

A Review of the Distribution, Morphometrics, and Habit of Owl's Spiny Rat *Carterodon sulcidens* (Lund, 1841) (Rodentia: Echimyidae)

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(Accepted April 7, 2011)

Alexandra M. R. Bezerra, Jader Marinho-Filho, and Ana Paula Carmignotto (2011) A review of the distribution, morphometrics, and habit of Owl's spiny rat *Carterodon sulcidens* (Lund, 1841) (Rodentia: Echimyidae). *Zoological Studies* 50(5): 566-576. The genus *Carterodon* Waterhouse, 1848 contains a single species, *C. sulcidens* (Lund, 1841), restricted to Neotropical savannas and known from a few sites in central Brazil, where it is endemic to the Cerrado biome. Current knowledge about this rare species comes from a handful of specimens deposited in scientific collections. The recent acquisition of additional samples prompted an assessment of the morphological variability in the species. Multivariate analyses of 25 craniodental measurements obtained from 27 whole specimens pooled into 3 geographic samples and representative of all available *Carterodon* specimens, revealed no morphometric structuring. Two new records were obtained from museum specimens. One extends the species' distribution southward to a new Brazilian state, but many *Carterodon* localities have lost their natural habitats. While natural history notes indicate no reproductive seasonality, more females than males were captured in both the wet and dry seasons. The species is a habitat specialist with a small litter size, a low reproductive rate, and a high risk of extinction due to habitat loss. <http://zoolstud.sinica.edu.tw/Journals/50.5/566.pdf>

Key words: *Carterodon*, Cerrado, Endemism, Morphometrics, Natural history.

The genus *Carterodon* Waterhouse 1848 contains a single species, *C. sulcidens* (Lund, 1841), known as Owl's spiny rat. The species is restricted to tropical savanna and grassland habitats of central Brazil, where it is endemic to the Cerrado biome (Carmignotto 2005, Machado et al. 2008). *Carterodon* is a rare, medium-sized, semifossorial rodent (Moojen 1952), and has conspicuous, grooved upper incisors (Bishop 1974), unique among extant echimids.

Data on the distribution, morphological variability, and natural history of this species are scarce and mostly originate from the few *Carterodon* specimens that were collected and deposited in scientific collections. The type locality of *C. sulcidens* is the Quaternary deposits from "Lagoa Santa", in the state of Minas Gerais, Brazil

(Lund 1841: 99), from which the species was originally described from fossil specimens. Current records are restricted to the Cerrado biome of central Brazil in the states of Goiás, Mato Grosso, and Minas Gerais, and in that country's Federal District, locally Distrito Federal (Bishop 1974, Carvalho 1999, Carmignotto 2005).

In the last few decades, an increase in taxonomic studies in the Cerrado revealed new records for several species (Carmignotto 2005, Bezerra et al. 2009). The recent acquisition of additional samples (Carmignotto 2005, this study) that extend the known geographical range of *C. sulcidens* prompted an evaluation of morphological variability in the genus. In order to better characterize the morphology of *C. sulcidens*, we present analyses of morphometric variability of

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craniodental characters and a description of some qualitative data from the hind- and forelimbs. We also report 2 new records of *C. sulcidens* and provide an overview of other information (e.g., habitat, habit, reproduction, and seasonality) gleaned from specimens housed in museums worldwide and from the published literature.

MATERIAL AND METHODS

Samples

Data on collecting localities, morphometrics, and ecology of *C. sulcidens* were obtained from specimens deposited in scientific collections, recently collected specimens, and from the scientific literature. These data are summarized in table 1, and the localities are mapped in figure 1. Specimens reported here are deposited in the following institutions: BMNH (Natural History Museum, London, UK), FMNH (The Field Museum of Natural History, Chicago, IL, USA), MN (National Museum, Univ. Federal do Rio de Janeiro, Rio de Janeiro, Brazil), MZUSP (Zoological Museum of the Univ. de São Paulo, São Paulo, Brazil), UNB (Mammal Collection of the Zoology Department, Univ. de Brasília, Distrito Federal, Brazil), ZMUC (Zoologisk Museum, Copenhagen, Denmark), and ZSM (Zoologische Staatssammlung München, Munich, Germany). Field numbers cited in the text belongs to APC (Ana Paula Carmignotto). The map was generated using ArcView GIS software, vers. 3.1 (1998).

Habitat

The description of habitat types follows Ribeiro and Walter (1998). Briefly, the Cerrado habitat types used here are as follows, in order of increasing tree cover: campo úmido, an open, wet grassland with no shrubs or arboreal cover; campo limpo, an open, dry grassland with no shrubs or arboreal cover; campo sujo, a grassland formation with scattered shrubs and small trees; campo cerrado, an open arboreal savanna with bushes and trees comprising up to 15% of the vegetation cover; cerrado sensu stricto, the classic Cerrado vegetation type, a dense arboreal savanna in which trees and shrubs mostly 3–8 m tall account for up to 40% of the cover; cerradão, a savanna in which trees up to 15 m tall account for up to 60% of the cover; and dry forest (i.e., semideciduous forest) where 50% of trees, on average, lose their

leaves in the dry season.

Morphometric analyses

Twenty-five craniodental measurements (Appendix I, Fig. 2) modified from Bezerra and Oliveira (2010) were taken using digital calipers (Mytutoyo, Tokyo, Japan) at a 0.01-mm resolution from each of 27 whole or almost-whole specimens. The 8 ontogenetic classes of specimens, modified from Bezerra and Oliveira (2010), were defined on the basis of upper-molar wear: the 1st 4 dental classes were considered 'juvenile' (M3 unerupted or unworn), while classes 5–8 were considered 'adult' (all upper molars erupted and functional).

For individuals that lacked up to 20% of the craniodental measurements, missing values were generated using the Expectation-Maximization method (Dempster et al. 1977), a maximum-likelihood procedure, using MatLab software, vers. 4.2 (MathWorks 1994).

Due to the small sample sizes from most localities, it was necessary to pool locality samples for the morphometric analysis. Samples were pooled based on geographic distance within the same morphoclimatic region (or ecoregion). Pooled samples are labeled as follows: specimens from Distrito Federal and Goiás State (DFGO), specimens from Minas Gerais State (MIGE), and specimens from Mato Grosso State (MTGR).

The entire matrix with original and estimated values was log-transformed prior to the statistical analysis. An exploratory principal component analysis (PCA) was performed on the covariance matrix of log-transformed craniodental measurements of all 27 specimens to investigate trends in skull shape evolution among populations without specifying a priori grouping but showing the centroids by pooled samples.

Values for the weight and 5 external measurements were taken from specimen labels. In some cases, which are specified, the head and body length (HBL) was obtained by subtracting the tail length (TL) from the total length.

RESULTS

Distribution

The 32 whole specimens (i.e., with skulls and/or skins) found in scientific collections are listed in table 1. A pair of new localities is reported here: Pedras, Bataguassu municipality (locality 3 in Fig.

Table 1. Summary of collecting localities and collection years for extant specimens, voucher specimens, and habitat information for *Carterodon sulcidens* based on label information, the scientific literature, and the present data. The number for each record corresponds to dots representing the localities in figure 1. s&s, skin and skull

Locality/Year	Collection and specimen no.	Habitat	Source of locality
▲ Type locality. Lagoa Santa, Minas Gerais State, Brazil; 1851 and 1854 19°38'S, 43°53'W	ZMUC s/n (fossil fragments) (types of <i>Echimys sulcidens</i>); ZMUC 73 (body in spirits), 403 (skull; skin and arms in spirits), 588 (skin prepared for exposition), 590 (skin), 591 (s&s); BMNH 88.1.9.9 (s&s; skin with the no. BMNH 87.1.9.9)	Pleistocene and Recent deposits (for the types) neighboring a mosaic of open savannas and dry forest vegetation, at ca. 760 m elevation	Lund 1841, Reinhardt 1851, Winge 1887
1. Fazenda Lapa Vermelha, Pedro Leopoldo, Minas Gerais, Brazil; 1970 19°37'S, 44°02'W	MN 24226 (mandible fragments), 24227 (skull), 24228 (mandible fragments)	Not available; today this locality is near a mosaic of open savanna and dry forest vegetation, at ca. 730 m elevation	Carmignotto 2005, this study
2. Grande Sertão Veredas National Park, Formoso, Minas Gerais, Brazil; 2001 15°16'S, 45°52'W	APC 784 (s&s) (un-catalogued MZUSP specimen)	Campo limpo, ca. 780 m elevation	Carmignotto 2005
3. Pedra am Rio Pardo, Pedras, Bataguassu, Mato Grosso do Sul, Brazil; 1938 21°44'S, 52°59'W	FMNH 98092 (the anterior number ZSM 1938/172) (skin only, skull lost)	Cerradão as referred by Krieg (1948), collector of the specimen; 408 m elevation	This study
4. Brasília, Distrito Federal, Brazil; 1960 15°47'S, 47°56'W	MN 22235 (s&s), 22238 (s&s)	Not available; today Brasília is bordered by several savanna habitats such as cerrado sensu stricto, campo úmido, campo limpo, campo sujo, and cerradão; ca. 1130 m elevation	Carvalho 1999, Carmignotto 2005, this study
5. AHE Serra da Mesa, Minaçu, Goiás, Brazil; 1997 13°53'S, 48°19'W	MN 54368 (skull and post-cranium)	Campo úmido; 450 m elevation	Salles et al. 1999, Carvalho 1999, Carmignotto 2005
6. Serra de Caldas Novas State Park, Caldas Novas, Goiás, Brazil; 2003 17°47'S, 48°40'W	UNB 2716 (s&s)	Cerrado sensu stricto; ca. 1000 m elevation	This study
7. Serra das Araras Ecological Station, Porto Estrela, Mato Grosso, Brazil; 2002 15°39'S, 57°12'W	APC 1070 (s&s), 1082 (s&s), 1100 (s&s) (un-catalogued MZUSP specimens)	Campo limpo and campo cerrado; ca. 230 m elevation	Carmignotto 2005
8. APM Manso, Chapada do Guimarães, Mato Grosso, Brazil; 1989 and 2000 14°52'S, 55°48'W	UNB 0888 (s&s), 1663 (s&s)	Cerrado sensu stricto and campo sujo, ca. 258 m elevation	Carmignotto 2005, this study
9. Expedition Base Camp/ Campo near Base Camp/ Cerrado near Base Camp/all sites 260 km N of Xavantina, Serra do Roncador, Ribeirão Cascalheira, Mato Grosso, Brazil; 1968 ca.12°51'S, 51°46'W	BMNH 79.212 (s&s); 79.213 (skull), 79.214 (skull), 79.216 (s&s), 79.217 (s&s), 79.218 (s&s), 79.219 (s&s), 79.220 (s&s), 79.221 (s&s), 79.222 (s&s); MN 24230 (s&s)	Cerrado and campo are written on some specimen labels; the region of study of the Xavantina-Expedition (Bishop 1974), at ca. 386 m elevation	Bishop 1974, this study
10. Caiê-Malú, Chapada dos Parecis, Mato Grosso, Brazil; 1909 11°20'S, 59°00'W	MN 1946 (s&s)	Dry grasslands (= open grasslands), at ca. 460 m elevation	Miranda-Ribeiro 1914, Carvalho 1999, Carmignotto 2005

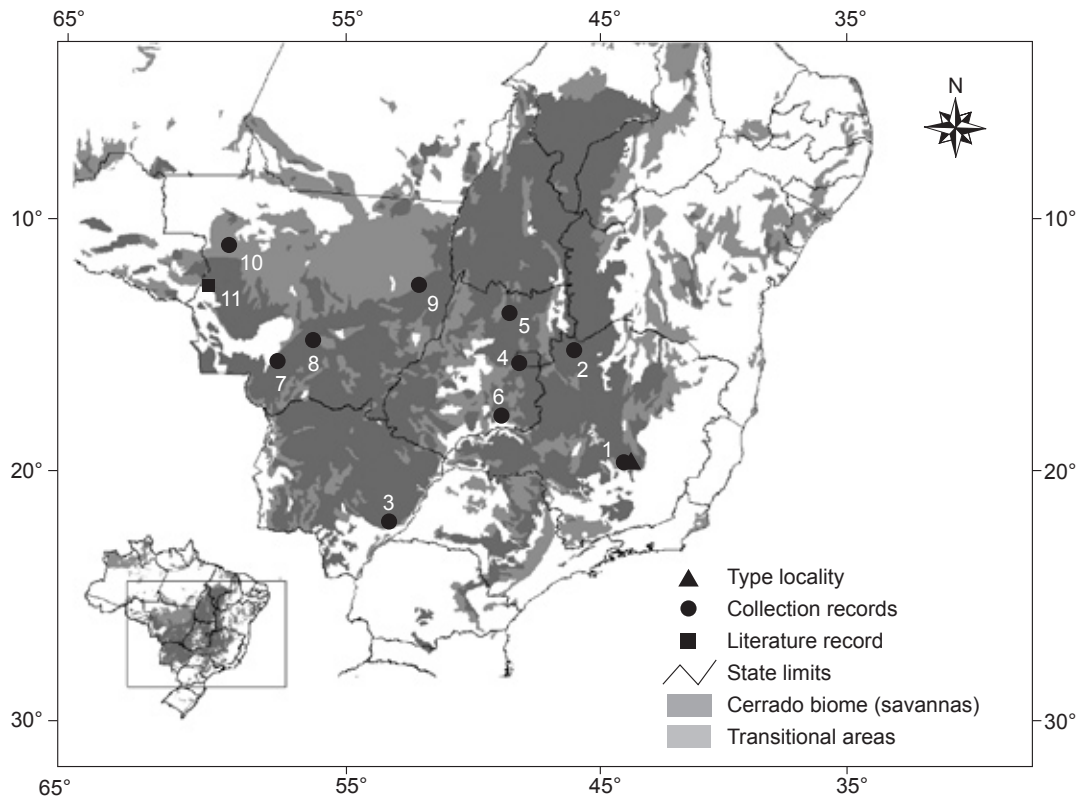


Fig. 1. Map of collecting localities of the Brazilian endemic *Carterodon sulcidens*: ▲, type locality – Lagoa Santa, Minas Gerais State; 1, Fazenda Lapa Vermelha, Pedro Leopoldo, Minas Gerais State; 2, Grande Sertão Veredas National Park, Formoso, Minas Gerais State; 3, Pedra am Rio Pardo, Pedras, Bataguassu, Mato Grosso do Sul State; 4, Brasília, Distrito Federal; 5, AHE Serra da Mesa, Minaçu, Goiás State; 6, Serra de Caldas Novas State Park, Caldas Novas, Goiás State; 7, Serra das Araras Ecological Station, Porto Estrela, Mato Grosso State; 8, APM Manso, Chapada do Guimarães, Mato Grosso State; 9, Expedition Base Camp, 260 km north of Xavantina, Serra do Roncador, Ribeirão Cascalheira, Mato Grosso State; 10, Caiê-Malú, Chapada dos Parecis, Mato Grosso State; 11, Campos Novos, Serra do Norte, Mato Grosso State.

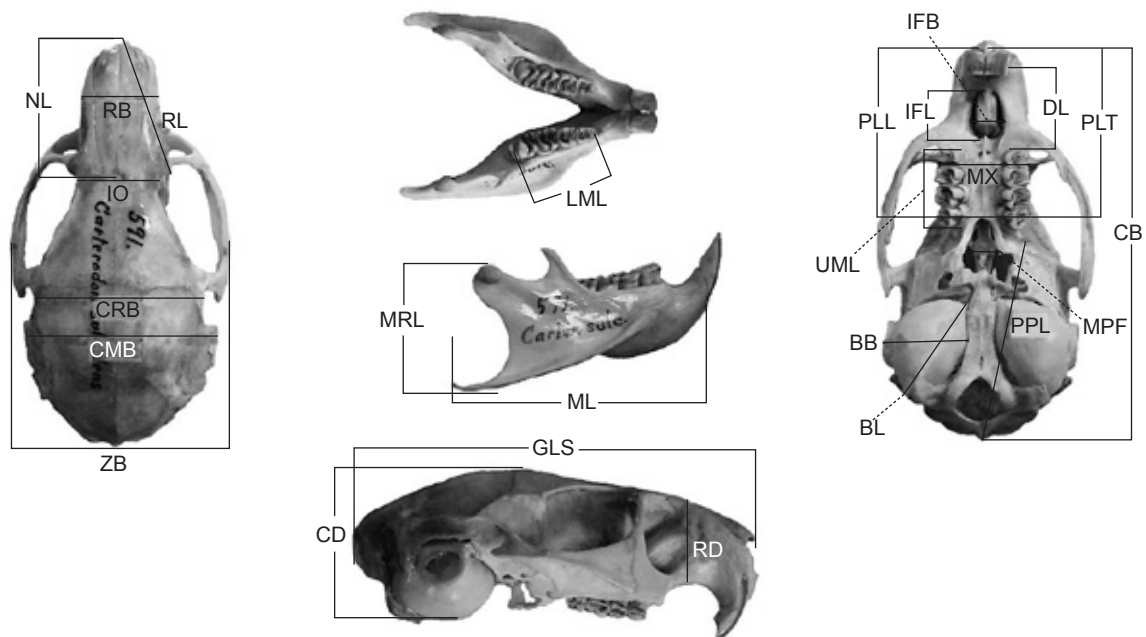


Fig. 2. Craniodental measurements of *Carterodon sulcidens* used in the morphometric analysis as described in Appendix I.

1) and Serra de Caldas Novas State Park (locality 6). The latter extends the previously known distributional range of the species (Carmignotto 2005, Woods and Kilpatrick 2005). Habitat descriptions from these new localities are provided below.

1) Pedras, within and around the town of Bataguassu (locality 3), is an agricultural area in a savanna located in southern Mato Grosso do Sul State (IBGE 2004). The scarce remnants of savanna vegetation are mostly campo sujo and cerrado sensu stricto, as well as contact zones of "cerrado sensu stricto" with semideciduous forest (Prefeitura de Bataguassu 2005).

The specimen (Fig. 3) from this locality was collected during the 1938 Zwischen Anden und Atlantik expedition (Krieg 1948) and deposited in the Field Museum (FMNH: Chicago, IL, USA). The locality and town were inferred from the map and text in Krieg (1948). This new locality is the 1st record of *C. sulcidens* for the state of Mato Grosso do Sul and extends the known austral limit of the species distribution by ~628 km (Fig. 1). Krieg (1948) noted various types of Cerrado vegetation in Pedras, Mato Grosso do Sul State, such as open grassland, shrubby vegetation, and cerradão, but he did not specify the vegetation type in which

the specimen was captured.

2) The Serra de Caldas Novas State Park (locality 6), located within and around the towns of Caldas Novas and Rio Quente, is a 125-km² protected area located in the Serra de Caldas Novas Mountains in Goiás State, central Brazil. The vegetation is typical of the Cerrado biome, with a mosaic of gallery forests, semideciduous forests, cerrado sensu stricto, cerradão, and open grasslands (Santos 2003). The specimen from this locality was collected in the cerrado sensu stricto with aid of a "Young" live trap type which was 41 × 13 × 13 cm.

Natural history

Of the 32 specimens with a collection date, 18 were captured during the dry season (May-Sept.): in Distrito Federal, the collections were made in June (1 specimen) and July (1); in Goiás State, in Aug. (1); in Mato Grosso, in June (1), Aug. (3), and Sept. (3); in Mato Grosso do Sul, in June (1); and in Minas Gerais, in May (4) and July (3). Fourteen specimens were captured during the rainy season (Oct.-Apr.). In Goiás, the collection was made in Dec. (1); in Mato Grosso, in Jan. (1), Feb. (1), Oct. (4), Nov. (2), and Dec. (3); and in Minas Gerais, in



Fig. 3. Spirit-preserved skin of *Carterodon sulcidens* (FMNH 98092) from the state of Mato Grosso do Sul. (A) Lateral view of head and foremost 1/3 of the body; (B) the short, densely-covered tail in detail. Scale bar = 1 cm.

Oct. (1) and Dec. (1).

Two pregnant females were captured at Serra do Roncador (locality 9), Mato Grosso State. One was collected during the dry season (Aug.) and had a single fetus weighing 16 g, while the other was collected in the wet season (Dec.) and had 2 embryos weighing 12 g each (Bishop 1974). This author also collected juveniles in both dry (1 juvenile in Aug. and 2 in Sept.) and wet seasons (1 in Oct., 2 in Nov., and 1 in Dec.). At Chapada dos Guimarães (locality 8), also in Mato Grosso State, 1 pregnant female with 2 fetuses was collected in the wet season (Jan.; this study, label data from a museum specimen). At the Serra das Araras Ecological Station (locality 7), we captured 2 pregnant females (1 female with 2 embryos and the other with 1 embryo) and 1 juvenile in the early wet season (Oct.). At Lagoa Santa, Minas Gerais State, Reinhardt (this study, label data from museum specimens) captured 3 juveniles in the dry season (July). At Grande Sertão Veredas National Park (locality 2), we captured 1 juvenile in the early wet season (Oct.). In Distrito Federal (locality 4), 2 juveniles were captured during the dry season (June and July; this study, label data from museum specimens).

Recent collections of *C. sulcidens* (at localities 2, 5, 6, and 7) were made with 3 types of live traps: Young, Tomahawk (Tomahawk, WI, USA) (both measuring about 41 × 13 × 13 cm), and Sherman (23 × 9 × 8 cm) (Tallahassee, FL, USAI).

Morphology

External and craniodental measurements of 27 specimens are shown in table 2. The previously known ranges of size and weight for the species were extended (Reinhardt 1851, Bishop 1974). The 1st 2 principal component functions accounted for 87.82% of the total variance; projections of the scores are depicted in figure 4. All coefficients extracted from the 1st principal component functions showed high positive values (Table 3), indicating mainly size-latent variation. No grouping was revealed with respect to the 3 pooled samples analyzed. Due to the very small number of specimens in each pooled sample, a size-free canonical discriminant analysis, which permits the inclusion of juvenile specimens (see Reis et al. 1990), could not be performed as the matrix was close to being singular.

DISCUSSION

C. sulcidens is a rare species. Only 32 whole specimens are known to exist in scientific collections, and these are from 11 localities in 4 Brazilian states and that country's Federal District. Lund's original specimens were fossil fragments obtained from Quaternary cave deposits from Lagoa Santa in Minas Gerais State. The locality "Lagoa Santa" as referred to by Lund (1841) was split in 3 municipalities in 1938: Lagoa Santa,

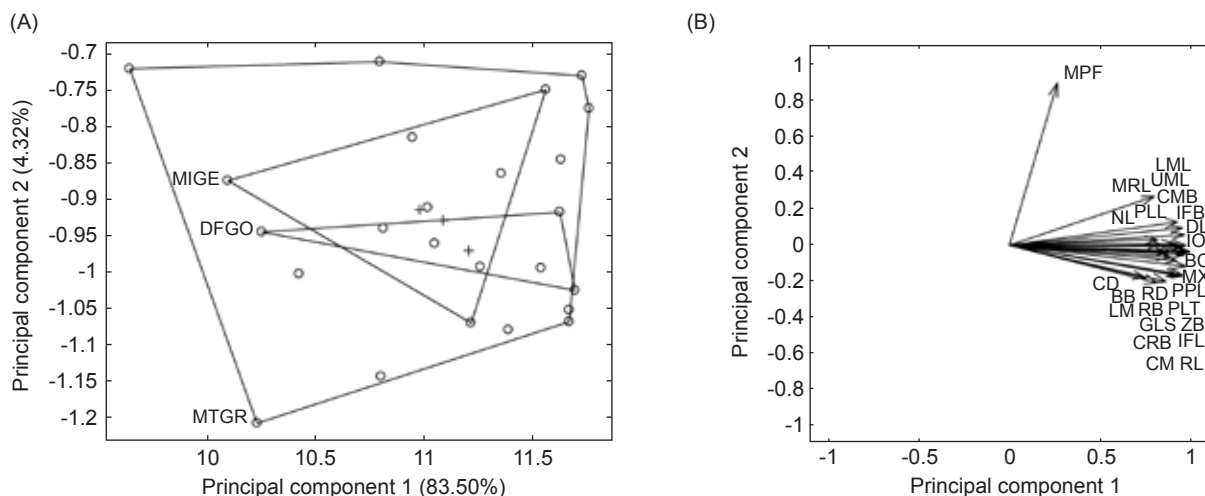


Fig. 4. Results of the principal component (PC) analysis. (A) Scatterplot of the scores for the 1st 2 PC functions extracted from the covariance matrix of log-transformed craniodental measurements of *Carterodon sulcidens* pooled samples; (B) correlation vectors between the original characters and the 1st 2 PC functions (only magnitudes > |0.3| are labeled). Pooled groups are described in "MATERIAL AND METHODS". Character abbreviations as given in Appendix I.

Pedro Leopoldo, and Santa Luzia (IBGE 2009). Therefore, it is not possible to determine exactly where the type locality is.

The 1st non-fossil specimens were collected by Reinhardt (1851) and are labeled as from “the open Pampas” habitat. Since the Pampas occur in southern Brazil, a climatic region that is colder and wetter than the Cerrado biome and where there is no record of *C. sulcidens*, this description is probably an error of interpretation. In fact, all specimens collected by Reinhardt were from Lagoa Santa, Minas Gerais State (specimens deposited

in the Copenhagen Museum and in the Natural History Museum). All subsequent specimens were collected in open areas of the Cerrado biome, reinforcing the strict habitat preferences of this species. The habitat ‘campo’ appears on the labels of 6 specimens captured by I. Bishop and deposited in the BMNH with the numbers BMNH 79.216-79.220 and 79.223, but it is not clear whether this corresponds to campo limpo, campo sujo, or campo úmido. Moreover, Bishop’s (1974) discussion about the specimens captured in ‘campo’ describes “stands of grasses and sedges

Table 2. External and craniodental measurements (in mm) for 27 *C. sulcidens* specimens deposited in scientific collections. Separate values are given for adults (A) (11 specimens) and juveniles (B) (16 specimens), and by locality (see Table 1). Dental classes are as described in “MATERIAL AND METHODS”. Weight (WG) is in grams. Asterisks (*) indicates values estimated by the Expectation-Maximization method. F, female; M, male

(A)

Locality	Type locality	5	7	8		9				10	
Voucher	ZMUC	MN	APC	UNB		BMNH				MN	MN
	591	54368	1070	0888	1663	79.212	79.213	79.216	79.218	24230	1946
Dental class	6	6	6	7	6	5	7	5	6	5	8
Sex	F	F	F	F	M	M	F	F	M	F	M
WG	-	158	160	195	92	60	-	179	202	158	-
HBL	-	180	178 ¹	250	135	180	-	180	185	180	-
TL	-	87	89	75	-	45	-	88	45	87	-
HF	-	-	25	-	-	25	-	28	30	29	-
HFC	-	29	29	30	27	-	-	-	-	-	40
IE	-	16	17	17	10	15	-	-	-	16	-
BB	8.41	8.11	8.83	10.91	7.32	7.98	8.12	8.59	8.64	8.23	9.4
BL	10.70	10.93	11.04	11.13	10.83	11.02	11.19	11.17	11.5	10.72	11.62
CB	37.68	39.34	38.13	38.36	36.95	37.12	37.74	36.32	38.29	37.54	38.94
CD	14.07	14.99	14.74	16.09	14.61	13.96	16.64	-	15.64	14.36	15.18
CMB	19.68	19.22	18.38	20.52	18.09	17.75	19.30	-	18.86	18.15	20.26*
CRB	17.48	17.76	17.15	18.10	16.99	17.56	17.98	-	17.96	17.59	17.65
DL	7.64	8.32	8.23	8.46	7.69	7.66	8.19	7.02	7.69	7.35	7.96
GLS	41.53	43.16	42.49	42.80	40.93	41.06	42.33	-	43.38	40.56	44.19
IFB	3.80	3.51	3.69	3.71	3.29	3.50	4.35	3.58	3.63	3.77	4.38
IFL	5.29	5.96	5.37	5.43	5.32	5.34	5.68	5.61	5.93	6.04	5.79
IO	8.38	8.67	8.73	9.15	8.27	8.35	9.05	8.10	8.85	8.58	8.95
LML	9.06	8.73	8.62	7.86	8.34	8.09	9.12	9.24	8.67	8.90	8.10
ML	23.08	23.89	23.18	23.27	21.84	22.23	23.44	-	23.96	22.76	24.57
MPF	3.52	2.72	3.15	2.79*	3.00*	2.43	3.68	-	2.59*	2.63	3.83*
MRL	11.50	11.12	11.69	11.27	11.41	10.03	11.09	-	11.52	11.62	11.97
MX	8.93	9.28	8.62	9.12	8.41	8.37	8.55	8.92	8.69	9.02	9.16
NL	14.08	15.34	16.31	14.74	13.09*	14.12	15.75	13.56	15.43	14.09	15.00
PLL	17.05	17.44	17.34	19.91	18.20	16.45	18.77	16.57	17.40	17.35	19.07
PLT	14.27	14.73	15.01	15.58	13.57	13.62	15.90	13.95	14.61	14.27	16.01
PPL	20.87	21.63	20.43	21.20	20.12	20.32	20.25	-	22.01	20.96	21.47
RB	8.12	8.63	7.51	7.71	7.51	7.33	8.29	7.87	7.81	7.78	8.40
RD	8.13	9.09	7.89	7.69	8.50	8.33	8.24	8.00	8.78	8.23	8.94
RL	14.29	15.35	15.79	15.09	12.49	14.42	15.22	14.13	15.50	13.03	15.19
UML	7.93	8.18	8.19	7.59	7.45	8.11	7.93	8.11	7.92	8.21	7.39
ZB	22.65	22.93	21.86	23.47	21.87	21.23*	22.29	-	23.65	22.91	22.95*

free from or with only sparse tree cover; usually found where soil tends to saturate during wet season". This definition seems to correspond to areas classified in this study as campo úmido.

The scientific literature also reports *C. sulcidens* from Campos Novos, Serra do Norte, Chapada do Parecis, in western Mato Grosso State (Bishop 1974), but there is no voucher material associated with the record. Salles et al. (1999) recorded additional fossil remains from Quaternary deposits in Igrejinha cavern in the Serra da Mesa region of Goiás State (locality 5).

All locality records are from the Cerrado biome, and most of the localities are impacted by agriculture and grazing. Therefore, *C. sulcidens*

may be restricted to remnant fragments of open habitats. The Cerrado biome co-occurs with Amazonian forest at Chapada dos Parecis (locality 10) and Serra do Roncador (locality 9), and co-occurs with Atlantic forest at Lagoa Santa (type locality; indicated by a black triangle, ▲, on the map) and Bataguassu (locality 3). This implies reduced habitat availability for the species in these regions of the Cerrado, and perhaps distributional range limits.

C. sulcidens is known to have a strict herbivorous diet, considering the few direct observations (Reinhardt 1851, this study) and the morphology of the incisors and molars. It is possible that the traditional use of a complex bait (a

Table 2. (continued)

(B)

Locality	Type locality		1	2	4	6	7	9									
Voucher	ZMUC	BMNH	MN	APC	MN		UNB	APC		BMNH							
	403	88.1.9.9	24227	784	22235	22238	2716	1082	1100	79.214	79.217	79.219	79.220	79.221	79.222	79.223	
Dental class	1	3	4	3	3	1	4	2	2	2	2	1	2	1	1	1	
Sex	F	-	-	F	F	M	M	F	F	F	F	M	F	M	F	M	
WG	-	-	-	115	-	-	150	75	105	-	110	65	86	65	60	20	
HBL	-	-	-	160	-	-	1771	1301	1461	-	130	120	140	120	70	70	
TL	-	-	-	81	-	-	92	69	70	-	77	-	-	65	65	75	
HF	-	26	-	28.5	-	-	28	24	28	-	27	24	27	24	24	25	
HFC	-	-	-	31	-	-	32	26	31	-	-	-	-	-	-	-	
IE	-	14	-	17.5	-	-	17	15	16	-	15	12	17	13	22	11	
BB	7.23	8.41	8.57	8.13	8.04	6.49	8.58	7.38	7.60	7.86	7.98	6.96	7.76	7.53	5.82	5.98	
BL	8.82	10.68	11.15	10.69	10.12	8.85	10.46	10.54	10.31	10.07	10.48	9.56	10.71	9.27	8.62	8.84	
CB	28.00	35.58	36.91	34.84	36.31	30.08	38.92	31.57	32.88	33.29	31.76	30.13	32.13	28.56	23.56	25.66	
CD	13.39	14.19	-	13.49	14.14	12.82	14.60	13.12	13.40	13.87*	15.03	13.55	14.14	14.12	16.13	12.77	
CMB	15.57	19.14	-	17.53	17.43	15.54	20.04	15.49	16.67	17.07	17.16	16.42	16.48	16.45	14.96	15.57	
CRB	15.88	16.98	-	16.51	16.95	15.56	17.96	15.70	16.81	16.43	16.74	16.08	15.92	15.81	15.22	15.60	
DL	5.32	7.30	7.75	7.11	7.32	5.84	7.93	7.09	7.32	7.19	6.39	6.34	6.88	5.67	4.93	5.06	
GLS	31.79	38.90	41.15	38.88	40.28	33.31	42.68	35.50	37.04	37.17	35.70	34.55	36.34	32.65	26.47	28.35	
IFB	2.97	3.57	3.41	3.19	3.57	2.95	3.55	3.40	3.33	3.33	3.33	3.41	3.21	3.39	-	2.44	
IFL	3.51	4.51	5.11	5.24	4.89	4.13	5.55	4.45	4.84	4.99	4.25	4.89	4.81	3.73	-	3.34	
IO	7.15	8.67	-	7.86	8.13	7.65	8.93	7.94	7.58	8.09	7.97	7.76	7.75	7.70	8.15	8.08	
LML	5.18	7.45	-	7.45	7.01	5.09	8.84	7.66	7.31	7.56	7.45	4.81	7.29	4.56	3.48	4.41	
ML	17.14	21.94	-	21.29	22.42	17.68	23.73	18.85	20.10	20.06	19.40	18.54	19.44	18.00	-	13.44	
MPF	3.07	2.54	-	2.71	2.78*	2.81*	3.00	3.2	3.07	2.91	2.28	2.77	2.86	2.31	-	-	
MRL	8.08	10.48	-	10.00	10.71	8.18	11.16	9.54	9.71	9.07	8.93	8.84	9.24	8.21	-	-	
MX	6.80	8.18	8.33	7.24	8.79	7.01	8.31	6.92	7.56	7.30	7.84	7.17	7.53	6.93	-	5.61	
NL	9.98	13.92	-	12.82	14.17	11.17	14.98	12.02	12.43	12.99	11.34	10.48	11.47	10.73	6.58	7.87	
PLL	12.52	16.58	17.81	15.65	16.98	13.36	17.46	14.25	14.89	15.06	14.14	13.25	14.08	13.20	-	10.53	
PLT	10.45	13.51	15.15	13.41	14.21	11.37	15.21	12.33	12.37	12.58	11.64	10.87	11.94	11.26	-	8.76	
PPL	17.56	19.41	22.54	20.17	20.79	17.57	21.78	17.62	19.96	19.85	19.21	17.84	19.14	17.94	14.92	15.83	
RB	6.40	7.48	7.88	6.55	7.89	6.63	7.73	6.52	6.77	7.10	7.23	7.02	6.78	6.65	6.10	6.22	
RD	6.12	7.75	-	7.09	7.35	6.04	8.37	6.27	6.59	7.83	7.55	6.93	8.10	7.00	5.24	5.85	
RL	9.94	13.73	-	13.07	13.64	10.73	15.08	12.20	12.72	12.46	11.53	11.27	11.57	10.88	9.07	9.46	
UML	4.78	6.62	8.45	6.28	7.01	4.69	7.94	6.44	6.71	6.83	6.08	4.91	5.64	4.52	3.48	4.61	
ZB	18.36	22.21	-	20.09	21.72	18.38	23.34	18.93	19.80	20.10	20.63	19.04	19.48	18.49	15.53	15.90	

*Head and body length (HBL) was obtained by subtracting the tail length (TL) from total length. Variables are defined in Appendix I.

mixture of peanut butter, sardines, bananas, and corn flour), which is attractive to a broad range of species, may have been less efficient at capturing diet specialists (Bressiani and Graipel 2008, Galliez et al. 2009).

Although the specimens that we examined were collected with a variety of live trap methods, the tendency is towards a similar number of captures in both dry and rainy seasons. The scarce available data on reproduction do not indicate any patterns of reproductive seasonality. Year-round breeding was recorded for other species of this subfamily, such as *Clyomys laticeps* (Bishop 1974), suggesting that reproduction is not restricted to the wet season. While water availability in the Cerrado varies greatly during the year, grass may be available year-round.

This monotypic genus is listed as 'data deficient' by the IUCN (Reis and Lacher 2008) due to the absence of recent information concerning its extant range, conservation status, and ecological requirements. However, almost all existing records

Table 3. Correlation coefficients between the original variables and the 1st 2 principal component (PC) scores

Variable	PC 1	PC 2
BL	0.9087	0.0039
BB	0.8121	-0.2087
CB	0.9901	-0.0360
CD	0.7499	-0.1851
CMB	0.8848	-0.0658
CRB	0.9173	-0.0880
DL	0.9653	0.0541
GLS	0.9909	-0.0426
IFB	0.8326	0.0031
IFL	0.9252	-0.0039
IO	0.8147	0.0276
LML	0.9257	0.1290
ML	0.9746	-0.1204
MPF	0.2609	0.8909
MRL	0.8005	0.2673
MX	0.9348	-0.1691
NL	0.9671	-0.0571
PLL	0.9668	-0.0349
PLT	0.9739	-0.0036
PPL	0.9433	-0.1615
RB	0.8735	-0.0410
RD	0.8616	-0.2010
RL	0.9594	-0.0066
UML	0.9540	0.0907
ZB	0.9602	-0.1706

Variables are defined in Appendix I.

of *C. sulcidens* come from localities that are today highly impacted by cropland, pastures, urban development, or hydroelectric dams. The species is known from just 3 protected areas: the Grande Sertão Veredas National Park (locality 2), the Serra de Caldas Novas State Park (locality 6), and the Serra das Araras Ecological Station (locality 7). Moreover, decades of ongoing research on small non-volant mammals in Brazil have resulted in very few records of *C. sulcidens*. These data, together with both habitat and diet specificities and considering the small litter size and the intense parental care shared with other echimid rodents, suggest that this species should be considered at least 'vulnerable' in the *IUCN Red List*, based on an estimated extent of occurrence of < 20,000 km², a severely fragmented geographic range, and a current presence at no more than 10 localities.

Acknowledgments: We thank the following curators and collection managers for their helpfulness and hospitality in the museums we visited: P. Jenkins, L. Tomsett, and R. Portela Miguez (BMNH), B. Patterson (FMNH), J.A. de Oliveira and S. Franco (MN), M. de Vivo (MZUSP), and M. Andersen (ZMUC). We are grateful to R. Kraft (ZSM) for valuable information about Krieg's 1938 expedition and to B. Patterson for photos of the FMNH specimen. Two anonymous reviewers pointed out several improvements that were needed in previous versions of the manuscript. AMRB was supported by a postdoctoral fellowship from CNPq (150599/2008-0) and 2 grants for museum visits from Conservation International-Brazil (Pcog/esp/02/2008 and Pcog/esp/03/2008). JMF was supported by a research fellowship from CNPq (305415/2007-7). APC received a master's fellowship from CNPq and financial support from FURNAS, FAPESP (00/06642-4-doctoral fellowship), BIOTA FAPESP (98-05075-7), and WWF-Brasil (CSR 203-2001).

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Appendix I. External and craniodental measurements used in this study

WG, weight in grams
HBL, head and body length
TL, tail length
HF, hindfoot length
HFC, hindfoot length with claw
IE, internal ear length, from notch
BB, greatest breadth of the tympanic bulla
BL, greatest length of the tympanic bulla
CB, condylobasal length
CD, cranial depth at the tympanic bulla
CMB, cranial breadth at the external auditory meatus
CRB, cranial breadth immediately posterior to the zygomatic arches
DL, diastema length
GLS, greatest length of the skull
IFB, incisive foramina breadth
IFL, incisive foramina length
IO, interorbital constriction
LML, length of the lower molar row
ML, mandible length
MPF, mesopterygoid fossa breadth
MRL, mandibular ramus length
MX, palatal breadth measured at dP4-M1
NL, nasal length
PLL, palatal length
PLT, palatilar length
PPL, postpalatal length
RB, rostral breadth
RD, rostral depth
RL, rostral length
UML, upper molar row length
ZB, greatest zygomatic arch breadth
