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Cytogenetic study of the genus *Saguinus* (Callithrichidae, Primates)

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ABSTRACT

Eight subspecies from the genus *Saguinus* (*S. fuscicollis fuscicollis*, *S. fuscicollis weddelli*, *S. bicolor bicolor*, *S. bicolor martinsi*, *S. mystax mystax*, *S. imperator imperator*, *S. midas midas*, *and S. midas niger*) were studied. Five of them (*S. f. fuscicollis*, *S. f. weddelli*, *S. b. martinsi*, *S. m. mystax* and *S. i. imperator*) had their karyotypes described for the first time. Conventional coloration, banding patterns G, C and NOR, and G/C sequential banding tecniques were used. All samples showed the same diploid number (2n = 46). The patterns of the G, C and NOR bands were very similar with little differences in the quantity and constitutive heterochromatin distribution of the autosomes. Constitutive heterochromatin was observed only in telomeric regions of some chromosomes of *S. f. fuscicollis* and *S. f. weddelli*. The X chromosome was the same in all subspecies, but chromosome Y differed in size and morphology. XX/XY chimerism was verified in all subspecies.

INTRODUCTION

Saguinus are small callithrichid primates. They constitute the largest and most diverse genus of the New World primates, with 10 species. They show extraordinary variation in pile patterns and facial pile distribution (Hershkovitz, 1977).

This genus occurs in Colombia, Ecuador, Peru, Guyana, Surinam, Bolivia and Brazil (in the high Amazon Basin). In Central America it is found from northern Colombia to Costa Rica. *Saguinus fuscicollis* is the species with the greatest number of subspecies (14 subspecies), and has the widest geographic distribution in the highest part of the Amazon region, where it exists in sympatry with its congeneric species of the groups *S. mystax* and *S. nigricollis* (Terborgh, 1983; Snowdon and Soini, 1988; Garber, 1989). They inhabit region from southeastern Colombia to Central Bolivia. In Brazil they are found in the western side of the Japurá, Solimões, Ipixuna and Madeira Rivers (Hershkovitz, 1977) and on the margins of the Jiparaná River, which is an affluent of the Madeira River (Ferrari, 1993). *S. bicolor* (three subspecies) is distributed in the northern Amazon River, in Brazil. *S. Mystax* is seen in northeastern Peru and northwestern Brazil (Acre State). *S. imperator*, with two subspecies, is found in southeastern Peru, northwestern Bolivia and southwestern Brazil. *S. midas* (two subspecies) is distributed in Guyana, Surinam and northern Brazil including Marajó Island (Hershkovitz, 1977).

There are some controversies concerning the origin of *Saguinus*. Based on morphologic reports, Hershkovitz (1977) described *Saguinus* as being derived from prototypes of the *Callithrix argentata* group. Nowadays, most authors (Terborgh, 1983; Sussman and Kinzey, 1984; Ford, 1986; Martin, 1992 and Ferrari, 1993), based on ecological and morphological data, disagree with Hershkovitz. Molecular reports (Schneider *et al*., 1993) showed that *Saguinus* is the base-genus of the callithrichids. Cytogenetic studies (Nagamachi, 1995) have also shown evidence of this condition.

Cytogenetic studies in *S. fuscicollis* and *S. oedipus* (Bedard *et al*., 1978), *S. i. subgricescens* (Benirschke *et al*., 1982), *S. l. labiatus* (Marczynska *et al*., 1983; Minezawa and Borda, 1984), *S. b. bicolor* (Ferrari and Peixoto, 1984), *S. m. midas* (Nagamachi *et al*., 1990) and *S. m. niger* (Nagamachi and Pieczarka, 1988) showed clear uniformity in chromosomic morphology and in banding patterns G, C and NOR from *Saguinus* karyotype, with diploid number 2n = 46 chromosomes. Moreover, these studies have demonstrated the presence of chromosomic chimerism with XX/XY lineages.

MATERIAL AND METHODS

This study was carried out on 38 specimens belonging to eight subspecies: *S. f. fuscicollis* (one couple), *S. f. weddelli* (two males and one female), *S. b. bicolor* (one male and three females), *S. b. martinsi* (one male), *S.m. mystax* (one couple), *S. i. imperator* (one couple), *S. m. midas* (four males and two females) and *S. m. niger* (ten males and eight females). All specimens were from captivity. *S. midas* karyotype was described by Nagamachi and Pieczarka (1988) and used for comparison in the present study.

Blood samples were collected from the femural vein and mixed with heparin. Chromosomes were obtained by the classic method of lymphocyte culture (Moorhead *et al*., 1960) with some modifications. The techniques developed by Scheres (1972), Sumner (1972) and Howell and Black (1980) were used to get the banding patterns G, C and NOR, respectively. Sequencial banding G/C was also used in this study.

About 30 metaphases from each individual were analyzed to verify its diploid number, banding patterns and the presence of XX/XY chromosomic chimerism. The karyotype building followed the model presented by Nagamachi and Pieczarka (1988).

RESULTS AND DISCUSSION

All subspecies showed a karyotype of 2n = 46 chromosomes, with two metacentric pairs (4-5), thirteen submetacentric pairs and/or subtelocentric (1-3 and 6-15) and seven acrocentric pairs (16-22). The G^+ band pattern (Figure 1) was similar among the subspecies, with little differences. *S. f. fuscicollis* and *S. f. weddelli* karyotypes showed telomeric G^+ band in both arms of pair 5, and in the short of the chromosomes 3 and 8-15. This characteristic was not found in any other subspecies. In *S. m. midas* the pair 7 had G^+ band distal in the short arm which was proximal in other subspecies. For C banding (Figure 2), these same regions showed constitutive heterochromatin. The presence of G^+/C^+ telomeric bands means that this chromosome region is characteristically rich in A-T (adenin and timin) and probably has late replication (Holmquist, 1989).

All specimens had centromeric heterochromatin and/or pericentromeric heterochromatin in all chromosomes, except *S. f. fuscicollis* and *S. f. weddelli.* The latter also showed telomeric C^+ and G^+ bands in both arms of pair 5 and on the short arms of pairs 3, 8-15.

Heteromorphism was found in subspecies for the short arm size in all acrocentric autosomes, when using conventional coloration. This was characterized on the C banding by a variation in constitutive heterochromatin quantities of these pairs.

The X chromosome was mid-sized and submetacentric. The Y chromosome differed in size and morphology. In the subspecies *S. f. weddelli*, *S. b. bicolor*, *S. b. martinsi*, *S. i. imperator*, *S. m. midas* and *S. m. niger*, it appeared as a small acrocentric. In *S. f. fuscicollis* and *S. m. mystax* the Y chromosome was very small, being almost sharp and submetacentric and metacentric, respectively. It was not possible to determine what happened in the Y chromosome evolution. This was because the G bands were diffuse for *S. f. fuscicollis* and *S. m. mystax.* The chromosomes appeared to be very small, being almost sharp and submetacentric and metacentric, respectively. The same happened for the diffuse G bands of *S. f. weddelli*, *S. b. bicolor*, *S. b. martinsi* and *S. i. imperator*. In *S. f. fuscicollis* and *S. m. mystax* subspecies Y was totally blushed, and in *S. m. midas* and *S. m. niger* this chromosome had proximal and distal G^+ band.

Ag-NOR coloration (Figure 3) showed a proximal nucleolus organizer region in the long arms of the four smallest acrocentric autosomes in all subspecies.

All subspecies showed XX/XY chromosomic chimerism in almost all specimens (Table I). Presence of chromosomic chimerism in this genus confirms reports of the high incidence of chimerism in the callithrichidae family without causing any fertility problem on co-twin feminine sex.

Table I - XX/XY chromosomic chimerism present in Saguinus subspecies in this study.

Subspecies	Specimens number		Chimera number		Chimera total %
	M	F	M	F	
S. f. fuscicollis	1	1	1	1	100
S. f. weddelli	2	1	2	1	100
S. b. bicolor	1	3	1	3	100
S. b. martinsi	1	-	1	-	100
S. m. mystax	1	1	1	1	100
S. i. imperator	1	1	1	1	100
S. m. midas	4	2	4	2	100
S. m. niger	10	8	7	6	72.2

M = Male; F = female.

The chromosome stability in *Saguinus* indicates an absence of chromosomic modification in its karyotype evolution. This resulted in almost perfect identity between homologous chromosomes of the various species of this genus. Little variation was observed in the quantity and distribution of constitutive heterochromatin. Despite being an important differentiation factor for other groups, the variation was not enough to explain the extraordinary phenotypic variability observed in *Saguinus*. Considering therefore that the group karyotype ancestor must have been similar to living species in our days, this intense level of genic variability probably accounted for this phenotypic diversity among *Saguinus* species.

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RESUMO

Oito subespécies do gênero *Saguinus* (*S. f. fuscicollis, S. f. weddelli, S. b. bicolor, S. b. martinsi, S. m. mystax*, *S. i. imperator, S. m. midas* e *S. m. niger*) foram estudadas citogeneticamente, das quais cinco (*S. f. fuscicollis, S. f. weddelli, S. b. martinsi, S. m. mystax* e *S. i. imperator*) tiveram seu cariótipo descrito pela primeira vez neste estudo. Os cariótipos foram analisados por coloração convencional, pelos padrões de bandas G, C e NOR, e pelo método de bandeamento sequencial G/C. Todos os espécimens mostraram o mesmo número diplóide (2n = 46 cromossomos) e os padrões de bandas G, C e NOR foram muito similares entre as subespécies, diferindo apenas na quantidade e distribuição de heterocromatina constitutiva de alguns autossomos. Heterocromatina constitutiva presente na região telomérica de alguns cromossomos foi observada apenas em *S. f. fuscicollis* e *S. f. weddelli*. O cromossomo X foi igual em todas subespécies, porém, o cromossomo Y diferiu em morfologia e tamanho. Quimerismo cromossômico XX/XY foi verificado em todas as subespécies.

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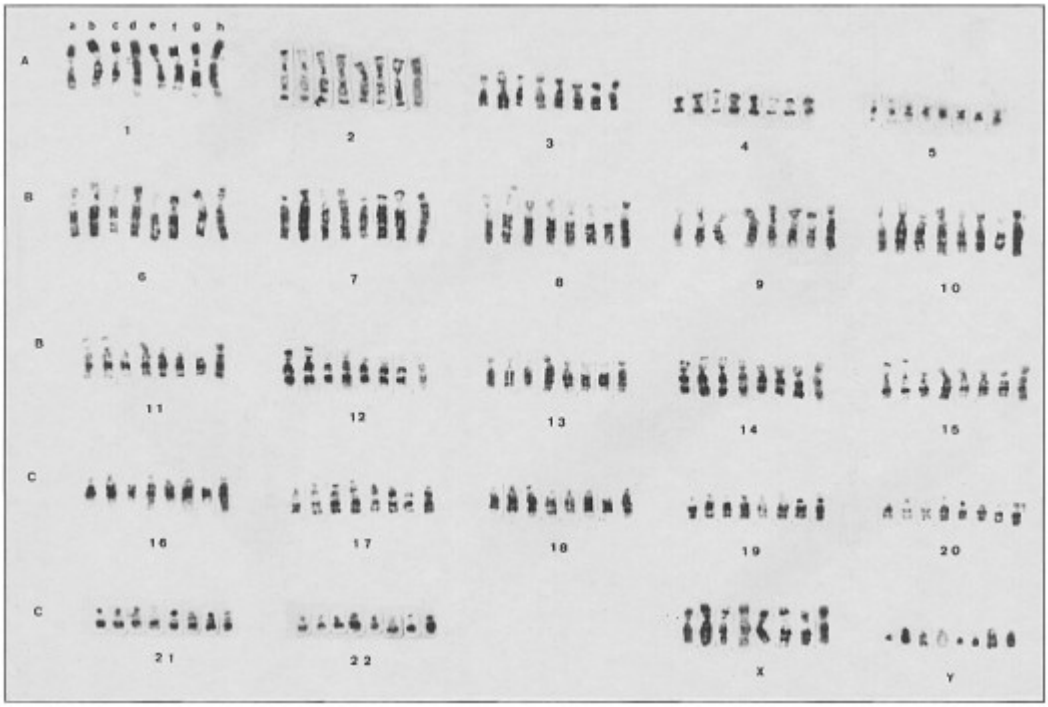

Figure 1 - Karyotypic comparison of G band patterns on eight *Saguinus* subspecies: a) *S. f. fuscicollis*; b) *S. f. weddelli*; c) *S. b. bicolor*; d) *S. b. martinsi*; e) *S. m. mystax*; f) *S. i. imperator*; g) *S. m. midas*, and h) *S. m. Niger*.

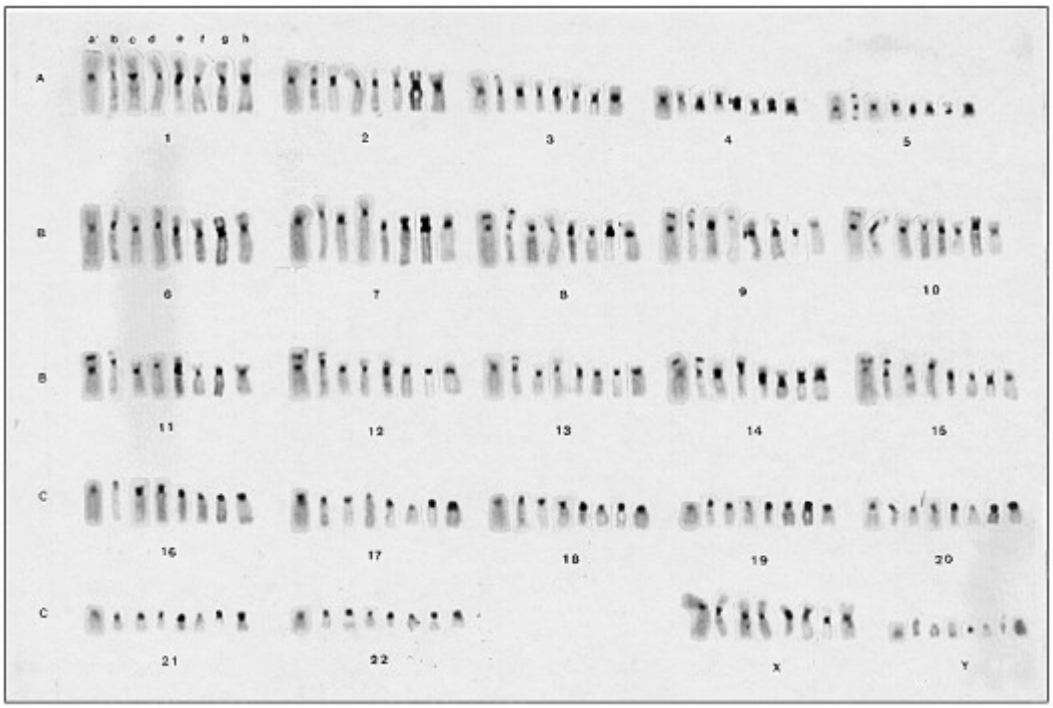

Figure 2 - Karyotypic comparison of C band patterns on eight *Saguinus* subspecies: a) *S. f. fuscicollis*; b) *S. f. weddelli*; c) *S. b. bicolor*; d) *S. b. martinsi*; e) *S. m. mystax*; f) *S. i. imperator*; g) *S. m. midas*, and h) *S. m. Niger*.

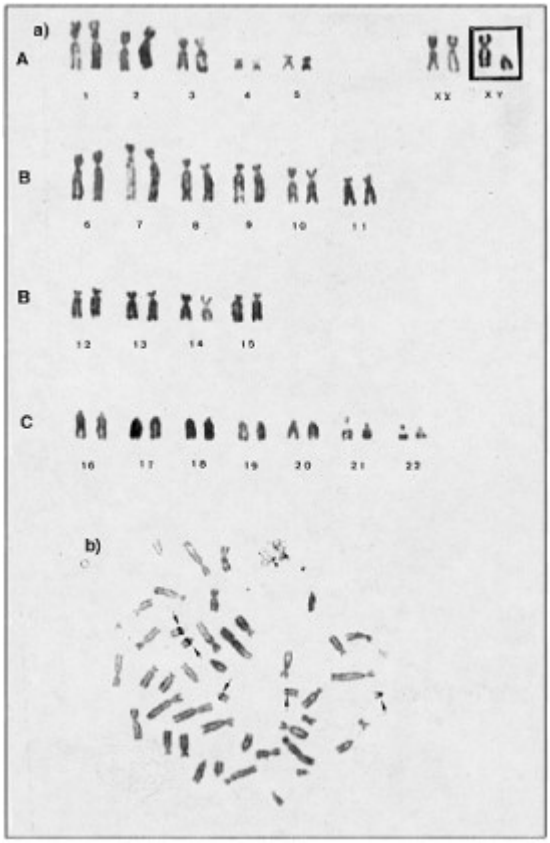

Figure 3 - a) Conventional coloration; b) Ag-NOR coloration. Arrows mean positive NOR.

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