COMPARISON OF PERFORMANCES OF YOUNG CALVES IN SEVERAL HOUSING SYSTEMS IN THE WINTER OF COLD REGIONS

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Summary

A total of thirty male Holstein calves were reared outdoors with simple housings or in warmed pens in three experiments conducted in three consecutive midwinters in Hokkaido. Average outdoor air temperatures during the experiments were between −5.3 and −6.1℃, and average minimum air temperatures were between − 9.7 and −10.6℃. The age of calves at the start of the experiments were 16 ± 6 hours. There was no difference in the liquid feed intake, while the solid concentrate (artificial milk) intake by the calves in the simple housing systems (outdoors, calf hutch and open shed) tended to be higher than those in the warmed pen. No significant differences in the daily gain or the monthly development of wither height were observed among housing systems. There were no serious cases of diarrhea. However, coughing was observed in several of the calves reared in the poorly ventilated warmed pens.

(Key Words: Calf, Growth, Winter, Housing, Ventilation, Cold Region)

Introduction

In cold regions, rearing pens for newborn calves often have environmental problems during midwinter. Lower critical temperature of newborn calves are around 9℃ (Gonzalez-Jimenez and Blaxter, 1962; Webster et al., 1978) and it has been recommended that air temperature be kept above 5℃ to avoid adverse effects on growth and feed conversion efficiency (Webster et al., 1978). However, supplying heat or insulation to maintain warmth requires extra cost. Attempts to maintain warmth without supplemental heat result in poor ventilation and recurring health problems.

Outdoor calf rearing systems with individual portable pens, called calf hutches, have become widespread in North America and are successful in overcoming health problems and high death loss in conventional facilities (Davis et al., 1952; Davis et al., 1954; Murley and Culvahouse, 1958; Jorgenson et al., 1970; McKnight, 1978). The portable pen is covered and protected on three sides but shows little proficiency in keeping a higher air temperature. That is to say, the calf hutch attaches importance to ventilation rather than warmth (Hoshiba et al., 1985).

Okamoto (1989) calculated an average lower lethal temperature of −63.5℃ for newborn calves from summit metabolism (Okamoto et al., 1986). However, there are wide individual differences in summit metabolism. Air movement and wetting reduce insulation considerably (Okamoto, 1989). Therefore, low vigor calves in wet, windy conditions might not survive at + 1.5℃ (Okamoto, 1989).

The objective of the present study was to investigate the relative importance of warmth and ventilation during the cold of winter, and to examine minimum housing requirements for young calves in cold regions.

Materials and Methods

A total of thirty Holstein calves were used in three experiments in three consecutive midwinters in Hokkaido.

Experiment 1

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Three calves born from December 18th to 29th were kept in three individual pens in each of three environments within 24 hours after birth; (a) outdoors with a feed box covered with a small roof (the calves were partially protected from wind by the wall of the feed box but not from precipitation snowfall); (b) calf hutch having walls for three sides and covered with a roof (open to the south); and, (c) an insulated and warmed room (10℃) which was ventilated at the rate of 70 m^3/h/head.

All pens were bedded with rice straw, but straw outdoors was often covered with snow and ice, and therefore, not effective as bedding during most of the experiment. The feeding regimen is shown in table 1: equal amounts of liquid feed (whole milk and milk replacer) were fed both morning and evening. Live weight was measured every week and wither height and chest girth were measured every two weeks. Outside and inside air temperature and relative humidity of the housings, outdoor wind velocity at 2 m elevation, and precipitation were monitored every hour.

TABLE 1. FEEDING REGIMEN (KG / DAY)

Feed	Weeks of age								
	0	1	2	3	4	5	6	7	8-11
Whole milk	4.0	5.0	5.0	5.0 (4.0)					
Milk replacer				0.5 (0.4)	0.6	1.1	1.1 (0.8)	0.8 (0.4)	0.4 (0.0)
Concentrate*	..... *ad lib.* up to 1.5 kg								2.0
Timothy hay	..... *ad lib.*								

Whole milk: 3.8% fat, 8.7% SNF.
Milk replacer: 26% crude protein, 15% fat, 1% crude fiber.
* Artificial milk: 18% crude protein, 2% fat, 6% crude fiber.
( ); Experiment 2 and 3.

Experiment 2

Three calves born form January 9th to 11th were assigned for each environment; (a) calf hutch; (b) warmed room to 10℃ with high ventilation (95.4 m^3/h/head); and, (c) warmed room to 10℃ with poor ventilation (9.5 m^3/h/head). The feeding regimen was changed a little from experiment 1 (table 1). Monthly measurements of CO_2 and NH_3 concentration in the warmed room were added to the measurements of experiment 1.

Experiment 3

An open shed with three individual pens divided by plywood boards for three sides was added to the housings in experiment 2. The calves in the open shed were protected from precipitation by a roof higher than that of the calf hutch and from wind by plywood boards. Three calves born from January 6th to 13th were assigned to each of four housing systems. The feeding regimen and measurments were the same as experiment 2.

The calves were checked for diarrhea and coughing at feeding time every day.

Results

Monthly averages of weather records inside and outside of the housings are shown in table 2. The average daily mean outdoor air temperature in January and February was between −7.1 and −10.1℃. Average daily minimum outdoor air temperature in these months was between −11.0 and −15.0℃. Air temperature in the calf hutch was 2 to 6 degrees higher than outdoors. Air temperature of the open shed was between that outdoors and the calf hutch.

An attempt was made to keep air temperature in the warmed pens around 10℃, however, it was lower throughout experiment 1, and higher in experiments 2 and 3 in the month of April

TABLE 2. MONTHLY AVERAGES OF WEATHER RECORDS

	Experiment 1				Experiment 2				Experiment 3			
	Dec.[1]	Jan.	Feb.	Mar.	Jan.[1]	Feb.	Mar.	Apr.[1]	Jan.[1]	Feb.	Mar.	Apr.[1]
Average daily mean air temperature (°C)												
Outdoor	−5.2	−7.6	−7.1	−4.5	−7.1	−10.1	−3.1	1.9	−9.6	−8.5	−3.9	2.6
Calf hutch	−10.1	−4.8	−2.3	−0.3	−3.8	4.7	0.9	4.4	−5.8	−3.6	−0.6	5.9
Warmed room (W-V)	7.1	6.4	7.6	9.4	10.3	10.5	10.6	11.2	11.1	10.2	9.5	9.9
Warmed room (P-V)	—	—	—	—	9.7	9.5	12.7	16.2	9.2	8.9	10.2	13.0
Open shed	—	—	—	—	—	—	—	—	−7.2	−5.2	−2.1	4.5
Average daily minimum air temperature (°C)												
Outdoor	−10.1	−11.1	−12.2	−8.9	−11.0	−15.0	−7.0	−2.9	−14.6	−13.2	−8.0	−2.3
Calf hutch	−8.3	−8.7	−7.2	−6.2	−6.8	8.9	−4.0	−0.6	−9.5	−6.9	−4.0	0.7
Warmed room (W-V)	6.4	5.8	6.9	8.5	10.0	9.6	9.9	10.2	8.0	7.7	7.1	7.9
Warmed room (P-V)	—	—	—	—	8.9	8.9	11.5	14.0	7.3	7.5	8.7	11.0
Open shed	—	—	—	—	—	—	—	—	−11.2	−8.9	−5.5	0.6
Average daily maximum air temperature (°C)												
Outdoor	1.0	−4.3	−2.0	0.0	−2.8	−5.1	0.9	4.9	−5.2	−3.8	0.2	8.0
Calf hutch	5.4	−0.5	2.9	7.0	1.5	1.5	10.9	15.3	−0.6	1.5	4.1	15.9
Warmed room (W-V)	8.3	7.4	8.6	10.5	11.1	11.4	11.9	13.0	13.4	13.1	13.3	12.5
Warmed room (P-V)	—	—	—	—	11.1	10.6	13.7	17.9	12.8	11.8	11.9	16.2
Open shed	—	—	—	—	—	—	—	—	−2.6	−1.0	2.2	10.6
Wind velocity at 2 m elevation (m/s)												
Daily average	1.3	1.7	1.3	1.6	1.5	1.2	1.3	1.2	1.0	0.5	1.0	0.9
Daily maximum	2.3	2.9	2.7	2.7	2.6	1.8	2.9	2.5	1.6	1.3	1.7	1.9
Monthly precipitation (mm)	17.0	28.0	39.0	38.5	39.5	4.5	40.0	78.5	11.0	14.5	27.5	42.5

[1] Averages of 10 or 20 days during the experiment.
W-V: Well ventilated.
P-V: Poorly ventilated.

in poorly ventilated rooms. The capacity of the heater in experiment 1 and the ventilation rate in experiments 2 and 3 were not enough to keep the set temperature. Average daily wind velocity at 2 m elevation was between 0.9 and 1.7 m/s. When wind velocity exceeded 3 m/s, snow on the land was blown up. Wind velocity at 10 m elevation was about 5 times higher than that at 2 m elevation. Monthly precipitation (snowfall) was between 4.5 and 78.5 mm.

Ventilation rate and air condition in the warmed room in experiments 2 and 3 are shown in table 3. Ventilation rate in the well ventilated room was about 10 times higher than that in the poorly ventilated room. Relative humidity was between 44 and 71% in the well ventilated room, and between 69 and 88% in the poorly ventilated room. Concentrations of CO_2 and NH_3 gases gradually increased as the days progressed. The concentration of these gases were clearly higher in the poorly ventilated room than in the well ventilated room.

TABLE 3. AIR CONDITIONS IN THE WARMED ROOM IN THE EXPERIMENTS 2 AND 3

	Experiment 2				*Experiment 3*			
	Jan.	Feb.	Mar.	Apr.	Jan.	Feb.	Mar.	Apr.
Ventilation rate (m^3/hr/head)								
Well ventilated	63.0	98.9		70.1	122.1	112.9		95.5
Poorly ventilated	9.3	9.9		7.8	10.8	12.1		12.6
Relative humidity in the warmed room (%)								
Well ventilated	44	45	49	65	74	59	55	68
Poorly ventilated	69	81	77	83	74	77	79	88
Concentration of CO_2 gas in the warmed room (%)								
Well ventilated	ND	ND	ND	0.07	0.05	0.05	0.05	0.07
Poorly ventilated	ND	0.04	0.03	0.25	0.10	0.15	0.18	0.18
Concentration of NH_3 gas in the warmed room (ppm)								
Well ventilated	ND	ND	2.0	6.0	ND	5.0	10.0	17.5
Poorly ventilated	ND	20.0	25.0	30.0	ND	25.0	35.0	35.0

ND: not detected.

Artificial milk intake of calves in the calf hutch during the first month ranged from 4.4 to 7.5 kg in the series of experiments (table 4). During the first two months it ranged from 31.4 to 41.6 kg. During the first month of experiment 1, calves exposed to the outdoor environment tended to consume more artificial milk than calves in the calf hutch and the warmed room. In the later stage (2nd month), artificial milk intake of calves in the calf hutch was as high as that of exposed calves, and tended to be higher than that of calves in the warmed room. In experiments 2 and 3, calves in either well or poorly ventilated warmed rooms tended to consume less artificial milk than those in the calf hutch or the open shed.

No significant difference was observed in initial size of the calves among housing systems, except in chest girth in experiment 2 (table 4). There were no significant differences in daily live weight gain among housing treatments in any experiment. The daily live weight gain of calves in the well ventilated warm pen (experiment 3) was lowest of all the housing treatments. No significant differences in monthly development of wither height or chest girth among housing treatments were observed, except in chest girth in experiment 2. The development of chest girth of the calves in the poorly ventilated warm room was less than those of the other treatments, and the difference in the initial chest girth became negligible by the end of fourth month.

The cummulative number of days in which any calf had coughing or diarrhea are shown in table 5. No calf had coughing or diarrhea in experiment 1 but some calves experienced one

TABLE 4. PERFORMANCES OF CALVES REARED IN THE SEVERAL HOUSING SYSTEMS

	Experiment 1				Experiment 2				Experiment 3				
	Exposed outdoor	Calf hutch	Warmed room	SEM	Calf hutch	Warmed room (W-V)	Warmed room (P-V)	SEM	Calf hutch	Open shed	Warmed room (W-V)	Warmed room (P-V)	SEM
Artificial milk intake (kg)													
First month	10.0	7.5	7.4	2.29	4.4	1.5	2.2	0.99	6.5	7.9	2.0	6.5	1.14
First and 2nd month	43.2	41.6	35.1	4.12	31.7	22.7	22.0	4.04	37.3	35.2	15.6	28.9	4.26
Initial size of calves													
Live weight (kg)	47.1	50.4	49.6	2.38	46.4	46.0	51.8	1.96	46.5	46.7	52.3	50.4	2.86
Wither hight (cm)	77.9	80.7	77.0	0.95	78.1	76.8	79.8	1.10	78.9	78.9	77.4	77.4	1.26
Chest girth (cm)	81.8	83.0	80.8	1.11	79.3[a]	80.2[a]	84.2[b]	0.88	81.7	81.0	83.7	83.7	1.35
Daily live weight gain (kg)													
First month	0.71	0.68	0.79	0.09	0.64	0.65	0.59	0.06	0.66	0.61	0.48	0.63	0.07
Second month	0.83	0.98	0.96	0.06	0.77	0.76	0.75	0.05	0.84	0.78	0.69	0.85	0.08
First-4th month	0.76	0.79	0.82	0.05	0.75	0.71	0.74	0.04	0.80	0.74	0.72	0.78	0.05
Monthly development of wither height (cm)													
First month	6.0	5.0	8.6	1.11	5.4	6.6	5.6	0.89	5.1	5.3	6.4	7.6	0.72
Second month	3.5	5.1	4.7	0.75	4.8	4.7	3.9	0.31	6.5	3.5	4.4	4.1	0.79
First-4th month	4.9	5.0	6.4	0.40	5.0	5.2	4.8	0.38	5.5	5.1	4.9	6.0	0.32
Monthly development of chest girth (cm)													
First month	12.7	11.2	12.7	1.36	10.7[ab]	11.8[a]	8.2[b]	0.84	10.5	9.6	10.6	9.9	1.14
Second month	10.6	10.1	8.0	0.86	10.5	8.7	8.3	0.77	9.5	9.1	6.8	9.8	1.32
First-4th month	10.1	9.8	9.0	0.83	10.1[a]	9.7[a]	8.3[b]	0.33	9.7	9.0	8.7	8.9	0.60

of the ailments in experiments 2 and 3. Most diarrhea was observed in the first month, and there was no difference among housing treatments. On the other hand, most coughing was observed after four weeks of age, especially in the poorly ventilated room. Calves in the well ventilated room also had persistent coughing during experiment 3. Large-type mycoplasma was detected in snivel from all calves, except one calf in the calf hutch in experiment 2. No myco- and ureaplasma were detected, and antibody titre for adeno virus−7 and para-influenza-3 did not increase during experiment 3.

TABLE 5. CUMMULATIVE NUMBERS OF DAY ON WHICH ANY CALF HAD COUGHING OR DIARRHEA

	Experiment 1		Experiment 2		Experiment 3	
	Coughing	Diarrhea	Coughing	Diarrhea	Coughing	Diarrhea
Outdoor	0	0	–	–	–	–
Calf hutch	0	0	2	4	2	6
Warmed room						
(W-V)	0	0	2	1	17	6
(P-V)	–	–	22	6	30	5
Open shed	–	–	–	–	8	7

Coughing and diarrhea were observed during feeding.

Discussion

Outdoor air temperature stayed below freezing point throughout in January and Feburuary, and daily minimum temperature often dropped to −20℃. Though it was slightly warmer than outdoors, calves in the simple housings had to experience colder environment than their critical temperature (Gonzalez-Jimenez and Blaxter, 1962; Webster et al., 1978). As Hoshiba et al. (1988) pointed out, calf hutches protected calves from snowfall and wind from any direction. However, calves in the open shed sometimes had some snow on their back after blizzard. This indicates that protection from wind is less perfect in the open shed than the calf hutch.

Calves exposed to the outdoors consumed more artificial milk during the first month than those in the calf hutch and warmed room. However, no beneficial effects on growth and development were observed. This indicates that the calves had to consume more nutrients to maintain body temperature in the severe coldness of the outdoors. Higher artificial milk consumption in the calves in the open shed or in the calf hutch than the warmed room also reflects cold environment, and may be explained by the same causes.

Calves in the poorly ventilated room consumed more artificial milk than those in the well ventilated room in experiment 3. The cause of the difference is not clear.

The results of the present study indicate that provision of such simple housing with enough bedding as a calf hutch or an open shed allows normal growth without any adverse effect of coldness.

Okamoto (1989) pointed out that newborn calves with average capacity for summit heat production rarely succumb to hypothermia so long as their hair coat is kept dry in the still air. The results obtained in experiment 1, which included exposure to outdoor environment confirm this theory.

On the other hand, there are wide variations in summit metabolism of newborn calves (Okamoto et al., 1986), and therefore, low vigor calves may not survive in wet windy conditions near freezing point. It is recommended that newborn calves should be protected from wind and precipitation to maintain a minimum thermal requirement for low vigor calves and also thermal comfort for normal calves.

A tendency towards an increase in coughing with increasing CO_2 and NH_3 gas concentration in poorly ventilated room indicated that the ventilation rate was not enough. While no microbial evidences were available, it is considered

that enough ventilation is important to prevent pneumonia or catching a cold.

In conclusion, satisfactory ventilation should be considered in preference to keeping a warm temperature. However, a roof for protection from rainfall or snowfall, and walls for protection from wind, are considered to be essential for newborn calves. Dry bedding such as straw is helpful for thermal comfort. Calf hutches or open sheds can satisfy both thermal and ventilation requirements of newborn calves. Calves in such simple housing require more artificial milk, and should be fed artificial milk *ad libitum* during the first two months to enhance normal growth and development.

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