Chromosomal Evidences of Adaptive Convergence in the Tail Morphology of Neotropical Psittacidae (Aves, Psittaciformes)

Mercival Roberto Francisco¹, Vitor de Oliveira Lunardi²
and Pedro Manoel Galetti Junior^{2,*}

¹ Programa de Pós-Graduação em Ecologia e Recursos Naturais, Departamento de Genética e Evolução,
Laboratório de Citogenética, Universidade Federal de São Carlos, Brazil

² Departamento de Genética e Evolução, Laboratório de Citogenética, Universidade Federal de São Carlos,
Caixa Postal 676; 13565–905, São Carlos-SP, Brazil

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Summary Behavioral and morphological characters, as well as DNA hybridization and sequencing data strongly suggests that New and Old World Psittacidae evolved independently, supporting the tribe status for the American species (Arini). However, species and genera relationships within this group remain poorly known, and convergence was detected in various morphological characters, which could lead to artificial classifications. Most authors have subdivided Arini tribe in 2 monophyletic groups based on the comparative length of the tail, what is still controversial. In this paper we are describing for the first time the karyotypes of *Pionites leucogaster* and *Pionopsitta pileata*, both short-tail species which presented the same karyotypical pattern only previously observed to the long-tail genera. The remarkable karyotypical dichotomy presented by the Neotropical Psittacidae emphasize the existence of 2 distinct monophyletic groups within the Arini tribe. Nevertheless, the karyotypes of *P. leucogaster* and *P. pileata* short-tail species, suggests that the generalization long and short-tail is not valid to represent these both monophyletical groups, and there could occurs convergence in tail morphology character.

Key words Avian karyotype, Chromosome, Cytotaxonomy, *Pionites leucogaster*, *Pionopsitta pileata*, Psittaciformes.

The Psittaciformes order is one of the most natural among major taxa of birds, and various morphological, anatomical and behavioral characters make this group clearly distinct (Smith 1975, Sick 1997). However, despite the external variation presented by the different species, specially regarding to the plumage colorful (Forshaw 1989), the overall morphologic similarity shared among species contribute for making difficult further subdivisions. Convergences were detected in various morphological characters, such as orbital and auditory regions of the skull, bill, furcula and digestive tract anatomy, which could lead to artificial classifications (Smith 1975, Sick 1990, 1997).

Previous studies on behavioral and morphological characters (Smith 1975, Sick 1990, 1997), DNA hybridization and sequencing analyses (Sibley and Alquist 1990, Miyaki *et al.* 1998), strongly suggest that New and Old World Psittacidae evolved independently, supporting the tribe status for the American species (Arini) (Smith 1975). It has been claimed the paleogeographic cenario (Gondwanaland fission) to suggest that Neotropical species diverged from an Australasian form in the Cretaceous-Tertiary boundary (Miyaki *et al.* 1998). Neotropical parrots have been often separated in 2 groups, long-tailed and short-tailed ones (Miyaki *et al.* 1998). However, evolutionary relationships among species or even among genera are still weakly known (Sick 1990, Miyaki *et al.* 1998).

On the cytogenetical point of view, Psittacidae is one of the most studied neotropical bird fam-

* Corresponding author, e-mail: galettip@power.ufscar.br

ily (Lucca 1984, Van Dongen and De Boer 1984, Schmutz and Prus 1987, Duarte and Giannoni 1990, Lucca *et al.* 1991, Duarte and Caparroz 1995, Goldschmidt *et al.* 1997).

In general, long-tail species from genera *Ara*, *Aratinga* (Lucca 1984, Lucca *et al.* 1991), *Nandayus*, *Propyrrhura* (Francisco and Galetti Jr. in press.), *Guaruba* (Goldschmidt *et al.* 1997) and *Cyanopsitta* (Duarte and Giannoni 1990) present a very similar karyotype pattern, which is mainly characterized by a conserved pair 1 metacentric, pairs 2, 3, 4, 5, and 6 varying of submetacentric to subtelocentric, pairs 7 and 8, varying of metacentrics to submetacentrics, and pairs 9 and 10, varying of metacentric to telocentric. A different standard karyotype is observed among the short-tail species from *Amazona* genera (Aquino and Ferrari 1990, Giannoni *et al.* 1993, Duarte and Caparroz 1995), mainly characterized by pairs 1, 5, 6 and 7 telocentrics. Nevertheless, several species still have to be analyzed for better understanding of the cytotaxonomic relationships within the group.

In the present work, the karyotypes of 2 Neotropical short-tail Psittacidae species, *Pionites leucogaster* Kuhl, 1820 and *Pionopsitta pileata* Scopoli, 1769 were first described and chromosomal evidences for adaptive convergence in tail morphology are presented.

Materials and methods

Five males and one female of *Pionites leucogaster* and 2 males of *Pionopsitta pileata* captive birds owned by Ecological Park Antonio T. Vianna (São Carlos-SP, Brazil) were analyzed. The mitotic chromosomes were obtained from cells of growing feather pulps, as described elsewhere (Francisco and Galetti Jr. 2000).

Three to four young feathers with approximately 15 days old were obtained from each animal. The soft pulp tissues were removed, gently dissociated and directly transferred to Hank's solution. Five drops of 0.0025% colchicine solution were added to the cell suspension and led to incubate at 37°C for 30 min. In the next steps, the material was first led to hypotonization in 0.075 M KCl solution (37°C, 30 min.) and then 3 times fixed in methanol-acetic acid mix (3 : 1). The cell suspension was dropped on to clean slides and stained with 5% Giemsa-phosphate, pH 6.8. The chromosome typology followed Levan *et al.* (1964).

Results

P. leucogaster had a diploid number of $2n=70$, comprising macro- and micro-chromosomes. The pairs 1, 7, 8, 9 and the Z chromosome were metacentrics, pairs 3 and 5 submetacentrics, pairs 2, 4 and 6 subtelocentrics and pairs 10, 11 and the W chromosome telocentrics. Microchromosomes were telocentrics up to the point where the morphology could be identified. The Z chromosome was sized between the pairs 4 and 5 and the W chromosome between the pairs 7 and 8 (Fig. 1).

P. pileata, also with a diploid number of $2n=70$, presented the pairs 1, 7, 8, 9, 10, 11 and Z chromosome metacentrics and pairs 2, 3, 4, 5 and 6 subtelocentrics. Microchromosomes were telocentrics and the Z chromosome was sized between the pairs 4 and 5 (Fig. 2).

Discussion

Parrots of Arini tribe have been often separated in 2 monophyletic groups based on the comparative length of the tail (Miyaki *et al.* 1992, 1995, 1998). However, both short-tailed species here studied, *P. leucogaster* and *P. pileata*, presented the karyotypic pattern observed for long-tailed species from *Ara*, *Aratinga*, *Guaruba*, *Nandayus*, *Cyanopsitta* and *Propyrrhura* genera (Lucca 1984, Duarte and Giannoni 1990, Lucca *et al.* 1991, Goldschmidt *et al.* 1997, Francisco and Galetti Jr. in press.).

Fig. 1. Mitotic metaphase and female karyotype of *Pionites leucogaster*.

Fig. 2. Mitotic metaphase and male karyotype of *Pionopsitta pileata*.

The karyotype of *P. leucogaster* appears closer to the chromosome complement of *Ara chloroptera* and *Nandayus nenday* (Francisco and Galetti Jr. in press) only differing by the pair 9 metacentric and pair 10 telocentric, which are respectively telocentric and metacentric in both *A. chloroptera* and *N. nenday*. In addition, in the karyotype of *P. leucogaster* the pairs 8 and 9 are sized very similar while in the long-tail species the pair 9 has been described shorter than the pair 8 (Francisco and Galetti Jr. in press.). Considering the morphology of the chromosomes 9 and 10 of *P. leucogaster*, a translocation of part of chromosome 10 metacentric over the short arm of chromosome 9 telocentric, both typical chromosomes of *A. chloroptera* and *N. nenday*, could result the current chromosomes 9 and 10 of *P. leucogaster* and also explain the increased size of chromosome 9 related to the 8, in the latter species.

P. pileata presented a karyotype similar to those of *Guaruba guarouba* (Goldschmidt *et al.* 1997), only differing by presents a further metacentric pair (pair 11). Although *P. pileata* has also a diploid number $2n=70$, it presents the higher fundamental number found to the neotropical Psittacidae, which suggests that this karyotype pattern was derived by pericentric inversions.

Several other evidences for a higher relationship between *Pionites* and long-tail Psittacidae have been already described, such as osteological (Thompson 1900) and behavioral (Tavistock 1954 cited in Forshaw 1989, Smith 1975) similarities and species hybridization (Sick 1997).

The remarkable karyotypical dichotomy presented by the Neotropical Psittacidae emphasize the existence of 2 distinct monophyletic groups within the Arini tribe, as previously suggested by minisatellites and DNA sequencing data (Miyaki *et al.* 1992, 1995, 1998). However, the present detection, in both short-tail species studied, of a karyotype pattern only previously observed in the long-tail genera, suggest that the generalization long and short-tail is not valid to represent these both monophyletical groups. As previously suggested (Smith 1975), it is quite probably that could

occur evolutionary convergence in the tail morphology among the Neotropical Psittacidae.

Furthermore, chromosome studies has been pointed out as important in determine the success of captive propagation programs, by detecting chromosomal polymorphism (Benirschke *et al.* 1980) or sexing species which not present sexual dimorphism (Giannoni *et al.* 1993). In this way, the karyotype characterization of *P. leucogaster* and *P. pileata* also constitute an important tool for conservation intents, since both species are suffering populational reduction caused by deforestation and illegal trade, being *P. pileata* listed as locally endangered in Brazil.

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