ISSN 1682-8356
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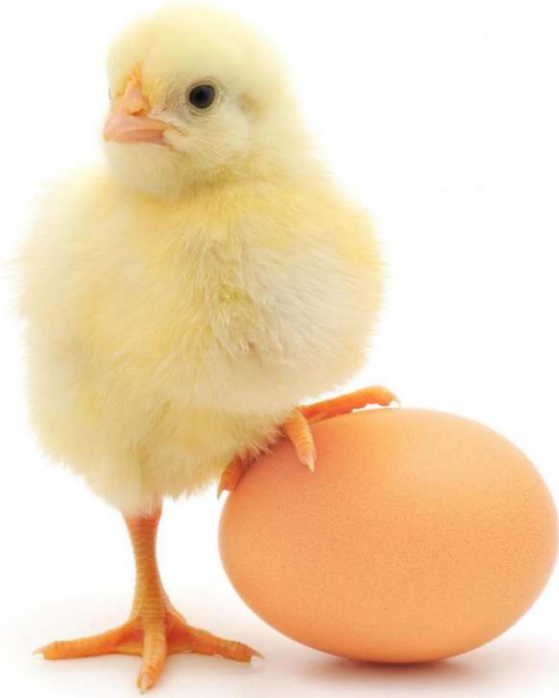

INTERNATIONAL JOURNAL OF POULTRY SCIENCE

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International Journal of Poultry Science 12 (10): 590-595, 2013
ISSN 1682-8356
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Improving Performance of Laying Hens in Hot Regions by Desert Coolers

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Abstract: The efficacy of desert coolers to improve thermal responses and performance of laying hens under heat stress conditions was investigated. Two identical layers houses of deep litter system providing 1600 cm^2/hen were used. The first house was equipped with a desert cooler while the other was left without control on air temperature (the control treatment). At 32 week of age, 100 hens from 2 commercial lines (Shaver and Hyline) were housed in each house. The average air temperature in the cooled house was 5.4°C lower ($p<0.05$) than in the control house. Drinking water temperature in the cooled house was 3.4°C lower ($p<0.05$) than that in the control house. Rectal temperatures of hens in the cooled house were significantly lower than that of the control. Hens housed in the cooled house showed a significant improvement in feed conversion, significant increase in egg production, egg weight, egg mass, eggshell thickness and eggshell density and significant decrease in unmarketable eggs compared to the control hens. Hyline showed higher ($p<0.05$) egg production than Shaver when ambient temperature was controlled by the desert cooler. Line had no significant effects on egg weight and egg mass. The net income per hen in the cooled house was US $ 6.80/hen compared to US $ 4.20/hen for the controls, which represented a net gain of US $ 2.60/hen more for the desert cooled hens. Based on these results, the use of desert cooler under hot conditions is efficient and economically feasible.

Key words: Heat stress, laying hens, desert coolers, egg production

INTRODUCTION

The poultry industry has occupied a leading role among agricultural industries in many parts of the world. The hot regions of the world probably have greatest potential for further growth since the level of consumption is still very low. One of the most important detrimental effects on poultry industry in warm and hot regions is heat stress. Jordan is one of these regions but with arid climate where the air temperature ranges in summer between 19-41°C. The maximum air temperature ranges in Jordan valley between 44-55°C (Jordan Meteorological Department, 2012). The average air temperature is above the thermoneutral zone of poultry, which is 18 to 22°C (Star *et al*., 2008). Heat stress has dramatic impacts on poultry industry, reducing performance and profitability (St-Pierre *et al*., 2003). Jordan characterized by diverse agricultural works with intensive production systems. Therefore, many farmers avoid investment in poultry sector during hot periods. The risk of chronic heat stress represents a major threat as the elevated ambient temperature inside poultry houses can easily rises beyond the thermoneutral zone of chickens. Laying hens are susceptible to heat stress due to their high metabolic heat production as a result of egg production and the limited heat loss due to feather cover and absence of sweat glands (Etches *et al*., 1995; Dawson and Whittow, 2000). As a result, hens reduce feed intake to limit the metabolic heat production, which in turn impairs egg production and eggshell quality (Blem, 2000; Star *et al*., 2008).

Different cooling systems have been developed to reduce the inside air temperature in poultry houses and to alleviate heat stress during the summer. The most common systems used in hot regions were the high pressure fogging system or the sprinkling system. Cooling in both systems is achieved by water evaporation either as fine mists in the air or as large droplets on the skin of the hens so that the evaporated water cools the air and the birds. However, effectiveness of these methods is often limited during periods of sever heat stress due to the dense insulating feathers that limit water penetration to the skin. In addition, excess water can wet the manure and the feed which increase the incidence of molds and ammonia emissions (Wolfenson *et al*., 1981). Evaporative fan-pad cooling system is widely used because its efficiency can reach over 80% in hot and dry conditions (Kittas *et al*., 2003; Cruz *et al*., 2006). However, this system requires excessive amount of water and its initial cost is considered high for small farmers (Lertsatitthanakorn *et al*., 2006). An alternative approach is the desert cooler. Desert coolers are among cooling solutions that can be affordable to small farmers and supposed to provide optimal cooling with the minimal amount of water necessary to prevent hyperthermia. This system can provide effective cooling in regions with hot and dry conditions like Jordan. Desert cooler decreases the air temperature by the evaporation of water which known as adiabatic humidification process (Ganguly and Ghosh, 2007). In this process, sensible heat is converted into

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latent heat, resulting in a reduction in the dry bulb temperature and an increase in the relative humidity of the air. Therefore, desert cooler is proposed to be more efficient in the regions with a high air temperature and low relative humidity. The potential of using desert coolers to reduce heat stress impacts on poultry and their performance in hot regions needs to be evaluated. The objective of this study was to investigate the efficacy of using desert coolers to improve thermal responses and performances of two lines of laying hens under heat stress conditions.

MATERIALS AND METHODS

Experimental birds and settings: The experiment was conducted during the periods of high ambient temperatures over the year in Jordan Valley; from March 3 to October 2 (based on the Meteorological data of Jordan Department of Meteorology, 2012). The experiment was conducted on 2 commercial lines (Shaver and Hyline) of White Leghorn hens that had been obtained from a commercial hatchery. Hens were kept under routine management at the experimental poultry farm of the University of Jordan. At 32 week of age, 200 hens (100 from each line) were selected according to average body weight and egg production and moved to the University experimental farm in Jordan Valley. Before the start of real experiment, hens were allowed a 1-wk adaptation period. Hens were housed in two identical and adjacent layers houses of deep litter system providing 1600 cm^2 per hen and a total of 16 h of light. One of the houses was equipped with a desert cooler. The other house was left without control on air temperature and followed the outdoor temperature (the control treatment). The position of the cooler was adjusted to obtain maximal and equal cool air distribution. After the adaptation period, 50 Shaver hens and 50 Hyline hens were moved to the cooled house, while 50 Shaver hens and 50 Hyline hens were moved to the uncooled house (control). Each house was divided by wire mish into 2 sections, one for each line. Hens were in their first production phase and had an average laying rate of 85%. Feed was provided ad libitum from a commercial layer feed containing 12 MJ/kg, 18.5% protein and 4% calcium (NRC, 1994).

Measured parameters: Performance parameters were measured on all hens for 30 weeks. Body weight, feed intake and feed conversion ratios were measured weekly for each line to an accuracy of ±1 g. Total eggs produced, deformed eggs, eggs weight, eggshell thickness and mortality were recorded on a daily bases. Shell thickness was the average thickness measured at air cell, equator and sharp end by using a micrometer caliper. Shell density (mg/cm^2) was calculated as the weight of the dry shell divided by the surface area. The surface area of the egg was calculated according to Carter (1975). Rectal temperature was measured 3 times a day (at 9:00 Am, 12:00 Am and 4:00 PM) with an accuracy of ±0.1°C by a digital thermometer inserted into the cloaca. Electrical power consumed was monitored in each house on a daily basis to evaluate the economic efficiency of using the desert cooler. Maximum and minimum ambient temperatures were recorded using mercury thermometers inside both houses. Relative humidity was recorded as dry and wet bulb using Whirling Hygrometer (Branan Thermometers Cumberland, U.K) and estimated from a standard curve describes the percentage of relative humidity scale. Air velocity was measured by air velocity meter (AVM 501 TC, Prosser scientific instruments Ltd.). All environmental measurements were taken inside both houses 3 times a day (9:00 Am, 12:00 Am and 4:00 PM) at different sites.

Statistical analysis: Data were analyzed by ANOVA using the general linear models procedure of the Statistical Analysis System software (SAS, 2010). Data were analyzed in models based on within-hen repeated measurements. The statistical models included experimental groups (desert cooled group vs. uncooled control groups), strain (nested within group) and their interactions. Time or period effects and their interactions were tested against the residual error. Proc corr procedure of SAS was used to estimate the Pearson Correlation Coefficients between house ambient temperature (Ta), drinking water temperature (Tw), hen rectal temperature (Tr) and performance parameters.

RESULTS AND DISCUSSION

Environmental Measurements: Desert cooler significantly ($p<0.05$) reduced the average inside-house ambient temperature as soon as the cooler was turned on. The overall air temperature in the cooled house was 4°C below ($p<0.05$) that in the control house when measured during the heat of the afternoons (Table 1). During summer season, average air temperature in the cooled house was 5.4°C lower ($p<0.05$) than in the control house. The relative humidity averaged 0.7% higher in the desert cooler house than in the control house. This difference was not significant ($p>0.05$) during the study period. This can be justified because Jordan is located in hot and arid region, where dry conditions prevent the accumulation of humidity inside the poultry houses. The maximum relative humidity inside poultry houses is not recommended to exceed 80% (Longhouse *et al.*, 1963) and this level was not exceeded during the entire experimental period as the area is generally characterized by arid climatic condition throughout the year. Drinking water temperature was significantly affected by the inside air temperature as the average drinking water temperature in the cooled house was 3.4°C lower ($p<0.05$) than drinking water

Table 1: Environmental data and drinking water temperature from layer houses with and without cooling measured during the hottest period of the day

	House air temperature °C			RH%			Drinking water temperature °C		
Month	Control	Desert cooler	SE	Control	Desert cooler	SE	Control	Desert cooler	SE
April	27.4	26.3	1.11	21.1	21.0	1.34	24.4	23.8	1.64
May	32.5	29.8	1.23	14.6	14.8	2.34	26.4	24.4	1.84
June	37.4	32.1	1.47	14.6	17.5	2.14	28.2	25.7	1.67
July	38.2	32.8	2.07	9.8	10.3	1.54	30.1	26.6	2.09
August	38.8	33.2	0.97	12.9	13.3	1.72	31.0	26.8	1.47
September	36.4	32.3	1.65	16.3	16.4	1.17	29.0	26.0	1.45

Table 2: Mean performance data of laying hens from layer houses with and without cooling over the study period

	Hyline		Shaver			
Parameter	Control	Desert cooler	Control	Desert cooler	SE	P- value
Egg production (%)	68.5[c]	72.8[a]	68.0[c]	71.6[b]	0.87	0.041
Egg weight (g)	58.3[b]	60.2[a]	58.1[b]	59.8[a]	0.62	0.021
Egg mass (g/hen/day)	39.9[b]	43.8[a]	39.6[b]	42.7[a]	0.24	0.043
Feed intake (g/d)	112.6[a]	110.3[a]	103.0[b]	98.9[b]	0.94	0.033
Eggshell thickness (mm)	0.37[b]	0.41[a]	0.35[b]	0.39[a]	0.18	0.018
Eggshell density (mg/cm^2)	72.6[b]	76.2[a]	73.4[b]	75.6[a]	0.28	0.009
Feed conversion (kg/kg)	2.8[a]	2.5[b]	2.6[b]	2.3[c]	0.08	0.014
Unsalable egg (%)	1.4[a]	0.5[b]	1.7[a]	0.6[b]	0.21	0.023
Hen mortality (%)	0.6[a]	0.3[b]	0.7[a]	0.3[b]	0.06	0.039

Means in the same row with different superscripts are significantly different at $p<0.05$

SE: Pooled standard error of the means

temperature in the control house during the periods of acute high ambient temperatures (Table 1). Providing cooled drinking water is proposed to maintain normal feed intake and improve poultry performance in hot regions (Puma *et al*., 2001; Xin *et al*., 2002; Gutierrez *et al*., 2009).

Performance parameters: Hens housed in the cooled house showed a significant ($p<0.05$) increase in egg production compared to the control hens that were housed in the naturally ventilated house. This trend was exhibited from the first week of the study and continued throughout the experiment (Table 2). Although both lines showed similar egg production in the control treatment; Hyline showed higher ($p<0.05$) egg production than Shaver when ambient temperature was controlled by the desert cooler. Egg weight and egg mass were significantly ($p<0.05$) improved in hens housed under desert cooling system compared to the control hens. Line had no significant effects on egg weight and egg mass. Feed intake was not affected by desert cooling in both lines, although Shaver hens tended to consume less ($p<0.05$) feed than Hyline hens under hot and cooled environmental conditions. Feed conversion was significantly ($p<0.05$) improved by desert cooling system in both lines compared to the control, however Shaver hens tended to be more efficient in feed conversion under both environmental conditions (Table 2). Installation of the desert cooler improved ($p<0.05$) eggshell quality traits as the control group of both lines produced the least ($p<0.05$) eggshell thickness and eggshell density. As a results, the desert cooler hens tended to lay less ($p<0.05$) unmarketable eggs than the control hens throughout the experimental period. The impaired eggshell quality observed in the control hens were attributed to the decrease in the plasma concentration of bicarbonate (Odom *et al*., 1985) or to the depressed blood supply to the shell gland under heat stress (Wolfenson *et al*., 1981). Hen mortality was significantly higher in the control house compared to the desert cooled house with no significant effect of line (Table 2).

Rectal temperature: Rectal temperatures (Tr) of hens housed under desert cooling system were significantly ($p<0.05$) lower than those housed under uncooled environment (control) during the periods from June toward the end of the study (Table 3). Rectal temperatures of hens housed under desert cooling system measured at 8:00 am (before operating the cooling system) were also significantly ($p<0.05$) lower than those housed under uncooled environment during the same periods. This indicated that uncooled hens were suffering the load of heat stress from the previous day (s), while cooled hens were able to dissipate the heat load during the night. The low Tr of cooled hens that were measured after operating the cooling system (12:00 and 4:00 pm) clearly indicated that the desert

Table 3: Mean rectal temperature (Tr) measured at different times during the day on laying hens housed in layer houses with and without cooling

		Tr at 8:00 am				Tr at 12:00 pm				Tr at 4:00 pm			
Line	Month	Control cooler	Desert	SE	P-value	Control cooler	Desert	SE	P-value	Control cooler	Desert	SE	P-value
Hyline	April	39.4	39.4	0.45	NS	40.4	40.1	0.67	NS	40.3	40.1	0.64	NS
	May	40.1	39.8	0.32	NS	41.2^a	40.3^b	0.64	0.006	40.5	40.2	0.47	NS
	June	40.8^a	40.0^b	0.35	0.021	41.5^a	40.7^b	0.48	0.008	41.1^a	40.5^b	0.21	0.034
	July	40.9^a	40.2^b	0.27	0.014	41.8^a	41.1^b	0.94	0.015	41.3^a	40.7^b	0.35	0.043
	August	41.0^a	40.3^b	0.35	0.008	41.9^a	41.2^b	0.55	0.024	41.5^a	40.7^b	0.46	0.007
	September	40.7^a	40.1^b	0.41	0.034	41.6^a	40.6^b	0.74	0.018	41.3^a	40.4^b	0.74	0.024
Shaver	April	39.4	39.3	0.14	NS	40.4	40.0	0.34	NS	40.3	40.1	0.54	NS
	May	40.0	39.7	0.24	NS	41.1^a	40.3^b	0.54	0.033	40.3	40.1	0.52	NS
	June	40.6^a	39.9^b	0.42	0.023	41.3^a	40.7^b	0.44	0.042	40.9^a	40.3^b	0.33	0.031
	July	40.7^a	40.2^b	0.34	0.004	41.6^a	41.0^b	0.17	0.021	41.2^a	40.5^b	0.29	0.018
	August	40.9a	40.2^b	0.22	0.002	41.8^a	41.1^b	0.47	0.004	41.3^a	40.6^b	0.43	0.027
	September	40.6a	40.1^b	0.14	0.008	41.5^a	40.7^b	0.65	0.034	41.1^a	40.4^b	0.44	0.009

Means in the same row with different superscripts are significantly different at p<0.05

NS: not significant (p>0.05)

SE: Pooled standard error of the means

cooling system was significantly effective in reducing the heat load on hens during the afternoons. Both lines showed significant decrease in their Tr after operating the desert cooling system, however Hyline showed an average of 0.1°C less Tr than Shaver. Although Shaver hens were more efficient in converting feed to egg than did Hyline hens (Table 2) but Hyline hens were more efficient in controlling their body temperature under both environmental conditions. This indicated that Hyline hens had diverted part of the consumed energy to operate their body thermoregulatory mechanisms. Shaver hens consumed less feed than Hyline, but Shaver had converted their consumed energy toward performance at the expense of thermoregulatory mechanisms. This is in accordance with the results of Smith (2001) who concluded that energy use by poultry is distributed between maintenance and production including the needs for physiological mechanisms, such as the needs to maintain body temperature.

Reliability of desert cooler: To characterize the reliability of installing a desert cooler in poultry houses, a correlation coefficients analysis between measured parameter was conducted. The correlation coefficients analysis showed that rectal temperature significantly followed the house temperature (r = 0.94, p<0.0001) and drinking water temperature (r = 0.96, p<0.0001). Drinking water temperature was positively correlated with house temperature (r = 0.95, p<0.0001). House Ta, drinking water temperature and hen Tr had a significant negative correlation with egg production, egg weight and egg mass and a significant positive correlation with unmarketable egg and hen mortality (Table 4). The negative impacts of house Ta and drinking water temperature were considerably high and significant on egg production and eggshell thickness (r = 0.88, p<0.0001) and moderate on egg weight, egg mass, eggshell density and unmarketable egg (r = 0.67-0.78, p<0.001). Hen mortality was positively (p<0.0001) correlated with House Ta, drinking Tw and hen Tr (Table 4).

Economic feasibility: The control hens had significantly higher feed cost/hen than that of the desert cooled hens. The cost of electrical power/hen used to operate the desert cooler were not significant (p>0.05) among treatments (Table 5). Total return/hen was significantly higher in the desert cooled hens compared to the control hens. In addition, the net income for the hens in the desert cooled house was US $ 6.80/hen compared to US $ 4.20/hen for the controls, which represented a net gain of US $ 2.60/hen more for the desert cooled hens. There were no significant interactions of line and treatment on the cost-benefit criteria, except for egg production. Cooled Hyline hens produced more egg per unit of feed consumed. However egg weight and egg

Table 4: Pearson correlations coefficients between house ambient temperature, drinking water temperature, hen rectal temperature (Tr) and performance parameters

Parameters	House ambient temperature	Drinking water temperature	Hen rectal temperature
Drinking water temperature	0.95**		
Hen rectal temperature	0.94**	0.96**	
Egg production	-0.90**	-0.93**	-0.87**
Egg weight	-0.76*	-0.72*	-0.77*
Egg mass	-0.73*	-0.76*	-0.74*
Eggshell thickness	-0.91**	-0.90**	-0.88**
Eggshell density	-0.78*	-0.73*	-0.71*
Unsalable egg	0.67*	0.75*	0.76*
Hen mortality	0.83**	0.89**	0.91**

*p<0.001, **p<0.0001

Table 5: Feed and electrical power costs and returns per hen in layer houses with and without cooling during the study period

Parameter	Control house	Cooled house	SE	P-values
Days of experimentation	182	182	1.23	NS
No of hens (both lines)	100	100	1.11	NS
Total feed consumed (kg/hen)	19.7[a]	19.0[b]	0.65	0.021
Feed cost (US $/hen)	14.30[a]	13.50[b]	0.32	0.035
Electrical power cost (US $/hen)	0.14	0. 50	0.08	NS
Total return from egg (US $/hen)	18.60[a]	20.80[b]	0.94	0.008
Net return (US $/hen)	4.20[a]	6.80[b]	0.42	0.011

Means in the same row with different superscripts are significantly different at p<0.05

NS: Not significant (p>0.05)

SE: Pooled standard error of the means

mass were not affected (p>0.05) by line. The feed intake comparison is valid because we compared the cost of the nutrients consumed per unit of egg produced. Therefore, if the objective is to obtain larger egg size per unit of feed consumed, this experiment indicate that the desert cooling system can improve egg weight and egg mass with lower feed costs regardless of line.

The experimental conditions in both layer houses were identical except in the cooling system. Therefore, the results of the present experiment suggested that improvements in performance achieved by hens in the cooled house were due to the low ambient temperature achieved by the desert cooler. Further more, desert cooler did not increase the relative humidity inside the layer houses, as the evaporative coolers have been developed primarily for use in hot arid regions because they are most effective when the relative humidity is low. Desert cooler did not increase the initial inputs cost as the increase in production had increased the net outcome and overcome the cost.

Conclusion: In the present study, desert cooler reliably reduced the load of hot conditions and decrease the heat stress exposure in both lines. Desert cooler is very effective in reducing the average ambient temperature in layer houses, which improved laying performance. The reduction in heat stress resulted in a significant improvement in egg production, egg weight, egg mass, eggshell quality traits and a significant decrease in mortality rate. The use of desert cooler under hot condition is efficient and economically feasible.

Conflict of interest: The authors declare that they have no conflict of interest.

ACKNOWLEDGMENTS

This research was funded by Faculty of Agriculture, the University of Jordan, under promotion of research scheme.

REFERENCES

Blem, C.R., 2000. Energy balance. Pages, 327-341 in: Sturkie's Avian Physiology. 5th ed. G.C. Whittow, ed. Academic Press, New York, NY.

Carter, T.C., 1975. The hen's egg, estimation of shell superficial area and egg volume, using measurements of fresh egg weight and shell length and breadth alone or in combination. Br. Poult. Sci. 16: 541-543.

Cruz, V.F., M. Perissinotto and E. Lucas, 2006. Cooling livestock buildings by pad and fan evaporative cooling system (pad cooling). In: Animal Housing in Hot Climates: a Multidisciplinary View (Naas I A Ed), pp: 37-38, CIGR section II working group in cooperation with Eurageng, Campinas, SP-Brazil.

Dawson, W.R. and G.C. Whittow, 2000. Regulation of body temperature. Pages, 343-390 in: Sturkie's Avian Physiology. 5th ed. G.C. Whittow, Ed. Academic Press, New York, NY.

Etches, R.J., T.M. John and G.A.M. Verrinder-Gibbins, 1995. Behavioural, physiological, neuroendocrine and molecular responses to heat stress. Pages, 31-66 in: Poultry Production in Hot Climates. N.J. Daghir, Ed. CAB International, Cambridge, UK.

Ganguly, A. and S. Ghosh, 2007. Modeling and analysis of a fan-pad ventilated floricultural greenhouse. Energy and Buildings, 39: 1092-1097.

Gutierrez, W.M., W. Min and H.H. Chang, 2009. Effect of chilled drinking water on performance of laying hens during constant high ambient temperature. Asian-Aust. J. Anim. Sci., 22: 694-699.

Jordan Meteorological Department, 2012. http://www.jmd.gov.jo/. Accessed on 25.09.2013.

Kittas, C., T. Bartzanas and A. Jaffrin, 2003. Temperature gradients in a partially shaded large greenhouse equipped with evaporative cooling pads. Biosystems Eng., 85: 87-94.

Lertsatitthanakorn, C., S. Rerngwongwitaya and S. Soponronnarit, 2006. Field experiments and economic evaluation of an evaporative cooling system in a silkworm rearing house. Biosystems Eng., 93: 213-219.

Longhouse, A.D., G.O. Bressler, C.S. Shafefner, H.I. Garver, 1963. Poultry housing-basic data useful for design purposes in the northeastern states. West Virginia Agri. Exp. Station Bull., Vol. 486.

NRC (National Research Council), 1994. Nutrient Requirements of Poultry, 9th rev. ed. Natl. Acad. Press, Washington, DC.

Odom, T.W., P.C. Harrison and M.J. Darre, 1985. The effects of drinking carbonated water on the egg shell quality of Single Comb White Leghorn hens exposed to high environmental temperature. Poult. Sci., 64: 594-596.

Puma, M.C., H. Xin, R.S. Gates and D.J. Burnham, 2001. An instrumentation system for measuring feeding and drinking behavior of individual poultry. Appl. Eng. Agri. 17: 365-374.

SAS, Institute, Inc., 2010. SAS OnlineDoc® Version 9.1.3. SAS Institute, Inc., Cary, NC, USA.

Smith, A.J., 2001. The Tropical Agriculturalist-Poultry. Macmillan Education Ltd., London, UK.

Star, L., B. Kemp, I. van den Anker and H.K. Parmentier, 2008. Effect of Single or Combined Climatic and Hygienic Stress in Four Layer Lines: 1. Performance. Poultry Sci., 87: 1022-1030.

St-Pierre, N.R., B. Cobanov and G. Schnitke, 2003. Economic losses from heat stress by US livestock industries. J. Dairy Sci., 86 (E. Suppl.), E52-E77.

Wolfenson, D., Y.F. Frei, N. Snapir and A. Berman, 1981. Heat stress effects on capillary blood flow and its redistribution in the laying hen. Eur. J. Physiol., 390: 86-93.

Xin, H., R.S. Gates, M.C. Puma and D.U. Ahn, 2002. Drinking Water Temperature Effects on Laying Hens Subjected to Warm Cyclic Environments. Poult. Sci., 81: 608-617.