THE EFFECTS OF HOUSING SYSTEMS ON PHYSIOLOGICAL PERFORMANCE AND PRODUCTIVITY OF LOCAL DAIRY CATTLE (PFH)

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ABSTRACT

Three types of housing systems i.e. open, semi-open, and closed barns for logical dairy cattle (PFH) calves, heifers and lactating cows were used in this study. The study was conducted partly in the Department of Dairy Science UGM and partly on 20 dairy farms in the Yogyakarta area (DIY) in either the dry or wet seasons of 1994, 1995, and 1996. Data on physiological measurements, barn microclimate, feed intake, and productivity were collected. The results showed that most measurements of physiological status or productivity were not affected by type of housing. There were no effects on concentrate on forage intake, water intake, daily weight gain, or milk production. Barn microclimate was affected by housing systems especial-ly relative humidity and barn air temperatures. However, possible environ-mental stressors were apparently within limits that could be overcome by self-regulation of some physiological functions by these adapted PFH cattle.

Key words: Housing systems, Physiological performance, Productivity, Local dairy cattle (PFH)

INTRODUCTION

Williamson and Payne (1993) wrote that heat stress could cause physiological disturbances such increased rectal temperature and water intake, and decreased feed intake, milk productions and daily weight gain of livestock. Mc Dowell (1972) stated that under confined conditions relative humidity was a more crucial factor influencing livestock physiological status than it was animals in field situations. Hafez (1968) found that physiological environmental stressors could cause increases rate, pulse rate and rectal temperature.

Feed intake of livestock was found to be higher in cool than in hot environments (Wing, 1963). At air temperatures of 30-35 °C, feed intakes was decreased, and water intake was increased (Davendra and Burns, 1970). High air temperatures can cause decreases in basal metabolic rate, in muscular activity and in productivity. Hafez and Dyer (1969) stated that homeortherms would decrease feed intake at high air temperatures and increase it at low mechanism air temperatures. Decreasing feed intake was one of the physiological mechanisms for avoiding heat accumulation.

Increase in respiration rate of livestock in hot environmental conditions is one of the quick reactions for regulating normal body temperature, especially at air temperatures above 29 °C (McDowell, 1972). Respiration rate is also affected by body size, age, body activities, air relative humidity, digestive tract status (Duke, 1957; Hafez, 1968; and Jeffrey, 1975). The ideal barn air temperature for the tropics is 50 to 80 °F (10 to 27 °C) (Williamson and Payne, 1993). Ideal rectal temperature of dairy cattle is usually observed at 30 to 60 °F (-1 to 15.5 °C) air temperature. Normal rectal temperatures is usually maintained in a temperature ranges of 60 up 85 F (15.5 to 29.4 °C) (Faley *et al.*, 1972).

MATERIALS AND METHODS

This study included 5 trials. All barn microclimatic conditions, such as: barn air temperature, maximum and minimum barn temperatures, and relative humidity were

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measured and recorded daily at 1 p.m. Flaying fish household wall thermometers made in the people's Republic of China were used to measure barn air temperature. A Widder maximum and minimum thermometers made in west Germanys was used to measure maximum and minimum barn air temperatures. A Dong Feng Model 201 Hygrometer made in the people's Republic of China was used to measure barn relative humidity. Blood samples were taken weekly for laboratory analysis. Feed (concentrate and forage) intake, water intake and milk production were measured and recorder daily. Weight gain was recorded weekly.

Trial 1

This trial was conducted in the Department of Dairy Science UGM to study the effects of open and closed barns on physiological performances of local dairy (PFH) calves in the wet season of 1994-1995. Six males and six males and six female PFH calves were used. They were divided into two groups that were balanced for sex, age and body weight. A crossover design was used. One group was confined in an open barn while another group was in a closed barn. Physiological characters measured daily were rectal temperature, respiration rate, and pulse rate. Blood samples were taken weekly, and laboratory analyses were done on PCV, RBC, WBC counts, and Hb. Feed (concentrate and grass) and water intake was recorded daily, and weight gain was recorded weekly. Barn microclimate conditions were recorded daily at 1 p.m., i.e.: air temperature, maximum and minimum air temperatures, and relative humidity.

Trial 2

This trial was conducted to study the effects of dry versus wet concentrate feeding in open and closed barns on physiological performance and weight gains of local (PFH) dairy calves in the wet season of 1994-1995.

Wet concentrate feeding is generally practiced by local dairy farms. Twelve female PFH calves were used in this trial. They were 83.5-129.0 kilos in body weight and 6-8 months of age. They were divided into two groups. The first group was fed concentrate in dry form, while another group was fed concentrate mixed with water in a ratio of 1 to 3.3 of water by weight. Each group was further divided into two groups of three animals and these subgroups were confined alternately in either opened or closed barns, using a switch-back design. All parameters were measured and recorded in the same manner as trial 1.

Trial 3

This trial was conducted to study the effects of closed versus open barn on physiological performance and productivity of local (PFH) dairy calves during the dry season 1996.

Six females and four male PFH calves were used in this trial. The calves were 5-7 months of age 60-100 kilos of weight. They were divided into to groups of five, balanced in sex, age, and weight. A crossover design was used. Each period of this was trial was proceeded by 7 days of acclimatization and followed by 28 days of observation. Individual forage and watering were on an *ad libitum* basis. All parameters were measured and recorded in the same manner as in trial 1.

Trial 4

The purpose of this trial was to study the effects of closed and semi-open barns on physiological performance of privately owned PFH dairy cattle in the Yogyakarta area (DIY) in the wet season of 1994-1995.

Ten dairy farms with closed barns and another ten dairy farms with semi-open barns were used. At each farm two lactating cows, two heifers, and two calves were used to measure physiological performance as well as barn microclimate conditions. All parameters were measured and recorded the same manner as trial 1.

RESULTS AND DISCUSSION

Trial 1

Results of this trial are shown in Table 1. Barn air temperature at 1 p.m., barn relative humidity, and respiration rate, water intake and daily weight gain of calves were significantly higher ($P<.05$) in the closed than in the open barn. However, one calf in the

Table 1. Microclimatology and physiological data of calves in closed versus open barns during the wet season in 1994-1995 (Trial 1)

Item	Open barn	Closed barn
Barn Climatology		
1. Barn temperature, at 1 p.m. (°C)	30.98	32.64*
2. Maximum temperature, (°C)	33.66	35.55
3. Minimum temperature, (°C)	24.21	25.00
4. Relative humidity, (%)	62.68	67.45*
Calf's Physiology		
5. Respiration rate per minute	52.09	62.09*
6. Pulse rate per minute	80.34	82.71
7. Rectal temperature, (°C)	39.62	39.54
8. Packed Cell Volume (PCV), (%)	24.76	24.68
9. Hemoglobin (Hb), g per 100 ml	1.18	7.15
10. Erythrocytes (RBC), 10^6 per 100 ml	6.36	6.28
11. Leukocytes (WBC), 10^3 per ml	6.26	6.68
Feed Intake		
Concentrate, kg/animal/day	3.06	3.12
Forage, kg/animal/day	7.36	7.34
Water, l/animal/day	8.25	9.93*
Daily gain, kg/animal/day	0.26	0.27*

* Significantly different (P<.05)

open barn suffered from severe diarrhea during the initial period of this trial and this may have reduced its gain. The differences in other measurements, such as: barn maximum and minimum air temperatures, and pulse rate, rectal temperature, PCV, Hb, RBC, and WBC counts, concentrate, and forage intake, between open and closed barn were not significant. The differences in microclimatic condition of these two types of housing (closed vs. open) during the rainy season were probably due to the fact that air circulation in the closed barn was less. According to Esmay (1965) and Williamson and Payne (1993), microclimatic conditions in these two types of housing were with in normal ranges for dairy cattle adapted to humid tropical conditions.

Trial 2

Results of this trial are in Table 2. The barn microclimatic conditions measured including barn air temperature at p.m, maximum and minimum temperatures, and relative humidity were slightly higher in the closed barn than in the open barn, but only differences in minimum air temperature and relative humidity significant (P<.05 and P<.01). Neither type of barn nor form of concentrate affected physiological performances, as evaluated by respiration rate, pulse rate, rectal temperature, PCV, Hb, RBC, and WBC counts, percentage of neutrophils and lymphocytes, feed (concentrate and forage) intake, water intake, or daily weight gain of PFH calves. From these two trials (trial 1 and 2) one could conclude that during the wet season, physiological performances of dairy calves was not affected by either type of housing, or form on concentrate feeding.

Trial 3

Results of this trial are shown in Table 3. All differences in microclimatic conditions measured between these types of housing (open vs. closed barn) were significant (P<.05 and P<.01). Among the physiological measurements only those for between calves confined in open and closed

Table 2. Microclimatology and physiology data of calves in closed versus open barns feed concentrate in two forms during the wet season in 1994-1995(Trial 2)

Item	Open barn		Closed barn	
Barn Climatology				
1. Barn temperature, at 1 p.m. (°C)	29.80		30.60	
2. Maximum temperature, (°C)	33.00		33.80	
3. Minimum temperature, (°C)	24.80		24.92*	
4. Relative humidity, (%)	69.60		81.20**	
	Concentrate		Concentrate	
	Dry	Wet	Dry	Wet
Calf's Physiology				
5. Respiration rate per minute	61.00	63.00	58.00	65.00
6. Pulse rate per minute	98.00	10.00	97.00	104.00
7. Rectal temperature, (°C)	39.30	39.20	39.30	39.20
8. PCV, (%)	26.60	26.70	27.10	27.10
9. Hemoglobin, g per 100 ml	7.71	7.78	7.82	7.28
10. Erythrocytes, 10^6 per 100 ml	6.56	5.58	5.97	5.94
11. Leukocytes, 10^3 per ml	5.76	7.24	6.82	6.75
12. Neutrophils, (%)	14.34	15.57	17.32	14.72
13. Lymphocytes, (%)	84.34	79.44	79.23	74.44
Feed Intake				
Concentrate, kg/animal/day	2.76	2.94	2.52	3.03
Forage, kg/animal/day	5.48	3.96	5.78	5.06
Water, l/animal/day	11.88	14.53	10.99	14.72
Daily gain, kg/animal/day	0.46	0.48	0.58	0.58

* Significantly different (P<.05)
** Significantly different (P<.01)

barn. Pulse rate, rectal temperature, Hb, RBC and WBC counts, percentage of neutrophils and lymphocytes, feed (concentrate and forage) intake, water intake, and daily weight gain did not differ significantly. It appears microclimatic conditions differ in these two types of housing, especially dry season. However, the mild microclimatic stressors in the closed barn were apparently compensated for by these adapted calves with increasing respiration rate decreasing PCV, and increasing water intakes. These adjustments were small and with the small numbers of animals were often not statistically significant.

Trial 4

As shown in table 4, relative humidity was significantly higher (P<.05) but differences in other microclimatic conditions between closed and open barns were not significant. The differences in physiological measurements of these PFH lactating cows, heifers, and calves were not significant between those confined in closed and semi-open barns, expect for respiration rate. This was significantly higher in all three age classes for animals in closed barns as compared to those in semi-open barns (P<.05). There is an indication that the increase in relative humidity in closed barns is compensated for by increased respiration rates of lactating cows, heifers, and calves.

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Table 3. Microclimatology and physiology data of calves in closed versus open barns during the dry season in 1996 (Trial 3)

Item	Open Barn	Closed Barn
Barn Climatology		
1. Barn temperature, at 1 p.m. (°C)	30.16	31.72**
2. Maximum temperature, (°C)	32.14	32.83*
3. Minimum temperature, (°C)	22.86	24.01**
4. Relative humidity, (%)	59.14	70.43**
Calf's Physiology		
5. Respiration rate per minute	41.00	50.90**
6. Pulse rate per minute	86.20	86.70
7. Rectal temperature, (°C)	39.30	39.20
8. Packed Cell Volume (PCV), (%)	26.60	24.80**
9. Hemoglobin (Hb), g per 100 ml	7.73	7.26
10. Erythrocytes (RBC), 10^6 per 100 ml	7.40	7.26
11. Leukocytes (WBC), 10^3 per ml	6.37	6.03
12. Neutrophils, (%)	16.82	16.71
13. Lymphocytes, (%)	80.64	80.17
Feed Intake		
Concentrate, kg/animal/day	1.59	1.47
Forage, kg/animal/day	8.77	8.86
Water, l/animal/day	4.49	4.80
Daily gain, kg/animal/day	0.22	0.22

* Significantly different (P<.05), ** Significantly different (P<.01)

Table 4. Microclimatology and physiology data of dairy animal in closed versus semi-open barns during the wet season in 1994-1995 (Trial)

Item	Open barn	Closed barn
Barn Climatology		
1. Barn temperature, at 1 p.m. (°C)	31.67	31.78
2. Maximum temperature, (°C)	32.71	32.81
3. Minimum temperature, (°C)	25.02	24.62
4. Relative humidity, (%)	82.30	82.23*
Cow's Physiology		
5. Respiration rate per minute	58.00	54.00*
6. Pulse rate per minute	82.00	83.00
7. Rectal temperature, (°C)	38.57	38.47
Heifer's Physiology		
8. Respiration rate per minute	62.00	55.00*
9. Pulse rate per minute	87.00	86.00
10. Rectal temperature, (°C)	38.60	38.70
Calf's Physiology		
11. Respiration rate per minute	61.00	55.00*
12. Pulse rate per minute	88.20	87.10
13. Rectal temperature, (°C)	39.30	39.10

* Significantly different (P<.05)

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