RESEARCH ARTICLE Indian Journal of Animal Research, Volume 54 Issue 7: 846-850 (July 2020)

The potential of the development of Holstein crossbreed dairy cows in tropical lowland Indonesia: study of physiological and milk production by body cooling treatment

Arif Qisthon[1,2], Woro Busono[3], Puguh Surjowardojo[3], Suyadi[3]

10.18805/ijar.v0iOF.6992

ABSTRACT

The research aimed to evaluate the effectiveness of body cooling techniques on physiological and milk production of Holstein crossbred dairy cow at lowland area during the dry season. Three treatments have been done for 30 days that were: none, fans, and water sprinkling cooling, for 30 minutes each at 08.00 and 11.00 h. The effects of treatment are not significant (P > 0.05) on air temperature, RH, THI, respiration rate, heart rate and heat tolerance coefficient. The rectal temperature by sprinkling (38.76°C) was within the normal range, lower (P < 0.05) than the fans (39.59°C) and none (39.57°C). Sprinkling increased serum T3 concentrations (2.81 ng/ml), higher than none (1.58 ng/ml) (P < 0.05). The effect of treatment is not significant (P > 0.05) on milk production, dry matter, TDN and crude protein intake. The research highlighted that water sprinkling was effective in maintaining normal physiological condition of Holstein crossbreed cows in hot lowland environments.

Key words: Air temperature, Fans, Heat Stress, Sprinklers, Temperature-humidity index

INTRODUCTION

The breed of dairy cows in Indonesia is mostly Holstein Friesian and Holstein crossbred. Holstein crossbred dairy cows are hybrids of Holstein-Friesian cow and Java or Madura cow (Rukmana, 2008). The dairy cow in Indonesia is mostly (99%) located in Java (Matondang *et al*., 2012) that are concentrated in some highland areas. This happens because of the agroclimatic factors, especially the air temperature which is more suitable for their productivity. This reality has indirectly made people's mindset that dairy cow can only be bred in the highlands. As a result, the development of dairy cow in the lowlands has not been a priority option to solve the import of milk that is quite dominant. Holstein cows are the type of cow originating from the subtropical regions with *temperate* climates, so they will only produce well in the climatic condition which is suitable for their thermoneutral zone, i.e 5-25°C (Ohnstad, 2013).

In Indonesia as a tropical country, the combination of high temperatures and humidity are a major obstacle for dairy cow development in the lowlands because it causes heat stress which has a negative effect on the physiological and productivity. The combination of temperature and humidity is expressed in the Temperature Humidity Index (THI) (Du Preez, 2000; Smith *et al*., 2006; Dikmen and Hansen, 2009). THI exceeding 72 causes the cow to experience heat stress (Smith *et al*., 2006; Shekhawat, 2012).

One way to overcome the problem of environmental heat is using technology to manipulate the microenvironment. Some techniques to cope with heat stress have been reported by researchers, such as the use of shade, water spraying and using fans (Collier *et al*., 2006; Kendall *et al*., 2007; Marcillac-Embertson *et al*., 2009; Berman, 2010; Chanchai *et al*., 2010; Koluman and Daskiran, 2011; Worley, 2012; Ohnstad, 2013), modification of feed management (Brosh *et al*., 1998; Granzin, 2006; Ohnstad, 2013) and modification of housing design (Kennedy, 1999; Brouk *et al*., 2001; Worley, 2012). In practice, the cooling techniques can be done separately, or by combining them by considering the climatic conditions, practicality, and the economic side. The effectiveness of the techniques vary, but in general, they can help reduce heat stress by improving the physiological responses, production and reproduction. Cooling technique by watering with a sprinkler and the airflow with a fan are practical to be applied (Ohnstad, 2013) and relatively inexpensive. However, the effectiveness of dairy cow cooling on the physiological response and

[1]Post Graduate Program, Faculty of Animal Science, Brawijaya University, Jl. Veteran, Malang, East Java, Indonesia.
[2]Department of Animal Husbandry, Faculty of Agriculture, University of Lampung, Jl. Sumantri Brojonegoro 1, Bandar Lampung, Lampung, Indonesia.
[3]Faculty of Animal Science, Brawijaya University, Jl. Veteran, Malang, East Java, Indonesia.

Corresponding Author: Arif Qisthon, Suyadi, Post Graduate Program, Faculty of Animal Science, Brawijaya University, Jl. Veteran, Malang, East Java, Indonesia. Email: arqisthon@gmail.com; suyadi2008@yahoo.com

How to cite this article: Qisthon, A., Busono, W., Surjowardojo, P. and Suyadi (2020). The potential of the development of Holstein crossbreed dairy cows in tropical lowland Indonesia: study of physiological and milk production by body cooling treatment. Indian Journal of Animal Research. 54(7): 846-850.

Submitted: 23-06-2016 **Accepted**: 21-10-2016 **Published**: 03-02-2017

milk production were mostly conducted in the sub-tropical and arid climate, while on the Holstein crossbred dairy cow in the tropical environment, especially in the lowland areas in Indonesia, are still quite limited. Therefore, this study aimed at evaluating the effectiveness of body cooling technique through airflow using fans and watering using sprinklers on the physiological and milk production of Holstein crossbred dairy cow in the lowlands during the dry seasons.

MATERIALS AND METHODS

This research was conducted at the Farm of Cooperative Livestock Farming of dairy cow *Suka Makmur, Trewung* village, *Grati* sub-districts, Pasuruan, East Java from October until December 2014. The location of the research is at a lowland of 86 m above sea level with the daily average maximum air temperature 33°C, minimum air temperature of 21°C, relative humidity of 79% and rainfall of 107 mm/month. Twelve Holstein crossbred dairy cow with the initial body weight of 428 ± 36.9 kg, 3-10 months of lactation, parity 1-4 and 3-4 BCS were used in a randomized block design. Three treatments were administrated for 30 days, namely: none (NC), fans (FC) and water sprinkling cooling (SC), for 30 minutes each at 08:00 and 11.00 h.

Two fans with the diameter blade of 450 mm circulating 84.5 m3/min air and a wind speed of 4.38 m/sec (Maspion, PW-455W) were placed at the back of the cow as high as 230 cm from the floor, or about 100 cm from the backs of a cow. The fans were set 45° from the vertical position toward the back of a cow with a rotational movement of 90°. The watering was done with a sprinkler that placed at 210 cm from the floor or approximately 80 cm above the backs of each cow, spraying water as much as 2.43 ± 0.29 L/min with a temperature of 25.31 ± 0.53°C.

The variables were measured for 30 days. Air temperature (Ta) and relative humidity (RH) were daily measured every 60 minutes from 07.00 until 17.00 h. Temperature humidity index (THI) was calculated according to Thompson and Dahl (2012) formula: THI = (1.8 x aT + 32) - [(0.55 - 0.0055 x RH) x (1.8 x Ta -26)]. The physiological variables consisted of: respiration rate (RR), heart rate (HR), and the rectal temperature (RT) measured before and after the cooling at 7.30, 08.30, 09.30, 10.30, 11.30, 12.30 and 13.30 h. The daily data of RR, HR and RT were the average of the measurements conducted within once in five days, and every measurement took about 30 minutes (Fig 1).

The rectal temperature was measured by inserting a digital clinical thermometer into the rectum. The respiration rate was observed by counting the time required to move ten times up and down in the movement area between the last rib and flank and then converted into one minute. The heart rate was observed by calculating the time required per ten times heartbeat by placing the stethoscope near the left *axila* bone and then converted into one minute. Heat tolerance coefficient (HTC) was calculated by the Benezra formula (Maylinda, 2007), that is HTC = (RT/38.3) + (RR/23). The concentrations of serum T3 and T4 were measured by using Elisa method using a commercial kit (Shanghai Crystal Day Biotech Co. Ltd, China; Cat.No: E0215Bo (T3) and E0216Bo (T4). Blood samples were collected from *coccygea* vein at 11.30 to 12.30 h in the mid and end of the research period. Milk production is the average of daily milk production per cow during 30-days measurement. The milk production corrected in 4% fat was calculated with formula: 4% FCM = (0.4 x milk production) + (15 x Fat Production). Data were analyzed using analysis of variance and then preceded with Duncan post hoc test in the statistical software IBM-SPSS ver. 20.

RESULTS AND DISCUSSION

Microclimates

The average daily air temperature, relative humidity (RH), and THI are presented in Table 1.

The activation of the fans and water sprinkling did not affect (P > 0.05) the average of air temperature, humidity, and THI (Table 1). The temperatures in all pens exceed the thermoneutral zone of a dairy cow, which is 5-25°C (Ohnstad, 2013). The value of THI also exceed the comfort zone 72 (Smith *et al.*, 2006; Shekhawat, 2012) and it placed the animal in the environment with heat stress in the medium category (Smith *et al.*, 2006; Lang, 2011). The response patterns of THI indicate that the cows were always in a state of heat stress from morning until evening (Fig 2). Thus, THI

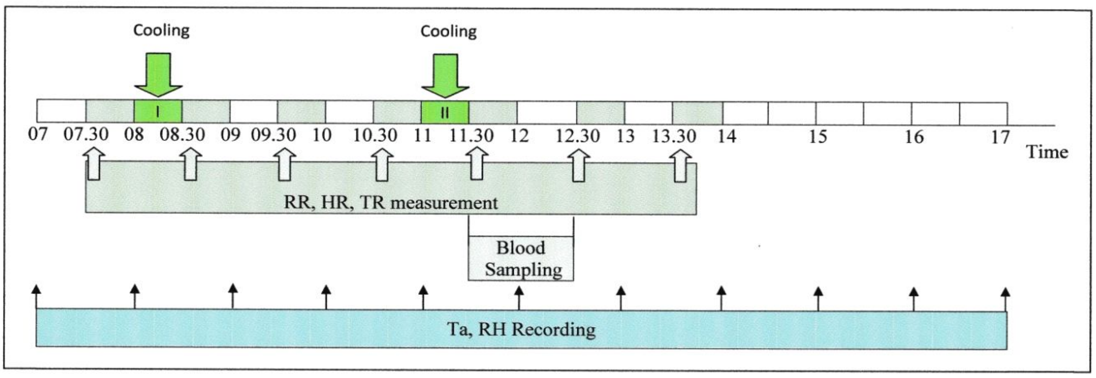

Fig 1: Timing diagram of the cooling treatment, physiological measurements and recording of microclimates.

value of the research location might reduce the possibility of reproductive performance and production.

Physiological

The average of physiological responses during the research is shown in Table 2. It shows that the effect of treatment is significant ($P < 0.05$) at the rectal temperature and the T3 serum concentrations, whereas the respiration rate, heart rate, HTC and the serum concentrations of T4 were not affected by the treatment.

The rectal temperature of the sprinkler cooling indicates that the values are within normal range, that is, from 38.5 to 39.3°C (Venugopal, 2011), and it was lower than that using fans cooling and that with none cooling. The sprinkler cooling was able to lower the rectal temperature of 0.8°C. It shows that the wetting surface of the body is effective to maintain the rectal temperature in a comfortable condition through the mechanism of thermoregulation. These results are in line with Lang (2011) and Granzin (2006). Body heat transfer to the environment effectively happens through the conduction between the surface of the body with water droplets wetting the surface and then followed with the evaporation by wind gusts.

The high respiration and heart rates indicated that the body cooling with fans and water sprinkling were not significantly able to increase the release of body heat

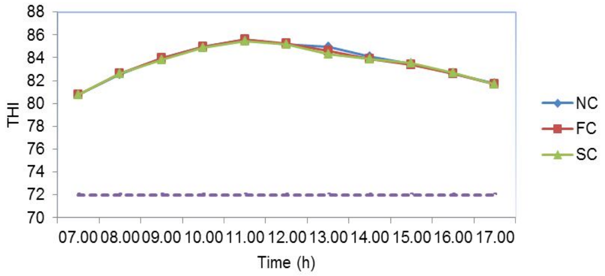

Fig 2: The average of THI of the experimental pen, NC=none cooling, FC=fan cooling, SC=sprinkler cooling. The dashed line denotes a THI equal to 72 (the level of cut-off for heat stress).

through conduction, convection, and evaporation through the skin surface. This might be due to the short of the cooling treatment (2 x 30 minutes), performing a brief of releasing body heat process to the environment. This assumption was based on the high value of THI indicating that heat stress occurred from morning until afternoon. This is in line with Lang (2011) stating that the respiration rate and body temperature will be decreased by shortening the interval or increase the frequency of watering. Koluman and Daskiran (2011) reported that the sheep cooled by fans from 10.00 to 16.00 h showed the response of respiration rate was significantly lower than that of the control.

The respiration rate, heart rate and HTC of the sprinklers cooling, although not statistically significant, tend to be lower than that without cooling and that with a fan cooling. This means that sprinkling tends to be able to increase the release of heat to the environment through the surface of the skin so that it is more comfortable (Granzin, 2006) and increase the adaptability to hot environments. The pattern of physiological responses (Fig 3 to 6) indicates that sprinklers cooling is generally effective to help reducing respiration rate, heart rate, rectal temperature, and HTC up to 30 minutes after watering. On the other hand, respiration rate, heart rate, rectal temperature, and HTC of the fans cooling tends to increase from morning until afternoon similar with none cooling. The observed phenomenon is that the water sprinkling was able to minimize the increase and maintain the respiration rate, heart rate, rectal temperature, and HTC lower than the fans cooling.

Sprinklers cooling could increase the higher concentration of serum Triiodothyronine (T3) compared with none cooling. On the other hand, either sprinkling or fans cooling could not significantly increase the concentration of serum Thyroxin (T4) (Table 2). Nonetheless, there is a tendency that sprinkling also increased the concentration of serum T4. It is assumed that watering enabled cow to feel more comfortable although all the animals were exposed to heat stress. On the contrary, the fact that T4 and T3 level in the fans cooling and none was lower indicating that the

Table 1: Microclimates data and THI of the pens during the experimental period.

	NC	FC	SC	SEM	Sign.
Air temperature, °C	31.5	31.4	31.4	0.30	0.98
Humidity, %	72.3	72.7	72.8	1.19	0.99
THI	83.6	83.6	83.5	0.26	0.99

Table 2: Mean value of physiological variables of cows during the experimental period.

Variables	NC	FC	SC	SEM	Sign.
RR, breaths/min	84	84.1	70.1	2.81	0.09
HR, beats/min	89.1	89.2	82.6	2.32	0.57
RT, °C	39.6^{a}	39.6^{a}	38.8^{b}	0.12	0.01
HTC	4.69	4.69	4.06	0.12	0.1
T3, ng/ml	1.58^{a}	239^{ab}	2.81^{b}	0.23	0.04
T4, ng/ml	4.91	5.64	7.31	0.62	0.26

Means with different superscripts in the same row differ at $P < 0.05$.

Table 3: Nutrients intake and milk production of cows in the cooling treatments.

	NC	FC	SC	SEM	Sign.
Nutrient intake, g/BW $^{0.75}$/day:					
DM	161	160	172	4.37	0.16
TDN	109	108	113	2.7	0.44
CP	27.8	27.4	28.3	0.66	0.68
Milk production, kg/head/day	12.4	12.4	14	1.46	0.13
4% FCM, kg/head/day	11.4	11.9	13.9	1.4	0.07

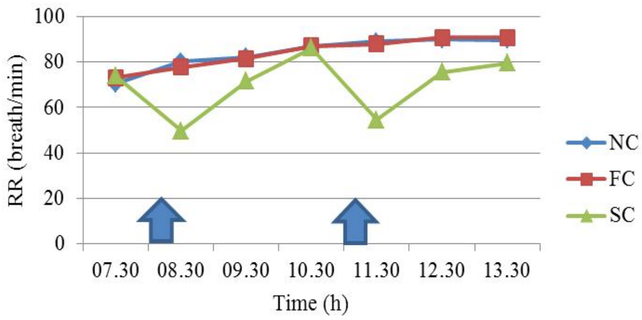

Fig 3: The response patterns of respiration rate (arrow shows the cooling time, that is at 08.00 to 08.30 h and 11.00 to 11.30 h).

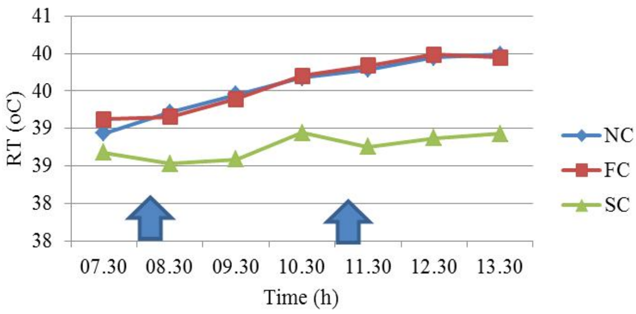

Fig 5: The response patterns of rectal temperature (arrow shows the cooling time, that is at 08.00 to 08.30 h and 11.00 to 11.30 h).

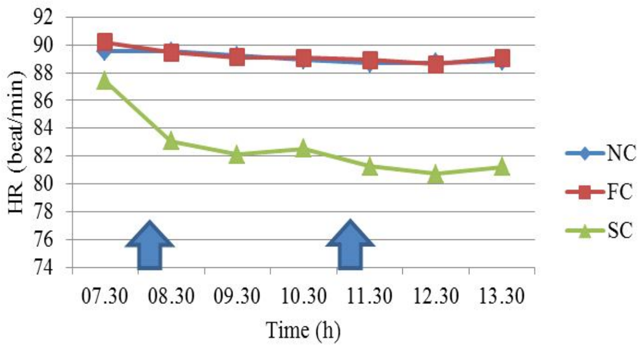

Fig 4: The response patterns of hearth rate (arrow shows the cooling time, that is at 08.00 to 08.30 h and 11.00 to 11.30 h).

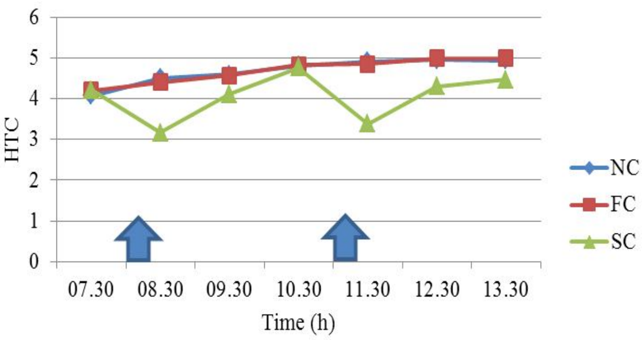

Fig 6: The response pattern of heat tollerance coeffocient (arrow shows the cooling time, that is at 08.00 to 08.30 h and 11.00 to 11.30 h).

adaptation efforts to heat stress were greater. Magdub *et al*. (1982) stated that the concentration of T3 and T4 in lactation cow increased in the lower heat stress conditions or more comfortable; otherwise, the concentration of thyroid hormone decreased when the cow experience an increased heat stress.

Milk production

The average of nutrients intake (dry matter, TDN, crude protein) and milk production are given in Table 3. The effect of body cooling is not significant (P > 0.05) on DM, TDN, and CP intake. This consequence to no significant difference in milk production. A similar study was reported by Noach (2000) and Granzin (2006) that additional watering on cow under the shade did not significantly increase milk production. The results of this research also indicate that cow can anticipate heat stress at medium category by physiological adjustment to accelerate the release of heat, through evaporation from the respiratory tract or skin, so that the cow do not significantly reduce nutrients consumption to reduce the heat production from the food reaction in the body (Tillman *et al*., 1991).

CONCLUSION

Water sprinkling is effective to maintain the rectal temperature at a normal range and to increase the concentrations of serum T3, but it had no effect on milk production. Water sprinkling and airflow using fans have a similar response to none cooling at respiration rate, heart rate, HTC, concentrations of serum T4 and nutrient intake.

ACKNOWLEDGEMENT

The authors are grateful to the Livestock Farming of dairy cow Cooperative Suka Makmur for supporting this project.

REFERENCES

Berman, A. (2010). Forced heat loss from body surface reduces heat flow to body surface. J. Diary Sci. 93: 242-248. Doi: 10.3168/jds.2009-2601.

Brosh, A., Aharoni, Y., Degen, A.A., Wright, D. and Young, B.A. (1998). Effects of solar radiation, dietary energy and time of feeding on thermoregulatory responses and energy balance in cattle in a hot environments. J. Anim. Sci. 76: 2671-2677. PMID: 9814908.

Brouk, M.J., Smith, J.F. and Harner, J.P.S. (2001). Facility and climate effects on dry matter intake of dairy cattle. Proceeding of the 5th Western Dairy Management Conference, April 4-6, Las Vegas, Nevada. In: Arizona and New Mexico Dairy Newsletter Cooperative Extension, The University of Arizona New Mexico State University, May 2005. Available from: URL: http://www.publish. csiro.au/?act= view_file &file_id=SA0501219.pdf; accessed on: 19 September 2013.

Chanchai, W., Chanpongsang, S. and Chaiyabutr, N. (2010). Effects of cooling and supplemental recombinant bovine somatotropin on diet digestibility, digestion kinetics and milk production of cross-bred Holstein cattle in the tropics. J. Agr. Sci. 148: 233-242. Doi: 10.1017/S0021859609990505.

Collier, R.J., Dahl, G.E., and VanBaale, M.J. (2006). Major advances associated with environmental effects on dairy cattle. J Diary Sci. 89: 1244-1253. PMID: 16537957.

Dikmen, S. and Hansen, P.J. (2009). Is the temperature-humidity index the best indicator of heat stress in lactating dairy cows in a subtropical environment?. J. Diary Sci. 29: 109-116. Doi: 10.3168/jds.2008-1370.

Du Preez, J.H. (2000). Parameters for the determination and evaluation of heat stress in dairy cattle in South Africa. Onderstepoort J. Vet. Res. 67: 263-271. PMID: 11206394.

Granzin, B.C. (2006). Cooling and forage supplementation of grass-fed Holstein cows during hot conditions. Trop. Anim. Health Prod. 38: 141-150. PMID: 17682599.

Kendall, P.E., Verkerk, G.A., Webster, J.R. and Tucker, C.B. (2007). Sprinklers and shade cool cows and reduce insect-avoidance behavior in pasture-based dairy systems. J. Dairy Sci. 90: 3671-3680. PMID: 17638978.

Kennedy, B.S. (1999). Thermoregulation and the Effects of Heat Stress on Dairy Cattle. Mississippi State University College of Veterinary Medicine, Production Medicine Graduate Program. Available from: URL: http://gpvec.unl.edu/heat drought/ HSDairyReview.htm; accessed on: 19 September 2013.

Koluman, N. and Daskiran, I. (2011). Effects of ventilation of the sheep house on heat stress, growth and thyroid hormones of lambs. Trop. Anim. Health Prod. 43: 1123-1127. Doi: 10.1007/s11250-011-9811-7.

Lang, B. (2011). Heat Stress in Dairy Cows. Available from: URL: http://www.omafra.gov.on.ca/english /livestock/ dairy/ facts/stressthres.htm; accessed on: 26 January 2013.

Magdub, A., Johnson, H.D. and Belyea, R.L. (1982). Effect of environmental heat and dietary fiber on thyroid physiology of lactating cows. J. Dairy Sci. 65: 2323-2331. PMID: 6298292.

Marcillac-Embertson, N.M., Robinson, P.H., Fadel, J.G. and Mitloehner, F.M. (2009). Effects of shade and sprinklers on performance, behavior, physiology and the environment of heifers. J. Dairy Sci. 92: 508-517. Doi: 10.3168/jds.2008-1012.

Matondang, R.H., Talib, C. and Herawati, T. (2012). Prospek pengembangan sapi perah di luar Pulau Jawa mendukung swasembada susu di Indonesia. Wartazoa. 22: 161-168.

Maylinda, S. (2007). Marker genetik penentu potensi produksi susu pada sapi perah impor dan lokal di Grati Pasuruan (Genetic marker of milk production potential in imported and local dairy cattle in Grati Pasuruhan). Ph.D Thesis, Bogor Agricultural University of Bogor, Indonesia.

Noach, Y.R. (2000). Pengaruh penyemprotan air pada tubuh terhadap kondisi fisiologis dan kinerja produksi sapi Holstein laktasi (Effect of showering the body surface on physiological condition and productive performance of lactating holstein cows). M.Sc. Thesis, Gadjah Mada University, Yogyakarta.

Ohnstad, I. (2013). Managing heat stress in dairy cows. National Animal Disease Information Service (NADIS). Available from: URL: http://www.nadis.org.uk/bulletins/managing-heat-stress-in-dairy-cows. aspx?altTemplate=PDF; accessed on: 26 September 2013.

Rukmana. (2008). Pemeliharaan Sapi Perah Secara Intensif. Bandung: Titian Ilmu.

Shekhawat, L.S. (2012). Effect of roof modifications in loose house on intake and utilization of nutrients and milk yield in lactating crossbred cows during winter season. Indian J. Dairy Sci. 65: 501-507. Doi: 10.5146/ijds.v65i6.29794.

Smith, T.R., Chapa, A., Willard, S., Herndon, C. Jr, Williams, R.J., Crouch, J., Riley, T. and Pogue, D. (2006). Evaporative tunnel cooling of dairy cows in the Southeast. I: Effect on body temperature and respiration rate. J. Dairy Sci. 89: 3904-3914. PMID: 16960066.

Thompson, I.M. and Dahl, G.E. (2012). Dry-period seasonal effects on the subsequent lactation. Professional Anim. Sci. 28: 628-631. Doi: 10.15232/S1080-7446(15)30421-6.

Tillman, A.D., Hartadi, H., Reksohadiprodjo, S., Prawirokusumo, S. and Lebdosoekojo, S. (1991). Ilmu makanan ternak dasar. Yogyakarta: Gadjah Mada University Press.

Venugopal, R. (2011). Managing dairy cattle in Indian summer. Vetconcern-Centre for Livestock Wealth studies. Available from: URL: http://vetconcerns.org /content/managing-dairy-cattle-indian-summer; accessed on: 19 September 2013.

Worley, J.W. (2012). Cooling systems for Georgia dairy cattle. The University of Georgia. Available from: URL: http:/www. caes.uga.edu/applications/publications/files/pdf/B% 2011724.PDF; accessed on: 23 September 2013.