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STRUCTURAL AND MICROCLIMATIC CHARACTERISTICS OF DAIRY CATTLE SHELTERS IN KERALA

Divya Sasi[*1], Harikumar S.[2], Prasad A.[3], Beena V.[4], Gleeja V.L.[5], Nameer P.O.[6]

*[*1] PG Student, Academy of Climate Change Education and Research, KAU, Vellanikkara*
[2, 3] Assistant Professor, Department of Livestock Production Management, CVAS, Mannuthy,
[4] Associate Professor and Implementing Officer, Centre for Animal Adaptation for Environment and Climate Change Studies, KVASU, Mannuthy, Thrissur,
[5] Assistant Professor, Department of Statistics, CVAS, Mannuthy, Thrissur,
[6] Professor and Special Officer, Academy of Climate Change Education and Research, KAU, Vellanikkara, Thrissur
** Corresponding author: divyasasi1308@gmail.com*

ABSTRACT

Thermal environment and structural characteristics of cattle shelters have profound influence on the overall welfare of dairy animals. A field study was conducted to examine the structural characteristics of dairy farms in four THI zones of Kerala during the summer months of February and March in 2020. Total 100 farms were selected from different THI zones for the study. Results confirmed the predominance of small and medium farms which has been a typical feature of dairy sector of Kerala. Most of the farms, irrespective of the size were having Galvanised Iron (GI) sheet and concrete flooring with rubber mat as major roofing and flooring material respectively. The mean dry bulb temperature and LPHSI recorded from all zones exceeded the upper critical point of thermoneutral zone indicating the thermal strain of dairy cattle. Thus the overall welfare and productivity of dairy cattle are under extreme stress which necessitates the need for advanced ameliorative strategies.

Keywords: Cattle shelter structure, Microclimate, THI zones, Thermal stress, Roofing and Flooring materials

INTRODUCTION

Shelter management in livestock farming is an important factor for ensuring productivity of animals. Proper shelter designs and selection of materials are salutary for protecting animals from predators and harsh weather conditions and for ensuring optimal production. Since Kerala comes under tropical humid zone, cattle shelters should be designed to reduce the thermal load as thermal stress affects productivity and welfare. In Kerala, intensive system of rearing cattle is widely

practiced where cows spend most of their productive life inside shelter necessitating the need for providing favourable microclimatic conditions. Diverse factors such as air, temperature, humidity, solar radiation, wind speed, precipitation etc. influence the environmental conditions interior to the cattle shelter (Schüller*et al*., 2013; Hill and Wall, 2015).The thermal environment has a significant influence on overall welfare of dairy cattle. Livestock and Poultry Heat Stress Index (LPHSI) accounting ambient temperature and relative humidity is considered as a comprehensive index to evaluate severity of heat stress under tropical humid climate of Kerala (Harikumar, 2017). In addition to these climatic parameters, various other factors such as animal density, building materials, ameliorative interventions, nearness to vegetation, orientation of shelter etc. significantly influence the microenvironment inside the shelter (Shock *et al.,* 2016). Defective shelter design and wrong choice of building materials result in cumulative loss in production as it was evident from change in milk yield in different climatic conditions (Ambazamkandi *et al.*, 2015). Thus serious considerations are required while selecting site and designing shelter to provide ideal environment for enhanced productivity and future expansion requirements of the animals to be reared, as it is difficult to frequently modify animal houses according to climatic needs (Sejian *et al*., 2012). Fittingness of shelter management with respect to the microclimatic conditions needs to be carefully identified and addressed in order to acquaint farmers to initiate suitable ameliorative interventions to combat various climatic stressors. In the present study the structural and microclimatic characteristics of cattle shelters in different THI zones of Kerala were assessed.

MATERIALS AND METHODS

A detailed field study was conducted in four THI zones of Kerala (Prasad, 2017) during the summer months of February and March in 2020. The higher THI zones HI, H2, and H3 included Moncombu in Alappuzha district, Vellanikkara in Thrissur district and Pattambi in Palakkad district respectively which belonged to coastal and midlands of Kerala. The lower THI zone L1 included Pambadumpara in the high range areas of Idukki district. Total hundred dairy farms were surveyed by selecting twenty five farms from each zones which was further grouped into three classes based on the number of milch animals (Sabin, 2016) viz. small farms (1-2 animals), medium farms (3-10 animals) and large farms (more than 10 animals) which were located within 10km geographical radius from the zone centres. Ambient temperature and relative

humidity both exterior and interior of the shelter were measured using electronic digital heat stress meter (HT30, Extech Instruments Corporation, USA) and THI (LPHSI, 1990) was calculated using the formula

$THI=T_{db}-\{(0.55-0.55RH)\ (T_{db}-58)\}$

Where,

T_{db} - Ambient temperature (^{o}F), RH-Relative humidity (%)

Information regarding the structural characteristics of shelters such as type of shelter, orientation, roofing and flooring materials, length, width, height from centre, height at eves of the shelters were measured. Heat abatement strategies adopted in the shelters, proximity to vegetation and other shade structures were observed.

RESULTS AND DISCUSSION

General characteristics of cattle farms in Kerala

Classification of dairy farms based on the number of milch cows confirmed the predominance of small and medium farms which are the typical characteristics of dairy farming in Kerala. The results indicated that medium sized farms with 3-10 milch cows were predominant in each zone with a total share of nearly 50 per cent for medium farms and 14 per cent for large farms. On contrary to this, Sabin (2016) found the predominance of small-sized farms in five agro-climatic zones of Kerala with a share of nearly 80 per cent whereas in the present study it was 36 per cent only. This variation in the farm size with respect to the previous study was due to the difference in the study area and number of samples studied. The crossbreds constituted 95.2 per cent of the total cattle studied across the four zones of Kerala. Among these crossbred Holstein Friesian (HF) formed the major category followed by crossbred Jersey, whereas non-descript cattle formed the least category. Preference for crossbred cattle in Kerala is due to its high milk production potential. Most of the cows (60 per cent) were yielding 5-10 L milk per day and highest milk yield was reported from the lower zone L1. This was in accordance with the findings of Prasad (2014). Nearly fifty per cent of cattle studied had black skin colour as 68 per cent of cattle belonged to crossbred HF. It was found that intensive stall fed system of rearing cattle was practised over the entire study area due to low per capita availability of land owing to high population density. Similar trend was followed in the individual zones also.

Structural characteristics of cattle shelter

Majority of the cattle shelters were permanent and provided with feeding

passage, manger, standing space, dung and urine channel and milking passage. No structural variations were found among higher zones H1, H2, H3 and lower zone L1. However it varied considerably with the size of farms categorized based on the number of cows.

While analysing structural parameters (Table 1) it was found that mean roof height at the centre of the shelter was 2.54 ± 0.09 and 2.56 ± 0.08m for small and medium farms respectively whereas, large farms recorded 3.97 ± 0.25 m height. Belsare and Pandey (2008) and Sharma *et al.* (2019) recommended roof height of 3.0 - 5.0 m for commercial cattle shelters in hot humid climate. Thus, it could be assumed that the present height of cattle shelters in large farms were sufficient with respect to the prevailing weather condition of Kerala.

The mean width of the large farms found in the study was more or less similar to the recommended mean width of 5-6m (Belsare and Pandey, 2008). In the present study, width of shelter did not account for the manger space and front extensions. Wide width of the shelter help to lower ground temperature underneath the animal and reduces heat load to animal from ground surface.

Large farms recorded a mean length of 13.20 ± 1.15m while small and medium farms measured 6.54 ± 0.39m and 4.13 ± 0.19m respectively. Length of the shelters varied with respect to the number of animals as suggested by Belsare and Pandey (2008).

Roofing and Flooring materials of the shelter

In Kerala, a wide variety of materials are being used for roofing cattle shelters irrespective of the THI zones (Table 2). Majority of cattle shelters were made of Galvanised Iron (GI) sheet followed by asbestos, tin sheets and clay tiles. However, temporary roofing such as tarpaulins and thatching were also observed but constituted less than 10 per cent of the total cattle shelters studied. It

Table 1. Structural details of cattle shelters

Type of farm	Length (m) (Mean ± SE)	Width (m) (Mean ± SE)	Roof Height (m) (Mean ± SE)	Space density (m^2/ animal) (Mean ± SE)
Small	4.13 ± 0.19	2.64 ± 0.08	2.54 ± 0.09	7.10 ± 0.63
Medium	6.54 ± 0.39	3.13 ± 0.2	2.56 ± 0.08	5.09 ± 0.60
Large	13.20 ± 1.15	6.38 ± 0.72	3.97 ± 0.25	5.70 ± 0.72
Overall	**6.88 ± 0.44**	**3.53 ± 0.20**	**2.80 ± 0.08**	**5.81 ± 0.31**

was found that there existed a sigificant association between roof materials and categories of farms using Fisher's Exact Test ($p<0.05$). Organized large farms made use of either GI (92.9 per cent) or asbestos roofing sheets (7.1 per cent) as they are easy to install and highly durable. This observation was in agreement with the earlier findings of Sastry and Thomas (2012). Sahu *et al*. (2018) suggested thatch roof as a good insulator and cheap material when compared to other roofing, which was observed only in 2.86 per cent of small and four per cent of medium farms in this study because of its poor durability. Sivakumar *et al.* (2017) found that thatched roofing pattern was most suitable for cattle shelters in North East Zone of Tamil Nadu based on climatic conditions. Locally available thermal insulating materials such as palm leaves, wooden planks, hay, cardboard and thermocol were observed in eight per cent of total farms as a false ceiling under GI, asbestos, tin sheet and clay tiles. Das *et al*. (2015) also observed similar false ceilings in cattle shelters of Northern and Southern districts of Goa.

According to Sharma *et al*. (2019) earthen flooring was a characteristic feature of Indian cattle shelters. But in the present study concrete flooring was a common feature in 99 per cent of the large, medium and small farms across different THI zones of Kerala. Similar to roofing materials, flooring materials also showed a significant association with categories of farm using Fisher's Exact Test ($p < 0.01$). In large and medium farms rubber mats were laid on concrete floor which was less common in small farms. Thermal conductivity, strength, durability and cushioning effect of rubber mat on hooves were beneficial for cows but the high cost was a limiting factor especially in small farms. Farmers preferred rubber mat as it reduced the risk

Table 2. Percentage distribution of different roofing materials

Roofing materials	Type of farms			Overall(%)
	Small (%)	Medium (%)	Large (%)	
Galvanised Iron (GI)	20	48	92.9	44.44
Asbestos	28.6	20	7.1	21.21
Tin sheet	11.43	10	0	9.09
Roof with false ceiling	11.43	8	0	8.08
Clay tile	17.14	6	0	9.09
Tarpaulin	5.71	4	0	4.04
Thatched	2.86	4	0	3.03
Concrete	2.86	0	0	1.01

of developing hoof problems as observed by Vanegas *et al*. (2006).

Presence of shade trees, shelter orientation and ameliorative measures

Features of cattle shelters such as shades, orientation and thermal stress ameliorative measures used were studied in all zones together. It was also observed that 75 per cent of farms were under the shadow of vegetation with shade varying from 25 per cent to 100 per cent and the rest of the farms were directly exposed to the sun. It could be observed that a major fraction of the no shaded cattle (zero per cent shade) shelters were mostly located near paddy fields where shade trees were at the bare minimum which was mainly seen in zone HI (Moncombu). In accordance with the findings of Abdel-Aziz *et al.* (2015), shade trees were effective to reduce the incidence of solar radiation directly on the building facades and significantly reduced the dependence on mechanical cooling.

During peak summer period 77 per cent of the farms practiced wetting animal body with cool water two to three times in a day as an ameliorative method against thermal stress. This observation was in agreement with earlier findings of Prasad (2014). Results also indicated that fan was installed in nearly 21 per cent of the farms, but only nine per cent of them were in working condition. Lack of maintenance facilities and extra electricity charges might be the reason , especially in small holder farmers.

In tropical climate orientation of the building is a major factor in reducing thermal load inside the shelter. Several reports suggested that alignment of long axis of building in an East-West direction reduced the entry of direct solar radiation on the side walls or inside the shelter and provided maximum shade under the structure in hot climate (Schultz *et al*., 2010; Das *et al*., 2015). However, findings from the present study revealed that East-West orientation was observed only in 36 per cent, whereas North - South orientation was found in 64 per cent farms. This could be attributed to the fact that farmers considered the availability of land, its shape and location with respect to adjacent structures to construct the cattle shelter as reported by Mohapatra *et al*., 2013.

Microclimatic conditions inside the shelter

The ambient temperature was a noble predictor of body temperature of heat-stressed cows in subtropical environment and effectively approximated the magnitude of hyperthermia as suggested by Dikmen and Hansen (2009). In the present study the mean exterior

and interior ambient temperature showed an increasing trend from zone H1 to H3. Lowest ambient temperature, both exterior and interior, was recorded from the zone L1. These observations were in agreement with the findings of Prasad (2014) from the respective zones. Interior temperature was lower than exterior, although the difference was less. Similar findings were reported by Harikumar (2017) when pooled data from all THI zones were considered. The mean ambient temperature exterior and interior of the shelter (Table 3) was higher than the upper critical temperature of 28.4°C as reported by Dikmen and Hansen (2009) and the overall welfare and production of animals was under stress.

Both ambient temperature and relative humidity recorded exterior to the shelter exhibited a strong positive correlation with interior values but relative humidity measured inside the shelter was found to be approximately two per cent higher than outside in all THI zones. This might be due to management practices such as regular cleaning of shelter and washing of animals with water. This was in accordance with the observations reported by Harikumar (2017). Among these zones, higher relative humidity was reported from zone H1, which belonged to coastal regions of Kuttanad where high humidity is experienced throughout the year, compared to mid land and high ranges (Sreejith, 2013).

It was generally considered that when THI value exceeded 85, cows were likely to begin experiencing thermal stress and significant reductions in milk yield in Kerala (Prasad, 2017). THI values recorded from all zones exceeded 80 except in zone L1 but these values were based on the data recorded at the time of visiting the farm during the beginning of summer season in

Table 3. Microclimatic conditions in different LPHSI zones of Kerala

L P H S I Zones	Dry bulb temperature (Mean ± SE) (□)		Relative Humidity (Mean ± SE) (%)		THI (Mean ± SE)	
	Exterior	Interior	Exterior	Interior	Exterior	Interior
HI	34.28± 0.49	33.34±0.38	52.30±1.47	53.90±1.4	84.21±0.49	83.29±1.73
H2	35.06±0.29	34.30±0.39	34.98±1.63	36.86±1.70	81.77±0.27	81.22±0.36
H3	36.23±0.35	35.13±0.28	45.76±0.88	47.85±0.90	84.85±0.38	84.51±0.27
L1	30.0±0.40	29.44±0.32	42.29±1.10	44.14±0.90	77.10±0.39	77.02±0.31
Over All	33.91±0.30	33.05±0.28	43.83±0.90	45.69±0.89	82.14±0.38	81.42±0.34

Kerala. Whereas, according to Harikumar (2017) maximum THI recorded outside the shelter exceeded 85 during peak summer period (March to May) in Kerala. This indicated that during peak summer months dairy cattle from these higher zones required ameliorative interventions to combat thermal stress.

All variables recorded exterior to the shelter have a strong significant positive correlation ($p<0.01$) with the same variable recorded interior in all zones

SUMMARY

The present study confirmed that small and medium dairy farms existed in Kerala with total number of milch animals ranging from one to ten. Presence of permanent cattle shelters for housing animals was visible across different zones. Ambient temperature recorded interior to the shelter exceeded upper critical point of thermoneutral zone indicating the thermal strain of dairy cattle, which necessitated the need for adopting suitable stress alleviating measures.

REFERENCES

Abdel-Aziz, D.M., Al, S.A., Al-Kurdi, N.Y. and Eng, A.J.E. 2015. Effects of tree shading on building's energy consumption-the case of residential buildings in a Mediterranean climate. *Am. J. Environ. Eng.* **5**(5): pp.131-140.

Ambazamkandi, P., Thyagarajan, G., Sambasivan, S., Davis, J., Shanmugam, S. and Joseph, B.A. 2015. Shelter design for different livestock from a climate change perspective. In: *Climate Change Impact on Livestock: Adaptation and Mitigation*. Springer, New Delhi, pp. 399-424.

Belsare, V.P. and Pandey, V.Y.A.S. 2008. Management of heat stress in dairy cattle and buffaloes for optimum productivity. *J. Agrometeorol*. **10**:365-368.

Das, S., Karunakaran, M., Barbuddhe, S. and Singh, N. 2015. Effect of Orientation, Ventilation, Floor Space Allowance and Cooling Arrangement on Milk Yield and Microclimate of Dairy Shed in Goa. *J. Anim. Res*. **5**(2): 231-235.

Harikumar, S. 2017. Behavioural, physiological and biochemical stress responses of crossbred cows to varying thermal indices in different management systems. Ph.D. thesis. Kerala veterinary and animal sciences university. Mannuthy. 145p.

Hill, D.L. and Wall, E. 2015. Dairy cattle

in a temperate climate: the effects of weather on milk yield and composition depend on management. *Animals*. **9** (1): pp.138-149.

Prasad, A. 2014. Climatic adaptation and stress evaluation of crossbred cattle of Kerala. Ph. D thesis, Kerala Veterinary and Animal Sciences University, Pookode, 163p.

Prasad, A., Muhammed, E. M., Kannan, A. and Aravindakshan, T.V. 2016. Thermal stress in dairy cattle. *J. Ind. Vet. Assoc*. **10**(3): pp 45-51.

Sabin, G. 2016. Economics of dairy farming systems in Kerala. Ph.D. thesis, Kerala Veterinary and Animal Sciences University, Pookode, 145p.

Sahu, D., Mandal, D.K., Bhakat, C., Chatterjee, A., Mandal, A. and Mandal, M. 2018. Effects of Roof Ceiling and Flooring on Microclimate of Shed and Physiological Indices of Crossbred Jersey Cows. *Int. J. Livest. Res*. [e-journal] **8**(4):272- 280. Available: http://dx.doi.org/10.5455/ijlr.20171012061118 [28 January 2020].

Sastry, N.S.R. and Thomas, C.K. 2012. Livestock Production Management. 4th revised edition reprinted, Kalyani Publisher, Ludhiana, pp.271-272

Schüller, L.K., Burfeind, O. and Heuwieser, W. 2013. Comparison of ambient temperature, relative humidity, and temperature-humidity index between on- farm measurements and official meteorological data. *J. Dairy Sci*., **96**(12): pp.7731-7738.

Schütz, K.E., Rogers, A.R., Poulouin, Y.A., Cox, N.R. and Tucker, C.B. 2010. The amount of shade influences the behavior and physiology of dairy cattle. *J. Dairy Sci.* **93** (1): pp.125-133.

Sejian, V., Valtorta, S., Gallardo, M. and Singh, A.K. 2012. Ameliorative measures to counteract environmental stresses. In *Environmental Stress and Amelioration in Livestock Production*. Springer, Berlin, Heidelberg. Pp.153-180.

Sharma, A., Kennedy, U., Schuetze, C. and Phillips, C.J. 2019. The welfare of cows in Indian shelters. *Animals*. ***9*** (4):172.

Shock, D.A., LeBlanc, S.J., Leslie, K.E., Hand, K., Godkin, M.A., Coe, J.B. and Kelton, D.F. 2016. Studying the relationship between on-farm environmental conditions and local meteorological station data during the summer. *J. Dairy Sci.* **99** (3): 2169-2179. Mohapatra, A.K., Swain, S.K.,

Dash, A.K. and Behura, N.C. 2013. Survey on structural details and evaluation of cattle sheds in coastal Odisha. *Res. J. Animal Hus. & Dairy Sci.* **4**(2): 74-76.

Sivakumar, T., Suraj, P.T., Yasotha, A. and Phukon, J. 2017 Identification of suitable housing system for dairy cattle in North East Zone of Tamil Nadu, India, with respect to microclimate, Veterinary World, **10**(1): 1-5.