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Effect of housing on the performance of double-muscled rearing calves*

Leo Fiems**, Sam De Campeneere, Bernard Cottyn, Charles Boucque

National Institute for Animal Nutrition, Agricultural Research Centre-Ghent, Scheldeweg 68, B-9090 Melle-Gontrode, Belgium

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Abstract – The effect of housing in indoor pens or outdoor hutches was investigated with 23 male and 22 female double-muscled calves of the Belgian White-blue breed during a 20-week rearing period. Calves in both housing systems were fed the same diet, consisting of a restricted amount of milk products, a maximum of 3 kg of concentrate per day and grass hay ad libitum. They were weaned when the weekly concentrate intake was 3.5 kg at least. Preweaning daily liveweight gain was higher for hutch-housed calves (0.58 kg) than for the indoor-housed animals (0.46 kg), without an effect on intake. This resulted in a better energy efficiency (14.6 MJ/kg gain) in comparison with pen-housing (17.8 MJ). Postweaning daily liveweight gain was not dependent on housing (1.01 kg for hutches vs. 1.04 for pens), but hutch-housed calves consumed slightly more feed, so that energy efficiency was lower (19.2 vs. 18.3 MJ/kg gain). For the entire period, animal performance of calves housed in outdoor hutches or indoor pens was not significantly different. The major effect of housing was a reduction of the number of morbid calves for hutch-housing during both the preweaning period and the whole experiment (9 and 22%) in comparison with pen-housing (55 and 73%). Furthermore, the number of days with medication within sick calves as well as within all calves present was also higher for pen-housed calves. (© Elsevier / Inra)

calf / rearing / housing / growth / intake / health

Résumé – Effet de la stabulation sur les performances des veaux d'élevage culards. L'effet de la stabulation dans des boxes individuels à l'intérieur ou dans des huttes à l'extérieur a été étudié avec respectivement 23 veaux mâles et 22 femelles Blanc-Bleu-Belge de type culard, pendant une période d'élevage de 20 semaines. Tous les veaux ont reçu la même ration à base d'une quantité limitée de produits laitiers, un maximum de 3 kg de concentrés par jour et du foin à

* Communication No. 1029 of the Institute

** Correspondence and reprints
Tel.: (32) 09 252 26 01; fax: (32) 09 252 52 78.

satiété. Ils ont été sevrés à partir d'une ingestion hebdomadaire de 3,5 kg de concentrés. Le gain de poids vif journalier avant le sevrage a été plus élevé pour les veaux logés dans les huttes (0,58 kg) en comparaison avec celui des veaux logés dans les boxes (0,46 kg), sans que l'ingestion n'ait été modifiée. Par conséquent, l'efficacité alimentaire était plus favorable (14,6 MJ/kg de gain) comparativement au logement en box (17,8 MJ). Après sevrage, le gain de poids vif journalier n'a plus été influencé par le mode de stabulation (1,01 kg dans les huttes et 1,04 dans les boxes), mais les veaux logés dans des huttes ont consommé davantage, d'où une efficacité alimentaire inférieure (19,2 vs. 18,3 MJ/kg de gain). Pour la période d'élevage totale, les performances n'ont pas été influencées par le mode de stabulation. L'effet le plus important de la stabulation a été la réduction du nombre des veaux malades dans les huttes avant le sevrage et pendant la période totale (9 et 22 %) en comparaison avec le logement à l'intérieur (55 et 73 %). En outre, le nombre de jours avec médication, exprimé par veau malade ou par veau présent, a été plus élevé chez les veaux élevés à l'intérieur. (© Elsevier / Inra)

veau / élevage / stabulation / croissance / consommation / santé

1. INTRODUCTION

During the last decades, more and more attention has been devoted to the housing of animals to improve their welfare [21]. The type of housing for rearing calves may vary from a controlled-environment house to an improvised shelter, and depends on the method of rearing. Daenicke and Piotrowsky [6] reported higher growth rates for calves kept in an uninsulated barn in comparison with warm housing. However, Bøe and Havrevoll [2] found that uninsulated housing resulted in a lower daily gain during the first weeks, compared to warm housing. Van Horn et al. [25] compared three housing systems for calves: bedded pens in a closed barn, outdoor movable pens, and elevated slatted floor pens, and found that growth rate was similar for the three systems. Other studies were conducted to investigate the effect of housing on health aspects. Holstein male calves reared in confinement housing had more stress, resulting in a decreased immune response to a specific antigen, as well as a decreased plasma ascorbate concentration in comparison with calves housed in hutches [5]. Furthermore, the calves had lower plasma immunoglobulin-G concentrations and a higher plasma cortisol concentration. Roth and Kaeberle [20] showed that glucocorticoids are immunosuppressive in cattle. Quigley et al. [18] reported that the prevalence of *Cryptosporidium* and *Eimeria* was reduced with a tendency for a reduced prevalence of rotavirus when Jersey calves were housed in hutches, in comparison with individual calf barn housing.

Based on the improved health aspects of calves in hutches, a better animal performance would also be anticipated. This condition may become more important in double-muscled calves, as a poor viability has been reported for this type of animal [14]. Moreover, the reduced lung capacity of these animals [11, 12] may make them more susceptible to respiratory problems when confined indoors.

This report compares the effect of housing in a 'closed barn' or in hutches on animal performance in double-muscled rearing calves.

2. MATERIALS AND METHODS

Forty-seven double-muscled calves of the Belgian White-blue breed (25 males and 22 females) were involved in a comparison of type of housing on animal performance and health

during a 20-week rearing period. They were born to the beef cow herd at the Institute and were allocated to one of the housing facilities after a stay in the nursing house up to 3 days after birth. They were individually housed, either in a 1.45 × 1.6 m indoor pen (14 males and 10 females) or in a 1.4 × 2.3 m outdoor hutch with a 1.3 × 1.75 m fenced area in front (11 males and 12 females). Hutches were foreseen with an air vent at the back. The 'calf barn' was insulated and air-warmed up to at least 5 °C. Calf pens and hutches were bedded with straw. The calves were weighed at 2-week intervals. A double weighing occurred at weaning and at the end of the experiment.

During the first weeks the calves received a restricted milk diet of 4 L daily, fed in two meals. The milk diet consisted of surplus colostrum, diluted with water and fed in the ratio 3:1, cow's milk from the dairy herd at the Institute produced above the milk quota, or else milk replacer [8]. Similar quantities of each were fed within each treatment. Weaning occurred when the concentrate intake was at least 3.5 kg per week. Concentrate was administered ad libitum from an actual age of 2 weeks onwards and intake was near ad libitum up to 3 kg per day. Grass hay in a rack (from 2 weeks onwards) and drinking water (via a nipple for indoor-housed calves or a bucket for hutch-housed calves) were freely available throughout the experiment. Feed administration was recorded daily and refusals were weighed after each meal for the milk diet, or at least once a week for concentrate and hay. Mean composition and nutritive value of the feeds are shown in *table I*. Net-energy-lactation (NEL) value [24] of the dairy products was estimated using the digestibility coefficients reported by Parrish et al. [17]. NEL-value of solid feeds was calculated according to Cottyn et al. [4], while the protein values were expressed according to Tamminga et al. [23].

Data were statistically analyzed according to a 2 × 2 factorial design, using housing and sex as the main factors. Differences between the four groups were also tested for significance. As the initial live weight differed among groups, it was used as a covariate. The number of sick calves within each housing system was compared by a χ^2 test.

3. RESULTS

Two male calves in the indoor pens died after 21 and 123 days, respectively, because of diarrhea and influenza. In the surviving calves, 16 of the 22 calves in indoor pens (73%) became morbid in the course of the experiment, compared with only five of the 23 animals in outdoor hutches (22%). The frequency of morbid calves was higher for indoor housing than

Table I. Chemical composition and nutritive value of the feeds.

	Milk**	Milk replacer	Concentrate	Grass hay
Dry matter (DM; g/kg)	129	955	873	847
DM composition (g/kg)				
Crude protein	223	240	191	136
Ether extract	357	140	17	19
Crude fibre	–	–	90	293
Ash	58	88	73	96
Nutritive value of DM				
NEL (MJ/kg)	14.2	10.6	7.5	5.8
PDI* (g/kg)	205	221	111	83
RDP* (g/kg)			23	– 27

* Protein values (protein digested in the small intestine, and degradable protein balance in the rumen) expressed according to Tamminga et al. [23]. ** Mean composition of cow's milk and diluted colostrum.

for outdoor hutches ($P = 0.001$). Moreover, calves housed in hutches needed fewer days of medical treatment (*table II*). As both the frequency of morbidity and the lower number of days of medication per morbid calf in hutch-housed calves, the number of days of medical treatment per calf present was significantly lower for hutch-housing. Most sanitary problems occurred prior to weaning, where 12 indoor-housed calves (55%) were morbid, compared with six animals (27%) after weaning. The frequency of morbidity in outdoor-housed calves amounted to 9 and 14%, respectively.

There was a significant effect of housing and sex on live weight at weaning (*table III*). Male calves were heavier than females, and calves housed in hutches were heavier than calves kept indoors. Postweaning liveweight gain was not different. Live weight at the end of the experiment was not significantly affected, either by housing or by sex.

Total DM-intake nor total net-energy intake for the entire period were different among groups (*table IV*). However, calves housed in hutches ate more grass hay ($P = 0.002$). Daily DM intake per kg $W^{0.75}$ was not affected by the two main factors (house and sex), but there was a tendency for a higher postweaning intake in calves housed in hutches. Initial NEL intake was not affected by housing, but energy intake was higher in male animals ($P = 0.006$). Sex exerted no effect on the conversion

Table II. Effect of housing on aspects of animal health.

	Indoor pens		Outdoor hutches		Pooled	Significance		
	Males	Females	Males	Females	S.E.	Housing	Sex	Interaction
Initial number of calves	14	10	11	12				
Calf losses	2	0	0	0				
Start-weaning								
Morbid calves*	6	6	1	1				
Days of medication*								
per animal treated	2.72[a]	4.42[a]	4.64[a]	0.47[a]	2.02	0.675	0.592	0.180
per animal present	1.52[ab]	2.23[a]	0.62[ab]	0.05[b]	2.65	0.018	0.922	0.297
Weaning-20th week								
Morbid calves*	3	3	2	1				
Days of medication*								
per animal treated	3.95[a]	5.34[a]	1.08[a]	0.95[a]	1.92	0.174	0.788	0.743
per animal present	0.88[a]	1.78[a]	0.07[a]	0.28[a]	2.94	0.047	0.355	0.639
Start 20th week								
Morbid calves*	8	8	3	2				
Days of medication*								
per animal treated	3.33[ab]	5.90[a]	1.24[ab]	0.21[b]	2.96	0.036	0.644	0.264
per animal present	2.41[ab]	4.00[a]	0.48[b]	0.32[b]	2.39	0.001	0.434	0.275

* Within the surviving animals; least square means, adjusted for initial weight.
[ab] Values with similar superscripts are not different ($P > 0.05$).

Table III. Effect of housing on live weight and daily liveweight gain (least square means, adjusted for initial weight).

	Indoor pens		Outdoor hutches		Pooled	Significance		
	Males	Females	Males	Females	S.E.	Housing	Sex	Interaction
Number	12	10	11	12				
Initial weight (kg)	50.1^{ab}	42.9^{c}	54.6^{a}	45.6^{bc}	7.4	0.109	0.000	0.674
Weight at weaning (kg)	83.2^{a}	69.2^{b}	85.7^{a}	83.3^{a}	9.1	0.006	0.013	0.040
Final weight (kg)	160.0^{a}	157.6^{a}	165.6^{a}	163.8^{a}	15.8	0.234	0.700	0.950
Days on milk diet	68.2^{a}	49.6^{b}	64.4^{a}	60.7^{ab}	13.4	0.391	0.020	0.070
Daily gain (kg)								
– start to weaning	0.51^{ab}	0.42^{b}	0.58^{a}	0.57^{a}	0.11	0.002	0.141	0.233
– weaning to end	1.05^{a}	0.98^{a}	1.05^{a}	1.02^{a}	0.12	0.551	0.237	0.628
– entire period	0.80^{a}	0.78^{a}	0.84^{a}	0.82^{a}	0.11	0.233	0.699	0.951

^{ab} Values with similar superscripts are not different ($P > 0.05$).

of the DM and NEL. The conversion of DM and NEL showed an opposite result prior to and after weaning. Feed efficiency was better in hutch-housed calves during the preweaning period, but less favorable afterwards. During the entire period, there was no effect of housing on feed conversion, while females showed a tendency for a higher feed conversion.

There was hardly an interaction between housing and sex. The interactions were related to the preweaning period, i.e., the weaning live weight and the number of days on the milk diet (*table III*), and the DM intake from the milk diet (*table IV*).

4. DISCUSSION

The reduced medical treatment in hutch-housed calves in our experiment may be the consequence of isolation from other calves offered by the hutches. This was particularly true as during the 3-month calving period, calves were housed in hutches which were clean and in a disease-free environment, while the indoor calves were introduced to clean pens in an airspace contaminated by the presence of older calves. The young calf is rather in an uncomfortable position, because of the postnatal process of immunological maturation [26]. A higher plasma concentration of immunogobulin-G has been reported by Cummins and Brunner [5] for hutch-housed calves. These authors also found lower plasma cortisol concentrations in calves housed in hutches. Furthermore, corticosteroids are known to be immunosuppressive in cattle [20]. Reduced sanitary problems in hutch-housed calves were found in experiments of McKnight [13], Anderson and Bates [1] and Larsen et al. [10]. Although there is no evidence of any deficiency in the immune response of double-muscled animals [15], they are more susceptible to respiratory diseases [12]. Therefore, it may be concluded that double-muscled animals benefit more from hutch-housing than non-double-muscled ones. Nevertheless, Webster [27] stated that housing is one of the most

Table IV. Effect of housing on feed intake (least square means, adjusted for initial weight).

	Indoor pens		Outdoor hutches		Pooled	Significance		
	Males	Females	Males	Females	S.E.	Housing	Sex	Interaction
Dry matter intake (kg)								
milk diet	33.5[a]	22.3[b]	31.5[a]	30.8[a]	7.8	0.188	0.032	0.029
concentrate	176.9[a]	206.9[a]	184.8[a]	192.4[a]	33.1	0.751	0.107	0.266
grass hay	33.2[a]	32.4[a]	48.9[b]	42.9[b]	12.9	0.002	0.453	0.501
total	243.6[a]	261.7[a]	265.2[a]	266.1[a]	33.0	0.209	0.408	0.391
Total net energy intake (MJ)	1990[a]	2056[a]	2079[a]	2126[a]	203	0.210	0.427	0.872
Dry matter intake per kg $W^{0.75}$ (g/d)								
start-weaning	34.8[a]	34.4[a]	36.8[a]	34.7[a]	3.6	0.306	0.328	0.419
weaning-20th week	71.3[a]	71.6[a]	73.6[a]	74.4[a]	4.8	0.099	0.754	0.878
start-20th week	53.1[a]	57.7[ab]	56.8[ab]	57.5[b]	5.1	0.262	0.146	0.211
per kg gain (kg)								
start-weaning	1.59[ab]	2.03[b]	1.45[a]	1.46[a]	0.49	0.026	0.194	0.141
weaning-20th week	2.50[a]	2.55[ab]	2.63[ab]	2.71[b]	0.21	0.032	0.390	0.785
start-20th week	2.22[a]	2.39[a]	2.27[a]	2.32[a]	0.20	0.939	0.113	0.304
Net energy intake per kg $W^{0.75}$ (MJ/d)								
start-weaning	0.37[a]	0.32[b]	0.37[a]	0.33[b]	0.05	0.721	0.006	0.748
weaning-20th week	0.52[a]	0.52[a]	0.53[a]	0.53[a]	0.03	0.271	0.628	0.770
start-20th week	0.43[a]	0.45[ab]	0.44[ab]	0.45[b]	0.03	0.230	0.109	0.573
per kg gain (MJ)								
start-weaning	17.4[ab]	18.1[a]	15.2[ab]	13.9[b]	4.2	0.016	0.849	0.448
weaning-20th week	18.2[a]	18.5[a]	19.0[ab]	19.4[b]	1.5	0.076	0.484	0.828
start-20th week	17.8[a]	18.7[a]	17.7[a]	18.2[a]	1.7	0.580	0.281	0.683

[ab] Values with similar superscripts are not different ($P > 0.05$).

important stressors, but he estimated that a possible heat or cold stress from outdoor housing is offset by a greatly superior air hygiene.

Hutch-housing exerted a beneficial effect on preweaning growth rate, which is in agreement with the findings of Richard et al. [19]. Improved initial performance may be due to a better health in calves housed in hutches. For the entire period, housing did not affect daily liveweight gain, a finding similar to results of Van Horn et al. [25], McKnight [13] and Richard et al. [19]. A significant effect of housing type on growth rate was not observed in experiments of Murley and Culvahouse [16] and Willett et al. [28].

The improved preweaning growth rate in hutch-housed calves was not provoked by an increased feed intake, but coincided with an improved feed efficiency in terms of DM, as reported by Richard et al. [19]. It is known that the integrated response after pathogenic challenges is one in which nutrients are repartitioned to immune-related processes that take prece-

dence over growth [22]. Postweaning feed efficiency was better in pen-housed calves in spite of equal liveweight gains. Some compensatory effect was also observed by Richard et al. [19]. The postweaning period coincided with summer. The higher ambient temperature during the summer may have increased heat stress. The lower feed efficiency in hutch-housed calves during the postweaning summer months in the present experiment may be a consequence of a higher temperature [3].

Outdoor housing stimulated calves to consume more grass hay, although total DM intake was not different ($P = 0.209$). There was no indication that indoor-housed calves have a greater preference for straw, so that total roughage intake would be similar for both treatments. A higher feed intake was also observed in the experiment of McKnight [13]. However, Jorgenson et al. [9] did not observe any effect of housing on feed intake. Murley and Culvahouse [16] reported that concentrate consumption was not affected by type of housing, but calves in outdoor hutches consumed 19% more hay than in indoor pens. Fallon [7] compared hutches and conventional housing for male Friesian calves. There was no difference in intake and daily gain between the housing types, but the number of hutch-housed calves treated for respiratory disease was reduced.

In conclusion, double-muscled calves raised in hutches had an improved health status with a similar overall liveweight gain and feed efficiency as pen-housed animals.

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