ORIGINAL ARTICLE

Effect of supplementary lighting on eating behaviour by corralled swamp buffalo (*Bubalus bubalis*) heifers in Thailand

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Abstract

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Effect of supplementary lighting on eating behaviour by corralled swamp buffalo (*Bubalus bubalis*) heifers in Thailand

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Sixteen 14-month-old swamp buffalo (*Bubalus bubalis*) heifers were used to study the effect of supplementary lighting on eating time, number of meals and meal duration and growth performance. Eight heifers were allocated to a natural photoperiod regime, receiving approximately 12 h of daylight, (control treatment) and eight heifers were allocated to a supplementary lighting regime, receiving an additional 6 h

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of artificial light during the night, (light supplemented treatment) using a cross-over design. Rice straw was offered ad libitum and commercial concentrate was also offered approximately 1.5 kg/animal/day. Supplementary lighting was provided by eight 60 W white fluorescent tubes placed approximately 2.5 m above the ground under the roof. Supplementary lighting did not significantly effect eating behaviour, daily intake or live weight gain. It is concluded that the performance of corralled buffalo heifers cannot be improved by the provision of supplementary lighting.

Key words : swamp buffalo, supplementary light, eating behaviour

บทคัดย่อ

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อิทธิพลของการเสริมแสงสว่างต่อพฤติกรรมการกินของกระบือปลักเพศเมียภายใต้สภาพการเลี้ยงแบบขังคอกในประเทศไทย

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ศึกษาอิทธิพลของการเสริมแสงสว่างต่อพฤติกรรมการกินของกระบือปลักสาว ได้แก่ ระยะเวลาที่ใช้ในการกิน จำนวนมื้อและระยะเวลาในแต่ละมื้อ และสมรรถภาพการเจริญเติบโต โดยใช้กระบือปลักเพศเมียอายุ 14 เดือน จำนวน 16 ตัว แบ่งออกเป็น 2 กลุ่มๆ ละ 8 ตัว สุ่มให้ได้รับทรีทเมนต์ตามแผนการทดลองแบบ crossover ได้แก่ ทรีทเมนต์ที่ 1 เลี้ยงกระบือในคอกซึ่งได้รับแสงสว่างจากธรรมชาติ เฉลี่ย 12 ชั่วโมง/วัน และทรีทเมนต์ที่ 2 เลี้ยงในคอกซึ่งได้รับแสงธรรมชาติ และเสริมแสงสว่างโดยใช้หลอดไฟฟลูออเรสเซนต์ ขนาด 60 วัตต์ จำนวน 8 หลอด เป็นระยะเวลา 6 ชั่วโมง/วัน ตั้งแต่เวลา 18:00-24:00 น. ซึ่งติดสูงจากพื้นคอกประมาณ 2.5 เมตร และกระบือจะได้รับฟางข้าวอย่างเต็มที่และอาหารข้น 1.5 กก./ตัว/วัน โดยประมาณ พบว่า การเสริมแสงสว่างนาน 6 ชั่วโมง/วัน ไม่ส่งผลต่อพฤติกรรมการกิน ปริมาณอาหารที่กิน และการเพิ่มน้ำหนักตัวของกระบือสาว ผลจากการศึกษาครั้งนี้แสดงให้เห็นว่าสมรรถภาพของกระบือไม่สามารถปรับปรุงได้ โดยการเสริมแสงสว่าง

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Supplementary lighting has been shown to enhance growth in beef cattle (Tucker *et al*., 1984) and milk production in dairy cows (Stainisiewski *et al*., 1985) under indoor conditions. A possible explanation is that increasing lighting beyond the natural photoperiod stimulates the animal to feed for longer, since most feeding takes place in the light and observation of periodicity of feeding in different day-lengths suggests that animal prefer to feed in the light (Phillips and Leaver, 1986). However, Perera *et al*. (1989) investigating the effect of light supplementation on the performance and physiology of buffaloes found no positive effect on body weight gain, although they did not investigate its effect on behaviour. The present study was designed to compare eating behaviour by swamp buffalo heifers when kept under natural photoperiods of 12 h light and 12 h dark (12L : 12D) with those kept under a supplementary lighting regime of 18 h light and 6 hours dark (18L : 6D). An additional objective was to investigate the effect of supplementary light on the growth of the heifers.

Materials and methods

1. Site and period of study

The experiment was carried out at the Surin

Livestock Breeding Station, Surin Province (lat. 14° 45' N and long. 103° 26' E, alt. 146 m), between 15 October 2001 and 3 March 2002. Mean times of sunrise and sunset were 06:20 and 17:51 h, respectively (range 06:02 to 06:35 and 17:33 to 18:14 h). This study was undertaken during the late rainy and winter seasons.

2. Animals and management

Sixteen-swamp buffalo heifers, of about 14 month of age and weight between 240-262 kg were used. The animals were randomly allocated to the following treatments: natural photoperiod (control) and supplementary lighting (light supplemented) treatments, in a crossover design with two periods each of 55 days. The eight heifers allocated to the control treatment received natural daylight conditions, i.e. an average of 12 h of light, from 06.00 h to 18.00 h, and 12 h of darkness. Heifers on the light supplemented treatment received natural daylight conditions from 06.00 h to 18.00 h and supplementary lighting for 6 hours during the night, between 18:00 and 24:00 h, by means of eight 60 W white fluorescent tubes. The animals in the two treatment groups were housed 14 days before the start of treatments in two identical corrals, where they remained throughout the 110 days of the experiment. Each corral was divided into a shaded area, covered by corrugated metal-sheet roof, and an open un-shaded area. The lighting tubes were placed approximately 2.5 m above the ground under the roof. Mean intensity of the artificial light was 115 lux (Forbes, 1982) at cow head height when lying (50 cm above ground) as measured in the six bays of the corral using a light meter (range 0.1-100,000 lx, TES 1332, Taiwan)

The heifers were weighed at 14-day intervals during the trial. Toward the end of each 55-day measurement period, animals were weighed on four successive days following an overnight fast. Animals within each treatment were fed as a single group. Roughage (i.e. rice straw) was offered ad libitum at approximately 07:00 to 08:00 h and 15:00-16:00 h each day, in concrete troughs (0.70 m x 12 m) along the side of the roofed section of the corral. The amount of roughage offered each day was 30 g/kg in excess of that consumed during the previous 24 h. Refusals were collected, weighed and discarded on the following morning. 1.5 kg of a commercial concentrate diet, containing 15% crude protein, was offered per animal per day at approximately 11:00 h. The total daily concentrate ration for each group was placed along the feed trough and on top of the roughage diet. Mineral blocks and water were available to animals at all times. Because the individual variance in feed intake was calculated rather than measured, mean daily dry matter (DM) intake is referred to throughout the paper as 'calculated DM intake' (Phillips *et al*., 1998).

3. Behaviour observations

Visual observations of behaviour were recorded over 24-hours on three occasions in each period (3, 24 November and 9 December, and 12 Jan, 16 Feb and 3 Mar in Periods 1 and 2, respectively), commencing at 07:00 h. Both groups were observed once every 5 min to determine whether each animal was eating, ruminating, drinking or idling, and lying or standing. The total time spent per day in each of these activities was calculated by assuming that the activity was representative of the remainder of the 5-min. To aid individual identification, all heifers had a number painted on their sides (25 cm), rump and shoulders (15 cm) with white matt paint. When necessary, at night, identification was assisted by use of a small 3-V hand torch, which was not considered to be sufficient to affect the animals' behaviour (Phillips and Weiguo, 1991).

4. Feed sampling

During each 55-day measurement period, samples of the roughage and concentrate rations were taken at about 4-week intervals. Samples were dried to constant weight in an oven at 70°C and weighed to determine dry matter.

5. Meteorological data

Meteorological data including ambient and dew-point temperatures were recorded at hourly intervals using a data logger (Onset Computer Corporation, USA). One data logger was placed outside the corral in a Stevenson's screen and another was placed inside a corral 1.5 m above the floor. Black-globe thermometers were constructed by inserting thermocouples into 15 cm diameter copper spheres, which were painted matt black. One globe thermometer was placed outside a corral 1.5 m above the ground and another was placed centrally inside a corral about 1.5 m above the floor. Daily rainfall (07:00 to 07:00 h) was measured on site using a volumetric rain gauge. 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 ^{o}C and T_{dp} is the dew point temperature in ^{o}C (Yousef, 1985).

6. Statistical analysis

The 24-h behaviour observation periods were divided into day (sunrise to sunset) and night (sunset to sunrise) sub-periods. Social facilitation of the eight 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, with each observation day of each 55-day measurement period (1 and 2) providing the unit of replication. For the statistical analysis of weight gain, individual animals in each group within each period were treated as replicates. Differences between group means were tested using MIXED procedure (SAS Institute Inc., 2000). Calculated DM intake was also analyzed using the mean values for each group with each period providing the unit of replication. Differences between group means were tested by paired t-test, using UNIVARIATE procedure (SAS Institute Inc., 1994).

The mean time spent eating by the eight heifers within each group was calculated for each of 144 hourly periods during the course of the experiment. This mean series was analyzed for periodicity by calculating the smoothed spectrum using a Parzen window. These calculations were performed using the SPECTRA procedure of SAS Institute Inc. (1993). Periodicities were tested using Fisher's g test (Priestley, 1981).

Results

1. Meteorological Data

During the course of the experiment, the weather was typical of that normally experienced in the Northeast Region of Thailand. The daily maximum THI did not exceed 84 and the daily minimum THI was never higher than 74 over the course of experiment (Figure 1). The mean daily THI declined around the middle of Period 1. During the course of Period 2, the daily THI increased gradually.

The patterns of rainfall are also shown in Figure 1. The number of rainy days and total rainfall during the experiment were 13 days and 134 mm, respectively.

Figure 2(a) shows hourly mean outside and inside black-globe temperatures and inside air temperature. The outside black-globe temperatures exceeded the air and black-globe temperatures under the roofed area throughout most of the hours of daylight (08:00 to 17:00 h), with the maximum differences in excess of $7^{o}C$ during the three hours before and after midday. The black-globe temperatures recorded under the roofed area were between 1 and $2^{o}C$ higher than air temperatures under the roofed areas. Between sunset to sunrise, the mean hourly black-globe and air temperatures under the roofed area were similar, but were consistently higher than those recorded in the unroofed area of the corral.

2. Temporal pattern of behaviour

The mean time spent eating, number of meal and meal duration are shown in Table 1. Supplementary light did not affect the time that heifers spent eating. The total eating time ranged from 316-496 min/day (average 373 min/day) in treatment C compared with 283-441 min/day (average 369 min/day) in treatment L. The number of meals and meal durations were also not affected by treatment. The mean time spent standing and lying

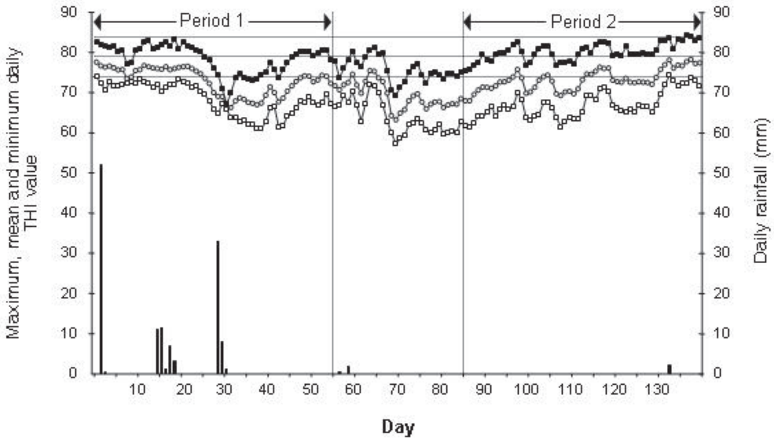

Figure 1. Daily maximum (■), mean (O) and minimum (□) THI value and daily rainfall throughout the experiment. Livestock welfare conditions: alert (THI = 75 to 78), danger (THI = 79 to 83) and emergency (THI ≥ 84).

Table 1. Mean time spent eating, standing, lying, ruminating and idling by swamp buffalo heifers, with or without supplementary lighting.

Behaviour	Treatment			
	Control		Supplementary Light	
	Mean	s.e.	Mean	s.e.
Eating time (min)				
Day	299.38	16.82	292.92	18.50
Night	73.85	12.87	76.35	10.36
Total	373.23	27.80	369.27	25.27
Number of meals				
Day	6.88	0.25	6.36	0.55
Night	3.84	0.44	3.69	0.55
Total	10.71	0.54	10.05	1.02
Meal duration (min)				
Day	42.51	3.13	47.31	6.09
Night	18.79	2.83	23.30	3.43
Total	34.19	2.51	38.45	4.72
Standing time (min)				
Day	176.67	17.40	166.87	25.23
Night	159.58	24.13	157.92	14.84
Total	336.25	26.39	324.79	19.09
Lying time (min)				
Day	243.96	16.10	260.21	20.61
Night	486.56	18.49	485.73	14.01
Total	730.52	23.28	745.94	20.12
Ruminating time (min)				
Lying ruminating	347.29	46.81	329.06	44.25
Standing ruminating	77.71	16.81	88.13	16.16
Total	425.00	42.14	417.19	53.94
Idling time (min)	641.77	49.45	653.54	67.39

are also in Table 1. There was no effect of treatment on the time that heifers spent standing and lying.

Total time spent ruminating whilst either standing or lying and idling (i.e. time during which no eating, ruminating or drinking activity was recorded) are shown in Table 1. There was no significant difference in total ruminating time between treatments. The majority of ruminating activity occurred during the night.

The time spent ruminating within each hour by the heifers on treatment C and L are shown in Figure 2(b) and 2(c), respectively. The overall pattern of eating within each hour is shown in Figure 2(d), with major peaks of eating activity occurring at approximately 07:00 to 08:00 h, 11:00 h, and between 15:00 and 18:00 h and a small peak occurring at around 21:00 to 22:00 h (night peak).

The temporal pattern of eating behaviour by individual heifers in periods 1 and 2 are shown in Figure 3(a) and 3(b), respectively.

The periodogram obtained by fitting the smoothed spectral analysis to the frequency of eating activity by the eight heifers in each group during the six days of behaviour recording are shown in Figure 4. Periodicities were significant (P<0.001) for treatments C and L.

3. Live weight gain and dry matter intake

Figure 5 shows live weight changes during period 1 and 2. Live weight gain and calculated DM intake per day were not affected by supplementary lighting (Table 2).

Discussion

According to livestock safety categories for environmental management decisions (Livestock Conservation Institute,1970), animals do not suffer from heat stress when THI≤74. In the present experiment, the maximum daily THI was consistently below 84 and minimum daily THI never exceeded 74. Thus the heifers were rarely subjected to periods of heat stress of more than a few hours over the course of the experiment. In contrast, whilst the abrupt drop in THI, which coincided with heavy rainfall during week 5 (the transitional period from the rainy season to the winter).

At sunrise, the black-globe temperature recorded in the unroofed area of the corral was similar to the air temperature and black-globe temperature under the roof. As the angle of the sun increased through the morning, the air temperature and black-globe temperature under the roof increased. However, in the absence of roof the black globe recorded a very much greater rise in temperature (mean maximum temperature 42°C), being more than 7°C higher than the inside black globe for 7 hours, between 09:00 and 15:00 h. Towards sunset, the outside black-globe cooled steadily and after sunset recorded lower temperatures than under the roofed area, due to exposure to the night sky and wind (Stowell *et al*., 1998).

The higher temperature recorded under the roof by the black globe, compared with the air temperature, demonstrates that there was some radiant heat exchange under the roofed area of the

Table 2. Mean body weight, live weight gain and calculated DM intake.

Treatment	Period 1		Period 2		Average			
	C	L	C	L	C	S.E.	L	S.E.
Initial weight (kg)	240.63	262.38	278.88	249.50	259.75	6.37	255.94	5.36
Final weight (kg)	243.63	270.63	308.63	264.63	276.13	9.73	267.63	7.48
Live-weight gain (kg/day)	0.05	0.15	0.54	0.28	0.30	0.08	0.21	0.06
Calculated DM intake (kg/day)	4.94	5.09	5.05	6.00	5.00	0.06	5.55	0.46

C = Control (natural light)
L = Supplementary light

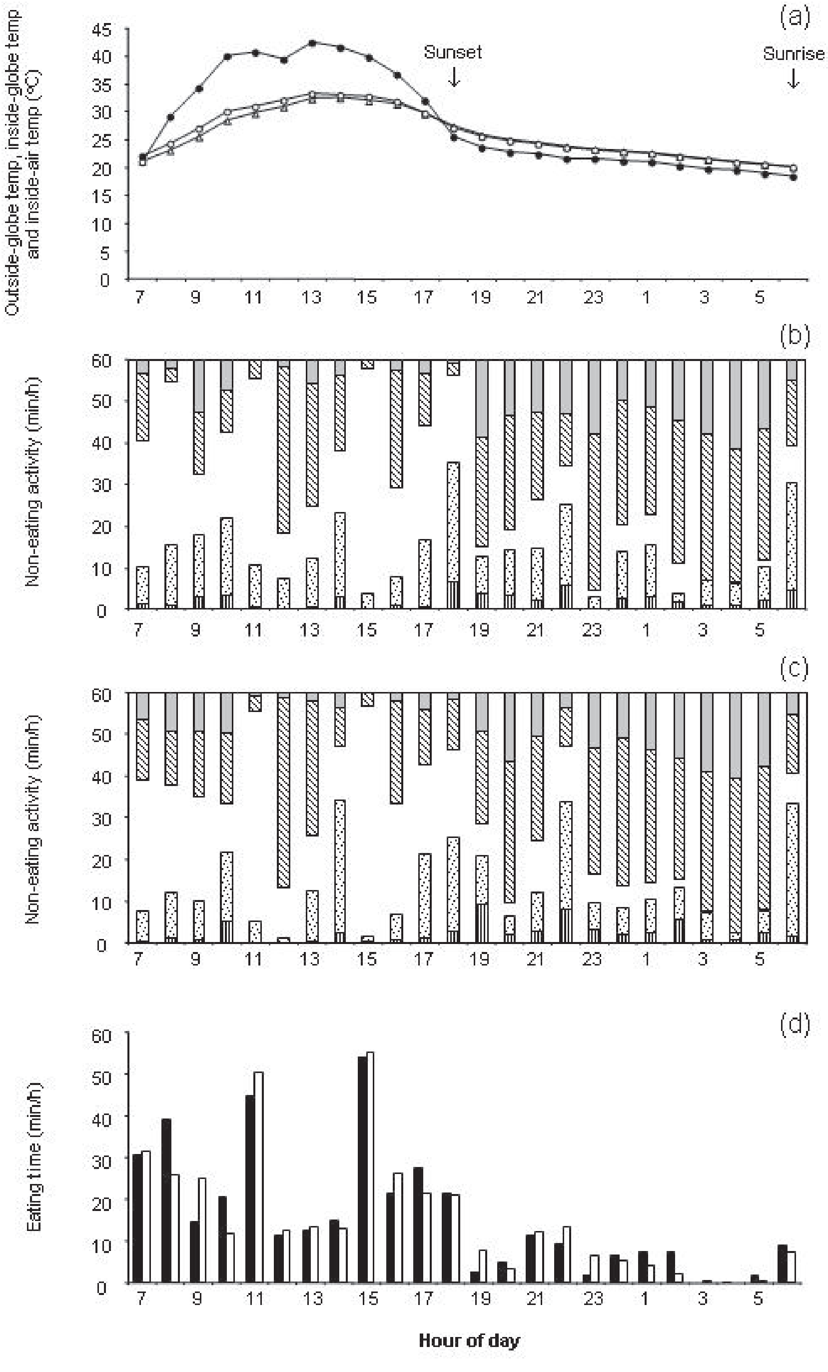

Figure 2. (a) Hourly mean outside-black globe temperature (●), inside-black globe temperature (O) and inside-air temperature (△): mean time (min/h) spent in non-grazing activities by buffalo heifers provided with natural light (b) supplementary light (c); lying ruminating ▒, other lying , other standing and standing ruminating ▯; (d) mean time (min h^{-1}) spent eating by buffaloes on supplementary light □ and control ■ treatments.

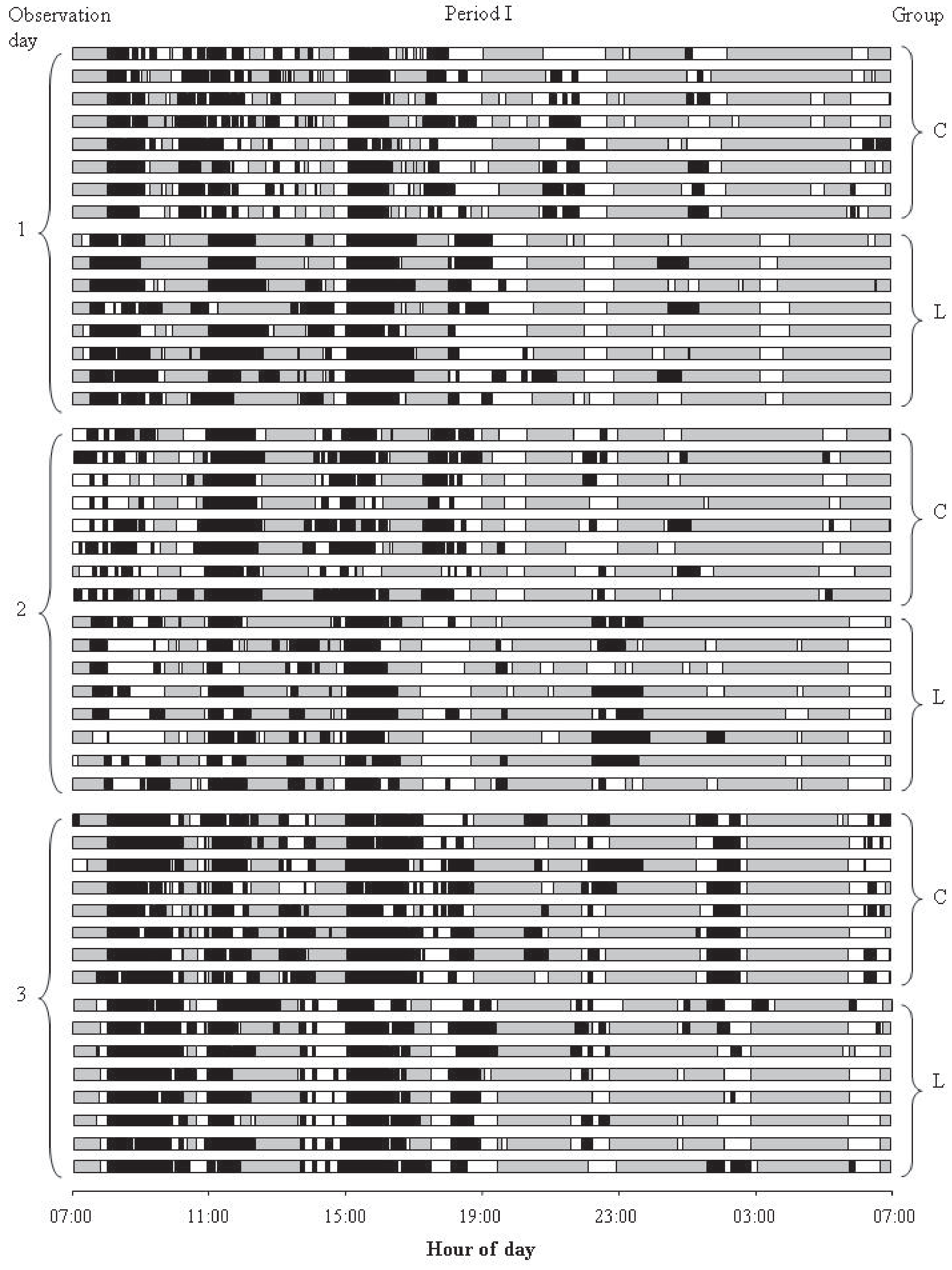

Figure 3. (a) Temporal patterns of eating (■) lying (▢) and standing (□) behaviour by individual swamp buffalo heifers provided with either natural light (C) and supplementary light (L) on the given day in period 1.

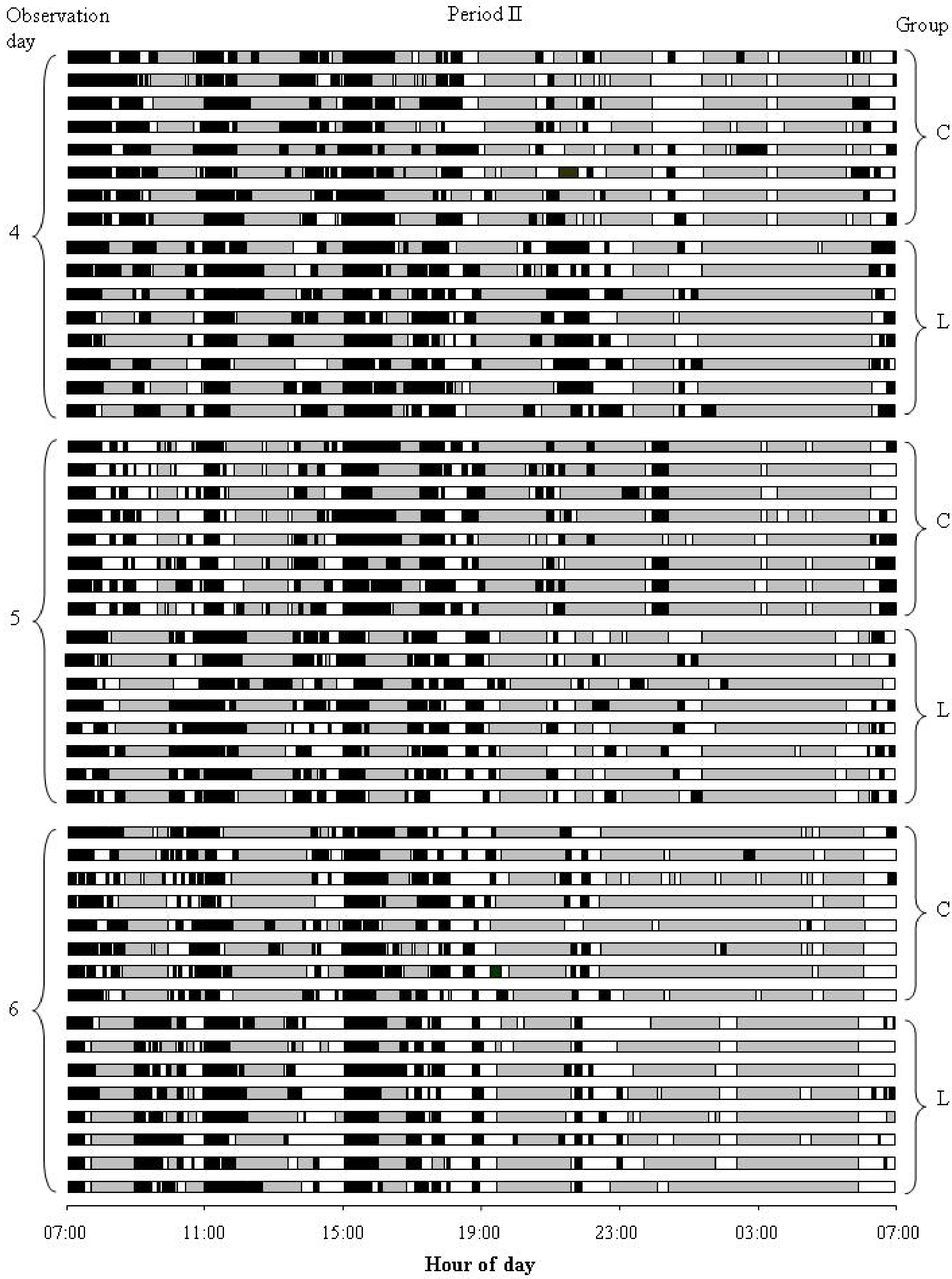

Figure 3. (b) Temporal patterns of eating (■) lying (▒) and standing (□) behaviour by individual swamp buffalo heifers provided with either natural light (C) and supplementary light (L) on the given day in period 2.

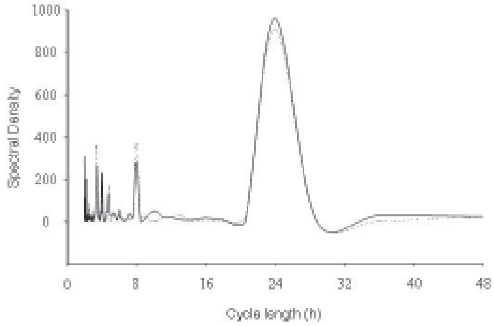

Figure 4. Smoothed spectral analysis of eating activity data showing eating cycles by buffalo heifers on control (C) — and supplementary light (L) ---- treatments within each day of behaviour recording.

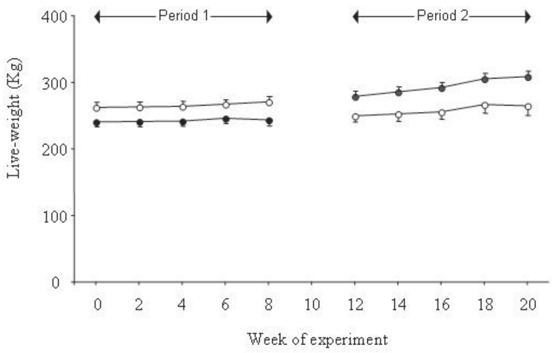

Figure 5. Live-weight change of buffalo heifers on control (●) and supplementary light (O) treatment.

corral. As a result, the heifers should have been considerably better off inside the corral, under shade, than outside in the sun.

In the present experiment, the heifers lay down during the hottest part of day (12:00 h to 14:00 h) and showed little ruminating activity at this time. Possibly the animals benefited from conductive cooling by the floor, because despite daily routine cleaning, the floor was always slightly wet during the day as a result of the habit of swamp buffaloes to urinate and defecate at a common point. By lying on a cool wet surface the heifers would have experienced greater conductive heat transfer, compared with when standing (Kadzere *et al.*, 2002).

Peaks of feeding activity at dusk have been reported by several authors studying housed and grazing buffalo cows (El-Kaschab *et al.*, 1991; Lourenco Junior *et al.*, 2001). Although, ruminants prefer to feed and be active during the light, which is probably a vestigial defence mechanism, they also need to maintain their rumen filled by a regular supply of substrate to the rumen in order to promote efficient microbial digestion. The peak of feeding at dusk probably represents an attempt to compromise these two factors (Phillips and Schofield, 1989). Other peaks of feeding behaviour occurred after offering feed to heifers in the morning and the afternoon as well as a low peak in both groups at night.

In the present study, nighttime peaks in eating activity were frequently observed between 21:00 h to 22:00 h. However, the average night meal duration was 24 min shorter than during the day. When presented as a continuum over 24 h (Figure 3(a) and 3(b)), the temporal patterns of eating showed considerable synchronicity between treatments, but different patterns between the two periods. In general, animals in treatment C and L had more long meals during the day, and only a few short meals during the night.

Despite provision of additional lighting to enable the heifers to see the food for a longer period of time, this did not increase eating activity or intake. Tanida *et al.* (1984) speculated that change of ambient temperature and background natural light at sunrise and sunset and times of feeding, rather than the artificial lighting regimen, had an overriding effect on eating behaviour. As shown in figure 3(a) and 3(b), eating activity was probably initiated and synchronized by offering the fresh feed. In addition, the synchronicity in standing and lying occurred both in daylight and night period. Although it is unlikely that the climatic factor related directly to eating activity, such behaviour rarely occurred during the hottest time of day. Possibly, the animals prefer to reduce activity or heat production in order to keep cool around midday.

The smoothed spectrum (Figure 4) showed a strong 24 h periodicity in eating activity. The major component contributing to the 24 h pattern appears to be the large evening bout of eating. Similar results, with peaks at 24 h, have been shown in grazing sheep (Champion *et al.*, 1994) and heifers fed silage (Deswysen *et al.*, 1993). Many studies have shown that ruminants take a large meal just before sunset, with the next largest meal at dawn (Rook, 2000). El-Kaschab *et al.* (1991) observed circadian pattern of eating activity in Egyptian buffalo cows all the year round and found that, there were two main peaks in eating activity at sunrise and sunset.

Although they were offered food *ad libitum*, some of the heifers in both groups lost their weight during period 1 (Figure 5). However, although not significantly different overall, heifers in treatment L gained less weight than heifers in treatment C. Phillips *et al.* (1998) reported that dairy cows lost weight and body condition and decreased their calculated feed intake when supplementary lighting was provided in the cubicle area compared with unlighted controls. The previous study by Perera *et al.* (1989) of water buffalo in Sri Lanka, similarly showed poorer performance when supplementary lighting was provided, with light-supplemented heifers gaining only 16.2 kg live weight over 9 weeks compared with 20.8 kg gain by non-supplemented heifers.

In the current study, the poor live-weight gains, particularly during period 1, achieved by the heifers indicated that they suffered from stress under the confined conditions without the provision of a wallow. Behavioural indicators of welfare are useful in that they are relatively easy to obtain and probably reflect an animal's first attempts to cope with less than optimum conditions (Keeling and Jensen, 2002). Occasionally, some heifers in both groups attempted to behave as if a wallow available and beat their head and/or soaked their limbs in the water in the drinking troughs. Such behaviour may well result in injury to the animal and is likely to pose a welfare problem resulting in further stress and subsequently loss of production. In addition, as a consequence of insects being attracted towards the lights, the heifers in treatment L were observed to spend most of their time during the night away from the vicinity of the light standards.

In the current study, the rations provided should have been sufficient to support some (0.5 kg/day or more) live weight gain. Thus, the poor live-weight gains achieved by the heifers were probably due to stress under the confined conditions or the corral and the absence of a wallow. Swamp buffaloes have an innate tendency to wallow anyway, whether they are heat stressed or not. In the absence of a wallow they make considerable efforts to exhibit this behaviour, and animals prevented from doing so show behavioural and physiological abnormalities (Keeling and Jensen, 2002) and are likely to result in welfare problems (Broom and Johnson, 1993). Consequently, prevention of wallowing behaviour reflects poor welfare practice for corralled swamp buffalo.

Conclusion

Buffalo heifers kept in corrals do not benefit from supplementary lighting either with regard to live weight gain, eating behaviour or calculated daily DM intake.

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