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Ecological Habit Inferences of the Extinct Porcupine *Coendou magnus* Lund, 1839 (Rodentia, Erethizontidae) from Brazilian Intertropical Region

Inferências Sobre o Hábito Ecológico do Porco-Espinho Extinto Coendou magnus Lund, 1839 (Rodentia, Erethizontidae) da Região Intertropical Brasileira

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Abstract

Through the use of two indices estimated from measurements of the humerus and ulna, we suggested the possible ecological habit of the extinct porcupine *Coendou magnus* Lund, 1839 from the Late Pleistocene in the Brazilian Intertropical Region. The analyzed specimen was found in Toca da Barriguda cave (Campo Formoso/BA, Brazil), weighed 9 kg, and lived in a low-density forest at 33,171-33,765 cal yr BP. All extant species of the *Coendou* genus are suspensory, and these indices suggest the same ecological habit for *C. magnus*.

Keywords: Paleoecology; Rodentia; South America

Resumo

Através do uso de dois índices estimados a partir de medições do úmero e das ulna, sugeriu-se o possível hábito ecológico do porco-espinho extinto *Coendou magnus* Lund, 1839 do Pleistoceno final na Região Intertropical Brasileira. O espécime analisado foi encontrado na Toca da Barriguda (Campo Formoso/BA, Brasil), pesava 9 kg e viveu em uma floresta de baixa densidade há 33.171-33.765 cal anos BP. Todas as espécies existentes do gênero *Coendou* são arborícolas, e os resultados encontrados nos ajudam a sugerir o mesmo hábito ecológico para *C. magnus.*

Palavras-chave: Paleoecologia; Rodentia; América do Sul

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1 Introduction

Coendou Lacépède, 1799 is a Central and South American genus of herbivorous arboreal rodents, with fur modified in quills, and prehensile tails, weighting between 1-10 kg, being nowadays classified into 16 species (Menezes *et al.*, 2021). The unique quaternary species was *Coendou magnus*, which is found only in South America, with fossil records including only skull, dentaries, and isolated teeth from Argentina (Reguero *et al.*, 2007; Sussman, 2011; Vezzosi and Kerber, 2018), Bolivia (Hoffstetter, 1963), Uruguay (Ubilla, 1996), and Brazil (Paula Couto, 1950; Lessa *et al.*, 2008; Kerber *et al.*, 2014).

It is assumed that *C. magnus* was also a herbivore that eats flowers, stems, leaves, and fruits (Sussman *et al.*, 2016), and the only ecological information available suggests that it weighed 9 kg and lived in a low-density forest in Caatinga or Cerrado at 33,171-33,765 cal yr BP in Campo Formoso, Bahia, Brazil (Alves-Silva et al., 2023). The main studies on this taxon have focused on taxonomy or biogeography (Reguero *et al.*, 2007; Sussman, 2011; Kerber *et al.*, 2014; Sussman *et al.*, 2016; Vezzosi and Kerber, 2018) leaving a gap in the ecological habits of this species; thus, the main objective of this study was to establish the ecological habits of this species using two morphometric indices using humerus and ulna.

2 Material and Methods

This paper analyzed the right humerus (LEG 0331) and right ulna (LEG 0333) of *C. magnus* collected in Toca da Barriguda cave, Campo Formoso/BA (Alves-Silva *et al.*, 2023) housed in the scientific collection of Laboratório de Ecologia & Geociências (LEG) of the Universidade Federal da Bahia (IMS/CAT; Vitória da Conquista/BA). During the Late Pleistocene/Early Holocene, this municipality was part of the Historically Stable Area of the Brazilian Intertropical Region (Dantas *et al.*, 2024; Figure 1).

For comparison were measured the humerus and ulnae of *Coendou* spp. from the collection of the Mastozoology Sector of the Department of Vertebrates of the Museu Nacional da Universidade Federal do Rio de Janeiro (MN/UFRJ) (Rio de Janeiro, Brazil): *Coendou prehensilis* (Linnaeus, 1758), MN 252, MN 2681, MN 4923, MN 4924, MN 4937, MN 4938, MN 5305, MN 34186, MN 70375, MN 89728; *Coendou spinosus* (Cuvier, 1823), MN 46936, MN 69871, MN 69793, MN 73266, MN 74408, MN 79029, MN 79424, MN 80439, MN 80969, MN 81989, MN 89916, MN 91621; and *Coendou insidiosus* (Olfers, 1818) MN 89926).

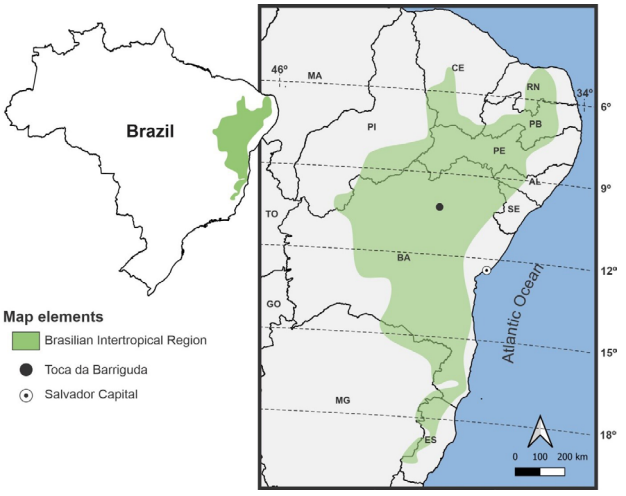

Figure 1 Brazilian Intertropical Region – BIR (*sensu* Dantas *et al.*, 2024).

2.1 Ecological Habit Indices

To suggest the ecological habits (suspensory, climbing, or terrestrial) of *C. magnus* the Index of humeral cross-sectional shape (I_{max}/I_{min}; Patel *et al.*, 2013) and the Index of Dorsal Olecranon projection (IDO; White, 1993; Santos *et al.*, 2023) were used.

The I_{max}/I_{min} was calculated by dividing the value of the maximum diameter (I_{max}) by the value of the minimum diameter (I_{min}) of a cross-section of the humerus at the minimum width of the diaphysis (Figure 2A-B), being able to generate information on how much the shape of the cross-section varies from the shape of a circle. IDO is the result of the division of the dorsal extent of the olecranon process with the length of the trochlear notch from the most proximal and anterior point to the junction of the trochlear and radial notches (Figure 2C).

Following Santos et al. (2023), the use of body mass (BM; transformed to logarithm values at base 10) associated with the I_{max}/I_{min} (varying between 0.87-1.73) and IDO (varying between 0.44 to 1.24), helps to classify the ecological habits of the studied taxon as suspensory (log_{10}BM values varying between 0.22-1.30, BM = 1.6-20 kg), climber (log_{10}BM values varying between 1.70-2.40, BM = 50-250 kg), and terrestrial (log_{10}BM greater than 2.40, BM > 250 kg; Figure 3A-B).

These values were compared with the indices of humeral cross-sectional shape (I_{max}/I_{min}) and dorsal olecranon projection (IDO) associated with the body mass (transformed to logarithm values at base 10) of extant primates, xenarthrans (Santos et al., 2023), and extant *Coendou* spp. which have suspensory and climber habits (Table 1).

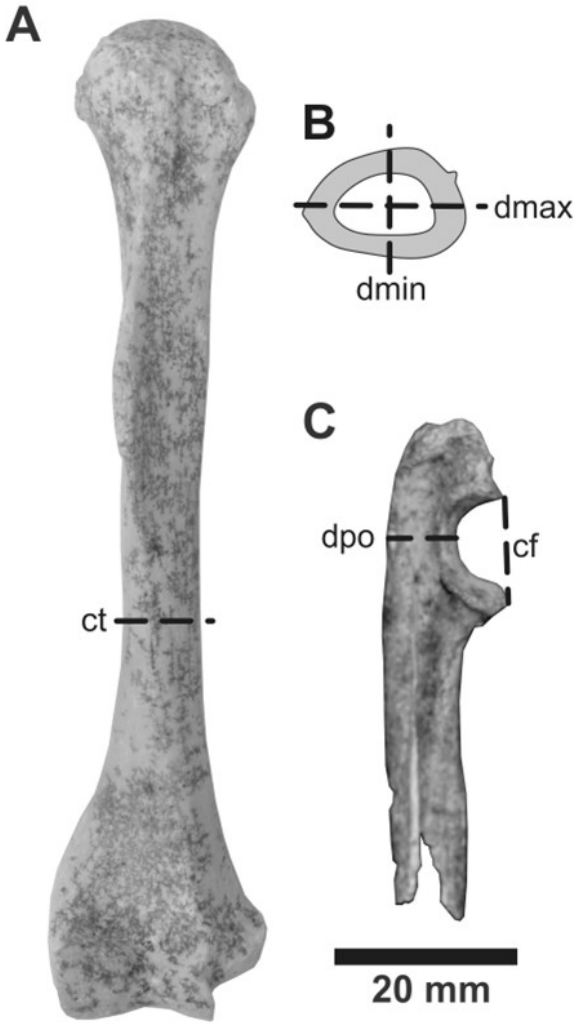

Figure 2 *Coendou magnus* bones. Cross-section (ct) of the right humerus (LEG 0333) in the minimum width of the diaphysis (A) and the maximum (d_{max}) and minimum (d_{min}) diameter (B). Right ulnae (LEG 0336), (C) dorsal extent of the olecranon process (dpo) and length of the trochlear notch (cf).

3 Results and Discussion

3.1 Paleoecological Habit of *Coendou Magnus*

The value found for *C. magnus* for I_{max}/I_{min} was 1.07, which was lower than those found for primates and xenarthrans, but in the range of *Coendou* spp. (White, 1993; Figure 3A; Table 1). This value is close to one, with an almost rounded cross-section, which is a strong indication that the animal was a suspensory mammal (Patel *et al.*, 2013).

The IDO value for *C. magnus* was 0.65, which falls within the expected interval for suspensory animals (Figure 3B; Table 1). Suspensory animals have small olecran and IDO values owing to the minimum need for forearm extension (Santos *et al.*, 2023).

Currently, there are sixteen species within the genus *Coendou*. Half of these species are found in Brazil, distributed across biomes such as the Amazon, the Atlantic Forest, the Pantanal, and forests in Caatinga and Cerrado (Voss *et al.*, 2013; Nascimento & Santos 2013). Regarding the Quaternary fossil record, we can mention *C. magnus*, a suspensory mammal species that inhabited forested environments (Alves-Silva *et al.*, 2023).

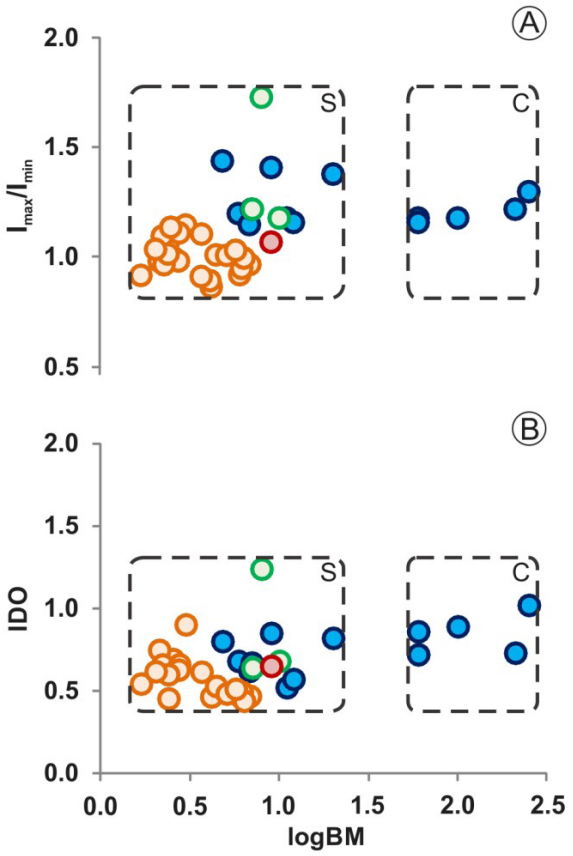

Figure 3 Bi-plot graph between log10 of body mass: A. Log10 of index of humeral cross-sectional shape (I_{max}/I_{min}); B. Log10 of index of dorsal olecranon projection (IDO). Labels: orange circles (*Coendou* spp.), red circle (*Coendou magnus*), blue circles (Primate taxa), and green circles (Xenarthra taxa). S: Suspensory; C: Climbers.

Table 1 Body mass and indices of humeral cross-sectional shape (I_{max}/I_{min}), dorsal olecranon projection (IDO), and ecologial habit for primates, xenarthrans, extant *Coendou* spp., and *Coendou magnus*. Labels: [1]Santos, McDonald & Dantas (2023, and references therein), [2]Results from this study. S: Suspensory; C: Climber.

Taxa	BM	logBM	I_{max}/I_{min}	IDO	Habit
Primate[1]					
Cebus apella	4.8	0.68	1.44	0.80	S
Hylobates lar	5.9	0.77	1.20	0.68	S
Alouatta palliata	6.8	0.83	1.15	0.62	S
Ateles fusciceps	7.0	0.85	1.22	0.67	S
Macaca fascicularis	9.0	0.95	1.41	0.85	S
Symphalangus syndactylus	11.0	1.04	1.18	0.52	S
Lagothrix lagotricha	12.0	1.08	1.16	0.57	S
Papio cynocephalus	20.0	1.30	1.38	0.82	S
Pan paniscus	60.0	1.78	1.18	0.72	C
Pan troglodytes	60.0	1.78	1.16	0.86	C
Pongo pygmaeus	100.0	2.00	1.18	0.89	C
Gorilla g. beringei	210.0	2.32	1.22	0.73	C
Gorilla g. gorilla	250.0	2.40	1.30	1.02	C
Xenarthra[1]					
Choloepus sp.	7.0	0.85	1.22	0.64	S
Bradypus sp.	10.0	1.00	1.18	0.68	S
Tamandua tetradactyla	8.0	0.90	1.73	1.24	S
Rodentia[2]					
Coendou magnus	9.0	0.95	1.07	0.65	S
Coendou prehensilis	5.2±1.1	0.71±0.09	0.96±0.06	0.48±0.03	S
Coendou spinosus	2.5±0.5	0.39±0.08	1.05±0.08	0.65±0.12	S
Coendou insidiosus	2.0	0.31	1.04	0.62	S

4 Final Remarks

Two biomechanical analyses of the humerus and ulna suggest a suspensory habit to the *Coendou magnus*, which was expected, as all extant species of the genus have the same ecological habit.

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Author contributions
Mário André Trindade Dantas: conceptualization; formal analysis; methodology; validation; writing-original draft; writing – review and editing; visualization. **João Paulo da Costa:** writing – review and editing.

Conflict of interest
The authors declare no conflict of interest.

Data availability statement
All data included in this study are publicly available in the literature.

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