Medidas biométricas, avaliação do escore corporal e índice de massa corpórea em Quatis (*Nasua nasua*) de vida livre da região Centro Sul do estado de São Paulo, Brasil

Biometric Measures, Body Score and Body Mass Index Evaluation in Wild Coatis (*Nasua nasua*) Living in the South-Central Region of São Paulo State, Brazil

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ABSTRACT

Background: Coatis (*Nasua nasua*) have easy interaction with man, besides being sociable and curious animals. The proximity to urbanized areas encourages them to intake food from anthropogenic sources, and it can change their eating habits and make them prone to obesity. The body condition evaluates the animals' energetic status and measures variations in their body fat reserves. There are direct-invasive methods and indirect methods that rely on size and body mass to evaluate the body condition, like body condition score and body mass index. Thus, the aim of the present study was to assess different methods to determine the body condition of wild coatis (*Nasua nasua*) living in urban areas.

Materials, Methods & Results: Sixteen wild coatis (*Nasua nasua*), nine females and seven males, were captured at Faculty of Veterinary Medicine and Animal Science (FMVZ) of São Paulo State University, Botucatu, in pitfalls. The animals were anesthetized with ketamine and midazolam and subjected to biometric evaluation after physical exams proved normal. The following variables were analyzed: body weight, body condition score (BCS) based on the five-point scale for dogs, thoracic and abdominal circumference, height at the withers, spine length and distance from the patella to the calcaneus. Two body mass index (BMI) were calculated from these data, one was based on dogs (BMI1) and another one on cats (BMI2), as well as the body fat percentage (%BF). Results showed that 25% of the assessed coatis were overweight. Body weight, thoracic and abdominal circumference, height at the withers, spine length and distance from the patella to the calcaneus were significantly higher in males than in females and the other assessed parameters did not present differences between sexes. The correlation between fat percentage and body weight was significant, and that between fat percentage and BCS was not. There was closer correlation between BMI2 and body weight, and BCS, than between BMI1 and these two parameters.

Discussion: Anthropogenic interactions could change the body condition of these animals and make them prone to obesity, since their body condition scores were altered. With regard to the nutritional body condition, although males were bigger than females, the measures did not show significant differences between them. Results of this parameter varied in different studies with coatis, some studies have shown that males have body mass 1/3 higher than that of females and others have not recorded any difference between sexes. Fat percentage estimated through the metrics used in cats is not a good method when it is applied alone in body condition evaluations. A study that has correlated body mass, body condition score, body fat estimates, body mass index and abdominal circumference recorded positive results between these two evaluation methods. Such finding corroborated with the present study, but it was differed from it in abdominal circumference, which did not correlate to the two body mass indices and to body fat percentage. Therefore, it is possible saying that there is biometric difference between male and female coatis. The body condition score adopted for dogs was efficient for coatis (*Nasua nasua*), as well as the body mass index used for dogs and cats - the one used for cats was even more efficient. The proximity wild coatis (*Nasua nasua*) have to humans could change the body condition of these animals and make them prone to obesity.

Keywords: *Nasua nasua*, biometry, body mass index, body condition score.

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INTRODUCTION

The genus *Nasua* is characterized by coarse hair, medium height, short legs and ring tail [3,8]. Animals belonging to this genus are omnivore, gregarious and active; they depend on smells and on the sensitivity of their long and pointed nose to find their prey [16]. They are curious and sociable; therefore, they easily interact with people [15]. The proximity to humans encourages them to intake food from anthropogenic source, and it can change their eating habits and, consequently, change their metabolism [10].

Body condition refers to the animal's energetic status; it measures variations in their fat reserves [13]. There are direct and indirect methods available for this evaluation; the direct methods are more expensive and destructive for animals [13]; thus, the indirect ones become an alternative and are more often used in association with size and body structure metrics [5].

The body condition score is assessed by making a visual analysis of the animal's silhouette and by palpating some specific regions in their bodies [6,14]. The fat percentage evaluation uses two body measures to predict the fat content [2]. The body mass index uses a specific formula to analyze the real condition [9].

Studies focused on assessing the diet of wild coatis, as well as the effects of anthropogenic interaction, are lack in the literature [11]. Because these animals are easily adaptable, the over population of these species can lead to adverse consequences for both the environment and the public health, since they participate in zoonotic transmission cycles and are often found in zoos [12]. Therefore, it is important knowing their diet and behaviors in order to formulate their diet and to distinguish possible nutritional and behavioral affections [16]. Thus, the aim of the current study is to assess the nutritional condition of wild coatis (*Nasua nasua*) living close to people, besides testing the methods used to determine their nutritional condition.

MATERIALS AND METHODS

Nasua nasua specimens from both sexes were captured at Faculty of Veterinary Medicine and Animal Science (FMVZ) of São Paulo State University, Botucatu, São Paulo, Brazil (GPS Location: latitude – 20° 53' 09" S; longitude – 48° 26' 42" W). In total, seven males and nine females were captured using tomahawk pitfalls¹. They were attracted by fruits and boiled chicken eggs.

Chemical contention was necessary for the easy handling of the animals and to avoid risks for both researchers and subjects. Animals were subjected to 12 h food fasting and 3 h water fasting before the anesthesia. A mixture of ketamine (Quetamina® - 20 mg/kg)² and midazolam (Midazolam® - 2.0 mg/kg)³ in the same syringe was administered through intramuscular (*vastus lateral* muscle) route.

Animals were identified by sex after anesthesia and, next, they were subjected to body morphometry in order to measure the following parameters: nose length, distance from the nose to the tail, thoracic circumference (right below the thoracic limbs), length of the right foot, height at the withers, spine length, distance from the patella to the calcaneus, height of the pelvic limbs, abdominal circumference, thoracic circumference and thigh circumference. Measurements were taken with a tape measure⁴. Body weight was measured on digital scale⁵.

The body condition score (BCS) was determined based on the proposition for dogs in the body condition analysis. This proposition takes into account the presence, or absence, of muscle mass, fat reserves and the visual bone structure [7]. The five-point scale, which was elaborated to classify coatis' body scores based on the classification for dogs and according to data on coatis themselves (Figure 1A, 1B, 1C, 1D and 1E), was used in the body condition score classification: Cachectic - ribs, lombar vertebrae and bone prominences very evident. There is no perceptible body fat. Loss of muscle mass; Thin - ribs easily palpable and without fat. Spinal process of lombar vertebrae visible. Less prominent pelvic bones. Perceptible waist; Normal - palpable ribs but without excess fat. No perceptible of pelvic bones. Less perceptible waist under top vision; Overweight - More difficulty to palpable ribs and presence of fat layer. Fat over the lombar region and at the base of the tail. Little or no apparent waist; Obese - Fat in the thorax, abdomen, spine, base of the tail, shoulders and limbs. Abdominal distension.

Two equations were used to determine BMI, one of them was used for dogs and divides the body weight by height (spine length + hindlimb length) squared (BMI1) [9], and another one is adopted for cats and divides body weight (kg) by the spine length (m) (BMI2) [1].

The formula used for cats was applied to calculate fat percentage: $\{[(TC / 0.7067) - DPC] / 0.9156\} - DPC$ [2].

The non-paired Student's *t* test for parametric data was used in data statistical analysis (body weight, thoracic circumference (TC), abdominal circumference (AC), spine length (SL), distance from the patella to the calcaneus (DPC), height at the wither (HW), fat percentage (% BF), BMI1 and BMI2, whereas the Mann-Whitney test was applied for non-parametric data to compare male and female coatis. Data normality was tested through Kolmogorov-Smirnov test.

The Pearson's correlation was used to assess the association between BMIs (BMI1 and BMI2) and the calculated fat percentage, and the biometric data. It was done to assess the influence of these data on variables presenting normal distribution (body weight, thoracic circumference, abdominal circumference). Spearman's correlation was applied to abnormal data (BCS). Pearson's correlation was used to assess the association between fat percentage and the two BMIs (BMI1 and BMI2), as well as to correlate the two assessed BMIs to each other. The 5% significance level was adopted for all the conducted analyses.

RESULTS

Ten animals (62.5%), five males and five females, presented adequate BCS (BCS = 3) in the body condition score evaluation, and only two females (12.5%) recorded underweight condition (BCS = 2). However, four animals (25%) [two males and two females] were overweight (BCS = 4).

Parameters such as body weight, abdominal circumference, thoracic circumference, spine length and the distance from the patella to the calcaneus were statistically higher in males. The other assessed parameters did not show differences between males and females (Table 1). Despite the body weight and measure differences between males and females, there was no significant difference (Table 1) in these numbers when BCS, BMI1, BMI2 and the fat percentage of each sex were compared.

In order to find whether the two BMIs used in the present study presented discrepancies, they were compared to each other based on the BMI1 used in dogs and on the BMI2 adopted for cats. These data were analyzed by gathering the animals in three different groups: females, males and a group of males and females. The analysis evidenced that, regardless of the group, there was no significant difference between the two BMIs. The group with females recorded $P = 0.5021$

and the one with males had $P = 0.2554$, whereas the group with both sexes showed $P = 0.2061$.

The correlation analysis was applied to the assessed BMIs (BMI1 and BMI2) and there was strong positive correlation between them. When the assessed BMIs were correlated to parameters such as body mass, BCS, fat percentage, and thoracic and abdominal circumference, BMI1 had weak positive correlation to body mass and to BCS (Table 2), whereas BMI2 evidenced stronger positive correlation to these parameters (Table 2).

There was positive correlation between fat percentage and body mass ($R = 0.7$ and $P = 0.0092$), but the same did not occurs to BCS ($R = 0.3$ and $P = 0.2896$); thus, these results evidenced that this index did not have proper correlation to body score. There was significant positive correlation ($R = 0.6$ and $P = 0.0162$) when body mass was correlated to BCS.

DISCUSSION

The 16 wild coatis (*Nasua nasua*) used in the present study showed different BCS between them, and only four animals were overweight (BCS = 4). On the other hand, the anthropogenic interaction can make these animals prone to obesity since they eat food garbage [11]. Similar study regarding to diet of coatis in two conservation units in southeastern Brazil with different degrees of interaction of animals with the human population showed an anthropic influence by identified with the occurrence of ingestion of processed foods, discarded non - digestible residues and cultivated fruits [11].

The body weight and measures between males and females of wild coatis (*Nasua nasua*) showed that males were bigger than females, and otherwise there was no difference in their nutritional body conditions, or significant occurrence of malnutrition and overweight/obesity in any of the sexes. Both BMIs assessed in the present study were high-quality methods to determine body condition, since they presented good association with BCS. However, the BMI2 used in the clinical routine of cats was more efficient to detect body condition in wild coatis (*Nasua nasua*), since it had stronger positive correlation to body weight and to BCS than the BMI1 used in dogs. The used formulas were quite different from each other, both led to similar estimates about the animals' BMI.

Figure 1. Adaptation of the Body Condition Score (BCS) of dogs [8] for quatis, using the 5-point scale. A- Cachectic, B- Thin, C- Normal; D- Overweight, E- Obese.

Table 1. Mean values, standard deviation (SD), *P* values, confidence interval (CI) (minim value - maximum value) of BW (body weight), BCS (body condition score), AC (abdominal circumference), DPC (distance from the patella to the calcaneus), SL (spine length), HW (height at the wither), BMI1 (body mass indices in dogs), BMI2 (body mass indices in cats), TC (thoracic circumference) and % BF (fat percentage - cats) of female (*n* = 9) and males (*n* = 7) of wild coati (*Nasua nasua*).

Parameter	Male (Mean±SD)	Female (Mean±SD)	<i>P</i> value	CI (minim value - maximum value)
BW	4.8 ± 0.5	3.9 ± 0.5	0.0054	F: 3.5 - 4.3 M: 4.3 - 5.3
BCS	3.3 ± 0.5	3 ± 0.8	0.4908	F: 2.4 - 3.6 M: 2.8 - 3.9
AC (cm)	36.7 ± 3.0	31.9 ± 2.9	0.0083	F: 29.8 - 34.1 M: 33.5 - 39.8
DPC (cm)	15.8 ± 1.2	14.4 ± 0.7	0.0212	F: 13.9 - 15.0 M: 14.5 - 17.0
SL (m)	0.4 ± 0.02	0.3 ± 0.02	0.001	F: 0.3 - 0.4 M: 0.37 - 0.40
HW (m)	0.3 ± 0.02	0.3 ± 0.02	0.7634	F: 0.24 - 0.27 M: 0.2 - 0.3
TC (cm)	36.7 ± 2.3	32.9 ± 1.6	0.0038	F: 31.5 - 34.2 M: 34.2 - 39.1
BMI1	11.4 ± 1.4	11.0 ± 1.6	0.6147	F: 9.7 - 12.3 M: 10.0 - 12.9
BMI2	12.3 ± 1.4	11.5 ± 1.4	0.2889	F: 10.3 - 12.7 M: 10.9 - 13.8
%BF (cats)	23.7 ± 4.6	20.6 ± 2.8	0.1419	F: 18.2 - 23.0 M: 18.9 - 28.5

Table 2. Correlation values (r) and P values obtained in the correlation analysis between BMI1 and BMI2 with body weight (BW), %BF (fat percentage - cats), BCS (body condition score), TC (thoracic circumference) and AC (abdominal circumference) and for correlation between BMI2 (body mass indices in cats), and BMI1 (body mass indices in dogs) in males and females wild coati (*Nasua nasua*) [n = 16].

	(r)	P value		(r)	P value
BMI1 x BW	0.6	0.0181	BMI2 x BW	0.8	0.0004
BMI1 x %BF	0.2	0.5183	BMI2 x %BF	0.4	0.205
BMI1 x BCS	0.5	0.0455	BMI2 x BCS	0.7	0.005
BMI1 x TC	0.3	0.3697	BMI2 x TC	0.5	0.0843
BMI1 x AC	0.3	0.2902	BMI2 x AC	0.5	0.085
			BMI2 x BMI1	0.9	<0.0001

Adult male coatis tend to present body mass approximately 1/3 higher than that of females and the mean body mass of males and females lie between 4.6 and 4.1 kg, respectively [16]. Such results are similar to values observed in the present study. Study conducted in Mexico also mentioned that the body mass of male coatis was higher than that of females [4].

The fat percentage of wild coatis (*Nasua nasua*) of the present study did not showed a good method for morphometric measures when used separated from BMI and BCS. Similar in cats, the fat percentage estimated through morphometric measures shall not be used as the single method in cats' body evaluations [1]. A study based on the Spearman's correlation test showed positive correlation among five body evaluation methods in 50 domestic cats after their body mass, body condition score determination (BCS), body fat percentage estimate, body mass index (BMI) and abdominal circumference were correlated [1]. This study corroborated the present one, but their results were different from the herein observed results of abdominal circumference, which did not correlate to BMI1, BMI2 and fat percentage.

CONCLUSION

The evaluation methods adapted from the BMI used in dogs and cats, and from the body condition score (BCS) adopted for dogs, can be applied to wild coatis (*Nasua nasua*). Body mass index method adopted for cats is a slight better to assess wild coatis (*Nasua nasua*) than the one used for dogs.

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Declaration of interest. The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the paper.

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