# EFFECTS OF DIFFERENT COOLING TECHNIQUES ON DRAUGHT CAPACITY OF BUFFALO

P. Bunyavejchewin[1], K. Kaewsomprasong, S. Chotemethepirom[2], B. Tanta-ngai, A. Tajima[3] and T. Chikamune[3]

Buffalo and Beef Production Research and Development Center, Kasetsart University, P.O. Box 1014, Kasetsart P.O., Bangkok 10903, Thailand

## Summary

Four male swamp buffaloes weighing 460.5 ± 44.6 kg were used to study the effects of different cooling techniques on draught capacity. Each animal carted an 882 kg load on the same asphalt road for one hour during four different time periods: 9:00-10:00 A.M., 10:30-11:30 A.M., 2:00-3:00 P.M. and 3:30-4:30 P.M. Simultaneously, all animals were subjected to five different treatments on five days of similar environmental conditions. In Treatment 1, animals were put stationary in a field and did no work; in Treatment 2, animals were worked without any cooling method; in Treatment 3, fifteen-minute wallow was allowed to animals prior to working; in Treatment 4, animals were covered with wetted jute bags while working, and in Treatment 5, two buckets of water were poured over the buffaloes' trunks just prior to working. The experiment was conducted from April to July 1989, when the weather was very hot. It was found that cooling methods and working times did not affect the draught efficiency of buffaloes during the one hour, but did affect physiological traits. The work load had a larger partial effect on physiological responses of buffalo other than respiration rate than did climatic variables except on the respiration rate of the buffaloes. One cooling technique that seemed to slow the increase of body temperature while working was covering the buffalo's back with wetted jute bags. Animals working at different times had significant differences in the increase of physiological traits except pulse rate.

**(Key Words**: Swamp Buffalo, Cooling Techniques, Draught Capacity, Physiological Traits)

## Introduction

Farmers in rural Thailand have long utilized draught buffalo as the major source of power and they are likely to have economic importance for years to come. However, there are constrains on the use of the buffalo for work. One is that heat stress always develops, when the buffalo are worked in the heat of the day. Therefore, farmers have traditionally limited their use of buffaloes to the early morning or late afternoon. While recognizing that heatstress reduces the capacity of buffaloes to work, this study sought to determine how buffaloes might work most efficiently in the heat of the day.

## Materials and Methods

Four male swamp buffaloes with the age over four years weighing 460.5 ± 44.0 kg were used in this study. Each animal pulled a 280 kg pneumatic wheeled cart with a constant load of 602 kg on the same asphalt road for one hour during each of four different time periods: – 9:00 10:00 AM; 10:30-11:30 AM; 2:00-3:00 PM and 3:30-4:30 PM –. Also each animal was subjected to five different treatments on five days of similar environmental conditions: Treatment 1, animals stationary in a field without working; Treatment 2, animals worked without any cooling method; Treatment 3, a fifteen-minute wallow was allowed to animals prior to working; Treatment 4, the backs of the animals were covered with wetted jute bags with the size of 75 cm × 105 cm while working; and Treatment 5, two buckets of water were poured over the buffaloes'

[1]Address reprint requests to Mrs. P. Bunyavejchewin, Buffalo and Beef Production Research and Development Center, Kasetsart University, P.O. Box 1014, Kasetsart P.O., Bangkok 10903, Thailand.

[2]Department of Animal Science, Kasetsart University, Bangkok 10903, Thailand.

[3]Institute of Agriculture and Forestry, University of Tsukuba, Ibaraki 305, Japan.

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trunks just prior to working. Normally, these animals were grazed along an unimproved para grass pasture during the day. They were driven back to their barn in the evening where rice straw and/or hay, mineral lice and water were available. The experiment was conducted from April to July 1989, when the weather was very hot. The environmental data in terms of solar radiation, ambient temperature, and relative humidity were collected during the study period.

Physiological traits recorded as criteria for comparing the responses of buffaloes receiving different treatments were pulse rate, respiration rate, rectal temperature and skin temperature. Pulse was measured as pulses per minute as sensed at the base of the tail and the respirations per minute were recorded by observing flank movements. Rectal temperature was measured by inserting a probe of thermister into the rectum, while skin temperature was measured by touching the tip of the thermister probe to the skin on the back of the animals (figure 1). These measurements were taken before and after one hour's work.

Draught force (D), speed of carting (V), and tractive horsepower were used to determine for draught capacity of the buffaloes. D was calculated from pull force (P), which was measured with a spring dynamometer, using the equation:

$D = P \cos \theta$; where $\theta$ was the angle of line of pull from the horizontal. Tractive horsepower was calculated using the equation given by Goe and McDowell (1980):

$$\text{Tractive hp} = \frac{D(\text{kg}) \times V\ (\text{km/hr})}{270}$$

All data were subjected to analysis of variance, and treatment means were tested for differences by Duncan's New Multiple Range Test (Chantalakhana, 1980).

## Results

Statistical analysis revealed significant differences in physiological traits but not draught capacity of buffaloes receiving different cooling treatments and at different times of the day. Environmental parameters: solar radiation, ambient temperature, and relative humidity, for each time period are shown in tables treatment and each 1 and 2 respectively.

### Draught Capacity

#### Influence of Treatments

Table 1 shows that buffaloes covered with wetted jute bags generated less draught force (24.54 kg) than those receiving other treatments. The highest force was produced by buffaloes worked without any cooling method (26.16 kg). The speed of carting was lowest in the group doused with two buckets of water prior to working (3.34 km/hr), followed by those receiving Treatments 4, 2, and 3 (3.43, 3.46, and 3.47 km/hr). When the power of the animals was

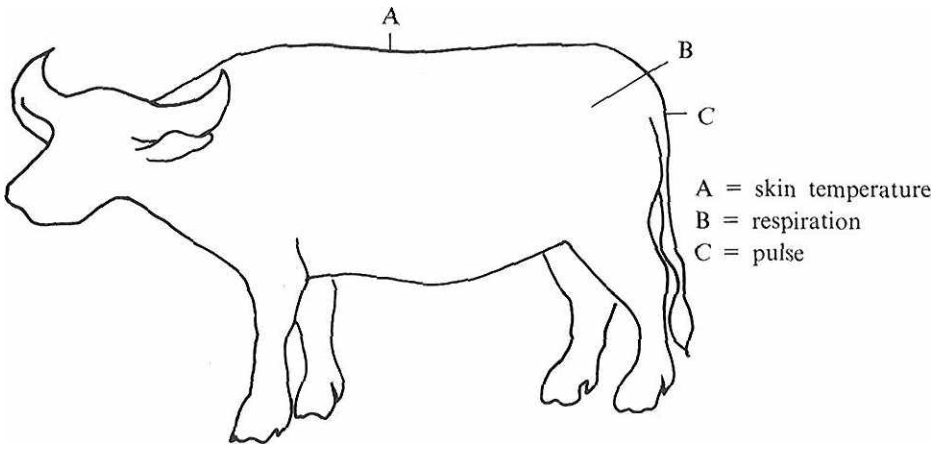


Figure 1. Sites at which physiological traits were measured.

TABLE 1. THE EFFECT OF TREATMENTS ON PHYSIOLOGICAL TRAITS AND DRAUGHT CAPACITY OF BUFFALOES

| Trait | Treatment | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 |
| Number of buffaloes: | 16 | 16 | 16 | 16 | 16 |
| Environmental parameters: | | | | | |
| Solar radiation ($W/m^2$) | 567 | 579 | 566 | 546 | 520 |
| Ambient temperature (℃) | 35 | 35 | 35 | 35 | 35 |
| Relative humidity (%) | 63 | 60 | 61 | 63 | 63 |
| Draught parameters: | | | | | |
| Draught force (kg) | – | 26.16 | 24.76 | 24.54 | 25.97 |
| Speed (km/hr) | – | 3.46 | 3.47 | 3.43 | 3.34 |
| Tractive hp | | 0.33 | 0.31 | 0.31 | 0.31 |
| Physiological parameters: | NW | (..... W .....) | | | |
| Pulse rate (per min) | | | | | |
| initial | 49.75 | 50.75 | 49.50 | 51.75 | 50.87 |
| final | $26.16^{a}$ | $78.18^{b}$ | $71.50^{b}$ | $74.62^{b}$ | $76.68^{b}$ |
| difference | $4.37^{a}$ | $27.43^{b}$ | $22.00^{b}$ | $22.87^{b}$ | $25.81^{b}$ |
| Rectal temperature (℃) | | | | | |
| initial | $39.05^{a}$ | $38.19^{bc}$ | $37.91^{c}$ | $38.59^{ab}$ | $38.42^{b}$ |
| final | 39.75 | 40.04 | 39.74 | 39.96 | 40.14 |
| difference | $0.70^{a}$ | $1.85^{b}$ | $1.83^{b}$ | $1.37^{c}$ | $1.72^{b}$ |
| Skin temperature (℃) | | | | | |
| initial | $40.13^{a}$ | $35.93^{b}$ | $32.87^{c}$ | $34.03^{d}$ | $34.86^{d}$ |
| final | $41.36^{a}$ | $40.70^{ab}$ | $40.00^{b}$ | $38.76^{c}$ | $40.00^{b}$ |
| difference | $1.23^{a}$ | $4.77^{b}$ | $7.13^{c}$ | $4.73^{b}$ | $5.14^{b}$ |
| Respiration rate (per min) | | | | | |
| inital | $22.56^{ab}$ | $23.50^{ab}$ | $21.13^{b}$ | $24.31^{a}$ | $21.13^{b}$ |
| final | $65.87^{a}$ | $96.87^{b}$ | $86.00^{b}$ | $89.31^{b}$ | $96.50^{b}$ |
| difference | $43.31^{a}$ | $73.37^{b}$ | $64.87^{b}$ | $65.00^{b}$ | $75.37^{b}$ |

$^{abcd}$ Mean on the same row under the same parameter with different superscripts are significantly different ($p < 0.05$).

NW = no work, W = work

calculated in terms of tractive horsepower, it was revealed that buffaloes worked without any cooling method generated much more power than other groups. However, the differences among the values for buffaloes receiving different treatments was not statistically significant

**Influence of time periods**

The buffaloes were scheduled to work for one hour at four different time periods: 9:00-10:00 A.M. (Period 1), 10:30-11:30 A.M. (Period 2), 2:00-3:00 P.M. (Period 3), and 3:30-4:30 P.M. (Period 4). The draught parameters of buffaloes did not differ significantly among the four time periods (table 2). However, the buffaloes which worked in Period 2 generated the highest draught force (27.51 kg), but at the lowest carting speed (3.34 km/hr), followed by those worked in Period 4 (25.31 kg), Period 1 (24.45 kg), and Period 3 (24.17 kg), with carting speeds of 3.45, 3.52, and 3.39 km/kr, respectively. The tractive horsepower of the buffaloes in Period 2 was higher than that of the others.

**Physiological Traits**

**Influence of treatments**

The pulse rate, respiration rate, rectal temperature and skin temperature (table 1) of non working buffaloes increased less than those of

TABLE 2. THE EFFECT OF TIME PERIODS ON PHYSIOLOGICAL TRAITS AND DRAUGHT CAPACITY OF BUFFALOES

| Trait | Periods | | | |
|---|---|---|---|---|
| | 1 | 2 | 3 | 4 |
| Number of buffaloes: | 20 | 20 | 20 | 20 |
| Environmental parameters: | | | | |
| Solar radiation ($W/m^2$) | 519 | 731 | 621 | 354 |
| Ambient temperature (℃) | 33 | 35 | 37 | 36 |
| Relative humidity (%) | 65 | 66 | 58 | 58 |
| Draught parameters: | | | | |
| Draught force (kg) | 24.45 | 27.51 | 24.17 | 25.31 |
| Speed (km/hr) | 3.52 | 3.34 | 3.39 | 3.45 |
| Tractive hp | 0.32 | 0.33 | 0.30 | 0.32 |
| Physiological parameters: | | | | |
| Pulse rate (per min) | | | | |
| initial | 48.25$^{a}$ | 50.05$^{ab}$ | 51.20$^{b}$ | 52.60$^{b}$ |
| final | 67.95$^{a}$ | 70.85$^{ab}$ | 74.75$^{b}$ | 70.55$^{ab}$ |
| difference | 19.70 | 20.80 | 23.55 | 17.95 |
| Rectal temperature (℃) | | | | |
| initial | 38.17$^{a}$ | 38.10$^{a}$ | 38.72$^{b}$ | 38.74$^{b}$ |
| final | 39.68$^{a}$ | 39.78$^{ab}$ | 40.22$^{b}$ | 40.03$^{ab}$ |
| difference | 1.51$^{ab}$ | 1.68$^{a}$ | 1.50$^{ab}$ | 1.29$^{b}$ |
| Skin temperature (℃) | | | | |
| initial | 34.89$^{a}$ | 35.62$^{ab}$ | 35.77$^{ab}$ | 35.99$^{b}$ |
| final | 40.24$^{a}$ | 41.37$^{b}$ | 40.70$^{ab}$ | 38.36$^{c}$ |
| difference | 5.35$^{a}$ | 5.75$^{a}$ | 4.93$^{a}$ | 2.37$^{b}$ |
| Respiration rate (per min) | | | | |
| initial | 21.10 | 21.00 | 23.70 | 24.30 |
| final | 70.95$^{a}$ | 88.00$^{b}$ | 104.40$^{c}$ | 84.30$^{b}$ |
| difference | 49.85$^{a}$ | 67.00$^{b}$ | 80.70$^{c}$ | 60.00$^{ab}$ |

$^{abc}$ Mean on the same row under the same parameter with different superscripts are significantly different ($p < 0.05$).

working buffaloes ($p < 0.05$). Buffaloes receiving a fifteen minute wallow prior to working (Treatment 3) and the group covered with wetted jute bags (Treatment 4), tended to have a lower increase of pulse rate and respiration rate than those doused with water prior to working (Treatment 5) and those receiving no cooling method (Treatment 2), although the differences were not statistically significant. The increase of rectal temperature was lowest ($p < 0.05$) in buffaloes wetted with bags. The skin temperature of buffaloes allowed to wallow increased significantly more than the other working groups. Physiological traits measured before work of buffalo receiving Treatment 3 were lower than those receiving other treatments, but the differences were significant only for rectal and skin temperatures.

### Influence of time periods

Except for pulse rate physiological parameters of buffaloes were affected by working during different time periods. The highest were recorded during the middle of the day withrespiration rate reaching 80.7 in period 3 and rectal and skin temperatures 1.67℃ and 5.75℃, respectively, during Period 2.

### Variation of physiological traits

The relationships between physiological response and environment were calculated by means

of multiple regresssion equations:

$\Delta$ Pulse rate = $-57.28 + 0.62SR + 1.38AT + 0.47RH$ ($R^2$=0.30)

$\Delta$ Skin temperature = $2.80 + 7.21SR - 0.18AT + 0.06RH$ ($R^2$=0.74)

$\Delta$ Rectal temperature = $-0.90 + 0.55SR + 0.03AT + 0.02RH$ ($R^2$=0.21)

$\Delta$ Respiration rate = $-96.13 + 48.66SR + 5.21AT - 0.79RH$ ($R^2$=0.39)

where $\Delta$ is the increase in physiological traits,

SR is the solar radiation,

AT is the ambient temperature,

RH is the relative humidity, and

$R^2$ is the coefficient of determination of the equation.

The multiple regression equations reveal that solar radiation had a marked effect ($p < 0.05$) on the increase in skin temperature of buffaloes and that ambient temperature had a similar effect on the change in respiration rate.

## Discussion

The work efficiency of buffaloes drawing a laden pneumatic wheeled cart remained steady for one hour under strong sunlight without the use of any cooling technique. While cooling methods may be effective for buffaloes which work for longer periods, the work period in this experiment was not prolonged because of the risk to the animals. The reason is that if the animals considerably increase their respirations or the other words they are panting, they can suddenly die without any help. With the load used, buffaloes generated a force of about 5 percent of their body weight, or about half of their limitation (Goe and McDowell, 1980). The draught efficiency of the buffaloes did not appear to be affected by the time of day over the range studied (9 AM to 4:30 PM). These findings are similar to those reported by Bunyavejchewin et al. (1985a, 1985b), although the draught parameters were measured in terms of relative values.

It is obvious that the increases in all physiological traits of working buffaloes were higher than those of non-working buffaloes ($p < 0.05$). In contrast to the observations of Upadhyay and Rao (1985), in this study physiological responses of working buffaloes were less affected by climatic variables than work load except in the case of respiration rate. The ratios of the effects of climatic variables and work load on pulse rate, rectal temperature, skin temperature and respiration rate were 1:5.2, 1:1.6, 1:2.9 and 1:0.7, respectively. Regardless of the work load, the change in each trait was mainly dependent on different climatic variables. Solar radiation influenced buffalo skin temperature, while ambient temperature was the major factor affecting respiration rate. Pietersen and Ffoulkes (1988), who studied thermoregulatory responses of working buffaloes, reported that respiration rate and rectal temperature were positively related to ($p < 0.05$) ambient temperature, but respiration was negatively related ($p < 0.05$) to relative humidity. There was no significant relationship between any thermoregulatory indices and solar radiation.

Both cooling techniques and time of day directly affected physiological responses of working buffaloes. Fifteen minute wallows prior to working seemed to lower changes in physiological traits, with significant differences in rectal temperature and skin temperature. The significant increase of skin temperature of this group was due to the lower initial temperature; the final temperature was not different from the other groups. De Los Santos and Momongan (1988) found that the provision of wallows before working significantly lowered initial and final respiration rate and body temperature but had no effect on pulse rate. The other cooling technique in this experiment which slowed down the rate of increase in body temperature of buffaloes was covering the backs of the buffaloes with wetted jute bags. Similarly, Pietersen and Ffoulkes (1988) reported that the increase of thermoregulatory responses of buffaloes covered by wet sacking were significantly lower than that of buffaloes left uncovered. Also, Chikamune and Shimizu (1985) found that covering the trunks of buffaloes with white cloth was an effective method to protect the buffalo against the effect of solar radiation.

Changes in physiological traits, except pulse rates, were lower during 3:30-4:30 PM work period, however, measurements were not taken in the very early morning or late in the afternoon because the information from previous studies (Bunyavejchewin, 1985a, 1985b) showed that those times were suitable times for buffaloes to work. If farmers have extra work, the results of this study suggest that they can use their buffalo by giving the similar work load to this study under

summer environmental conditions for one hour with the safe range in physiological changes and without any decline in draught capacity.

## Conclusions

It can be concluded that cooling methods and changing times of working did not affect the draught efficiency of buffaloes although there was an effect within one hour on physiological traits. Work load had a larger effect than climatic variables on these physiological responses, except in the case of respiration rate.

One cooling technique that appeared to slow down the increase of body temperature was the covering of the buffalo's back with wetted jute bags. In addition to working in the early morning or late afternoon on hot summer days, farmers may use their buffaloes for one hour during the middle of the day without great effect on their physiological responses.

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