Journal of Animal Research: v.12 n.2, p. 199-204. April 2022

DOI: 10.30954/2277-940X.02.2022.6

Electrocardiographic Variables in Kankrej Cattle Calves

Sarita Devi[1*], Jagdeesh Prasad Varshney[2], Harshad H. Panchasara[3] and Ramesh M. Patel[1]

[1]Department of Veterinary Medicine, College of Veterinary Science & Animal Husbandry, Kamdhenu University (KU), Sardarkrushinagar, Gujarat, INDIA
[2]Nandini Veterinary Hospital, Surat, Gujarat, INDIA
[3]Livestock Research Station (LRS), Sardarkrushinagar Dantiwada Agricultural University (SDAU), Sardarkrushinagar, Gujarat, INDIA

**Corresponding author: S Devi; E-mail: drsarita17@yahoo.co.in*

Received: 03 Dec., 2021 **Revised:** 04 March, 2022 **Accepted:** 12 March, 2022

ABSTRACT

Present paper recorded electrocardiographic (ECG) variables in 22 Kankrej cattle calves using the base apex lead system (Lead I). The mean values of heart rate (HR), 'P' amplitude, 'P' duration', 'PR' interval, 'QRS' duration, 'ST' segment, 'T' amplitude, 'T' duration, 'S' amplitude, 'R' amplitude, 'QT' interval and 'RR' interval recorded were 66.59±2.33 (40-80) bpm, 0.231 ±0.016 (0.1-0.5) mV, 0.086±0.003 (0.08-0.14) s, 0.232±0.123 (0.16-0.44) s, 0.089± 0.002 (0.08-0.12) s, 0.301 ± 0.015 (0.18-0.4) s, 0.365± 0.034 (0.1-0.7) mV, 0.108±0.005 (0.08-0.16) s, 1.140±0.094 (0.4-1.9) mV, 0.500±1.00 (0.0-1.0) mV, 0.499± 0.158 (0.4-0.6) s and 0.927± 0.368 (0.75-1.5) s respectively. Significantly ($P \leq 0.05$) higher HR was observed in the female calves (71.36±2.78) as compared to male calves (61.81±3.25). Also, significant ($P < 0.05$) differences between RR interval of male (1.00±0.058) and female (0.854±0.035) calves were recorded. It is concluded that the base apex system is a suitable lead for monitoring heart rhythm in cattle calves. This study provided information on the HR, duration, and amplitude of ECG deflections in Kankrej cattle calves, one of the common cattle breed of Gujarat state of India. Values of electrocardiographic indices for Kankrej cattle calves reported here in can be used as reference values by the practitioners to clinically evaluate cardiac healthiness/cardiovascular fitness, life threatening arrhythmias and, to take appropriate therapeutic measures.

HIGHLIGHTS

- This study proposes the reference range of HR and, the amplitude and duration of ECG indices, analyzed for the base apex system in Kankrej cattle calves.
- This study also determines the electrocardiographic values (Mean ±S.E) between genders in bipolar derivation /base-apex lead I in Kankrej cattle calves.
- Cardiac arrhythmias observed in the clinically healthy Kankrej cattle calves in this study could be accepted as the physiological arrhythmias.

Keywords: ECG, electrocardiographic variables, female, heart rate, Kankrej cattle calves, male

Electrocardiography (ECG) a well-recognized standard diagnostic technique, hold an important position in cardiovascular examination. Evaluating the heart rate and rhythm, damage to myocardium, electrolyte imbalances and adverse drug effects are the indications for the use of electrocardiography in large animals (Radostits *et al*., 2007; Trefz *et al.*, 2018).

The Kankrej breed of cattle, one of the heaviest of the Indian breeds of cattle holds a very important place in the agricultural economy of the whole of Gujarat and parts of Rajasthan. Out of country's population of 192.49 million cattle which is 17% of the total world population of cattle (20th Livestock census 2019), the estimated population

How to cite this article: Devi, S., Varshney, J.P., Panchasara, H.H. and Patel, R.M. (2022). Electrocardiographic Variables in Kankrej Cattle Calves. *J. Anim. Res.,* **12**(02): 199-204.

Source of Support: None; **Conflict of Interest:** None

of Kankrej breed is 30.28 lakh including 19.45 lakh pure bred and 10.83 lakh graded cattle (Rathod *et al*., 2020). It is very highly prized for the production, powerful draft bullocks, for grading-up local cattle and importantly is having more disease resistant power.

Electrocardiographic variables have been published for various exotic breeds of adult dairy cattle so far (Rezakhani *et al*., 2004; Reddy and Sivajothi, 2016; Varshney, 2019). Occurrences of heart arrhythmias in bovines are not rare, but their significance is not always clear (Rezakhani *et al*., 2004) emphasizing the importance of knowledge of reference values of electrocardiogram. The prognosis of heart disease in cattle is classically reported to be guarded to poor even if heart failure is absent. A survey of the surfed literature strikingly assigns an immature documentation about base-line electrocardiographic variables in Indigenous breeds in India. Referring to above context, thorough knowledge of the normal limits of ECG indices of cattle to compare with clinical conduction abnormalities is the need of the hour and thus in turn saving the superior germplasm from cardiac deaths. The purpose of this study was to establish normal reference values for ECG indices in Kankrej cattle calves for clinical use, using the base apex lead system.

MATERIALS AND METHODS

The study was conducted on 22 clinically healthy Kankrej cattle calves, one month – one year old at Livestock Research Station (LRS), Sardarkrushinagar Dantiwada Agricultural University, SDAU, Gujarat. Data had also been compared gender-wise (male=11 and female=11) to observe differences in electrocardiographic parameters, if any. Electrocardiograms (ECGs) were recorded on base apex lead system; using lead I in the Kankrej cattle calves as described by Buczinski and Boerboom (2010). Cardiart 6208 (BPL) ECG machine, with paper speed 25 mm/s and calibration of 10 mm equal to 1 mV was used for recording of ECGs. Heart rate was calculated according to the RR interval in lead-I and expressed in beats per minute (bpm). The following variables were measured: amplitude of 'P', 'Q', 'R, 'S' and 'T' waves expressed in millivolts (mV) and, duration of 'P' wave, 'QRS' complex, PR interval, ST segment and 'T' wave expressed in second (s) for lead I. Configuration of P wave (positive/negative), QRS complex (positive/negative) and, different QRS wave forms were also measured.

Statistical analysis was carried out using ANOVA with Tukey's post-hoc test performed with SPSS software (version 20, IBM), considering level of significance ($P < 0.05$). Mean, standard error of mean (SEM), median, minimum (min.) and maximum (max.) values were computed. To evaluate the existence, or not, significant differences between genders, independent t-test was employed. There was no sacrifice or animal experimentation involved in the present study therefore approval from Institutional Animal Ethics Committee (IAEC) was not required. However, there was no deviation from rules of ethical treatment to animals during the study.

RESULTS AND DISCUSSION

The mean values, their standard error of mean (SEM) and median for HR and, the amplitude and duration of ECG parameters, are shown in the table 1 for Kankrej cattle calves. The heart rate of 22 Kankrej calves was in the range of 40-80 bpm, with a mean and standard error of 66.59±2.33, and a median of 60. The predominant rhythm in all the 22 Kankrej cattle calves was sinus except in a 86 days old calf having "sinus block" (Fig. 1A), a 105 days old calf showing "QS alternans" (Fig. 1B) and 69 days calf showing sinus bradycardia (Fig. 1C). Significantly ($P \leq 0.05$) higher HR was observed in the female calves (71.36±2.78) as comparison to male calves (61.81±3.25) (Table 2).

The P wave amplitude and duration was 0.231±0.016 mV (0.1-0.5 mV) and 0.086±0.003 s (0.08-0.14 s), respectively. The P wave was oriented in the positive direction in all the tracings (n=21) and 'W' shaped in one case in configuration (Table 3). The R and Q wave was evident in 13 out of all the 22 ECG tracings having amplitude of 0.0-1.2 (median 0.1, range 0.0-1.0) and 0.0-1.9 (median 0.8, range 0.0-1.9). The S wave amplitude was recorded in all the 22 tracings with the mean and standard error of 1.140±0.04.

The mean value of PR interval, QT interval and ST segment duration in Kankrej cattle calves was 0.232±0.123, 0.499±0.158 and 0.301±0.152 s respectively. The RR interval lasted for 0.927±0.368 s (median 1.0, range 0.75-1.5). Statistically significant ($P \leq 0.05$) differences were recorded between male (1.000±0.055) and female (0.854±0.035) Kankrej cattle calves for RR interval duration (Table 2).

Table 1: Values of various electrocardiographic indices in Kankrej cattle calves (Base-Apex Lead System)

ECG parameters	Number (N)	Min.	Max.	Median	Mean ±SEM
Heart rate (beats/min)	22	40	80	60	66.59 ± 2.33
P duration (s)	22	0.08	0.14	0.08	0.086 ± 0.003
P amplitude (mV)	22	0.1	0.5	0.2	0.231 ± 0.016
PR interval (s)	22	0.16	0.44	0.22	0.232 ± 0.123
R amplitude (mV)	13*	0.0	1.0	0.1	0.500 ± 1.00
RR interval (s)	22	0.75	1.5	1.0	0.927 ± 0.368
S amplitude (mV)	22	0.4	1.9	1.15	1.140 ± 0.094
QRS duration (s)	22	0.08	0.12	0.08	0.089 ± 0.002
ST segment (s)	22	0.18	0.4	0.3	0.301 ± 0.152
T duration (s)	22	0.08	0.16	0.1	0.108 ± 0.005
T amplitude (mV)	22	0.1	0.7	0.3	0.365 ± 0.034
Q amplitude (mV)	13*	0.0	1.9	0.8	0.736 ± 0.147
QT interval (s)	22	0.4	0.6	0.51	0.499 ± 0.158

*Countable in 13 ECGs' only and in rest are negligible; Min.= Minimum; Max.= Maximum.

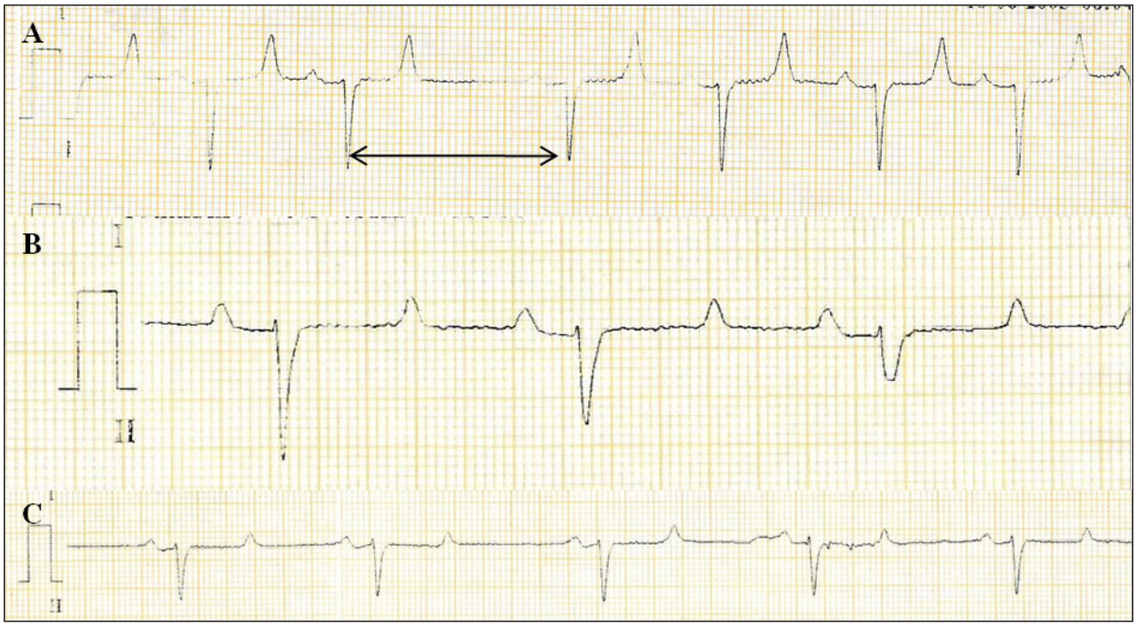

Fig. 1: (A) Sinus block (RR interval (arrow): 1.28 seconds in a 86 days old male calf); **(B)** 'QS' alternans (amplitude of QRS varying from 1.3 mV-0.5 mV (Left-Right) in a 105 days old male calf); **(C)** sinus bradycardia (HR: 40 bpm in a 69 days old male calf) (Base apex lead I, paper speed 25 mm sec^{-1}, sensitivity 1)

The QRS duration ranged from 0.08 to 0.12 having mean duration of 0.089±0.002s. The most frequent configuration of QRS was 'rS' pattern (61.18%) followed by 'QS' pattern (31.81 %) (Table 3). The configuration of the T wave was monophasic positive in 95.45% (21/22) and monophasic negative in 4.54 % (1/22) calves (Table 3) with its amplitude varying from 0.1-0.7 (mean 0.365± 0.034, median 0.30 mV) and duration from 0.08 to 0.16 s (0.108± 0.005, median 0.10).

Table 2: Comparison of electrocardiographic values (Mean ±S.E) between genders in bipolar derivation /base-apex lead I in Kankrej cattle calves

ECG Values	Female				Male				P value
	N	Min.	Max.	Mean ±S.E.	N	Min.	Max.	Mean ±S.E.	
Heart rate (beats/min)	11	60	80	71.36±2.78	11	40	80	61.81±3.25	0.037*
P duration (s)	11	0.08	0.10	0.085±0.002	11	0.1	0.3	0.087±0.005	0.774
P amplitude (mV)	11	0.20	0.50	0.254 ±0.027	11	0.1	0.3	0.209 ±0.018	0.186
PR Interval (s)	11	0.20	0.30	0.218±0.009	11	0.16	0.44	0.247±0.022	0.250
R amplitude (mV)	6	0.00	0.30	0.100± 0.035	7	0.0	1.00	0.200± 0.089	0.310
RR interval (s)	11	0.75	1.00	0.854± 0.035	11	0.75	1.5	1.000± 0.058	0.046*
S amplitude (mV)	11	0.40	1.9	1.195±0.15	11	0.55	1.90	1.086±0.12	0.575
QRS (s)	11	0.08	0.12	0.093± 0.004	1	0.08	0.10	0.085± 0.002	0.152
ST segment (s)	11	0.18	0.36	0.274 ± 0.018	11	0.22	0.40	0.329 ± 0.21	0.73
T duration (s)	11	0.08	0.16	0.116±0.007	11	0.08	0.16	0.100±0.007	0.131
T amplitude (mV)	11	0.10	0.70	0.409± 0.053	11	0.10	0.65	0.322± 0.04	0.220
Q amplitude (mV)	6	0.00	1.80	0.690± 0.219	7	0.00	1.9	.781± 0.20	0.766
QT interval (s)	11	0.40	0.58	0.484± 0.021	11	0.40	0.60	0.514± 0.023	0.357

*P<0.05.

Table 3: Electrocardiographic patterns in Kankrej cattle calves

ECG configuration	P-Wave		QRS Complex		T-Wave	
	+ve	'W' shaped	rS	QS	-ve	+ve
ECG patterns	21	1	15	7	1	21
Number (N)	22	22	22	22	22	22
Percent (%)	95.45%	4.54%	68.18	31.81	4.54	95.45

This study proposes the reference range of HR and, the amplitude and duration of ECG indices, analyzed for the base apex system in Kankrej cattle calves. Severe irregularity in HR and rhythm can cause unexpected deaths in the calves. Death in neonatal calves imposes a great challenge to dairy farming system; 20% calf mortality reduces net profit to approximately 40% (Singh *et al*., 2009). For diagnosing conduction system abnormalities, ECG has been proposed as an important cost-effective easily reproducible and available non-invasive tool, having easy field application (Lessa *et al*., 2012). Electrocardiography can be used as a clinical method of choice to assess the cardiac problems regarding heart electrical activities, initiation and conduction of waves of depolarization and repolarization and associated abnormalities, making it an indispensable tool in prognostic and therapeutic considerations (Santamarina *et al*., 2001; Rezakhani *et al*., 2004).

Further, clinical application of ECG indeed requires standardization of normal values for various ECG indices to compare with the abnormal findings. The data generated in this study will be helpful in terms of interpretation of cardiac conduction abnormalities in bovine calves of indigenous breeds. Electrocardiographic diagnosis of dysrhythmias associated with different pathological condition/diseases - theileriosis, foot-and-mouth disease, tetralogy of Fallot, traumatic reticulo-pericarditis *etc.,* had been documented in cattle and buffalo/bovines (Mendes *et al*., 1999; Devi *et al*., 2014; Jafari *et al*., 2014; Fartashvand *et al*., 2013; Devadevi *et al*., 2018; Fakour *et al*., 2017; Nikvand *et al*., 2019**).** As compared to dogs and equines, standardized electrocardiographic values in ruminants are few (Reddy *et al*., 2014). Attempts have been made to record electrocardiograms in apparently healthy cross bred cattle in Andhra Pradesh and Holstein Friesian calves

in Gujarat of India (Reddy and Sivajothi, 2016; Varshney, 2019).

All ECGs were obtained using base apex lead system in Kankrej cattle calves (Machida *et al*., 1993; Rezakhani and Papahn, 2002). Animal movement has a minimum effect on the ECG recording in base apex lead system, contributing towards clear and large wave's complexes (Radostits *et al*., 2007; Santamarina *et al*., 2001). The base apex lead facilitates measuring conduction times (i.e., durations of component deflections, intervals, and segments) because the origins and terminations of deflections could be identified easily (Santamarina *et al*., 2001).The results of the present study showed that in the studied Kankrej cattle calves, mean values of T-duration, P-R interval, RR interval, Q-T interval, S-T interval, Q amplitude and S amplitude were found increased and, T duration and R amplitude mean values decreased and, P amplitude as well as duration were almost similar with slight variation as compared to the standard electrocardiographic parameters reported for 89 clinically healthy Holstein Friesian cattle comprising of new born calves upto 7 years of age (Chalmeh, 2015).

Proposed reason for this could be Kankrej cattle being one of the heaviest breed with excellent draught ability/ capacity, reflects the large/massive cardiac mass/ musculature of this breed well suited to push blood with great strength, coping up with the quick energy demands resulting into slightly longer conduction time, prolonging the intervals and amplitudes associated with ventricular contraction. Mass of heart in larger animals became larger in the process of growth and thus the duration of transfer of cardiac electrical activity also increases (Schmidt-Nielsen, 1997).

Comparing the components of electrocardiograms between both sexes, there is a significant difference in HR and RR interval ($P<0.05$). The HR in females was higher than that in males and, RR interval in males was longer than that of in females ($P<0.05$). Significant gender correlations between ST segment and QT interval were observed. The impact of gender on electrocardiogram remains incompletely delineated. The cellular and ionic basis of sex hormones on gender-related differences in cardiac electrophysiology and drug-induced arrhythmias has been addressed in rabbits (Pham and Rosen, 2002). Estrogen showing impact on cardiac vagal function and influencing autonomic modulation is been demonstrated in mice species (Du *et al*., 1994), paving a research thrust area in veterinary cardiac medicine. Smaller average size of female heart as compared to average larger male heart, make it to beat at a faster rate to pump more blood with each beat and also to make-up with larger output of male heart (Prabhavati *et al*., 2014). Higher vagal tone is indicative of efficient autonomic regulatory activity owing to which an organism is more sensitized and responsive to physiological and environmental challenges (Von Borell *et al*., 2007). RR interval indicates the period between ventricular contractions. A shorter resting RR interval reflects a higher resting HR in female calves. It was observed that ST segment and QT interval was positively correlated ($P<0.01$) in females. Gender differences, which are determined by physiological, humoral, and the anatomical and histological constitution of each sex are being argued to contribute to the gender differences recorded (Matsui *et al*., 1983).

CONCLUSION

The study contributes to the bovine electrocardiography normal reference values of HR and different ECG components for clinical assessment of cardiac conduction abnormalities as well as cardiovascular soundness of Kankrej cattle calves, an indigenous and important cattle breed of India. Nevertheless, the ECG still contains distinctive information and mandates as a vital test relating to cardiovascular fitness. It could be stated that aging can affect electrocardiographic findings, but wide range of data covering different ages still need to be collected to propose a reference value. Gender ascertained its effect on HR and RR interval. Furthermore, it may be suggested that the cardiac arrhythmias observed in the clinically healthy Kankrej cattle calves in this study could be accepted as the physiological arrhythmias.

REFERENCES

Buczinski, S. and Boerboom, R.A. 2010. Heart disease in cattle: diagnostic, therapeutic approaches and prognosis. *Vet. J*., **184**(3): 258-263.

Chalmeh, A. 2015. Changes of the electrocardiographic parameters during aging in clinically healthy Holstein cattle. *Bulg. J. Vet. Med*., **18**(2): 105-111.

Devadevi, N., Rajkumar, K. and Vijayalakshmi, P. 2018. Electocardiographic changes in cattle with bovine benign theileriosis. *J. Cell Tissue Res*., **18**(2): 6463-6465.

Devi, S., Varshney, J.P., Undirwade, S.C. and Jadhav, K.M. 2014.Cardiac troponin-I and electrocardiographic findings in buffaloes with traumatic reticulo-pericarditis. *Rumin. Sci*., **3**(2):177-180.

Du, X.J., Dart, A.M. and Riemersma, R.A. 1994. Sex differences in the parasympathetic nerve control of rat heart. *Clin. Exp. Pharmacol. Physiol*., **21**(6): 485-493.

Fakour, S., Alimohammadzadeh, P. and Vaziry, A. 2017. Evaluation of cardiac troponin I (cTnI), creatine kinase (CK), aspartate aminotransferase (AST) and electrocardiography, in diagnosis of selenium deficiency in goat kids. *Iran. J. Vet. Med*., **11**(2): 125-133.

Fartashvand, M., Nadalian, M.G., Sakha, M. and Safi, S. 2013. Elevated serum cardiac troponin I in cattle with theileriosis. *J. Vet. Intern. Med*., **27**(1): 194-199.

Jafari, D.A., Mohebbi, A.N. and Balali, D.S.H. 2014. Evaluation of dysrhythmias and myocardial biomarkers in high and low yielding dairy cows. *Iran. J. Vet. Med*., **8**(2): 101-109.

Lessa, D., Escodro, P. and Notomi, M. 2012. Considerations on the use of electrocardiography and its interpretation in horses. *Rev. Bras. Med. Equina*, **42**: 4-12.

Machida, N., Nakamura, K., Kiryu, K. and Kagota, K. 1993. Electrocardiographic features and incidence of atrial fibrillation in apparently healthy dairy cows. *J. Vet. Med. Series A.,* **40**(1-10): 233-239.

Matsui, K., Akio, A., Sawasaki, T. and Cano, Y. 1983. Changes in electrocardiographic parameters with growth in Thoroughbred Horses and Shetland Ponies. *Bull. Equine Res. Inst*., **20**: 77-86.

Mendes, L.C.N., Camacho, A.A., Alves, A.L.G., Borges, A.S., Souza, R.C.A and Ferreira, W.L. 2001. Standard electrocardiographic values in Holstein calves. *Arq. Bras. Med. Vet. Zootec.,* **53**(6): 641-644.

Nikvand, A.A., Jalali, S.H., Mohammad, N., Mashhadi, A.G. and Amirabadi, S.H. 2019.Electrocardiogram and serum cardiac biomarkers changes in FMD in cattle. *Turkish J. Vet. Anim. Sci*., **43**(2): 285-291.

Pham, T.V. and Rosen, M.R. 2002. Sex, hormones, and repolarization. *Cardiovasc. Res*., **53**(3): 740-751.

Prabhavathi, K., Selvi, K.T., Poornima, K.N. and Sarvanan, A. 2014. Role of Biological Sex in Normal Cardiac Function and in its Disease Outcome – A Review. *J. Clin. Diagn. Res*., **8**(8): BE01–BE04.

Radostits, O.M., Gay, C.C., Hinchcliff, K.W. and Constable, P.D. 2007. Diseases of the cardiovascular system. 10th Ed., Saunders Elsevier, Philadelphia, US. pp. 399-438.

Rathod, B.S., Patel, M.P., Chaudhari, A.B., Gami, Y.M. and Panchasara, H.H. 2020. Conservation and Improvement of Kankrej Cattle (*Bos indicus*): Status *vis-a-vis* strategies. *Indian J. Anim. Sci*., **90**: 102–105.

Reddy, B.S., Reddy, L.S., Raju, K.G. and Sivajothi, S. 2014. Electrocardiographic studies in adult Osmanabadi goats. *J. Vet. Sci*. *Photon*, **115**(2014): 333-337.

Reddy, B.S. and Sivajothi, S. 2016. Electrocardiographic parameters of normal dairy cows during different ages. *J. Vet. Med. Sci*., **4**: 1-5.

Rezakhani, A. and Papahn, A.A. 2002. Study on the prevalence of cardiac arrhythmias in dairy calves. *Iran. J. Vet. Res*., **3**: 157-162.

Rezakhani, A., Paphan, A.A. and Shekarforush, S. 2004. Analysis of base apex lead electrocardiograms of normal dairy cows. *Vet. Arh*., **74**(5): 351-358.

Rezakhani, A., Paphan, A.A. and Gheisari, H.R. 2004. Cardiac dysrhythmias in clinically healthy heifers and cows. *Rev. Med. Vet*., **155**: 159-162.

Santamarina, G., Espino, L. and Suarez, L.M. 2001. Electrocardiographic parameters of free-ranging roe deer (*Capreolus capreolus*). *J. Zoo Wildl. Med*., **32**: 441-446.

Schmidt-Nielsen K. 1997. Animal physiology: adaption and environment. Cambridge University Press.

Singh, D.D., Kumar, M., Choudhary, P.K. and Singh, H.N. 2009. Neonatal calf mortality - An overview. *Intas Polivet*, **10**(2): 165-169.

Trefz, F.M., Lorenz, I. and Constable, P. D. 2018. Electrocardiographic findings in 130 hospitalized neonatal calves with diarrhea and associated potassium balance disorders. *J. Vet. Intern. Med*., **32**(4): 1447-1461.

Varshney, J.P. 2019. Cardiac arrhythmia and conduction disturbances in crossbred cattle. *Intas Polivet*, **20**(1): 44-46.

VonBorell, E., Langbein, J., Despres, G., Hansen, S., Leterrier, C., Marchant-Forde, J., Marchant-Forde, R., Minero, M., Mohr, E., Prunier, A., Valance, D. and Veissier, I. 2007. Heart rate variability as a measure of autonomic regulation of cardiac activity for assessing stress and welfare in farm animals – a review. *Physiol. Behav*., **92**(3): 293-316.