Biological aspects of Amazonian fishes. IX. Cytogenetic studies in two species of the genus *Semaprochilodus* (Pisces, Prochilodontidae)

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Corresponding Editor: G. D. Burkholder
Received April 7, 1986
Accepted September 4, 1986

FELDBERG, E., L. A. C. BERTOLLO, L. F. DE A. TOLEDO, F. FORESTI, O. M. FILHO, and A. F. DOS SANTOS. 1987. Biological aspects of Amazonian fishes. IX. Cytogenetic studies in two species of the genus *Semaprochilodus* (Pisces, Prochilodontidae). Genome, **29**: 1–4.

The karyotype of *Semaprochilodus insignis* and *Semaprochilodus taeniurus* were analyzed through the conventional Giemsa staining, C-banding, and the nucleolar organizer regions. The diploid number is the same ($2n = 54$) in both species, but *S. taeniurus* shows a chromosomic system of the ZZ/ZW type. This and some other differences between the two karyotypes will be useful in further studies on the possible hybrid origin of the "jaraqui açú," a low frequency form that is observed together with *S. insignis* and *S. taeniurus*.

Key words: fish, ZZ/ZW system, constitutive heterochromatin, nucleolar organizing regions.

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Révélées par la coloration conventionnelle de Giemsa, les bandes C et les régions organisatrices des nucléoles ont servi à l'analyse des caryotypes des espèces *Semaprochilodus insignis* et *Semaprochilodus taeniurus*. Chez les deux espèces, le nombre diploïde est le même ($2n = 54$); toutefois, le *S. taeniurus* possède un système chromosomique de type ZZ/ZW. Cette différence entre les deux caryotypes, et certaines autres, devraient s'avérer utiles dans des études ultérieures sur l'origine hybride possible de "jaraqui açũ," une forme de faible fréquence parmi les espèces *S. insignis* et *S. taeniurus*.

Mots clés : poisons, système ZZ/ZW, hétérochromatine constitutive, régions organisatrices de nucléoles.

[Traduit par la revue]

Introduction

The genus *Semaprochilodus*, encountered only in the Amazonian basin and in the Orenoco river, is a fish of considerable economic value. From a taxonomical point of view, two species are recognized in the Negro river (State of Amazonas, Brazil), *S. insignis* and *S. taeniurus* (Mago-Leccia 1972), respectively, denoted "thick-scaled jaraqui" and "thin-scaled jaraqui." These two species migrate extensively, are usually captured in the same school, and have practically identical feeding habits and spawning sites, with partially overlapping spawning seasons. A third form, denoted "jaraqui açú," possibly a hybrid between the two species, is also encountered, though at very low frequencies (Ribeiro 1983). The karyotype constitution of these species has not been reported in the literature.

The objective of the present study was to report the karyotypes, the distribution of constitutive heterochromatin, and the location of the nucleolar organizer regions (NORs) of *S. insignis* and *S. taeniurus*, emphasizing their differences at the cytogenetical level and the importance of these results for future studies on "jaraqui açú."

Material and methods

Seventeen specimens (7 males and 10 females) of *S. insignis* and 21 specimens (11 males and 10 females) of *S. taeniurus* were analyzed. The animals were collected from lower Negro river (State of Amazonas, Brazil) near the city of Manaus.

Each animal was injected intraperitoneally with a 0.08 to 0.16% colchicine solution, 1 mL/100g body weight, and sacrificed 1 to 1.5 h later. Mitotic chromosomes from kidney cells and meiotic chromosomes from the testes were obtained by the methods described by Bertollo et al. (1978) and Bertollo and Moreira Filho (1979). C-banding and the NORs followed the procedures of Sumner (1972) and Howell and Black (1980), respectively.

Printed in Canada / Imprimé au Canada

TABLE 1. Chromosomal numbers and relative length (RL) of pairs 1 and 2 in the karyotypes of *S. insignis* and *S. taeniurus*. All the specimens had a modal chromosome number of $2n = 54$. The lowest percentage of cells without 54 chromosomes must be due to the loss of some chromosomes during the technical procedures

Species and sex	No. of animals	No. of cells	No. of chromosomes <52	52	53	54	% of cells with 54 chromosomes	RL 1st pair	RL 2nd pair
S. insignis									
♂	7	226	26	19	31	150	66.3	6.1	4.8
♀	10	400	47	50	38	265	66.3		
S. taeniurus									
♂	11	342	75	43	34	190	55.5	6.0	5.5
♀	10	395	44	40	52	259	65.6		

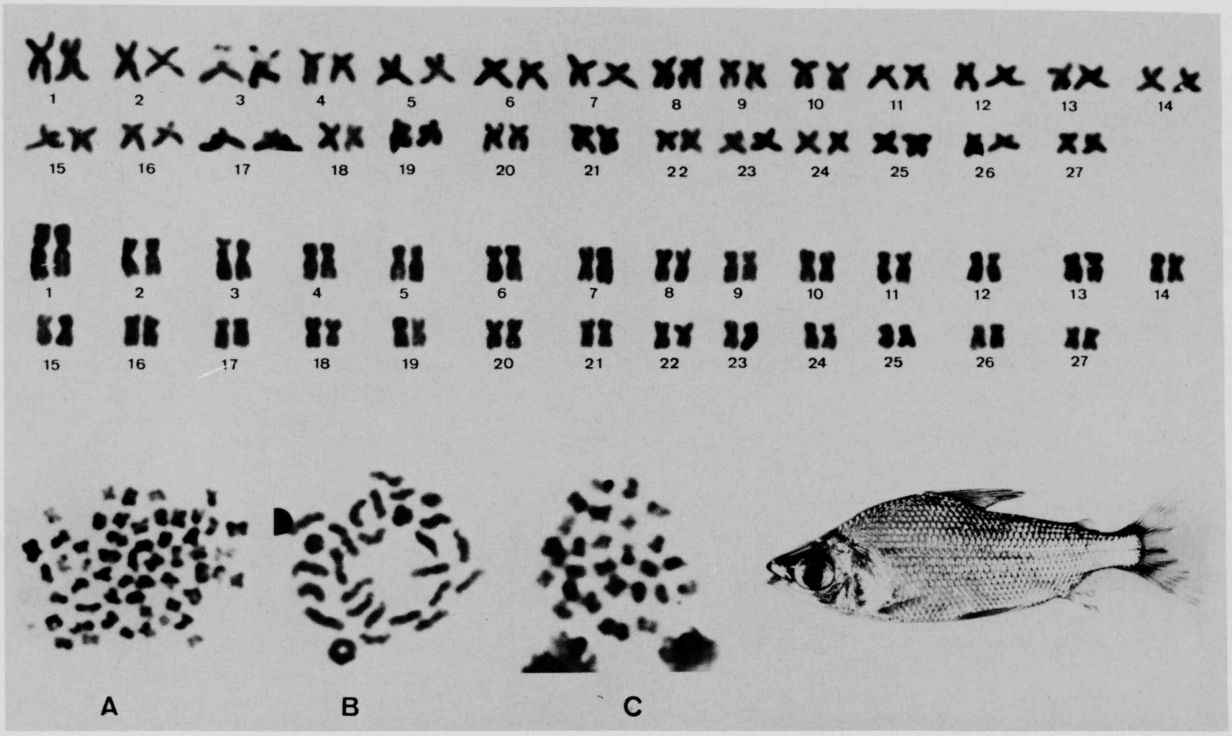

FIG. 1. Karyotypes ($2n = 54$) of female (upper row) and male (lower row) chromosomes. Meiotic chromosomes of males (A, spermatogonial metaphase; B, metaphase I; C, metaphase II) and a specimen of *S. insignis*. (10.5 cm). No heteromorphic sex chromosomes can be seen in this species. The 3rd pair shows a secondary constriction in the upper arm, which corresponds to the nucleolar organizing regions (NOR).

Results

The diploid number obtained for *S. insignis* and *S. taeniurus* was 54 chromosomes, both for males and females (Table 1). The fundamental number (FN) was 108. Figures 1 and 2 show the chromosomes grouped according to the arm ratio, into the metacentric–submetacentric category, in decreasing order of size. A heteromorphic pair can be observed in *S. taeniurus* females, which consists of a metacentric, possibly equivalent to pair no. 1 of the male, and a large metacentric, the largest in the complement and absent in the male, whereas all pairs are homomorphic in the male complement (Fig. 2).

The data obtained from the analysis of meiotic chromosomes in the males agreed with the somatic results, with 54 chromosomes in spermatogonial metaphases, 27 bivalents in metaphase I, and 27 chromosomes in metaphase II in both species (Figs. 1 and 2).

Both *S. insignis* and *S. taeniurus* have a NOR that coincides with a secondary interstitial constriction, probably on the 3rd pair in the karyotype (Figs. 3B and 4B).

The C-banding pattern of both species is characterized by the presence of C-positive blocks in the pericentromeric regions of all chromosomes. In addition, *S. insignis* has a submetacentric chromosome pair with mostly heterochromatic short arms. *Semaprochilodus taeniurus* has a chromosome pair with telomeric blocks in both arms, in addition to the large odd metacentric chromosome of females that is largely heterochromatic (Figs. 3A and 4A).

Discussion

Comparative analyses of the karyotypes of *S. insignis* and *S. taeniurus* shows the occurrence of a chromosome system of sex determination of the ZZ/ZW type in *S. taeniurus*. Chromosome

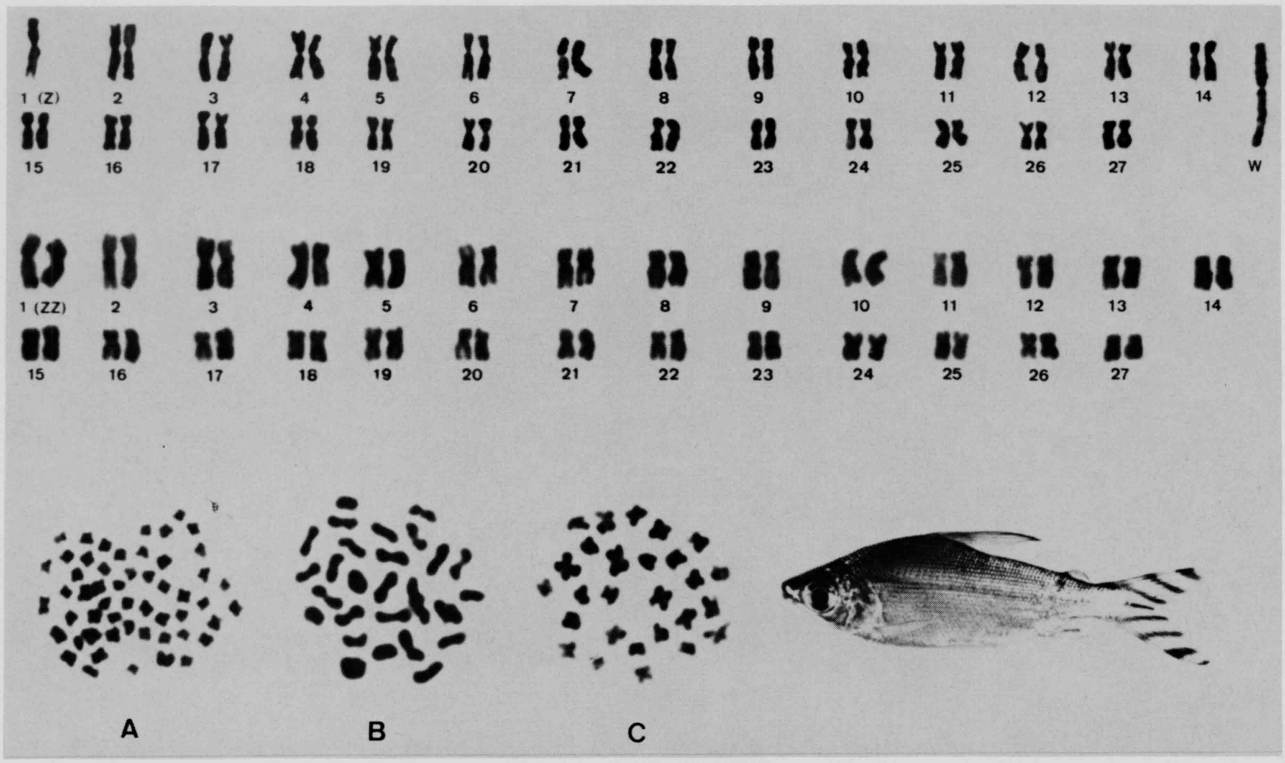

FIG. 2. Karyotypes ($2n = 54$) of female (upper row) and male (lower row) chromosomes. Meiotic chromosomes of males (A, spermatogonial metaphase; B, metaphase I; C, metaphase II) and a specimen of *S. taeniurus* (10.0 cm). A ZZ/ZW system is detected in this species. The 3rd pair also shows a secondary constriction on the upper arm, more evident in the karyotype of the female, corresponding to the NOR location.

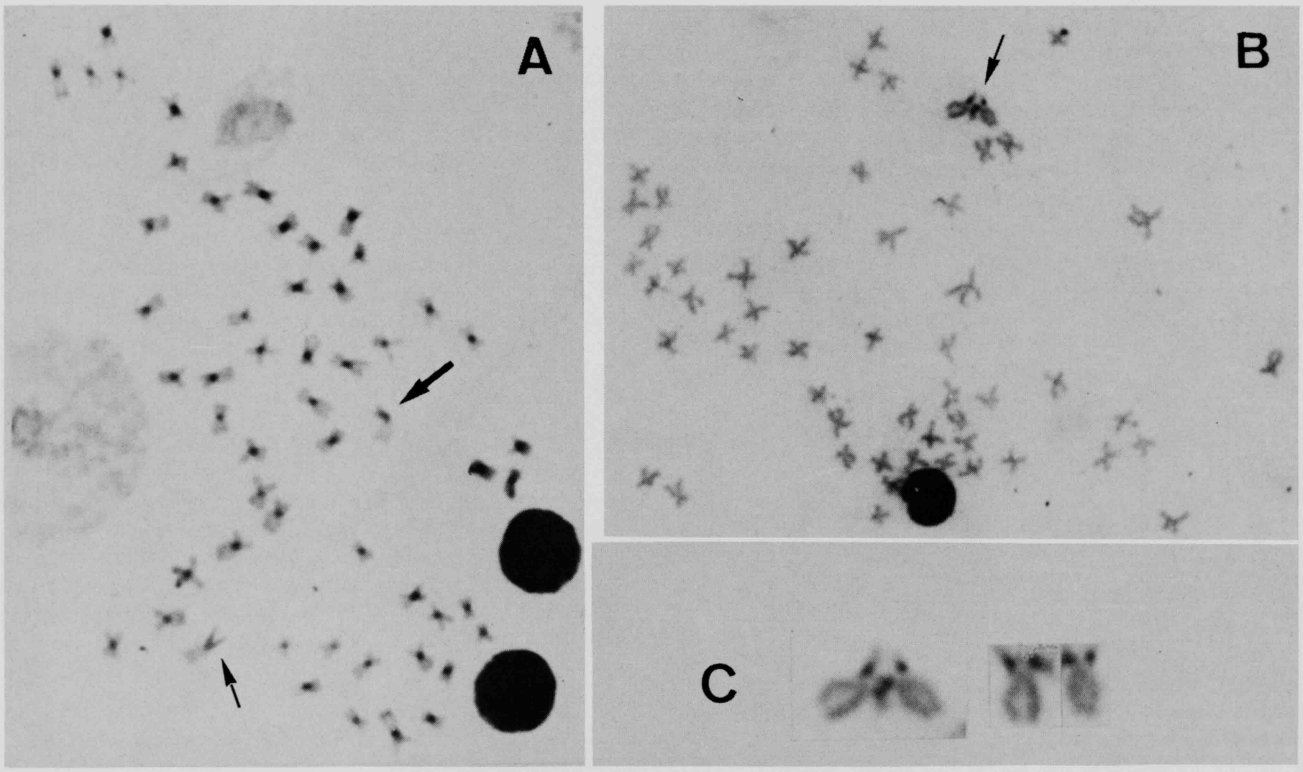

FIG. 3. Somatic metaphases of *S. insignis* showing (A) the C-banding pattern (the arrows indicate the pair with heterochromatin in short arms) and (B) and (C) the chromosomes bearing NORs.

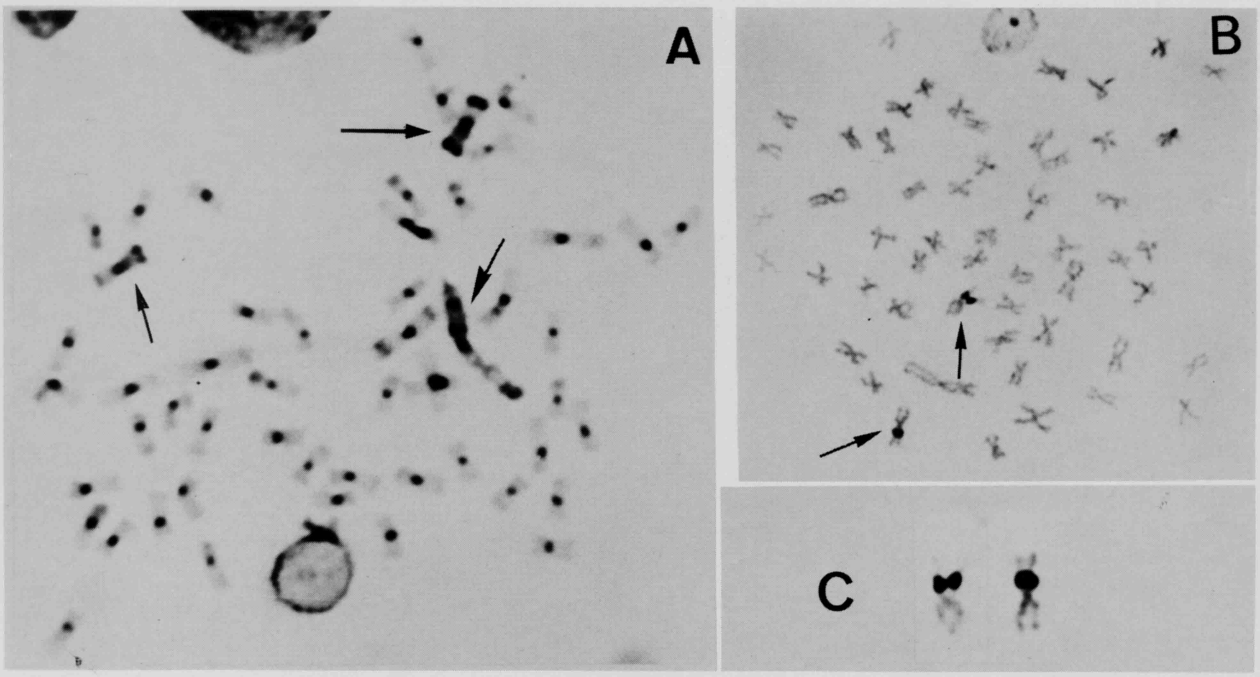

FIG. 4. Somatic metaphases of *S. taeniurus* showing (A) the C-banding pattern (the arrows indicate the odd W chromosome of the female and the pair with telomeric heterochromatin blocks) and (B) and (C) the chromosomes bearing NORs.

W, present in the females of this species, is the largest in the complement and almost entirely C positive. Chromosome Z is the next largest in the complement and was tentatively considered as pair no. 1 in the male. The location and distribution of C-positive regions in this heteromorphic pair suggests that the differentiation of chromosome W may have occurred by a process of heterochromatin addition, as suggested from some species of *Leporinus* (Galetti 1984). No chromosomal sex differentiation was observed in *S. insignis*.

Analysis of chromosome morphology in the two species showed a difference with respect to the relative size of pairs 1 and 2, with a more marked difference in relative size between these pairs in *S. insignis* than in *S. taeniurus* (Table 1). The C-banding patterns also reveals some differences between the two species, showing a marker chromosome pair with heterochromatin in the short arms in *S. insignis* and with an heterochromatic block in the telomeric regions of the two arms in *S. taeniurus*. The NOR is probably located in the same chromosome pair both in *S. insignis* and *S. taeniurus*. As often C-banded material is associated with NORs, an integrated banding procedure (C and NOR) would be desirable to test if the chromosome pairs with additional heterochromatic regions have some relation with the nucleolar chromosomes. The morphology and relative size of these chromosomes do not lead up to a clear conclusion about this question.

The karyotypic characteristics of the two species clearly show the existence of markers both in terms of chromosome morphology and location of constitutive heterochromatin and in terms of the sex-determination mechanism, a fact that may be of great help in clarifying the possible hybrid origin of jaraqui açú, in future studies.

Acknowledgements

This work was supported by Superintendência do Desenvolvimento da Amazônia/Polamazônia/Conselho Nacional de Desenvolvimento Científico a Tecnológico/Programa Integrado de Genética. The authors are grateful to Otacílio Soares da Silva who helped during the fishing and to Jorge Saldanha who helped with the figures.

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