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Development of an Automatic Data Acquisition System to Study the Work Performance of Buffaloes

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ABSTRACT. *The use of animal power for agricultural activities has been a common practice especially in the developing countries. It is a low cost and environmentally friendly source of power, which is also affordable to a majority of the farming communities in these countries. However, little attention has been paid to optimize the output from draught animals used in farming operations. Even though many studies on the work performance of animals have been done in the past, most of the measurement systems used require improvement. Continuous monitoring of physiological parameters of the animal is expected to provide a clear picture of the physiological condition of the animal at any instance during work. This paper describes the development of instrumentation for the simultaneous measurement of environmental parameters and physiological parameters of working buffaloes.*

Both indigenous and crossbred buffaloes were used separately to drag a cart which was to act as the load to measure the draught power. The body temperature, respiration rate, pulse rate, and the speed of travel of the buffaloes and the environmental temperature and relative humidity were measured during the tests using the developed instrumentation system. A comparative analysis of the work performance will be performed with the data obtained by using the instrumentation system described in this paper.

INTRODUCTION

Various on-farm agricultural operations are accomplished by different power sources such as humans, animals, petroleum oils, electricity and wind. Of these, most important and the common source in the developing countries is animal power. It is estimated that about 70% of the

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energy input in farming comes from animals, 20% from humans and 10% is derived from other forms of energy. Animals are one of the cheapest sources of energy. Fossil fuel is not only becoming more costly day by day, but also limited. Hence, the need to exploit animal energy output and its efficient utilization has become increasingly vital for sustainable agriculture especially in the developing countries (Yadav, 1976).

In order to achieve the efficient use of animals' capacity to work, a thorough knowledge of the magnitude of the load it can pull, how fast and how steadily these animals can provide power under different climatic conditions need to be determined. Furthermore, it is important to study the various physiological factors that affect the working ability of the animal in the search for ways of improving its efficiency. One of the few studies on Sri Lankan draught cattle and buffaloes was by Illangatilake *et al.*, (1982) where a simple mechanism to measure the draught force of animals was developed and tested. The measuring device in this case was a coil spring. One end of it was attached directly to the plough beam and the other end to the yoke of the animal through a solid iron bar with a rigidly fixed pen on it. The pen recorded the extensions of the spring that was proportional to the load during work. The walking speed of the animal was measured by manual methods.

In another study, the draught capabilities of buffaloes were tested under regulated conditions using a loading cart (Seneviratne and Jayasekara, 1991). The force was measured using a load cell. Speed was measured using a counter which was connected to the wheels of a loading cart. The pulse rate, respiration rate, rectal temperature and the skin temperature of the animals were measured during the test.

The sledge, treadmill type and winch type loading systems can be listed as some of the mechanisms used for the measurement of draft power. Many of these had the disadvantage of being different from the actual working activity besides the need to take manual measurements (Pathak, 1985).

The recent developments in the field of transducers and microprocessors make it possible to perform very sophisticated measurements at speeds that can never be achieved by manual techniques. Continuous monitoring of physiological parameters of the animal will provide a clear picture of the physiological condition of the animal at any instance during work. The parameters measured (sampled) at a pre-determined frequency will be sufficient to reconstruct the actual variation. The objective of this part of the research was the development of instrumentation for the simultaneous measurement of environmental parameters and physiological parameters of working buffaloes to be used to quantify the differences in work performance of indigenous buffaloes and their crosses.

MATERIALS AND METHODS

Both indigenous and Surti x local crossbred buffaloes were used for the experiment. This paper describes the instruments that were used in the measurement of various parameters during the study. The method of operation of all the transducers used in the experiment, installation methodology, and the ranges of output of the sensors are given.

Load measuring device

The load pulled by the buffalo was measured using a load cell (B.L.H Electronics type U3G1, no. 06945) which was fixed onto a loading cart using a special frame designed for the purpose (Figure 1). The device consisted of four strain gauges arranged as a Whetstone bridge circuit. When a tension or a compression was applied to the load cell, the resistance changed accordingly. By supplying a constant excitation voltage, the resistance variation could be converted to a voltage variation which was in turn measured as a function of the load.

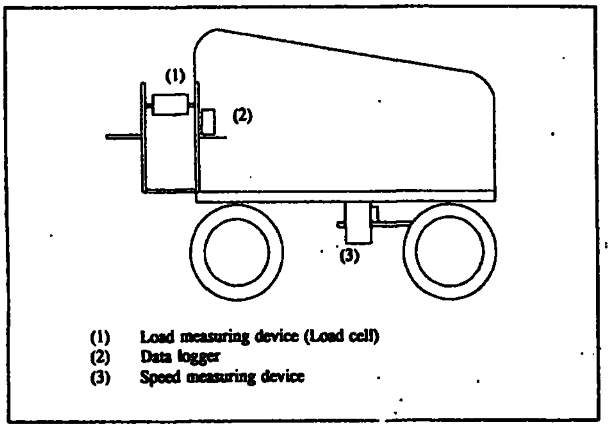

Figure 1. Sketch of the loading cart.

Speed measuring device

This instrument was also fixed to the cart. It consisted of a wheel connected perpendicular to the main axle of the rear wheels of the cart (Figure 1). A cam fixed along with the device activated a mechanical switch once for the revolution of the wheel. The switching action thus generated was monitored by the recording device and could be used to estimate the speed of travel of the cart.

Temperature measuring instruments

(a) Environmental temperature:

In order to study the effect of environmental temperature and relative humidity (RH) on the activity of the animal, wet and dry bulb temperature measurements were made.

(b) Internal body temperature:

A temperature transducer was used to measure the internal body temperature of the animal, while pulling the loading cart. The sensor used for all temperature measurements was an Integrated Circuit (IC) type temperature transducer that produced 10 mV/°C linear voltage output (Fonest, 1979).

Respiration rate measuring equipment

The respiration rate was measured by means of a respiration sound recording unit. This system consisted of an audio cassette recorder, a condenser microphone and an audio amplifier. The microphone was directed to the nose of the animal. An audio amplifier (LA 4100) was used to amplify the signal. This sound was recorded on audio tape. When played back, the respiration rate could be counted manually by listening to the breathing sound.

Methods of measurements

Test site

Experiments were carried out at the university farm, Peradeniya. The test site is situated in the mid country wet zone at an elevation of 1500 ft. Relative humidity was 60 - 80% and the ambient temperature was 25°C. Farm yard road was selected for carting with the objective of achieving close-to-normal field conditions.

Duration of tests

The trials were conducted on three consecutive days for one animal. Each buffaloe was trained for one or two days before testing. No special feed was given during the testing period. Every trial was carried out at the same time of the day to improve the compatibility of the data.

Sampling rates

Draught and speed were recorded at five second intervals. Speed was counted as a cumulative value of the counts collected during a five second time period. Temperature measurements were taken at each minute. Respiration rate was taken at 2 min intervals. Pulse rate was measured manually after every run of the day. Weight was measured before testing the animal. One test consisted of three runs in a day. Duration of a run was 20 min and a resting time of 15 - 20 min was given to the animal to simulate actual field conditions under which farmers use them.

RESULTS AND DISCUSSION

The variations shown in graphical form (Figures 2, 3 and 4) are based on the values computed directly from raw data. These must be processed further to obtain useful information such as the average or maximum work done per unit time, total work done, power, average or maximum speed, and other physiological parameters. It is anticipated that this data can be used in comparing the breeds, types of buffaloes (light, medium, heavy), different ages, and weights with regard to their work performance.

Figure 2 shows the force variation with time.

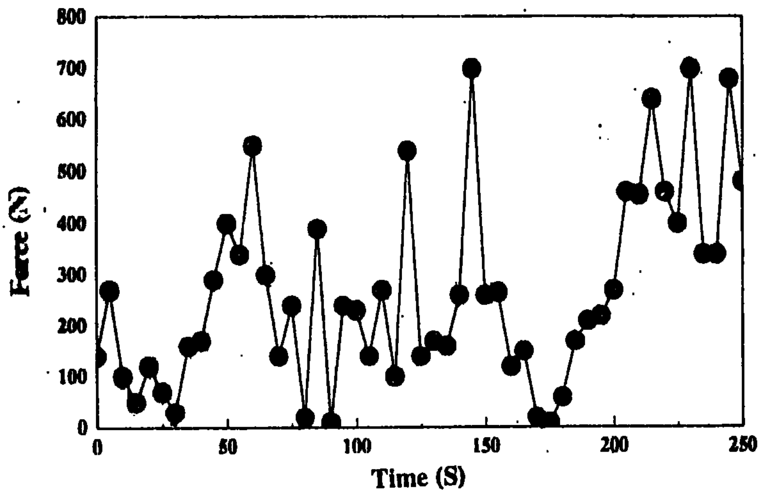

Figure 2. Force variation with time.

The calibration equation obtained by linear regression was,

$$F = (88.2V - 55.3) / 2.2 + 9.81$$

where, F = Force in Newtons; V = Voltage output in millivolts.

The output of the speed sensor was 2.1 pulses per meter. The calibration equation was,

$$D = P/2.1$$

where, D = distance in meters; P = number of pulses.

Speed was calculated as the distance travelled in five seconds. The equation for the speed conversion was,

$$S = 0.72 * D.$$

where, S = speed km/h; D = distance travelled in meters.

Figure 3 shows a sample of the speed variation with time.

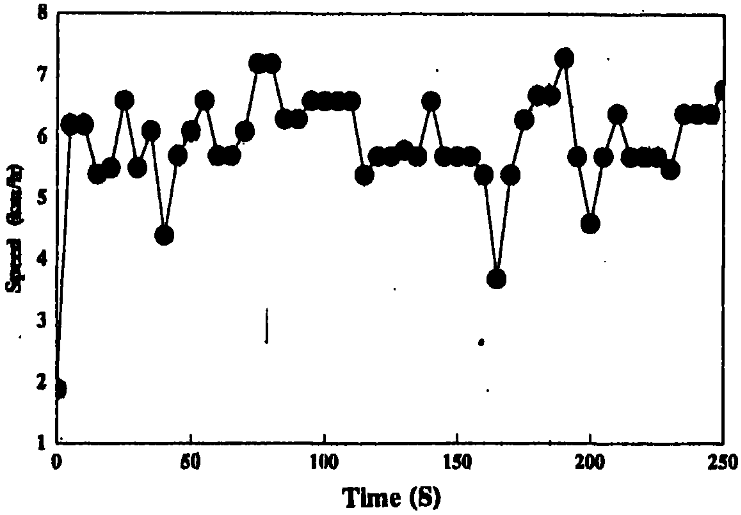

Figure 3. Speed variation with time.

Body temperature and ambient temperature were estimated using the below given formulae which were based on the relationship between temperature and voltage output.

Body temperature: $T_b = 65.4 - 0.116\ V_1$
Wet bulb temperature: $T_w = 70.8 - 0.118\ V_2$
Dry bulb temperature: $T_d = 76.3 - .120 V_3$.

where, $T_{b,w,d}$ = Temperature in °C,
$V_{1,2,3}$ = Output in millivolts.

Figure 4 shows the variation of temperature with time.

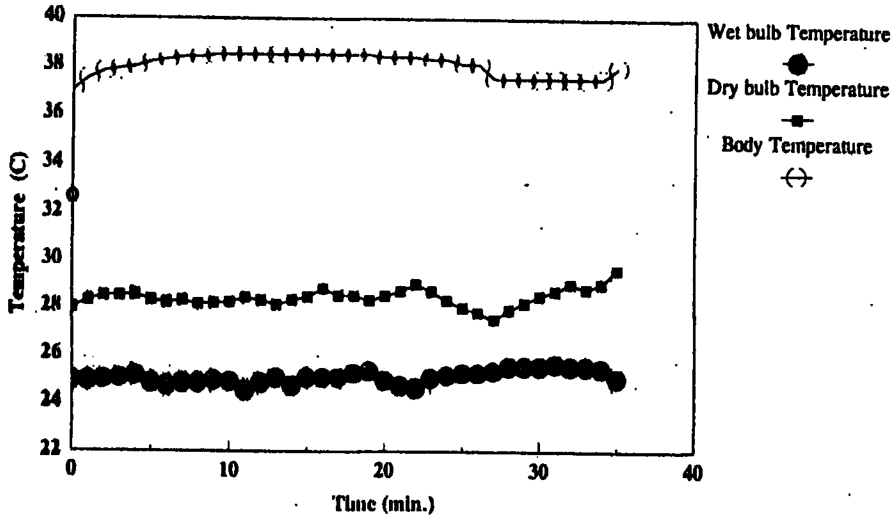

Figure 4. Temperature variation with time.

In this experiment, pulling the cart was done on a road which was not a common working condition for the Sri Lankan buffalo. The effect of working in a watery environment on physiological factors has been found to be different because of better heat dissipation. When the animal works outside a muddy field, the surrounding environment which is dryer than that of a muddy field causes the body temperature to increase, thus reducing its working ability (Devadattam and Mayura, 1978).

The temperature sensor that was installed in the rectum, was thrown away when the animal excreted. The wire that connects the sensor to the data logger was damaged several times during trials due to the movement of the animal. Therefore, it is suggested that a wireless data transmission system be introduced to overcome the problem.

Several attempts were made to design a sensor to detect the heart rate. But those were not sensitive enough or were not capable of separating heart sounds from external noise thus preventing their integration to the automated data acquisition system. The manual method of detecting the pulse rate was identified to be the only reliable technique.

The respiration sound recorded was accompanied by outside noises causing difficulties in extracting the respiration rate. Modifications or introduction of a different technique is suggested.

Most of the land preparation activities in Sri Lanka are done by pairs of buffaloes. But in this experiment, only a single animal was used. This may have excited the animal, easily causing errors. This research should be further extended to develop instrumentation to measure the work performance of pairs of buffaloes.

The instrumentation system developed for this study worked successfully making it possible to measure and record several parameters at different sampling rates. It is expected that this setup will be useful for future research in which the automatic measurement of physiological parameters of animals is required.

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