Vital parameters of Holstein calves from birth to weaning*

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ABSTRACT. Silva B.T., Henklein A., Marques R. De S., de Oliveira P.L., Leite S.B.P., Novo S.M.F., Baccili C.C., Reis J.F. & Gomes V. **Vital parameters of Holstein calves from birth to weaning.** [Parâmetros vitais de bezerros Holandeses do nascimento ao desmame.] *Revista Brasileira de Medicina Veterinária, 38(3):299-304, 2016*. Departamento de Clínica Médica, Faculdade de Medicina Veterinária e Zootecnia, Universidade de São Paulo, Av. Prof. Dr. Orlando Marques de Paiva 87, São Paulo, SP 05508-270, Brasil. E-mail: brunotoledovet@hotmail.com

The neonatal period is represented by the inability of newborns to adapt themselves to extra-uterine environment and execution of vital functions until then executed by the mother, such as thermoregulation, basic acid balance, cardiorespiratory functions, nutrition and development of the immune system. This study aimed to evaluate the physiological adaptations of Holstein calves during milk-feeding period (60 days). We selected 22 newborn Holstein male calves, born between the months of September to March (n = 18) and April to August (n = 4). Heart rate values (HR), respiratory rate (RR) were recorded daily for 60 days by semiotic technique of auscultation, and the rectal temperature (RT) was measured with the use of digital clinical thermometer. The daily results of the experiment were divided in periods of six days each (P1 to P10). The first week of postnatal life was marked by physiological changes related to the adaptation of cardiorespiratory functions of newborns, observing stabilization of HR and RR on subsequent periods, with few variations probably attributed to climate fluctuation (10 a 37ºC) of the calves' rearing environment. These data demonstrated direct impact of extra-uterine adaptation period on physiological parameters of newborn calves.

KEY WORDS. Calf, neonatal period, heart rate, respiratory rate, body temperature, physiological parameters, neonatal period.

RESUMO. A fase neonatal é representada pela incapacidade adaptativa dos recém-nascidos ao ambiente extrauterino e execução de funções vitais até então exercidas pela mãe, como a termorregulação, equilíbrio acidobásico, funções cardiorrespiratórias, nutrição e desenvolvimento do sistema imunológico. Objetivou-se com este estudo, avaliar as adaptações fisiológicas de bezerros Holandeses durante a fase de aleitamento (60 dias). Foram selecionados 22 bezerros recém-nascidos machos da raça Holandesa, nascidos entre os meses de setembro à março (n=18) e Abril à Agosto (n=4). Valores de frequência cardíaca (FC), frequência respiratória (FR) foram registrados diariamente durante 60 dias pela

* Received on November 21, 2015.
Accepted for publication on March 3, 2016.

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técnica semiológica da auscultação, bem como a temperatura retal (TR) mensurada com a utilização de termômetro clínico digital. Os resultados obtidos diariamente durante os 60 dias do experimento foram agrupados em períodos compostos por seis dias cada (P1 à P10). A primeira semana de vida pós-natal foi marcada por modificações fisiológicas inerentes a adaptação das funções cardiorrespiratórias dos recém-nascidos, observando-se estabilização da FC e FR nos períodos subsequentes, com algumas variações provavelmente atribuídas à oscilação climática (10 a 37ºC) do ambiente de criação dos bezerros. Estes dados demonstraram impacto direto do período de adaptação extrauterina nos parâmetros fisiológicos dos neonatos bovinos.

PALAVRAS-CHAVE. Bezerro, Frequência cardíaca, frequência respiratória, temperatura corpórea, parâmetros fisiológicos, período neonatal.

INTRODUCTION

The neonatal period is the most critical phase of the dairy farming system, due to high morbidity rates from 10.5 to 21.6%, and mortality of 3.5% (Windeyer et al. 2014). Most problems is due to the inability of newborns to adapt themselves to extra-uterine environment and execution of vital functions until then executed by the mother, such as thermoregulation, basic acid balance, cardiorespiratory functions, nutrition and development of the immune system (Kasari 1994, Quigley & Drewry 1998).

Rupture of the umbilical cord occurred during calving is characterized by hypoxia, responsible for the decreased oxygen tension and increased blood concentrations of carbon dioxide, a substance that stimulates gasping reflexes, responsible for high lung compliance and establishment of final lung air volume. Increased oxygen tension in the blood and increased peripheral vascular resistance initiate closure of the *ductus arteriosus*, *foramen ovale*, and *ductus venosus*, also preparing the neonatal cardiovascular system for extra-uterine life (Nagy 2009).

Thermoregulatory mechanisms in newborns are established by thermogenic mechanisms, such as tremor and consumption of brown adipose tissue, which are stimulated by the evaporation of fetal fluids and conditions of extra-uterine environment. These physiological events require equivalent heat production and loss by the organism (Carstens 1994).

Inadequate physiological adaptation of the newborn associated with immunological immaturity and failure of passive immunity transfer, contributes to the high incidence of umbilical diseases, diarrhea, bronchopneumonia and bloats during the milk-feeding period (Benesi 1993, Grundy 2006, Windeyer et al. 2014). Thus, the routine evaluation of the newborn should include preventive health examinations and treatment protocols, which must be strategically integrated into calf hutches management to minimize stress, reduce the occurrence of diseases and costs arising from this phase of the raising system (McGuirk 2011).

Given the importance of physiological changes related to the critical period of adaptation of the newborn in the environment and high morbidity rate, the knowledge of physiological vital parameters is essential for monitoring health. In addition, it highlights the lack of longitudinal studies to define cardiorespiratory clinical standards and thermoregulation for Holstein calves during milk-feeding phase; as well as applicable studies to the bioclimatic diversity and managements conditions found in subtropical climates. Thus, the hypothesis of this study is that the physiological parameters of newborn calves display variations in the first two months of life due to the extra-uterine physiological adaptation and management conditions used, therefore, aimed to evaluate the physiological adaptations of Holstein calves during milk-feeding phase.

MATERIALS AND METHODS

Animals and experimental procedure

Twenty two newborn Holstein male calves were selected, from a commercial farm, located in São Paulo between latitude 22º 21'25"S and longitude 47 23'03"W and 646 meters of altitude. According to the International System of Köppen (1948), the local climate is Cwa, with humid temperate climate characteristics, presenting dry winter, hot and wet summer. The experiment was approved by the Ethics Committee the number 2574/2013.

The animals (n = 22) were obtained in the 2013-2014 period, mostly between spring and summer (n = 18). Calves were held in the supplier farm to a maximum period of five postnatal days. They were then transported and housed in pairs in pens with approximately 10 m² (2,96m x 3,30m) in experimental animal facility, located in the capital of São Paulo, at a 23° latitude 24'7"S and longitude 46° 44'24"W, and 725m of altitude. The local climate is also classified as humid subtropical (Cwa type according Köppen), but presenting mild winters and summers with moderately high temperatures, increased by the effect of pollution and urbanization.

The experiment was conducted from September to March (n = 18) and April to August (n = 4). The first stage is characterized by increased precipitation rates and higher temperatures than the rest of the year; however, the second period was characterized by lower rainfall and temperatures. The highest temperature recorded during this study period was on January (31.9 °C) and the lowest on July (12°C).

The assessment of calves started in the first three hours after birth, and the vitality of newborns was given by the APGAR test, adapted to cattle (Gasparelli et al. 2009). In this test, the criteria adopted were: muscle tone, membrane mucous color, eyelid and interdigital reflexes, and respiratory activity. For each aspect was given a score from zero to two points. The sum of scores of these variables resulted in the final score from zero to eight. The sum of these scores was interpreted as follow: zero to three - low vitality; four to six - depressed; seven and eight - good vitality. Thus, as an inclusion criteria were selected only calves that performed good vitality at birth.

Calves received the usual postnatal care, as drying of the newborns and navel care. The navel disinfection was performed by complete immersion in 10% iodine for a minute and half, being repeated after 12 hours. From the second day of life, it was used 5% iodine, twice daily until mummification and complete fall of the umbilical cord, around the seventh day of life.

To ensure adequate immune assistance to newborns, colostrum feeding was performed by administration of four liters of a colostrum *pool* through a bottle and/or esophageal tube, divided into two feeds of three liters each, with six hour interval, being the first performed within the first six hours after birth (a.b.).

The animals' diet consisted in administration of milk replacer (Sprayfo Violeta®, Sloten of Brazil Ltda., Santos, SP, Brazil) in an equal amount of 10% body weight/day, divided into two daily feedings using teat buckets. Furthermore, there was supplied water and feed "*ad libitum*", in order to accelerate the development of pre-stomachs and provide weaning at two months of life. The animals were gradually weaned from 53 to 60 days of age, by diluting the concentration of the milk replacer with water.

Assessment of physiological parameters

Heart rate values (HR), respiratory rate (RR) and rectal temperature (RT) were recorded daily right after birth up to 60 days of age, following the procedures recommended by Feitosa & Gonçalves (2014). The HR and respiratory (bpm) of calves was evaluated by semiotic technique of listening using the stethoscope. The animals were auscultated preferably in standing position and at rest.

The RT was measured using a clinical digital thermometer inserted in the rectum, in contact with the mucosa until stabilization of the temperature, which was recorded in centigrade degrees (°C).

Statistical analysis

The daily results during the 60 days of the experiment were divided into periods of six days each (P1 to P10) and were subjected to the Mauchly's test of sphericity, followed by analysis of factorial variance (ANOVA) for repeated measures, with Bonferroni test as *post-hoc* procedure. The significance level used in this study was $p \leq 0.05$. The daily results of the first six days of life (P1) were also compared each other, to identify the most representative oscillation from this period of great challenge for extra-uterine adaptation.

The means from results of the first period (P1) compared with the others (P2-P10) was submitted to percentage range (Δ%) in order to analyze the evolution of frequencies throughout the experimental period. Therefore, the equation was used $\Delta\% = [(Ff - Fi)/ Fi] \times 100]$, where Fi is the mean rate observed in the first period, and Ff is the mean rate obtained in the following period. All statistical analysis procedures were performed by SPSS 17.0 software package (SPSS Inc., Chicago, IL, USA).

RESULTS

Means and standard deviations of respiratory and cardiac rate, and rectal temperatures obtained in the ten periods are presented in Table 1. Statistical differences detected between these periodic evaluations are shown in Table 2.

Rectal temperature ranged between 37.1 (P1) and 40.7°C (P3) during the experimental period. There were no statistical differences among the mean of rectal temperatures throughout all periods ($p \geq 0,185$).

The maximum respiratory rate (148 bpm) was observed in the first period, noting gradual reduction to 16 bpm to P5 ($p = 1.000$). In subsequent periods, the RR values showed an increase (from 16 to 92 bpm), demonstrating variations of 36,38-46,61 bpm, 42.50-50.73 bpm, 35.99-43.66 bpm, 47.06-52.99 bpm, 44.18-50.53 bpm, for the periods of P6-P10, respectively.

The maximum values of heart rate (220 bpm) could also be obtained in the first experimental period (P1), with a gradual decrease up to P5, with 52 bpm ($p = 1.000$). In the sixth period (P6) was observed a peak (160 bpm; $p = 0.014$) of HR. In subsequent periods, the HR values remain sta-

Table 1. Respiratory rate, heart rate and rectal temperature in Holstein calves, measured periodically during the milk-feeding period.

Periods	Corresponding days	Means and standard deviations		
		RR (mpm)	HR (bpm)	RT (°C)
P1	01-06	58.53±6.20	127.95±7.92	38.63±0.24
P2	07-12	46.92±6.31	104.91±8.88	38.99±0.26
P3	13-18	41.67±6.43	97.86±8.03	38.91±0.22
P4	19-24	34.08±6.64	86.53±5.82	38.72±0.21
P5	25-30	35.92±6.74	86.40±7.71	38.81±0.16
P6	31-36	41.50±9.48	97.70±11.36	38.88±0.19
P7	37-42	48.26±7.82	96.24±7.45	38.83±0.27
P8	43-48	41.68±8.05	92.41±7.88	38.77±0.18
P9	49-54	52.52±6.20	93.59±9.48	38.81±0.13
P10	55-60	50.36±7.30	98.43±6.67	38.76±0.13

Table 2. Multiple comparisons among periods for respiratory and heart rates of Holstein calves.

Periods	p-values for respiratory rates									
	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10
P1	-	0.003*	0.000*	0.000*	0.000*	0.001*	0.029*	0.000*	0.050*	0.002*
P2	0.000*		1.000	0.002*	0.032*	1.000	1.000	0.154	1.000	1.000
P3	0.000*	1.000		0.567	1.000	1.000	1.000	1.000	0.050	0.550
P4	0.000*	0.000	0.002*		1.000	0.446	0.002*	0.725	0.000	0.001*
P5	0.000*	0.003*	0.002*	1.000		0.534	0.000	1.000	0.000	0.016*
P6	0.000*	1.000	1.000	0.127	0.014*		0.918	1.000	0.570	1.000
P7	0.000*	0.794	1.000	0.570	0.590	1.000		0.098	1.000	1.000
P8	0.000*	0.104	1.000	1.000	1.000	1.000	1.000		0.003*	0.273
P9	0.000*	0.252	1.000	0.558	1.000	1.000	1.000	1.000		1.000
P10	0.000*	1.000	1.000	0.008*	0.005*	1.000	1.000	0.414	1.000	-
	p-values for cardiac rates									

*Significant statistical data

Table 3. Respiratory and cardiac rates of Holstein calves assessed daily during the first post-birth period.

Days	Means and standard deviations	
	RR (bpm)	HR (bpm)
1	64.95±25.89	160.00±23.51
2	61.56±14.55	126.18±23.89
3	59.30±21.35	133.36±23.80
4	58.78±20.79	112.00±9.82
5	58.95±14.17	114.54±29.2
6	51.47±16.54	121.63±22

ble featuring variations from 91.57 to 100.90 bpm; 87.52-97.29 bpm; 88.14-99.03 bpm; 94.55-102.30 bpm, in the periods of P7-P10, respectively.

For presenting larger variations during the first period of life, the daily results of P1 for respiratory and heart rates were also compared each other. The means and standard deviations are shown in Table 3.

There were no statistical differences in respiratory rate among the days of the first period of calves' life. On the other hand, there was significant difference among the HR values obtained on 1st day (160 bpm) *versus* the 2nd day (126.18 bpm, p = 0.006), 3rd day (133.36 bpm, p = 0.027), 4th day (112 bpm; p = 0.000), 5th day (114.54 bpm, p = 0.000) and 6th day (121.63 bpm, p = 0.000); and between 3rd day (133.36 bpm) *versus* 4th day (112 bpm, p = 0.018).

According to the results observed for the means of respiratory and heart rates during the first period of life in relation to others, it was decided to use a percentage change (Δ%), as shown in Figure 1.

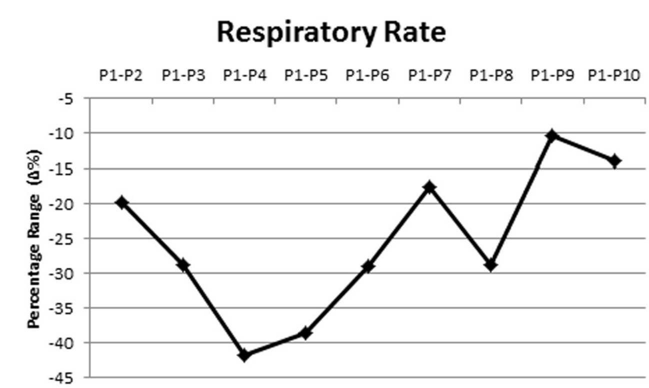
It was possible to increase gradually the percentage range (Δ%) for P1 to respiratory rate values up to the fifth period; subsequently was observed decline in these deltas from P6 to P10, with a slight increase in the eighth period.

For heart rate, the progressive increase of the percentage difference was observed up to the fifth period, with a slight decrease of variation (Δ%) in the P6-P8 and stabilization around the ninth/tenth period.

DISCUSSION

This research evaluated the physiological adaptation of Holstein calves from birth to 60 days by measuring vital functions.

The respiratory rates detected during the first week of life revealed that the values found are included in the intervals referenced by the literature, which considers normal values for bovine neonates from 50 to 75 bpm at the first hour after birth (Varga et al. 1999, Mee 2008b).



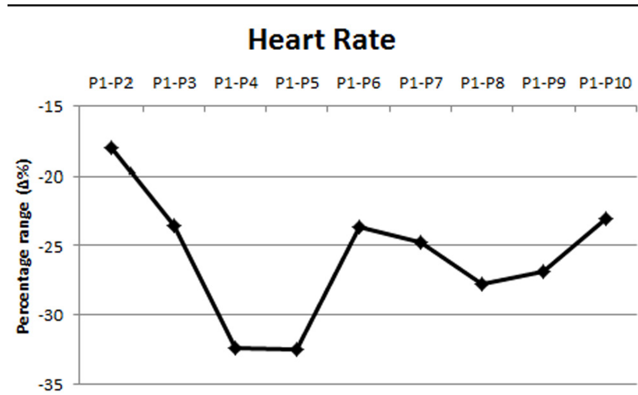


Figure 1. Respiratory and heart rate of Holstein calves of the first period of life compared to all others.

The respiratory rate decreased up to the fifth period (30 days old), whereupon was found major variations in the delta. Linke et al. (2013) emphasized the need of a minimum period of at least two weeks (14 days) for the lung units are integrated in the gas exchange. Similar studies with Limousin calves (Piccione et al. 2010) and lambs (Davey et al. 1998, Piccione et al. 2007b) also reported changes in the RRs during the first month of life, displaying the homeostatic physiological variability during the neonatal period, and the incomplete development of the anatomical and functional roles of newborns.

Cardiac evaluation allowed detecting significant differences of the rates obtained in the first week of life compared to the other studied periods. Therefore, we analyzed the daily vital functions of this period, verifying that the first few hours were the most critical for adaptation of newborns. The literature review proposed by Mee (2008b) indicates that the mean heart rate variation for newborn calves in the first hours of life is 100-150 bpm, agreeing with the values found in this study.

Means of heart rates also showed a decrease from the first period up to the fifth week of life, and increase the percentage ranges of the delta. Similar findings were reported by Piccione et al. (2010) for the Limousin calves, which described declining HRs from 115.50±2.94 to 102±0.75 bpm at birth and 30 days of life. These authors explained that immediately after birth, newborns have low systolic volume. However, the heart needs to pump blood at a higher systolic rate on the cardiovascular system, which has a high elasticity and peripheral resistance. Thus, for the inability to change the cardiac output, the systolic volume should be hardboard by increase in heart rate. These facts justify the reduction of the values reflecting the adaptability of newborns over the time (Piccione et al. 2007b).

The rectal temperature parameters did not show significant variations throughout the experimental period. The calves had similar mean values to those reported in the literature (39.0°C to 40.5°C), which often presented temperature of 0.5 to 1.0°C higher than adult cattle (Mee 2008b, Piccione et al. 2010). It is noteworthy that the lowest temperature recorded throughout the study could be observed on the first week of life (P1); period in which the newborn's ability to maintain the heat homeostasis is particularly limited because the hypothalamus may not be fully developed at birth. As a result, newborn calves need to quickly activate the thermogenic mechanisms, such as tremor and metabolism of brown adipose tissue. This adjustment depends on the environment and colostrum intake, wherein the body heat production increases body temperature, which becomes normal within 48 to 72 hours (Leonel 2009).

In general, variations in vital parameters of cattle may be related to intrinsic factors as responses to exercise, fear, arousal, physiological condition and milk production (Carvalho et al. 1995, Marai et al. 1999). In addition, we must consider the extrinsic factors to the animal, which can be attributed to the environment, as weather, temperature and humidity, solar radiation, wind speed, season, time of day, density and shading (Pires et al. 1998b, Marai et al. 1999).

Another important fact is that 18 animals were raised in spring/summer and only four during the fall/winter, referring us to the climatic differences that may have occurred during this period of creation. Heat stress can cause changes in physiologic parameters such as rectal temperature, respiratory and heart rate (Ferreira et al. 2006, Kovács et al. 2014). These facts could justify what happened in P6-P8 periods when the animals of this study had variations in RRs and HRs, even if not significant. However, the interference of these limiting factors in the vital functions of the calf has not been evaluated.

The significant increase of the mean respiratory rate was also demonstrated in P9-P10 periods in relation to the previous period (P8). The HR, although not significant, increases in the means were also identified in the P9-P10 periods. These changes in the patterns of the rates can be explained by the stress effects caused by the initial period of weaning at 53 days of life. According to Carroll & Forsberg (2007), stressors activate the adrenal glands (part of the sympathetic division of the autonomic nervous system), which increases the synthesis and secretion of catecholamines, reflecting in higher heart rate, vasoconstriction, dilated bronchioles, and increased metabolism. Thus, Clapham et al. (2007) identified significant stress in their study by the heart rate variability of calves at the time of weaning. Isolated from the mother, but still maintaining eye contact, calves showed that parasympathetic tone decreased (lower RMSSD - a short-term variability index) over a period of 12 days, corroborating our findings.

As discussed, the study could demonstrate by physiological parameters that the first few days of life (P1) represented major impact on the adaptation of the neonatal period of newborn calves faced to extra-uterine environment; and therefore, make it important to know the reference values for young cattle in order to maintain homeostasis of the physiological mechanisms.

CONCLUSION

The data obtained indicated that the extra-uterine adaptation period exerted a direct impact on physiological parameters of newborn calves. The first week of postnatal life was marked by physiological changes related to the adaptation of cardiorespiratory functions of newborns, observing stabilization of HR and RR on subsequent periods, with few variations probably attributed to climate fluctuation (10 a 37ºC) of the calves' rearing environment.

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