

RESEARCH ON THE VALUES OF SOME ELECTROCARDIOGRAPHIC PARAMETERS IN GOAT RECORDED USING DUBOIS LEADS

Marian GHIȚĂ¹, Ana ROTARU², Carmen Daniela PETCU¹, Simona NICOLAE¹,
Oana Diana MIHAI¹, Gabriel COTOR¹

¹University of Agronomic Sciences and Veterinary Medicine of Bucharest, Faculty of Veterinary Medicine, 105 Splaiul Independentei, 050097, District 5, Bucharest, Romania

²Technical University of Moldova, Faculty of Veterinary Medicine,
168 Stefan cel Mare și Sfânt Boulevard, 2004, Chișinău, Republic of Moldova

Corresponding author email: simona.calin93@yahoo.com

Abstract

The aim of the present research paper was to evaluate the main electrocardiogram parameters in goat. The electrocardiograms were performed on a batch of 20 Carpathian goats, using the Dubois lead system. By analysing the results obtained, we concluded that, using the Dubois lead system, the best method of performing the electrocardiogram in goats is using lead II, the amplitude values being 0.117 mV for the P wave, 0.310 mV for the ventricular complex and 0.386 mV for the T wave, while lead I is not suitable for the EKG exam in this species, due to the extremely low waves' amplitude, resulting in an almost obscure recording. Regarding the duration of the electrocardiographic waves, the values obtained were 0.048±0.016 seconds for the P wave, 0.046±0.014 seconds for the QRS complex and 0.088±0.016 seconds for the T wave. As for the segments and intervals, the durations obtained were 0.062±0.020 seconds for the P-R segment, 0.246±0.014 seconds for the Q-T interval, 0.384±0.037 seconds for the P-T interval and 0.096±0.020 seconds for the T-P segment. The heart rate, electrographically calculated, was 128.5 bpm ± 12.215.

Key words: goat, leads, Dubois lead system.

INTRODUCTION

The electrocardiogram represents the graphic recording of the heart's electrical activity through repeated cardiac cycles, exploring the heart using a non-invasive method. Clinically, the ECG is used to investigate the cardiac conduction system's integrity, to determine the duration and frequency of the atrial and ventricular systoles and also to evaluate the heart's topography and the relative size of the cardiac compartments (Codreanu, 2018; Ghiță, et al., 2007; Șerdean, 2010). The ECG also allows the diagnosis of rhythm disorders and several other heart conditions (Pourjafar et al., 2012; Cotor et al, 2020). In the research field, the ECG is used to detect the effects of some substances on cardiac activity (Brăslașu et al., 2015; Ghiță et al., 2008; Codreanu, 2018).

The proper execution of the ECG exam has a great importance in the clinical field, being recommended in the calculation of duration (for waves, segments and intervals) and amplitude (for waves), as well as in

determining the electrical cardiac axis (Ghiță, et al., 2007).

Currently, the electrocardiogram recording represents one of the most common used methods of investigating the cardiac activity, in the speciality literature the information about goat-performed ECGs is poor, this subject not being commonly studied (Ghiță, M. et al., 2022). In this study, we recorded the ECG in goats using Dubois leads, the aim being to determine the electrocardiographic parameter values in goats. Studying the specialty literature, we found a relatively reduced number of studies regarding the subject, most of them made by Asian authors (Mohan et al., 2005; Jafrin et al., 2016; Fakour et al., 2013; Atmaca et al., 2014; Ghiță et al., 2008; Mohapatra et al., 2018).

The main objective of our study was to determine the electrocardiographic waves amplitude registered using the help of Dubois leads, tracking their aspects and the recorded values (mV) for each individual lead. The resulted values were then compared between

each other to discover and reveal which lead allows optimal recordings.

Regarding the ECG components duration, in our research we wanted to discover the duration length of the main event which take place in the heart during a cardiac cycle. Therefore, we determined the heart frequency (calculated based on the P-R interval) and the durations of the: P wave, P-R (P-Q) segment, P-R (P-Q) interval, the ventricular complex (QRS interval), Q-T interval, T wave, P-T interval, T-P segment, S-T segment and R-R interval. The resulted values were subsequently compared with other author's communicated values.

MATERIALS AND METHODS

The research was carried out on an experimental batch consisting of 20 goats from the Carpathian breed, aged between 3 and 5 years, at the end of the lactation period.

The ECG recording's in goats involved using an electrocardiography device (we used a portable device with 10 channels which allowed the recording for each individual lead), metal electrodes (we used „alligator” - like shaped electrodes because they are easy to attach to the goat's skin without having to trim its fur), and electrically conductive medium (we used rubbing alcohol - isopropyl alcohol, being easy to apply through pulverisation and non-irritating to the skin).

In order to record the ECG using the Dubois leads, the electrodes are placed on the body as follows: the red electrode in front of the right shoulder, the yellow electrode in front of the left shoulder, the green electrode between the xiphoid appendix and the umbilical scar, the black electrode anywhere, except for the triangle formed by the active electrodes. This lead system differentiates itself from the limbic lead system by the fact that the triangle is smaller, therefore allowing the recording of higher amplitudes.

The recordings were performed at the speed of 25 mm/s and the miniVolt amplitude of 10 mm.

RESULTS AND DISCUSSIONS

Using the Dubois leads system we can record electrocardiograms in 3 bipolar leads (marked as LI, LII, LIII) and in 3 augmented unipolar

leads (marked as aVR, aVL, aVF). Analysing the resulted electrocardiograms, we observed that they presented an easy to interpret graph, without artifacts and the electrocardiographic wave amplitudes fairly high.

As far as the electrocardiographic wave amplitude values, the results we obtained are presented in the Tables 1, 2 and 3 and in the graphs form Figures 1, 2 and 3.

Table 1. The amplitude values of the P wave (mV) recorded using the Dubois leads system in goats

No.	I	II	III	aVR	aVL	aVF
1	0.1	0.15	0.1	0	0.05	0.05
2	0	0	0.05	0.1	0	0.1
3	0.05	0.15	0.1	0	0.05	0.05
4	0	0.1	0.1	0.1	0	0
5	0.1	0.1	0.15	0.05	0	0.1
6	0	0.15	0.1	0	0.1	0.05
7	0.05	0.1	0.05	0.1	0	0.1
8	0	0.15	0.1	0	0.1	0.05
9	0.05	0.1	0.05	0.1	0	0.1
10	0.05	0.15	0.1	0.1	0.05	0.1
11	0	0.1	0	0.1	0	0.05
12	0	0	0.1	0.05	0	0.1
13	0.1	0.15	0	0.1	0.05	0.1
14	0	0.1	0.05	0.1	0.05	0.15
15	0	0.15	0.1	0	0.1	0.05
16	0.05	0.1	0.05	0.1	0	0.1
17	0.1	0.15	0.1	0	0.05	0.05
18	0	0.15	0.1	0	0.1	0.05
19	0.1	0.15	0.05	0	0.05	0.05
20	0	0.15	0.1	0	0.1	0.05
MEAN	0.037	0.117	0.077	0.05	0.042	0.072
Standard error	0.009	0.010	0.008	0.010	0.009	0.007
Standard deviation	0.045	0.046	0.037	0.048	0.040	0.034
Variant	0.001	0.002	0.001	0.002	0.001	0.001

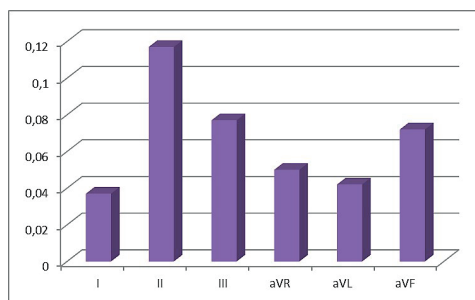


Figure 1. The average amplitude of the P wave (mV) recorded using the Dubois leads system in goats

Table 1 and Figure 1 show that the highest amplitude of the P wave is recorded in lead II, with an average value of 0.117 mV, the variability being minor (variant of 0.002 and standard deviation of 0.046). High amplitudes of the P wave can also be observed in lead III - 0.077 mV, and in aVF, with 0.072 mV. The

lowest amplitude is recorded in lead I (0.037 mV), which concludes that in this type of lead, the P wave is very hard to observe.

Table 2. The amplitude values of the QRS complex (mV) recorded using the Dubois leads system in goats

No.	I	II	III	aVR	aVL	aVF
1	0.15	0.25	0.3	0.2	0.25	0.25
2	0.15	0.3	0.25	0.25	0.2	0.2
3	0.3	0.35	0.2	0.2	0.25	0.15
4	0.15	0.3	0.3	0.15	0.2	0.25
5	0.15	0.25	0.35	0.15	0.15	0.3
6	0.15	0.2	0.25	0.15	0.2	0.25
7	0.3	0.45	0.45	0.25	0.15	0.3
8	0.25	0.2	0.35	0.2	0.15	0.25
9	0.1	0.3	0.25	0.2	0.2	0.2
10	0.3	0.3	0.2	0.2	0.25	0.15
11	0.15	0.35	0.3	0.15	0.2	0.25
12	0.15	0.3	0.35	0.2	0.15	0.35
13	0.15	0.2	0.25	0.15	0.2	0.25
14	0.1	0.35	0.3	0.2	0.15	0.3
15	0.3	0.35	0.2	0.2	0.25	0.15
16	0.3	0.35	0.2	0.2	0.25	0.15
17	0.15	0.25	0.35	0.15	0.15	0.3
18	0.15	0.35	0.3	0.15	0.2	0.25
19	0.25	0.45	0.45	0.25	0.15	0.35
20	0.3	0.4	0.4	0.25	0.15	0.35
MEAN	0.194	0.310	0.305	0.192	0.189	0.255
Standard error	0.017	0.017	0.017	0.008	0.009	0.014
Standard deviation	0.074	0.075	0.076	0.038	0.039	0.064
Variant	0.005	0.005	0.005	0.001	0.001	0.004

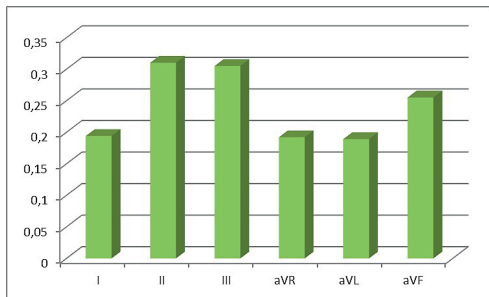


Figure 2. The average amplitude of the QRS complex (mV) recorded using the Dubois leads system in goats

Table 2 and Figure 2 show that the highest amplitude of the ventricular complex is recorded using the IInd lead, with a value of 0.310 mV (variant of 0.005 and standard deviation of 0.075). High amplitudes of the ventricular complex can also be seen in lead III, with the value of 0.305 mV (variant of 0.004 and standard deviation of 0.076), in aVF, with a value of 0.255 mV (variant of 0.004 and standard deviation of 0.064). The lowest amplitudes of the ventricular complex are recorded in aVL (0.189 mV), aVR (0.192 mV) and lead I (0.194 mV), leads which, in our

opinion, can't be used to gather data regarding the electrical ventricular activity.

Table 3. The amplitude values of the T wave (mV) recorded using the Dubois leads system in goats

No.	I	II	III	aVR	aVL	aVF
1	0.15	0.45	0.4	0.25	0.2	0.4
2	0.1	0.4	0.35	0.2	0.15	0.25
3	0.15	0.25	0.3	0.15	0.2	0.2
4	0.1	0.3	0.25	0.1	0.15	0.25
5	0.15	0.5	0.45	0.25	0.25	0.4
6	0.1	0.35	0.3	0.2	0.15	0.35
7	0.1	0.5	0.35	0.25	0.1	0.25
8	0.15	0.45	0.4	0.3	0.25	0.4
9	0.1	0.4	0.3	0.2	0.15	0.25
10	0.25	0.25	0.3	0.1	0.25	0.15
11	0.1	0.35	0.25	0.15	0.15	0.2
12	0	0.4	0.45	0.3	0.25	0.4
13	0.1	0.35	0.3	0.25	0.1	0.35
14	0.15	0.5	0.3	0.25	0.15	0.3
15	0.15	0.45	0.45	0.25	0.2	0.45
16	0.20	0.25	0.35	0.1	0.25	0.35
17	0.1	0.4	0.45	0.3	0.25	0.45
18	0.15	0.35	0.3	0.2	0.15	0.35
19	0.1	0.45	0.35	0.25	0.15	0.35
20	0.1	0.5	0.45	0.25	0.1	0.35
MEAN	0.126	0.386	0.347	0.213	0.184	0.321
Standard error	0.011	0.019	0.015	0.015	0.012	0.020
Standard deviation	0.051	0.083	0.067	0.066	0.052	0.088
Variant	0.002	0.006	0.004	0.004	0.002	0.007

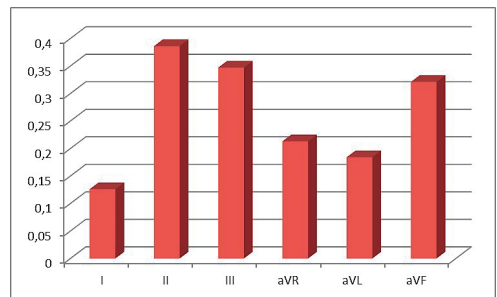


Figure 3. The average amplitude of the T wave (mV) recorded using the Dubois leads system in goats

As concerning the T wave's amplitude (Table 3 and Figure 3), the highest value was recorded using the IInd lead, with a value of 0.386 mV with high variability (variant 0.006 and standard deviation 0.083). A high amplitude of T wave is also recorded using the IIIrd lead, with a value of 0.347 mV with low variability (variant 0.004 and standard deviation 0.067), but also in aVF, with 0.321 mV and low variability (variant 0.007 and standard deviation 0.088). For all the other leads, the average values of the T wave are lower than 0.3 mV, therefore we consider that they should not

be used to gather information regarding the ventricular repolarisation.

Comparing our results with the communicated results of other authors, we notice that they obtained: the highest amplitude of the P wave in leads I, II and aVF (Atmaca, N. et al., 2014), in lead I (Jafrin, A. et al., 2016; Kumar, V. et al., 2016) and in leads II and aVF (Mohan, N. et al., 2005), the highest amplitude of the QRS complex in lead II (Pogliani, F. et al., 2013), in leads III and aVR (Atmaca, N. et al., 2014) and in leads II and III (Fakour, S. et al., 2013) and the highest amplitude of the T wave, in lead II (Pogliani, F. et al., 2013; Pradhan, R. et al., 2017), in leads II and III (Atmaca, N. et al., 2014) and in lead III (Mohan, N. et al., 2005). These results obtained by several authors are

similar with the results we obtained during this study. To determine the duration of some electrocardiogram components, we used lead II, due to its easy to interpret graph, being the lead that offers the highest amplitude for most of the electrocardiographic waves, as proven previously.

We also determined the cardiac frequency (based on the R-R interval) and the durations of the: P-wave, P-R (P-Q) segment, P-R (P-Q) interval, ventricular complex (QRS), Q-T interval, T wave, P-T interval, T-P segment, S-T segment and R-R interval. In Table 4, we present the values of the electrocardiogram components in goat, resulted following the analysis of our recordings.

Table 4. The duration (seconds) of the electrocardiogram's main components in goats

No.	P	P-R segment	P-R interval	QRS	Q-T	T	P-T	T-P	S-T	R-R	H.R.
1	0.04	0.04	0.08	0.04	0.24	0.12	0.4	0.08	0.2	0.4	150
2	0.04	0.08	0.12	0.04	0.4	0.08	0.4	0.12	0.16	0.52	115
3	0.04	0.08	0.12	0.04	0.2	0.08	0.4	0.08	0.12	0.48	125
4	0.08	0.04	0.12	0.08	0.16	0.08	0.4	0.08	0.12	0.44	136
5	0.04	0.04	0.08	0.04	0.24	0.12	0.36	0.08	0.08	0.4	150
6	0.04	0.04	0.08	0.04	0.2	0.08	0.28	0.12	0.08	0.44	136
7	0.08	0.04	0.12	0.04	0.12	0.12	0.4	0.12	0.12	0.52	115
8	0.04	0.04	0.08	0.04	0.24	0.12	0.36	0.08	0.08	0.4	150
9	0.04	0.08	0.12	0.04	0.2	0.08	0.4	0.08	0.12	0.48	125
10	0.04	0.04	0.08	0.04	0.2	0.08	0.28	0.12	0.08	0.44	136
11	0.04	0.08	0.12	0.04	0.4	0.08	0.4	0.12	0.16	0.52	115
12	0.04	0.08	0.12	0.04	0.2	0.08	0.4	0.08	0.12	0.48	125
13	0.04	0.08	0.12	0.04	0.4	0.08	0.4	0.12	0.16	0.52	115
14	0.04	0.08	0.12	0.04	0.2	0.08	0.4	0.08	0.12	0.48	125
15	0.08	0.04	0.12	0.08	0.16	0.08	0.4	0.08	0.12	0.44	136
16	0.04	0.08	0.12	0.04	0.4	0.08	0.4	0.12	0.16	0.52	115
17	0.04	0.08	0.12	0.04	0.2	0.08	0.4	0.08	0.12	0.48	125
18	0.04	0.08	0.12	0.04	0.4	0.08	0.4	0.12	0.16	0.52	115
19	0.08	0.04	0.12	0.08	0.16	0.08	0.4	0.08	0.12	0.44	136
20	0.04	0.08	0.12	0.04	0.2	0.08	0.4	0.08	0.12	0.48	125
MEAN	0.048	0.062	0.110	0.046	0.246	0.088	0.384	0.096	0.126	0.470	128.5
Standard error	0.003	0.004	0.003	0.003	0.021	0.003	0.008	0.004	0.007	0.009	2.731
Standard deviation	0.016	0.020	0.017	0.014	0.095	0.016	0.037	0.020	0.032	0.042	12.215

The waves and the ventricular complex had the following durations, as presented in Table 4: the P wave duration was 0.048 ± 0.016 seconds (average and standard deviation), the ventricular complex duration was 0.046 ± 0.014 seconds and the T wave duration was 0.088 ± 0.016 seconds. Regarding other segments and intervals durations: the P-R segment duration was 0.062 ± 0.02 seconds, the P-R interval duration (which represents the atrial systole and diastole) was 0.110 ± 0.017

seconds, the Q-T interval duration (which represents the ventricular systole and diastole) was 0.246 ± 0.014 seconds, the P-T interval (which represents one cardiac cycle duration) was 0.384 ± 0.037 seconds, the T-P segment duration (which represents the general diastole duration) was 0.096 ± 0.02 seconds, the S-T segment duration was 0.126 ± 0.032 seconds and the R-R interval duration (which represents the interval between two cardiac cycles) was 0.470 ± 0.042 . The heart rate calculated

electrocardiographically based on the R-R interval was 128.5 ± 12.215 . Studying the data presented in the speciality literature, the values obtained by different authors were between 0.02 s (Atmaca et al., 2014) and 0.06 s (Jafrin et al., 2016) for the P wave; 0.08 s (Pogliani et al., 2013) and 0.12 s (Jafrin et al., 2016) for the P-R interval; 0.03 s (Mohan et al., 2005) and 0.063 s (Fakour, et al., 2013) for the ventricular complex; 0.23 s (Mohan, et al., 2005) and 0.267 s (Fakour et al., 2013) for the Q-T interval; 0.06 s (Atmaca et al., 2014) and 0.113 s (Mohan, et al., 2005) for the T wave and 0.03 s (Pogliani, et al., 2013) and 0.48 s (Mohan, et al., 2005) for the R-R interval. Comparing the results obtained during this study with the data presented above, it is clearly proven that our research values are in direct accordance with the values mentioned in the speciality literature.

CONCLUSIONS

In goats, using the Dubois lead system, the lead that provides the highest amplitude to the electrocardiographic waves is lead II, the values being: 0.117 mV for the P wave, 0.310 mV for the ventricular complex and 0.386 mV for the T wave.

The values of the electrical events that take place in the cardiac compartments were: 0.048 ± 0.016 seconds for the atrial depolarization, 0.046 ± 0.014 seconds for the ventricular depolarization and 0.088 ± 0.016 seconds for the ventricular repolarization.

The main components of the electrocardiogram had the following values: 0.110 ± 0.017 seconds for atrial systole and diastole, 0.246 ± 0.014 seconds for the ventricular systole and diastole, and 0.384 ± 0.037 seconds for a cardiac cycle.

The average value for the heart rate in goats was 128.5 ± 12.215 , calculated based on the R-R interval.

Based on the results obtained, for the electrocardiogram recording in goats using the Dubois leads system, the II, III and aVF leads for the ventricular complex and T wave, and the II and aVF leads for the P wave, can successfully be used. The aVR and aVL leads both present, in our opinion, a restricted recommendation, meanwhile lead I cannot be used for recording the electrocardiogram

because it records extremely low amplitude electrocardiographic waves, therefore making the ECG extremely difficult to interpret.

REFERENCES

- Atmaca, N., Şimşek, O. & Emre, B. (2014). Some electrocardiographic values of Angora goats. *Ankara Üniv Vet Fak Derg*, 61, 15-19.
- Brălaşu, M., Brălaşu, D., Simiz, F., Ghiță, M., Tudor, P. & Cotor, G. (2015). Electrocardiographic studies on adult cattle. *Journal of Biotechnology*, Vol. 208, Supplement, S90.
- Codreanu, I. (2018). *Animal physiology, IInd volume*. Bucharest, RO: Printech Publishing House.
- Codreanu, I. (2018). *Textbook of animal physiology*. Bucharest, RO: Printech Publishing House.
- Cotor, D.C., Găjăilă, G., Damian, A., Zagrai (Maiorean), A.M., Petcu, C., Călin (Nicolae), S., Raduță, A., Andrei, C. & Zagrai, G. (2020). Research on the values of amplitudes of electrocardiographic waves depending on age in kids. *Bulletin UASVM Veterinary Medicine*, 77(2), 80-84, doi:10.15835/buasvmcn-vm:2020.0019.
- Fakour, S., Mokhber Dezfali, M.R., Nadalian, M.G., Rezakhani, A. & Lotfollah Zadeh, S. (2013). Electrocardiographic parameters of Markhoz goat using base apex lead and six standard limb leads. *Iranian Journal of Veterinary Research*, 14(3), 241-244.
- Ghiță, M., Codreanu, I., Petcu, C., Răduță, A., Popescu, D. & Cotor, C. (2022). Research on the duration of electrocardiogram components in pregnant goats. *Medycyna weterynaryjna*, 78(3), 148-150.
- Ghiță, M., Cotor, G. & Brălaşu, M. (2008). The values of ECG parameters in newborn calves. *Bulletin of USAVM Cluj-Napoca*, 65(1), 473.
- Ghiță, M., Cotor, G. & Brălaşu, M. (2008). The value of some ECG components in dairy cows, using Dubois leads. *Bulletin of USAVM Cluj-Napoca*, 65(1), 474.
- Ghiță, M., Cotor, G., Brălaşu, C. & Botezatu R. (2007). Studies on the duration of some ECG parameters in cats. *Lucr. Ştiinţ. Medicină Veterinară Timişoara*, 40, 393-396.
- Ghiță, M., Cotor, G., Brălaşu, C. & Botezatu R. (2007). Researches on the variation of the mean electrical axis in dogs depending on the recording position. *Lucr. Ştiinţ. Medicină Veterinară Timişoara*, 40, 389-392.
- Jafrin, A.A., Nawab, N. & Anand. K. P. (2016). The normal electrocardiogram of non-migratory bakarwali goats. *Bhartiya Krishi Anushandhan Patrika*, 31(1), 69-73.
- Kumar, V., Hoque, M., Saxena, A., Bodh, D., Mahendran, H. & Verma, M. (2016). Electrocardiographic and serum biochemical reference values of Black Bengal goats. *Indian J. Vet. Med.*, 36, 10-14.
- Mohan, N.H., Niyogi, D. & Singh, H.N. (2005). Analysis of normal electrocardiograms of Jamunapari goats. *J. Vet. Sci.*, 6(4), 295-298.

- Mohapatra, S., Pradhan, S.R., Jyotiranjana, T., Sahoo, P.R., Mahapatra, A.P.K. & Kundu, A.K. (2018). Deciphering electrocardiogram of healthy male Ganjam goats (*Capra Hircus*). *Applied Biological Research*, 20(1), 94-97.
- Pradhan, R.R., Mahapatra, A.P.K., Mohapatra, S., Jyotiranjana, T. & Kundu, A.K. (2017). Electrocardiographic reference values and configuration of electrocardiogram waves recorded in Black Bengal goats of different age groups. *Veterinary World*, 10(9), 1020-1025.
- Pogliani, F., Birgel, E., Monteiro, B., Grisi Filho, J. & Raimondo, R. (2013). The normal electrocardiogram in the clinically healthy Saanen goats. *Pesq. Vet. Bras.*, 33, 1478-1482.
- Pourjafar, M., Badieli, K., Chalmeh, A.A., Sanati, A.R., Shahbazi, A., Badkobeh, M. & Bagheri, M.H. (2012). Age-related cardiac arrhythmias in clinically healthy Iranian Najdi goats. *Bulg. J. Vet. Med.*, 15(1), 37-43.
- Șerdean, C., Codreanu, M.D., Fernoagă, C., Codreanu, I. & Cornilă, M. (2010). Non-cardiac thoracic ultrasound investigation in companion animals. *Lucrări Științifice - Universitatea de Științe Agricole a Banatului Timișoara, Medicină Veterinară*, 43 (1), 354-361.