



## Nota

## CHROMOSOMAL DIFFERENTIATION IN *Kerodon rupestris* (RODENTIA: CAVIIDAE) FROM THE BRAZILIAN SEMI-ARID REGION

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**ABSTRACT.** *Kerodon rupestris* (Wied, 1820) is the most specialized species among caviid rodents and is endemic to the extensive rocky outcrops in the semi-arid region in Brazil. Herein we describe different karyotypes for *K. rupestris*, based on samples collected in Itapajé, Ceará (CE), Iraquara in Bahia (BA), and Botumirim in Minas Gerais (MG). Our samples included northern, center and southern populations in the range of the species distribution. The results were compared with a karyotype from Pernambuco previously described for the species. The diploid number ( $2n=52$ ) was constant among the analyzed population samples, but the fundamental number (FN) varied from 92 in Itapajé (CE) and Iraquara (BA), to 94 in Botumirim (MG). Pericentric inversions affecting one small pair of acrocentric chromosomes may explain this variation. C-Bands showed that constitutive heterochromatin was distributed in the pericentromeric region of all chromosomes, constant for all examined populations. NOR sites were found in chromosomes pairs 10 and 11, constant for all populations. X chromosome was entirely heterochromatic, with greater heterochromatin concentration in interstitial and distal parts of the arms. Y chromosome was completely heterochromatic. Differences in chromosomal composition in Botumirim sample are congruent with the results of previous studies about cranial variability: Botumirim had the largest cranial size and was discriminated from other population samples in the multivariate character space. Since Botumirim is only 100 Km away from the type locality, it is proposed—in congruence with previously published results—that the FN for the species is polytypic (94/92).

**RESUMO.** Diferenciação cromossômica em *Kerodon rupestris* (Rodentia: Caviidae) da região semiárida brasileira. *Kerodon rupestris* (Wied, 1820) é a espécie mais especialista entre os roedores caviídeos endêmica dos afloramentos rochosos da região semiárida do Brasil, a Caatinga. No presente trabalho foram descritos diferentes cariótipos para *K. rupestris*, baseado em amostras coletadas em Itapajé, Ceará (CE), Iraquara na Bahia (BA) e Botumirim em Minas Gerais (MG). As amostras incluem populações do norte, centro e sul da distribuição da espécie. Os resultados foram comparados com um cariótipo de Pernambuco, previamente descrito para a espécie. O número diploide ( $2n=52$ ) foi constante para as populações analisadas, mas o número fundamental (FN) variou de 92 em Itapajé (CE) e Iraquara (BA), para 94 em Botumirim (MG). Inversões pericêntricas afetando um pequeno par de cromossomos acrocêntricos podem explicar essa variação. Bandas C mostraram que a heterocromatina constitutiva estava distribuída na região pericentromérica de todos os cromossomos, constante para todas as amostras estudadas. Sítios de NOR foram encontrados nos pares de cromossomos 10 e 11, também constantes para todas as populações. O cromossomo X é inteiramente heterocromático, com grande concentração de heterocromatina nas porções intersticial e distal dos braços. Diferenças na composição cromossômica nas amostras de Botumirim são congruentes com os resultados prévios sobre a variabilidade cranial: os indivíduos de Botumirim apresentaram tamanho cranial maior do que os de outras populações no espaço de caracteres multivariados.

Uma vez que Botumirim está a apenas 100 Km de distância da localidade-tipo, propõe-se —de acordo com os resultados publicados previamente— que o FN para a espécie seja classificado como politípico (94/92).

**Key words:** C-Bands. Cytogenetics. *Kerodon rupestris*. NOR.

**Palavras-chave:** Bandas C. Citogenética. *Kerodon rupestris*. NOR.

*Kerodon rupestris* (Wied, 1820) is the most specialized species among caviid rodents and it is considered endemic to the extensive rocky outcrops that occur in the Caatinga semi-arid region in Brazil, from Piauí State to northern Minas Gerais State (Lacher, 1979, 1981; Alho, 1982; Mares and Ojeda, 1982; Oliveira et al., 2003; Lessa and Pessoa, 2005). Despite its wide distribution and habitat specialization, little effort has been made to examine karyological variation in this species (Maia and Hulak, 1978; Maia, 1984).

Maia (1984) analyzed karyological variation in the three genera of Brazilian caviids, *Cavia* (Pallas, 1766) *Galea* (Meyen, 1833) and *Kerodon* (Cuvier, 1825), and showed that 80% of their chromosomal complement was composed of biarmed chromosomes and considerable karyological symmetry occurred in the genera. In the same study she gave the diploid and fundamental numbers for *K. rupestris* from Pernambuco as  $2n = 52$  and  $FN = 92$ . C-band results showed that all constitutive heterochromatin was confined to the X chromosome, differing from the pattern observed in *Cavia* and *Galea*. No study focusing on karyological variability in *K. rupestris* has been published since then.

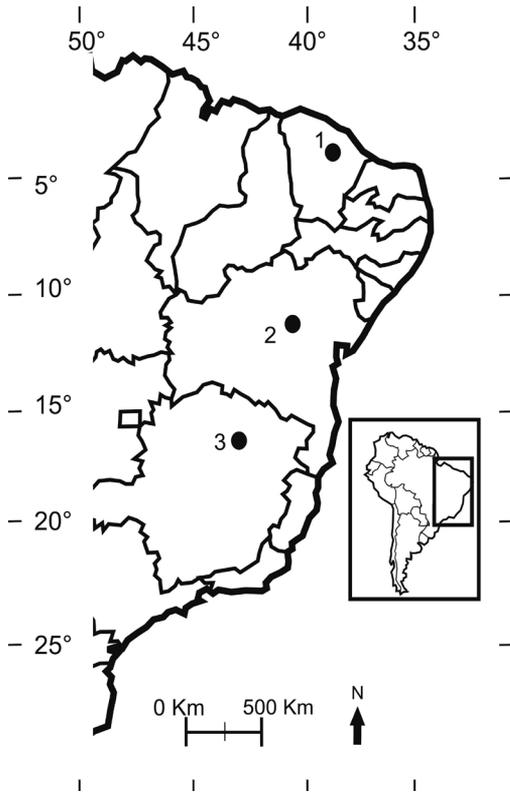
Lessa et al. (2005), studying morphometric characters in *K. rupestris*, found a clinal increase in cranial size from north to south. The population from Botumirim was completely discriminated in morphometric multivariate space from the other population in the northeastern part of the species range. These authors also suggested that this cranial variation pattern was associated with the distribution of rocky outcrops. Moojen et al. (1997) suggested this association when describing *Kerodon acrobata*, a new species within this genus.

Central to the understanding of variability in *K. rupestris* is the inclusion of samples from throughout its range and from places as near as possible to the type locality of the species. The aim of this study is therefore to describe karyological variation in samples from the northern, central and southern parts of the species range, the last area being within 100km of the type locality, and to compare it with information previously described for a population sample from Pernambuco. A further objective was then to test whether karyological variation corroborated the found morphometric cranial pattern for the species.

We karyotyped one specimen of *K. rupestris* collected in Itapajé (CE) (03°41'S - 39°34'W), Ceará State (CE) in November 2003. A second karyotyped sample consisted of two specimens collected in Iraquara (BA), (12° 15'S - 41°36'W), in April 2004. The third sample was composed of six specimens collected in Botumirim (MG) (16°52'S - 43°01'W), between June 2001 and July 2002 (Fig. 1).

The skins and skulls of the karyotyped specimens are deposited in the mammal collection of Museu Nacional (MN) in Rio de Janeiro: one female from Itapajé (CE), (MN 67469); two males from Iraquara (BA), (MN 68092 and MN 68094); two males and two females from Botumirim (MG), (MN 65151, MN 67465, MN 67466, MN 67467).

Cytogenetic analyses were based on mitotic metaphase chromosomes from bone marrow, following Ford and Harmerton (1956) with modifications. Chromosomes were stained with Giemsa and classified following Levan et al. (1964). Metacentric, submetacentric and subtelocentric chromosomes are considered biarmed and acrocentric ones uniarmed. C-bands were showed by techniques described by Sumner (1972).



**Fig. 1.** Geographical plot of cytogenetically studied localities of *Kerodon rupestris* in Brazil: (1) Itapagé, Ceará,  $2n = 52$  and  $FN = 92$ ; (2) Iraquara, Bahia,  $2n = 52$  and  $FN = 92$ , and (3) Botumirim, Minas Gerais,  $2n = 52$  and  $FN = 94$ .

The karyotype of the northern population specimen from Itapagé (MN 67469), had a diploid number ( $2n$ ) of 52 and a fundamental number ( $FN$ ) of 92, and was comprised of 21 pairs of metacentric/submetacentric chromosomes, and four pairs of acrocentrics. The X chromosome is a large metacentric, the largest of the karyotype, and the Y is a medium-sized acrocentric (**Fig. 2a**). The distribution of constitutive heterochromatin (C-banding) in this specimen showed pericentromeric bands in all autosomes. The X chromosome was entirely heterochromatic (with stronger marks in interstitial regions) whereas the Y chromosome was totally heterochromatic (**Fig. 3a**).

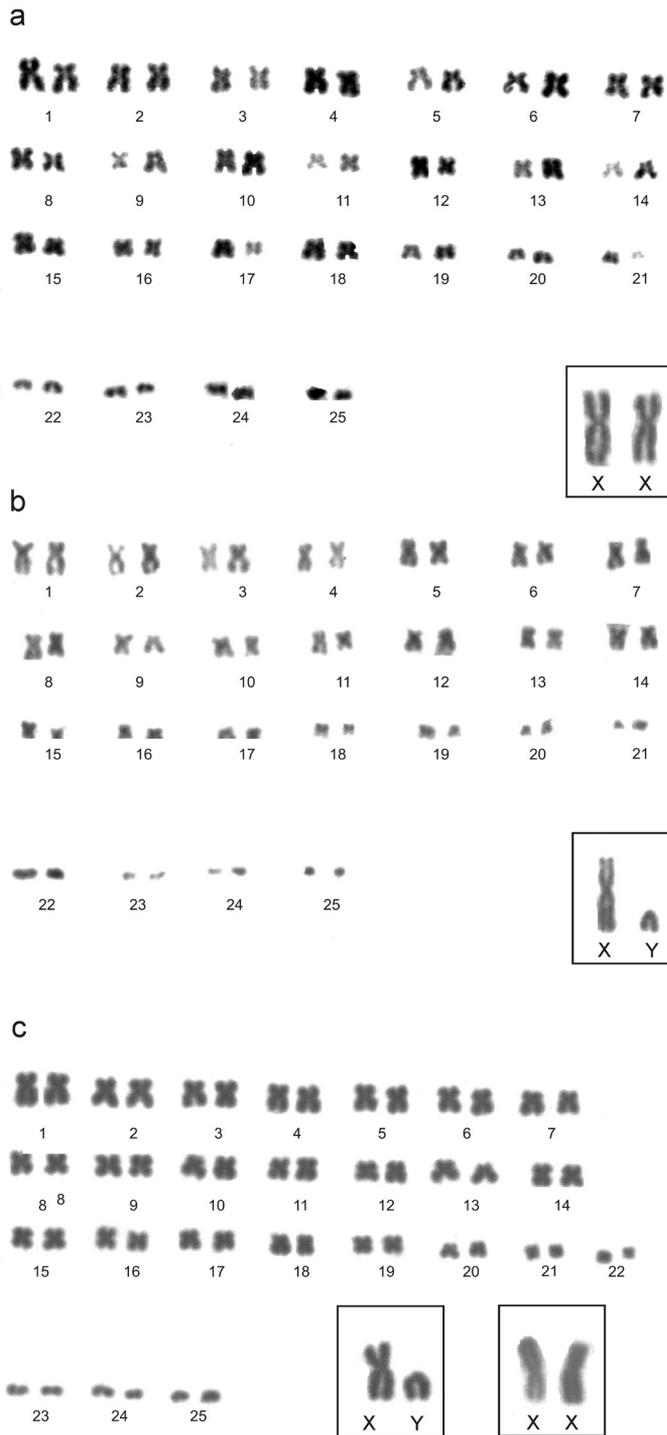
The karyotype of specimens from the central population, Iraquara (MN 68092 and MN 68094) and distribution of constitutive hetero-

chromatin (C-banding; **Fig. 3b**), was identical to that of the Itapagé specimen (**Fig. 2b**).

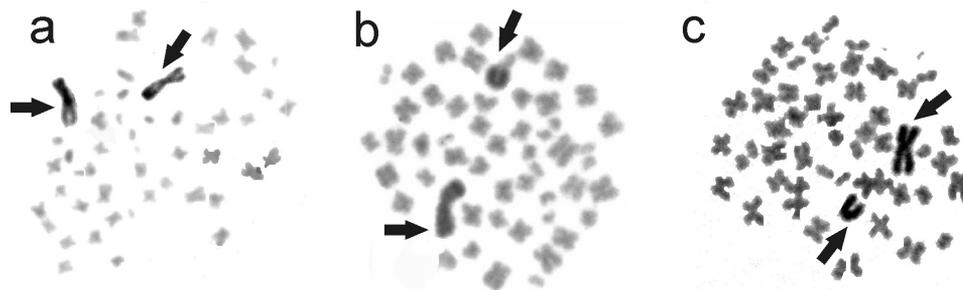
The karyotype of specimens from Botumirim (MN 65150, MN 65151, MN 67465, MN 67466, and MN 67467), the southern population sample, had  $2n = 52$  and  $NF = 94$ , and was comprised of 22 pairs of metacentric/submetacentric chromosomes, and three pairs of acrocentrics. As in the Itapagé and Iraquara karyotypes, the X chromosome was a large metacentric, the largest of the complement, and Y was a medium-size acrocentric (**Fig. 2c**). The distribution of constitutive heterochromatin (C-banding) showed pericentromeric bands in all autosomes. The X chromosome was entirely heterochromatic (with stronger marks in interstitial regions) whereas the Y chromosome was totally heterochromatic, as in the other two populations (**Fig. 3c**). For all populations, NOR sites were found in the short arms of chromosome pairs 10 and 11.

Karyological examination of these specimens and Maia's (1984) results revealed that the karyotype of the southern population (Botumirim) has conspicuous differences when compared with northern and central populations. Diploid and fundamental numbers described here ( $2n = 52$  and  $FN = 92$ ) for *K. rupestris* from Itapagé (north) and Iraquara (central) corroborate Maia's (1984) results from the Pernambuco population, although our results for distribution of heterochromatin differ from Maia's. Maia's study revealed that all heterochromatin was confined to the X chromosome in the Pernambuco population; in contrast, in all samples used here the distribution of constitutive heterochromatin (C-banding) showed pericentromeric bands in all autosomes. The X chromosome was entirely heterochromatic (with stronger marks in interstitial regions) whereas the Y chromosome was totally heterochromatic. In all samples, NOR sites were found in the short arms in metacentric chromosomes 10 and 11. That seems to be constant in all populations of *K. rupestris*.

Species within Caviinae have a high diploid number ( $2n = 64$ ) and only three of them differ from this number: *Galea musteloides* (Meyen, 1833) ( $2n = 68$ ), *K. rupestris* ( $2n = 52$ ) and *Cavia* aff. *C. magna* (Ximénez, 1980) ( $2n = 62$ )



**Fig. 2.** Karyotype of *Kerodon rupestris*: (a) conventional staining of a female (Itapajé, MN 67469;  $2n = 52$ ,  $FN = 92$ ); (b) conventional staining of a male (Iraquara, MN 68094;  $2n = 52$ ,  $FN = 92$ ); (c) conventional staining of a male (MN 65150) and XX (inset) of a female specimen (MN 67466;  $2n = 52$ ,  $FN = 94$ ). Scale = 10  $\mu$ .



**Fig. 3.** C-banding of *Kerodon rupestris* from Itapajé (a), Iraquara (b), and Botumirim (c); arrows point heterochromatic regions in sexual chromosomes.

(George and Weir, 1972; Maia, 1984; Gava et al., 1998). Comparisons and more details in diploid and fundamental numbers are shown in **Table 1**.

A difference in FN was also observed within *K. rupestris*: between northern and central population samples (NF=92) and southern population sample (NF=94). This difference can be explained by a pericentric inversion in one pair of autosomes. These differences in FN found in other caviomorph rodents have led authors to suggest that a complex of species may be involved. For example there are a

number of taxa within Echimyidae which show this pattern. Species in the genus *Trinomys* have the same 2n but different FNs (Corrêa et al., 2005). The same occurs within species of *Proechimys* collected in Brazilian Amazon and Cerrado regions (Weksler et al., 2001) and *Isothrix* (Vié et al., 1996).

In the case of *K. rupestris*, the difference in FN found in the southern population sample is congruent to the variability described in cranial morphometric characters for this population (Lessa et al., 2005). These results indicate that southern population sample has

**Table 1**

Summary of karyotype data of the subfamily Caviinae with data of present study. Acronyms read as follows: 2n = diploid number; FN = fundamental number. Modified from George and Weir (1974), and Kasahara and Yonenaga-Yassuda (1984).

Species	n	FN	X	Y	Reference
<i>Cavia aperea</i>	64	118	Small	Micro	George et al. (1972)
<i>C. aperea</i>	64	116	-	-	Kasahara (1981), Mariano et al. (1983), Maia (1984), Maia and Hulak (1974)
<i>Cavia porcellus</i>	64	118	Small	-	Cohen and Pinski (1966)
<i>Cavia</i> aff. <i>C. magna</i>	62	112	Large	Large	Maia and Hulak (1978)
<i>Cavia tschudii</i>	64	104-108	Medium	Medium	Dunnun and Salazar-Bravo (2006)
<i>Galea musteloides</i>	68	130	Medium	Small	George et al. (1972)
<i>Galea spixii</i>	64	118	Small	Small	Gava et al. (1998)
<i>Kerodon rupestris</i> [Pernambuco]	52	92	Medium	Medium	Maia (1984)
<i>K. rupestris</i> [Itapajé; Iraquara]	52	92	Medium	Medium	Present study
<i>K. rupestris</i> [Botumirim]	52	94	Medium	Medium	Present study

probably undergone processes of differentiation in relation to the other two populations. Future studies on other kinds of chromosomal banding and on molecular data will elucidate the level of divergence among these populations. It is noteworthy that the southern population sample is only 100 km from the type locality reported by Wied (1820) as Rio Belmonte, on the border between northern Minas Gerais State and southern Bahia State. We suggest that the karyotype of the *K. rupestris* should be taken to be  $2n=52$ ,  $FN=94/92$  as this group is located in the type locality region.

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## LITERATURE CITED

- ALHO CJR. 1982. Brazilian rodents: their habitats and habits. Pp. 143-166, *in*: Mammalian Biology in South America (MA Mares and HH Genoways, eds.). Pittsburgh, University of Pittsburgh.
- COHEN MM and L PINSKY. 1966. Autosomal polymorphism via a translocation in the guinea pig *Cavia porcellus*. *Cytogenetics* 5:120-122.
- CORRÊA MMO, MOG LOPES, EVC CÂMARA, LC OLIVEIRA, and LM PESSÔA. 2005. The karyotypes of *Trinomys moojeni* (PESSÔA, OLIVEIRA and REIS, 1992) and *Trinomys setosus elegans* (LUND, 1841) (RODENTIA, ECHIMYIDAE) from Minas Gerais, eastern Brazil. *Arquivos do Museu Nacional* 63:169-174.
- DUNNUM JL and J SALAZAR-BRAVO. 2006. Karyotypes of some members of the genus *Cavia* (Rodentia: Caviidae) from Bolivia. *Journal of Mammalian Biology - Zeitschrift für Säugetierkunde* 71:366-370.
- FORD CE and JL HARMERTON. 1956. A colchicine hypotonic citrate squash sequence for mammalian chromosomes. *Stain Technology* 31:247-251.
- GAVA A, TRO FREITAS, and J OLIMPIO. 1998. A new karyotype for the genus *Cavia* from a southern island of Brazil (Rodentia-Caviidae). *Genetic Molecular Biology* 21:1-7.
- GEORGE W and BJ WEIR. 1974. Hystricomorph chromosomes. *Symp. Zoological Society of London* 34:79-108.
- GEORGE W, BJ WEIR, and J BEDFORD. 1974. Chromosome studies in some members of the family Caviidae (Mammalia: Rodentia). *Journal of Zoology* 168:81-89.
- HOWELL WM and DA BLACK. 1980. Controlled silver staining of nucleolus organizer regions with a protective colloidal developer: A 1-step method. *Experientia* 36:1014-1015.
- KASAHARA S. 1981. Estudos citogenéticos no roedor *Cavia aperea* (Familia Caviidae). *Ciência e Cultura* 33:657.
- KASAHARA S and Y YONENAGA-YASSUDA. 1984. A progress report of cytogenetic data on Brazilian rodents. *Revista Brasileira de Genética* 7:509-533.
- LACHER TE. 1979. Rates of growth in *Kerodon rupestris* and an assessment of its potential as a domesticated food source. *Papeis Avulsos de Zoologia* 33:67-76.
- LACHER TE. 1981. The comparative social behavior of *Kerodon rupestris* and *Galea spixii* and the evolution of behavior in the Caviidae. *Bulletin Carnegie Museum of Natural History* 17:1-71.
- LESSA G and LM PESSÔA. 2005. Variação ontogenética e sexual em caracteres cranianos de *Kerodon rupestris* (Wied, 1820) (Rodentia: Caviidae). *Arquivos do Museu Nacional* 63:599-618.
- LESSA G, PR GONÇALVES, and LM PESSÔA. 2005. Variação geográfica em caracteres cranianos quantitativos de *Kerodon rupestris* (Wied, 1820) (Rodentia: Caviidae). *Arquivos do Museu Nacional* 63:75-88.
- LEVAN A, K FREDGA, and AA SANDEBERG. 1964. Nomenclature for centromeric position on chromosomes. *Hereditas* 52:201-220.
- MAIA V. 1984. Karyotypes of three species of Caviinae (Rodentia, Caviidae). *Experientia* 40:564-566.
- MAIA V and A HULAK. 1978. Estudo cromossômico de duas espécies da família Caviidae (Rodentia). *Revista Nordestina de Zoologia* 1:119-124.
- MARES MA and RA OJEDA. 1982. Patterns of diversity and adaptation in South American hystricognath rodents. Pp. 393-412, *In*: Mammalian Biology in South America (MA Mares and HH Genoways, eds.). Pittsburgh, University of Pittsburgh.
- MARIANO JS, I FERRARI, and SA SANTOS. 1983. Estudos citogenéticos em preparações obtidas de cultura de linfócitos nos gêneros *Hydrochoerus* e *Cavia* (Rodentia, Mammalia) *Ciência e Cultura* 35:656.
- MOOJEN J, M LOCKS, and A LANGGUTH. 1997. A new species of *Kerodon* Cuvier, 1825 from the state of Goiás, Brazil (Mammalia, Rodentia, Caviidae). *Boletim do Museu Nacional, Nova Série, Zoologia* 377:1-10.
- OLIVEIRA JA, PR GONÇALVES and CR BONVICINO. 2003. Mamíferos da Caatinga. Recife Publicação Especial, Recife.

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- SUMNER AT. 1972. A simple technique for demonstrating centromeric heterochromatin. *Experimental Cell Research* 75:304-306.
- VIE JC, V VOLOBOUEV, JL PATTON, and L GRANJON. 1996. A new species of *Isothrix* (Rodentia: Echimyidae) from French Guiana. *Mammalia* 60:393-406.
- WEKSLER M, CR BONVICINO, IB OTAZU, and JS SILVA-JÚNIOR. 2001. Status of *Proechimys roberti* and *P. oris* (Rodentia: Echimyidae) from eastern Amazonian and central Brazil. *Journal of Mammalogy* 82:109-122.
- WIED M. 1820. Ueber ein noch unbeschriebenes Säugertier aus der Familie der Nager. *Isis von Oken* 6:43.