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Chromosomal Number and Evolution in two Brazilian Species of *Callithrix*

The Karyotypes of the Brazilian marmosets *C. jacchus* and *C. penicillata* are very similar. Both have $2n = 46$. *C. jacchus* has one more metacentric pair and *C. penicillata* has one more submetacentric pair, while the sex chromosomes show distinct morphological differences.

On the basis of the chromosome complement of these species some considerations about the process of chromosomal evolution are presented.

A short comparative study of these and other species of the same genus shows that basic mechanisms such as centric fusion and pericentric inversions can explain the observed morphologic chromosomal variations.

1. Introduction

Some authors have suggested that there is no variation in chromosomal number among the species of the same genus in Platyrrhini. Chu & Bender (1962) did not find any differences in the groups they studied. However, later research showed numeric variations in more than one species of the genus *Callithrix* (Table 1). This intrageneric variation does not permit conclusions about possible evolutionary mechanisms without consideration of structural variations in certain chromosomes. In addition different genera may have the same numbers as, for example, *Callithrix jacchus*, *Leontocebus rosalia* and *Homo sapiens*, all with 46 chromosomes; and *Pongo pygmaeus*, *Gorilla gorilla* and *Pan troglodytes* with 48 chromosomes. Really more important to evolutionists is variation of the acrocentric-metacentric relation, as pointed out by Clarke (1964) Hamerton (1963), Klingler (1963) and Chiarelli (1969) etc. In examining primate chromosomes, it appears that the decrease in the total number of chromosomes is related to the increase in the number of metacentric chromosomes at the expense of acrocentric chromosomes. The Robertsonian theory of centric fusion rests upon this mechanism.

Many authors point to the lower number of acrocentrics as a sign of specialization, e.g. *Ateles* is "highly specialized" among the Platyrrhini because of its karyotype of only 34 diploid chromosomes and a small number of acrocentrics. (Bender & Chu, 1962).

In the genus *Callithrix* we find *C. chrysoleucos* with 46 chromosomes: 10 acrocentrics, 30 submetacentrics and 4 metacentrics, X submetacentric and Y metacentric. In three other species of the same genus, *C. pygmaea*, *C. aurita* and *C. argentata*, there is a reduction of the total number. The diploid set consists of 44: 10 acrocentrics, 28 submetacentrics 4 metacentrics, X submetacentric and Y acrocentric. (Bender & Mettler, 1960; Chiarelli, 1963; Egozcue Benirschke, 1969).

The intrageneric changes observed may be due to reciprocal translocations, pericentric inversions, centric fusions, isochromosomes, meiotic non-disjunction, as shown by researchers on chromosomal evolution of species.

The variations mentioned in this example seem to be due to centric fusion, with the probable loss of 1 chromosome (*C. pygmaea*, *C. aurita*, *C. argentata*).

Hsu & Benirschke (1967) believe that in *C. pygmaea* two acrocentrics may have joined together resulting in a new submetacentric element. Because of their numeric reductions in the chromosomal complement and concomitant acrocentric reduction, *C. pygmaea*,

Table 1. Variation in chromosomal number among species of the same genus

Species	Number	M	S	A	X	Y	Author
<i>C. jacchus</i>	46	4	28	12	S	A	Chiarelli*
<i>C. jacchus</i>	46	4	28	12	S	A	Benirschke*
<i>C. chrysoleucos</i>	46	4	30	10	S	M	Bender*
<i>C. pygmaea</i>	44	4	28	10	S	A	Benirschke*
<i>C. pygmaea</i>	44	4	28	10	S	A	Egozcuc*
<i>C. aurita</i>	44	4	28	10	S	M	Egozcuc*
<i>C. argentata</i>	44	4	28	10	S	M	Egozcuc*
<i>C. penicillata</i>	46	2	28	14	M	S	Pedreira & Peixoto (1972)
<i>C. jacchus</i>	46	4	26	14	S	M	Pedreira & Peixoto (1972)

* In Egozcuc *et al.* (1968).

C. aurita and *C. argentata* would show some specialization in comparison with others of the same genus.

In *C. chrysoleucos* the number of acrocentrics, but not the number of the chromosomal set, is reduced.

Results of chromosomal analysis on two Brazilian species, *C. penicillata* and *C. jacchus* have been presented elsewhere. The present analysis aims at comparing our findings with other work on the subject and to examine possible evolutionary mechanisms of speciation in the genus *Callithrix*.

External characteristics of these two species are very similar in many aspects and hence are not a basis for systematics. The characteristics most frequently shown by taxonomists are the preauricular hairs or black tufts of *C. penicillata* and the white auricular frame of *C. jacchus* as well as the colour of body hair, mandibular details and dental particularities. Certain morphological aspects have led some evolutionists to consider the marmoset a truly primitive primate. However, others admit that secondary specialization has occurred while these animals have kept their primitive characteristics. Hershkovitz (1966, 1970), Bender & Mettler (1958) point out the karyologic investigation as a support to taxonomic and evolutionary positions.

2. Comparison between the Karyograms of *C. penicillata* and *C. jacchus*

The karyotypes of *C. penicillata* and *C. jacchus* are almost alike; the chromosomal complements have the same total number and the number of acrocentrics is identical. Differences occur in the sex chromosomes and in the number of metacentrics (M) which is larger in *C. jacchus* than in *C. penicillata*. The X chromosome is submetacentric (S) in *C. jacchus* while in *C. penicillata* it is metacentric. The Y chromosome, the smallest of the set, is metacentric (M) in *C. jacchus* and submetacentric (S) in *C. penicillata* as shown in Plate 1.

Bender & Mettler state that these morphological classifications are somewhat arbitrary. Because a classification relying upon metrical values inspires more confidence we use the centromeric index as a support to our conclusions.

Plate 1. Comparison between (a) *C. penicillata* and (b) *C. jacchus* karyotypes. In the details, the following are shown for *C. penicillata*: A, chromosomes 17 with clear satellite; B, acrocentric autosomes in configuration of "rosette".

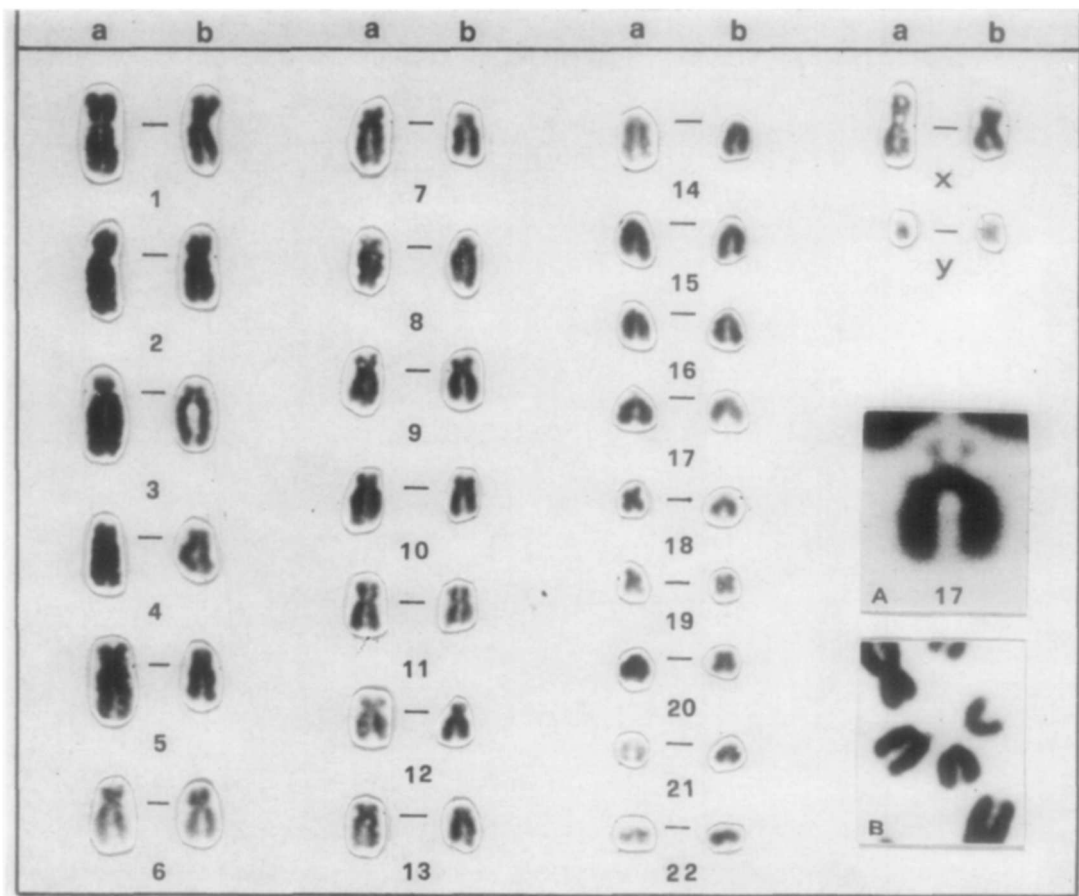


Table 2. Chromosome types in two Brazilian species according to classification of Tjio & Levan (1956)

Species	Number	M	S	A	X	Y	Author
<i>C. jacchus</i>	46	4	28	12	S	A	Chiarelli, in Egozcue <i>et al.</i> (1968)
<i>C. jacchus</i>	46	4	28	12	A	A	Benirschke, in Egozcue <i>et al.</i> (1968)
<i>C. jacchus</i>	46	4	26	14	S	M	Pedreira & Peixoto (1972)
<i>C. penicillata</i>	46	2	28	14	M	S	Pedreira & Peixoto (1972)

The small dissimilarities observed can be attributed to differences in methodology, or to intraspecific polymorphism which, as stated by Egozcue & Perkins (1969), is frequent in the primates. The observation of both polymorphism and structural abnormalities, recorded in many mammals, was not confirmed in the cells under analysis here. In the karyotypes of the two species described above as almost similar we can find few morphological variations. Pair 18 is metacentric (M) in *C. penicillata* and acrocentric (A) in *C. jacchus*. Pair 19 is submetacentric (S) in *C. penicillata* and metacentric (M) and *C. jacchus*. Pair 20 is acrocentric (A) in *C. penicillata* and metacentric (M) in *C. jacchus*. In Table 2, we can see one more metacentric chromosome in *C. jacchus* and one less submetacentric pair.

We would postulate one of two events:

- (a) the occurrence of pericentric inversion of a metacentric pair of *C. jacchus*, giving rise to one more submetacentric in the *C. penicillata* karyotype;
- (b) a submetacentric in *C. penicillata*, by the same mechanism, would change itself to metacentric, characterizing the *C. jacchus* complement.

The following would be another of the available processes of specialization in this case.

The secondary constriction in one member of pair 17, as evidenced by the presence of satellites (Plate 1, A) suggests that in *C. penicillata* this acrocentric autosome may be the nuclear organizer. Several authors including Hungerford (1964) have discussed that the association of acrocentrics by their short arms, (Plate 1) strengthens the suspicion that these elements carry nucleolus organizers and would associate by nucleolar fusion.

3. Conclusions

(1) The karyotype of *Callithrix penicillata* is $2n = 46$ chromosomes, as in other marmosets of the same genus. *C. jacchus*, a common marmoset considered a typical species of the genus, also has the same diploid number.

- (a) *C. penicillata* has one pair of metacentric autosomes (M) less than *C. jacchus*. On the other hand it has 14 submetacentric pairs (S) *C. jacchus* has only 13 submetacentrics (S). This suggest pericentric inversion of 1 M pair resulting in one more S pair, or the transformation of 1 S pair to M by the same structural alteration.
- (b) The comparative analysis of the relative size of chromosomes expressed in percentage does not offer valuable contributions to the systematicist or evolutionist's definitions. The small differences emerging in this analysis could be dismissed as due to polymorphism or several stages of chromatic contractions or also possible technical influences.

- (c) The sex chromosomes present morphologic variations. The X chromosome of *C. penicillata* is metacentric while that of *C. jacchus* is submetacentric (S). The Y chromosome is the smallest of the complement in both species and is submetacentric in *C. penicillata* and metacentric in *C. jacchus*.
- (2) Speciation seems to have occurred by simple morphological changes in the sex chromosomes and in the metacentric-submetacentric relationship.
- (3) In comparative studies with some other species of the same genus, *Callithrix penicillata* seems to follow the same evolutionary trend as *C. jacchus*, from which its karyotype differs by minimal morphological changes.
- (4) It should be remembered that the understanding of the complex evolutionary process should not be based on an isolated cytologic genetic or ecologic evaluation but on the interaction of various factors.

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