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Chromosome Comparison Among Five Species of Platyrrhini (*Alouatta caraya*, *Aotus azarae*, *Callithrix jacchus*, *Cebus apella*, and *Saimiri sciureus*)

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ABSTRACT. Karyotypes of 82 individuals from five Platyrrhini species (*Alouatta caraya*, *Aotus azarae*, *Callithrix jacchus*, *Cebus apella*, and *Saimiri sciureus*) were studied and compared using a G-banding technique. Cytogenetic analysis showed full chromosome or full arm homologies among these geographically neighbouring species. A small number of chromosomal rearrangements (inversions, deletions, and translocations) could be detected among these taxa. These five species are closely related in chromosomal evolution. An interesting correspondance was found between *Cebus apella* chromosomes and those of the other four species. *Alouatta caraya* and *Cebus apella* are the closest species. *Callithrix jacchus* and *Aotus azarae* would have the most separated karyotypes.

Key Words: Mammalian chromosomes; Platyrrhini; New World monkeys; Chromosome comparison.

INTRODUCTION

In the last years, chromosome studies on closely related species of great apes, including man, were performed (CHU & BENDER, 1962; CHIARELLI, 1962; HAMERTON et al., 1963; TURLEAU et al., 1972; WARBURTON et al., 1973; MILLER, 1977; DUTRILLAUX & COUTURIER, 1981; DE GROUCHY, 1987). Concurrently, a more accurate chromosomal evolution through banding techniques had been observed (WARBURTON et al., 1973; EBERLE, 1975; DE GROUCHY, 1977; DE GROUCHY et al., 1977; DUTRILLAUX, 1979a, b; SEUÁNEZ, 1979; DUTRILLAUX et al., 1980; DUTRILLAUX & COUTURIER, 1981; ESTOP et al., 1983). In addition, chromosome homologies were deduced from studies of gene loci of *Aotus* and other primates and evidences on chromosome evolution were obtained (MA, 1983a, b, 1984). A small number of studies with banded karyotypes of New World monkeys were published. Among Platyrrhini, in the species of the genus *Cebus* a more similar karyotype compared with those of the common ancestor of all simians was evident (DUTRILLAUX, 1979b; COUTURIER & DUTRILLAUX, 1981). The analogies of chromosomes among *C. capucinus* and some of Ceboidea species (*C. apella*, *C. nigrivittatus*, *Saimiri sciureus*, *Lagothrix lagotricha*, or *Ateles paniscus*) using R-, C-, or Q-band techniques have previously been reported (DUTRILLAUX, 1979a; DUTRILLAUX et al., 1980; DUTRILLAUX & COUTURIER, 1981; COUTURIER & DUTRILLAUX, 1981; COCHET et al., 1982).

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Following with this line of study, in this particular paper we have compared the results of G-banding technique from peripheral blood of *Cebus apella*, *Saimiri sciureus*, *Alouatta caraya*, *Aotus azarae*, and *Callithrix jacchus* in order to determine the possibility of a relationship between chromosomes or chromosomic arms from these species.

MATERIALS AND METHODS

A total of 82 individuals from five species of the superfamily Ceboidea have been studied: *Cebus apella* ($N = 33$), *Alouatta caraya* ($N = 11$), *Aotus azarae* ($N = 14$), *Saimiri sciureus* ($N = 23$), and *Callithrix jacchus* ($N = 1$) (Table 1). The present study takes into account the measurements and chromosome banding patterns from the above mentioned animals. The numbering of chromosome pairs and their classification were previously published (MUDRY DE PARGAMENT et al., 1981, 1982a, b, 1984a, b, c; MANTECON et al., 1984). The references for geographic distribution of the examined specimens is given in Table 1. Chromosome studies were carried out after lymphocyte cultures were taken by conventional methods (BUCKTON & EVANS, 1973). Trypsin banding procedure with Giemsa stain (SEABRIGHT, 1971) was used for each species.

RESULTS

Modal numbers, chromosomal formulas, and secondary constrictions from the analyzed species are shown in Table 2. Four metacentric chromosomes were observed in *Alouatta caraya*, *Saimiri sciureus*, *Callithrix jacchus*, and *Cebus apella*. The Y chromosome is acrocentric (A) in four of the genera, except in *Aotus azarae* where a *t*(Y; 23) was seen (MUDRY DE PARGAMENT et al., 1984c).

Table 1. Data on the source and sex of the examined animals.

Species/subspecies	No. of studied animals	Sex		Source
		Male	Female	
Alouatta caraya	11	9	2	(Chaco) Argentina
Aotus azarae azarae	8	7	1	(Formosa) Argentina
Aotus azarae boliviensis	6	3	3	(Sta. Cruz de la Sierra) Bolivia
Callithrix jacchus	1	—	1	Brazil
Cebus apella vellerosus	8	4	4	(Misiones) Argentina
Cebus apella paraguayanus	7	6	1	(Misiones) Argentina
Cebus apella paraguayanus	18	9	9	(South western) Paraguay
Saimiri sciureus	23	14	9	(Sta. Cruz de la Sierra) Bolivia

Table 2. Modal number, chromosomic formula, and secondary constrictions of the analyzed species.

Species/subspecies	Modal number	Chromosomic formula			Secondary constrictions	
		Autosomas	Sex chromosomes		Chromosome	
			X	Y	*N*	Morphology
Alouatta caraya	2n = 52	4M-16SM-30A	SM	A	21-22-24	A
Aotus azarae	2n = 50	6M-16SM-26A	M-SM	—	6	SM
	2n = 49		M-SM	*t* (Y; 23)	6	SM
Callithrix jacchus	2n = 46	4M-27SM-13A	SM	A	18	A
Cebus apella	2n = 54	4M-8SM-40A	SM	A	22-23	A
Saimiri sciureus	2n = 44	4M 28SM-10A	SM	A	13	SM

SM: Submetacentric chromosome; M: metacentric chromosome; A: acrocentric chromosome.

Table 3. Chromosomic homologies in the five studied species.

C. apella	*S. sciureus*	*A. caraya*	*A. azarae*	*C. jacchus*
t (1p; 17q)	1	inv (1)	1	*t* (2p; 15q)
2	—	*t* (2q; 25q)	—	—
ter del (3)	3	4	2	ter del (7)
4	5	3	4	4
5	inv (4)	—	3	—
6	6	5	6	—
7	7	10	5	—
8	8	—	—	5
9	15	18	—	—
10	16	—	—	20
18	—	17	17	13
19	—	6	inv (7)	—
20	—	inv (15)	—	inv (9)
21	—	—	21	—
22	19	—	—	17
23	—	21	—	18
26	—	—	—	21
—	14	—	—	12
—	17	16	—	16
—	—	12	15	—
—	—	19	inv (14)	—
—	—	20	—	19
—	—	24	24	—
X	X	X	X	X
Y	Y	Y	—	Y

t: Translocations; ter del: terminal deletions; inv: inversions.

Table 3 shows the relation among G-banding chromosome patterns of these New World monkeys. Six inversions, two terminal deletions, and three translocations were found among the five species analyzed (Fig. 1).

DISCUSSION

In the present paper, we found homologies in full chromosomes and full chromosome arms in five species of New World monkeys using G-banding patterns. A similar X chromosome was found in all the analyzed species. The Y chromosomes from *Cebus apella*, *C. jacchus*, *S. sciureus*, and *A. caraya* are also identicals (Fig. 1). These results are in agreement with those previously reported (KOIFFMAN, 1982; PEIXOTO & PEDREIRA, 1982). As regards the Y chromosome of *Aotus azarae*, a *t*(Y; 23) was published by MA et al. (1976) in *Aotus* of different geographic regions, and a similar finding was reported by us in *Aotus* of Argentina and Bolivia (MUDRY DE PARGAMENT, 1984a). Furthermore, this study showed that only two autosomes have the most consistent presence in these five species (Fig. 1).

Cebus apella showed the major chromosome homology with the other four studied species.

Table 4. Number of homologous chromosome pairs among the five compared species.

Species	*C. apella*	*S. sciureus*	*A. caraya*	*A. azarae*	*C. jacchus*
C. apella	—	12	14	10	13
S. sciureus	13	—	9	7	11
A. caraya	14	9	—	11	11
A. azarae	11	7	11	—	6
C. jacchus	13	10	10	5	—

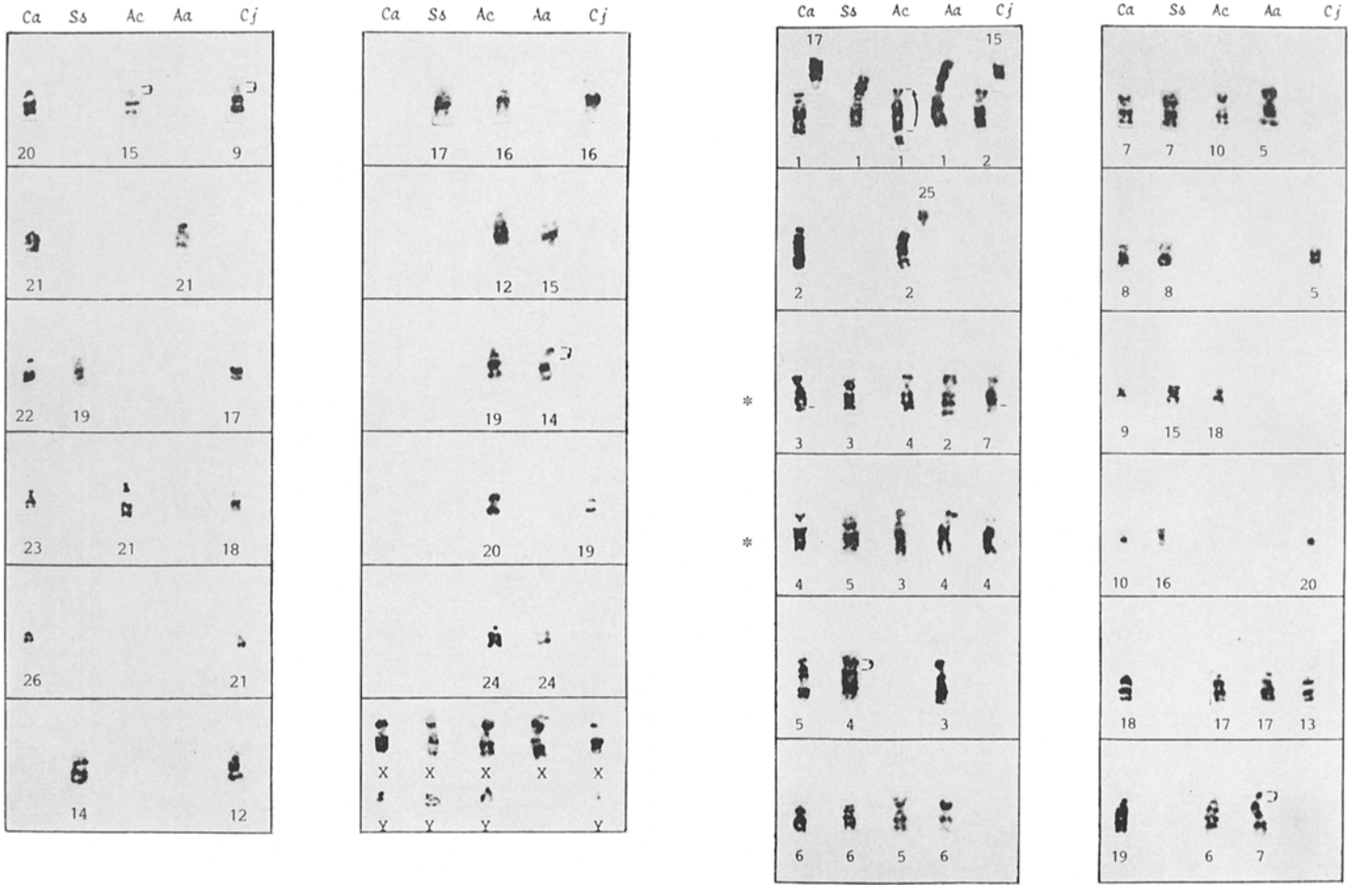

Fig. 1. Comparison of Giemsa patterns between chromosomes of *Cebus apella* (Ca), *Saimiri sciureus* (Sc), *Alouatta caraya* (Ac), *Aotus azarae* (Aa), and *Callithrix jacchus* (Cj). →: Inversions; —: terminal deletions; *the only two autosomes with consistent presence in these five species.

However, some chromosomes showed a completely different morphology and G-banding pattern. Among them, it is of note that chromosome No. 11 of *C. apella* (Fig. 1) has a clearly different G-banding pattern and has not counterpart in any other of these species. This is in agreement with the pattern showed by other authors (TORRES DE CABALLERO et al., 1976; MATAYOSHI et al., 1986).

The most frequent rearrangement was pericentric inversion. It is similar to those previously discussed in reference to specific rearrangements in different phyla (DUTRILLAUX, 1979a; SEUÁNEZ, 1979; DUTRILLAUX et al., 1986; DE GROUCHY, 1987) as well as in different specimens of *Cebus apella* (GARCÍA et al., 1978; MUDRY DE PARGAMENT & SLAVUTSKY, 1987). It is difficult to assert exactly all the possible structural rearrangements involved in this karyotypic relationship within the various taxa analyzed in this study (DE BOER, 1974). However, we consider that *Alouatta caraya* and *Cebus apella* are the closest species, with the nearest modal number and the similar pairs with secondary constrictions with chromosome No. 14 in closest resemblance (Table 4). It is not clear by what rearrangement their complements are related. Possibly a first translocation between the long arms of chromosome No. 1 and No. 7 of *Cebus apella* originated chromosome No. 1 of *Alouatta caraya*. The step for evolution from 2n = 53 to 2n = 52 is not known by the present authors. On the other hand, the most disparate karyotypes, taking into account these chromosomic comparisons would be those of *C. jacchus* and *A. azarae*, as they show only five similar chromosomes.

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