Journal of Animal and Veterinary Advances 9 (1): 88-95, 2010
ISSN: 1680-5593

The Effects of Seasons on the Time Budget and Area Usage of Animals in Open Loose Dairy Cattle Housing

Selda Uzal and Nuh Ugurlu
Department of Farm Structures and Irrigation, Faculty of Agriculture,
Selcuk University, Konya, 42031, Turkey

Abstract: The design of appropriate housing for cow comfort is important to increase animal production. This study was carried out to determine annual time budget and shelter area usage of cows between 2006 and 2008 in Konya-Turkey. Behavior of animals (n = 24) and barn area usage of dairy cattle was investigated loose dairy housings. Behavior of cows was observed by recording during 24 h of a day with video cameras mounted at suitable places in barn parts. The animals behaviors related to barn area preference were investigated and seasonal variation of dairy cattle housing area usage observed during to 10 days for each season. Annually average barn area usage of dairy cattle were determined as 5.84 h resting area, 8.92 h courtyard, 7.74 h feeding, 1.5 h watering and milking area in open loose barn. The effect of season on the time budget activity of dairy cattle was important. Under low temperatures and dry ground at autumn, the animal courtyard area usage increased from 2.42-13.62 h by comparison to winter. The lying behavior of animals in winter and summer increased from 32.1-47.1%, respectively. The annually time budget of dairy cattle were found as 42.2% lying, 32.3% feeding, 11.1% standing, 6.3% walking, 4.6% milking and 1.6% drinking and 1.7% others behaviors in the research. The present study showed that well design of courtyard, resting and feeding areas very important for animal health and high and qualified milk production as well as cattle management.

Key words: Cattle behavior, open loose housing, area usage of cattle, time budget, lying behavior, feeding behavior

INTRODUCTION

The animal production which has ample protein is important for well nutrition of people. Consumption of animal production shows the development level of a country in today's world. Milk consumption of a person was 85 L year^{-1} in European Countries and 25 L year^{-1} in Turkey (Anonymous, 2005).

The most important parameter in dairy farming is annual milk production of an animal. Mean milk production was 8.9 tons animal^{-1} in USA, 5.9 tons animal^{-1} in European Countries (Anonymous, 2006a) 2.6 tons animal^{-1} in Turkey and 3.1 tons animal^{-1} in Konya (Anonymous, 2006b). This situation shows that milk production per cow is low in Turkey. Poor environmental conditions, malnutrition and genetic factors are main causes low milk production (Uzal and Ugurlu, 2008).

Environmental conditions consist of structural, climatic and social factors for cows. Structural environment is constitute to dry, clean, soft and enough sized shelter areas in which animals spend their daily time without stress. Climatic environment is climatic conditions of the area, in which animals take shelter. Social environment represents groups of animals formed according to social properties of them and group size.

Webster (1994) expressed convenient temperature values between 10 and 20°C for dairy cattle. Gebremedhin and Wu (2001) emphasized that high air flow decreased temperature tolerance by increasing heat losses carried out by means of convection and evaporation from animal skin especially in the conditions of getting dirty and wet.

Animal productivity decreases in high stress factors in housing condition. Animal spends a part of their energy to overcome stress. The effects of these factors can be alleviating to design of comfortable barn areas in planning of animal houses (Ugurlu and Uzal, 2007). Design new housing model will be possible by observation of animals' behavior reaction in any area and relation between animal behavior and areas. Therefore,

Corresponding Author: Selda Uzal, Department of Farm Structures and Irrigation, Faculty of Agriculture, Selcuk University, Konya, 42250, Turkey

the lying behaviour of dairy cows attracts a lot of research interest. Changes in the behavioral activity of farm animals are widely used as welfare indicators (Muller and Schrader, 2003) and to investigate animal production parameters (Phillips and Rind, 2001). The duration and frequency of lying bouts are behavioral indicators of cow comfort (Haley *et al*., 2000).

Blowey (1994) found that dairy cows spend 45% of lying in daily time and with respect to different housing systems their lying behavior changed between 46-50%. Grant and Albright (2000) determined time budget of dairy cows in feeding behavior 3-5 h day^{-1}, lying behavior 12-14 h day^{-1}, social behavior 2-3 h day^{-1}, rumination 7-10 h day^{-1}, drinking 0.5 h day^{-1} and outside the stall (milking, walking, grooming) 2.5-3.5 h day^{-1}.

The development of alternative housing systems for dairy cattle becomes more and more important. However, low cost alternatives that offer potential benefits with regard to cow comfort are currently under investigation worldwide (O'Driscoll *et al*., 2008a, b; Tucker *et al*., 2007; Barberg *et al*., 2007).

The research was planned for developing of criteria to design new dairy cattle barns, which are suitable for animal behavior and high production performance and welfare.

Shelter area preferences of cattle were observed in different season with climatic changes (temperature, relative humidity) and time budget of animals were studied open loose housing in Konya-Turkey. The developing of correct building structure models were aimed by analyzing of animal behaviors in the research.

MATERIALS AND METHODS

The study was conducted in open loose dairy barn that sheltered 150 cows in Konya-Turkey between 2006 and 2008. In barn facilities, resting area stocking density, courtyard area stocking density, feeding length, feed alley width were 7.50 m^2/animal, 19.70 m^2/animal, 1.25 m/animal and 1.5 m, respectively.

Digital temperature-humiditymeter were utilized to determine climatic data in the barn (temperature measurement range: -40°C, +100°C, resolution: 0.03°C, accuracy: ±0.3°C; relative humidity measurement range: 0-100% rh, resolution: 0.4%, accuracy: ±3%). Measurement values were recorded at 7 different points in open loose barn. Temperature and relative humidity measurements were carried out in 3 main groups in the building. These were outside area, resting area and courtyard area. The live view system was set in experimental barn for observation of animal behaviors. The system consist of digital, colorful and day/night vision cameras (1/3" Sony HQ1 color CCD sensor, 752 (H) x582 (V) pixel, minimum light sensitivity) and 1 portable, 8 channels recording device (15" LCD display, 8 sensor inputs, 500 GB memory). Four cameras were mounted outside and inside areas of barn. The view plan of experimental building and measurement devices location was given in Fig. 1.

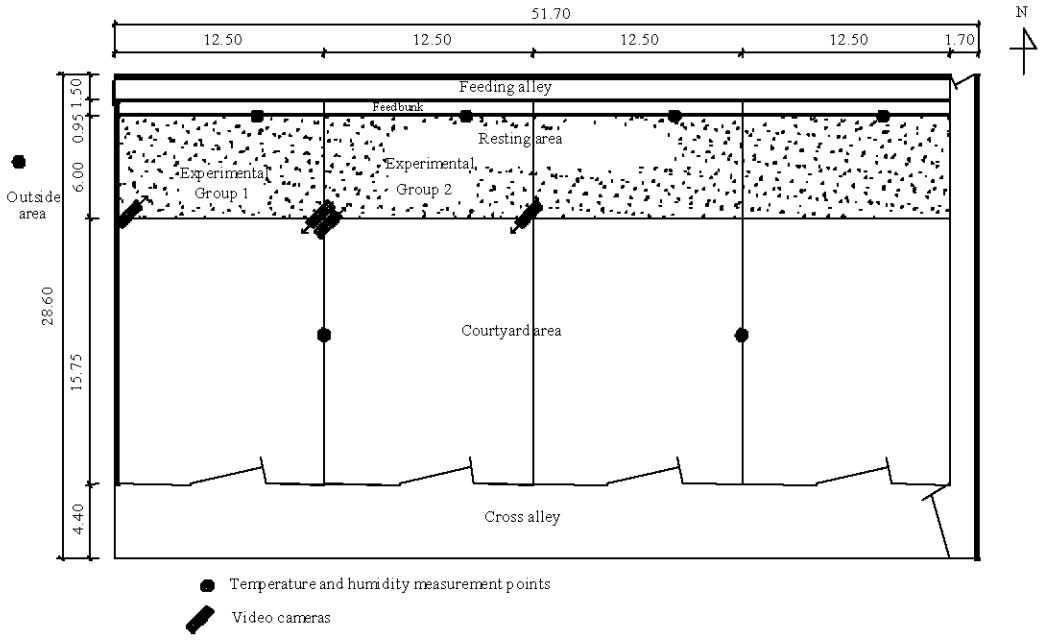

Fig. 1: The view plan of the experimental open loose housing system and location of measurement devices (m)

In study, 6 dairy cattle were selected in 1/3 ratio of experimental group and observation data was recorded during 24 h by continuous sampling method by Mitlohner *et al.* (2001), Martin and Bateson (1993), Yurtman *et al.* (2002) and Bogner (1984). In addition, Martin and Bateson (1993) was reported that the start and end time of the observed behavior, duration and frequency to be measured should be used for the continuous observation method in behavioral observations. In this research, it was used continuous recording method in order to observing of cows daily activity (lying, standing, feeding, drinking, walking, milking and social behavior). Totally, 24 animals were observed during all year in open loose dairy barn at two pen have 8-10 dairy cattle. The selected dairy cattle freely move in their pens with other animals in theirs test group. The dairy cattle behavior was timed over than 960 h by video recordings in experimental pen. To guarantee identification of dairy cattle, each of them was marked at least one day before the start of the video recordings with patterns by using yellow, green and red paints. Ten days was selected for each season with totally 40 days as recommended by of Frazzi and Calegari (2003), Wagner-Storch and Palmer (2003), Hayasaka and Ark (2002), Mitlohner *et al.* (2001) and Hernández *et al.* (2006).

RESULTS AND DISCUSSION

Temperatures and relative humidity in open loose barn for different seasons during to observation periods are given in Table 1. As shown in Table 1, temperatures at courtyard and resting area of the barn were found almost close to each other at autumn. An average high temperature was 13.7°C at resting area and 12.4°C at courtyard and average low temperatures changed between -0.8 and -2.2°C. In winter, the average low temperature was measured as -8.7°C at resting area of the barn and average high temperature was nearly -0.2°C. Average relative humidity was 87% at resting area and 95% at courtyard in winter. In spring, although average low and high temperatures were 11.7 and 27.9°C at resting

Table 1: Climatic conditions for experimental open loose barn for different observation period

		Barn parts (areas)		
Seasons	Climatic properties	Outside	Resting	Courtyard
Autumn	**Temperature (°C)**			
	Average temp.	4.1	5.6	4.4
	Average low temp.	-2.6	-0.8	-2.2
	Average high temp.	12.2	13.7	12.4
	Relative humidity (%)			
	Average rh.	75	75	77
	Average low rh	46	48	47
	Average high rh	93	90	96
Winter	**Temperature (°C)**			
	Average temp.	-6.3	-4.2	-5.9
	Average low temp.	-10.7	-8.7	-10.2
	Average high temp.	-2.0	-0.2	-1.9
	Relative humidity (%)			
	Average rh.	100	87	95
	Average low rh	87	75	86
	Average high rh	100	94	100
Spring	**Temperature (°C)**			
	Average temp.	18.0	19.3	18.4
	Average low temp.	10.4	11.7	10.9
	Average high temp.	25.3	27.9	25.7
	Relative humidity (%)			
	Average rh.	52	49	50
	Average low rh	27	25	26
	Average high rh	83	76	78
Summer	**Temperature (°C)**			
	Average temp.	24.9	26.5	25.6
	Average low temp.	17.2	18.1	17.4
	Average high temp.	31.6	36.3	33.1
	Relative humidity (%)			
	Average rh.	36	35	34
	Average low rh	18	17	17
	Average high rh	61	60	59

area, they were 10.9 and 25.7°C, respectively at courtyard. Temperature difference between resting area and courtyard was 1-2°C in summer. Resting area was found a little cooler than courtyard. While average low and high relative humidity were 17 and 60% at resting area in summer, they were 17 and 59% at courtyard, respectively. By analyzing climatic properties of barn, temperature and humidity of outside and courtyard area in all season were very close. In general, temperature value of resting area was found higher than courtyard area in all season.

The time budget of dairy cattle was shown in Fig. 2 for different season in open loose dairy barn. In the results of behavioral studies, the average annually time budget of animals were found as 42.4% lying, 32.3% feeding, 11.1% standing, 6.3% walking, 4.6% milking, 1.6% drinking 1.7% other behavior.

By examine of animal behaviors in Fig. 2 for different season, time budget of dairy cattle varied notably. Lying behaviors of animals were found about as 47% in autumn, 32% in winter, 45% in spring and 47% in summer. Lying behavior is extremely important for the well being of dairy cows and cows show strong motivation to perform the activity (Metz, 1985).

Cows modify their lying behavior according to environmental conditions and have an aversion to lying on wet and muddy substrates (Fregonesi *et al*., 2007; Tucker *et al*., 2007; Muller *et al*., 1996). The difference in lying behaviors in spring and winter are seen obviously. In addition, as lying periods was reduced and standing and feeding periods increased in winter period. The most important reason of time budget variation is wet and too dirty courtyard and resting areas. Since, animals limited lying behaviors under undesired ground conditions. The lying time is very important for milk production and efficiency decreases when the lying time is <10-12 h (40-50% of total time). As a result, for successful dairy housed system, barn areas must be well designed in aspect of animal behavior. Adequate lying times are essential to the well being of the dairy cow and indeed dairy cow comfort is often measured in terms of time spent lying (Overton *et al*., 2002). Cows also stood for prolonged periods, which resulted in lying times that were well below the normal 12-13 h day^{-1} (50% of time budget) (Jensen *et al*., 2005; Munksgaard *et al*., 2005). Lying time was suggested as 50% of time budget by Wolf (2000). Dairy cattle are reaching high production performance in 14 h day^{-1} (58% of time budget) lying behavior (Grant, 2004).

Feeding behavior were the longest in winter (38.3%) and the decreased to 27.6% in summer. Cattle will also increase the duration spent eating in response to colder temperatures (Redbo *et al*., 2001) and due to high

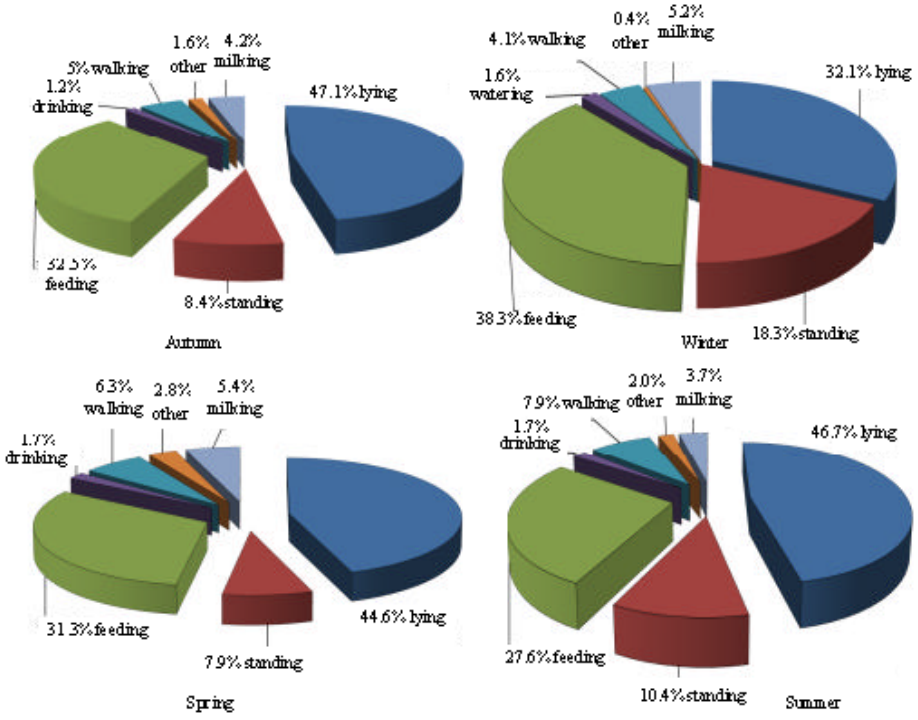

Fig. 2: Distribution of dairy cattle time budget in open loose housing for different season

temperature, feed consumption in cows decreases (Goings, 2003). Since, the temperature is high in summer season cows face a difficulty to adapt their body temperatures and they go through heat stress. To decrease heat production from digestion which is another heat source in addition to heating through metabolism and productivity, cows prefer to eat less feed. This situation causes a decrease of feeding duration in summer season. West (2001) stated that the main factors affecting the emergence of heat stress in dairy cows were environmental conditions, lactation periods, exercise, race, color, productivity level and feed consumption. McGuire *et al.* (1991) emphasized that temperature raised to 30 from 26°C, dairy cows feed intake decreased to 90% compared to optimum and its reduced to 75% in 32°C and 67% in 40°C.

The animals spent more duration for standing in winter according to other season. Standing duration of dairy cattle increased about to 18% from 8%, in winter and in spring, respectively. The walking behavior of dairy cattle decreased to 4 from 8%, in winter and in summer, respectively. During winter due to snow, mud ground and low temperature animals preferred to stand close to each other in lying area and they do not moved much. It was seen that walking behaviors increased in summer months.

The main reason was that due to heat stress animals got away from comfortable housing conditions thus their behavioral durations decreased and repetitions, back and front movements increased. It was observed that as 1.2-1.7% for drinking behaviors. Cook *et al.* (2007) observed that duration spent on drinking varies between 0.3-0.5 h day^{-1} (1.3-2% of time budget). It was observed that as 0.4-2.8% for other behaviors and as 3.7-5.4% for milking in all season.

Seasonal area usages of dairy cattle in different parts of loose barn are shown in Fig. 3. The resting area usages duration of dairy cattle were found as 1.24, 4.90, 6.37 and 10.75 h day^{-1} in autumn, spring, summer and winter, respectively. It was observed that ratios of courtyard area usages were 13.62 h day^{-1} in autumn, 10.00 h day^{-1} in spring and 9.73 h day^{-1} in summer. Resting area usage period was the highest in winter. Animals preferred this area to be protected from rain, snow and adverse effects of wind.

Resting area was draught free area and the animals used more in this season, since floor of courtyard area was wet. When area usage in open loose housing is analyzed, courtyard area usage duration of dairy cattle was high ratio with 9.73-13.62 h (40.5-56.7% of total time) in all season at except of winter.

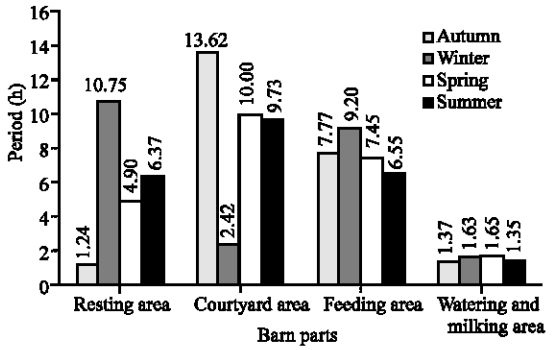

Fig. 3: The distribution of different barn area usage for dairy cattle in different seasons

Well drainage of the yard and shadow areas in the summer may increase the utilization rate of these areas. Further, this may provide significant advantages in cow comfort. Courtyard area usage of dairy cattle reached high level in autumn (13.6 h day^{-1} to 57% of total time). The good climatic condition and dry floor increase area usages in autumn. In this season, average high temperature is 12.4°C but, the other season spring and summer average high temperatures are 25.7 and 33.1°C, respectively (Table 1). Temperature was low and courtyard area was wet in winter so the animals used more resting and feeding area of barn (Fig. 3). Stocking density in resting area of barn was 7.5 m^2/animal. Feeding and resting area were in same place at experimental house so that although resting area was enough, it was observed very dirty during winter period. Thus, animal reduced lying duration in winter (Fig. 2).

Animals in those periods did not find sufficient dry area so they were mostly standing. As the stocking density of this area increased, pollution also increased but, resting comfort decreased. Lying behavior of dairy cattle is very important for increasing milk yield. Matzke (2003) studied the effect of daily behavior of dairy cow on average and maximum milk yield and reported that increasing the resting duration resulted in high milk yield.

It was observed that feeding area usage duration was between 6.5-9.2 h day^{-1}. The animals spent were more time with 9.20 h day^{-1} in winter. In other seasons, it was close to each other. Increase of use of feeding area was resulted from inadequate courtyard and resting area in winter. The design of feeding area in barn also is very important. This area should be separated from resting area, but it should be reached very easily from courtyard and resting area. These results showed that dairy cattle preferred using dry, clean, soft ground, draught free areas.

It is very important to give an attention in design barns for animal comfort. Cows spent varying proportions of daily time in the different functional areas (activity area 10-20%, feeding area 30-40%, lying area 40-60%), which are typical for loose housing system (Krohn *et al*., 1992; Munksgaard *et al*., 2005; Neisen *et al*., 2009).

Annual average area usages of dairy cattle was found as 8.92 h day^{-1} in courtyard, 7.74 h day^{-1} in feeding, 5.84 h day^{-1} in resting area, 1.50 h day^{-1} in watering and milking area. Dairy cattle spent most time at courtyard under suitable climatic and good area (dry and soft floor) conditions. The courtyard comfort (dry ground, shaded and draught free, or slowly draught in hot days, 2-3 m sec^{-1}) is sufficient in all season, usage of this area will also increase.

CONCLUSION

As a result, dairy cattle usually preferred open areas. To improve milk production, dairy housings should be first well designed and managed. The sheltering comfort of animals is improvement to climatic, structural and social stress. The present study showed that well design of courtyard, resting and feeding areas very important for animal health and high and qualified milk production as well as cattle management.

ACKNOWLEDGEMENTS

This research is supported by the Coordinatorship of Selçuk University' Scientific Research Projects No. SU-06101039.

REFERENCES

Anonymous, 2005. http://faostat.fao.org/02.06.2008.

Anonymous, 2006a. http://faostat.fao.org/02.06.2008.

Anonymous, 2006b. Ministry of Agriculture. Directorate Documents, Konya.

Barberg, A.E., M.I. Endres, J.A. Salfer and J.K. Reneau, 2007. Performance and welfare of dairy cows in an alternative housing system in Minnesota. J. Dairy Sci., 90: 1575-1583. http://proquest.umi.com/pqdweb?index=0&did=1261934581&SrchMode=1&sid=1&Fmt=6&VInst=PROD&VType=PQD&RQT=309&VName=PQD&TS=1255091304&clientId=41950.

Blowey, R., 1994. Dairy Cow Housing. In: Wathes, C.M. and D.R. Charles (Eds.). Livestock Housing. Universty Pres, Cambridge, pp: 340-357. ISBN: 08519 87745.

Bogner, H., 1984. Verhaltensbeobachtungen, Versuch-sanlage und-Auswertungen. In: Bogner, H. and A. Grauvogl (Eds.). Verhalten landwirtschaft-licher Nutztiere, Verlag Eugen Ulmer, Stuttgart, pp: 61-74. ISBN: 3800143453, 978380014 3450.

Cook, N.B., R.L. Mentink, T.B. Bennett and K. Burgi, 2007. The effect of heat stress and lameness on time budgets of lactating dairy cows. J. Dairy Sci., 90: 1674-1682. DOI: 10.3168/jds.2006-634.

Frazzi, E. and F. Calegari, 2003. Behaviour of Dairy Cows in Hot Season in a Barn Equipped with Automatic Milking System. In: Lacetera, N., U. Bernabucci, H.H. Khalifa, B. Ranchi and A. Nardone (Eds.). Interactions Between Climate and Animal Production. Wageningen Academic Publishers, The Neterlands. ISBN: 9076998264.

Fregonesi, J.A., D.M. Veira, M.A.G. Von Keyserlingk and D.M. Weary, 2007. Effects of bedding quality on lying behaviour of cows. J. Dairy Sci., 90: 5468-5472. http://proquest.umi.com/pqdweb?index=3&did=1394439881&SrchMode=1&sid=2&Fmt=6&VInst=PROD&VType=PQD&RQT=309&VName=PQD&TS=1255091984&clientId=41950.

Gebremedhin, K.G. and B. Wu, 2001. A Model of Evaporative Cooling of Wet Skin Surface and Fur Layer. J. Thermal. Biol., 26: 537-545. http://www.sciencedirect.com/science?_ob=PublicationURL&_cdi=5104&_pubType=J&_acct=C000046701&_version=1&_urlVersion=0&_userid=867461&md5=a5bd051005b413e821306f130399888b&jchunk=26#26.

Goings, R., 2003. Heat stress also affects dry cows. http://www.vigortone.com/heat_stress_article.htm.

Grant, R.J., 2004. Incorporating dairy cow behavior into management tools. In: Proc. Cornell Nutrition Conference For Feed Manufacture, Oct. 19-21, Cornell University, Wyndham Syracuse Hotel, Syracuse, NY. http://www.cornell.edu.

Grant, R.J. and J.L. Albright, 2000. Feeding Behavior. In: D'Mello, J.P.F. (Ed.). Farm Animal Metabolism and Nutrition. CABI Publishing, New York. ISBN: 0851 993788.

Haley, D.B., J. Rushen and A.M. De Passille, 2000. Behavioural indicators of cow comfort: Activity and resting behaviour of dairy cows in two types of housing. Can. J. Anim. Sci., 80: 257-263. http://article.pubs.nrc-cnrc.gc.ca/RPAS/rpv?hm=HInit&calyLang=eng&journal=cjas&volume=80&afpf=A99-084.pdf.

Hayasaka, K., T. Masubuchi, M. Kamo, H. Kawamoto and H. Shimonasako, 2002. Effects of localized air flowing system in free stalls on behavior of lactating cows in a hot environment. Bull. National Inst. Livest. Grassland Sci., 1: 49-54. http://sciencelinks.jp/j-east/article/200305/000020030503A0030564.php.

Hernández, M.V. and F. Calmenáres, 2006. The utility of genelizability theory in the study of animal behaviour. J. Anim. Behav., 71: 983-988. DOI: 10.1016/j.anbehav.2005.04.023.

Jensen, M.B., L.J. Pedersen and L. Munksgaard, 2005. The effect of reward duration on demand functions for rest in dairy heifers and lying requirements as measured by demand functions. Applied Anim. Behav. Sci. 90: 207-217. http://www.sciencedirect.com/science/journal/01681591.

Krohn, C.C., L. Munksgaard and B. Jonasen, 1992. Behaviour of dairy cows kept in extensive (loose housing/pasture) or intensive (tie stall) environments. 1. Experimental procedure, facilities, time budgets-diurnal and seasonal conditions. Applied Anim. Behav. Sci., 34: 37-47. http://www.sciencedirect.com/science/journal/01681591.

Martin, P. and P. Bateson, 1993. Measuring Behaviour. Cambridge University Press, Cambridge. ISBN: 0521 446147.

Matzke, W.C., 2003. Behavior of large groups of lactating dairy cattle housed in a free stall barn. MS. Thesis. University of Nebraska, Lincoln.

McGuire, M.A., D.K. Beede, R.J. Collier, F.C. Buonomo, M.A. DeLorenzo, C.J. Wolcox, G.B. Huntington and C.K. Reynolds, 1991. Effect of acute thermal stress and amount of feed intake on concentrations of somatotropin. Insulin-like Growth Factor (IGF)-I and IGF-II. and Thyroid Hormones in Plasma of Lactating Holstein Cows. J. Anim. Sci., 69: 2050-2056.

Metz, J.H.M., 1985. The reaction of cows to a short-term deprivation of lying. Applied Anim. Behav. Sci., 13: 301-307. http://www.sciencedirect.com/science/journal/01681591.

Mitlohner, F.M., J.L. Morrow-Tesch, S.C. Wilson, J.W. Dailey and J.J. McGlone, 2001. Behavioural sampling techniques for feedlot cattle. J. Anim. Sci. 79: 1189-1194. http://proquest.umi.com/pqdweb?index=9&did=73702416&SrchMode=3&sid=6&Fmt=3&VInst=PROD&VType=PQD&RQT=309&VName=PQD&TS=1255102057&clientId=41950&aid=1.

Muller, C.J.C., J.A. Botha and W.A. Smith, 1996. Effect of confinement area on production, physiological parameters and behaviour of Friesian cows during winter in a temperate climate. S. Afr. J. Anim. Sci., 26: 1-5. http://www.sasas.co.za/sites/sasas.co.za/files/muller96issue1.pdf.

Muller, R. and L. Schrader, 2003. A new method to measure behavioural activity levels in dairy cows. Applied Anim. Behav. Sci., 83: 247-258. http://www.sciencedirect.com/science/journal/01681591.

Munksgaard, L., M.B. Jensen, L.J. Pedersen, S.W. Hansen and L. Matthews, 2005. Quantifying behavioural priorities: Effects of time constraints on behaviour of dairy cows, *Bos taurus*. Applied Anim. Behav. Sci., 92: 3-14. http://www.sciencedirect.com/science/journal/01681591.

Neisen, G., B. Wechsler and L. Gygax, 2009. Choice of scan-sampling intervals: An example with quantifying neighbours in dairy cows. Applied Anim. Behav. Sci., 116: 134-140. http://www.sciencedirect.com/science/journal/01681591.

O'Driscoll, K., L. Boyle, P. French and A. Hanlon, 2008a. The effect of outwintering pad design on hoof health and locomotion score of dairy cows. J. Dairy Sci., 91: 544-553. http://jds.fass.org.

O'Driscoll, K., L. Boyle, P. French, B. Meaney and A. Hanlon, 2008b. The effect of out-wintering pad design on dirt score, somatic cell score and mastitis incidence in dairy cows. Animal, 2: 912-920.

Overton, M.W., W.M. Sischo, G.D. Temple and D.A. Moore, 2002. Using timelapse video photography to assess dairy cattle lying behavior in a freestall barn. J. Dairy Sci., 85: 2407-2413. http://jds.fass.org.

Phillips, C.J.C. and M.I. Rind, 2001. The effects on production and behavior of mixing uniparous and multiparous cows. J. Dairy Sci., 84: 2424-2429. http://jds.fass.org.

Redbo, I., A. Ehrlemark and P. Redbo-Torstensson, 2001. Behavioural responses to climatic demands of dairy heifers housed outdoors. Can. J. Anim. Sci., 81: 9-15. http://article.pubs.nrc-cnrc.gc.ca/RPAS/rpv?hm=Hinit&journal=cjas&volume=81&afpf=A00-071.pdf.

Tucker, C.B., A.R. Rogers, G.A. Verkerk, P.E. Kendall, J.R. Webster and L.R. Matthews, 2007. Effects of shelter and body condition on the behaviour and physiology of dairy cattle in winter. Applied Anim. Behav. Sci., 105: 1-13. http://www.sciencedirect.com/science/journal/01681591.

Ugurlu, N. and S. Uzal, 2007. Besi Sigirciliginda Sosyal Gruplu Acik Sistem Mikro Yapi Tasarimi (The design of micro beef cattle barn and social group in the loose housing system). Selcuk Univ. J. Agric. Fac., 21 (43): 68-74. http://www.ziraat.selcuk.edu.tr/dergi.

Uzal, S. and N. Ugurlu, 2008. The effect of climatic condition on area preference of animals in dairy cattle houses. J. Int. Environ. Applied Sci., 3 (4): 224-233. http://www.jieas.com.

Wagner-Storch, A.M. and R.W. Palmer, 2003. Feeding behaviour, milking behaviour and milk yields of cows milked in a parlor versus an automatic milking system. J. Dairy Sci., 86 (4): 1494-1502. http://jds.fass.org.

Webster, A.J.F., 1994. Comfort and Injury. In: Wathes, C.M. and D.R. Charles (Eds.). Livestock Housing. University Press, Cambridge, pp: 49-67. ISBN: 08519 87745.

West, J.W., 2001. Management Considerarions for the Dairy Cow During Heat Stress, http://www.cals.nscu.edu/an_sci/extension/dairy/repr2000/west.htm.

Wolf, J., 2000. Housing of milking cows taking account of high milk yields. Arch. Tierzucht, 43 (Special), 51-57.

Yurtman, I.Y., T. Savas, F. Karaagac and L. Coskuntuna, 2002. Effects of daily protein intake levels on the oral stereotypic behaviours in energy restricted lambs. Applied Anim. Behav. Sci., 77: 77-88. http://www.sciencedirect.com/science/journal/01681591.