

## PROVISION OF DESIGNATED DEFECATION AREAS TO REDUCE THE SPATIAL DISTRIBUTION OF FAECES BY GRAZING SWAMP BUFFALO HEIFERS

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### ABSTRACT

Feral swamp buffaloes adopt discrete areas for grazing, defecation and sleeping. In contrast, domesticated buffaloes stocked within enclosed paddocks usually defecate over the whole area and, because they avoid grazing near dung pats, the area over which they graze is reduced and the sustainability of the sward may be compromised. The aim of this experiment was to examine whether the total area over which faeces are distributed in a small paddock can be reduced by offering a 'designated faecal area' for defecation. Four groups of three 2-year-old swamp buffalo heifers were each subjected to four treatments, during four periods in a 4x4 Latin square design experiment. The treatments provided a pasture which included either a designated faecal area and wallow (DW), only a designated faecal area (D), only a wallow (W), or neither a designated faecal area nor a wallow (N). Buffalo behaviour was scan sampled at 1 minute intervals over a 24 h period. All defecations were surveyed and mapped using the ArcView program. The results show that there was no treatment effect on time spent grazing, ruminating or idling ( $P>0.05$ ). Buffalo heifers averaged five defecations per day, each having a mean weight of 0.27 kg dry matter and covering a mean area of 0.14 square meters. Providing a wallow (treatments DW and W) had little effect

of concentrating defecations within a smaller area, with less than 20% of defecations occurring within a 10-metre radius of the wallow. In contrast when a designated faecal area was provided (treatments DW and D) more than 80% of all defecations occurred within a 10-metre radius of that area. On treatment N defecations were widely spread across the paddock. Results indicate that providing a designated faecal area can reduce the area over which faeces are distributed by grazing swamp buffaloes.

**Keywords:** swamp buffalo, defecation, wallowing, grazing behaviour

### INTRODUCTION

Gastrointestinal parasitic infestations are one of the major causes of loss in buffalo production. More than 90% of swamp buffalo production systems in Thailand can be classified as occurring on smallholdings or small farms in which they are an integral part of crop production systems. In addition, buffaloes are frequently allowed to graze communal grasslands. It is most likely that communal grazing by ruminants at high stock densities is more conducive to the development and transmission of various gastrointestinal

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parasites, and the incidence of mortality because of internal parasites is particularly high (30-40%) in buffalo calves (Jittapalpong *et al.*, 1993). In northern Australia, free-ranging buffaloes move over very limited areas or home ranges. Within these areas they instinctively select fixed places which they visit regularly, including drinking points, feeding grounds, wallows, camping areas and certain trees on which they rub their bodies. They also have defined faecal voiding areas or dung heaps (Tulloch, 1969), which may act to reduce the chances of helminth infection (Bryan *et al.*, 1976). However, it is likely that selective defecation in swamp buffaloes depends on paddock size. A previous study of swamp buffalo heifers by Somparn *et al.* (2008) showed that if paddocks are too small (i.e. less than 0.64 ha), the distribution of defecations is widely spread across the paddock. This may have been because the buffalo heifers cannot allocate paddock efficiently. The objective of the present experiment was to examine whether the area over which faeces are distributed can be reduced by providing a designated area for defecation.

## MATERIALS AND METHODS

### Study area and period

The experiment was carried out at the Surin Livestock Research and Breeding Center, Surin Province (lat. 14° 45' N and long. 103° 26' E, alt. 146 m), between 7 November 2008 and 1 January 2009. The study was conducted over two periods. Period I was between 7 November 2008 and 4 December 2008 and Period II was between 5 December 2008 and 1 January 2009.

### Herbage, animals, experimental design and management

A uniform stand of ruzi grass (*Brachiaria ruziziensis*), established in July 2008, was used during the experiment. The field was divided into eight paddocks of 0.48 ha using barbed wire. The herbage was cut two months prior to the start of the experiment. No fertilizer or irrigation was applied during the experiment. Each paddock contained a few large trees and fresh water, to which the heifers had free access throughout the experiment.

Twelve 2-year-old swamp buffalo heifers were randomized to four groups of three heifers each, two weeks before the start of experiment in order to allow them to form socially stable groups and collect to their faeces. The average live weight at the start of the experiment was  $358. \pm 17.3$  kg.

The experiment was a 4 x 4 Latin square design with two replicates (Periods) in time, providing four treatments and a total of eight sub-periods. Each group of three heifers was considered as an experimental unit. Each sub-period lasted 7 days. Groups were randomly allocated to paddocks within 4 x 4 designs. The treatments tested, provided a paddock which included either a faecal area and wallow (DW), only a designated faecal area (D), only a wallow (W), or neither a designated faecal area nor wallow (N) (Table 1). During Periods I and II, groups of heifers were randomly assigned to one of the treatment paddocks (Figures 1 and 2, respectively), where they were stocked continuously for 6 days. In paddocks where there was a designated faecal area and/or wallow, heifers had free access throughout the sub-period. Each sub-period, heifers were allowed to graze for six consecutive days and on day 7 the animals were removed to another paddock. As soon as animals were removed from a paddock, all faeces were collected and removed, except those

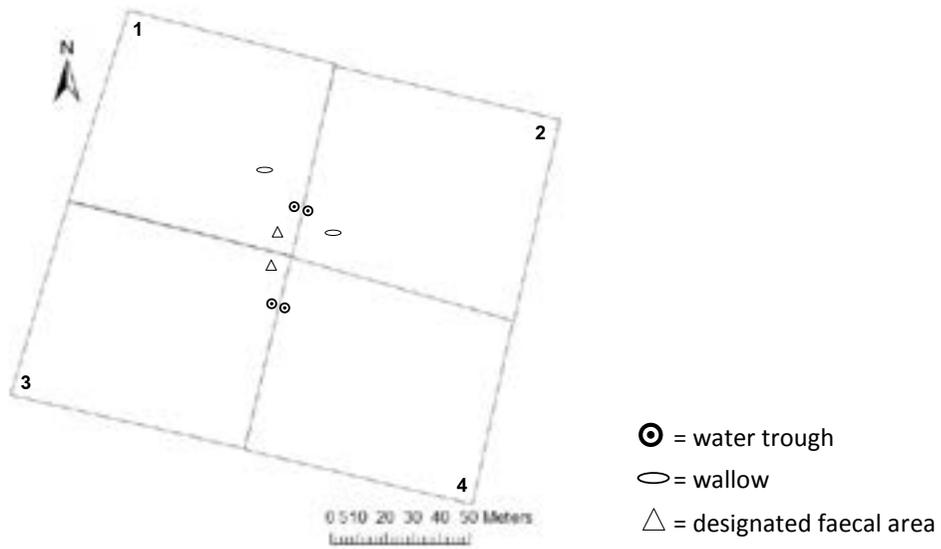


Figure 1. Layout of grazing paddocks during sub-periods 1-4, providing (1) a designated faecal area and a wallow, (2) a wallow only, (3) a designated faecal area only and (4) neither a designated faecal area nor wallow.

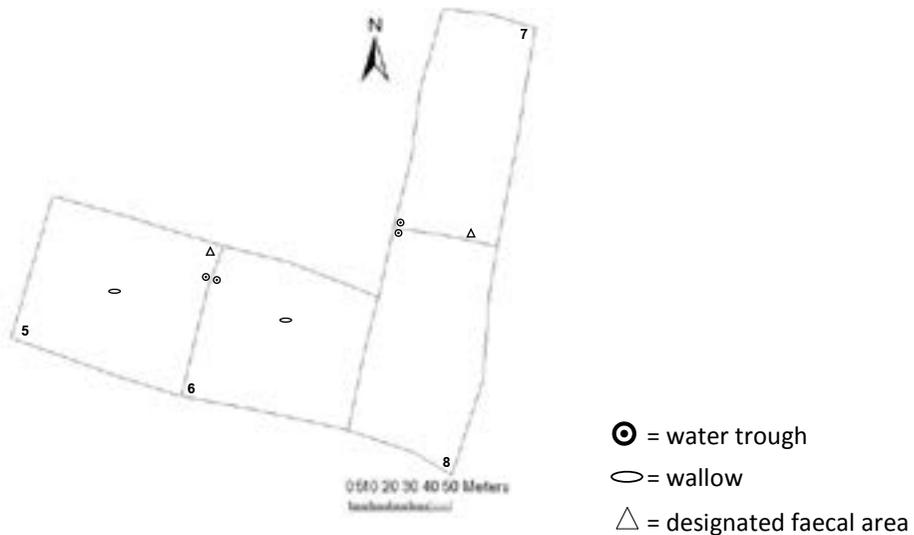


Figure 2. Layout of grazing paddocks during sub-periods 5-8, which providing (5) a designated faecal area and a wallow, (6) a wallow only, (7) a designated faecal area only and (8) neither a designated faecal area nor wallow.

deposited on designated faecal areas and wallows. The designated faecal areas measured 2 m x 2 m and were created by spreading approximately one cubic meter of faeces, which had been collected before the start of experiment, over the area. The wallows were approximately 4 m<sup>2</sup> and approximately 30 centimetres deep, and were maintained daily by adding sufficient water. The heifers were weighed at the beginning and the end of experiment following an overnight fast.

### **Behaviour observations**

Visual observations of behaviour were recorded over 24-hours, once during each sub-period. The group was observed at 1 minute intervals to determine whether each animal was grazing, lying, standing, ruminating, wallowing and defecating. All heifers were fitted with a coloured neck band and a reflective sticker on their horns to aid identification. At night, identification was assisted by use of a small 3 V hand torch and night vision monocular (Model PYGMY 2M, Newcon<sup>®</sup> Optik, Canada).

### **Weight, area coverage and location of faeces**

Every faecal deposit from each heifer was marked with a white flag. Two or three faecal deposits by each animal in each sub-period were weighed and the covered ground area was measured. When more than one dung pat was produced during a defecation, their total weight was measured. Weighed faeces were returned to their original place of defecation, after taking a small sample (10-15 g fresh weight) for determination of dry matter (DM) content. The DM content of the faeces sample was measured by oven-drying at 100°C.

On day 7 of each sub-period, every faecal

deposit was surveyed using the Garmin Etrex Legend GPS receiver, for which the accuracy of locations is considered to be <3 m. Maps were developed using ArcGIS software (ESRI, 2004). Arcs radiating out either from designated faecal area or wallow were drawn in 10 m increments.

### **Meteorological data**

Meteorological data including ambient and dew-point temperatures were recorded at 30 minutes intervals using a data logger (Oneset Computer Corporation, USA). Daily rainfall was collected from Surin meteorological station situated 15 km from the study area. The temperature-humidity index (THI) was calculated using the equation for livestock, dimensionless statistic defined as:

$$THI = T_{db} + 0.36 \times T_{dp} + 41.2$$

where  $T_{db}$  is the dry bulb temperature in degrees Celsius and  $T_{dp}$  is the dew-point temperature in degrees Celsius (Yousef, 1985)

### **Herbage mass and sward height**

The paddocks were sampled to determine herbage mass (DM kg ha<sup>-1</sup>) at the beginning of Periods I and II. Herbage was cut at ground level in ten random places 0.25 m x 0.25 m quadrats in each paddock. The herbage samples were dried to constant weight at 70°C in an oven and ground to pass through a 1 mm mesh sieve before laboratory analysis. In addition, thirty sward height readings were also made at random in each paddock, using a simple disc meter (Sharrow, 1984).

### **Laboratory Analysis**

Samples of herbage were analyzed for nitrogen content by the Kjeldahl procedure. Neutral detergent fiber and acid detergent fiber content were determined by the detergent system of Van Soest (1994).

### Statistical Analysis

Social facilitation by the three heifers within a group meant that individual animals were not considered to be independent replicates (Mead and Curnow, 1983). The data were therefore analyzed using the mean values for each group, within the observation day of each of the eight sub-periods providing the unit of replication.

1) An analysis of variance (ANOVA) technique was used to analyse the total time spent in each activity, number of defecations per sub-period and areas covered by each faecal deposit, using general linear models procedures in SAS (SAS Institute Inc., 2000).

2) The mean values of the number of defecations occurring within a 10 m radius of designated faecal area were calculated.

3) R statistic was calculated to determine

if the distribution of faeces was more clustered or more dispersed than a random pattern. When  $R=0$ , all points are found at the same location, whereas when  $R=1$ , the distribution of defecation was a random pattern and when  $R=2.15$ , the pattern displays perfectly uniform, random, and aggregated pattern of distribution (Clark and Evans, 1954). The mean values of R statistics were examined by analysis of variance using SAS (SAS Institute Inc., 2000). Analyses were carried out in the following order:

## RESULTS

### Meteorological conditions

Hourly air temperature, black-globe temperature and temperature-humidity index (THI)

Table 1. Treatment allocation of each group in each sub-period.

Period		1				2			
Sub-period		1	2	3	4	8	6	7	8
Group	1	D	DW	W	N	DW	D	N	W
	2	DW	W	N	D	D	N	W	DW
	3	W	N	D	DW	N	W	DW	D
	4	N	D	DW	W	W	DW	D	N

Table 2. Mean values of sward characteristics in the experiment.

Measurement*	Period I	Period II
Crude protein (g/kg DM)	74.1	62.9
NDF (g/kg DM)	610	676
ADF (g/kg DM)	354	409
Pre-grazing pasture mass (kg DM/ha)	7820	6370
Leaf-and-stem ratio (DM basis)	1 : 1.7	1 : 1.5

\*Measurement at the beginning of sub-periods 1 and 5.

Table 3. Mean ( $\pm$  standard deviation) time spent in each activity and defecation statistics by grazing swamp buffalo heifers and nearest neighbor statistic in each treatment.

	Treatment							
	DW*		W		D		N	
Grazing (min)	658.46 $\pm$ 36.37		659.63 $\pm$ 15.14		633.83 $\pm$ 41.56		655.04 $\pm$ 45.64	
Ruminating (min)	570.96 $\pm$ 43.01		591.96 $\pm$ 45.19		581.25 $\pm$ 37.62		555.71 $\pm$ 31.06	
Idling (min)	210.58 $\pm$ 58.39		188.42 $\pm$ 46.19		224.92 $\pm$ 22.70		229.25 $\pm$ 30.51	
Wallowing (min)	184.25 $\pm$ 32.02		192.08 $\pm$ 40.84		-		-	
Number of meals	8.67 $\pm$	0.50 <sup>a</sup>	8.83 $\pm$	0.56 <sup>a</sup>	7.00 $\pm$	0.59 <sup>b</sup>	7.08 $\pm$	0.68 <sup>b</sup>
Meal duration (min)	76.82 $\pm$	2.04 <sup>a</sup>	75.46 $\pm$	4.62 <sup>a</sup>	93.03 $\pm$	14.15 <sup>b</sup>	94.89 $\pm$	12.82 <sup>b</sup>
Number of defecations (defecation/head/day)	5.13 $\pm$	0.62	5.33 $\pm$	0.53	4.88 $\pm$	0.31	5.08 $\pm$	0.43
Total defecations (defecation/paddock/6 days)**	66.75 $\pm$	2.92 <sup>a</sup>	68.75 $\pm$	7.07 <sup>a</sup>	80.75 $\pm$	5.92 <sup>b</sup>	82.00 $\pm$	3.88 <sup>b</sup>
Defecation area (square meter/defecation)**			0.14 $\pm$ 0.02					
Weight of faeces (kg DM/defecation)***			0.27 $\pm$ 0.03					
Nearest neighbor statistic	0.20 $\pm$	0.08 <sup>a</sup>	0.24 $\pm$	0.07 <sup>a</sup>	0.16 $\pm$	0.05 <sup>a</sup>	0.44 $\pm$	0.12 <sup>b</sup>

<sup>ab</sup> Within a row, values with different letters differ significantly ( $P < 0.05$ )

\* DW= designated faecal area and wallow; W= wallow only; D= designated faecal area only;

N= neither designated faecal area nor wallow

\*\* Only non-overlapping defecations

\*\*\* Calculated from 80 defecations

are shown in Figures 3(a) and 4(a). During the course of the experiment, the daily air temperature, black-globe temperature and THI were 22.69°C (range 14-33°C), 25.02°C (range 13-53°C) and 70.24 (range 60-83°C), respectively. The number of days during which rain fell and total rainfall during the experiment were 1 day and 1.5 mm, respectively.

### Pasture production and composition

More than 60% of DM mass in the swards comprised green material. Sward heights ranged from 60 to 70 cm. Crude protein, NDF and ADF content of dry matter and pre-grazing pasture mass are shown in Table 2.

### Animal behaviour

Results of 24-h behaviour observations are shown in Table 3 and Figures 3(b) and 4(b). There was no significant treatment effect on grazing, ruminating and idling times (Table 2); overall means were 652, 575 and 213 minutes, respectively. However, the heifers on DW and W treatments had shorter meal durations ( $P<0.05$ ), but more meals than heifers on treatments D and N. Almost all defecations occurred during grazing periods. Average total number of defecation was affected by treatment ( $P<0.05$ , Table 3). Buffalo heifers averaged five defecations per day. The total time spent wallowing did not differ significantly between DW and W treatments.

### Spatial pattern of defecation

The distribution of defecations in all sub-periods was similar. Figures 5 and 6 represent data from periods 1 and 2, respectively. The nearest neighbor statistics (R) in each sub-period ranged from 0.10 to 0.66 and showed a significant tendency toward clustering ( $P<0.05$ , Figure 7).

The mean value of R statistics in treatment DW, W and D were 0.20, 0.24 and 0.16, respectively, and differed significantly ( $P<0.01$ ) from treatment N (0.44). Calculation of the number of defecations showed that more than 65% of all defecation occurred within a 10-m radius of the designated faecal area, compared with less than 20% having occurred within a 10-m radius of wallow.

### Animal live-weight performance

There was no significant treatment effect on mean daily live-weight gains over the 56 days of the experiment; mean 0.67 kg.

## DISCUSSION

During the experiment, weather conditions were considered to be comfortable for grazing animals in this region. Mean daily THI did not exceed 78, which is considered to be the value above which animal production may be compromised (Somparn *et al.*, 2004). However, during period from 11.00 to 13.00, which was the hottest of the day, buffaloes in all treatment stopped grazing. Buffaloes on treatments D and N stood under tree shade. Whilst large trees were available on all paddocks, buffalo heifers on treatments DW and W preferred to wallow. Data from previous work during summer season of Somparn *et al.* (2006) also showed similar results. Figures 3 and 4 showed that during hot periods, buffalo heifers on treatments DW and W still grazed but interspersed short grazing bouts with wallowing. As a result, heifers in both treatments had shorter meal duration but had a higher number of meals than the D and N heifers. Wallowing improves conductive and convective heat loss and facilitates sensible heat loss, as well as, evaporative heat loss

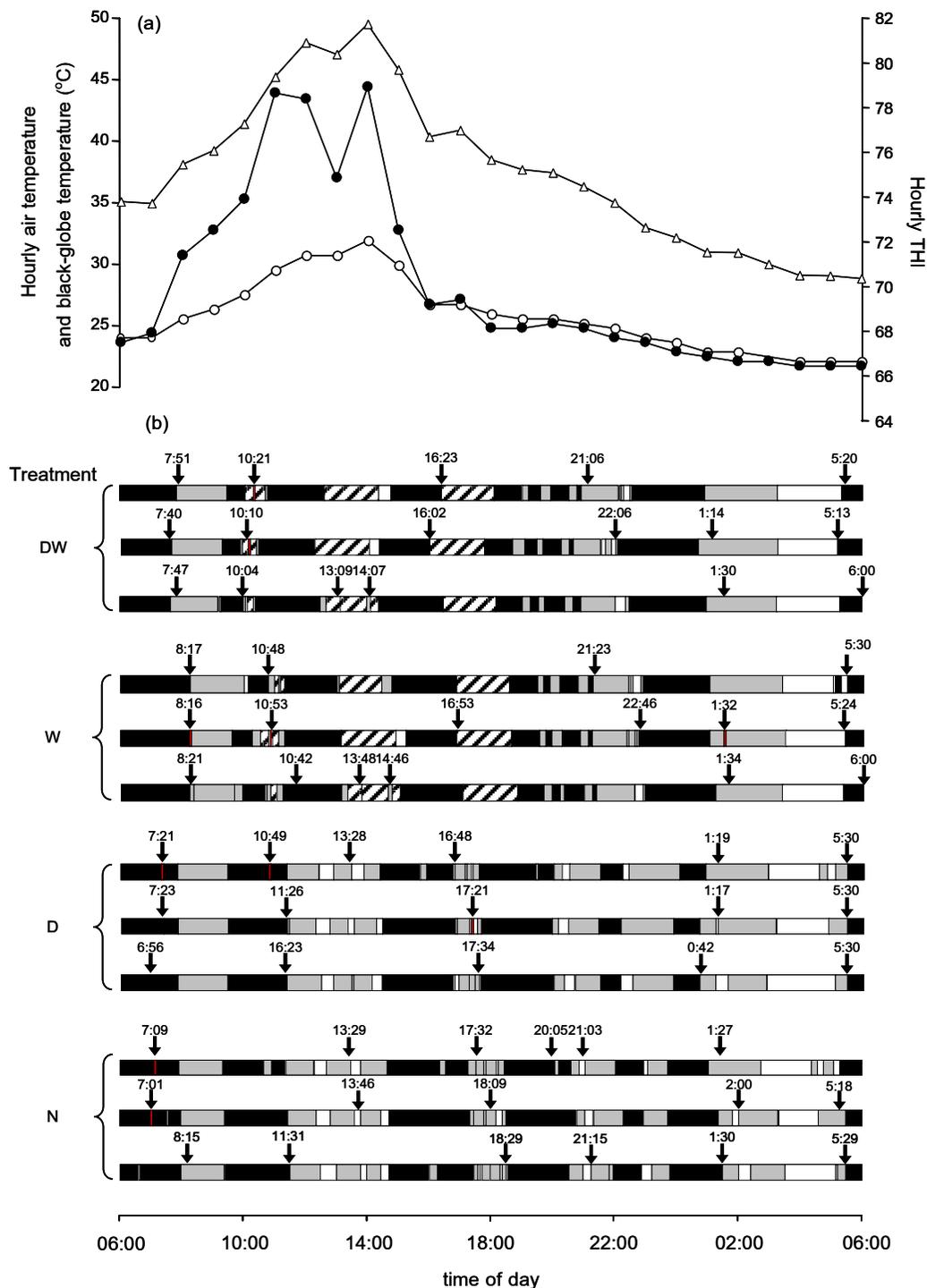


Figure 3. (a) Hourly air temperature (○) black-globe temperature (●) and temperature-humidity index (△); (b) temporal pattern of grazing (■) ruminating (▒) idling (□) and wallowing behaviour (▤) by grazing swamp buffaloes in each treatment during sub-period 1. Arrows denote times of defecation by each heifer.

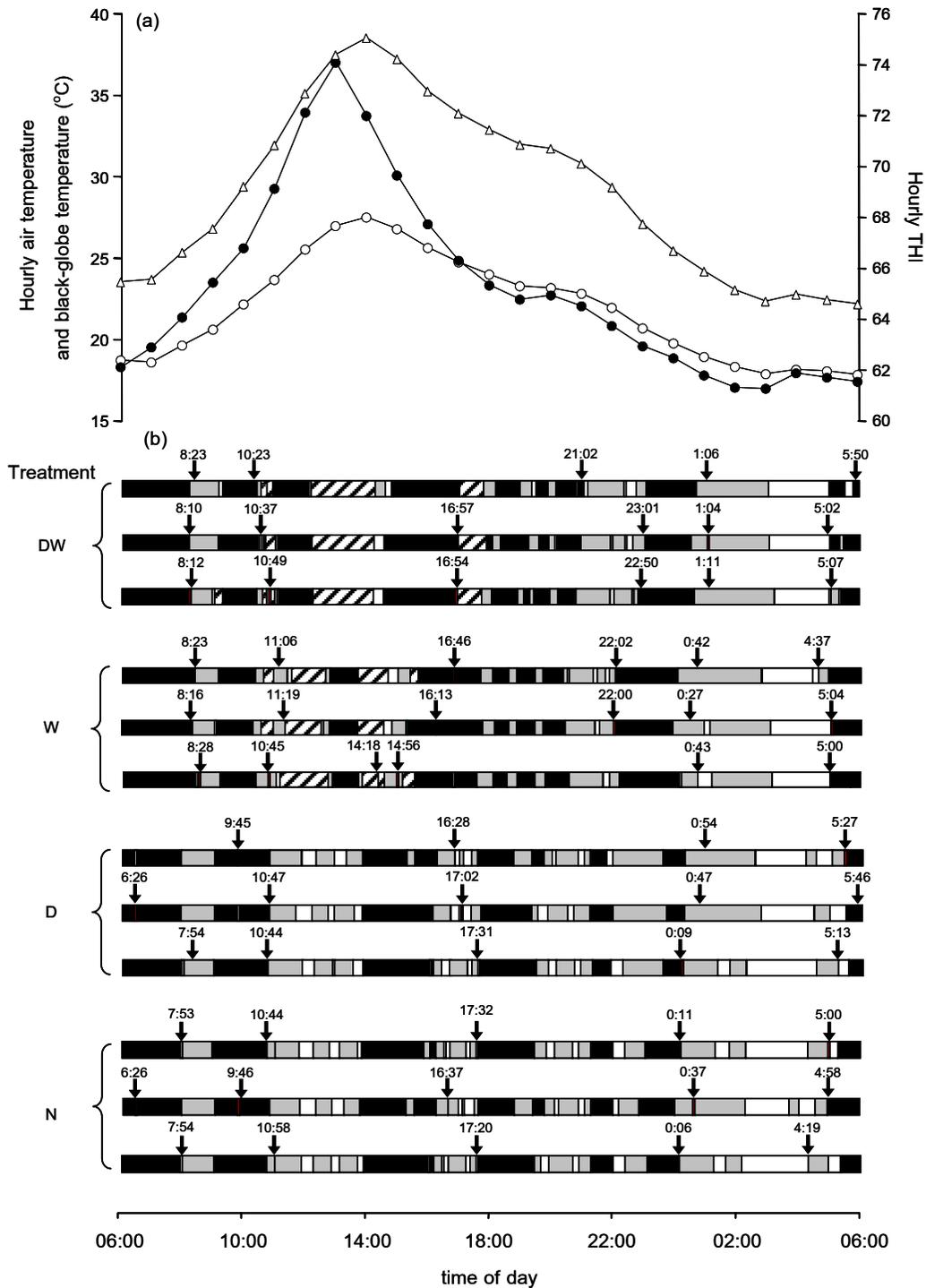


Figure 4. (a) Hourly air temperature (○) black-globe temperature (●) and temperature-humidity index (△); (b) temporal pattern of grazing (■) ruminating (▒) idling (□) and wallowing behaviour (▨) by grazing swamp buffaloes in each treatment during sub-period 5. Arrows denote times of defecation by each heifer.

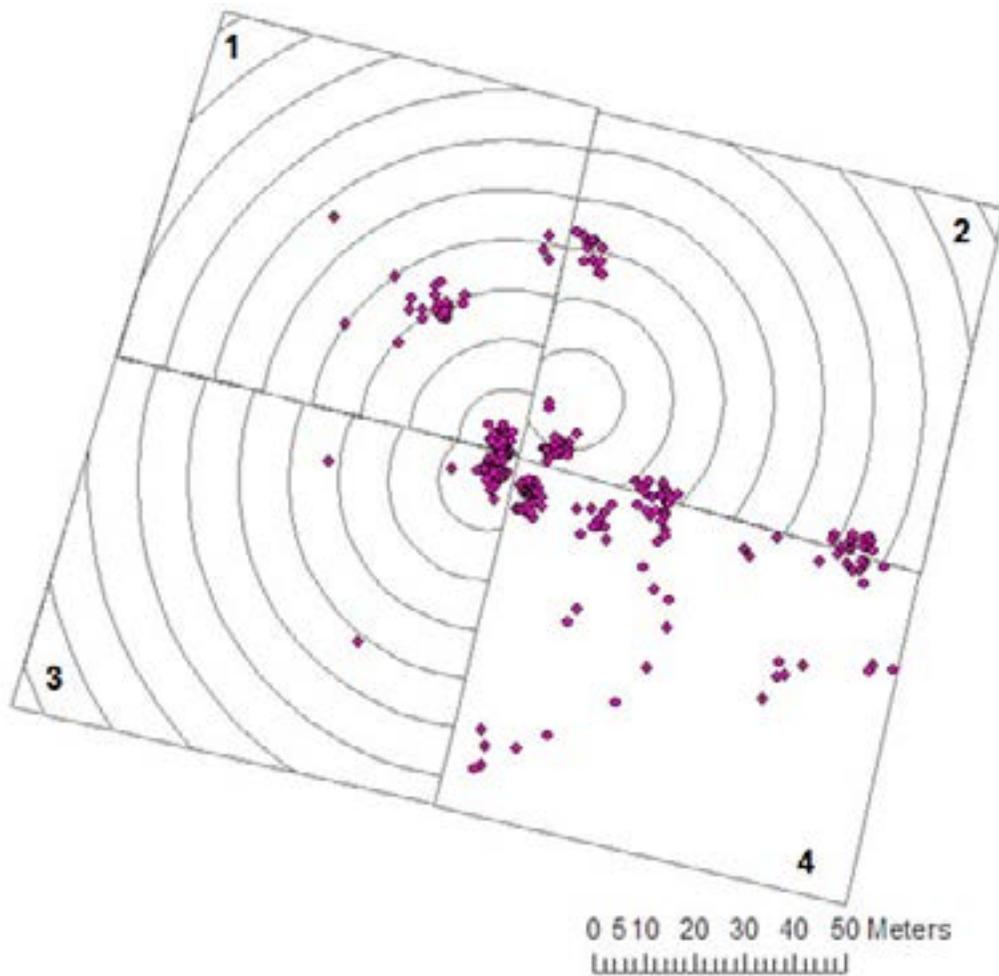


Figure 5. Faeces distribution (solid circle) during sub-period 1 over a 6-day period by swamp buffaloes grazing in paddocks provided with (1) a designated faecal area and a wallow, (2) a wallow only, (3) a designated faecal area only and (4) neither a designated faecal area nor wallow. Concentric lines radiate at 10-m intervals from the designated faecal area (paddocks 1 and 3) or the wallow (paddock 2).

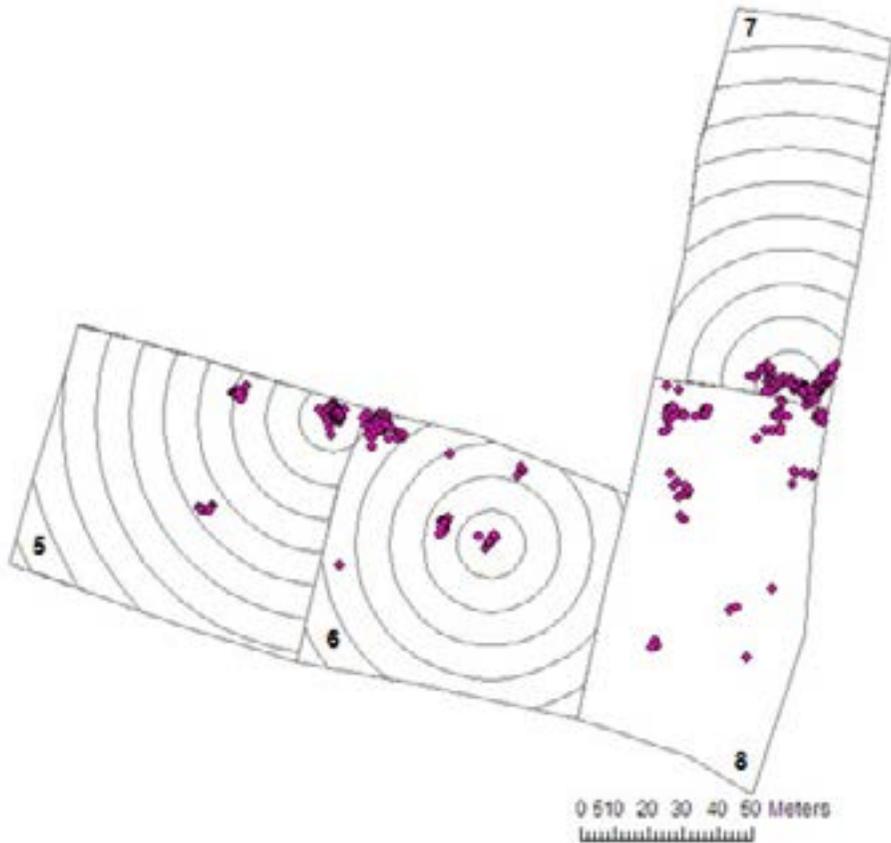


Figure 6. Faeces distribution (solid circle) over a 6-day period during sub-period 5 by swamp buffaloes grazing in paddocks providing (5) a designated faecal area and a wallow, (6) a wallow only, (7) a designated faecal area only and (8) neither a designated faecal area nor wallow. Concentric lines radiate at 10-m intervals from the designated faecal area (paddocks 5 and 7) or the wallow (paddock 6).

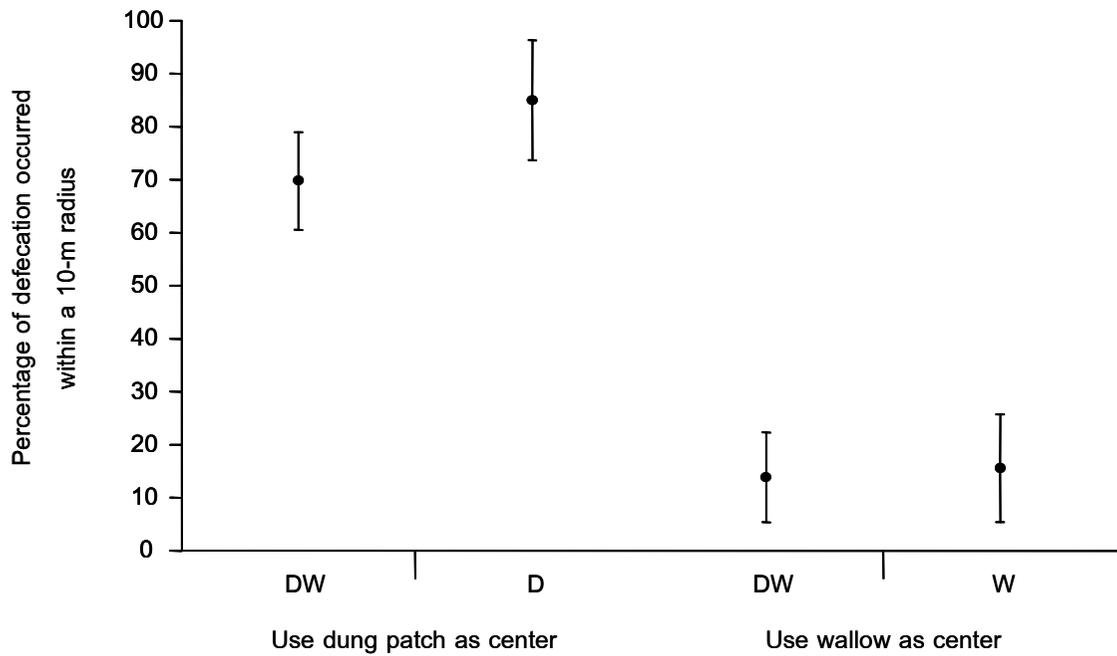


Figure 7. Mean  $\pm$  standard deviation of percentage of defecations which occurred within a 10-m radius of the designated faecal area and wallow throughout the 6-day periods.

by external water obtained during a wallowing. The 200-fold increase of heat loss occurred when a body is immersed in water compared to air (Clark and Edholm, 1985). Chikamune (1987) stated that wallowing behaviour is an energy-saving characteristic which has evolved to dissipate excess heat by utilizing ectosomatic water instead of endosomatic water. Because this results in less sweating, swamp buffaloes also limited loss of blood electrolytes from blood circulation.

Defecations occurred throughout the day (e.g. Figures 3(b) and 4(b)), however the majority took place immediately before or after a grazing meal. Groups of buffalo heifers often synchronized their defecation bout, especially when close to a designated faecal area. This evidence suggests that the appearance of dung pat is partially required to elicit defecation. Because buffalo heifers on DW and W treatments also defecated during wallowing, some defecations were immersed in the mud and were difficult to observe. Inevitably, the total number of defecation in those paddocks throughout 6 days in each sub-period was lower on the DW and W treatments compared to the D and N treatments. In northern Australia, most free-ranging buffaloes, when they enter a wallow, will defecate and/or urinate in it. This behaviour can occur for a number of reasons, one of which is a conditioned reflex; another is because the wallow is a fixed point in their home range and defecation is a marking process (Tulloch, 1992). Barrette (1977) emphasized that marking over scent marks and deposits of urine or feces in an individual's own home range has been interpreted as a device to keep up-to-date information on recent visits. However, we were not able to accurately record the number of defecations made in the wallows, so such event were not taken into account during analysis of nearest neighbor statistics.

Overall, the lower nearest neighbor statistics for treatments DW, W and D indicated that defecations on those paddocks were clustered; however, they did not signify that defecations were deposited on the designated area. If the percentage of defecations that occurred within 10-m radius was considered, the designated faecal area on treatment D produced the highest concentration of defecations (>80%). On treatment DW, which provided both a designated designated faecal area and a wallow, buffalo heifers preferred to defecate in the designated faecal area (>69%) rather than the wallow (<15%). This finding indicates that provision of a designated faecal area is the most effective method for limiting the distribution of faces by swamp buffalo heifers in small paddocks. Under the hot and humid conditions present in Thailand, providing a wallow during hot periods (i.e., afternoon or summer season) can help swamp buffaloes to alleviate excess heat and improve their physical well-being. Thus, provision of both a wallow and a designated faecal area can very much improve the management of these animals to sustain swamp buffalo production in the tropics. In this study, infection by gastro-intestinal parasites could not be measured. Buffaloes, however, clearly performed defecation on restricted area i.e. a designated faecal area. Such behaviour may thus be a natural mechanism of swamp buffaloes to avoid grazing a very contaminated fraction of pasture. Further study will be required to determine the distribution of gastro-intestinal larvae within the sward and spatially selective grazing of pasture by buffaloes.

## ACKNOWLEDGEMENTS

The authors wish to acknowledge Malcolm

John Gibb for the preparation of the paper, the support of director of Surin Livestock Research and Breeding Center, Department of Livestock Development for supplying the research facilities and Thammasat University and the National Research Institute of Thailand for financial support for the project.

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