Brazilian Journal of Genetics, 19, 3, 421-427 (1996)
(Revista Brasileira de Genética)

REVIEW ARTICLE

Cytogenetic studies of Brazilian marine fish

Mario Jorge Ignacio Brum

ABSTRACT

The available data on the karyotypes of marine fish occurring along the Brazilian coast were reviewed. The species investigated are representatives of the orders Clupeiformes, Siluriformes, Atheriniformes, Scorpaeniformes, Perciformes and Tetraodontiformes. This review provides data on chomosome numbers, sex and meiotic chromosomes, chromosome banding patterns, DNA content. Systematic implications are discussed. The chromosomes of 44 species found in Brazilian oceanic waters have been investigated thus far. The Perciformes are the best known, with 28 species, while the other fish groups are poorly known.

INTRODUCTION

Few cytogenetic studies of Brazilian coastal marine fish have been made when compared to freshwater species (Oliveira *et al.*, 1988). Of the thousands of fish species found in the Brazilian oceanic waters, the chromosomes of only 44 species have been investigated so far. This review summarizes and comments on all the available, but widely scattered data.

Analysis of data

The 44 species karyotyped so far from the coast of Brazil belong to six orders, 23 families and 38 genera (Table I). All of them belong to the class Osteichthyes and the infraclass Teleostei. The order Perciformes, the largest among fishes, comprising almost 9,300 species, of which about 75% are coastal marine (Nelson, 1994), is the group with the largest number of species investigated, 28, followed by five species of Siluriformes and four species of Scorpaeniformes. The most extensively studied families, with five species investigated, include Ariidae, Serranidae, Carangidae and Sciaenidae. Among the genera, *Brevoortia, Scorpaena, Diplectrum, Trachinotus, Menticirrhus* and *Sphoeroides* are the most extensively studied, with two species investigated in each.

Of the 44 species karyotyped so far (Table II), 34 were from specimens captured along the coast of Rio de Janeiro, nine from São Paulo and two from Rio Grande do Sul State. *Micropogonias furnieri* was the only species for which the specimens investigated originated from two locations, Rio de Janeiro and São Paulo.

Somatic karyotypes: chromosome numbers and karyotype morphology

Most of the species investigated (25) have diploid complements with 2n = 48 (Table II), 19 of them having karyotypes composed exclusively of uniarmed chromosomes, and so with a fundamental number (FN value) equal to 48. However, this general statement is undoubtedly due to the fact that the Perciformes species, which show a tendency to maintain this karyotype (Ohno *et al.*, 1968; Cataudella and Capanna, 1973; Alvarez *et al.*, 1986), dominate the karyotyped marine species of the region.

With respect to the clupeiform species from Brazilian coast, the few data obtained agree with the available karyotypic data from other localities. Although a considerable diversity of diploid numbers

Universidade Federal do Rio de Janeiro, Instituto de Biologia, Departamento de Zoologia, 21941-590 Rio de Janeiro, RJ, Brasil.

Table I - Marine fishes occurring along the Brazilian coast karyotyped to date. **Epinephelus marginatus, Mycteroperca acutirostris* and *Stephanolepis hispidus* were reported under names *Epinephelus guaza, Mycteroperca rubra* and *Monacanthus hispidus*, respectively.

Order	Family	Genus	Species	Common names
Clupeiformes	Clupeidae	*Brevoortia*	*Brevoortia aurea*	savelha
			Brevoortia pectinata	savelha
Siluriformes	Ariidae	*Bagre*	*Bagre bagre*	sarí-sarí
		Cathorops	*Cathorops* sp	congo
		Genidens	*Genidens genidens*	pareré
		Netuma	*Netuma barba*	bagre-branco
		Arius	*Arius parkeri*	cangatá
Atheriniformes	Atherinidae	*Odontesthes*	*Odontesthes* sp	peixe-rei
	Dactylopteridae	*Dactylopterus*	*Dactylopterus volitans*	peixe-voador
Scorpaeniformes	Scorpaenidae	*Scorpaena*	*Scorpaena brasiliensis*	mangangá
			Scorpaena isthmensis	mangangá
	Triglidae	*Prionotus*	*Prionotus punctatus*	cabrinha
Perciformes	Centropomidae	*Centropomus*	*Centropomus parallelus*	robalo
	Serranidae	*Diplectrum*	*Diplectrum formosum*	michole-de-areia
			Diplectrum radiale	michole-de-areia
		Epinephelus	*Epinephelus marginatus**	garoupa-verdadeira
		Mycteroperca	*Mycteroperca acutirostris**	badejo-mira
		Serranus	*Serranus flaviventris*	mariquita
	Priacanthidae	*Priacanthus*	*Priacanthus arenatus*	olho-de-cão
	Pomatomidae	*Pomatomus*	*Pomamatomus saltatrix*	enchova
	Carangidae	*Caranx*	*Caranx latus*	guarajuba
		Chloroscombrus	*Chloroscombrus chrysurus*	palombeta
		Selene	*Selene setapinnis*	peixe-galo
		Trachinotus	*Trachinotus carolinus*	pampo-verdadeiro
			Trachinotus falcatus	sernambiquara
	Gerreidae	*Eucinostomus*	*Eucinostomus gula*	carapicu
	Haemulidae	*Orthopristis*	*Orthopristis ruber*	cocoroca
	Sparidae	*Diplodus*	*Diplodus argenteus*	marimbá
	Sciaenidae	*Menticirrhus*	*Menticirrhus americanus*	papa-terra
			Menticirrhus litoralis	papa-terra
		Micropogonias	*Micropogonias furnieri*	corvina
		Cynoscium	*Cynoscium acoupa*	pescada-amarela
		Umbrina	*Umbrina coroides*	castanha-riscada
	Argentinidae	*Mullus*	*Mullus argentinae*	trilha
	Pomacentridae	*Abudefduf*	*Abudefduf saxatilis*	sargento
	Mugilidae	*Mugil*	*Mugil liza*	tainha
	Sphyraenidae	*Sphyraena*	*Sphyraena tome*	bicuda
	Labridae	*Bodianus*	*Bodianus rufus*	bodião
	Blenniidae	*Parablennius*	*Parablennius pilicornis*	maria-da-toca
		Scartella	*Scartella cristata*	maria-da-toca
Tetraodontiformes	Balistidae	*Cantherhines*	*Cantherhines macrocerus*	peixe-porco
		Stephanolepis	*Stephanolepis hispidus**	peixe-porco
	Tetraodontidae	*Sphoeroides*	*Sphoeroides greeleyi*	baiacu-pinima
			Sphoeroides spengleri	baiacu

Table II - Chromosome numbers and karyotypes of the marine fishes occurring along the Brazilian coast (for FN estimates, metacentric and submetacentric chromosomes are the only ones considered to be armed).

Species	Locality	n	2n	Chromosome types				FN	Sex chromosomes	References
				m	sm	st	a			
Brevoortia aurea ♀	L.R. de Freitas, RJ	23	46	2	2		42	50	$X_1X_1X_2X_2$	Brum *et al.*, 1992a
Brevoortia aurea ♂	L.R. de Freitas, RJ	23,22	45	3	2		40	50	X_1X_2Y	Brum *et al.*, 1992a
Brevoortia pectinata	L. Marapendí, RJ	-	46	2	2		42	50	-	Brum *et al.*, 1992b
Bagre bagre	Cananéia, SP	-	56	24	26	6	-	106	-	Gomes *et al*, 1990
Cathorops sp.	Cananéia, SP	27	54	13	13	28	-	80	-	Gomes *et al*, 1992
Genidens genidens	Cananéia, SP	28	56	12	20	20	4	88	-	Gomes *et al*, 1994
Netuma barba	Cananéia, SP	28	56	18	18	18	2	92	XX/XY	Gomes *et al*, 1994
Arius parkeri	Cananéia, SP	28	56	16	16	22	2	88	-	Gomes *et al*, 1994
Odontesthes sp.	Estuário R. Grande, RS	-	48	2-4		46-44		50-52	-	Brugger *et al.*, 1990
Dactylopterus volitans	Baía da Guanabara, RJ	-	48	16	14	6	12	78	-	Corrêa *et al.*, 1995
Scorpaena brasiliensis	Baía da Guanabara, RJ	-	46	4	10	14	18	60	-	Corrêa *et al.*, 1995
Scorpaena isthmensis	Baía da Guanabara, RJ	-	40	6	8	2	24	54	-	Corrêa *et al.*, 1994a
Prionotus punctatus	Baía da Guanabara, RJ	-	100-102	-	-	100-102		100-102	-	Corrêa *et al.*, 1995
Centropomus parallelus	Estado do R. Janeiro	-	48	-	-	-	48	48	-	Pauls *et al.*, 1995b
Diplectrum formosum	Baía da Guanabara, RJ	-	48	-	2	-	46	50	-	Brum *et al.*, 1992b
Diplectrum radiale	Baía da Guanabara, RJ	-	48	-	-	-	48	48	-	Brum *et al.*, 1991
Epinephelus marginatus	Baía da Guanabara, RJ	-	48	-	-	-	48	48	-	Brum *et al.*, 1992b
Mycteroperca acutirostris	Baía da Guanabara, RJ	-	48	-	-	-	48	48	-	Aguilar, 1993
Serranus flaviventris	Baía da Guanabara, RJ	-	48	-	-	-	48	48	-	Aguilar, 1993
Priacanthus arenatus	48°W; 23°S, RJ	-	50	-	-	-	50	50	-	Pauls and Coutinho, 1990
Pomatomus saltatrix	Litoral fluminense	-	48	-	-	-	48	48	-	Pauls *et al.*, 1991
Caranx latus	48°W; 23°S, RJ	-	46	-	-	-	46	46	-	Pauls and Coutinho, 1990
Chloroscombrus chrysurus	48°W; 23°S, RJ	-	48	-	-	-	48	48	-	Pauls and Coutinho, 1990
Selene setapinnis	48°W; 23°S, RJ	-	46	-	2	-	44	48	-	Pauls and Coutinho, 1990
Trachinotus carolinus	São Sebastião, SP	-	48	8		40		56	-	Zenaid and Almeida-Toledo, 1994
Trachinitus falcatus	São Sebastião, SP	-	48	10		38		58	-	Zenaid and Almeida-Toledo, 1994
Eucinostomus gula	48°W; 23°S, RJ	-	48	-	-	-	48	48	-	Pauls and Coutinho, 1990
Orthopristis ruber	Baía da Guanabara, RJ	-	48	-	2	36	10	50	-	Brum, 1994
Orthopristis ruber	Litoral fluminense	-	48	-	-	-	48	48	-	Pauls *et al.*, 1991
Diplodus argenteus	48°W; 23°S, RJ	-	48	-	-	-	48	48	-	Pauls and Coutinho, 1990
Menticirrhus americanus	Cananéia, SP	24	48	-	-	-	48	48	-	Gomes *et al.*, 1983b
Menticirrhus litoralis	Costa do R. G. do Sul	-	48	-	-	-	48	48	-	Reggi *et al.*, 1986
Micropogonias furnieri	Cananéia, SP	24	48	-	-	-	48	48	-	Gomes *et al.*, 1983a
Micropogonias furnieri	48°W; 23°S, RJ	-	46	-	-	-	46	46	-	Pauls and Coutinho, 1990
Cynoscium acoupa	48°W; 23°S, RJ	-	48	-	-	-	48	48	-	Pauls and Coutinho, 1990
Umbrina coroides	48° W; 23°S, RJ	-	46	-	4	-	42	50	-	Pauls and Coutinho, 1990
Mullus argentinae	Litoral fluminense	-	44	-	2	-	42	46	-	Pauls *et al.*, 1991
Abudefduf saxatilis	Baía da Guanabara, RJ	-	48	2	2	-	44	52	-	Corrêa *et al.*, 1994b
Mugil liza	48°W; 23°S, RJ	-	48	-	-	-	48	48	-	Pauls and Coutinho, 1990
Sphyraena tome	48°W; 23°S, RJ	-	48	-	-	-	48	48	-	Pauls and Coutinho, 1990
Bodianus rufus	Litoral fluminense	-	48	-	-	-	48	48	-	Pauls *et al.*, 1991
Parablennius pilicornis	Baía da Guanabara, RJ	-	48	-	-	-	48	48	-	Brum *et al.*, 1992b
Scartella cristata	Baía da Guanabara, RJ	-	48	-	2	26	20	50	-	Brum *et al.*, 1994a
Cantherhines macrocerus	Estado do R. de Janeiro	-	40	-	-	-	40	40	-	Pauls *et al.*, 1995a
Stephanolepis hispidus ♀	48°W; 23°S, RJ	17	34	-	-	-	34	34	$X_1X_1X_2X_2$	Pauls, 1993
Stephanolepis hispidus ♂	48°W; 23°S, RJ	17, 18	33	-	1	-	32	34	X_1X_2Y	Pauls, 1993
Sphoeroides greeleyi	Baía da Guanabara, RJ	-	46	±24		±22		±70	-	Brum *et al.*, 1994b
Sphoeroides spengleri	Baía da Guanabara, RJ	-	46	±18		±28		±64	-	Brum *et al.*, 1994b

has been observed (2n = 28-54) in this group, it seems quite likely that these variations are derived from a karyotype of 2n = 48 one-armed chromosomes (Doucette Jr. and Fitzsimons, 1988).

On the other hand, the karyotypes in Atheriniformes are also considered to derive from the 48 acrocentrics karyotype, even when they exhibit diploid numbers and/or FN values differing from 48. The available karyotypic data are consistent with taxonomic organization, indicating a close kinship between this group and Perciformes (Brum, 1995).

In terms of karyotypic diversification, the most conspicuous group is Scorpaeniformes, in which each of the four karyotyped species has not only different diploid numbers (40, 46, 48 and 100-102) but also different arm numbers (54, 60, 78 and 100-102). This fact seems to agree with the data obtained for representatives of Scorpaeniformes from the other locations, documenting the application of cytogenetics in the taxonomy of the group (Corrêa, 1995). The reasons for this diversification of Scorpaeniformes could be the same as those for the freshwater fishes. Since representatives of Scorpaeniform, in general, occur in benthonic habits, they not form schools, they have smaller and more isolated populations, they present a greater karyotype diversity, as opposed to the karyotypic uniformity present in marine species in general (Brum, 1994).

On the other hand, in the marine species of Siluriformes, what varies is mainly the number of chromosome arms, since these species have different FN values (88, 92 and 106), with the same diploid number (2n = 56) in four of the species karyotyped. This may reflect the evolutionary history of the group, since the Siluriformes are primarily a freshwater group, thus presenting the characteristic of diversification of the species from this type of environment (Oliveira *et al.*, 1988).

In the Brazilian species of Tetraodontiformes karyotyped so far the diploid numbers 33/34 and 40 (Balistidae) and 46 (Tetraodontidae) can be observed. The phylogenetic and karyotypic data available for Tetraodontiformes suggest that there may be two major chromosome evolution pathways in this group (Brum, 1995): the line of Triacanthidae, the most primitive, where 2n = 48 appears to be a common feature among species (Choudhury *et al.*, 1982) and a more specialized one, formed by balistids and tetraodontids, among others, where 2n = 46 might be considered the plesiomorphic condition (Arai and Nagaiwa, 1976). As suggested in Arai and Nagaiwa (1976), the values 2n < 46 observed in Balistidae, for example, probably resulted of centric fusions.

Of all species karyotyped so far, only two were investigated by different authors (*Orthopristis ruber* and *Micropogonias furnieri*), with a discrepancy in results occurring in both cases. In *O. ruber*, the discrepancy concerned the quantification of chromosome types, yielding two different FN values (48 and 50). Since the specimens were all from the coast of Rio de Janeiro, these variations may perhaps be attributed to technical artifacts. With respect to *M. furnieri*, the differences were more conspicuous, since they involve the diploid numbers (46 and 48). In this case the specimens were from different locations (Rio de Janeiro and São Paulo), so we may infer an interpopulational chromosome variation, or even a case of cryptic species.

Chromosome banding patterns and DNA contents

The locations of nucleolar organizer regions (NORs) were studied in 12 species (Table III). The predominant chromosomal NOR phenotypes include a single NOR-bearing pair classified as one of the largest in the complements, with telomeric to interstitial position. The only different NOR phenotype was discovered in *Diplectrum formosum*, where NORs are located in up to four NOR-bearing chromosomes. In species of *Scorpaena*, the location of NORs detected by silver staining was sequentially confirmed by counterstain-enhanced fluoroscence using Mithramycin A (Sigma), showing the corresponding signals.

While the G-banding (Table III) was detected for two species, with results unsatisfactory, positive C-banding (Table III) results were obtained for 11 species. In all of them the constitutive heterochromatin blocks were present in the centromeric region of nearly all chromosomes, with telomeric blocks also being detected in all chromosomes of five species.

The amount of DNA/cell (Table III) was estimated only for two species (*Menticirrhus americanus* and *Micropogonias furnieri*). These values were slightly higher than the amount of DNA of Perciformes in general (Hinegardner and Rosen, 1972).

Sex chromosomes and meiosis

The haploid number was determined in eight species and sex heteromorphism at the chromosome level was detected in only three species: *Brevoortia aurea*, *Netuma barba* and *Stephanolepis hispidus* (Table II). A multiple sex chromosome system of the $X_1X_1X_2X_2$/X_1X_2Y type was detected in *B. aurea* and *S. hispidus*, whereas the presence of simple XX/XY sex chromosomes was detected in *N. barba*.

Table III - Chromosome banding patterns revealed by the NORs, C-banding, and amount of DNA/cell of the marine fish species occurring along the Brazilian coast.

Species	Chromosomal NOR phenotypes	C-banding	G-banding	Amount of DNA/cell	References
Brevoortia aurea	2 terminal NORS in one of the largest acrocentric pairs	centromeric blocks in all chromosomes	-	-	Brum *et al.*, 1992b
Scorpaena brasiliensis	2 NORs detected both with $AgNO_3$ and Mithramycin A that are heteromorphic in terms of size, in the short arms of the second pair in the complement, identified as submetacentrics	small centromeric blocks in practically all chromosomes, in addition to more conspicuous blocks in the NOR position, which are therefore C-positive	-	-	Corrêa *et al.*, 1995
Scorpaena isthmensis	2 NORs detected both with $AgNO_3$ and Mithramycin A in the telomeres of the short arm of the fifth pair in the complement (submetacentrics)	small centromeric blocks in practically all chromosomes	-	-	Corrêa *et al.*, 1995
Prionotus punctatus	-	smaller blocks, mainly centromeric, in most chromosomes, side by side with more conspicuous telomeric blocks in the larger chromosomes	-	-	Corrêa *et al.*, 1995
Centropomus parallelus	2 interstitial NORs in one of the middle pairs	C-bands restricted on pericentromeric regions	-	-	Pauls *et al.*, 1995b
Diplectrum formosum	1 to 4 labelled chromosomes	centromeric and telomeric blocks	-	-	Aguilar, 1993
Diplectrum radiale	2 interstitial NORs in one of the largest pairs	centromeric and telomeric blocks	-	-	Brum *et al.*, 1992b
Caranx latus	2 NORs in the long arm of the submetacentric pair	-	-	-	Pauls *et al.*, 1994
Eucinostomus gula	2 NORs in the second pair in the complement	-	-	-	Pauls *et al.*, 1994
Orthopristis ruber	-	centromeric and telomeric blocks in all chromosomes	-	-	Brum, 1994
Menticirrhus americanus	-	-	undefined	1.57 ± 0.03 pg	Gomes *et al.*, 1983b
Menticirrhus litoralis	1 pair of NORs	centromeric and pericentromeric blocks	-	-	Reggi *et al.*, 1986

While the *B. aurea* multiple sex chromosome system characterizes the first description of sex chromosomes among the Clupeiformes, the same mechanism detected in *S. hispidus* is also present in *Stephanolepis cirrhifer*, from Japan (Murofushi *et al.*, 1980), these being the only two cases of sex chromosomes documented in tetraodontiform species.

In the Siluriformes, several sex-chromosome mechanisms were already detected (Moreira-Filho *et al.*, 1993), but among the ariid fishes studied so far, *N. barba* is the unique in possessing sex chromosome heteromorphism in the male.

Conclusions and systematic implications

The cytogenetic information obtained so far for marine fishes occurring along the Brazilian coast indicates that they have low karyotype variability when compared to freshwater species (Brum, 1995). This is surely due to the absence of barriers, to the greater vagility, and to population sizes, consisting of a large number of individuals. On the other hand, the predominant occurrence of the karyotype with 48 acrocentrics (and of karyotypes derived from it) in Perciformes, and at least in Clupeiformes, Atheriniformes and Tetraodontiformes, is consistent with the hypothesis that this karyotype represents a synapomorphy between the clupeiform fishes and the different groups of modern teleosts (Euteleostei) (Brum, 1995). Whereas this type of karyotype was nearly unchanged in marine species of these groups, it became more derived in freshwater groups of euteleost fish (Brum, 1995).

RESUMO

Neste trabalho são revisados os dados cariotípicos disponíveis para os peixes marinhos ocorrentes no litoral brasileiro. As espécies investigadas até o momento pertencem às ordens Clupeiformes, Siluriformes, Atheriniformes, Scorpaeniformes, Perciformes e Tetraodontiformes. A maior parte destes dados estão dispersos em anais de congressos ou em publicações de difícil acesso, a maioria escrito em língua portuguesa. A presente revisão contem dados de números cromossômicos, cromossomos sexuais, padrões de bandeamento, conteúdo de DNA e suas respectivas implicações sistemáticas. Das espécies ictíicas ocorrentes em águas oceânicas do Brasil, somente 44 foram investigadas, em termos cromossômicos, até o momento. Os Perciformes, com 28 espécies cariotipadas, constituem a ordem de peixes mais estudada, sendo a representatividade de outros grupos de peixes, neste sentido, pequena ou mesmo nenhuma.

ACKNOWLEDGMENTS

The author is grateful to Pedro M. Galetti Jr., Margaret M.O. Corrêa and Carla C. de Oliveira for their collaboration and suggestions during the preparation of the present paper.

REFERENCES

Aguilar, C.T. (1993). Estudos citogenéticos em Serranidae (Pisces, Perciformes). Master's thesis, Departamento de Genética, UFRJ, Rio de Janeiro, RJ.

Alvarez, M.C., Garcia, E. and **Thode, G.** (1986). Contribution to the karyoevolutive study of the Labridae (Perciformes). The karyotypes of *Ctenolabrus rupestris* and *Symphodus ocellatus*. *Caryologia 39*: 353-357.

Arai, R. and **Nagaiwa, K.** (1976). Chromosomes of Tetraodontiform fishes from Japan. *Bull. Natn. Sci. Mus. Tokyo, Serie A*, 2: 59-72.

Brugger, A.M., Born, G.G. and **Levy, S.A.** (1990). Estudos preliminares cariotípicos e bioquímicos do peixe-rei (Atherinidae) na costa oceânica e região estuarina do Rio Grande, RS. In: *III Simpósio de Citogenética Evolutiva e Aplicada de Peixes Neotropicais*, Botucatu, SP, Brasil, pp. 38.

Brum, M.J.I. (1994). Evolução cariotípica dos teleósteos marinhos e suas correlações com a filogenia deste grupo (com especial ênfase aos Clupeiformes, Perciformes e Tetraodontiformes). Doctoral thesis, Universidade Federal de São Carlos, São Carlos, SP.

Brum, M.J.I. (1995). Correlações entre a filogenia e a citogenética dos peixes teleósteos. Sociedade Brasileira de Genética - *Série Monografias* 2: 5-42.

Brum, M.J.I., Aguilar, C.T., Corrêa, M.M.O. and **Galetti Jr., P.M.** (1991). Estudos citogenéticos em Serranidae: Análise cromossômica preliminar em *Diplectrum radiale*. In: *IX Encontro Brasileiro de Ictiologia*, Maringá, PR, Brasil, pp. 179.

Brum, M.J.I., Aguilar, C.T., Corrêa, M.M.O. and **Galetti Jr., P.M.** (1992a). Multiple sex chromosomes in South Atlantic Clupeidae fish *Brevoortia aurea*. *Braz. J. Genet. 15*: 547-553.

Brum, M.J.I., Aguilar, C.T., Corrêa, M.M.O., Oliveira, C.C. de and **Galetti Jr., P.M.** (1992b). Estudos citogenéticos em peixes marinhos: Análises cromossômicas nas famílias Clupeidae (Clupeiformes), Serranidae, Pomadasyidae e Blenniidae (Perciformes). In: *IV Simpósio de Citogenética Evolutiva e Aplicada de Peixes Neotropicais*, Rio de Janeiro, RJ, Brasil, pp. 43.

Brum, M.J.I., Oliveira, C.C. de, Corrêa, M.M.O. and **Galetti Jr., P.M.** (1994a). Estudos citogenéticos em *Scartella cristata* (Perciformes, Blenniidae) do litoral do Estado do Rio de Janeiro. *In: V Simpósio de Citogenética Evolutiva e Aplicada de Peixes Neotropicais*, Botucatu, SP, Brasil, pp. 24.

Brum, M.J.I., Oliveira, C.C. de, Corrêa, M.M.O. and **Galetti Jr., P.M.** (1994b). Contribuição ao conhecimento citogenético da ordem Tetraodontiformes - cariótipo de *Sphoeroides* do litoral do Estado do Rio de Janeiro. In: *V Simpósio de Citogenética Evolutiva e Aplicada de Peixes Neotropicais*, Botucatu, SP, Brasil, pp. 49.

Cataudella, S. and **Capanna, E.** (1973). Chromosome complements of three species of Mugilidae (Pisces, Perciformes). *Experientia 29*: 489-491.

Choudhury, R.C., Prasad, R. and **Das, C.C.** (1982). Karyological studies in five Tetraodontiform fishes from the Indian Ocean. *Copeia*: 728-732.

Corrêa, M.M.O. (1995). Contribuição à citotaxonomia dos Scorpaeniformes (Osteichthyes - Teleostei): Estudos citogenéticos em espécies do litoral do Rio de Janeiro. Master's thesis, Museu Nacional, UFRJ, Rio de Janeiro, RJ.

Corrêa, M.M.O., Brum, M.J.I., Aguilar, C.T., Oliveira, C.C. de and **Galetti Jr., P.M.** (1994a). Estudos cromossômicos preliminares em *Scorpaena isthmensis* (Scorpaenidae, Scorpaeniformes) do litoral do Rio de Janeiro. In: *V Simpósio de Citogenética Evolutiva e Aplicada de Peixes Neotropicais*, Botucatu, SP, Brasil, pp. 27.

Corrêa, M.M.O., Brum, M.J.I., Aguilar, C.T., Oliveira, C.C. de and **Galetti Jr., P.M.** (1994b). Caracterização citogenética de *Abudefduf saxatilis* (Pomacentridae, Perciformes) Cariótipo, Bandas-C e Rons - Dados preliminares. In: *V Simpósio de Citogenética Evolutiva e Aplicada de Peixes Neotropicais*, Botucatu, SP, Brasil, pp. 26.

Corrêa, M.M.O., Aguilar, C.T., Brum, M.J.I. and **Galetti Jr., P.M.** (1995). Contribuição à citotaxonomia dos Scorpaeniformes (Pisces - Teleostei): Estudos citogenéticos em espécies ocorrentes na Baía de Guanabara, RJ. In: *41° Congresso Nacional de Genética*, Caxambu, MG, Brasil, pp. 448.

Doucette Jr., A.J. and **Fitzsimons, J.M.** (1988). Karyology of Elopiform and Clupeiform Fishes. *Copeia*: 124-130.

Gomes, V., Vazzoler, A.E.A. and **Ngan, P.V.** (1983a). Estudos cariotípicos de peixes da família Sciaenidae (Teleostei, Perciformes) da região de Cananéia, SP, Brasil: 1. sobre o cariótipo de *Micropogonias furnieri* (Demarest, 1823). *Bolm. Inst. Oceanogr. S. Paulo 32*: 137-142.

Gomes, V., Vazzoler, A.E.A. and **Ngan, P.V.** (1983b). Estudos cariotípicos de peixes da família Sciaenidae (Teleostei, Perciformes) da região de Cananéia, SP, Brasil: 2. sobre o cariótipo de *Menticirrhus americanus* (Linnaeus, 1758). *Bolm. Inst. Oceanogr. S. Paulo 32*: 187-191.

Gomes, V., Phan, V.N. and **Passo, M.J.A.C.** (1990). The karyotype of a marine catfish, *Bagre bagre*, from Brazil. *Japan. J. Ichthyol. 37*: 321-323.

Gomes, V., Phan, V.N. and **Passo, M.J.A.C.** (1992). The karyotype of *Cathrops* sp, a marine catfish from Brazil. *Bolm. Inst. Oceanogr. S. Paulo 40*: 87-91.

Gomes, V., Phan, V.N. and **Passo, M.J.A.C.** (1994). Karyotypes of three species of marine catfishes from Brazil. *Bolm. Inst. Oceanogr. S. Paulo 42*: 55-61.

Hinegardner, R. and **Rosen, D.E.** (1972). Cellular DNA content and the evolution of Teleostean fishes. *Amer. Natur. 106*: 621-644.

Moreira-Filho, O., Bertollo, L.A.C. and **Galetti Jr., P.M.** (1993). Distribution of sex chromosomes in Neotropical fish and description of a ZZ/ZW system in *Parodon hilarii* (Parodontidae). *Caryologia 46*: 115-125.

Murofushi, M., Oikawa, S., Nishikawa, S. and **Yosida, T.H.** (1980). Cytogenetical studies on fishes. III. Multiple sex chromosome mechanism in the Filefish, *Stephanolepis cirrhifer*. *Jpn. J. Genet. 55*: 127-132.

Nelson, J.S. (1994). *Fishes of the World*. 3rd edn. John Wiley and Sons Inc., New York. pp. 523.

Ohno, S., Wolf, U. and **Atkin, N.B.** (1968). Evolution from fish to mammals by gene duplication. *Hereditas 59*: 169-187.

Oliveira, C., Almeida-Toledo, L.F. de, Foresti, F., Britski, H.A. and **Toledo-Filho, S.A.** (1988). Chromosome formulae of neotropical freshwater fishes. *Braz. J. Genet. 11*: 577-624.

Pauls, E. (1993). Estudos citogenéticos em peixes marinhos visando o melhoramento genético. Tese de Concurso para Professor Titular da Disciplina Genética e Melhoramento Animal do Departamento de Zootecnia da Faculdade de Veterinária da UFF, Niterói, RJ.

Pauls, E. and **Coutinho, I.A.** (1990). Levantamento citogenético em peixes de maior valor econômico do litoral Fluminense (23^{o} Lat./S). In: *XVII Congresso Brasileiro de Zoologia*, Londrina, PR, Brasil, pp. 325.

Pauls, E., Coutinho, I.A. and **Procópio, R.C. de O.** (1991). Estudos citogenéticos nas species *Orthopristis ruber, Bodianus rufus, Pomatomus saltatrix* e *Mullus argentinae*. In: *IX Encontro Brasileiro de Ictiologia*, Maringá, PR, Brasil, pp. 180.

Pauls, E., Coutinho, I.A., Affonso, P.R.A.M. and **Germano, G.C.** (1994). Regiões nucleolares em duas espécies de peixes marinhos. In: *40° Congresso Nacional de Genética*, Caxambu, MG, Brasil, pp. 124.

Pauls, E., Affonso, P.R.A.M., Netto, M.R.C.B., Viestel, M.A. and **D. Pacheco, M.L.** (1995a). Levantamentos citogenéticos em peixes marinhos II: família Monacanthidae, *Canterhines macrocerus*. In: *41° Congresso Nacional de Genética*, Caxambu, MG, Brasil, pp. 449.

Pauls, E., Viestel, M.A., Affonso, P.R.A.M., Netto, M.R.C.B. and **D. Pacheco, M.L.** (1995b). Levantamentos citogenéticos em peixes marinhos III: família Centropomidae, *Centropomus parallelus*. In: *41° Congresso Nacional de Genética*, Caxambu, MG, Brasil, pp. 449.

Reggi, R., Périco, E., Suninsky, M. and **Camillo, J.C. de A.** (1986). Estudos citogenéticos em papa-terra, *Menticirrhus litoralis* (Perciformes, Serranidae). In: *Simpósio de Citogenética Evolutiva e Aplicada de Peixes Neotropicais*. São Carlos, SP, Brasil, pp. 57.

Zenaid, A.K. and **Almeida-Toledo, L.F. de** (1994). O cariótipo de *Trachinotus carolinus* e *T. falcatus* (Pisces, Carangidae). In: *Simpósio de Citogenética Evolutiva e Aplicada de Peixes Neotropicais*, Botucatu, SP, Brasil, pp. 25.