

SHORT COMMUNICATION

ROBERTSONIAN FUSION AND X CHROMOSOME POLYMORPHISM IN *Zygodontomys* (= *Bolomys*) *lasiurus* (CRICETIDAE, RODENTIA) FROM CENTRAL BRAZIL

Marta Svartman and Eunice Judith Cardoso de Almeida

ABSTRACT

Nineteen specimens of *Zygodontomys* (= *Bolomys*) *lasiurus* were analyzed cytogenetically and two karyotypes were identified (2n-34, FN-34; 2n-33, FN-34). An heterozygous fusion/fission involving pairs 6 and 7, responsible for the variation in the diploid number, was detected. X chromosome polymorphism was also present and three kinds of X, one acrocentric (Xa) and two subtelocentrics (Xb and Xc), were identified. C-banding patterns and chromosomal measurements led to the conclusion that gradual mechanisms of constitutive heterochromatin additions/deletions are responsible for this polymorphism.

INTRODUCTION

Previous cytogenetic reports on *Zygodontomys lasiurus* described a karyotype with 34 chromosomes and FN=34. The animals studied were collected in the states of Pará (Barroso and Barros, 1978) and São Paulo (Yonenaga, 1975; Kasahara and Yonenaga-Yassuda, 1983). *Bolomys lasiurus* (= *Z. lasiurus*) from the state of Pernambuco (Maia and Langguth, 1981) showed the same chromosomal complement, as also occurred with *B. lasiurus* from the states of Paraná and Rio Grande do Sul (Castro, 1989;

Sbalqueiro, 1989). All these forms represent the same taxonomic entity and the different denominations reflect the systematic difficulties it presents.

Alterations in the karyotype were found in specimens from Pernambuco (Maia and Langguth, 1981) and from Rio Grande do Sul (Castro, 1989), which showed $2n=33$, $FN=34$, due to heterozygous Robertsonian rearrangements. One mosaic with $2n=33$, $XO/34,XX$ was identified in the sample from São Paulo (Kasahara and Yonenaga-Yassuda, 1983).

Variations of the sexual chromosomes were also identified. The Y chromosome was a small submetacentric in all samples studied, except in the males from Rio Grande do Sul, which had an acrocentric Y (Castro, 1989), and the X chromosome was found as: a medium acrocentric (Yonenaga, 1975; Maia and Langguth, 1981; Kasahara and Yonenaga-Yassuda, 1983; Castro, 1989), a medium subtelo-centric (Kasahara and Yonenaga-Yassuda, 1983; Castro, 1989; Sbalqueiro, 1989) and a small submetacentric X (Kasahara and Yonenaga-Yassuda, 1983).

In the present work we present new data, including G-, R- and C-banding and NORs analysis, for *Z. (= Bolomys) lasiurus*, collected in the state of Goiás.

MATERIAL AND METHODS

Cytogenetical analysis was performed for nineteen specimens (thirteen males and six females) of *Z. lasiurus* collected from four areas of the Federal District, State of Goiás: Granja do Ipê ($15^{\circ}55'S$; $47^{\circ}59'W$), Parque Nacional de Brasília ($15^{\circ}43'S$; $47^{\circ}56'W$), Reserva Biológica de Águas Emendadas ($15^{\circ}33'S$; $47^{\circ}35'W$) and Reserva Ecológica do IBGE ($15^{\circ}56'S$; $47^{\circ}53'W$). The identification of the animals was made by Dr. Philip Hershkovitz of the Field Museum of Natural History, Chicago and by the group of Prof. Jader Marinho Filho of the Universidade Federal de Brasília. The skins and skulls were deposited in these two institutions (Table I).

Chromosomal preparations were obtained using cells from bone marrow and tail biopsy (Almeida and Yonenaga-Yassuda, 1985). G-, C- and R-bandings were performed as described by Seabright (1971), Sumner (1972) and Dutrillaux *et al.* (1976), respectively, and the NORs were demonstrated following the method of Howell and Black (1980).

RESULTS

Two karyotypes with different diploid numbers were identified in our sample: eighteen specimens displayed a karyotype with $2n=34$, $FN=34$, composed of thirteen large to small acrocentrics (pair 1 to 15) and two small metacentrics (pair 16) autosomes. One male showed a karyotype with $2n=33$, $FN=34$ (Figure 1), composed of twenty six

Table I - Cytogenetic data, localities, sex, sexual pair, field numbers and institution of deposition of the specimens studied.

Specimen	Locality	Sex	2n	FN	Sexual Pair	Field number	Institution
Bio 415	PNB	M	34	34	XaY	PII 9615	FMNH
Bio 416	PNB	F	34	34	XaXa	PII 9616	FMNH
Bio 417	PNB	M	34	34	XaY	PII 9610	FMNH
Bio 423	PNB	M	34	34	XaY	PII 9625	FMNH
Bio 425	PNB	M	34	34	XaY	PII 9624	FMNH
Bio 426	PNB	M	34	34	XaY	PII 9618	FMNH
Bio 427	REIBGE	M	34	34	XaY	PII 9607	FMNH
Bio 433	REIBGE	F	34	34	XaXa	PII 9605	FMNH
Bio 438	PNB	F	34	34	XaXa	PII 9628	PMNH
Bio 509	RBAE	M	34	34	XaY	MK 0070	UnB
Bio 510	RBAE	M	34	34	XaY	MK 0069	UnB
Bio 523	RBAE	M	34	34	XcY	MK 0170	UnB
Bio 524	RBAE	M	34	34	XaY	---	---
Bio 532	GI	M	34	34	XaY	PII 01	UnB
Bio 533	GI	F	34	34	XaXa	PII 02	UnB
Bio 534	GI	F	34	34	XaXb	PII 03	UnB
Bio 535	GI	M	33	34	XcY	PII 04	UnB
Bio 536	GI	M	34	34	XaY	PII 05	UnB
Bio 537	GI	F	34	34	XaXa	PII 06	UnB

FMNH - Field Museum of Natural History, Chicago.

GI - Granja do Ipê

PNB - Parque Nacional de Brasília

RBAE - Reserva Biológica de Águas Emendadas

REIBGE - Reserva Ecológica do IBGE

UnB - Universidade Federal de Brasília

Xa - medium acrocentric

Xb - medium subtelocentric

Xc - medium subtelocentric larger than Xb

large to small acrocentrics (pairs 1 to 5 and 8 to 15), one large metacentric odd chromosome (chromosome 6/7), two medium acrocentric odd chromosomes

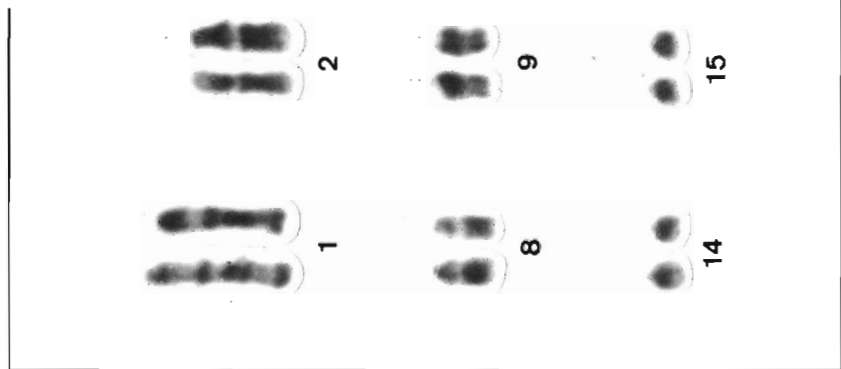


Figure 1 - G-banded karyotype of a male *Zygodontomys* (= *Bolomys*) *lasiurus* with $2n=33$, FN=34 and sexual pair XcY. In the inset, pairs 6 and 7 of a male with $2n=34$, FN=34. The bar represents 10 μm .

(chromosomes 6 and 7) and two small metacentric autosomes (pair 16). The Y chromosome was a small submetacentric in all males studied and three types of X were identified: a medium acrocentric (Xa) in eleven males and five females, a medium subtelocentric (Xb) present in heterozygosis in one female (XaXb), and a subtelocentric larger than Xb (Xc), identified in two males, one of them with $2n=34$ and the other with $2n=33$ (Figure 3). Chromosomal measurements showed that the Xa corresponds to 5.6% the Xb to 6.6%, and the Xc to 7.3% of the genome. The long arms of the three types of X are equivalent to 5.6% of the genome.

The G-banding patterns (Figure 1) allowed the identification of all chromosomal pairs and of a heterozygous Robertsonian rearrangement between pairs 6 and 7 in the animal with 33 chromosomes. The X chromosomes showed four positive bands in the long arms and the Y chromosome showed an indistinct banding pattern.

C-banding (Figures 2 and 3) revealed a small amount of constitutive heterochromatin in the pericentromeric regions of some acrocentric autosomal pairs and of the small metacentric pair. In the male with 33 chromosomes, the odd autosomes 6 and 6/7 did not show any constitutive heterochromatin, while chromosome 7 had its pericentromeric region positively stained and one homologue of pair 1 had an interstitial heterochromatic block in the long arm, near the centromere, in all cells analyzed (Figure 2). The Xa stained positively only in its pericentromeric region, while the Xb and Xc had their short arms also C-band positives. The Y chromosome was easily identified in C-banded metaphases, as it had the two more distal thirds of its long arm heavily stained (Figure 3).

R-banding (Figure 4), presented here for the first time, showed that the Y chromosome and one of the X chromosomes in the female were always late replicating.

In 231 cells from seven animals, the maximum number of NORs per cell was 13 and the minimum, five. The modal number of NORs was different in each specimen and most of the cells had 10 NORs (Table II). The chromosomes stained by silver nitrate were all acrocentrics and either the short arms or the telomeres of the long arms could bear NORs. In one female with a modal number of 10 NORs, most of the cells presented six NORs in the long arms and four in the short ones (Table III, Figure 5).

DISCUSSION

The cytogenetic analysis of *Z. lasiurus* showed a constant FN (34) and two diploid numbers (34 and 33), due to a heterozygous Robertsonian rearrangement between pairs 6 and 7. The heterozygous interstitial band in pair 1 of the animal with 33 chromosomes could have originated from the insertion of pericentromeric heterochromatin of the chromosome 7 involved in the Robertsonian fusion, as the odd chromosome 7 had pericentromeric heterochromatin and chromosome 6 and 6/7 were completely devoid of it.

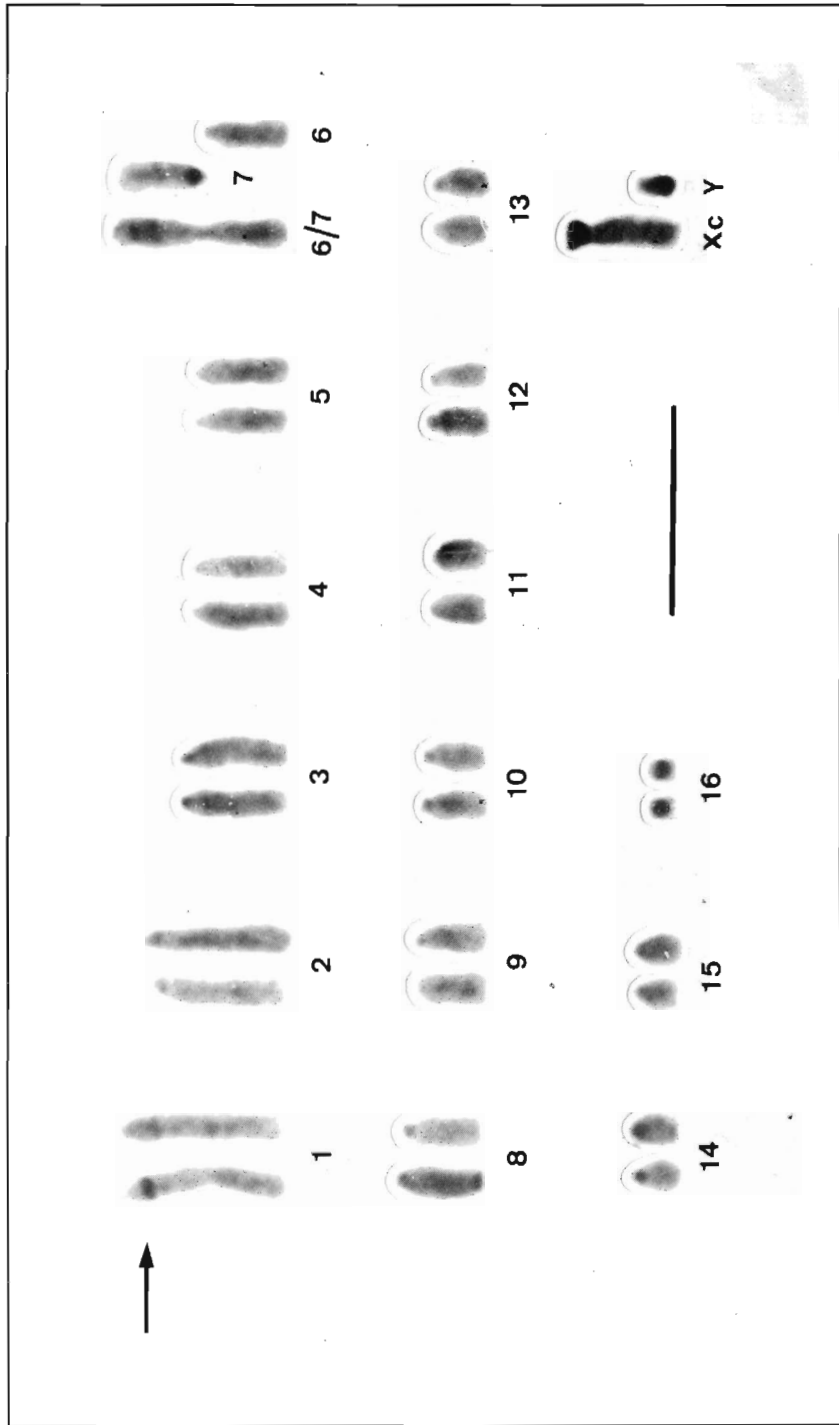


Figure 2 - C-banded karyotype of a male *Zygodontomys* (= *Bolomys*) *lasiurus* with $2n=33$, FN=34 and sexual pair XcY. The arrow indicates the interstitial heterochromatic block. The bar represents 10 μ m.



Figure 3 - Conventionally stained (A) and C-banded (B) sexual pairs of *Zygodontomys* (*Bolomys*) *lasiurus*.

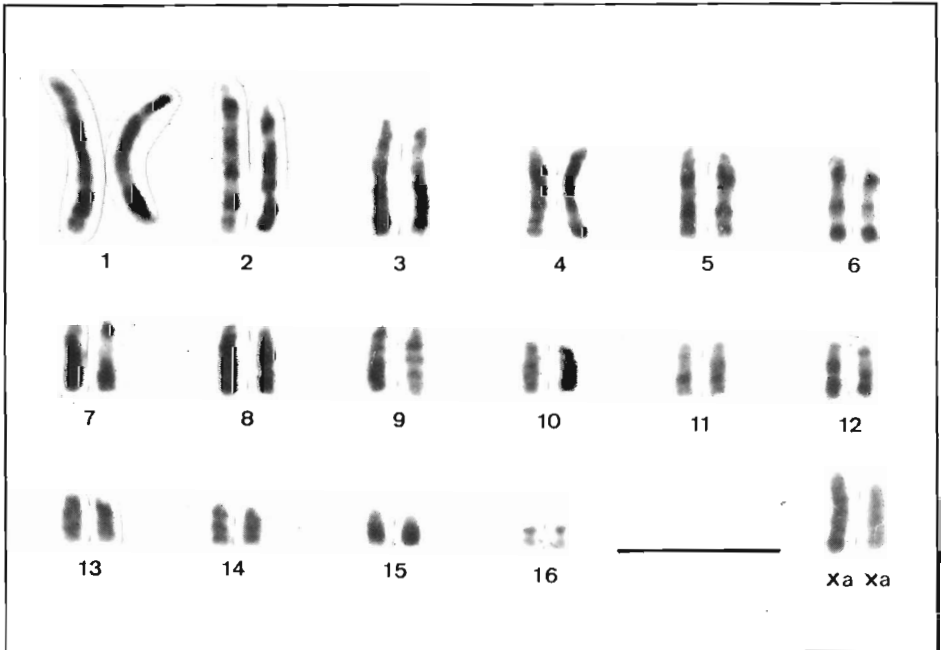


Figure 4 - R-banded karyotype of a female *Zygodontomys* (*Bolomys*) *lasiurus* with $2n=34$, $FN=34$ and sexual pair $XaXa$. The bar represents $10\ \mu\text{m}$.

Table II - Nucleolus Organizer Regions (NORs) in *Zygodontomys* (= *Bolomys*) *lasiurus*.

Specimen	Sex	Number of NORs per cell									Number of cells
		5	6	7	8	9	10	11	12	13	
Bio 438	F	-	-	-	-	1	30	5	-	-	36
Bio 523	M	-	-	1	2	8	16	4	-	-	31
Bio 532	M	-	6	14	11	3	2	-	-	-	36
Bio 533	F	-	-	2	7	2	14	3	2	1	31
Bio 534	F	-	1	16	8	5	3	1	-	-	34
Bio 535	M	-	3	2	9	12	5	2	-	-	33
Bio 537	F	1	5	9	6	7	2	-	-	-	30

Table III - Localization of NORs in a female *Zygodontomys* (= *Bolomys*) *lasiurus*.

NORs per cell	Number of NORs in the		Number of cells
	Long arms	Short arms	
11	7	4	1
	6	5	2
	5	6	2
10	7	3	6
	6	4	17
	5	5	3
	4	6	4
9	6	3	3
	5	4	1
	4	5	3

The karyotype with $2n=34$ from the specimens of Goiás is the same described for *Z. lasiurus* from the State of São Paulo (Yonenaga, 1975; Kasahara and Yonenaga-Yassuda, 1983), *B. lasiurus* (= *Z. lasiurus*) from Pernambuco (Maia and

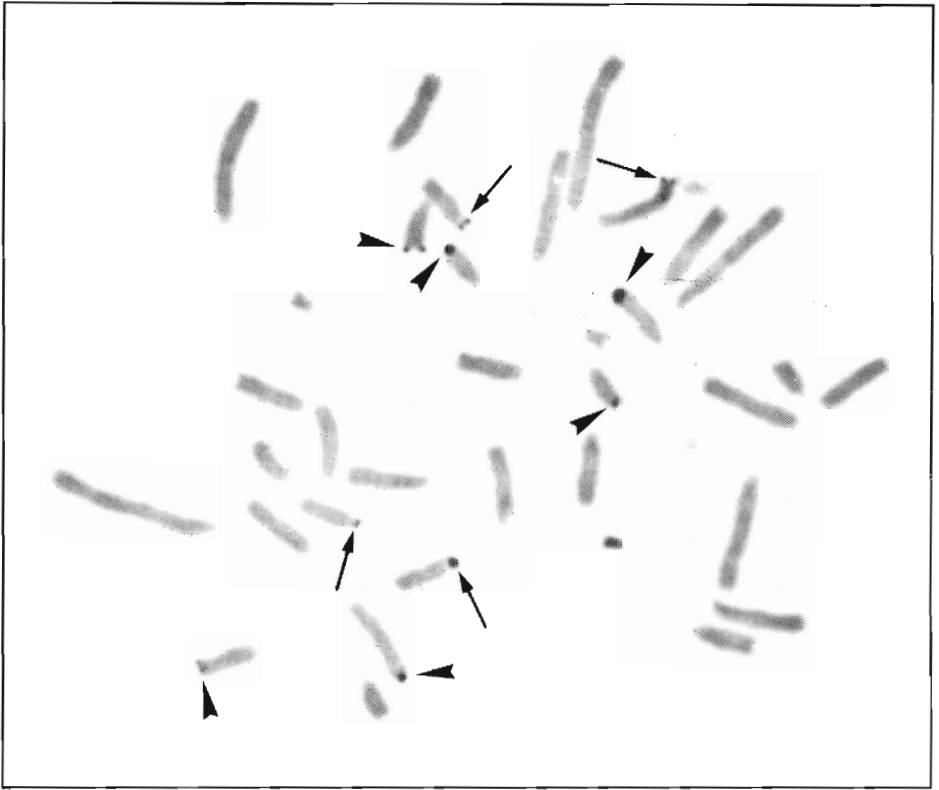


Figure 5 - NORs in a female *Zygodontomys* (= *Bolomys*) *lasiurus* ($2n=34$, FN=34). The arrow-heads indicate six NORs in the long arms and the arrow show four NORs in the short arms.

Langguth, 1981) and *B. lasiurus* from Santa Catarina and Rio Grande do Sul (Castro, 1989; Sbalqueiro, 1989). G-banding patterns were also similar.

The heterozygous Robertsonian rearrangement found in one male from Goiás is the same observed in the specimens with $2n=33$ from Pernambuco. The animals captured nearby always presented $2n=34$, which allowed Maia and Langguth (1981) to propose that the rearrangement originated in a restricted area and had not spread to neighboring populations. The finding of the same rearrangement in the male from the Federal District indicates that either it appeared more than once in different populations or that it is more frequent in this species than was supposed.

The three kinds of X chromosomes present in our sample (Xa, Xb and Xc) differ by gradual additions/deletions of constitutive heterochromatin, which can be concluded based on G-, C-banding and chromosomal measurements.

X chromosome polymorphisms were also described in animals from São Paulo (Kasahara and Yonenaga-Yassuda, 1983). Our results, which are the first to include the C-banding patterns for this species, showed that the three forms of X, as well as the Y chromosome, had a conspicuous C-banding pattern. The G-banding patterns of the long arms of the X chromosomes from our sample and from the specimens collected in São Paulo (Kasahara and Yonenaga-Yassuda, 1983) and Pernambuco (Maia and Langguth, 1981) show total homology; thus, the Xa corresponds to the X from São Paulo and Pernambuco, the Xc corresponds to the Xm from São Paulo and the Xb is described for the first time.

The karyotype of *Z. lasiurus* is very distinct from other *Zygodontomys* species, which present very high diploid numbers (Gardner and Patton, 1976). According to these authors, *Z. lasiurus* would be better classified as a member of the genus *Akodon*. Indeed, some karyotypical characteristics found in *Z. lasiurus* were considered typical of the Akodontine rodents studied by Bianchi *et al.* (1971). Besides, *Z. lasiurus* presents a chromosomal complement identical to the one reported for *A. obscurus* ($2n=34$) by Bianchi *et al.* (1971), and Kasahara (1978) was able to establish G-band homeology between 11 chromosomal pairs. More recently, Maia and Langguth (1981), based on taxonomic and cytogenetical data, concluded that *Z. lasiurus* would be best included in the genus *Bolomys*.

ACKNOWLEDGMENTS

We are indebted to Dr. Philip Hershkovitz, to Dr. Jader Marinho Filho and to Marcelo Lima Reis, who provided us with the specimens studied; to Dr. Hsi Tien Chiu, who performed the cell cultures, to Dra. Helena Luna Ferreira, who gave us working possibilities in her laboratory in Brasília and to Dr. Antônio Brito da Cunha for the critical reading of the manuscript.

This work was supported by Fundação de Amparo à Pesquisa do Estado de São Paulo (FAPESP), Programa Integrado de Genética (PIG) and Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq). Publication supported by FAPESP.

RESUMO

Foram analisados citogeneticamente dezanove espécimes de *Zygodontomys* (= *Bolomys*) *lasiurus*, nos quais foram identificados dois cariótipos ($2n=34$, NF-34; $2n=33$, NF-34). A variação do número diplóide foi atribuída a um mecanismo de fusão/fissão heterozigoto envolvendo os pares 6 e 7. Três tipos de cromossomos X estavam presentes na amostra: um acrocêntrico (Xa) e dois subtlococêntricos (Xb e Xc); a análise dos padrões de bandas C e medidas cromossômicas permitiram concluir que mecanismos graduais de adição/deleção de heterocromatina constitutiva estavam envolvidos em tal polimorfismo.

REFERENCES

- Almeida, E.J.C. and Yonenaga-Yassuda, Y. (1985). Robertsonian fusion, pericentric inversion and sex chromosome heteromorphisms in *Oryzomys subflavus* (Cricetidae, Rodentia). *Caryologia* 38: 129-137.
- Barroso, C.M.L. and Barros, R. (1978). Estudos citogenéticos em *Zygodontomys* da Amazônia. *Ciênc. Cult.* (Suppl.) 30: 514.
- Bianchi, N.O., Reig, O.A., Molina, O.J. and Dulout, F.N. (1971). Cytogenetics of the South American akodont rodents (Cricetidae). I. A progress report of Argentinian and Venezuelan forms. *Evolution* 25: 724-736.
- Castro, E.C. (1990). Ocorrência e caracterização cromossômica de roedores akodontinos no Rio Grande do Sul. Masters Thesis, Universidade Federal do Rio Grande do Sul, Porto Alegre.
- Dutrillaux, B., Couturier, J., Richer, C.L. and Viegas-Péquignot, E. (1976). Sequences of DNA replication in 277 R- and Q-bands of human chromosomes using a BrdU treatment. *Chromosoma* 58: 51-61.
- Gardner, A.L. and Patton, J.L. (1976). Karyotypic variation in Oryzomyine rodents (Cricetinae) with comments on chromosomal evolution in the Neotropical cricetine complex. *Occ. Pap. Mus. Zool. L.A. Univ.* 49: 1-48.
- Howell, W.M. and Black, D.A. (1980). Controlled silver-staining of nucleolus organizer regions with a protective colloidal developer: a 1-step method. *Experientia* 36: 1014-1015.
- Kasahara, S. (1978). Variabilidade cromossômica em quatro espécies de roedores das famílias Cricetidae e Muridae. Ph.D. Thesis, Instituto de Biociências, USP, São Paulo.
- Kasahara, S. and Yonenaga-Yassuda, Y. (1983). Sex chromosome variability in *Zygodontomys lasiurus* (Rodentia, Cricetidae). *Cytologia* 48: 569-576.
- Maia, V. and Langguth, A. (1981). New karyotypes of Brazilian akodont rodents with notes on taxonomy. *Z. Saugetierkunde* 46: 241-249.
- Sbalqueiro, I.J. (1990). Análises cromossômicas e filogenéticas em algumas espécies de roedores da região sul do Brasil. Ph.D. Thesis, Universidade Federal do Rio Grande do Sul, Porto Alegre.
- Seabright, M. (1971). A rapid technique for human chromosomes. *Lancet* 2: 971-972.
- Sumner, A.T. (1972). A simple technique for demonstrating centromeric heterochromatin. *Exptl. Cell Res.* 75: 304-306.
- Yonenaga, Y. (1975). Karyotypes and chromosome polymorphisms in Brazilian rodents. *Caryologia* 28: 269-286.

(Received December 12, 1991)