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Morphoquantitative evaluation of the heart of cutia (*Dasyprocta agouti*) and capybara (*Hydrochoerus hydrochaeris*)

[*Avaliação morfoquantitativa do coração da cutia (Dasyprocta agouti) e da capivara (Hydrochoerus hydrochaeris)*]

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ABSTRACT

The cutia (*Dasyprocta agouti*) and capybara (*Hydrochoerus hydrochaeris*) are hystricomorphic rodents of the Brazilian fauna. The wild animal anatomy is essential to the clinic and surgery practices and conservation programs. This work aimed to evaluate the heart quantitative morphology of the cutia and the capybara. For this, three hearts of cutia and three of capybaras were used from the collection of the Anatomy Sector of Domestic and Wild Animals of the Faculty of Veterinary Medicine and Animal Science of the University of São Paulo. The hearts were weighted and measured with a pachymeter. The left ventricle volume was estimated through the Cavalieri method. The hearts' mean weight was 16.76g (cutias) and 104.2g (capybaras). The mean values for the axis, width and base dimensions were of the cutia 4.3cm, 3.3cm and 3.3cm and for the capybara were 7.6cm, 6.0cm and 6.1cm, respectively. The mean volume of the left ventricle of the cutia and the capybara was 5.03cm^3 and 54.55cm^3, respectively. The quantitative results of the hearts were compatible with the average body weight of the rodents. Thus, these numerical data can be applied to veterinary cardiology.

Keywords: wild animal, anatomy, veterinary cardiology, rodent

RESUMO

*A cutia (*Dasyprocta agouti*) e a capivara (*Hydrochoerus hydrochaeris*) são roedores histricomorfos da fauna brasileira. A anatomia de animais silvestres é essencial para a prática clínico-cirúrgica e programas conservacionistas. Este trabalho objetivou avaliar a morfologia quantitativa do coração da cutia e da capivara. Para isso, foram utilizados três corações de cutias e três de capivaras, provenientes do acervo do Setor de Anatomia dos Animais Domésticos e Silvestres da Faculdade de Medicina Veterinária e Zootecnia da Universidade de São Paulo. Os corações foram pesados e as mensurações foram realizadas com paquímetro. O volume do ventrículo esquerdo foi calculado pelo método de Cavalieri. O peso médio dos corações foi de 16,76g (cutias) e de 104,2g (capivaras). Os valores médios para as dimensões eixo, largura e base foram, para a cutia, de 4,3cm, 3,3cm e 3,3cm e para a capivara, de 7,6cm, 6,0cm e 6,1cm, respectivamente. O volume médio do ventrículo esquerdo da cutia e da capivara foi respectivamente de 5,03cm^3 e de 54,55cm^3. Os resultados quantitativos dos corações foram compatíveis com o peso corporal médio dos roedores. Assim, esses dados numéricos podem ser aplicados à cardiologia veterinária.*

Palavras-chave: animais silvestres, anatomia, cardiologia veterinária, roedores

INTRODUCTION

Rodents are formed by 2021 distinct species, constituting the largest order of mammals and corresponding to 43.7% of terrestrial mammals. Among the wildlife rodents the cutia (Dasyprocta agouti) and the capybara (Hydrochoerus hydrochaeris) stand out with desirable

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characteristics for breeding in captivity because they have adaptations to adverse conditions, prolificacy and little nutritional requirement (Cavalcante *et al.*, 2005). In addition, the consumption of their exotic meats has grown, especially due to its low fat content (Pinto *et al.*, 2007).

Several anatomical studies of wild animals have already been described in the scientific literature, however, there are few involving the quantitative morphology of the heart of these rodents. Such research, in addition to contributing to the collection of species, facilitate breeding for commercial purposes, clinical-surgical practice and conservation programs (Aversi *et al.*, 2005). In this context, quantitative anatomy or morphometry consists of measuring anatomical structures for comparative purposes and describing the physiological or pathological state of an organ (Phalen *et al.*, 1978). The heart is the main organ in the circulatory system (Konig and Liebich, 2011), and the estimation of its ventricular volume in healthy animals can establish reference values for the diagnosis of cardiomyopathies such as dilated cardiomyopathy and ventricle hypertrophy (Werner *et al.*, 2001).

Thus, given the scarcity of scientific work on the cardiac morphology of wild rodents and the need for anatomical knowledge for medical, surgical, commercial and conservation applications, the objective of this work was to describe the morphology of cutia and capybara hearts under the quantitative aspect.

MATERIAL AND METHODS

Three cutia hearts and three adult capybara hearts, male and female, from the collection of the Sector of Anatomy of Domestic and Wild Animals of the Faculty of Veterinary Medicine and Zootechnics of the University of São Paulo were used (FMVZ-USP), fixated with a 10% formaldehyde solution at (Neon Comercial Ltda, São Paulo - SP). To obtain morphometric data, hearts were weighed (g) on a precision semi-analytical scale (Mettler Toledo Indústria e Comércio Ltda, Barueri - SP) and measured with the aid of Pachymeter (Mitutoyo Sul Americana, Suzano - SP) as for the length of the vertical axis (determined in cm by the distance between the apex and base of the organ), width (latero-lateral in cm from the organ) and width of the base (diameter of the cardiac base in cm).

The Cavalieri method was used to estimate the volume of left ventricles (Gundersen *et al.*, 1999; Tinajero-Bravo *et al.*, 2014); thus, the hearts were cross-sectioned into small serial fragments of approximately 0.6cm in cutias and 1.0cm in capybaras and subsequently photographed with a digital camera (Canon® EOS 400D coupled with digital Sigma lens 1:100 macro). The digitalized photographic images were randomly superimposed on a system of points spaced at regular intervals (point counting), counting the points that hit the left ventricle (Fig.1) and subsequently applied the following formula:

$$V(VE) = \sum p \times a(p) \times t$$

V: left ventricular volume (VE)
Σp: sum of points that touch the VE
a(p): area by point
t: cut thickness: 0.6cm (cutia) and 1.0cm (capybara)

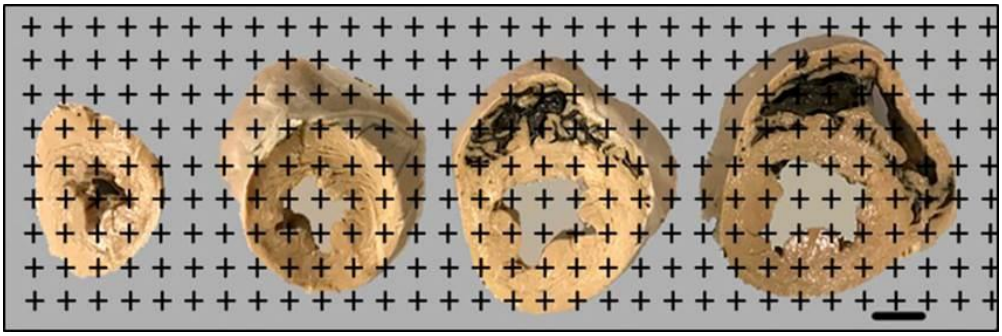

Figure 1. Digitalized photographic image of serial sections of the left ventricle of adult capybara, superimposed by a system of points spaced at regular intervals (Cavalieri method) to estimate the volume of the left ventricle in cm^3 (Bar scale: 1cm).

For the naming of the anatomical structures, the terminologies recommended in Nomina Anatomic Veterinary (2012) were used as standard.

RESULTS

The individual results and the average of the morphometric parameters of the hearts of the cutias and capybaras are shown in Table1 and the mean of the volume of the left ventricle of the hearts are shown in Table 2.

Table 1. Individual parameters and mean of the data morphometric (weight, axis, width and base) of the hearts of three cutias and three adult capybaras from the Sector of Anatomy of Domestic and Wild Animals of the Faculty of Veterinary Medicine and Zootechnics of the University of São Paulo (FMVZ-USP).

	Cutia 1	Cutia 2	Cutia 3	Mean Cutias	Capybara 1	Capybara 2	Capybara 3	Mean Capybara
Weight (g)	15.77	18.88	15.64	16.76	98.44	141.3	72.9	104.2
Axis (cm)	4.5	3.5	5.0	4.3	7.0	8.0	8.0	7.6
Width (cm)	3.5	3.0	3.5	3.3	6.0	6.5	5.5	6.0
Base (cm)	3.0	3.0	3.0	3.0	6.0	7.0	5.5	6.1

Table 2. Individual parameters and mean of the volume of the left ventricle (cm^3) of the hearts of three cutias and three adult capybaras from the Sector of Anatomy of Domestic and Wild Animals of the Faculty of Veterinary Medicine and Zootechnics of the University of São Paulo (FMVZ-USP).

	Cutia 1	Cutia 2	Cutia 3	Mean Cutias	Capybara 1	Capybara 2	Capybara 3	Mean Capybara
Volume (cm^3)	10.65	9.88	8.10	9.54	50.72	57.60	55.04	54.45

DISCUSSION

Morpho-quantitative data on the heart of cutias and capybaras are still scarce in the literature, which makes the discussion restricted. Thus, the current work aimed to contribute to the formation of reference parameters for the macroscopic assessment of cardiac normality in these rodents. Studies involving cardiac morphology, under the quantitative aspect, were carried out in dogs (Werner *et al.*, 2001), marmosets (Senos *et al.*, 2014), goats (Silva *et al.*, 2016), rats (Engelmann *et al.*, 1987) and equine (Leite *et al.*, 2004), facilitating early assessments of cardiomyopathies that manifest with changes in the dimensions and weight of the heart (Werner *et al.*, 2001). Still, in rats and mice, morphometry was used to investigate the consequences of arterial hypertension in the development of left ventricular hypertrophy (Engelmann *et al.*, 1987; Schipke *et al.*, 2016).

In accordance with other rodents such as paca (Ávila *et al.*, 2010), rat and mouse, the hearts of cutias and capybaras in the current study were elongated cone shaped, consisting of two atria and two right and left ventricles (tetracavitary) easily distinguishable; furthermore, similarity with that described in the literature in relation to domestic animals (Ciszek *et al.*, 2007; Ávila *et al.*, 2010; Dyce *et al.*, 2010; Konig and Liebich, 2011; Silva *et al.*, 2016), Pantanal alligators (Alves *et al.*, 2016) and swine (Lelovas *et al.*, 2014), especially as to the thickness of the left ventricular wall compared to the right.

In the present study, the mean heart weight of cutias and capybaras was 16.7g and 104.2g, respectively, equivalent to 0.2% of body weight in both species. On the other hand, in dogs, this percentage varied from 0.9 to 2.2%, although in this species this increase may occur due to variables such as physical training in athletes and game animals, obesity and physical inactivity (Ghoshal, 1986). Regarding the morphometric parameters, it was observed that the mean value of the apex-base axis and the width of the cutia heart corroborated with the descriptions by Ávila *et al.* (2010) when investigating the pacas. This similarity is probably related to the proximity of body weight between the two rodents. Conversely, in the capybara, these values were higher, possibly due to the greater body weight when compared to that of cutia and paca.

In dogs, as cardiac morphometric differences in relation to genders were not used by Bienvenu and Drolet (1991), in accordance with what was observed in the cutias and capybaras of this study. As for the volume of the left ventricle, the cutia had an average value of 9.54cm^3 and the capybara was 54.45cm^3. In goats, the mean value found by Silva *et al.* (2016) was 25.85cm^3 and, in humans, 160cm^3 for men and 123cm^3 for women, both with an average body weight of 67 kg (Tang *et al.*, 2009). Based on the findings of Tang *et al.* (2009) it is suggested that the ventricular volume may vary with the individual's gender; however, in this study, this variable could not be evaluated due to the lack of knowledge of the animals' sex.

In view of the applied methodology and the results obtained, it is assumed that the quantitative values of the heart are compatible with the average body weight of cutia and capybara, regardless of gender, as well as the average ventricular volume with the average weight of the organ, in both rodents. In this way, the estimation of two-dimensional and three-dimensional measurements of the heart of wild rodents, using quantitative morphology tools, can be applied to veterinary physiology and cardiology.

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