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Effect of Various Flooring Types on the Growth, Some Behavioural Characteristics and Hematological Parameters of Friesian Calves

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ABSTRACT

The early phase of the young animals' life is so crucial because the calves are too susceptible to environmental and housing factors such as floor and bedding materials. The goal of this study was to determine the effect of flooring materials on the behavior and performance of Friesian dairy calves. Twenty-seven female Friesian calves, with an average body weight of 38 ± 2.3 kg were randomly assigned according to their average body weight into three groups for a period of 120 days. Each group contained nine calves with three replicates. The calves in the first group were housed in an experimental pen with concrete floors. The calves in the second group were housed in an experimental pen with rubber mat. While, the calves in the third group were housed in an experimental pen with long rice straw bedding. The results revealed that there was a significant (P<0.05) increase in feed intake and body weight gain on the concrete and long rice straw beddings (P<0.05). The feed conversion ratio was significantly improved in rubber mat. The ingestive behavior (feeding and drinking time) was improved in the concrete floor group. On the other hand, the longest and shortest resting duration of the calves after feeding belonged to the rubber mat and straw bedding. However, bedding substrates had no effect on hemato-biochemical blood parameters except for oesinophils and neutrophils. It could be concluded that the concrete floor substrate was excellent in terms of growth performance and the behavior of calves. While, the rubber mat substrate is more comfortable for Friesian calves to get more rest.

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TMM-B presented conception and design of the study. Material preparation, data collection and analysis was performed by all authors. The first draft of the manuscript was written by TMM-B, and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

Key words
Concrete flooring, Growth performance, Behavioral traits, Friesian calves, Feed conversion ratio

INTRODUCTION

Good health and growth performance of dairy calves are important aspects of dairy herd management as, the animal welfare and performance are affected by the conditions underfoot (Kimeli *et al*., 2021). Improved flooring in dairy cattle housing systems has received considerable attention in recent years (Telezhenko, 2007).

It was observed that the floor and bedding materials are important during the early stage of a calf's life to provide comfort, decrease the risk of contracting disease, and reduce stress, as well as animal health and welfare are concerned (Panivivat *et al*., 2004). An effort has been undertaken to reduce the stress on the animals caused due to adverse climatic conditions resulting in improved production (Navarini *et al*., 2009). It was also reported that adequate rest is essential for the welfare of young growing animals, and there is a positive relationship between growth rate and the amount of rest (Hanninen *et al*., 2005).

The ideal floor of the calf pens has to be neither too slippery nor too hard (for lying). A slippery floor disturbs locomotion and may limit the animal from other behaviors (Stefanowska *et al*., 2002). The bedding substrate used in animal housing not only facilitates warmth and comfort, but can also affect the cleanliness (Panivivat *et al*., 2004), weight gain, the incidence of diarrhea (Hill *et al*., 2011), skin surface temperature (Sutherland *et al*., 2013) and behavior of animals. A number of organic (rice straw and sawdust) and non-organic (concrete and rubber mattress) bedding materials can be used as rearing substances as they provide more comfort to animals in adverse climatic conditions and result in improved health, better growth, and high productivity (Hill *et al*., 2011). Nowadays, the trend has moved away from organic bedding materials, due to hygiene concerns, labor and transportation costs, which can affect the total on-farm price and use (Kartal

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and Yanar, 2011). Vanegas *et al*. (2006) reported that dairy calves had a high preference for rubber bedding due to it having better legs and hoof health. On the other side, it is generally accepted that organic bedding material, such as straw, is favored by cows over non organic materials, such as concrete, and that cows lie for longer when offered organic material (Bergsten, 2010; Fraser *et al*., 2013).

The most essential daily activities of the animals are lying down. The time that animals normally spend lying down is between 8 and 16 hours each day (Tucker *et al*., 2009). Adequate rest is essential for the animal's health and welfare (Tucker *et al*., 2021). The growth hormone is reduced in calves deprived of rest (Munksgaard and Simonsen, 1996). Not only, the duration of rest is needed, but also, the quality of rest is important which is influenced by bedding characteristics such as the amount, type, and moisture (Schütz *et al*., 2019). There was a significant alteration in the lying behavior of calves housed on a concrete floor, such as a higher proportion of atypical lying down and standing up movements and fewer periods of lying when compared with calves kept in pens with a bedded lying area (Mayer *et al*., 2002; Ruis-Heutinck *et al*., 2002). Animal welfare improved by using deep, dry, and clean bedding materials (Fregonesi *et al*., 2004). Dairy calves raised on cattle farms are kept in pens with concrete floors and/or long rice straw as bedding material (Thickett *et al*., 2003). Cozzi *et al*. (2013) mentioned that there was relationship between floor type (concrete floors, a perforated floor and a perforated floor coated with a rubber mattress) and the average body weight gain of finishing dairy calves. Finally, Norheim and Simensen (1985) reported that calves kept on elevated, perforated floors had higher immunoglobulin-G (IgG) than calves kept on a solid floor without bedding However, when the calves were older than 30 days, concentrations of IgG were the greatest when the calves were kept on the solid floor with the use of some bedding. Therefore, this study was designed to evaluate the effect of different floor types (concrete, rubber mat, and long rice straw) on the performance, behavior and blood parameters of dairy Friesian calves.

MATERIALS AND METHODS

Ethical considerations

Ethical considerations of the protocol of this study have been approved and conducted in accordance with recommendations of the guide lines of animal care and use of lab animals in the research by the Animal Ethics Committee, Faculty of Veterinary Medicine, Kafrelsheikh University, Egypt.

Animals and experimental design

Twenty-seven female Friesian calves (n=27), with an average body weight of 38 ± 2.3kg, were randomly assigned to one of three groups for 120 days. Each group contained 9 calves with three replicates stocked at a density of 2.73 m^2/head. The calves in the first group were housed in an experimental pen with concrete floors. The calves in the second group were housed in an experimental pen with rubber mat. While, the calves in the third group were housed in an experimental pen with long rice straw bedding. The rubber mat were fixed on the concrete floor and the pen in the third group was bedded daily with 2 kg of long rice straw. The calves were allowed to suckle their dams and received colostrum for first three days. The amount of milk given to the calves was kept constant at 8 % of their birth weight during the milk feeding period as suggested by Yanar *et al*. (2010). All calves were weaned at two months of age. Each calf was fed individually on starter and dry hay *ad libitum* throughout the experiment. The chemical composition of the starter was 88% dry matter, 18% crude protein, 4.8% ether extract, 8.0% crude ash, 12% crude cellulose (The starter is a completely mixed diet. which was adjusted according to the NRC (2001).

Data collection

The body weights were determined at weaning, 3 and 4 months of age. The weighing system was calibrated in the morning before the animals were fed. The quantity of feed consumed daily was recorded. The feed was delivered twice (in the morning and evening). The feed was weighed into each pen every day throughout the experiment and refusals were measured at the pen level twice weekly. Animals had *ad libitum* access to drinking water.

Behaviors

Weekly behavioral activities of the calves were observed by using an instantaneous sampling method as described by Martin and Bateson (1993). Behavior was recorded for each of the following activities by a slight modification of the methods of Panivivat *et al*. (2004) in which (1) resting or lying (calf's body contacted bedding and ground), (2) standing (calf was inactive in an upright position), (3) feeding or eating (calf's head was in feed bucket), and drinking (calf's head was in water bucket). The percentage of time spent on each activity was calculated for each week. The animals were kept inside pens throughout the study except for the periods when they were moved to a holding pen for blood sampling and weighing.

Blood sampling

Under aseptic procedures, blood samples were taken

via jugular vein puncture on weaning day, 3 and 4 months. For this procedure, the animals were moved to a holding pen with a squeeze chute facility and blood sampled were taken with minimal restraint. Blood sampling was carried out by an experienced operator on each occasion to collect the blood samples was less than 60 s/animal. Blood samples were collected into (1×6 ml) K_3ethylene diamine tetra acetic acid (K_3EDTA) tubes (Vacuette, Cruinn Diagnostics, Ireland) for hematological analysis. Heparinized blood samples (1×9 ml) were collected and the plasma was separated by centrifugation at 3000 rpm for 10 minutes. Plasma was aspirated and subsequently stored at −20 °C until assayed for total protein using a handheld refractometer (Calloway *et al*., 2002) and albumin on an automatic clinical analyzer (Olympus AU400 Clinical Analyzer, Tokyo, Japan) using the reagents supplied by Olympus (catalogue number OSR6132) (Olympus UK Ltd., Voice House, Watford, Hertfordshire, WD24 4JL, UK). The concentration of albumin was determined (Calloway *et al*., 2002) on an automatic clinical analyzer (Olympus AU400 Clinical Analyzer, Tokyo, Japan) using the reagents supplied by Olympus (catalogue number OSR6102). The composition of the reagents (at final concentration) required for this test were; succinate buffer (pH 4.2) (100 mmol/L) and bromocresol green (0.2 mmol/L), and following gentle inversion the reagents were ready to use directly from the kit.

Hematology profiles were determined according to Leso *et al*. (2020). Using 6 ml of K3 EDTA whole blood using an automated hematology analyzer (Celltac MEK-6108K; Nihon-Kohdon, Tokyo, Japan) and reagents supplied by Celltac (Alpha Technologies, Dublin, Ireland).

Statistical analysis

Data were reported as means ± standard error (SE) and analyzed by one-way ANOVA using Graph Pad prism 5 (Graph Pad Prism v5.0, San Diego, CA, USA). The significance of difference among the different groups was evaluated by Tukey's post hoc multiple comparison test. The significance level was set at $P < 0.05$.

RESULTS AND DISCUSSION

Data in Table I show that the highest feed intake was related to the concrete and long rice straw beddings and the lowest consumption was related to the rubber mat bedding (P<0.05). Also, the highest weight gain was related to the concrete and rice straw, whereas the lowest weight gain was related to the rubber mat (P<0.05). The feed conversion ratio of calves on rubber mat bedding was significantly increased, i.e. not improved, in comparison to the rice straw and concrete bedding (P<0.05). The lower feed intake was reported in the rubber mat bedding group than the other groups, possibly due to the rubber mat floor providing the maximum comfort to calves and more time to lie down on the floor compared to the concrete floor and subsequently, consumption was reduced and eventually the animal lost weight (Gascon *et al*., 2012) These results are in accordance with Hanninen (2005) who stated that the rate of weight gain can be affected by the softness and comfort of the bedding so that more comfortable bedding allows the calf to consume more feed and grow more. These results are contrary to that obtained by Szyndler and Kaczor (2003) who mentioned that the total weight gains in the pre-weaning period and weaning and 4 month age groups were not significantly influenced by the type of floor.

The results related to the effect of flooring substrates on the behavior of calves are presented in Table II. The highest feeding time was related to the concrete floor, which was significantly different from the straw and rubber mat bedding (P<0.05). Moreover, the duration of drinking water in the concrete flooring increased significantly in comparison to the rubber mat, and straw bedding (P<0.05). On the other hand, the longest and shortest resting duration of the calves after feeding belonged to the rubber mat and straw bedding, respectively, which were significantly different from the concrete bedding (P<0.05).

Table I. Effect of flooring types on performance of Friesian calves.

	Concrete (n= 9)	Rice straw (n= 9)	Rubber mat (n= 9)	P-value (n= 9)
Initial body weight (kg)	38±0.63^a	38±0.71^a	38±0.49^a	0.1229
Final body weight (kg)	108.6±0.12^a	102.7±0.35^b	96±0.24^c	0.0071
Body weight gain (kg)	70.6±0.56^a	64.7±0.24^c	58±0.36^b	0.0040
Water intake (L)	46±0.51^a	40.2±0.62^b	40±0.35^b	0.0072
Food intake (kg)	54.2±0.64^a	46.8±0.82^b	40.3±0.74^c	0.0086
Food conversion ratio (FCR)	0.767±0.12^a	0.723±0.43^b	0.694±0.32^c	0.0124

*The means in the same row, which superscript different letter different have significant difference at ($P < 0.05$).

Table II. Effect of flooring types on behavior of Friesian calves.

	Concrete	Rice straw	Rubber mat	P value
Feeding time (h)	6.6±0.17[a]	6.1±0.11[b]	5.1 ± 0.11[c]	0.0001
Drinking time (h)	12.6±0.37[a]	11.3±0.26[b]	10.2± 0.26[c]	0.0008
Rest or lying time (h)	7.7±0.12[b]	7.2±0.37[b]	9.2 ± 0.37[a]	0.0076
Standing time(h)	6.4±0.37[a]	5.7±0.05[b]	4.7± 0.05 [c]	0.0043

*The means in the same row, which superscript different letter different have significant difference at ($P < 0.05$).

Table III. Effect of flooring types on hemato-biochemical parameters of Friesian calves.

	Concrete	Rice straw	Rubber mat	P-value
Hemoglobin (g/dl)	113.9±0.94[a]	112.8±1.31[a]	109.3±1.31[a]	0.1654
RBCs (10^6/µl)	10.0 ± 0.29[a]	10.1 ± 0.56[a]	10.2 ± 0.4[a]	0.1248
PCV (%)	0.3 ± 0.02[a]	0.4 ± 0.08[a]	0.3 ± 0.14[a]	0.2494
WBCs (x10^3/mm^3)	8.6 ± 0.55[a]	8.1 ± 0.39[a]	8.7 ± 0.49 [a]	0.1627
Neutrophils (%)	24.3 ± 0.09[a]	24.1 ± 0.35[a]	21.8 ± 0.50[b]	0.0101
Lymphocytes (%)	73.6 ± 0.12[a]	75.9 ± 0.26[a]	73.5 ± 0.24[a]	0.2108
Eosinophils	0.166± 0.11[a]	0.164±0.22[a]	0.153±0.12[b]	0.0130
Monocytes (%)	0.55 ± 0.11[a]	0.54 ± 0.09[a]	0.55 ± 0.07[a]	0.2376
Basophiles (%)	0.33 ± 0.01[a]	0.34 ± 0.09[a]	0.33 ± 0.06[a]	0.3103
Total protein (g/dl)	54.8 ± 1.44[a]	57.5 ± 0.67	56.7± 0.41[a]	0.1191
Albumin (g/dl)	34.0 ± 1.22[a]	35.9 ± 0.68[a]	34.5± 0.83[a]	0.4027

*The means in the same row, which superscript different letter different have significant difference at ($P < 0.05$).

These results may be attributed to the dirty and wet rice straw bedding material which might result in discomfort for the calves on it. As well, Hanninen *et al*. (2005) stated that this behavior originates from two characteristics of the rubber mat bedding: the first is that the bedding is cold and the second is that the bedding has low moisture, which indicates the comfort of the animals on the bedding (Camiloti *et al*., 2012). Similar results were reported for the adult animals by Fregonesi *et al*. (2007) who stated that dairy cows showed a clear preference for a dry lying surface, and they spend much more time standing outside the stall when only the wet bedding is available.

The animals in the comfort zone keep their physiological parameters in a normal range, so their body energy can be used for increasing body growth, whereas; stressed animals divert their body energy to maintain homeothermy (Kartal and Yanar, 2011). To evaluate the effect of rearing substrate on calf health and welfare, several blood hematological and biochemical parameters were measured in this study. Table III showed that the bedding substrates had no effect on any of these measures except eosinophils and neutrophils. Similar results are obtained by Panivivat *et al*. (2004) who mentioned that the flooring substrate had no effect on IgG and cortisol concentrations in calves. Also, Roland *et al*. (2014) reported that the bedding had no direct effect on the number of white blood cells in calves. However, in the present experiment, it was found that eosinophils in the two groups of straw and concrete bedding were significantly higher than in the rubber mat bedding substrate. As well as, neutrophil number decreased in calves on rubber mat (Table III). These data were attributed to the main function of eosinophils in the immune system is to fight infections and allergies arising from the dirty and wet rice straw bedding material (Majorek *et al*., 2012), and neutrophils are the first line of defense and play a major role in removing invading bacteria.

CONCLUSION

In conclusion, from the results of this study, it could be concluded that the concrete floor substrate appears to be suitable bedding material for dairy Friesian calves to get high performance. While, the rubber mat substrate is more comfortable for Friesian calves to get more rest and straw bedding is not suitable for calf raising in any aspect.

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IRB approval

The Animal Ethics Committee, Faculty of Veterinary Medicine, Kafrelsheikh University, Egypt granted IBR approval.

Ethical statement

Ethical considerations of the protocol of this study have been approved and conducted in accordance with recommendations of the guide lines of animal care and use of lab animals in the research by the Animal Ethics Committee, Faculty of Veterinary Medicine, Kafrelsheikh University, Egypt.

Statement of conflict of interest

The authors have declared no conflict of interest.

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