Cardiovascular profile of crab-eating foxes (Cerdocyon thous) in captivity anesthetized with ketamine and midazolam

Victor Ramon de Franca Ribeiro (mv.victorribeiro@gmail.com)
Universidade Estadual Paulista Julio de Mesquita Filho - Campus de Botucatu
https://orcid.org/0000-0002-7742-7534

Ariana Ramos
Universidade Estadual Paulista Julio de Mesquita Filho - Campus de Botucatu

Angélica Alfonso
Universidade Estadual Paulista Julio de Mesquita Filho - Campus de Botucatu

Alicia Hippolito
Universidade Estadual Paulista Julio de Mesquita Filho - Campus de Botucatu

Heloisa Coppini
Universidade Estadual Paulista Julio de Mesquita Filho - Campus de Botucatu

Viviane Codognoto
Universidade Estadual Paulista Julio de Mesquita Filho - Campus de Botucatu

Diogo Silva
Universidade Estadual Paulista Julio de Mesquita Filho - Campus de Botucatu

Miriam Tsunemi
Universidade Estadual Paulista Julio de Mesquita Filho Instituto de Biociencias Campus de Botucatu

Moacir Leomil Neto
Pontifícia Universidade Catolica de Minas Gerais

Alessandra Melchert
Universidade Estadual Paulista Julio de Mesquita Filho - Campus de Botucatu

Priscylla Okamoto
Universidade Estadual Paulista Julio de Mesquita Filho - Campus de Botucatu

Luiz Henrique Machado
Universidade Estadual Paulista Julio de Mesquita Filho - Campus de Botucatu

Maria Lourenço
Universidade Estadual Paulista Julio de Mesquita Filho - Campus de Botucatu

Short Report

Keywords: wild canids, cTnI, allometric equation, RLAD, VHS, VLAS
Abstract

The cardiac evaluation of wild animals is still a wide and largely unknown field for several species. Therefore, through complimentary examinations such as radiography, echocardiography and serum troponin levels, this study aimed at describing the values observed in 12 crab-eating foxes (Cerdocyon thous) anesthetized with a combination of intramuscular ketamine and midazolam. Through the use of this chemical restraint, a clinical, radiographic and echocardiographic (linear and indexed values in M-mode) evaluation of the 12 male specimens included in the sample group. Among the findings observed in comparison with domesticated dogs were a decrease in the dimensions of the septum, wall and cavity of the left ventricle, as well as a deceleration in the E wave (EDT), which could be correlated with the maintenance of the serum troponin dosage values (cTnI). Therefore, M-mode echocardiography has proven to be safer and comparative to other species of wild canids when performed through indexed values. In addition, when evaluating the systolic function and segmentary contractions, the anesthetic combination did not have any effects on the results of complementary examinations performed in crab-eating foxes (Cerdocyon thous) included in this study.

Introduction

One of the six species of wild canids living within the Brazilian territory, crab-eating foxes (Cerdocyon thous) have gained notoriety due to their distribution across the different biomes found in Brazil and other south American countries. This distribution may be correlated to the species’ dietary and reproductive adaptation, despite the closer contact with humans (Beisiegel 1999; Jorge & Jorge 2014; Reis 2011).

Nutritionally incomplete diets that promote metabolic deficiencies may predispose these animals do acquired cardiopathies (Freeman & Rush 2007), while congenital cardiopathies may indicate endogamic mating.

But there are very few reports of cardiac evaluations in wild canids, and the number becomes even more scarce when filtering the search specifically for Cerdocyon thous. However, due to the similarities in the execution and interpretation of imaging examinations in wild canids and domestic dogs (Jorge & Jorge 2014), this study sought to perform and correlate complementary examinations in healthy C. thous in order to aid in the diagnosis and treatment of possible cardiopathies in animals living in captivity or in the wild. The examinations performed were the measurement of the systemic arterial blood pressure, a chest radiograph (VHS, VLAS and RLAD), an echocardiogram, and the measurement of serum troponin dosage (cTnI) after the application of anesthesia with ketamine (10 mg/kg) and midazolam (1 mg/kg).

Materials And Methods

Animals
This study performed the evaluation of 12 male crab-eating foxes (*Cerdocyon thous*) of varied ages weighing between 4.32 and 7.44 kg forwarded to the Wild Animal Medicine and Research Center (CEMPAS, *Centro de Medicina e Pesquisa de Animais Selvagens*) by the Environmental Police after rescue and capture missions around the city of Botucatu, Brazil. Authorization by IBAMA (Brazilian Institute of Environment and Renewable Natural Resources) was acquired under registration SISBio 68707-1 for eight of the animals, and SISBio 51767-1 for the other four. The animals were only included in the study after the results of tests such as full blood count, blood sugar levels, kidney biochemistry (urea, creatinine, calcium and phosphorus), liver biochemistry (total cholesterol and triglycerides) and urinalysis (Jorge & Jorge 2014) were within the reference standards for the species. Radiographs of the chest and abdomen, as well as an electrocardiogram were also taken.

After dry fasting for 12 hours, the canids were restrained physically with a net and then chemically with a combination of ketamine (10 mg/kg) and midazolam (1 mg/kg) in the same syringe applied intramuscularly, with the due anesthetic monitoring of heart rate, respiratory rate, capillary refill time, coloration of the mucosae, rectal temperature and systolic arterial blood pressure through the Doppler method. After capture and sedation, the following examinations were performed: measurement of the systolic arterial blood pressure, measurement of the thoracic circumference, chest radiograph, echocardiograph and blood collection for the serum troponin dosage (cTnI) restraint during an interval of 40 to 60 minutes in average, without any complications during the anesthetic or recovery periods.

**Measurement of the systemic arterial blood pressure**

The systemic arterial blood pressure was measured by the Doppler Ultrasound method following the guidelines for domestic dogs, with the reference values oscillating between 110 and 140 mmHg (Acierno et al. 2018).

**Chest radiograph**

The animals were positioned accordingly for three radiographic projections (left and right lateral, and ventrodorsal) with a digital x-ray equipment (DR-F, GE Health Care Unit, USA) with a 150kVp/500mA high frequency generator at the Diagnostic Imaging Service of FMVZ – Unesp Botucatu.

Therefore, the Vertebral Heart Size (VHS) (Buchana & Bucheler 1995), the Radiographic Left Atrial Dimension (RLAD) (Salguero et al. 2018), and the Vertebral Left Atrial Size (VLAS) (Malcolm et al. 2018) were measured in the right lateral projection.

**Echocardiogram**

Based on the reference values described by Boon (2011) and with the animals positioned in right and left lateral decubitus, the echocardiogram was performed with an ultrasound device (M-turbo Sonosite - Fujifilm®) with Doppler function and a 2–8 MHz multi-frequency sectorial transducer in 2D Mode. The animals were monitored with the electrocardiogram during the echocardiographic examination.
After obtaining the dimensions of the heart, the indexed values were calculated by dividing the linear body weight values raised to a fixed exponent (with different values for the linear values), according to the values described for adult dogs (Cornell et al. 2004).

**Serum troponin dosage (cTnI)**

The blood was stored in individual, previously identified tubes without anticoagulant and frozen until the serum troponin dosage (cTnI) assay was performed. The assays were performed using the automated immunoenzymatic method mini-VIDAS® manufactured by Biomerieux. The technique employed was the Enzyme-Linked Fluorescent Assay (ELFA).

The clinical parameters and radiographic, echocardiographic and immunoenzymatic values from eight specimens of *Cerdocyon thous* were added to data previously collected from another four animals using the same directives, devices and inclusion/exclusion criteria mentioned in this study, totaling a sample group of 12 different *C. thous* specimens.

**Statistical analysis**

Descriptive statistics were calculated for the data obtained in order to obtain the mean ± standard deviation, maximum and minimum values, and confidence interval. Data normality was verified by the Shapiro-Wilks test. The aforementioned calculations were done using the software Excel and R.

**Results**

All experimental procedures were performed after approval in the Ethics Committee for Animal Use (CEUA, *Comitê de Ética no Uso de Animais*) of the School of Veterinary Medicine and Animal Science at the São Paulo State University, campus Botucatu (CEUA protocol no. 0183/2019).

**Chest radiograph**

For the analysis of quantitative parameters, the mean ± standard deviation, maximum and minimum values, and the confidence intervals for VHS, short and long axes, VLAS and RLAD are shown in Table 1.

**Echocardiogram**

The weighting the animals, measuring the heart rate (HR), systolic arterial pressure (SAP), echocardiographic measurements obtained using the Bidimensional Mode, M-Mode and the values obtained in the Doppler mode (Table 2), and the allometric measurements were calculated using the values obtained in M-Mode (Table 3). No arrhythmias were observed during the evaluation of the cardiac rhythm, and the sinus rhythm was predominant across the entire sample group.

**Serum troponin**

The serum troponin dosage assays of the 12 animals evaluated revealed levels below 0.01ng/ml. It was impossible to calculate the descriptive statistics and correlate the parameters since the values are within
the reference values for healthy domestic dogs (<0.01 to 0.03ng/ml) (O’Brien et al. 2006).

Discussion

Starting the clinical evaluation by weighing the animals, the mean and standard deviation for the 12 specimens of *C. thous* was 6.2 ± 0.96 kg, which is within the reference values for body mass described in the literature (4.5 to 8.5kg) (Jorge & Jorge 2014). The HR was also with the reference standards described in the literature (Camacho & Mucha 2014) for small domestic dogs, which correlate with the weight of the wild canids. On the other hand, SAP presented mean values within the reference range proposed for dogs with the Doppler method (Acierno et al. 2018) and were close to the systolic arterial pressure values measured in a population of 150 domestic dogs with the *petmap*® method (Tebaldi et al. 2012). However, after adding the standard deviation to the mean, the upper values exceed the acceptable threshold. These values may be correlated to increased systolic arterial pressure values in three animals included in the study, which increased the mean for the 12 animals. Therefore, we need to consider a possible discordance between systolic arterial pressure values exceeding 140 mmHg in comparison with values obtained through invasive methods (Garofalo et al. 2012).

The wild canids evaluated in this study presented VHS values within the reference standards, presenting a mean and standard deviation of 8.22 ± 0.55 vertebrae, a result that is close to the VHS values of 8.27 ± 0.48 observed in maned wolves (*Chrysocyon brachyurus*) (Estrada et al. 2009). The VHS evaluation in this study was performed by a single observer in the right latero-lateral projection, but it is important to highlight a possible interobserver difference reported in both healthy and sick dogs (1.05 ± 0.32 vertebrae) (Hansson et al. 2005).

Other innovative quantitative radiographic methods such as VLAS and RLAD are based on the specific evaluation of the left atrium, taking as reference the physiopathology of cardiac remodeling in myxomatous mitral valve disease, which is the most recurrent cardiopathy in domestic dogs. Therefore, considering reference values described in the literature of ≤ 2.3v and ≤ 1.8v respectively for VLAS and RLAD, the sample group of *C. thous* were within normality, presenting values of 1.77v ± 0.20v for VLAS, and 1.25v ± 0.18v for RLAD.

Starting the echocardiographic examination by positioning the transducer in the thorax of the animals, we noticed a higher degree of cardiac horizontality in *Cerdocyon thous* than in imaging examinations performed in domestic dogs, which is correlated to the different thoracic conformations in the species. However, the formation of echocardiographic images through different windows, axes and views in *C. thous* was similar to that of domestic felines. Progressing to the subjective analysis in bidimensional and colored Doppler modes, we did not observe engorged chambers, regurgitations, communications or stenoses in the 12 specimens of *C. thous* evaluated.

In the echocardiographic evaluation in M-Mode and B-Mode, the analyses were compared to the weight of the animals. When comparing only the echocardiographic findings to the values observed in the literature
for mean weight, LVd, IVSs, and the diameter of the root of the aorta obtained in bidimensional mode and M-Mode where lower in comparison to domestic dogs.

However, when we exclude weight as a variable through the allometric equation (Cornell et al. 2004), the values for left ventricular diameter in systole and diastole were lower (Table 3).

In the evaluation of the transmitral, aortic and pulmonary flows (Table 2), it is possible to note a reduction in EDT and the fusion of the E and A waves in three animals, both possibly happening due to the increased heart rate observed. Therefore, the statistical analysis of the velocity of the A wave and of the E/A ratio was calculated for nine animals, excluding those that presented the aforementioned fusion of the waves referring to the transmitral flow.

The subjective analysis of segmental contractions did not note any complications related to the action of the anesthetic agents applied and noticed that the values for left ventricular fractional shortening (LVFS) by the Teicholz method and for the ejection fraction (EF) were maintained. The evaluation of a maned wolf (*Chrysocyon brachyurus*) under the same protocol (Mantovani et al. 2012) presented similarities in the assessment of the systolic function in M-Mode, arterial flow, pulmonary flow and transmitral flow. The animal in question was described to weight 29 kg and, after adjusting the weight and the measurements obtained in the allometric scale (Cornell et al. 2004), the values were similar to those observed in this study.

Therefore, due to the absence of acquired or congenital cardiopathies in the sample group after the aforementioned complementary examinations, we understand the reason for the lack of alterations in the serum troponin dosage during the analysis, presenting values compatible with those found in healthy dogs (< 0.01 ng/ml) (O’Brien et al. 2006), which means these values could be used as a reference for *C. thous*. It is important to note the higher specificity of this test in mammals with heart disorders in comparison with birds and reptiles (Feltrer et al. 2016; Zafalon-Silva et al. 2018).

Given these results, the study may still be limited by the small sample group used. However, considering this study in a descriptive light, these results may be used as parameters for future studies dealing with exotic and wild animals, as well as in the evaluation of *Cerdocyon thous* and other wild canids in the field or in captivity, however, it is important to underline that utility of the allometric equation and the comparison of the values with wild animals of distinct body weights that belong to the same taxonomic class due to the scarcity of literature regarding cardiac evaluation in wild canids.

**Declarations**

**ACKNOWLEDGEMENTS:** We thank the entire School of Veterinary Medicine and Animal Science (UNESP-Botucatu/SP/Brazil) for the infrastructural support offered for the execution and completion of this study.
ETHICS APPROVAL: All experimental procedures were performed after approval in the Ethics Committee for Animal Use (CEUA, Comitê de Ética no Uso de Animais) of the School of Veterinary Medicine and Animal Science at the São Paulo State University, campus Botucatu (CEUA protocol no. 0183/2019).

CONFLICTING INTERESTS: The author declares there is no conflicting interests that may be perceived as detrimental to the impartiality of this study.

FUNDING: No funding was received for conducting this study.

CONFLICTING INTERESTS: The author declares there is no conflicting interests that may be perceived as detrimental to the impartiality of this study.

CODE AVAILABILITY: Not applicable

AUTHOR CONTRIBUTIONS: Victor Ribeiro, Maria Lucia, Luiz Henrique and Moacir Leomil: Conceptualization oh the manuscript, Alessandra Melchert, Diogo Silva and Priscylla Okamoto: Methodology, Vivianne Codognato: Immunoenzymatic assay, Angélica Alfonso, Alicia Hippolito, Heloisa Coppini and Ariana Ramos: Drafting – preparation of the original draft, Miriam Tsunami: Statistical analysis.

ETHICS APPROVAL: All experimental procedures were performed after approval in the Ethics Committee for Animal Use (CEUA, Comitê de Ética no Uso de Animais) of the School of Veterinary Medicine and Animal Science at the São Paulo State University, campus Botucatu (CEUA protocol no. 0183/2019).

CONSENT TO PARTICIPATE: All author declares have consent in participate of manuscript.

CONSENT FOR PUBLICATION: All author declares have consent for publication of manuscript.

AVAILABILITY OF DATA AND MATERIAL: The data sets generated during and/or analysed during the current study are available in the Repositório Institucional UNESP at http://hdl.handle.net/11449/194417.

References

1. Acierno MJ, Brown S, Coleman A, Jepson RE, Papich M, Stepien RL, Syme HM (2018) Acvim consensus statement: Guidelines for the identification, evaluation, and management of systemic hypertension in dogs and cats. J Vet Intern Med 32:1803–1822. doi 10.1111/jvim.15331.

2. Beisiegel BM (1999) Contribuição ao estudo da história natural do cachorro do mato, Cerdocyon thous, e do cachorro vinagre, Speothos venaticus. Dissertação, Universidade de São Paulo; Instituto de Psicologia

3. Boon JA (2011) Manual of veterinary echocardiography. Wiley- Blackwell, Baltimore

4. Buchanan JW, Bücheler J (1995) Vertebral scale system to measure canine heart size in radiographs. J Americ Vet Med Assoc 206:194–199
5. Camacho AA, Mucha CJ (2014) Sistema Circulatório- Seção B/Semiologia do sistema circulatório de cães e gatos. In: Feitosa FL (ed) Semiologia veterinária: A arte do diagnóstico, 3ª. ed. Roca, São Paulo, p 559

6. Cornell CC, Kittleson MD, Torre PD, Haggstrom J, Lombard CW, Pedersen HD, Vollmar A, Wey A (2004) Allometric scaling of M-mode cardiac measurements in normal adult dogs. J Vet Intern Med. https://10.1111 / j.1939-1676.2004.tb02551.x

7. Estrada AH, Gerlach TJ, Schmidt MK, Siegal-Willott JL, Atkins AL, Van Gilder J, Citino SB, Padilla LR (2009) Cardiac Evaluation of clinically healthy captive maned wolves (Chrysocyon brachyurus). J of Zoo Wildl Med 40:478–486. DOI: 10.1638 / 2008 – 0154.1

8. Feltrer Y, Strike T, Routh A, Gaze D, Shave R (2016) Point-of-care cardiac troponin I in non-domestic species: a feasibility study. J of Zoo Aq Res 4:99–103

9. Freeman LM, Rush JE (2007) Nutrition and cardiomyopathy: lessons from spontaneous animal models. Curr Heart Fail Rep 4:84–90. https://doi.org/10.1007/s11897-007-0005-6

10. Garofalo NA, Neto FJT, Alvaiides RK, de Oliveira FA, Pignaton W, Pinheiro RT (2012) Agreement between direct, oscillometric and Doppler ultrasound blood pressures using three different cuff positions in anesthetized dogs. Vet Anaesth Analg 39:324–334. DOI:10.1111 / j.1467-2995.2012.00711.x

11. Hansson K, Haggstrom J, Kwart C, Lord P (2005) Interobserver variability of vertebral heart size measurements in dogs with normal and enlarged hearts. Vet Radiol Ultrass 46:122–130. DOI: 10.1111 / j.1740-8261.2005.00024.x

12. Jorge RSP, Jorge MLSP (2014) Carnivora – Canidae (Cachorro-do mato, Cachorro vinagre,Lobo-guará e Raposa-do-campo). In: Cubas ZS, Silva JCR, Catão-Dias JL (eds) Tratado de Animais Selvagens: medicina veterinária, 1st edn. Roca, São Paulo, pp 764–778

13. Malcolm EL, Visser LC, Phillips KL, Johnson LR (2018) Diagnostic value of vertebral left atrial size as determined from thoracic radiographs for assessment of left atrial size in dogs with myxomatous mitral valve disease. J Amer Vet Med Assoc 253:1038–1045. https://doi.org/10.2460/javma.253.8.1038

14. Mantovani M, Silva AC, Muzzi RAL, Oberlender G, Resende RM, Muzzi LAL, Junior ACCL, Nogueira RB (2012) Strain and strain rate by two-dimensional speckle tracking echocardiography in a maned wolf. Pesq Vet Bras 32:1336–1340. DOI: 10.1590 / S0100-736X2012001200019

15. O'Brien PJ, Smith DEC, Knechtel TJ, Marchak MA, Pruimboom-Brees I, Brees DJ, Spratt DP, Archer FJ, Butler P, Potter AN, Provost JP, Richard J, Snyder PA, Reagan WJ (2006) Cardiac troponin I is a sensitive, specific biomarker of cardiac injury in laboratory animals. Lab Anim 11: 153–171 https://10.1016 / j.jvc.2009.04.002

16. Reis TRD (2011) Agentes infecciosos e dieta de carnivoros domesticos e silvestres em area de silvicultura do Alto do Parapanema: implicaçoes para a conservação. Dissertação, Escola Superior de Agricultura “Luiz de Queiroz”. Centro de Energia Nuclear na Agricultura, Piracicaba
Tables

TABLE 1. Means, standard deviations and confidence intervals (CI 95%) for radiographic parameters: long axis length (cm); short axis length (cm), number of vertebrae in the long axis, number of vertebrae in the short axis, VHS, VLAS and RLAD in crab-eating foxes (*Cerdocyon thous*)

| Parameters                      | Mean ± SD | Maximum | Minimum | CI (95%)               | Reference Values |
|--------------------------------|-----------|---------|---------|------------------------|------------------|
| Long axis length (cm)          | 6.93 ± 1.57 | 11.5    | 5.10    | 6.1-7.81               |                  |
| Short axis length (cm)         | 4.72 ± 0.91 | 7.39    | 4.03    | 4.21-5.23              |                  |
| Long axis Number of Vertebrae  | 4.78 ± 0.65 | 5.5     | 3.00    | 4.42-5.14              |                  |
| Short axis Number of Vertebrae | 3.43 ± 0.56 | 5.00    | 2.90    | 3.11-3.75              |                  |
| VHS                            | 8.22 ± 0.55 | 8.90    | 7.50    | 7.91-8.53              | ≤10.5*           |
| VLAS                           | 1.77 ± 0.20 | 2.0     | 1.40    | 1.66-1.88              | ≤2.3**           |
| RLAD                           | 1.25 ± 0.18 | 1.5     | 1.0     | 1.15-1.35              | ≤1.8***          |

Abbreviations: cm – centimeters; VHS – Vertebral Heart Size; VLAS – Vertebral Left Atrial Size; RLAD – Radiographic Left Atrial Dimension; SD – standard deviation; CI – confidence interval. *Buchanan & Bucheler; ** Malcolm et al., 2018 *** Salguero et al., 2018

TABLE 2. Means, standard deviations and confidence intervals (CI 95%) for the echocardiographic parameters: Weight (kg); heart rate (bpm), systolic arterial pressure (mmHg); IVSd (cm); LVd (cm); LVFWd
(cm); IVSs (cm); LVs (cm); LVFWs (cm); LVFS (%) ; EF (%) ; LA (cm), Ao (cm), LA:Ao ratio; EPSS (cm);
Pulmonary Flow (cm/s); Aortic Flow (cm/s); E-Wave (cm/s); EDT (ms); A-wave (cm/s); E/A ratio; IVRT
(ms); E/IVRT ratio in crab-eating foxes (Cerdocyon thous).
| Parameters      | Mean ± SD  | Maximum | Minimum | CI (95%) | Reference Values (Boon, 2011a) |
|-----------------|------------|---------|---------|----------|--------------------------------|
| Weight (kg)     | 6.2±0.96   | 7.44    | 4.32    | 5.7-6.7  | 5.24-7.16                      |
| SAP (mmHg)      | 126.92±38.97 | 200   | 90  | 105-149 |                                 |
| HR (bpm)        | 138.27±27.66 | 192  | 100  | 123-154 |                                 |
| IVSd (cm)       | 0.61±0.13  | 0.87    | 0.43    | 0.54-0.66 | 0.60-0.81                      |
| LVd (cm)        | 1.87±0.25  | 2.32    | 1.43    | 1.73-2.01 | 1.97-2.53                      |
| LVFWd (cm)      | 0.66±0.16  | 0.86    | 0.41    | 0.58-0.74 | 0.48-0.65                      |
| IVSs (cm)       | 0.86±0.14  | 1.12    | 0.63    | 0.79-0.93 | 0.91-1.16                      |
| LVs(cm)         | 1.22±0.22  | 1.60    | 0.87    | 1.10-1.34 | 1.11-1.54                      |
| LVFWs (cm)      | 0.83±0.12  | 1.06    | 0.65    | 0.77-0.89 | 0.81-1.03                      |
| LVFS (%)        | 37.14±12.54 | 65.3  | 18     | 30-44    | 30-46                          |
| EF (%)          | 68.08±14.7 | 94     | 41      | 60-76    | 55-75                          |
| LA (cm)         | 1.34±0.22  | 1.74    | 1.02    | 1.22-1.46 | 1.31-1.69                      |
| Ao (cm)         | 1.07±0.11  | 1.20    | 0.82    | 1.01-1.13 | 1.31-1.63                      |
| LA:Ao           | 1.26±0.17  | 1.54    | 0.99    | 1.17-1.35 | ≤ 1.6                          |
| EPSS (cm)       | 0.20±0.11  | 0.40    | 0.06    | 0.14-0.26 | ≤ 0.7                          |
| Pulmonary Flow (cm/s) | 82.43 ± 12.43 | 99.30 | 61.10 | 75-89 | ≤ 160 |
| Aortic Flow (cm/s) | 87.09 ± 24.34 | 136.90 | 52.60 | 74-100 | ≤ 200 |
| E-Wave (cm/s)   | 73.62 ± 18.21 | 109.90 | 53.40 | 63-83 | ≤ 52 - 81 |
| EDT (ms)        | 36.27 ± 6.93 | 52.20 | 27.60 | 33-39 | 52 - 108 |
| A-Wave (cm/s)   | 45.59 ± 12.82 | 66.80 | 20.90 | 38.34-52.84 | 45-78 |
| E/A Ratio       | 1.62 ± 0.54 | 2.67    | 1.11    | 1.32-1.92 | 1 – 2                          |
| IVRT (ms)       | 65.42 ± 18.52 | 100   | 40     | 55-75    | 31 – 73                         |
E/IVRT Ratio: 1.26 ± 0.64  

Abbreviations: HR – Heart rate; bpm- beats per minute; SAP – systolic arterial pressure; mmHg – millimeters of mercury; TC – thoracic circumference; cm – centimeters; IVSd – Interventricular septum in diastole; LVd – Left ventricular diameter in diastole; LVFWd – Left ventricular free wall in diastole; IVSs – Interventricular septum in systole; LVs – Left ventricular diameter in systole; LVFWs – Left ventricular free wall in systole; LVFS – Left ventricular fractional shortening; EF – Ejection fraction; LA – Left atrium; Ao – Aorta; LA:Ao – Left atrial-to-aortic root ratio; EPSS – E-point septal separation; cm – centimeter; cm/s – centimeters per second; ms – milliseconds; EDT – E-wave deceleration time; IVRT – Isovolumetric relaxation time; SD – standard deviation; CI – confidence interval

### TABLE 3. Means, standard deviations and confidence intervals (CI 95%) for the echocardiographic parameters normalized for the body weight of the animal: IVSd (cm); LVd (cm); LVFWd (cm); IVSs (cm); LVs (cm); LVFWs (cm) in crab-eating foxes (*Cerdocyon thous*).

| Parameters | Mean ± SD | Maximum | Minimum | CI (95%) | Normalized Reference Values (Cornell et al., 2004) |
|------------|-----------|---------|---------|----------|--------------------------------------------------|
| IVSd (cm)  | 0.39 ± 0.09 | 0.58    | 0.27    | 0.34-0.44 | 0.29-0.59                                        |
| LVd (cm)   | 1.09 ± 0.14 | 1.33    | 0.83    | 1.02-1.16 | 1.27-1.85                                        |
| LVFWd (cm) | 0.43 ± 0.10 | 0.55    | 0.28    | 0.38-0.48 | 0.29-0.60                                        |
| IVSs (cm)  | 0.62 ± 0.10 | 0.78    | 0.43    | 0.57-0.67 | 0.43-0.79                                        |
| LVs (cm)   | 0.69 ± 0.12 | 0.88    | 0.50    | 0.63-0.75 | 0.71-1.26                                        |
| LVFWs (cm) | 0.55±0.07 | 0.69    | 0.46    | 0.52-0.58 | 0.48-0.87                                        |

Abbreviations: IVSd – Interventricular septum in diastole; LVd – Left ventricular diameter in diastole; LVFWd – Left ventricular free wall in diastole; IVSs – Interventricular septum in systole; LVs – Left ventricular diameter in systole; LVFWs – Left ventricular free wall in systole; cm – centimeter; SD – standard deviation; CI – confidence interval