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Cooling Holstein cows and heifers before parturition during summer: physiological responses prepartum and productive responses postpartum

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ABSTRACT

The aim was to compare physiological parameters prepartum and productive responses postpartum of multiparous cows, and first-calf heifers cooled 30 d before parturition. Twelve cows and twelve heifers were subjected to a cooling system for 30 d before the predicted calving date. Before calving, respiration frequency (RF) was measured twice a day (AM and PM) once a week; also, a blood sample was obtained from the coccygeal vein once a week for a biochemical profile. After calving, productive parameters measured were calf birth weight and growth until weaning, colostrum, milk quality, and milk production. Mature cows had 6.5% less RF ($P<0.05$) than heifers during the morning, but this difference increased to 23% during the afternoon ($P<0.01$). Mature cows exhibited higher ($P<0.05$) mean corpuscular volume, mean corpuscular hemoglobin, and platelet distribution width than heifers; however, heifers showed higher ($P<0.05$) red blood cell count than mature cows. In comparison, colostrum fat was higher ($P<0.05$) in heifers, protein, SNF, and density were similar between groups. Milk quality did not differ between cows and heifers, but milk yield at 30, 60, 90, 120, and 150 d was higher ($P<0.05$) in mature cows than in heifers. Calf mortality, calf birth weight, body weight at 30 and 60 d, as well as daily weight gain at 60 d, were similar in both groups of mothers. In conclusion, mature cows showed better physiological and productive responses than heifers when cooled with spray and fans for 30 d prepartum under hot and dry stressful conditions.

Keywords: heat stress, dry period, milk production, colostrum quality, calf birth weight

INTRODUCTION

Climate change is associated with an increasing world temperature; according to climatic predictive models, by the year 2100, the mean global temperature will increase from 1.1 to 6.4°C (Hansen et al., 2010). Weather changes include more extended and more intense heat weaves during summer months, negatively impacting on agriculture and animal husbandry, especially those located in arid zones. As a result, summer heat stress (HS) produces hyperthermia in domestic animals reared outdoors and represents a critical challenge that the livestock industry has been facing with more emphasis in recent years (Sejian et al., 2018). In fact, the annual economic losses of dairy cattle originating from the effects of HS in the United States of America were estimated at about 900 million dollars, which included lower milk production, reduced reproductive rates, and depressed immune function (St-Pierre et al., 2003).

Most of the research on the evaluation of the effects of HS in dairy cattle has been completed during the lactation period of the cows, so they do not consider the dry period, that is, the last 60 d before parturition. The prepartum period is essential for the lactating cow. It has a significant impact not just on early lactation, but on the entire lactation period, as well as on the development of the newborn (Karimi et al., 2015). Several stressors occur in the dairy cow when she transits from the non-lactating to the lactating state, resulting in production and welfare impairments to the cow and its offspring. The presence of HS during the dry period of Holstein cows resulted in diminished milk production in the subsequent lactation at different stages and dysfunction of the immune system (Tao et al., 2012).

The mammary tissue during the dry period experiences extensive growth and cellular turnover that can be affected by HS conditions. Limited cooling during the dry period (shade or intermittent soaking) has shown to be ineffective since just modest increases in milk production have been reported (Collier et al., 1982; Avendaño-Reyes et al., 2008). However, when the cooling applied to dry cows is ampler (shade plus water and forced ventilation), milk production post-partum increased significantly. Tao et al. (2011) found that prepartum-cooled cows had more significant insulin resistance in peripheral tissues to direct more glucose to the mammary gland during early lactation compared to prepartum non-cooled cows, which suggests that this is a secondary metabolic pathway in which cooling cows during the dry period improves post-partum milk production. So the dry period is critical for maximizing milk yield and quality in the subsequent lactation.

In addition to these adverse effects of prepartum HS on dairy cows, colostrum quality and fetal growth are also affected. Cows that were non-cooled during the prepartum period exhibited lower serum IgG concentrations and efficiency in their absorption compared with cows that cooled during the same period (Tao et al., 2012). Consequently, when colostrum from cooled cows during the dry period was given to newborn calves, they showed higher blood IgG levels than those of non-cooled cows (Stott, 1980). Exposing Holstein heifers to HS before calving, Nardone et al. (1997) found that Ig concentrations in the colostrum were lower than their counterparts under thermoneutrality. Maternal HS reduces the birth weight of newborn calves, which reveals impaired fetal development in utero (Tao and Dahl, 2013). However, results on cooling first lactation cows before parturition during summer have yet to be studied. Therefore, the objective of this study was to compare some physiological and productive responses of first calf heifers and mature cows during the pre-and post-partum periods, which were cooled 30 d prepartum during summer in a hot and arid region.

MATERIALS AND METHODS

The care and management of the cows and heifers during the present study followed the procedures accepted by the Mexican Official Norms (NOM-051-ZOO-1995: humanitarian treatment of animals during mobilization).

Location of the study, experimental animals, and treatments

The study was carried on at a commercial dairy herd located in the rural community Ejido Jalisco, 27 km NW from the capital city of Mexicali, Baja California, México. Its geographic location is 115° 23´ longitude and 32° 52´ latitude, and it has 85 mm of average annual precipitation, 5 m above sea level, and an average yearly temperature of 24°C; this province is part of the ecosystem the Sonoran Desert and has a climate extremely arid, including maximum and minimum temperatures of 49 and -2°C during summer and winter, respectively (INEGI, 2017). The dairy herd milked around 600 cows. Twelve mature cows (4 to 6 years old) and twelve first-calf heifers (2 to 3 years old), all Holstein breeds, were used in the present study. All females were diagnosed as pregnant and had around eight months of gestation at the start of the study. Hence 30 d before their projected calving date, animals were assigned to one of two treatments: 1) Corral of mature cows with a cooling system under the shade, and 2) corral of first-calf heifers with the cooling system under the shade. All cows were fed twice a day at 07:00 and 14:00 h. A diet consisted of a mixture of two forages, oat straw, and sudangrass, given at 3% of the body weight (approximately 14 kg DM/cow). Fresh water was available all the time, having each corral having two waterers.

Corrals and cooling system

Two pens were used during the study, one for cows and one for heifers. The corral of the mature cows had an area of 2000 m^2 (50 x 40 m), while the corral of the heifers was 1443 m^2 (39 x 37 m). Each corral was equipped with a cooling system based on spray and fans. The fans had 76 cm of diameter (Universal Fog Cooling System®, Mesa, AZ, USA), 1 HP motor potency, and produced 15,000 CFM. They were installed at 2.50 m height and separated at 1.40 m each. A mature cow´s pen had five fans, and a heifer´s pen 3. A nylon high-pressure tubing line (Universal Fog Cooling System®, Mesa, AZ, USA) with sprayers at 1.35 m of separation was installed in front of the fans on each corral. The cooling system was activated with a thermostat set to operate when the ambient temperature reached 30°C.

Climatic variables

Climatic information was provided by the National Meteorological Service, a climatic station from the national weather network service in the state of Baja California, México. The climatic variables collected were ambient temperature (AT, °C) and relative humidity (RH, %) every 15 min, which were used to construct the temperature-humidity index (THI) following the formula proposed by Hahn (1999): THI = 0.81 (AT) + RH (AT - 14.4).

Physiological variables collection and analysis

Respiration frequency (RF) was recorded, registering the number of breaths during 30 seconds and multiplying this amount by 2 to obtain this variable in breaths per minute (bpm). This procedure was performed in all animals twice a day, twice a week, between 06:00 - 07:00 h (AM) and 15:00 - 16:00 h (PM) during the 30 d prepartum blood samples were collected weekly from the coccygeal vein in all females during the morning before the first feed was served. On each bleeding, two blood samples were collected, one in 10-ml vacutainer tubes containing EDTA, and the second in 5-ml tubes. The 10-ml samples were centrifuged at 3500 x *g* for 15 min at 10 ºC. Serum was stored at -20 ºC into 2-ml vials for determination of metabolites (i.e., glucose, cholesterol, triglycerides, urea, and total protein) in a blood auto-analyzer of liquid phase (EasyVet, KONTROLab, Morelia, Michoacán, Mexico). The second vial was used for the determination of electrolytes (i.e., sodium [Na^+], potassium [K^+], and chlorine [Cl^-]) using an electrolyte analyzer (LW E60A, LandWind, Shenzhen, China). Furthermore, the 5-ml tubes were used to analyze the hematological profile with the fresh blood samples in a blood auto-analyzer (Auto Hematology Analyzer, Mindray, BC-2800 Vet; Shenzhen, China). The hematological profile included the variables red/ blood cells (RBC), red blood cell distribution width (RDW), white blood cells (WBC), hemoglobin (HGB), monocytes (MON), lymphocytes (LYM), granulocytes (GRAN), procalcitonin (PCT), hematocrit (HCT), platelet distribution width (PDW), mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH); mean corpuscular hemoglobin concentration (MCHC), platelets (PLT), and mean platelet volume (MPV).

Production variables collection and analysis

Colostrum was collected after calving (0 h), 12, and 24 h postpartum. This sample was obtained from the four quarters of each animal and mixed in one sample for colostrum quality analysis which includes percentages of fat, protein, solids non-fat, and density. These determinations were performed in a LactiCheck LC-01 Milk Analyzer (Page & Pedersen International Ltd®, Hopkinton, MA, USA). Daily milk production was obtained by adding the volume of milk produced by each cow and heifer in the two milkings (04:00 and 16:00 h) per day. This information was collected from the electronic milking system of the dairy farm (DeLaval Herringbone Parlor HB50, Kansas City, Missouri, USA) using its supplementary software DeLaval DelPro™. Afterward, a milk sample from the four quarters of each animal was collected every week post-partum and mixed in one sample from morning and afternoon milking to be analyzed for the same milk quality parameters as colostrum until week four. Milk production was continuously recorded, and averages were calculated on days 30, 60, 90, 120, and 150 postpartum.

Statistical analysis

Respiratory frequency, metabolites, electrolytes, and hematological profile were analyzed with a 2 x 4 factorial arrangement in a completely randomized design with repeated measures, where factors were treatment (cows and heifers) and time (4 weeks). These models were performed with PROC MIXED of SAS (SAS, 2004), and the commands LSMEANS and PDIFF were used to estimate the least square means declaring significance at a 5% level. Colostrum and milk component variables were analyzed under a 2 x 3 or a 2 x 4 factorial arrangement in a completely randomized design, respectively. Factors of these models were treatment and time; the factor time had three levels for colostrum (0, 12, and 24 h post-partum) and four levels for milk production (7, 14, 21, and 28 d post-partum). Cow within treatment was the random effect, and the model was performed under a repeated measurement statement. When the factor time was significant, orthogonal polynomials were performed to determine the trend in the milk component as a function of time. Finally, milk production was analyzed with a 2 x 5 factorial arrangement in a completely randomized design, being the factors of treatment and time (30, 60, 90, 120, and 150 days post-partum). The PROC MIXED from SAS (SAS, 2004) was used, and the least square means were obtained with the PDIFF command. Significance was declared at a 5% level and a tendency between 5 and 10%.

RESULTS

Figure 1 shows the average of the climatic variables AT, RH, and THI during the 30 d before the calving date. The interaction treatment x time was significant ($P < 0.05$) for the variables of respiration frequency and milk production; however, the remaining variables were nonsignificant, so they are explained under these results. The averages of RF were 4.3 bpm higher ($P > 0.05$) during the morning, and this difference increased to 24.6 bpm ($P < 0.05$) during the afternoon in favor of heifers (Figure 2). The hematological profile of cows and heifers under cooling for 30 d before calving is presented in Table 1. The mature cows had higher ($P < 0.01$) MCV, MCH, and PDW than younger cows; meanwhile, RBC was higher ($P < 0.05$) in heifers than in cows; the remaining blood components were similar

(P > 0.05) between both groups. The average serum concentrations of the electrolytes Na^+, K^+, and Cl^- did not differ (P > 0.05) between cows and heifers (Table 1). Milk production was higher (P < 0.05) in cows than in heifers at 30, 60, 90, 120, and 150 days postpartum (Figure 3). For colostrum and milk components, there were differences (P < 0.05) by each factor individually. In colostrum, heifers produced more (P < 0.01) fat in milk than cows; the remaining colostrum components were similar (P > 0.05) in both female groups (Table 2). From calving to 24 h postpartum, colostrum protein showed a quadratic trend (P < 0.05) and density a linear trend (P = 0.0634) to reduce (Table 3). Milk fat and protein, as well as SNF, were similar (P > 0.05) in cows and heifers; however, SNF showed a trend (P = 0.0652) to be higher in heifers than in cows (Table 2). From day 7 to 28 postpartum (Table 4), milk fat showed a linear trend to decrease (P < 0.01), milk protein showed a quadratic trend (P = 0.0563), and milk SNF a trend to increase (P = 0.0996), while milk density a cubic response (P < 0.05). Calf birth weight in calves born from cows and heifers was similar (P > 0.05), as well as body weights at 30 and 60 d of age. Finally, calf mortality was similar (P > 0.05) in calves born from cows and heifers (Table 5).

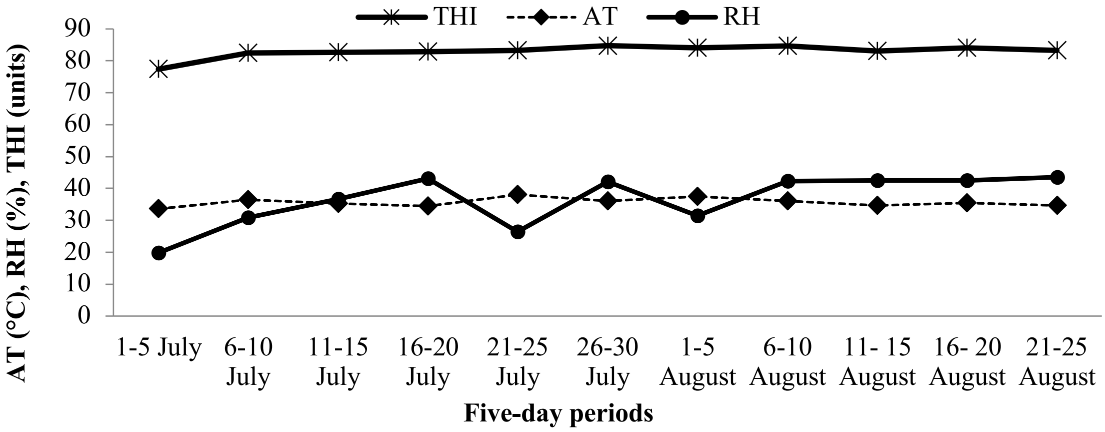

Figure 1. Average of climatic variables in five-day episodes during the prepartum period
THI= Temperature-Humidity Index [Units]; AT= Temperature of the dry bulb [°C]; RH= Relative Humidity [%].

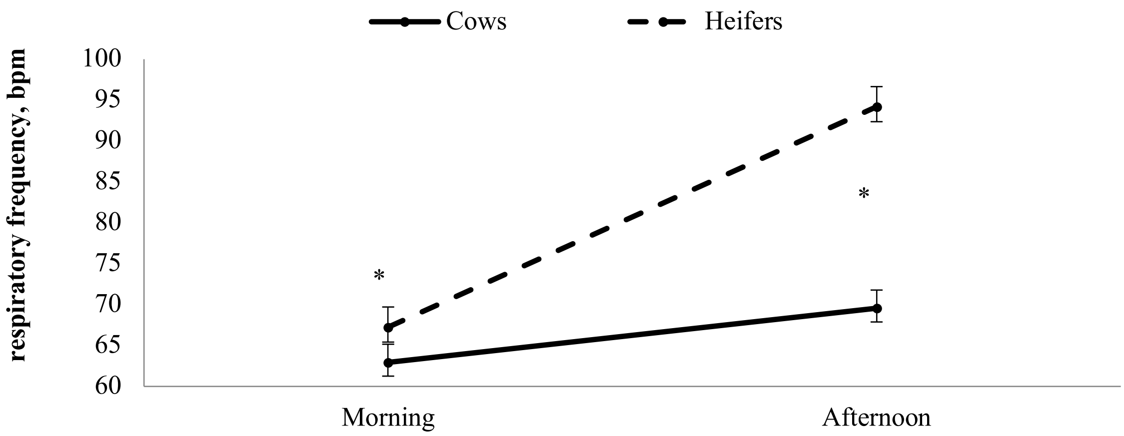

Figure 2. Averages of respiratory frequency (breaths per minute, bpm) during the morning and afternoon in cows and heifers under a cooling system 30 d prepartum [* (P<0.05)].

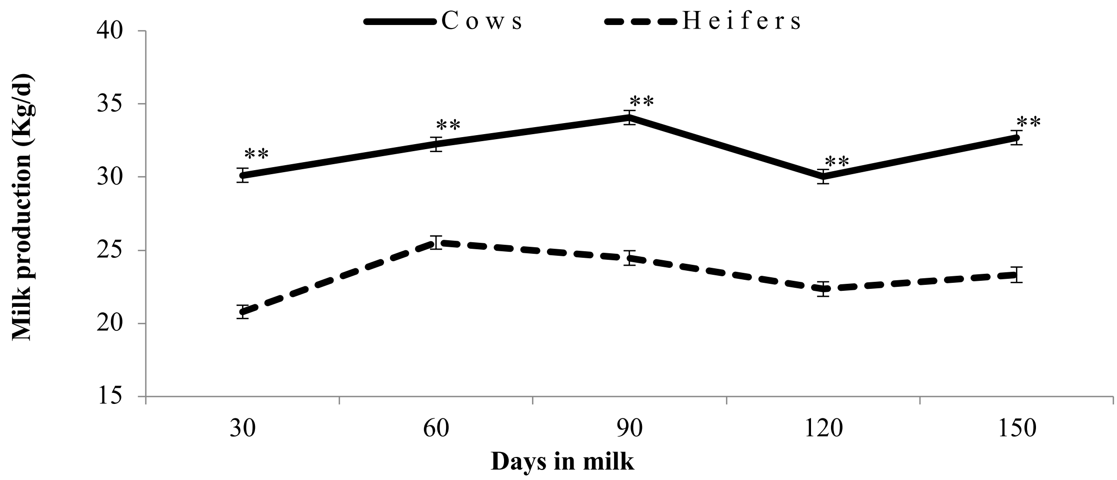

Figure 3. Milk production from day 30 to 150 in cows and heifers under a cooling system 30 d prepartum (** (P<0.05)].

Table 1. Hematological components and electrolyte concentrations in serum (mmol/L) of cows and heifers under a cooling system 30 d prepartum.

Parameter	Treatments		SEM	*P-value*
	Cows	Heifers		
Hematological				
MCV, fL	52.727	45.853	0.893	0.0001
MCH, pg	16.903	14.740	0.268	0.0001
MCHC, g/dL	32.192	32.168	0.200	0.9371
HCT, %	0.308	0.315	0.006	0.4710
PDW, %	16.710	16.280	0.112	0.0148
RBC, x12/L	5.862	6.884	0.169	0.0002
RDW, %	0.167	0.167	0.002	0.9848
WBC, x12/L	12.393	10.675	1.063	0.2885
HGB, g/L	9.910	10.084	0.190	0.5385
PLT, x12/L	369.29	352.77	20.438	0.5930
MPV, fL	5.157	4.998	0.065	0.1105
MON, x12/L	0.085	0.005	0.004	0.3231
LYM, x12/L	0.492	0.091	0.027	0.4063
GRAN, x12/L	0.425	0.452	0.026	0.4817
PCT, %	0.002	0.002	0.001	0.1649
Electrolytes				
Na^+	133.194	139.512	3.654	0.2519
K^+	4.825	5.147	0.317	0.4990
Cl^-	115.663	118.388	3.701	0.6239

MCV = Mean corpuscular volume; MCH = Mean corpuscular hemoglobin; MCHC = Mean corpuscular hemoglobin concentration; HCT = Hematocrit; PDW = Platelet distribution width; RBC = Red blood cells; RDW Red blood cell distribution width; WBC = White blood cells; HGB = Hemoglobin; PLT = Platelets; MPV = Mean platelet volume; MON = Monocytes; LYM = Lymphocytes; GRAN = Granulocytes; PCT = Procalcitonin; Na^+ = Sodium; K^+ = Potassium; Cl^- = Chlorine; SEM = Standard error of the mean.

Table 2. Colostrum and milk quality components in cows and heifers under a cooling system 30 d prepartum.

Item	Cows	Heifers	SEM	*P-value*
Colostrum, %				
Fat	3.10	5.89	0.31	<0.0001
Protein	6.83	6.67	0.26	0.6593
SNF	17.41	17.90	0.86	0.6835
Density	64.96	60.85	2.68	0.2823
Milk, %				
Fat	5.06	4.14	0.09	0.1398
Protein	3.44	3.58	0.07	0.1867
SNF	8.69	9.41	0.27	0.0652
Density	28.89	30.65	1.08	0.2593

SEM = Standard error of the mean; SNF = Solids non-fat.

Table 3. Trend in colostrum quality (%) by the time of sampling in cows and heifers under a cooling system 30 d prepartum.

Item	Time of sampling			SEM	*P-value*	
	At calving	12 hpp	24 hpp		Linear	Quadratic
Fat	4.69	4.68	4.12	0.38	0.2956	0.5577
Protein	7.49	6.19	6.58	0.32	0.0500	0.0344
SNF	18.96	17.29	16.72	1.05	0.1397	0.6693
Density	69.74	58.00	60.96	3.28	0.0634	0.0727

SNF = Solids non-fat; SEM = Standard error of the mean; hpp = hours postpartum.

Table 4. Trend in milk quality variables (%) by day post-partum in cows and heifers under a cooling system 30 d prepartum.

Item	Day post-partum				SEM	*P-value*		
	7	14	21	28		Linear	Quadr.	Cubic
Fat	4.98	4.59	3.87	2.89	0.57	0.0003	0.4291	0.1570
Protein	3.50	3.26	3.55	3.62	0.11	0.4435	0.0563	0.0693
SNF	8.23	8.38	9.27	9.65	0.47	0.0996	0.2358	0.2087
Density	29.0	25.84	31.05	33.07	1.41	0.0205	0.0616	0.0366

SNF= Solids non-fat; SEM= Standard error of the mean.

Table 5. Body weight at different times and mortality of calves born from cows and heifers under a cooling system 30 d prepartum.

Item	Cows	Heifers	SEM	*P-value*
CBW, kg	37.13	33.75	1.73	0.1737
W30d, kg	44.44	44.54	2.65	0.9782
W60d, kg	64.40	69.01	4.39	0.4720
TDWG, kg	0.442	0.581	0.08	0.2619
CMORT, %	16.67	33.36	--	0.3707

CBW = Calf birth weight; W30d = Weight at 30 d; W60d = Weight at 60 d; TDWG = Daily weight gain at 60 d of age; CMORT = Calf mortality; SEM = Standard error of the mean.

DISCUSSION

Climatic variables

As consistent environmental management practice, the most common stage to cool cows is during lactation, which means that during the period previous to parturition, cows are not cooled, even if this period is spent during the hot summer months. If cows are not cooled during the dry period, it is logical to think that first-calf heifers won´t be cooled either during the prepartum period. However, research on this topic has confirmed that cooling cows during the prepartum period has shown several advantages compared to dry cows not cooled (Adin et al., 2009; Karimi et al., 2015). Cooling pregnant heifers should also be beneficial from the physiological and productive perspective. This study was conducted to compare physiological parameters prepartum and productive parameters postpartum between MC and FCH when cooled 30 days prepartum. The average AT and THI registered during the experimental period were 36°C and 82 units, respectively, demonstrating the severity of HS in this arid region. Several researchers have mentioned that HS starts its detrimental effects on dairy cattle at THI > 72 units (Fuquay, 1981; Armstrong, 1994). However, more recent literature (Carabano et al., 2014; Herbut et al., 2018) states that selection for milk yield in Holstein cattle has made lactating cows more sensitive to hot weather, so the threshold of THI should be reduced to 68 units. The highest THI found in the present study was in the last week of July (26-30), where the THI reached an average of almost 85 units (84.8 units). Modern dairy practices during intensive hot temperatures have incorporated the model of cooling their cows using spray and fans. However, equalizing milk production in summer and winter has been a great challenge, particularly for dairy herds established in arid environments; that's why milk production becomes seasonal in hot regions and is a concern for the dairy industry located in the deserts.

Physiological variables

During the morning, first-calf heifers had a higher RF than adult cows during the last 30 d prepartum, even though this difference increased five times more in the afternoon. These discrepancies by the time of the day were probably caused by the fact that mature cows adapted more to the hot weather. Castro-Montoya and Corea (2021) reported that using ¾ Holstein x ¼ Brahman lactating cows, primiparous cows showed higher RF and rectal temperature than multiparous cows under tropical conditions. The averages of RF registered for heifers were similar to those reported by Marcillac-Embertson et al. (2009), who cooled first calf heifers during the prepartum period with sprinklers and fans; however, they were slightly higher than the RF of multiparous cows (Fabris et al., 2019). Similarly, González et al. (2016) found that first calf heifers cooled during the postpartum period showed more RF from 11:00 to 17:00 h compared to those non-cooled in the same period (64 vs. 83 bpm); this difference was also observed in multiparous cows, but with lower values of RF (55 vs. 73 bpm). In general, averages of RF were higher than 60 bpm, which indicates that the cows in the present study were under HS (Hansen, 2019). This situation could be related to the fact that the cooling time was ineffective in stabilizing body temperature in the cows since less than 60 bpm indicates a non-heat-stressed cow (Berman, 2005; Nienaber et al., 1999).

The hematological profile of dairy cows may change by several factors such as breed, age, physiological stage, and even environmental conditions at the time the sample is obtained (Bhan et al., 2012). However, all hematological parameters measured were within the normal ranges for dairy cows (Woods and Quiroz-Rocha, 2010). Gomes et al. (2013) provided evaporative cooling to cows during their dry period in the summer months, finding that they had a more significant blood count of leucocytes and a smaller proportion of T-lymphocytes compared to non-cooled cows. Ramírez-Iglesia et al. (2001) evaluated the hematology profile of the dairy breed Carora 15 d prepartum, finding that MCV, MCH, RBC, PLT, WBC, HGB, and PLT were similar to those observed in the present study; the authors found more variation in the estimation of these parameters during the postpartum period. On the other hand, Saeed et al. (2021) measured several hematological parameters in pregnant cows', subjected to hot climatic conditions and reported averages somewhat higher than those found in the present study, which could be attributed to the fact that their cows were not under a cooling system during summer conditions (THI = 77-81 units). Changes in the electrolytes Na, Cl, and K were minimal during the prepartum period in this study. Maintenance of electrolyte homeostasis during the late gestation period is essential for the proper development of the fetus and newborn calf, preparation of the mammary gland for the subsequent lactation, and reproductive system regeneration after parturition (Skrzypczak et al., 2014). In general, homeostatic mechanisms in adult cows are efficient enough to maintain concentrations of sodium, potassium, and chlorides within normal frames, which are attributed to a relatively stable osmotic pressure that provides electroneutrality of extracellular fluids (Meglia, 2004).

Productive variables

Colostrum from heifers contained, on average, 2.8% more fat than from multiparous cows, with no difference in the remaining colostrum components measured (protein, SNF, and density). Under thermoneutral conditions, colostrum quality from multiparous cows has been slightly better than that from primiparous cows because it has a higher amount of immunoglobulin, protein, total solids, and density (Fahey et al., 2020), whit a lower fat percentage (Aydogdu and Guzelbektes, 2018). High environmental temperatures during late gestation of first-calf heifers markedly affect the colostrum composition (total protein, fat, IgG, IgA, short and medium-chain fatty acids, and lactose) compared to heifers under thermal comfort (Nardone et al., 1997). Results of the present study agree with those found by Soufleri et al. (2021), who reported that colostrum from first parity cows had higher fat content than cows of greatest parities; also, they found that colostrum from cows calved in the spring season had higher fat percentage than cows that calved during summer and autumn seasons. Likewise, Sánchez-Castro et al. (2014) evaluated the colostrum quality of multiparous and primiparous cows in the same arid region of the present study, finding that although the colostrum volume was similar between both groups of cows, protein, solid non-fat, and total immunoglobulin content was higher in multiparous cows. However, colostrum fat was higher in primiparous cows than in adult cows, which agrees with the present study.

Even though milk components were similar between primiparous and multiparous cows, milk production was consistently higher in multiparous cows from calving to day 150 of lactation. Miller et al. (2006) compared different indicators related to metabolic activity, apoptosis, and endocrine control of the mammary gland in primiparous and multiparous Holstein cows. Primiparous cows presented lower milk production at 10 and 50 days in milk than multiparous cows; however, at 250 d, milk yield was similar between both groups of cows. These results agree with those found in the present study. In addition, primiparous cows exhibit lower secretory activity and DNA levels in their mammary gland in early lactation. Pollott (2011) evaluated milk yield at different lactation lengths in Holstein cattle, indicating that adult Holstein cows commonly produce more than 10,000 kg of milk during a complete lactation, while primiparous cows reach 8,000 kg, so milk yield undergoes a trend to increase with age. Several differences are responsible for this difference in milk yield. Heifers in their first lactation are still growing and acquiring body maturation, which requires additional energy expenditure, so they cannot produce enough metabolites and hormone signals to promote milk secretion (Akers, 2017). Some heifers did not reach complete mammary cell growth, and milk production is a direct function of the amount and activity of the mammary epithelial cells present in the mammary gland (Neave et al., 2017). Heat stress during the dry period causes a decrease in feed intake, which compromises the efficiency of the mammary gland reducing milk yield and quality in the subsequent lactation (Tao et al., 2011). Even though primiparous and multiparous cows were cooled during the last 30 d prepartum, it is possible that this cooling period was not enough to help cows to elude the negative effects of heat stress. Under heat stress, Holstein cows cannot save energy because of the fast adipose fat mobilization that occurs after calving when they are experiencing a negative energy balance. Considering a poor feed intake and the increase of energy supply for all body functions, the direct energy supply to the mammary gland is minimized, causing a drop in glucose absorption and fewer precursors to generate lactose, so milk production decreases (Baumgard and Rhoads, 2013). Cooling during the prepartum period has been demonstrated to increase prolactin secretion, recovers energy production, and decrease oxidative stress, improving animal welfare and production (Tao and Dahl, 2013).

Weights of calves at calving and growth until weaning were similar between primiparous and multiparous cows in the present study. Typically, under thermoneutral conditions, primiparous cows experience shorter gestation lengths, lower calf body weights, and higher percent of dystocia than multiparous cows, factors that also negatively impact milk yield and the lactation curve (Atashi and Asaadi, 2019). Heat stress during gestation affects placenta development, causing retardation in fetal development. First-calf heifers calving during hot conditions has been shown to produce calves with lower weights and slower antibody absorption from colostrum, which may compromise their health and growth (Karimi et al., 2015). It is important to state that all these negative effects of calves born from mothers subjected to severe heat stress during the prepartum period may remain during several generations, intensifying the problem of poor health and production in animals during their late lactations (Skibiel et al., 2018). So cooling strategies for cows prior to calving become essential for dairy herds located in regions with problems of high environmental temperatures. It is important to remark that the summer in the study site was especially hot since ambient temperatures were consistently higher than 30°C; hence no time for relief from heat stress was possible for the cows and heifers, even during the night-time. This scenario suggests that cooling should be given the completely dry period, not only 30 d prepartum.

CONCLUSIONS

Providing cooling during 30 d prepartum during moderate to severe heat stress conditions was more effective for mature cows than for first-calf heifers. This is based on their lower respiration frequency, lower number of erythrocytes, and average mean corpuscular hemoglobin. Also, milk yield was pointedly higher in mature cows than in heifers. Cooling Holstein cows and heifers should be part of the standard management practices of dairy herds in hot regions.

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