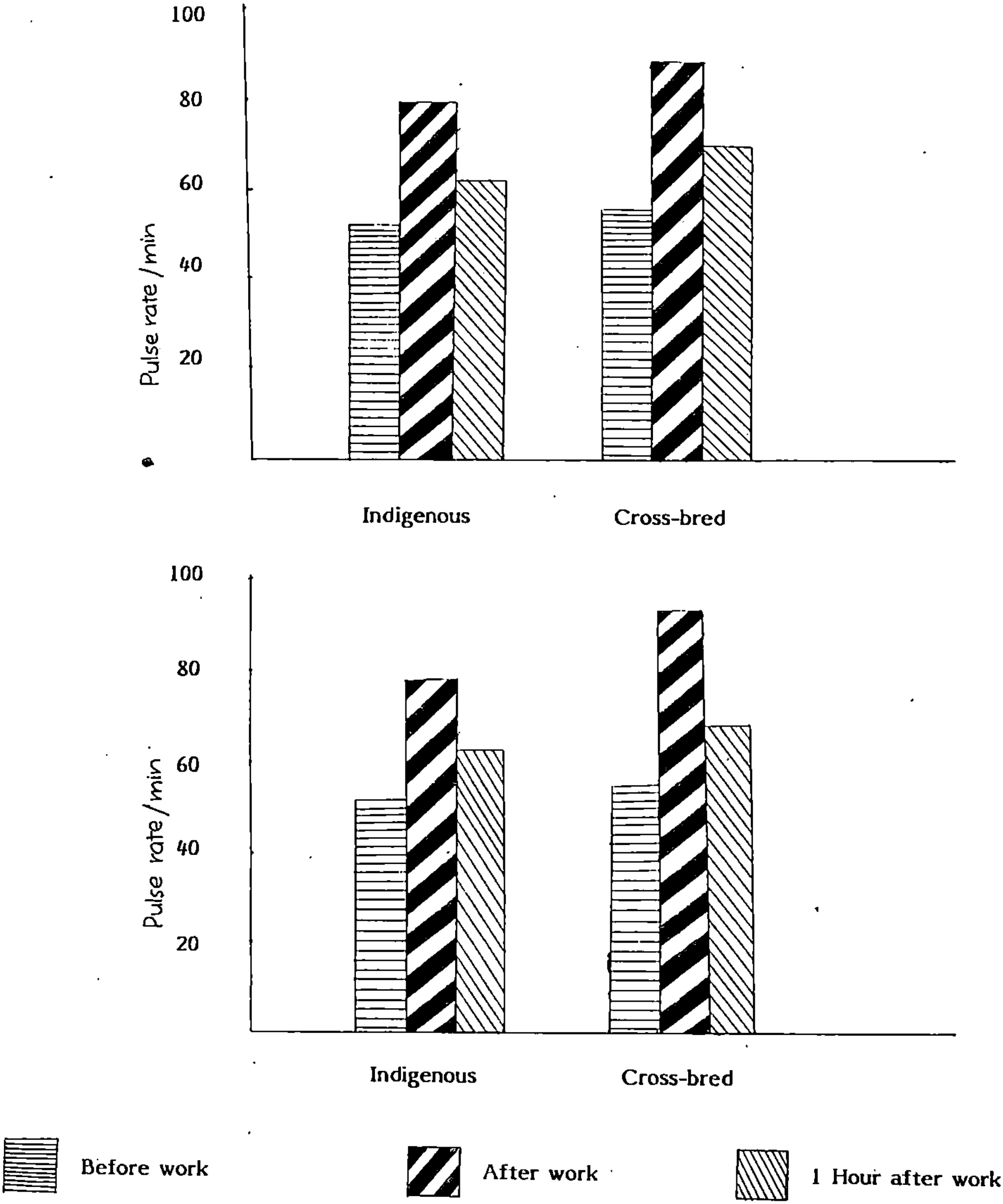

100
80
60
40
20
Pulse rate / min
Indigenous
Cross-bred
100
80
60
40
20
Pulse rate / min
Indigenous
Cross-bred
Before work
After work
1 Hour after work

Table 3. Mean pulse rate of indigenous and cross-bred bullocks during 4 hours and 5 hours of work

	4 hours			5 hours		
	Before work	After work	1 hour after work	Before work	After work	1 hour after work
Indigenous	51.6852 ±0.3182	77.6666 ±0.7794	61.4259 ±0.9045	51.2500 ±0.3831	79.1111 ±1.4171	62.1250 ±0.7501
Cross-bred	54.8148 ±0.3757	87.1458 ±0.5569	69.0000 ±9615	54.6666 ±0.3152	90.2778 ±1.1637	69.2500 ±0.7408

Table 4. Comparison of pulse rate (T values) between indigenous and cross-bred bullocks

	Before work	After work	1 hour after work
Indigenous x cross-bred 4 hours	11.25*	8.90*	11.81*
Indigenous x cross-bred 5 hours	12.12*	13.04*	13.89*

Comparison of pulse rate (T values) just before work immediately after work and after 1 hour of rest after work

	Before work x after work		Before work x 1 hour after work		After work x 1 hour after work	
	Indi-genous	Cross-bred	Indi-genous	Cross-bred	Indi-genous	Cross-bred
4 hours	21.34*	20.45*	10.79*	13.17*	13.40*	13.92*
5 hours	34.82*	52.82*	14.74*	20.43*	16.09*	16.37*

Comparison of pulse rate (T values) of indigenous and cross-bred bullocks between 4 hour and 5 hour work schedules

	Before work	After work	1 hour after work
Indigenous	0.88	1.02	0.07
Cross-bred	0.29	2.33*	0.20

* Significant at 5% level

bullocks. The pulse rate in both groups of animals did not come down to the values before work even after 1 hour of rest, but the decrease was significant.

In indigenous bullocks, pulse rate at the end of 5 hours of continuous work did not vary significantly ($P < 0.05$) from 4 hour work. But in the case of cross-bred bullocks, a longer duration (5 hour period) of work resulted in significantly ($P < 0.05$) higher pulse rate. After 1 hour of rest after work, significant ($P < 0.05$) difference was not observed in the pulse rate between 4 hours and 5 hours work regimes in indigenous and cross-bred bullocks.

Figures 9 and 10 present the mean rectal temperature of indigenous and cross-bred bullocks before work, just after work and after 1 hour rest after work in 4 hour and 5 hour continuous working regimes. The respective mean values are presented in table 5 and the results of statistical analyses are presented in table 6.

It has been found that there was a significant ($P < 0.05$) difference in the rectal temperature before the start of work between indigenous and cross-bred bullocks. The temperature increased significantly ($P < 0.05$) in both the genetic groups due to work. After 1 hour of rest, the rectal temperature decreased significantly ($P < 0.05$) in both the groups. However, the duration of rest was not sufficient to bring back the rectal temperature to the values before the start of work as the values

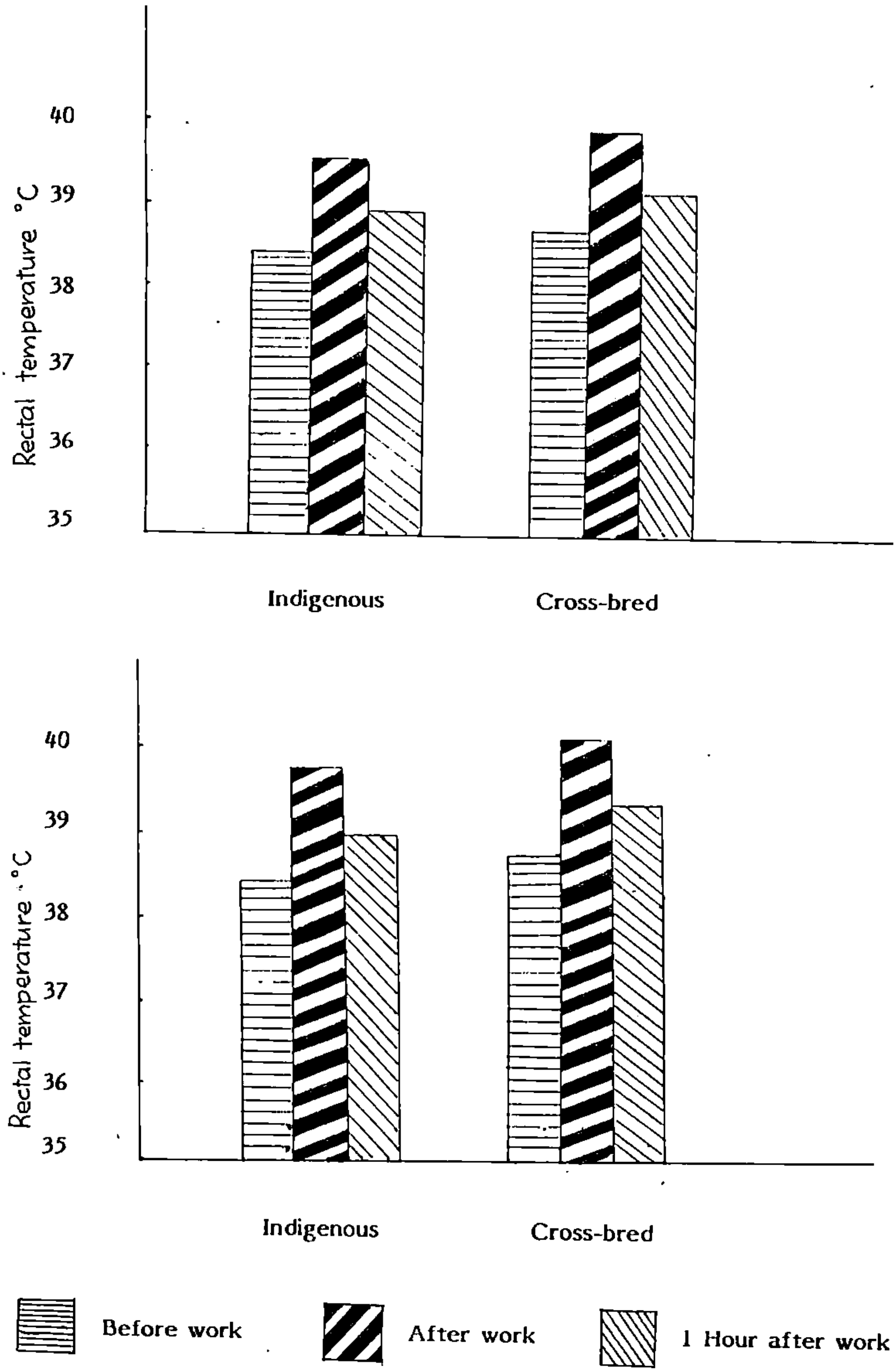

Rectal temperature °C
40
39
38
37
36
35
Indigenous
Cross-bred
Rectal temperature °C
40
39
38
37
36
35
Indigenous
Cross-bred
Before work
After work
1 Hour after work

Table 5. Mean rectal temperature of indigenous and cross-bred bullocks during 4 hours and 5 hours of work

	4 hours			5 hours		
	Before work	After work	1 hour after work	Before work	After work	1 hour after work
Indigenous	38.4167 ±0.0097	39.5944 ±0.0241	38.8982 ±0.0241	38.4461 ±0.0116	39.7275 ±0.0262	38.9271 ±0.0155
Cross-bred	38.6889 ±0.0183	39.8574 ±0.0123	39.1204 ±0.0189	38.7000 ±0.0125	40.0062 ±0.0276	39.2064 ±0.1765

Table 6. Comparison of rectal temperature (T values) between indigenous and cross-bred bullocks

	Before work	After work	1 hour after work
Indigenous x cross-bred 4 hours	11.79*	14.28*	12.95*
Indigenous x cross-bred 5 hours	15.17*	10.65*	13.54*

Comparison of rectal temperature (T values) just before work, immediately after work and after 1 hour of rest after work

	Before work x after work		Before work x 1 hour after work		After work x 1 hour after work	
	Indigenous	Cross-bred	Indigenous	Cross-bred	Indigenous	Cross-bred
4 hours	47.34*	2.22*	37.50*	1.74	31.78*	31.15*
5 hours	40.99*	43.55*	24.53*	19.65*	31.66*	30.09*

Comparison of rectal temperature (T values) of indigenous and cross-bred bullocks between 4 hour and 5 hour work schedules

	Before work	After work	1 hour after work
Indigenous	1.97	3.75*	1.52
Cross-bred	0.79	4.72*	3.28*

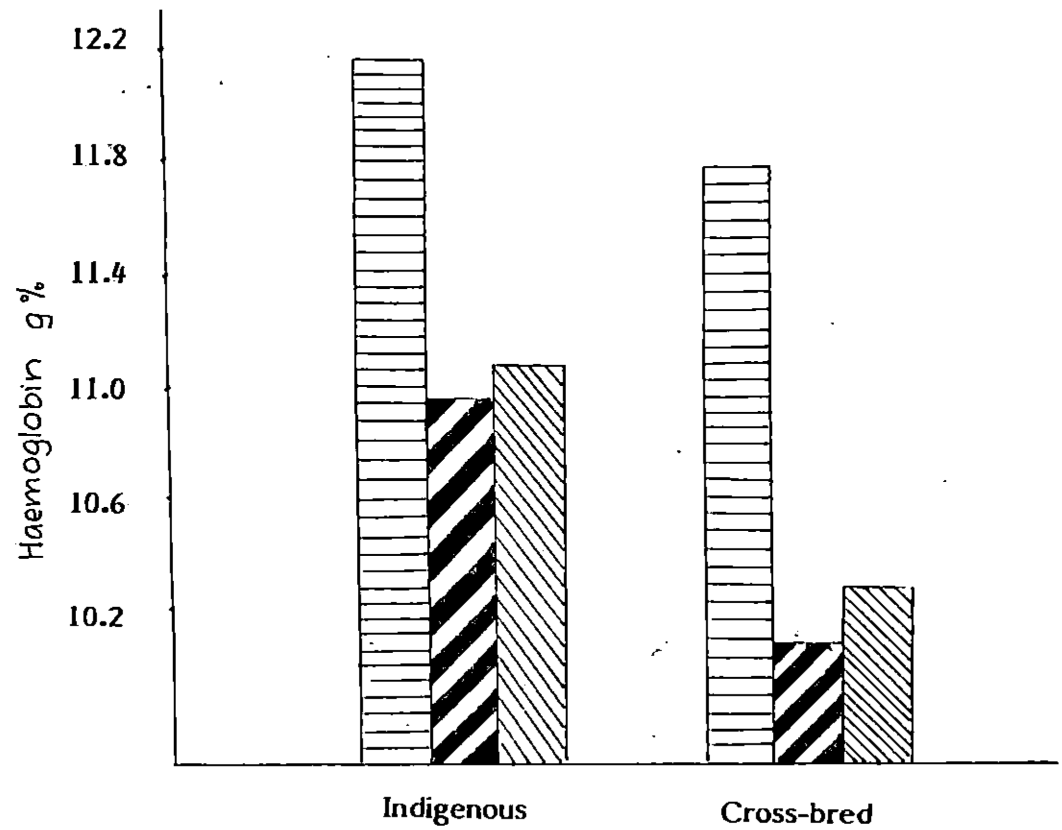
* Significant at 5% level

showed significant ($P < 0.05$) differences. The only exception was in the case of cross-bred bullocks working for a duration of 4 hours where the rectal temperature before work and after the rest period were similar. The rectal temperature after 1 hour of rest did not show significant ($P < 0.05$) variation from that before work in cross-breds while working for 4 hours continuously.

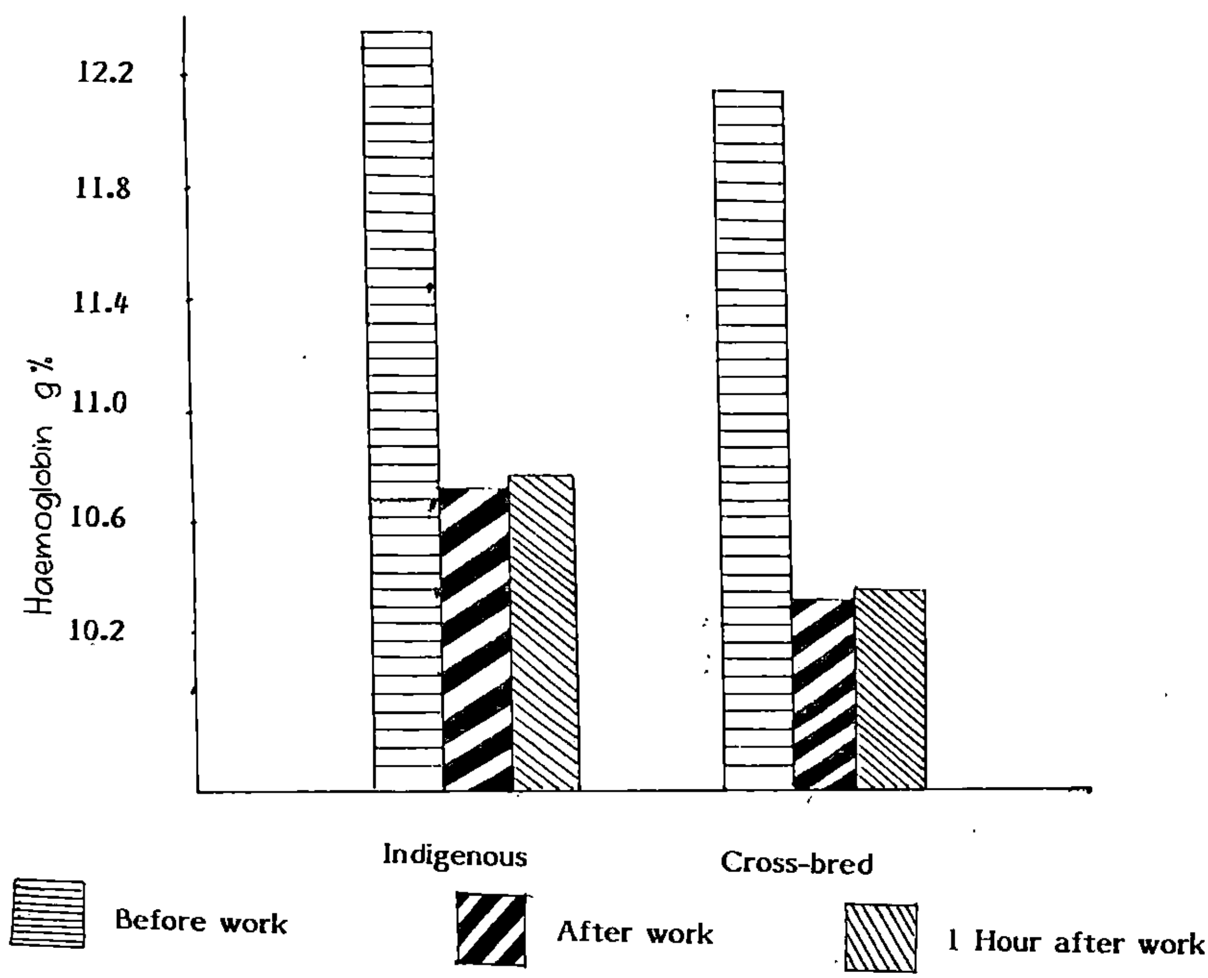
At the end of work, the rectal temperature showed a significant ($P < 0.05$) variation between 4 hour and 5 hour work schedule in both indigenous and cross-bred bullocks. After 1 hour of rest after work, the rectal temperature of indigenous bullocks did not differ significantly between 4 hour and 5 hour work schedule; but a significant ($P < 0.05$) difference was noticed in cross-bred bullocks due to the duration of continuous work.

Figures 11 and 12 present the mean haemoglobin content of blood of indigenous and cross-bred bullocks before the start of work, immediately after work and after 1 hour of rest after work in 4 hour and 5 hour continuous working regimes respectively. The respective mean values are presented in table 7 and the results of statistical analyses are presented in table 8.

The haemoglobin per cent in blood showed a significant ($P < 0.05$) decrease in both the genetic groups due to work. After 1 hour of rest after work, it slightly increased in both



12.2
11.8
11.4
11.0
10.6
10.2
Haemoglobin g%
Indigenous
Cross-bred



12.2
11.8
11.4
11.0
10.6
10.2
Haemoglobin g%
Indigenous
Cross-bred
Before work
After work
1 Hour after work

Table 7. Haemoglobin per cent in blood of indigenous and cross-bred bullocks during 4 hours and 5 hours of work

	4 hours			5 hours		
	Before work	After work	1 hour after work	Before work	After work	1 hour after work
Indigenous	12.1583 ±0.1495	11.0000 ±0.0904	11.0417 ±0.0925	12.3750 ±0.0698	10.6500 ±0.0900	10.6750 ±0.1023
Cross-bred	11.7583 ±0.1389	10.2833 ±0.1218	10.3208 ±0.1170	12.1250 ±0.0479	10.3083 ±0.0701	10.3833 ±0.0275

Table 8. Comparison of haemoglobin per cent (T values) between indigenous and cross-bred bullocks

	Before work	After work	1 hour after work
Indigenous x cross-bred 4 hours	1.96	4.72*	4.83*
Indigenous x cross-bred 5 hours	2.95*	2.99*	2.30*

Comparison of haemoglobin per cent (T values) just before work, immediately after work and after 1 hour of rest after work

	Before work x after work		Before work x 1 hour after work		After work x 1 hour after work	
	Indi-genous	Cross-bred	Indi-genous	Cross-bred	Indi-genous	Cross-bred
4 hours	6.63*	7.98*	6.35*	7.91*	0.32	0.22
5 hours	15.14*	21.39*	14.53*	20.76*	0.49	0.24

Comparison of haemoglobin per cent (T values) of indigenous and cross-bred bullocks between 4 hour and 5 hour work schedules

	Before work	After work	1 hour after work
Indigenous	1.31	2.74*	3.38*
Cross-bred	2.49*	0.18	0.27

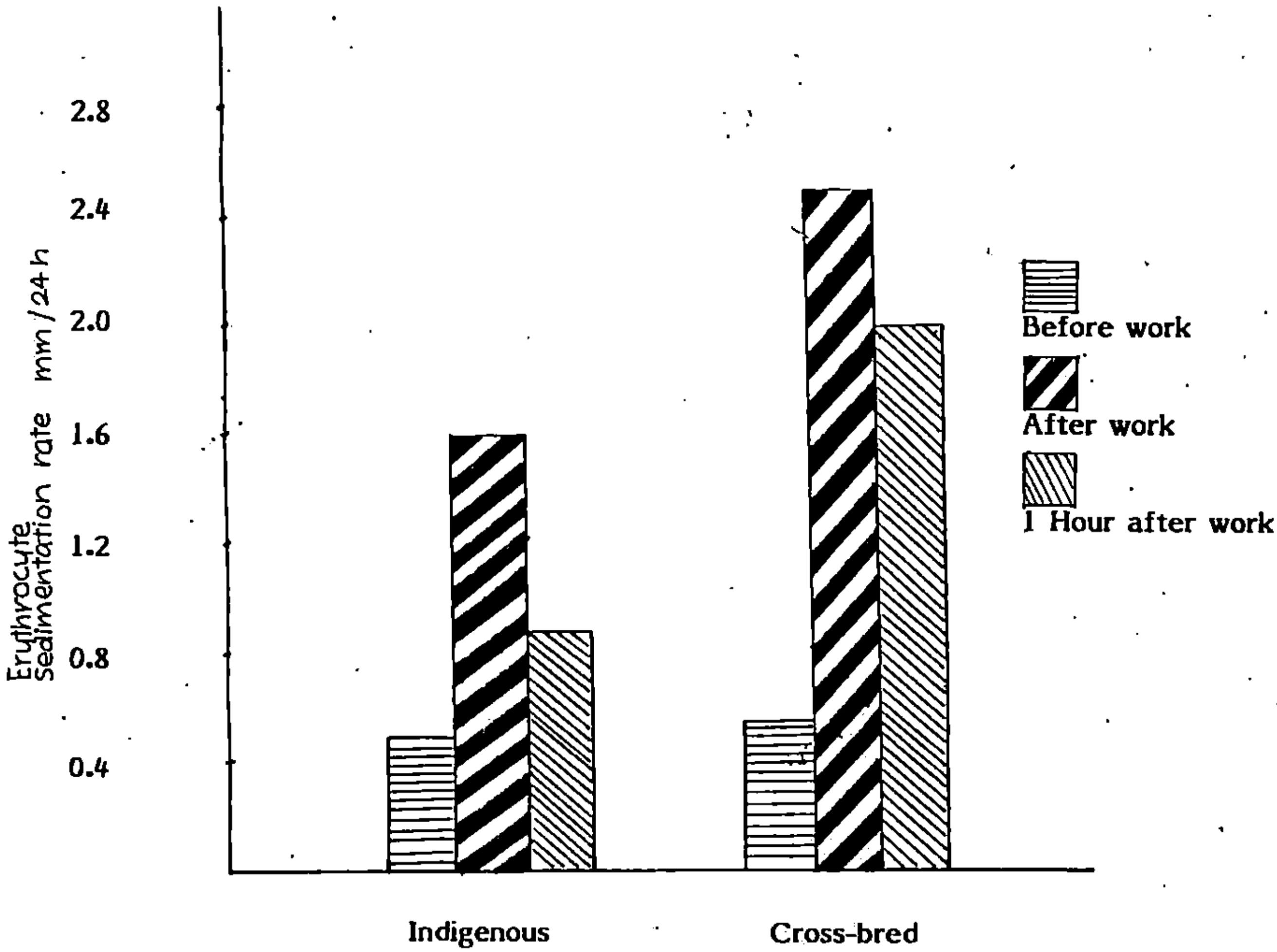
* Significant at 5% level

the groups and the rise was significant between the two groups of animals. This was also significantly ($P < 0.05$) different from the value before the start of work in both indigenous and cross-bred bullocks in both work schedules. But the values at the end of work and after 1 hour of rest did not differ significantly ($P < 0.05$) either in indigenous or in cross-bred bullocks during both work schedules.

At the end of work, in indigenous bullocks, the haemoglobin per cent showed a significant ($P < 0.05$) difference between 4 hour and 5 hour work schedules. There was no significant variation between time schedules in the case of cross-breds. After 1 hour of rest also a significant ($P < 0.05$) variation existed between 4 hour and 5 hour work schedule in the case of indigenous bullocks, but in the case of cross-bred bullocks the difference between 4 hour and 5 hour work regimes was non-significant ($P < 0.05$).

Figures 13 and 14 present the mean Erythrocyte Sedimentation Rate (ESR) of indigenous and cross-bred bullocks before the start of work, immediately after work and after 1 hour of rest after the end of work in 4 hour and 5 hour continuous working schedule. The respective mean values are presented in table 9 and the results of statistical analyses are presented in table 10.

The ESR in indigenous and cross-bred cattle were significantly ($P < 0.05$) different before the start of work. At the


Erythrocyte Sedimentation rate mm/24 h
2.8
2.4
2.0
1.6
1.2
0.8
0.4
Before work
After work
1 Hour after work
Indigenous
Cross-bred

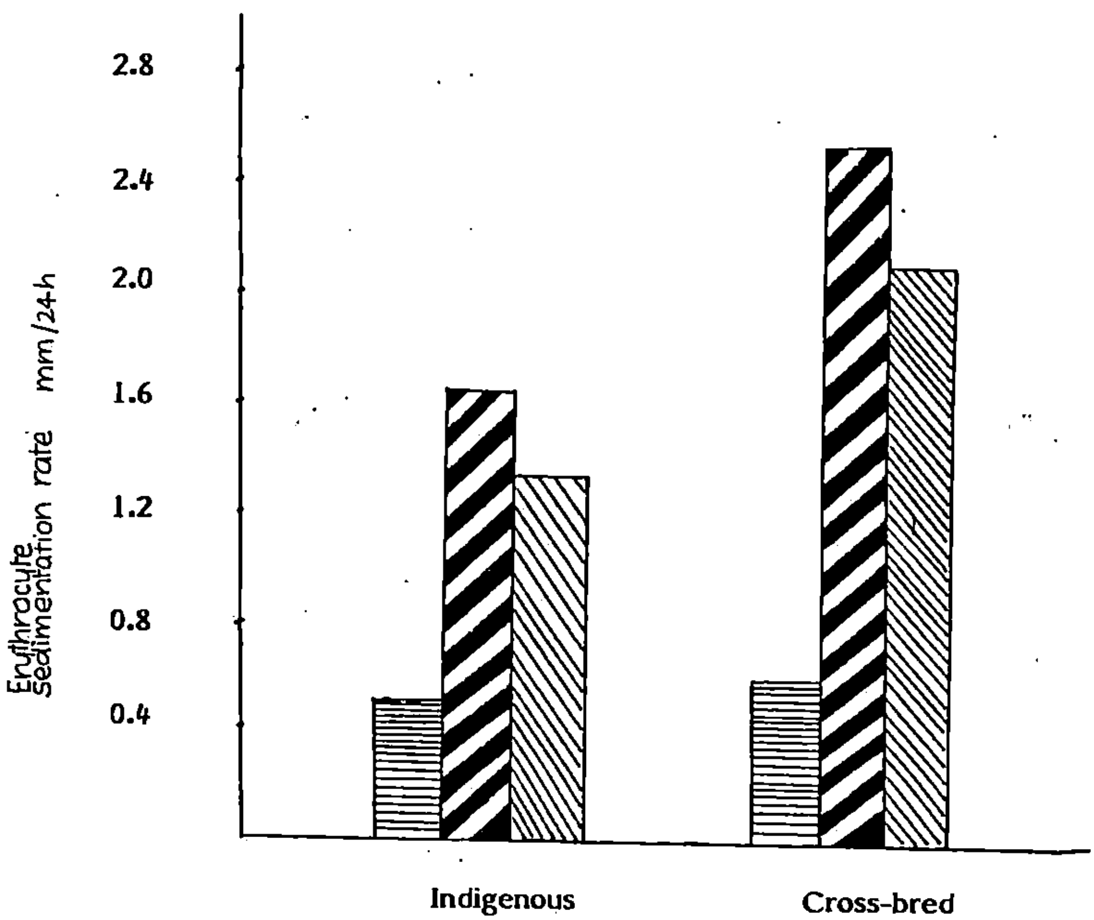

Erythrocyte Sedimentation rate mm/24 h
2.8
2.4
2.0
1.6
1.2
0.8
0.4
Indigenous
Cross-bred

Table 9. Mean erythrocyte sedimentation rate of indigenous and cross-bred bullocks during 4 hours and 5 hours of work

	4 hours			5 hours		
	Before work	After work	1 hour after work	Before work	After work	1 hour after work
Indigenous	0.5042 ±0.0179	1.6000 ±0.0369	0.9666 ±0.0419	0.4625 ±0.0089	1.6833 ±0.0188	1.3833 ±0.0345
Cross-bred	0.5833 ±0.0198	2.5125 ±0.0380	2.0330 ±0.0541	0.5675 ±0.0127	2.5874 ±0.0175	2.1208 ±0.0406

Table 10. Comparison of erythrocyte sedimentation rate (T values) between indigenous and cross-bred bullocks

	Before work	After work	1 hour after work
Indigenous x cross-bred 4 hours	2.97*	17.22*	15.58*
Indigenous x cross-bred 5 hours	6.74*	35.16*	13.86*

Comparison of erythrocyte sedimentation rate (T values) just before work, immediately after work and after 1 hour of rest after work

	Before work x after work		Before work x 1 hour after work		After work x 1 hour after work	
	Indigenous	Cross-bred	Indigenous	Cross-bred	Indigenous	Cross-bred
4 hours	26.70*	45.03*	10.15*	25.16*	11.34*	7.36*
5 hours	58.60*	93.02*	25.87*	36.53*	7.64*	10.56*

Comparison of erythrocyte sedimentation rate (T values) of indigenous and cross-bred bullocks between 4 hour and 5 hour work schedules

	Before work	After work	1 hour after work
Indigenous	2.08*	1.67	7.64*
Cross-bred	0.67	1.79	1.10

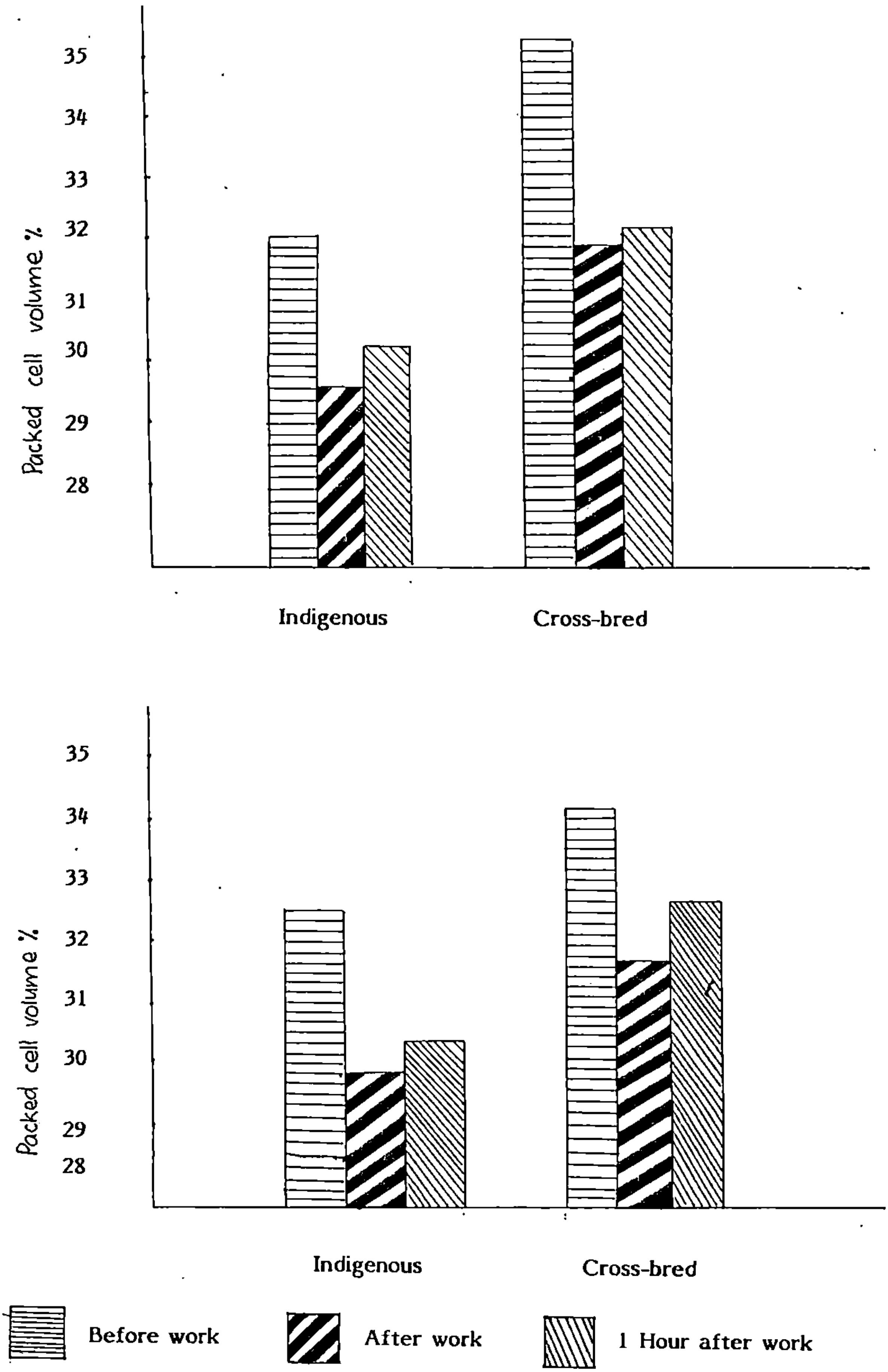
* Significant at 5% level

end of work, the ESR increased significantly ($P < 0.05$) in both the genetic groups of animals. After 1 hour of rest after work, there was a decrease in the ESR from the elevated value. The ESR values after 1 hour of rest were also significantly ($P < 0.05$) different between the two groups of animals.

In the case of indigenous bullocks and cross-bred bullocks, the ESR was not significantly ($P < 0.05$) different at the end of work due to duration of work. But after 1 hour of rest after the end of work, the ESR showed significant ($P < 0.05$) difference between 4 hour and 5 hour work schedule in indigenous bullocks whereas, the variation was non-significant ($P < 0.05$) with respect to cross-bred bullocks.

Figures 15 and 16 present the packed cell volume (PCV) of blood in indigenous and cross-bred bullocks before the start of work, immediately after work and after 1 hour of rest after work in 4 hours and 5 hours continuous work regimes. The respective mean values are presented in table 11 and the results of statistical analyses are presented in table 12.

The PCV was significantly ($P < 0.05$) higher in cross-bred bullocks before the start of work. As a result of work, the PCV of both indigenous and cross-bred bullocks showed a significant ($P < 0.05$) decrease. After 1 hour of rest after work, the difference was significant ($P < 0.05$) between the two groups of animals in both working regimes. During rest, the value slightly increased but did not reach the value before the start of work even after 1 hour of rest.



35
34
33
32
31
30
29
28
Packed cell volume %
Indigenous
Cross-bred
35
34
33
32
31
30
29
28
Packed cell volume %
Indigenous
Cross-bred
Before work
After work
1 Hour after work

Table 11. Mean packed cell volume of indigenous and cross-bred bullocks during 4 hours and 5 hours of work

	4 hours			5 hours		
	Before work	After work	1 hour after work	Before work	After work	1 hour after work
Indigenous	32.1000 ±0.2769	29.7000 ±0.2494	30.2000 ±0.1699	31.5500 ±0.3760	28.8500 ±0.2587	29.3500 ±0.2478
Cross-bred	35.4500 ±0.2833	32.0000 ±0.3162	32.1500 ±0.2892	33.1500 ±0.5824	30.9500 ±0.3023	31.6000 ±0.3399

Table 12. Comparison of packed cell volume (T values) between indigenous and cross-bred bullocks

	Before work	After work	1 hour after work
Indigenous x cross-bred 4 hours	8.46*	5.71*	5.26*
Indigenous x cross-bred 5 hours	2.31*	5.28*	5.35*

Comparison of packed cell volume (T values) just before work, immediately after work and after 1 hour of rest after work

	Before work x after work		Before work x 1 hour after work		After work x 1 hour after work	
	Indi-genous	Cross-bred	Indi-genous	Cross-bred	Indi-genous	Cross-bred
4 hours	6.44*	8.13*	5.85*	8.15*	1.66	0.35
5 hours	5.92*	3.35*	3.28*	2.29*	1.39	1.43

Comparison of packed cell volume (T values) of indigenous and cross-bred bullocks between 4 hour and 5 hour work schedules

	Before work	After work	1 hour after work
Indigenous	1.18	2.37*	2.83*
Cross-bred	3.55*	2.40*	1.23

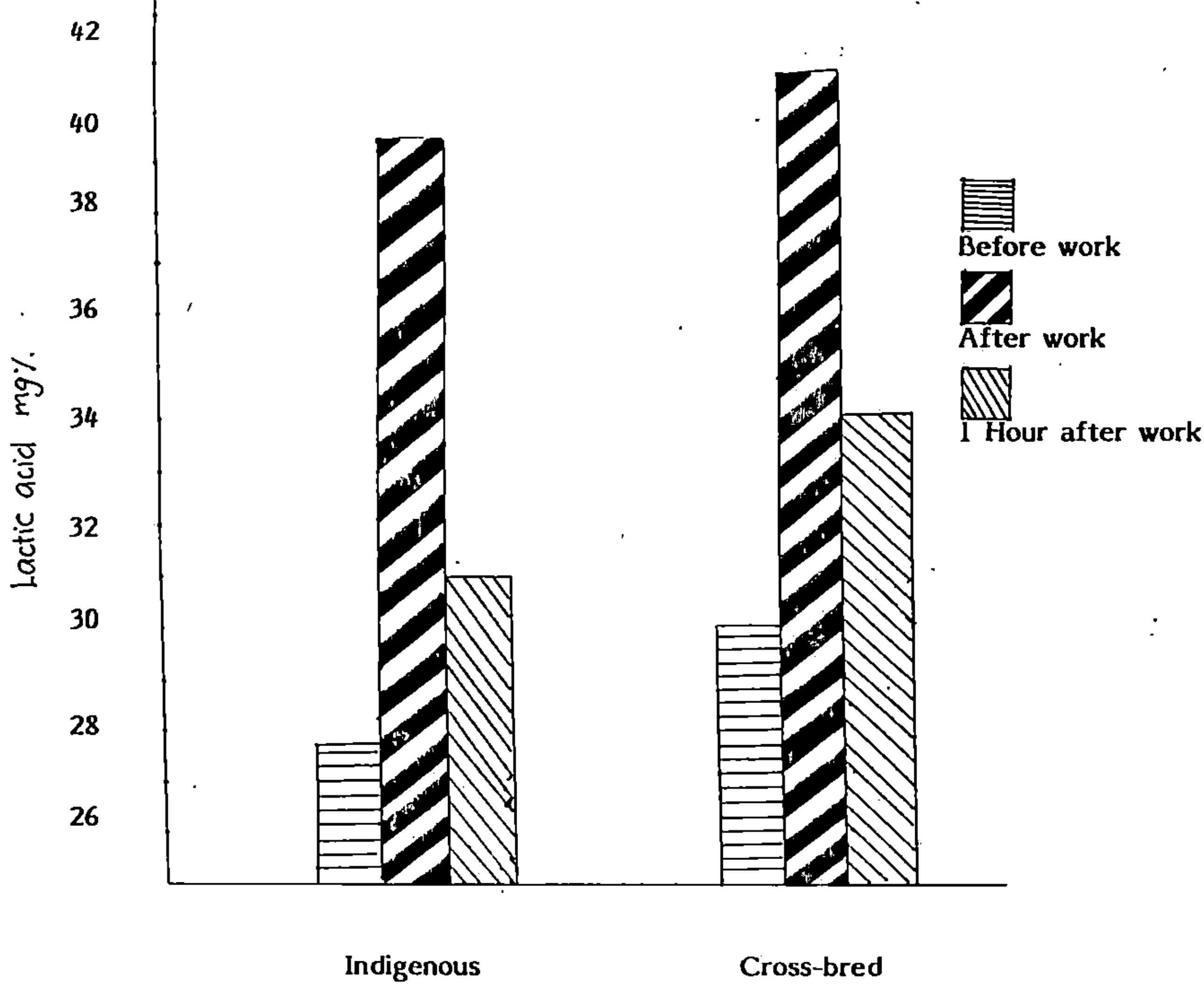
* Significant at 5% level

It has been found that there was a significant ($P < 0.05$) variation in the PCV at the end of work between 4 hour and 5 hour work schedule in both indigenous and cross-bred bullocks. But, the variation in PCV between 4 hour and 5 hour work schedule was significant ($P < 0.05$) in indigenous bullocks after 1 hour of rest, whereas, in the case of cross-bred bullocks, there was no significant ($P < 0.05$) difference.

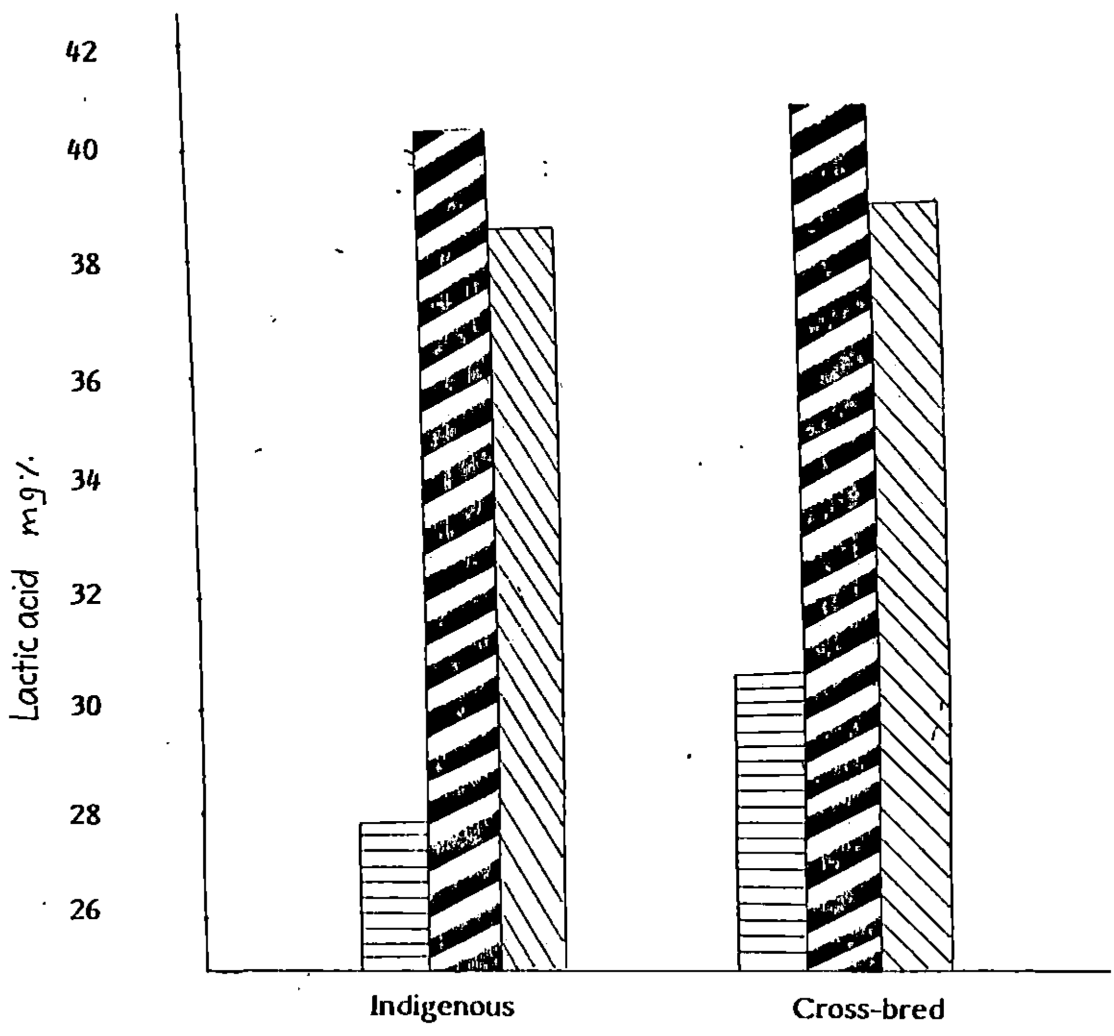
Figures 17 and 18 present the lactic acid content of blood in indigenous and cross-bred bullocks before the start of work, immediately after work and after 1 hour of rest after work in 4 hour and 5 hour working regimes. The respective mean values are presented in table 13 and the results of analyses are presented in table 14.

The lactic acid content of blood in cross-breds was significantly ($P < 0.05$) higher before the start of work. It has been found that it increased significantly ($P < 0.05$) in both the genetic groups of animals due to work.

The lactic acid content of blood in cross-breds was significantly ($P < 0.05$) higher than indigenous bullocks immediately after work for 4 hours. But in the case of 5 hour working regime, there was no significant ($P < 0.05$) variation between them. After 1 hour of rest after work, a significant ($P < 0.05$) variation was found in the blood lactic acid content between indigenous and cross-bred bullocks in 4 hour work schedule, whereas in 5 hour work schedule the differences in this respect were not significant ($P < 0.05$).



42
40
38
36
34
32
30
28
26
Lactic acid mg%.
Before work
After work
1 Hour after work
Indigenous
Cross-bred



42
40
38
36
34
32
30
28
26
Lactic acid mg%.
Indigenous
Cross-bred

Table 13. Mean blood lactic acid content of blood of indigenous and cross-bred bullocks during 4 hours and 5 hours of work

	4 hours			5 hours		
	Before work	After work	1 hour after work	Before work	After work	1 hour after work
Indigenous	27.7040 ±0.1297	39.3710 ±0.2091	30.9330 ±0.3133	27.8080 ±0.1150	40.3080 ±0.1931	38.6390 ±0.4974
Cross-bred	29.8380 ±0.3116	40.7240 ±0.1866	33.7460 ±1.1938	30.5170 ±0.4547	40.7260 ±0.2152	39.0580 ±0.5298

Table 14. Comparison of blood lactic acid (T values) between indigenous and cross-bred bullocks

	Before work	After work	1 hour after work
Indigenous x cross-bred 4 hours	6.32*	4.83*	2.28*
Indigenous x cross-bred 5 hours	5.78*	1.45	0.58

Comparison of blood lactic acid (T values) just before work, immediately after work and after 1 hour of rest after work

	Before work x after work		Before work x 1 hour after work		After work x 1 hour after work	
	Indigenous	Cross-bred	Indigenous	Cross-bred	Indigenous	Cross-bred
4 hours	47.41*	29.97*	9.52*	3.17*	22.39*	5.77*
5 hours	55.62*	20.29*	21.22*	12.23*	3.13*	2.92*

Comparison of blood lactic acid (T values) of indigenous and cross-bred bullocks between 4 hour and 5 hour work schedules

	Before work	After work	1 hour after work
Indigenous	0.59	3.29*	13.11*
Cross-bred	1.23	0.01	4.06*

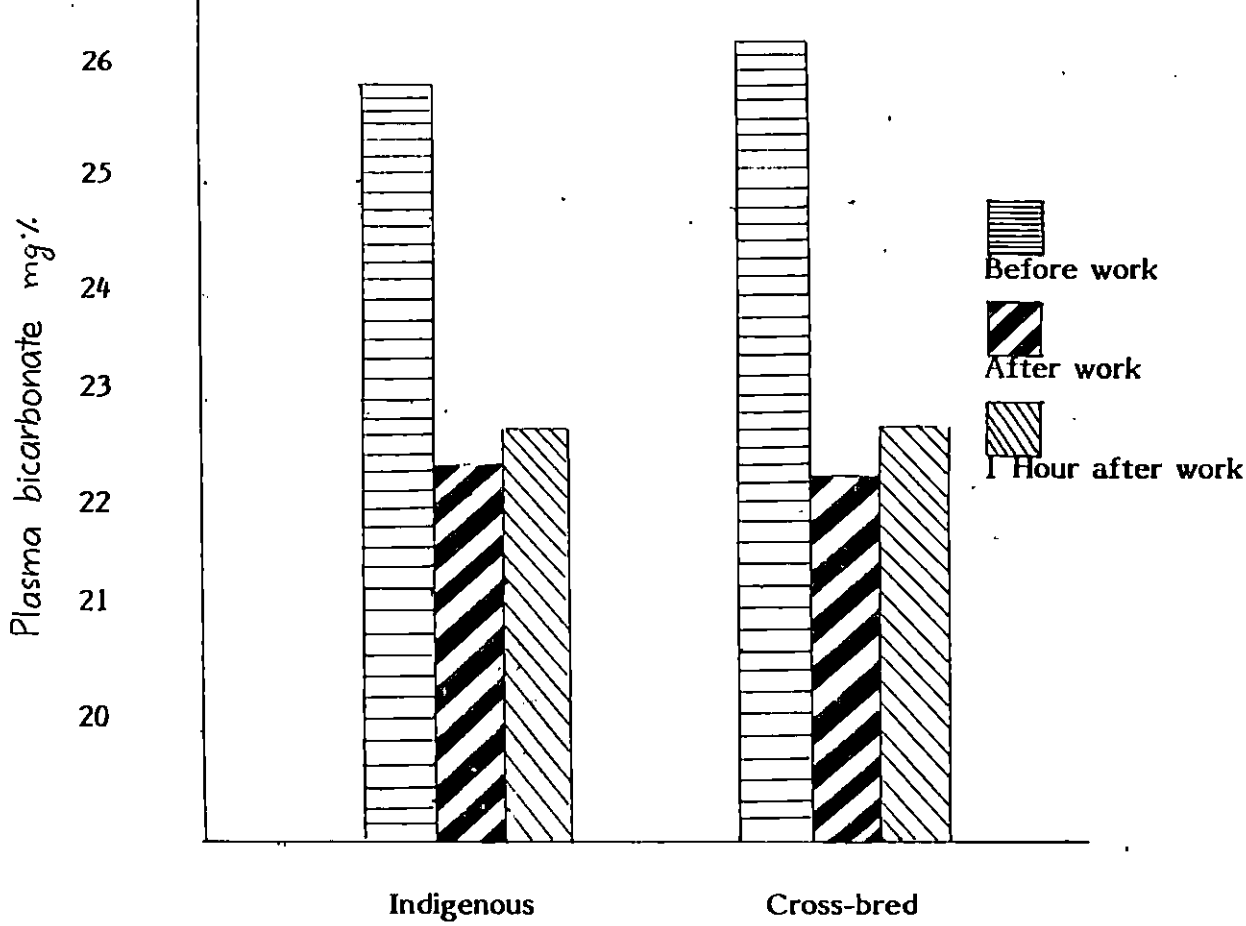
* Significant at 5% level

The lactic acid content of indigenous bullocks showed a significant ($P < 0.05$) difference between 4 hour and 5 hour work schedule, immediately after work and 1 hour after work. But, in the case of cross-bred bullocks, the lactic acid content immediately after work did not show any significant ($P < 0.05$) difference between 4 hour and 5 hour working schedules. The value after 1 hour of rest after work was found to be significantly ($P < 0.05$) different between 4 hour and 5 hour working regimes.

Figures 19 and 20 present the bicarbonate content of blood plasma of indigenous and cross-bred bullocks before the start of work, immediately after work and 1 hour after rest after work in 4 hours and 5 hours working regimes. The respective mean values are presented in table 15 and the results of statistical analyses are presented in table 16.

There was no significant ($P < 0.05$) difference in the plasma bicarbonate content between indigenous and cross-bred bullocks before the start of work. It has been found that the plasma bicarbonate content decreased in both the genetic groups of animals as a result of work. The decrease was significant ($P < 0.05$) in both indigenous as well as cross-bred bullocks during 4 hour and 5 hour work schedule immediately after work.

The plasma bicarbonate values after giving one hour of rest did not vary significantly from the values at the end of work. Naturally, they were significantly ($P < 0.05$) lower than


Plasma bicarbonate mg%
26
25
24
23
22
21
20
Before work
After work
I Hour after work
Indigenous
Cross-bred

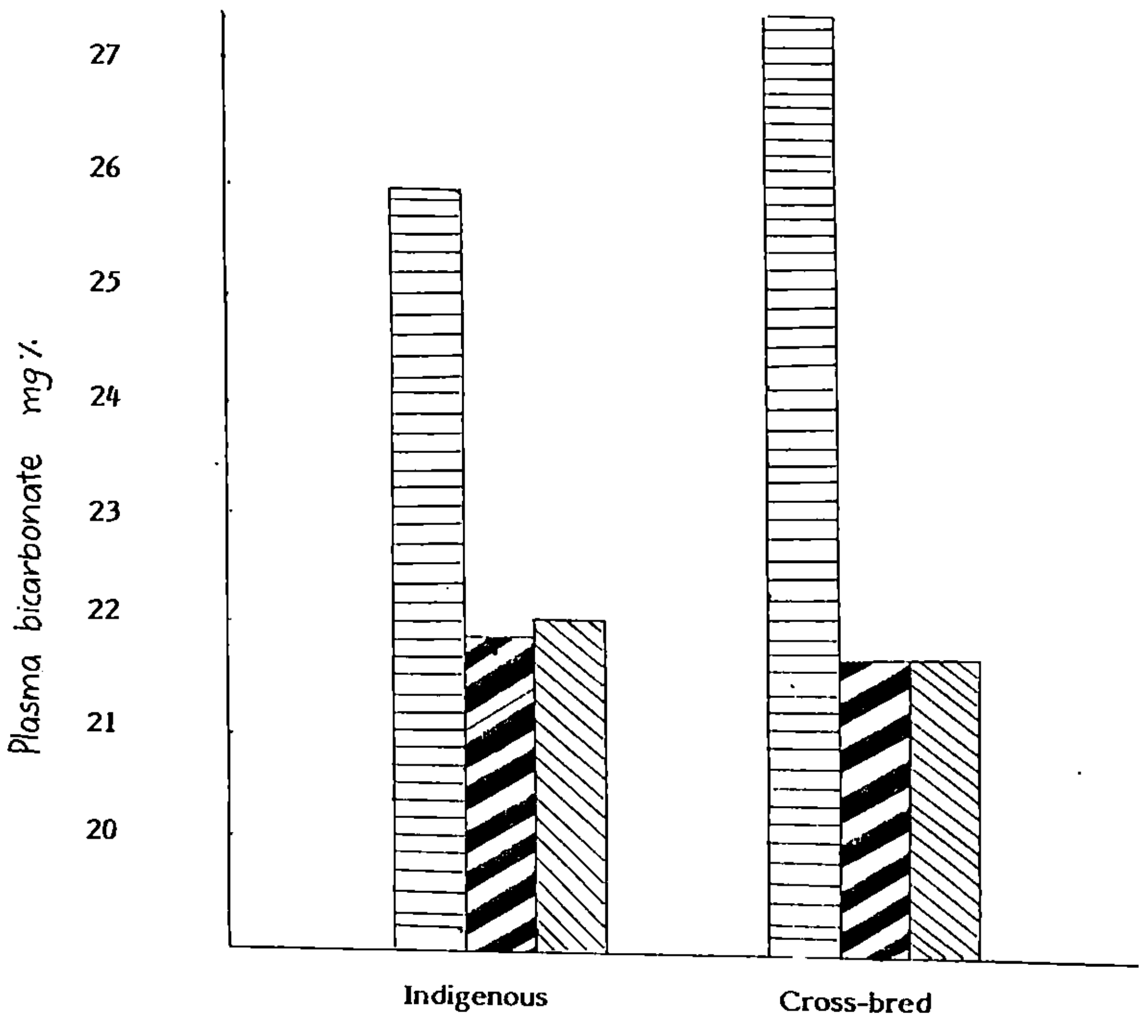

Plasma bicarbonate mg%
27
26
25
24
23
22
21
20
Indigenous
Cross-bred

Table 15. Mean plasma bicarbonate content of indigenous and cross-bred bullocks during 4 hours and 5 hours of work

	4 hours			5 hours		
	Before work	After work	1 hour after work	Before work	After work	1 hour after work
Indigenous	25.8640 ±0.2656	22.5120 ±0.2613	22.6220 ±0.2231	25.8720 ±0.2613	21.9520 ±0.1829	22.0640 ±0.1711
Cross-bred	26.5440 ±0.3360	22.2880 ±0.4853	22.6200 ±0.4663	27.7760 ±0.2239	21.7280 ±0.4480	21.7280 ±0.4480

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Table 16. Comparison of plasma bicarbonate content (T values) between indigenous and cross-bred bullocks

	Before work	After work	1 hour after work
Indigenous x cross bred 4 hours	1.59	0.41	0.004
Indigenous x cross-bred 5 hours	5.53*	0.46	0.701

Comparison of plasma bicarbonate content (T values) just before work, immediately after work and after 1 hour of rest after work

	Before work x after work		Before work x 1 hour after work		After work x 1 hour after work	
	Indi-genous	Cross-bred	Indi-genous	Cross-bred	Indi-genous	Cross-bred
4 hours	8.99*	7.21*	9.35*	6.82*	0.32	0.51
5 hours	12.29*	12.08*	12.19*	12.08*	0.45	0.00

Comparison of plasma bicarbonate content (T values) of indigenous and cross-bred bullocks between r hour and 5 hour work schedules

	Before work	After work	1 hour after work
Indigenous	0.02	1.76	1.98
Cross-bred	3.05*	0.85	1.38

* Significant at 5% level

the values at the start of work. The plasma bicarbonate of indigenous and cross-bred bullocks did not show significant ($P < 0.05$) variation due to 4 hour and 5 hour work schedule.

Figure 21 presents the total area ploughed by indigenous and cross-bred bullocks in 1 hour. The respective mean values and the results of statistical analyses are presented in table 17.

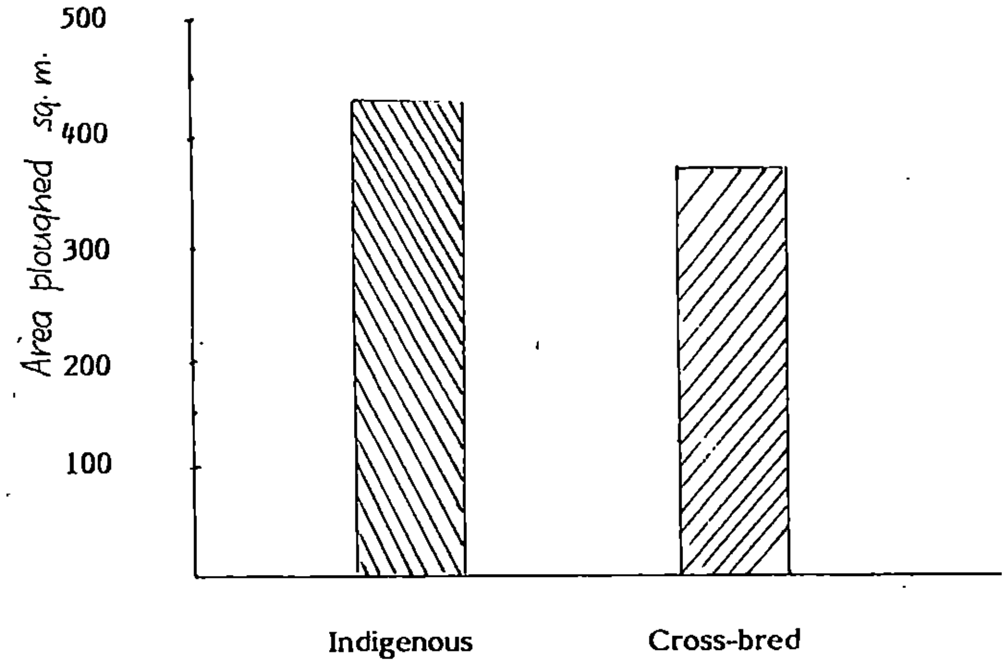
The area ploughed by indigenous bullocks in 1 hour was significantly ($P < 0.05$) more when compared to that ploughed by cross-bred bullocks. On an average, in 1 hour, the indigenous bullocks ploughed 426.24 sq.m. whereas the area ploughed by cross-bred bullocks was only 364.94 sq.m.

Figure 22 presents the average speed of walking of indigenous and cross-bred bullocks. The respective mean values and the results of statistical analyses of the data are presented in table 18.

The speed of walking of indigenous bullocks has been found to be greater than that of cross-bred bullocks. The average walking speed of indigenous bullocks was 1.24 m/sec whereas that of cross-bred bullock was 1.05 m/sec.

The total daily dry-matter intake of indigenous and cross-bred bullocks on days of work and on days on which no work was done along with results of analyses are presented in table 19.

Figure 23 presents the total dry matter intake per metabolic


500
400
300
200
100
Area ploughed sq. m.
Indigenous
Cross-bred

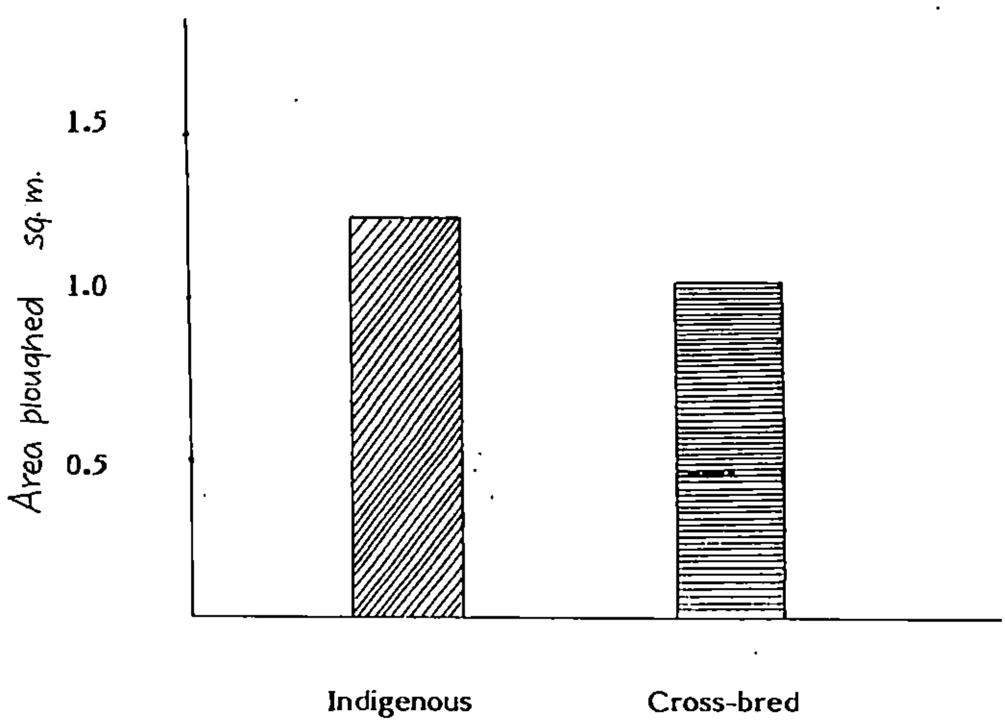

1.5
1.0
0.5
Area ploughed sq. m.
Indigenous
Cross-bred

Table 17. Comparison of the total area ploughed by indigenous and cross-bred bullocks in 1 hour (sq.m.)

	Indigenous	Cross-bred	T value
Area ploughed	429.24 ±13.62	364.94 ±12.74	3.54*

* Significant at 5% level

Table 18. Comparison of speed of walking of indigenous and cross-bred bullocks (m/sec)

	Indigenous	Cross-bred	T value
Walking speed	1.24±0.005	1.05±0.003	35.65*

* Significant at 5% level

Table 19. Comparison of daily total dry matter intake of indigenous and cross-bred bullocks on days of work and on days on which no work was done (kg DM/day)

	Indigenous	Cross-bred	T value
Days of work	9.3766 ±0.6702	10.3191 ±0.0315	13.1240*
Days of no work	9.4290 ±0.0568	10.3786 ±0.0262	15.1827*
T value	0.6009	0.4514	

* Significant at 5% level

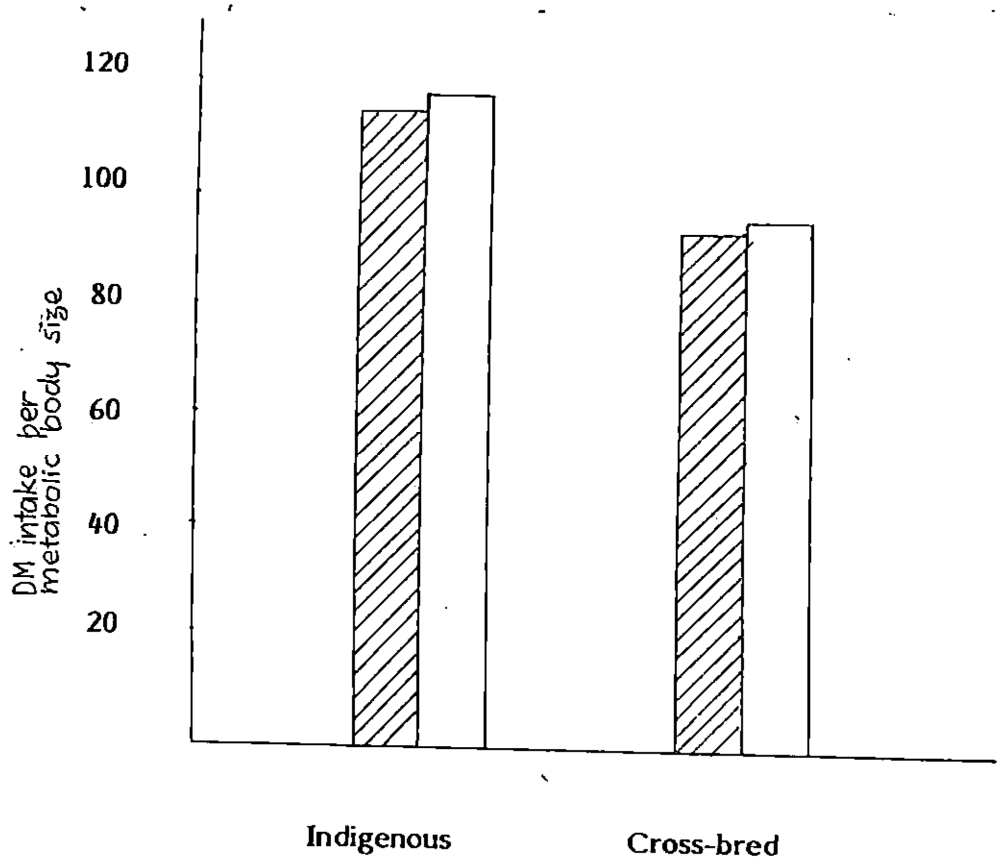
body size of indigenous and cross-bred bullocks on days of work and on days on which no work was done. The respective mean values and statistical analyses of the data are presented in table 20.

The dry matter intake per metabolic body size of indigenous bullocks on days on which work was done was comparatively less than that on days on which no work was done, but the difference was not found to be significant ($P < 0.05$). In the case of cross-bred bullocks also, the same trend was observed.

On comparison between indigenous and cross-bred bullocks on days on which work was done, indigenous bullocks were found to consume significantly ($P < 0.05$) more dry matter per metabolic body size. The same trend was observed between indigenous and cross-bred bullocks on days on which no work was done. It was found that both indigenous and cross-bred bullocks maintained body weight.

Figure 24 presents the water intake per dry matter intake per metabolic body size of indigenous and cross-bred bullocks on days of work and on days on which no work was done. The respective mean values and statistical analyses are presented in table 21.

In both indigenous and cross-bred bullocks, water intake expressed as per cent of dry matter intake per metabolic body size on days on which work was done was slightly more than that on days on which no work was done, the difference being non-significant ($P < 0.05$).


120
100
80
60
40
20
DM intake per metabolic body size
Indigenous
Cross-bred

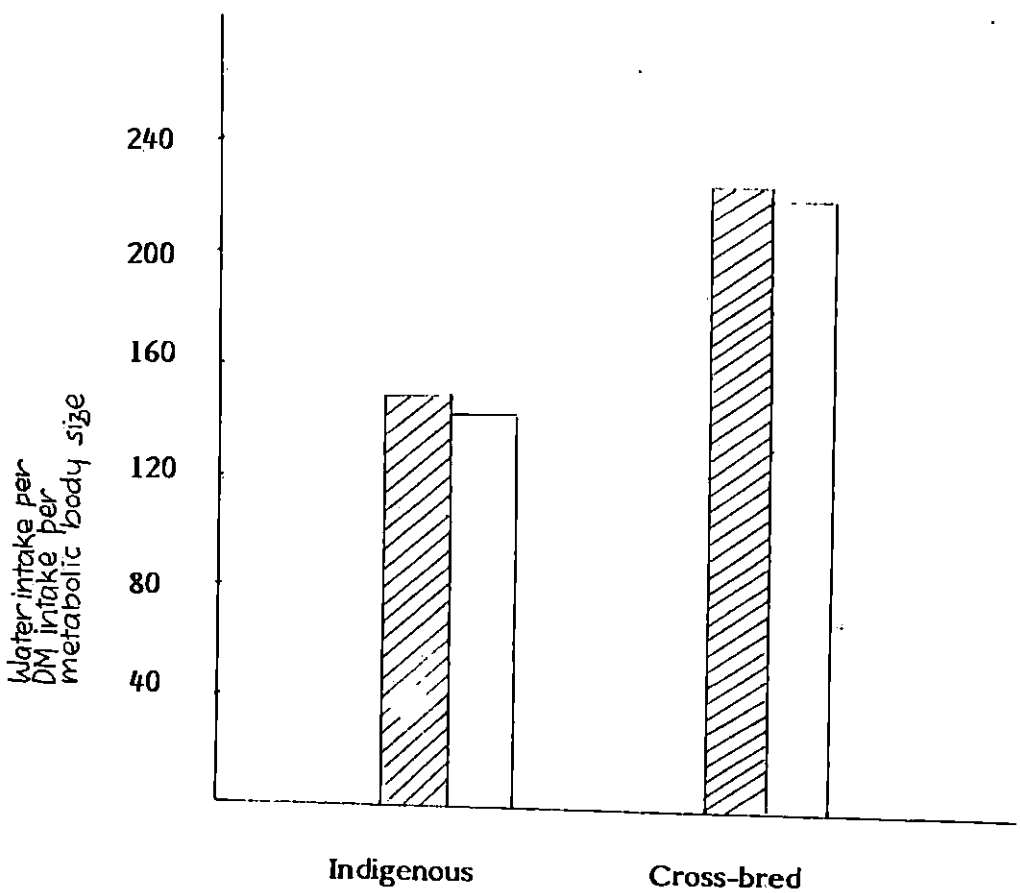

240
200
160
120
80
40
Water intake per DM intake per metabolic body size
Indigenous
Cross-bred

Table 20. Comparison of daily dry matter intake per metabolic body size of indigenous and cross-bred bullocks on days of work and on days on which no work was done (g DM/kg body wt 0.75)

	Indigenous	Cross-bred	T value
Days of work	115.0276 ±0.5215	93.5649 ±0.4452	31.3049*
Days of no work	116.1831 ±0.5821	94.0186 ±0.4194	30.8937*
T value	1.1479	0.7416	

* Significant at 5% level

Table 21. Comparison of daily water intake per dry matter per metabolic body size of indigenous and cross-bred bullocks on days of work and on days on which no work was done (l/DM/body wt 0.75)

	Indigenous	Cross-bred	T value
Days of work	155.5981 ±1.2512	222.8212 ±1.7995	30.7891*
Days of no work	152.9648 ±1.2049	221.3536 ±1.6336	33.8064*
T value	1.5160	0.6038	

* Significant at 5% level

It was also found that on days of work, the cross-breds consumed significantly ($P < 0.05$) more water per dry matter per metabolic body size. On rest days also, the cross-breds were found to consume more water, but the differences were not significant at 5% level.

Discussion

DISCUSSION

5.1. Respiratory rate

In the present study, it was found that the respiratory rate of cross-bred bullocks was significantly ($P < 0.05$) higher when compared to that of indigenous bullocks. This may be due to the fact that the thermoregulatory processes of cross-breds are set on a higher level. The respiratory rate showed a significant ($P < 0.05$) increase immediately after work in both indigenous and cross-bred bullocks subjected to ploughing on dry land continuously for 4 hours and 5 hours respectively. The respiratory rate showed a gradual decline from the elevated value but did not return to pre-exercise values in both the genetic groups of animals even after 1 hour of rest after work.

During work, the draught animals were exposed to a persistent hot-humid climate. Increased environmental temperature lowers the scope for sensible heat loss and the animal has to depend more and more on evaporative channels for thermolysis. When humidity is also elevated along with temperature (figure 1) heat stress increases. Increased respiratory rate may be a manifestation of the thermal stress and the compensatory effort by the animal to facilitate heat loss. The heat generated from exercise and metabolic heat production are also adding up to the stress factors. Besides, during heavy exercise, the tissues will be in need of more oxygen and nutrients and to transport enough oxygen from the lungs to the tissues, more oxygen should be dissolved in blood. In order to effect this, the animal will resort to increasing the rate of respiration. Thus it can be concluded that the increase in respiratory rate could have been brought about partly due to increased demand of oxygen by tissues, especially the working muscles and partly due to the heat stress.

Immediately after work, the respiratory rates were significantly ($P < 0.05$) higher than the pre-exercise values in both the genetic groups of animals in 4 hour as well as 5 hour work schedules. All the previous investigators observed a similar increase in respiratory rates due to different types of work in different classes and breeds of work bovines (Singh et al., 1968; Singh et al., 1970; Roy et al., 1972; Devadattam and Maurya, 1978; Rana et al., 1978; Acharya et al., 1979; Nangia et al., 1980; Garg et al., 1981; Maurya and Devadattam, 1982; Singh et al., 1982; Rao and Upadhyay, 1984; Gattewar, 1985; Upadhyay and Madan, 1985; Upadhyay and Rao, 1985; Thomas and Pearson, 1986).

The extent of rise of respiratory rate when compared to values before the start of work was significantly ($P < 0.05$) more in the case of cross-bred bullocks than in the case of indigenous bullocks in 4 hour as well as 5 hour working schedules. Similar observations were reported by Acharya et al. (1979); Gattewar (1983) and Upadhyay and Madan (1985). Cross-bred cattle are known to depend more on elevated respiratory rates for thermolyses than pure zebu (Thomas and Razdan, 1973).

The respiratory rates did not return to pre-exercise values even after 1 hour of rest after the end of work, but there was a gradual decline in the rate of respiration during the rest period. The values after 1 hour of rest were significantly ($P < 0.05$) different from the pre-exercise values and the values immediately after work for both 4 hour and 5 hour working schedules. This finding is similar to the observation made by Maurya and Devadattam (1982) in which a rest pause of 1/2-3/4 hour was not sufficient to bring the increased respiratory rates to come down to original values. But Singh et al. (1970) observed that in Hariana and Sahiwal bullocks subjected to ploughing, the respiratory rates came to normal within half-an-hour after work.

In the present study, after 1 hour of rest after work, the respiratory rate decreased from 87.39/minute to 48.07 per minute in 4 hour and 90.83 per minute to 48.54 per minute in 5 hour working schedule in the case of indigenous bullocks and from 97.44 per minute to 57.20 per minute and 102.44 per minute to 57.19 per minute in 4 hour and 5 hour work schedule respectively in cross-bred bullocks. Between 4 hour and 5 hour work schedule also there were significant ($P < 0.05$) differences in the case of indigenous and cross-bred bullocks immediately after work and after 1 hour of rest after work. In general, the respiratory rates were significantly ($P < 0.05$) higher when the duration of work was normal. This is understandable because longer duration of work is likely to increase the demands on gareous exchange and thermolysis. Maurya and Devadattam (1982) also reported a higher respiratory rate in Jersey x Red Sindhi cross-bred bullocks when the duration of work was more.

5.2. Pulse rate

It has been found that the pulse rate of cross-bred bullocks was significantly ($P < 0.05$) higher than that of indigenous bullocks before the start of work. This may be indicative of the general weakness of the cross-breds vis-a-vis indigenous bullocks with respect to adaptability to hot conditions.

The pulse rate showed a significant ($P < 0.05$) increase immediately after work in both indigenous and cross-bred bullocks subjected to ploughing on dry land continuously for 4 hours and 5 hours respectively. The pulse rate gradually declined from the elevated value but did not return to pre-exercise values in both the genetic groups of animals even after 1 hour of rest after work.

During work draught animals were subjected to great thermal stress from the environment and from their system. Apart from the effects of the hot-humid climate, the heat generated from exercise and metabolic heat production add up.

Regular heavy exercise leads to hypertrophy of the cardiac muscles and also enlargement of the ventricular chambers resulting in increased pumping by the heart (Guyton, 1981). During heavy exercise, the tissues will be in need of more oxygen and nutrients. In order to transport enough oxygen from the lungs to the tissues, cardiac output has to be increased with enhanced oxygen carriage of blood. The increase in cardiac output results in increased heart rate (pulse rate). The most important factor that increases the cardiac output is ventillation that occurs in all exercising muscles as a result of increased muscle metabolism during exercise. When large numbers of muscles are exercising simultaneously, the peripheral vasodilation may be so great and the venous return to the heart so voluminous that the heart cannot pump this extra amount of blood. Therefore, it is essential that the level of pumping by the heart to be greatly increased from its normal level.

Almost all the previous workers irrespective of type of animal and nature of work have noticed an enhancement of pulse rate due to exercise (Singh et al., 1968; Singh et al., 1970; Roy et al., 1972; Devadattam and Maurya, 1978; Rana et al., 1978; Acharya et al., 1979; Nangia et al., 1980; Maurya and Devadattam, 1982; Singh et al., 1982; Rao and Upadhyay, 1982; Gattewar, 1983; Upadhyay and Madan, 1985; Upadhyay and Rao, 1985 and Thomas and Pearson, 1986).

The increase in pulse rate when compared to pre-exercise values was significantly ($P < 0.05$) higher in the case of crossbred bullocks than in the case of indigenous bullocks in 4 hour as well as 5 hour working schedules. Similar observations were reported by Acharya et al. (1979); Gattewar (1985) and Upadhyay and Madan (1985).

The pulse rate did not return to pre-exercise values even after 1 hour of rest after the end of work, but there was a gradual fall in the pulse rate during the rest period. The values after 1 hour of rest after work was significantly ($P < 0.05$) different from the pre-exercise values and the values immediately after work in both 4 hour and 5 hour working schedule. Similar observations were made by Maurya and Devadattam (1982) in Jersey x Red Sindhi cross-bred bullocks while carting in which a rest pause of 1/2-3/4 hour was not sufficient to bring the increased pulse rate to pre-exercise values. Similarly Singh et al. (1970) observed that in Hariana and Sahiwal bullocks subjected to ploughing, the pulse rate did not record a fall within the first half hour but later showed a gradual fall.

In the present study, after 1 hour of rest after work, the pulse rate decreased from 77.67 $\pm$ 0.78 to 61.43 $\pm$ 0.90 per minute in 4 hour and 79.11 $\pm$ 1.42 to 62.13 $\pm$ 0.75 per minute in 5 hour working schedule in the case of indigenous bullocks and from 87.15 $\pm$ 0.56 to 69 $\pm$ 0.96 per minute in 4 hour and from 90.28 $\pm$ 1.16 to 69.25 $\pm$ 0.74 per minute in 5 hour work schedule respectively in cross-bred bullocks. Between 4 hour and 5 hour work schedule, there were no significant ($P < 0.05$) differences in the pulse rates in indigenous bullocks, but the differences were significant ($P < 0.05$) in the case of cross-bred bullocks. After one hour of rest after work, there were no significant ($P < 0.05$) differences in the pulse rates in indigenous as well as cross-bred bullocks. Maurya and Devadattam (1982) also reported a higher pulse rate in Jersey x Red Sindhi cross-bred bullocks when the duration of work was more.

5.3. Rectal temperature

It was found that the rectal temperature in the case of cross-bred bullocks was significantly ($P < 0.05$) higher than that of indigenous bullocks before the start of work. This indicates that the cross-breds could achieve thermal equilibrium at a higher body temperature only.

The rectal temperature showed a significant ($P < 0.05$) increase immediately after work in both indigenous and cross-bred bullocks subjected to ploughing on dry land continuously for 4 hours and 5 hours respectively. The rectal temperature gradually declined from the elevated value but did not return to pre-exercise values in both the genetic groups of animals even after 1 hour of rest after work.

During work the bullocks are exposed to strong sunshine while working and the heat gained from solar radiation coupled with metabolic heat and the heat produced by exercise add upto a very heavy heat load on the animal. Also, a considerable portion of the total energy liberated during muscle contraction is converted into heat.

In the present study, immediately after work, the rectal temperature was significantly ($P < 0.05$) higher than the pre-exercise value in both the genetic groups of animals in 4 hour as well as 5 hour work schedules. This observation is similar to the observations made by Singh et al. (1968), Singh et al. (1970), Roy et al. (1972), Devadattam and Maurya (1978), Rana et al. (1978), Acharya et al. (1979), Nangia et al. (1980), Garg et al. (1981), Maurya and Devadattam (1982), Singh et al. (1982), Gattewar (1983), Upadhyay and Madan (1985), Upadhyay and Rao (1985) and Thomas and Pearson (1986) in different types of work bullocks subjected to various kinds and intensities of work.

Rectal temperature immediately after work was significantly ($P < 0.05$) higher in cross-bred bullocks compared to Zebu bullocks in both the time schedules of work. Similar observations were reported by Acharya et al. (1979) during ploughing and carting, Gattewar (1983) while harrowing and Upadhyay and Madan (1985) during carting operations.

The rectal temperature did not return to pre-exercise values even after 1 hour of rest after work, but there was a gradual fall during the period of rest. The rectal temperature 1 hour after rest after work was significantly different from the values before the start of work and immediately after work in both working schedules except in the case of cross-bred bullocks in 4 hours of work regime where there was no significant ($P < 0.05$) variation in the rectal temperature 1 hour after rest after work and the pre-exercise value. This may be, because the pre-exercise values were already at a higher level in the cross-breds and during one hour's rest after a 4 hour exercise period, the animals could bring down the rectal temperature to this level.

Maurya and Devadattam (1982) reported that in Jersey x Red Sindhi cross-bred bullocks during carting, a rest period of 1/2-3/4 hour was not sufficient to bring down the elevated rectal temperature to the pre-exercise value. This is in similarity with the observations in the present investigation. Singh et al. (1970) observed that in Hariana and Sahiwal bullocks subjected to ploughing, the rectal temperature did not record a fall within the first half hour but later showed a gradual fall. In the present study also, a gradual decline was noticed in the rectal temperature from the elevated value during the rest period.

5.4. Haemoglobin

In the present study, it was found that the haemoglobin per cent of blood was higher in indigenous bullocks when compared to that of cross-breds before the start of work. There was a significant ($P < 0.05$) decrease immediately after work in both indigenous and cross-bred bullocks subjected to ploughing on dry land continuously for 4 hours and 5 hours respectively. After 1 hour of rest after work, the haemoglobin per cent showed a gradual increase in both the genetic groups of animals, but did not reach the pre-exercise values.

The decrease in haemoglobin per cent of blood can be partly due to haemodilution.

Thomas and Razdan (1973) reported expansion of plasma volume and haemodilution due to exercise. Also, there is a certain degree of red blood cell destruction during exercise which is indicated by a high icteric index (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.

Similar reduction in haemoglobin per cent was reported by previous investigators in different classes of work bovines (Georgie _et al._, 1970; Rana _et al._, 1977; Singh _et al._, 1980 and Singh _et al._, 1982). Gattewar (1983) on the other hand observed that exercise caused an increase in the haemoglobin per cent of blood in cross-bred bullocks whereas it decreased in Hariana bullocks.

The haemoglobin per cent of blood did not return to pre-exercise values even after 1 hour of rest after work, but there was a gradual rise during the rest period. The value after 1 hour of rest was significantly ($P<0.05$) higher in indigenous bullocks than cross-bred bullocks in both 4 hour and 5 hour of work regimes. The haemoglobin per cent after 1 hour of rest was not significantly ($P<0.05$) different from the value immediately after work in both the genetic groups of animals in both work schedules. This indicate that a rest pause of 1 hour was not sufficient to bring back the haemoglobin level to the pre-exercise values in both indigenous and cross-bred bullocks.

Between 4 hour and 5 hour work schedules, there was significant ($P<0.05$) difference in the haemoglobin level immediately after work in indigenous bullocks, but the difference was non-significant ($P<0.05$) in the case of cross-bred bullocks. A higher haemoglobin per cent in the indigenous bullocks and a significantly higher value in them after 4 hours of work in comparison to 5 hours of work are probably indicative of their greater adaptability. A higher haemoglobin level is indicative of greater oxygen carrying and carbondioxide removing capacity of blood. After 4 hours work, they were only mildly stressed and after 5 hours work, the haemoglobin level further decreased. The cross-breds on the other hand were under some degree of heat stress even before work as indicated by the lower values of haemoglobin. The fact that there was no difference between the values of haemoglobin immediately after 4 hour or 5 hour work, may indicate that even with 4 hours of work, the haemoglobin level had reached a very low value in them and perhaps further reduction was not possible. The level was found to be more in 4 hour work schedule when compared to that in 5 hour work schedule in indigenous bullocks. The same trend was observed after 1 hour of rest after work also.

5.5. Packed Cell Volume

It was found that the packed cell volume (PCV) was significantly ($P<0.05$) higher in cross-bred bullocks than indigenous bullocks before the start of work. As a result of continuous ploughing for 4 hours and 5 hours on dry land, the PCV showed a significant ($P < 0.05$) decrease in both the genetic groups of animals. After 1 hour of rest after work, there was a gradual increase in the packed cell volume, but it did not return to the value before the start of work.

The decrease in packed cell volume may be attributed to haemodilution and destruction of red blood cells during severe exercise. Similar reduction in the packed cell volume was observed by Rana et al., 1977; Singh et al., 1980; and Singh et al., 1982 as a result of different types of work in different classes of work bovines. On the other hand, an increase in the PCV was observed by Gattewar (1983) in cross-bred bullocks, whereas, a decrease in the PCV was observed in Hariana bullocks by the same investigator as a result of work.

The PCV did not return to pre-exercise values even after 1 hour of rest after work. The values after 1 hour of rest were significantly ($P < 0.05$) different from the pre-exercise values in both the genetic groups of animals. But, the difference was not significant ($P < 0.05$) from the values immediately after work in both genetic groups in both work schedules. In general, it can be seen that PCV behaved in the same manner as haemoglobin per cent. The conclusion drawn on the basis of the behaviour of haemoglobin per cent appears generally valid in the case of PCV also.

5.6. Erythrocyte sedimentation rate

The erythrocyte sedimentation rate (ESR) was significantly ($P < 0.05$) higher in cross-bred bullocks than indigenous bullocks before the start of work. This may indicate that the cross-breds are under some degree of stress even before the start of work. The ESR showed a significant ($P<0.05$) increase in both the genetic groups of animals immediately after work. After 1 hour of rest after work the ESR showed a gradual decline in both groups, but did not reach the pre-exercise values.

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 cells (Schalm, 1965), thus, smaller the volume, the greater the speed of settling. The increase in ESR may be partly due to red blood cell destruction during exercise. Exercise seems to cause stress in both the genetic groups and rest seems to result in slow recovery.

Similar increase in the level of ESR was reported by previous investigators in different classes of working animals (Rana et al., 1977; Singh et al., 1980 and Singh et al., 1982).

The ESR did not return to pre-exercise values even after 1 hour of rest after work, but there was a gradual decline during the rest period. The values after 1 hour of rest was significantly ($P<0.05$) higher in the cross-bred bullocks in both 4 hour and 5 hour work schedules. The values after rest was significantly ($P<0.05$) different from those before the start of work in both work regimes which indicates that a rest pause of 1 hour was not sufficient to bring back the values to the pre-exercise values in both indigenous and cross-bred bullocks.

Between 4 hour and 5 hour work schedules, there was no significant ($P<0.05$) variation in the ESR in indigenous and cross-bred bullocks at the end of work. But, after 1 hour of rest, significant ($P<0.05$) difference existed in indigenous bullocks, whereas the variation was non-significant ($P<0.05$) in cross-bred bullocks.

5.7. Lactic acid

It has been found that, the lactic acid content of blood was significantly ($P<0.05$) higher in the cross-bred bullocks than indigenous bullocks before the start of work. It showed a significant ($P<0.05$) increase immediately after work in both indigenous and cross-bred bullocks subjected to ploughing on dry land continuously for 4 hours and 5 hours respectively. After 1 hour of rest after work, the lactic acid content showed a gradual decline in both indigenous and cross-bred bullocks, but did not reach the pre-exercise values.

During very intense muscular activity, as is taking place during work, the circulatory system cannot bring oxygen and glucose to the skeletal muscles fast enough to meet the increased demand of the muscles for ATP. In this case, muscle glycogen is used as a reserve fuel and is rapidly broken down by glycolysis to form lactate, thus generating ATP which is the energy source for the contraction of muscle. Since, insufficient oxygen is available under these circumstances, the lactate cannot be metabolised further in the muscles and diffuses into the blood, where its concentration becomes very high during such intense muscular effort (Lehninger, 1984).

Similar increase in the lactic acid content of blood was reported by previous investigators in different working animals (Harmansen and Vaage, 1977; Singh et al., 1980; Agarwal et al., 1983; Gattewar, 1983 and Upadhyay et al., 1983).

Lactic acid content did not return to pre-exercise values even after 1 hour of rest after work, but there was a gradual decline during the rest period. This observation is in agreement with the observation made by Agarwal et al., 1983; that the lactic acid content did not return to pre-exercise values even after 3 hours of rest after work. After 1 hour of rest after work, the lactic acid content was significantly ($P<0.05$) higher in the cross-bred animals than indigenous animals in 4 hour work schedule, but in the case of 5 hour work schedule, the variation between indigenous and cross-bred bullocks was non-significant.

Between 4 hour and 5 hour work schedules, there was significant ($P<0.05$) difference in the lactic acid content in indigenous bullocks, whereas, the difference was non-significant in the case of cross-breds immediately after work. There was significant ($P<0.05$) variation between 4 hour and 5 hour work schedules in the lactic acid content after 1 hour of rest in both the genetic groups of animals.

5.8. Plasma bicarbonate

In the present study, cross-breds were found to have significantly ($P<0.05$) higher plasma bicarbonate values. It showed a significant ($P<0.05$) decrease immediately after work in both the genetic groups. After 1 hour of rest after work, the bicarbonate content showed a gradual increase.

Exercise increases the catabolic processes in the body resulting in the accumulation of various acids. The decrease in bicarbonate level may be related to the hyperventilation of the lungs due to increased respiration rate during exercise. Exercise increases the metabolism of the body and hence the requirement of oxygen. In response to this demand for more oxygen, the rate and depth of breathing are increased, which in turn results in hyperventilation of lungs. Therefore, the body fluids may sustain the loss of carbondioxide as a result of higher ventilation rate during exercise. Since more than 95% of carbondioxide is contributed by the carbonic acid-bicarbonate buffer system, the level of plasma bicarbonate might have been reduced as a result of excretion. The level of plasma bicarbonate content is the most satisfactory single index to judge the ability of the body as a whole to neutralise the acid and products of metabolism (Hawk *et al.*, 1954).

Similar decline in the plasma bicarbonate has been reported by previous investigators in different classes of draught animals (Garg *et al.*, 1981; Agarwal *et al.*, 1983; Gattewar, 1983). On the other hand, Nangia *et al.* (1980) and Singh *et al.* (1980)

found an increase in the plasma bicarbonate content as a result of exercise in work buffaloes.

The plasma bicarbonate content did not return to pre-exercise values even after 1 hour of rest after work. The values after 1 hour of rest were not significant ($P < 0.05$) between indigenous and cross-bred bullocks in both work schedules. The values after 1 hour of rest was not significantly ($P < 0.05$) different from that immediately after work in both the genetic group of animals.

Between 4 hour and 5 hour work schedules, there was no significant ($P < 0.05$) variation in the plasma bicarbonate content immediately after work and 1 hour after rest after work.

5.9. Area covered during ploughing

It has been found that the total area ploughed by indigenous bullocks was significantly ($P < 0.05$) higher than that of cross-bred bullocks. In 1 hour, the indigenous bullock pairs ploughed an area of 426.24 sq.m. compared to 364.04 sq.m. by cross-bred bullock pairs. Thus a pair of South Indian draught bullock ploughed 15 per cent more area compared to cross-bred bullocks. This is similar to the observations made by Anand and Sundaresan (1974) who found that the cross-bred bullocks ploughed only less area when compared to Hariana bullocks. Rao (1974) also found that the area ploughed by indigenous bullocks was more than that covered by cross-bred bullocks during summer and winter, with the difference increasing to 17% during hot-humid period. On the other hand, Roy and Co-workers (1972) observed that ploughing of wet land from 0800 hours to 1000 hours resulted in the cross-breds ploughing a slightly greater area than Hariana bullocks, whereas on dry land, equivalent amounts of land were ploughed by both the groups of animals. Nagpaul and associates (1984) were also of the opinion that cross-breds performed as good as Zebu and buffalo bullocks as evidenced by total area ploughed in 1 hour.

5.10. Speed of walking

In the present study, it has been observed that the indigenous bullocks walked at a greater speed than the cross-breds. The speed at which the indigenous bullocks walked while ploughing dry land was 1.24 m/sec whereas the cross-bred bullocks walked at a speed of 1.05 m/sec. The normal walking speed of cattle and buffaloes was estimated to be between 0.6 to 1.2 m/sec depending upon the type of job they are undertaking (Lawrence, 1985). Each work ox has a rate of movement best suited to its gait and an average of 0.88-1.2 m/sec can be considered as the normal rate (Williamson and Payne, 1975), whereas the maximum speed that can be attained by buffaloes is on an average of 0.88 m/sec.

5.11. Feed intake

In the present study, it was observed that the dry matter intake per metabolic body size of indigenous and cross-bred bullocks did not vary significantly ($P<0.05$) on days on which work was done and on days on which no work was done. This indicates that work had no effect on food intake. The indigenous bullocks consumed less total dry matter per day due to smaller size.

Similar observations were made by Upadhyay and associates (1983) who found that work had no effect on food intake of young cross-bred bullocks. Lawrence and Campbell (1985) reported that working bullocks were unable to supply their increased energy needs by eating more. Lawrence (1985) in a study of the voluntary feed intake of bullocks in Costa Rica, has found that work had little effect on appetite and work was not associated with any increase in voluntary feed intake. Thomas and Pearson (1986) found that animals when working at an ambient temperature of 33°C consumed significantly less food than they did on days on which no work was done and on days on which they worked at 15°C and they concluded that the reduced intake was more a reflection of the increased heat load due to work. Barton and Saadullah (1986) also observed that the voluntary dry matter intakes of bullocks were not significantly increased with the imposition of work.

There was significant ($P<0.05$) difference between indigenous and cross-bred bullocks in the dry matter intake, the indigenous bullocks consuming more. In general, the indigenous males consumed more dry matter than <u>Bos taurus</u> x <u>Bos indicus</u> cross-breds (Hower <u>et al.</u>, 1963; Thomas <u>et al.</u>, 1969 and Thomas and Razdan, 1973). Thomas and Pearson (1986) in a controlled environment experiment, on the other hand observed no significant difference in the dry matter intake between Brahman and Brahman x European cross-bred bullocks.

5.12. Water intake

In the present study, it was observed that the water intake expressed as per cent of dry matter per metabolic body size of indigenous and cross-bred bullocks did not vary significantly ($P < 0.05$) on days on which work was done and on days on which no work was done.

On comparing the water intake as per cent of dry matter per metabolic body size between indigenous and cross-bred bullocks, on days of work and on days on which no work was done, the cross-breds consumed significantly ($P < 0.05$) higher quantities.

In general, the indigenous bullocks consumed more dry matter per metabolic body size and less water per dry matter consumed. This may point towards better productive adaptability on their part mainly because they were able to consume more feed per unit metabolic body size in a thermally adverse environment. Higher level of feed consumption is a requirement for higher productivity. Similarly, a lower water intake is indicative that they required less water turnover for evaporative thermolysis or they exercised better water economy by reabsorbing more water from the rectum.

General conclusions

Even before the start of work, the cross-bred bullocks were found to have higher physiological responses like respiratory rate, pulse rate and rectal temperature. This probably indicates that the cross-breds were under some degree of thermal stress even before the start of work. Immediately after work, the extent of increase in these parameters was higher in the cross-bred bullocks when compared to indigenous bullocks. After 1 hour of rest after work, the extent of decline was less in the case of cross-breds.

The haemoglobin per cent of blood was higher in the indigenous bullocks before work. It decreased to a greater extent in cross-bred bullocks. A higher haemoglobin per cent is indicative of greater oxygen carrying capacity and hence greater adaptability. The rate of recovery was slow in cross-bred bullocks. Almost similar trend was observed with packed cell volume of blood also. The erythrocyte sedimentation rate was higher in the cross-breds even before the start of work. Similar trend was observed with blood lactic acid and plasma-bicarbonate content also. The rate of recovery of these haematological parameters was slow in the case of cross-bred bullocks.

The total dry matter intake of indigenous bullocks was found to be significantly less than that of cross-breds. But, when expressed as per cent of metabolic body size, the indigenous bullocks consumed more dry matter. On comparing the water intake, it was observed that the cross-bred bullocks consumed more water per dry matter per metabolic body size. These may point towards better adaptability on the part of indigenous bullocks mainly because they were able to consume more feed per metabolic body size and they were able to have better water economy and required less water turnover rate.

On comparing the relative efficiency of work, it was found that the indigenous bullocks were able to plough comparatively more area (15%) than cross-bred bullocks. The speed of walking was also significantly higher in indigenous bullocks.

In the light of the above findings the following inferences can be made:

1. The indigenous Kangayam type bullocks are faster and can plough approximately 15% more of dry land.
2. The indigenous bullocks consume more feed on a metabolic body size basis and therefore are likely to make available more energy for work.
3. The water intake is less in indigenous bullocks and therefore can be more suitable for water scarcity regions.
4. The cross-breds seem to be under some degree of thermal stress even without work as demonstrated by physiological reactions like respiratory rate, pulse rate and rectal temperature.

Blood studies like haemoglobin per cent, packed cell volume, plasma bicarbonate, lactic acid and erythrocyte sedimentation rate also point towards a lower capacity of the cross-breds to withstand the hot humid conditions of 27.74°C and 71% relative humidity.

5. Work resulted in greater thermal stress reactions in the cross-breds.

6. After one hour rest subsequent to work, the indigenous Kangayam type bullocks tended to return to pre-exercise values faster, thus indicating better adaptability.

7. Eventhough the dry matter intake per metabolic body size was higher in the indigenous bullocks, their actual total dry matter intake was lower than the cross-breds due to smaller size.

Lower dry matter intake coupled with more area ploughed per unit time and greater sustaining power due to lower heat strain experienced, make them a more economical and superior draught animal.

8. It may be said in favour of the cross-breds that they, eventhough under some degree of thermal stress were able to carry on with the work at a slower speed without losing body weight. It has to be ascertained whether they can put in more work, when they are pulling greater loads in carting as they may have greater power due to larger body size.

Summary

SUMMARY

The draught performance of *Bos indicus* x *Bos taurus* cross-bred bullocks was compared with that of bullocks belonging to a South Indian draught breed (Kangayam type) under the agro-climatic conditions of Kerala, with a hot-humid tropical climate.

Two pairs of adult cross-bred (Jersey x Sindhi) bullocks and two pairs of adult indigenous bullocks (Kangayam type), all trained earlier for work were selected for the study. They were used for ploughing on dry land for 4 hours and 5 hours continuously on alternate days, on each day there being one pair of indigenous and one pair of cross-bred bullocks. Physiological responses like respiratory rate, pulse rate and rectal temperature and haematological parameters like haemoglobin per cent of blood, erythrocyte sedimentation rate, packed cell volume, blood lactic acid and plasma bicarbonate were estimated before the start of work, immediately after work and after 1 hour of rest after work. The dry matter intake and water intake on days of work and on days on which no work was done were determined and compared. In order to evaluate the relative efficiency of work, the two groups of animals were made to plough similar but different fields. The average speed of walking and the total area ploughed in unit time were estimated and compared.

Even before the start of work, the cross-bred bullocks had significantly higher physiological responses. As a result of

work, there was significant increase in the physiological responses in both the genetic groups of animals. The respiratory rate, pulse rate and rectal temperature in the case of indigenous bullocks increased from 22.52 ± 0.18, 51.68 ± 0.32 and 38.42 ± 0.01 to 87.69 ± 0.56, 77.67 ± 0.78 and 39.59 ± 0.02 in 4 hour work schedule and from 22.12 ± 1.0, 51.25 ± 0.38 and 38.45 ± 0.01 to 90.83 ± 0.81, 79.11 ± 1.42 and 39.73 ± 0.03 in 5 hour work schedule respectively. The corresponding values in the case of cross-bred bullocks rose from 24.70 ± 0.23, 54.81 ± 0.38 and 38.69 ± 0.02 to 97.44 ± 0.29, 87.15 ± 0.56 and 39.86 ± 0.01 in 4 hour work schedule and from 25.04 ± 0.15, 54.67 ± 0.32 and 38.70 ± 0.01 to 102.44 ± 0.47, 90.28 ± 1.2 and 40.01 ± 0.03 in 5 hour work schedule respectively. After 1 hour of rest after work, the values dropped significantly, but did not reach the pre-exercise values. Five hour work schedule seemed to impose greater stress on the animals. Between indigenous and cross-bred bullocks, the cross-breds seemed to be greatly stressed.

The haemoglobin per cent of blood, packed cell volume and plasma bicarbonate content decreased significantly in both the genetic groups of animals as a result of work. The haemoglobin content of blood, packed cell volume and plasma bicarbonate content in the case of indigenous bullocks declined from 12.15 ± 0.15, 32.10 ± 0.28 and 25.86 ± 0.27 to 11.00 ± 0.09, 29.70 ± 0.25 and 22.51 ± 0.26 in 4 hour work schedule and from 12.38 ± 0.07, 31.55 ± 0.38 and 25.87 ± 0.26 to 10.65 ± 0.09, 28.85 ± 0.26 and 21.95 ± 0.18 in 5 hour work schedule respectively. The corresponding values in the case of cross-bred bullocks declined from 11.76 ± 0.14, 35.45 ± 0.28 and 26.54 ± 0.34 to 10.28 ± 0.12, 32.00 ± 0.32 and 22.28 ± 0.49 in 4 hour work schedule and from 12.13 ± 0.05, 33.15 ± 0.58 and 27.78 ± 0.22 to 10.31 ± 0.07, 30.75 ± 0.30 and 21.73 ± 0.45 in 5 hour work schedule respectively. The erythrocyte sedimentation rate and blood lactic acid content were found to increase significantly after work. The values of erythrocyte sedimentation rate and blood lactic acid content in indigenous bullocks increased from 0.50 ± 0.02 and 27.70 ± 0.13 to 1.6 ± 0.04 and 39.37 ± 0.21 in 4 hour work schedule and from 0.46 ± 0.01 and 27.81 ± 0.12 to 1.68 ± 0.02 and 40.31 ± 0.19 in 5 hour work schedule respectively. The corresponding values in the case of cross-bred bullocks increased from 0.58 ± 0.02 and 29.84 ± 0.31 to 2.51 ± 0.38 and 40.72 ± 0.19 in 4 hour work schedule and from 0.57 ± 0.01 and 30.52 ± 0.45 to 2.59 ± 0.02 and 40.73 ± 0.22 in 5 hour work schedule respectively. One hour of rest was not sufficient to bring the haematological parameters to pre-exercise levels.

The dry matter intake per metabolic body size of indigenous bullocks on days of work was comparatively less than that on days on which no work was done. The same trend was observed in the case of cross-bred bullocks also. The indigenous bullocks consumed more dry matter per metabolic body size on days of work and on days on which no work was done. The indigenous bullocks on days of work consumed 115.03 ± 0.52 g/kg body wt 0.75 of dry matter per metabolic body size and 116.18 ± 0.58 g/kg body wt 0.75 on days on which no work was done. The cross-breds on the other hand consumed 93.53 $\pm$ 0.45 g/kg body wt 0.75 and 94.02 $\pm$ 0.42 g/kg body wt 0.75 on days of work and on days on which no work was done. However, the total dry matter intake by the cross-breds was significantly higher than the indigenous due to larger body size.

The cross-bred bullocks consumed more water per dry matter per metabolic body size on days of work and on days on which no work was done.

The total area ploughed by indigenous bullocks in 1 hour was significantly more when compared to that ploughed by cross-bred bullocks. The indigenous bullocks ploughed on an average 426.24 sq.m. of dry land in 1 hour whereas that ploughed by cross-breds was 364.04 sq.m. Also, the average speed of walking of indigenous bullocks (1.25 m/sec) was greater than that of cross-bred bullocks (1.05 m/sec).

The cross-bred bullocks seemed to be under some degree of thermal stress even without work as demonstrated by physiological responses like respiratory rate, pulse rate and rectal temperature. Haematological studies like haemoglobin per cent, packed cell volume, plasma bicarbonate content, erythrocyte sedimentation rate and blood lactic acid also pointed towards a lower capacity of the cross-breds to withstand the hot-humid condition. It has been found that work resulted in greater thermal stress reactions in the cross-bred bullocks.

The indigenous bullocks were faster and could plough approximately 15 per cent more of dry land when compared to cross-bred bullocks. They consumed more feed on a metabolic body size basis and therefore are likely to make available more energy for work. The water intake was less in indigenous bullocks and therefore are more suitable for water scarcity regions. Lower total dry matter intake coupled with more area ploughed per unit time and greater sustaining power due to low heat strain experienced, make the indigenous bullocks a more economical and superior draught animal. In ploughing, where speed, stamina and capacity for sustained long spells of work are more important than the capacity to pull heavier loads, the indigenous bullocks appear to be superior on all counts.

References

REFERENCES

Acharya, S., Mishra, M. and Nayak, J.B. (1979). Working capacity and behaviour of cross-bred versus non-descript indigenous bullocks under Orissa conditions. Indian J. Dairy Sci., 32(1): 37-42.

Adeyemo, O., Heath, E., Adadevoh, B.K., Steinbach, J. and Olaloku, E.A. (1979). Some physiological and behavioural responses in Bos indicus and Bos taurus heifers acclimatized to the hot-humid seasonal equitorial climate. International J. Biometeorology, 23(3): 231-241.

Agarwal, S.P., Singh, N., Agarwal, V.K. and Dwarakanath (1983). Direct comparison of biochemical responses under work load in entire, vasectomised and castrated male buffaloes. Haryana Vet., 22(1): 1-5.

Amakiri, S.F. and Funsho, O.N. (1979). Studies of rectal temperature, respiratory rates and heat tolerance in cattle in the humid tropics. Anim. Prod., 28(2): 329-335.

Anand, U. and Sundaresan, D. (1974). Cross-bred bullocks can contribute to agricultural operations. Indian Farming, 24(5): 27-29.

Annual Report (1985-86). Part I, Technical, Indian Council of Agricultural Research, New Delhi.

Anon. (1961). Annual Report (1961). Indian Veterinary Research Institute, Izatnagar.

A.R.C. (1980). The Nutrient Requirement of Ruminant Livestock. Commonwealth Agricultural Bureau, Farnhan Royal.

Ashton, G.C. (1962). Comparative nitrogen digestibility in Brahman, Brahman x Shorthorn, Africander x Hereford and Hereford steers. J. Agric. Sci. Comb., 58: 333.

Baile, C.A. and Forbes, J.M. (1974). Control of feed intake and regulation of energy balance in ruminants. Physiol. Rev., 54: 160-214.

Barker, S.B. and Summerson, W.M. (1941). The colorimetric determination of lactic acid in biological materials. J. Biol. Chem., 138: 535-554.

Barton, D. and Saadullah, M. (1987). Draught animal power and nutrition in Bangladesh. Draught Animal News, 7: 16-17.

Benjamin, M.M. (1974). Outline of Veterinary Clinical Pathology. The Iowa State University Press, Iowa, U.S.A., Edn. pp. 56-64.

Coulomb, J. (1982). "Soins Veterinaires Aux Animaux De Trait". Paper presented to FAO expert consultation on appropriate use of animal energy in agriculture in Africa and Asia. Rome, 15-19 Nov. 1982.

Devadattam, D.S.K. and Maurya, N.L. (1978). Draftability of Hariana bullocks. Indian J. Dairy Sci., 31(2): 120-127.

Dinius, D.A. and Baumgardt, B.R. (1970). Regulation of food intake in ruminants. VI. Influence of caloric density of pelleted rations. J. Dairy Sci., 53: 311-316.

FAO (1972). Manual on the Employment of Draught Animals in Agriculture. FAO, Rome.

*Findlay, J.D. (1961). The Eighth Middleton Memorial Lecture, Cattle and Climate. Agric. Prog., 36: 1-15.

*Garcia, L., Rodriguez, U.N. and Martney, J.A. (1978). A comparative study on heat tolerance in Holstein-Friesian and Holstein-Friesian x Zebu F_1 cows. Memoria, Association Latinoamericana de Production Animal, 13: 180-181.

Garg, S.K., Singh, N. and Nangia, O.P. (1981). Effect of exercise on physiological reactions, blood electrolytes and body water distribution in buffalo male calves. Indian J. Dairy Sci., 34(2): 224-225.

Garillo, E.P., Salas, C.G., Neric, S.P., Quines, O.D. and Ranjhan, S.K. (1987). Studies on the draughtability of Swamp buffaloes and its crosses with Murrah (F_1) under wet and dry land tillage operation in the Philippines. Indian J. Anim. Sci., 57(6): 575-580.

*Gattewar, A.B. (1983). Working capacity and behaviour of cross-bred (F_1) vs Zebu cattle. Thesis submitted to the Haryana Agricultural University, Hissar.

Georgie, G.C., Sastry, N.S.R. and Razdan, M.N. (1970). Studies on the work performance by cross-bred cattle. ii. Some physiological and chemical responses of blood. Indian J. Anim. Prod., 1: 115-119.

Goe, M.R. (1983). Current status of research on animal traction. Wld. Anim. Rev., 45: 2-17.

*Goe, M.R. and McDowell, R.E. (1980). "Animal Traction, guidelines for utilization". Cornell International Agriculture Mimium. Ithaca, New York.

Guyton, A.C. (1981). Text book of medical physiology. W.B. Saunders Company, New York, pp. 278-279.

Harmansen, L. and Vaage, O. (1977). Lactate disappearance and glycogen synthesis in human skeletal muscle after exercise in man. Am. J. Physiol., 233: 422-429.

Hawk, P.B., Oser, B.L. and Summerson, W.M. (1954). Practical Physiological Chemistry. McGraw Hill Book Co., New York.

Holmes, C.W., King, C.T. and Sauwa, P.E.L. (1980). Effects of exposure to a hot environment on Friesian and Brahman x Friesian cattle, with some measurements of the effects of exposure to radiant heat. Anim. Prod., 30(1): 1-11.

*Horst, C. Vander and Steenkamp, J.D.G. (1975). Effect of breed and nutrition on the heat tolerance of cattle. Rhodesia Agric. J., 72(3): 81-85.

Howes, J.R., Hentges, J.F. and Daveis, G.K. (1963). Comparative digestive powers of Hereford and Brahman cattle. J. Anim. Sci., 22(1): 22-25.

I.C.A.R. (1977). Hand Book of Animal Husbandry. Indian Council of Agricultural Research, New Delhi, Edn., pp. 11-13.

Ishaq, S.M., Khan, M.A. and Shah, S.K. (1981). Experimental cross-breeding of Sahiwal cows for improved production performance. Pakistan Vet. J., 1(4): 154-160.

*Ingram, D.L. and Mount, L.E. (1975). "Man and animals in hot environments". Springer-Verlag, New York.

Lawrence (1985). The energy cost of pulling loads under various conditions by Brahman cattle and Swamp buffalo. Cited by Pearson, R.A. (1986).

Lawrence and Pearson, R.A. (1985). Factors affecting the measurements of draught force, work output and power of oxen. Journal of Agric. Sci., 105: 703-714.

Lehninger, A.L. (1984). Principles of Biochemistry. CBS Publishers and Distributors, Delhi.

Maurya, N.L. and Devadattam, D.S.K. (1982). Response of some physiological parameters of cross-bred bullocks to different draft and ambient conditions. Indian J. Dairy Sci., 35(1): 18-25.

McDowell, R.E. (1972). Improvement of livestock production in warm climates. Freeman and Company, New York, 27-40.

*Morais, M. and Espirose, J. (1982). Comparative evaluation of heat tolerance tests and of sweating rate in Holstein-Friesian, 3/4 Holstein-Friesian-1/4 Zebu and 5/8 Holstein-Friesian-3/8 Zebu cattle. In Second World Congress on Genetics applied to Livestock Production, 4th-8th October, 1982, Madrid, Spain.

Moran, J.B. (1973). Heat tolerance of Brahman cross, buffalo, Banteng and Shorthorn steers during exposure to sun and as a result of exercise. Aust. J. Agric. Res., 24(5): 775-782.

Moran, J.B., Satoto, K.B. and Dawson, J.E. (1983). The utilization of rice straw fed to Zebu cattle and swamp buffaloes as influenced by alkali treatment and lucerne supplementation. Aust. J. Agric. Res., 34: 73-84.

Mukherjee, D.P., Dutta, S. and Bhattacharya, P. (1961). Studies on the draught capacities of Hariana bullocks. Indian J. Vet. Sci., 31(1): 39-50.

Nagpaul, P.K., Rao, M.V.N., Singh, C.B. and Bhatnagar, D.S. (1984). Draught efficiency of cross-bred vis-a-vis Zebu and buffalo bullocks in India. Wld. Rev. Anim. Prod., 20(3): 52-55.

*Nair, P.N.R. (1973). Evolutionary cross-breeding as a basis for cattle development in Kerala State (India). Thesis presented to the Faculty of Veterinary Medicine, University of Zurich, 17.

Nangia, O.P., Singh, N. and Sukhija, S.S. (1980). Effect of exercise on thermal and acid-base balance in buffaloes. Trop. Anim. Hlth. Prod., 12(3): 185-188.

NRC (1981). Effect of environment on nutrient requirements of domestic animals. National Academic Press, Washington D.C.

Oser, B.L. (1965). Hawk's Physiological Chemistry, 14th Ed. Tata McGraw Hill Publishing Co., New Delhi.

Pearson, A. (1986). Feeding and management of draught animals. A review. Indian J. Anim. Prod. Mgmt., 2(2): 48-69.

Phillips, G.D. (1961). Physiological comparison of European and Zebu steers. 1. Digestibility and retention times and rate of fermentation of rumen contents. Res. Vet. Sci., 2: 202.

Ramaswamy, N. (1983). Draught animal power in the developing countries with specific reference to Asia - Part I. Asian Livestock, 8(5): 36-38.

Rana, R.D., Singh, N., Galhotra, M.M., Nangia, O.P. and Ahmad, A. (1978). Physiological responses to exercise in buffalo males. Indian J. Dairy Sci., 31(4): 338-340.

Rana, R.D., Singh, N., Nangia, O.P. and Ahmad, A. (1977). Effect of exercise on some haematological parameters in buffalo calves. Haryana Agric. Uni. J. Res., 7(4): 237-241.

Rao, M.V.N. (1974). A comparative study of the draught capacity of cross-bred bullocks and indigenous bullocks, Karnal, India. National Dairy Research Institute.

Rao, M.V.N., Raina, V.S., Tomar, O.S., Relwani, L.L. and Sharma, K.N.S. (1974). A comparative study of the draft capacity of cross-bred bullocks. NDRI Annual Report, 1974.

Rao, M.V.N. and Upadhyay, R.C. (1984). Work performance of cross-bred bullocks. Indian vet. J., 61(12): 1050-1053.

Reh, I. (1982). Animal Husbandry and veterinary aspects. In Animal Traction in Africa. Ed. Munzinger, G.T.Z., Eschborn, pp. 67-132.

*Rhoad, A.O. (1944). The Iberia heat-tolerance test for cattle. Trop. Agric. Trin., 21: 162.

Ribeiro, J.M., De, C.R., Brockway, J.M. and Webster, A.J.F. (1977). A note on the energy cost of walking in cattle. Anim. Prod., 15: 107-110.

Roy, S.R., Neogi, A.K. and Guha, H. (1972). Cross-bred bullocks vs indigenous bullocks for draught purposes under West Bengal conditions. Indian Dairyman, 14: 66-70.

Schalm, O.W. (1965). Veterinary haematology, 2nd ed. Lea and Febiger, Philadelphia.

Singh, A.S. and Mishra, M. (1980). Physiological responses and economic traits of Holstein, Jersey cross-bred and Hariana cows in hot and humid environment. Indian J. Dairy Sci., 33(2): 174-181.

Singh, N., Gupta, V.K. and Nangia, O.P. (1980). Blood cellular constituents in relation to work load in buffalo calves. Indian J. Dairy Sci., 33(1): 122-123.

Singh, N., Nangia, O.P. and Dwarakanath, P.K. (1980). Effect of exercise on biochemical constituents of blood in entire, castrated and vasectomised buffalo males. Indian J. Dairy Sci., 33(3): 299-303.

Singh, N., Nangia, O.P., Garg, S.K. and Dwarakanath, P.K. (1982). Draught capacity in male buffaloes - Autonomic and haematological responses in untrained entire, castrated and vasectomised animals. Indian J. Anim. Sci., 52(4): 216-221.

Singh, N., Nangia, O.P., Sukhija, S.S. and Dwarakanath, P.K. (1980). Draught capacity in buffalo males. Part I. Acid-base status in untrained entire, castrated and vasectomised animals. Indian J. Dairy Sci., 33(2): 182-184.

Singh, S.P., Soni, B.K. and Bhattacharya, N.K. (1968). Physiological responses in Hariana bullocks while performing different types of agricultural operations. Indian vet. J., 45(1): 34-40.

Singh, S.P., Soni, B.K. and Bhattacharya, N.K. (1968). Haematological changes evoked by exercise in working bullocks. Indian vet. J., 45(3): 212-216.

Singh, S.P., Soni, B.K. and Mehta, M.M. (1970). Studies on the performance of Sahiwal bullocks during various agricultural operations. Indian vet. J., 47(4): 218-222.

Smith, A.J. (1981). The role of draught animals in agricultural systems in developing countries. In "Vegetable Productivity". Macmilan, London, Ed. Spedding, C.R.W., pp. 247-262.

Snedecor, G.W. and Cochran, W.G. (1967). Statistical Methods. 6th Ed., Oxford & IBH Publishing Company, New Delhi.

Somanathan, V.L. and Rajagopalan, T.G. (1983). Bioclimatological studies on growing livestock. 1. A study of the climatic profile of Mannuthy. Kerala J. Vet. Sci., 14(2): 131-136.

Stott, G.H. and Moody, E.G. (1960). Tolerance of dairy cows to high climatic temperatures on low roughage ration. J. Dairy Sci., 43: 871.

Subrahmanyan, K.V. and Ryan, J.G. (1975). Livestock as a source of power in Indian agriculture - a brief review. International Crops Research Institute for the Semi-Arid Tropics, Hyderabad.

Thomas, C.K. and Acharya, R.M. (1981). Note on the effect of physical environment on milk production in Bos indicus x Bos taurus crosses. Indian J. Anim. Sci., 51(3): 351-356.

Thomas, C.K., Georgie, G.C. and Razdan, M.N. (1969). Studies on the performance of cross-bred dairy cattle. II. Effect of shelter and different environmental conditions on nutrient utilization by Sahiwal x Brown Swiss (F_1) and pure-bred Sahiwal cattle. Indian J. Dairy Sci., 22: 173-180.

Thomas, C.K. and Pearson, R.A. (1986). Effects of ambient temperature and head cooling on energy expenditure, food intake and heat tolerance of Brahman and Brahman x Friesian cattle working on treadmills. Anim. Prod., 43(1): 83-90.

Thomas, C.K. and Razdan, M.N. (1973). Adaptability of 1/2 Sahiwal-1/2 Brown Swiss cattle to sub-tropical conditions. 2. Physiological reactions. Indian J. Anim. Sci., 43(5): 358-363.

Thomas, C.K. and Razdan, M.N. (1974). Adaptability of 1/2 Sahiwal-1/2 Brown Swiss cattle to sub-tropical conditions. 3. Body water distribution. Indian J. Anim. Sci., 44(7): 432-436.

Thompson, G.E. (1973). Review of the progress of dairy science. Climatic physiology of cattle. J. Dairy Res., 40(3):441-473.

Underwood, E.J. (1981). "The mineral nutrition of livestock". 2nd Edn. Commonwealth Agriculture Bureaux, Farnham Royal.

Upadhyay, R.C., Rao, M.V.N. and Gupta, B.N. (1983). Effect of nutrients intake upon the efficiency of work in young cross-bred bullocks. Indian J. Anim. Sci., 53(12): 1335-1337.

Upadhyay, R.C. and Madan, M.L. (1985). Draught performance of Hariana and cross-bred bullocks in different seasons. Indian J. Anim. Sci., 55(1): 50-54.

*Vajrabukka, C. and Thwaites, C.J. (1984). The relative influence of exercise and coat type on the thermoregulatory responses of cattle. International J. Biometeorology, 28(1): 9-15.

Vanslyke, D.D. (1922). Studies of acidosis. XVIII. Determination of the bicarbonate concentration of the blood and plasma. J. Biol. Chem., 52: 495-500.

Williamson, G. and Paynee, W.J.A. (1975). An introduction to animal husbandry in the tropics. 2nd Ed. English Language Book Society, 237-247.

*Yeates, N.T.M. and Partridge, I.J. (1975). A study of heat-tolerance, growth rate and the onset of puberty in Brahman, Santa Gertrudis and Hereford heifers in a humid tropical climate. Fiji Agric. J., 37: 9-16.

* Originals not consulted

ABSTRACT

The draught performance of Bos indicus x Bos taurus cross-bred bullocks was compared with that of bullocks belonging to a South Indian draught breed (Kangayam type) under the agro-climatic conditions of Kerala, with a hot-humid tropical climate.

Two pairs of adult cross-bred bullocks (Jersey x Red Sindhi) and two pairs of adult indigenous bullocks (Kangayam type) were used for ploughing on dry land for 4 hours and 5 hours continuously on alternate days. Physiological responses like respiratory rate, pulse rate and rectal temperature and haematological parameters like haemoglobin per cent, erythrocyte sedimentation rate, packed cell volume, lactic acid and plasma bicarbonate were estimated before work, immediately after work and after 1 hour of rest after work. The dry matter intake and water intake on days of work and on days on which no work was done were measured and compared. In order to evaluate the relative efficiency of work, the average speed of walking and the total area ploughed in 1 hour were compared.

The cross-bred bullocks had significantly higher physiological responses even before the start of work. As a result of work the physiological responses increased significantly and during rest, the values declined but did not reach the pre-exercise values after one hour rest. The haemoglobin per cent of blood, packed cell volume and plasma bicarbonate content decreased significantly and the erythrocyte sedimentation rate and blood lactic acid content showed a significant increase as

a result of work, One hour of rest was not sufficient to bring these parameters to pre-exercise values.

The indigenous bullocks consumed more dry matter per metabolic body size than the cross-breds. However, the total dry matter intake by the indigenous bullocks was less due to smaller body size. It was found that work had no effect on dry matter intake as the dry matter intake of indigenous and cross-bred bullocks on days of work and on days on which no work was done was almost similar. The cross-breds consumed more water per dry matter per metabolic body size on days of work and no work.

The total area ploughed by indigenous bullocks in 1 hour was significantly more than the cross-bred bullocks. Also, the average speed of walking of indigenous bullocks was greater than that of the cross-breds.

The enhanced physiological reactions in the cross-breds even before the work pointed to the fact that they were under some degree of thermal stress due to the hot-humid climate. Exercise (work) increased the stress and widened the gap between the cross-breds and indigenous bullocks. The lower total feed intake and greater speed and more area ploughed per unit time make the indigenous Kangayam type bullocks a more economical animal. Their higher feed intake and lower water intake per unit metabolic size indicates that they can better sustain energy supply to the tissues for work and manage under lower water availability. Coupled with these advantages, their greater heat adaptability make them a superior draught animal.