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HÁBITO ALIMENTAR DE *Mimagoniates microlepis* STEINDACHNER, 1876 (CHARACIDAE: GLANDULOCAUDINAE) DO CANAL DE LIGAÇÃO ENTRE AS LAGOAS EMBOABA E EMBOABINHA, RIO GRANDE DO SUL, BRASIL

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RESUMO

No presente trabalho, o hábito alimentar de *Mimagoniates microlepis* é descrito. Para isso, foram realizadas coletas mensais, entre janeiro e dezembro de 1998, no canal de ligação entre as lagoas Emboaba e Emboabinha, no município de Osório, RS. A análise do conteúdo estomacal foi feita utilizando-se os métodos de freqüência de ocorrência, composição percentual e o índice de importância alimentar. Os resultados obtidos mostraram uma dieta praticamente sem variações sazonais, constituída basicamente por artrópodes alóctones, principalmente insetos. Este item pode ser considerado como alimento principal da espécie. A análise demonstra que insetos alóctones foram mais freqüentes na dieta dos indivíduos maiores (34,46 mm a 40,45 mm), sendo que os menores (16,45 mm a 22,45 mm) apresentaram freqüências mais altas de microcrustáceos. Os resultados apontam poucas diferenças na dieta de machos e fêmeas, com insetos alóctones constituindo o item principal.

Palavras-chave: hábito alimentar, insetos alóctones, cadeia trófica, *Mimagoniates*, conteúdo estomacal.

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ABSTRACT

Feeding habits of *Mimagoniates microlepis* Steindachner, 1876 (Characidae: Glandulocaudinae) from the channel linking Emboaba and Emboabinha lakes, Rio Grande do Sul, Brazil.

In this study, the feeding habit of *Mimagoniates microlepis* is described. Samples were collected monthly between January to December 1998 in the channel linking Emboaba and Emboabinha lakes within the district of Osório, RS. The stomach contents were analysed using methods such as frequency of ocurrence, percentage composition and the index of dietary importance. The results indicated a diet without seasonal variation based on allochthonous arthropods, being these mostly insects. It is possible to assume that insects constitute the main diet of this species. Insects were detected in higher frequency within bigger individuals (34.46 mm a 40.45 mm) while smaller fish (16.45 mm a 22.45 mm) tended to feed on microcrustaceans. There does not seem to be any difference between the diet of individuals of different sex, being allochthonous insects the main food item for both sexes.

Key words: feeding habit, allochthonous insects, food chain, *Mimagoniates*, stomach content.

INTRODUÇÃO

A Ordem Characiformes compreende um grupo de peixes com uma grande diversidade de formas e comportamentos (Vazzoler & Menezes, 1992). Dentre estes, a família Characidae é a que comporta o maior número de espécies conhecidas (Géry, 1977). A subfamília de caracídeos Glandulocaudinae é composta por pequenos peixes de água-doce neotropicais que ocorrem desde o sul da Costa Rica até o Equador em drenagens do Pacífico, e até o norte da Argentina em drenagens do Atlântico (Menezes & Weitzman, 1990). Até o momento são conhecidas cerca de 50 espécies distribuídas em 19 gêneros (Weitzman *et al.*, 1988; Menezes & Vazzoler, 1992; Weitzman *et al.*, 1994), os quais são comumente agrupados em sete tribos (Weitzman & Menezes, 1998).

Todas as espécies do gênero *Mimagoniates*, incluído na Tribo Glandulocaudini, são atrativamente coloridas e ativas, despertando o interesse dos aquaristas. A maioria dos membros desta Tribo habita corpos d'água margeados por florestas remanescentes da Mata Atlântica (Weitzman *et al.*, 1996) e *Mimagoniates microlepis* é a espécie com distribuição mais ampla, ocorrendo do sul da Bahia até o norte do Rio Grande do Sul (Menezes & Weitzman, 1990).

Nos últimos anos, vários estudos sobre o hábito alimentar de peixes de água-doce demonstraram a importância do ambiente de mata ciliar e arbustiva próximo aos arroios, rios e riachos na alimentação de espécies de Glandulocaudinae e de outros caracídeos (Lowe-McConnell, 1987; Costa, 1987; Sabino & Castro, 1990 e Azevedo *et al.*, 1997). Além disso, esses estudos contribuem para uma melhor compreensão acerca da partição de recursos nestes ambientes, sobre a diversidade de estratégias alimentares e o papel de cada espécie na cadeia trófica. Eles permitem ainda inferir a respeito da distribuição espacial destes peixes no ambiente aquático.

Nelson (1964), estudando diferentes espécies de glandulocaudíneos, afirmou que estes se alimentam mais na superfície do que outros grupos de caracídeos. Entretanto, Weitzman *et al.* (*in* Weitzman & Fink, 1985), discordam dessa hipótese e, baseados em observações ocasionais de campo, afirmam que os Tetragonopterinae se alimentam na superfície tão freqüentemente quanto os Glandulocaudinae que com eles dividem os ambientes. Recentemente, Azevedo *et al.* (1997), testaram estas hipóteses com base na análise do hábito alimentar de espécies de glandulocaudíneos e de outros caracídeos, corroborando os resultados de Nelson (1964).

Este trabalho tem por objetivo estudar a dieta de uma população de *Mimagoniates microlepis* do canal de ligação entre as lagoas Emboaba e Emboabinha através da análise do conteúdo estomacal, contribuindo para o conhecimento da biologia alimentar e da ecologia desta espécie. Visa também fazer uma comparação entre a dieta de machos e fêmeas e entre indivíduos de diferentes classes de comprimento, verificando possíveis diferenças no hábito alimentar.

MATERIAL E MÉTODOS

Os indivíduos analisados foram coletados mensalmente entre janeiro e dezembro de 1998 no canal de ligação entre as lagoas Emboaba e Emboabinha, na Estrada Osório-Tramandaí (29°57'57"S e 50°13'45"W) com rede de arrasto do tipo picaré. O canal possui áreas com correnteza média e áreas de remanso. A vegetação é constituída por espadanas (*Scirpus californicus*), árvores e arbustos juntos à margem constituindo a mata ciliar. Esta é uma área sujeita a inundação, apresentando espécies da restinga litorânea, resistentes à umidade do solo e com altura aproximada de 6 metros, estando sem alteração recente. O substrato é composto por areia e lodo, a água é escura e a profundidade varia de 0,5 a 1,5 m.

Os indivíduos coletados foram fixados em formol 10% no momento da coleta e, em laboratório, foram tomadas as medidas de comprimento padrão e o peso total de cada indivíduo. Em seguida os peixes foram dissecados para a retirada e pesagem dos estômagos, sendo estes guardados em álcool 70%. A análise do conteúdo estomacal foi feita em um microscópio estereoscópico e a identificação dos artrópodes, principalmente dos insetos, foi feita até o nível de ordem e, quando possível, até o nível de família. Esse material foi identificado através da consulta em bibliografia especializada (Borror & Delong, 1969).

O conteúdo estomacal foi analisado pelo método de freqüência de ocorrência (FO), segundo Hynes (1950). Foi utilizado também o método de composição percentual (CP), onde o número de vezes que cada item ocorreu é tratado como a porcentagem do número total de ocorrências de todos os itens (Hynes, 1950). Para utilizar tal método os itens alimentares foram agrupados em categorias taxonômicas e/ou ecológicas mais amplas. São elas: insetos alóctones, insetos autóctones, aracnídeos, microcrustáceos, ovos de insetos, outros invertebrados, matéria vegetal superior, matéria orgânica e sedimento.

Para estimar a importância de cada uma destas categorias alimentares na dieta de *M. microlepis* aplicou-se uma escala semiquantitativa de abundância, onde a contribuição de cada categoria é estimada de acordo com a área que a mesma ocupava em relação ao conteúdo total. Considerou-se a seguinte escala modificada de Granado & Garcia Novo (1981): 0 – ausente; 1 – escasso (menos de 25%); 2 – freqüente (25%-50%); 3 – muito freqüente (50%-75%); e 4 – abundante (75% ou mais). A partir dessa escala calculou-se o índice de importância alimentar (IIA), usando-se a seguinte fórmula, segundo Granado & Garcia Novo (1981):

$$IIA = (\Sigma X_k.K)/n\text{-}1$$

onde, X_k é igual a freqüência de ocorrência de um determinado componente da dieta, X_i, com categoria K; K é a categoria de abundância (0, 1...a) e n é o número de categorias da escala.

O IIA apresenta valores variando de 0 a 1. De acordo com Guillen & Granado (1984), considerou-se alimento principal aqueles com valores de IIA acima de 0,3; alimento adicional de 0,3 a 0,15 e alimento acidental, com valores inferiores a 0,15. Os dados foram avaliados mensalmente.

Para comparação da dieta entre indivíduos de diferentes tamanhos, foram estabelecidos quatro intervalos de classes de comprimento padrão (CCP) de 6 mm cada, os quais foram analisados separadamente segundo a composição percentual e o IIA. Da mesma forma, machos e fêmeas foram analisados separadamente para comparar a dieta entre os sexos.

RESULTADOS

Foram analisados 260 indivíduos sendo 91 machos, 117 fêmeas e 52 sexualmente indiferenciados com valores de comprimento padrão variando entre 16,45 e 40,23 mm. O primeiro intervalo de classe de comprimento apresentou 33 indivíduos (CCP1: 16,45 mm a 22,45 mm), o segundo 114 (CCP2: 22,46 mm a 28,45 mm), o terceiro 83 (CCP3: 28,46 mm a 34,45 mm), e o quarto, 30 indivíduos (CCP4: 34,46 mm a 40,45 mm).

A tabela de freqüência de ocorrência (Tab. 1) apresenta todos os itens identificados na análise do conteúdo estomacal. Destes, foram mais freqüentes ao longo do período estudado as ordens de insetos como Diptera e Hymenoptera, além de outros grupos como aracnídeos e Collembola e outros itens como ovos de insetos, matéria orgânica e sedimento.

Pelo método de composição percentual (Fig. 1), insetos alóctones alcançaram os maiores valores, seguido por matéria orgânica e sedimento. Os itens classificados na categoria outros invertebrados incluem artrópodes como Collembola, larvas de insetos de origem desconhecida e um molusco, que, por não apresentarem grande freqüência e/ou abundância, foram agrupados em uma única categoria, a qual apresentou valores altos de composição percentual.

Através do cálculo do índice de importância alimentar (Tab. 2), foi possível verificar que insetos alóctones enquadram-se como alimento principal em todos os meses. Ovos de insetos foram considerados alimento adicional apenas no mês de abril, sendo considerados acidental nos demais. A categoria outros invertebrados, nos meses de abril e junho foi considerada como adicional, sendo acidental nos demais. Insetos autóctones foi um item ausente nos meses de março, junho, agosto e setembro, sendo que nos meses em que esteve presente foi considerado acidental. Aracnídeos, microcrustáceos e matéria vegetal superior foram considerados alimento acidental em todos os meses estudados.

A análise da CP por classes de comprimento (Fig. 2) mostra que insetos alóctones aparecem com menor freqüência na dieta dos indivíduos de classes menores, aumentando sua freqüência nas classes de maior tamanho. Entretanto, quando se observa o IIA calculado para classes de comprimento (Tab. 3), os insetos alóctones são considerados alimento principal em todas as classes de comprimento. É interessante notar que o item microcrustáceos, tanto pelo método de CP, como pelo cálculo do IIA, apresenta valores altos para a classe de comprimento padrão 1, que corresponde aos indivíduos de menor tamanho e esse valor decresce gradualmente nas demais classes.

Os dados de CP para machos e fêmeas (Fig. 3) mostram uma pequena diferença na dieta com relação a aracnídeos, item que é consumido mais freqüentemente pelas fêmeas e cujo valor corresponde a quase o dobro do valor dos machos. Os dados do IIA (Tab. 4) também mostram uma pequena diferença entre a dieta de machos e fêmeas de *M. microlepis*, com relação ao item matéria vegetal superior, considerado alimento adicional para machos e acidental para fêmeas.

Pela análise do IIA para classes de comprimento (Tab. 3), insetos autóctones aparecem como alimento adicional entre os indivíduos da classe 2, sendo acidental nas demais. A categoria outros invertebrados é adicional para os indivíduos das classes 1 e 2 e acidental para as classes 3 e 4.

DISCUSSÃO

A partir dos resultados obtidos pode se observar que insetos alóctones predominam na dieta da espécie nos três métodos de análise utilizados, mostrando sempre valores altos para este item, independentemente do sexo ou classe de comprimento padrão.

O alto consumo de microcrustáceos por indivíduos da menor classe de comprimento pode ser explicado pela necessidade de ingestão de presas menores, devido à menor abertura bucal o que impossibilita a ingestão de presas de maior porte.

A explicação para a diferença na dieta de fêmeas e machos pode estar no fato de que foram analisados muito mais espécimes fêmeas. A alta freqüência e relativa abundância apresentada pela matéria orgânica pode ser atribuída ao adiantado estado de decomposição/digestão do conteúdo estomacal e sua conseqüente impossibilidade de identificação como algum outro item. O item sedimento, embora bastante freqüente, apresentou pouca abundância e acreditamos que sua presença se deva a ingestão de partículas minerais em suspensão durante a predação de outros itens na superfície d'água.

Matéria vegetal superior apresenta-se com baixa freqüência e abundância na dieta sendo considerada acidental em todas as classes, podendo, desta forma caracterizar a espécie como predominantemente insetívora.

Outros estudos com *M. microlepis* e outros glandulocaudíneos mostram resultados semelhantes. Costa (1987) estudando uma população desta espécie num pequeno riacho costeiro do Rio de Janeiro verificou que se trata de uma espécie de superfície e que de 70 a 90% da freqüência de ocorrência de sua dieta é composta por artrópodes terrestres. Sabino & Castro (1990) afirmaram que *M. microlepis* é uma espécie insetívora e que itens alóctones representaram 73,6% da composição percentual de sua dieta, sendo que insetos terrestres compuseram 63,1% da dieta, e os aracnídeos, 10,5%. Azevedo *et al.* (1997) estudando outras espécies de glandulocaudíneos, também chegaram a resultados semelhantes. Estes estudos também apontam para a importância do ambiente de mata ciliar e arbustiva em torno de rios e riachos como provedor de itens alimentares para certos peixes, conforme afirma Lowe-McConnell (1987).

Nossos resultados também corroboram a hipótese formulada por Nelson (1964) de que os Glandulocaudinae se alimentam tipicamente na superfície, assumindo-se que insetos terrestres, aqui denominados de insetos alóctones, quando caem em um corpo d'água, permanecem na superfície até que sejam apanhados. Cabe mencionar, inclusive, que *M. microlepis* apresenta a boca voltada para cima, sendo uma adaptação a este tipo de alimentação, caracterizado como "cata na superfície" (Uieda, 1995).

CONCLUSÃO

Os resultados mostraram que insetos terrestres são a alimentação básica de *M. microlepis* independentemente de sexo e classes de comprimento. A dieta da espécie é complementada esporadicamente por outros itens, mas em menores freqüências e/ou abundâncias. Assim, evidencia-se a importância da preservação e manutenção das matas ciliares, pois as mesmas são fontes de alimentos para as espécies consumidoras de invertebrados terrestres. As alterações antrópicas sobre estes ambientes, principalmente as constatadas na Mata Atlântica, podem influenciar a sobrevivência de muitas espécies de peixes através da diminuição dos recursos diretamente disponíveis ou, indiretamente, afetando outros elos da cadeia trófica. Assim, como a distribuição das espécies do gênero *Mimagoniates* está centrada em ambientes pertencentes à Mata Atlântica, o estudo da alimentação destas espécies é de crucial importância para o entendimento da sua dinâmica alimentar e seu papel na cadeia trófica.

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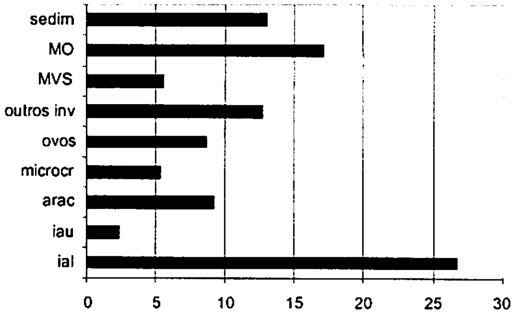
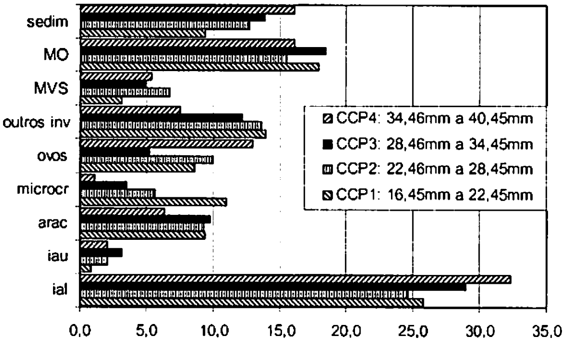


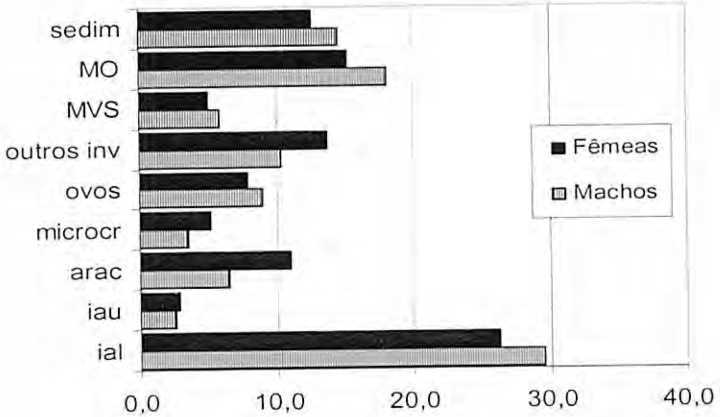
Composição Percentual Total (%)

Figura 1. Composição percentual total relativa aos itens alimentares encontrados nos estômagos de *Mimagoniates microlepis* no canal de ligação das lagoas Emboaba e Emboabinha, RS. Abreviaturas utilizadas: insetos alóctones (ial), insetos autóctones (iau), aracnídeos (arac), microcrustáceos (microcr), ovos de insetos (ovos), outros invertebrados (outros inv), matéria vegetal superior (MVS), matéria orgânica (MO) e sedimento (sedim).



Composição percentual por Classes de Comprimento Padrão (%)

Figura 2. Composição percentual por classes de comprimento padrão relativa aos itens alimentares encontrados nos estômagos de *Mimagoniates microlepis* no canal de ligação das lagoas Emboaba e Emboabinha, RS. Abreviaturas utilizadas: insetos alóctones (ial), insetos autóctones (iau), aracnídeos (arac), microcrustáceos (microcr), ovos de insetos (ovos), outros invertebrados (outros inv), matéria vegetal superior (MVS), matéria orgânica (MO) e sedimento (sedim).



Composição percentual por sexo (%)

Figura 3. Composição percentual para machos e fêmeas relativa aos itens alimentares encontrados nos estômagos de *Mimagoniates microlepis* no canal de ligação das lagoas Emboaba e Emboabinha, RS. Abreviaturas utilizadas: insetos alóctones (ial), insetos autóctones (iau), aracnídeos (arac), microcrustáceos (microcr), ovos de insetos (ovos), outros invertebrados (outros inv), matéria vegetal superior (MVS), matéria orgânica (MO) e sedimento (sedim).

Tabela 1. Freqüência de Ocorrência (FO) dos itens alimentares encontrados nos estômagos de *Mimagoniates microlepis* no canal de ligação das lagoas Emboaba e Emboabinha, RS. Os itens marcados com (*) têm sua origem desconhecida; aqueles marcados com (**) são autóctones e os demais itens são alóctones. Abreviaturas utilizadas: ñ id. = não identificado; autóct. = autóctone; alóct. = alóctone; MVS = matéria vegetal superior; indiv. analisados = número de indivíduos analisados.

Itens \ meses	JAN	MAR	ABR	MAI	JUN	JUL	AGO	SET	OUT	NOV	DEZ
Partes de Insetos	97,1	97,2	97,1	100	100	100	100	100	100	97,1	100
Coleoptera		8,3		5,9	20	8,3		23	12,5		5,7
Staphylinidae									3,1		
Ditiscidae (larva)**											2,8
Larva ñ id.*		2,8									2,8
Hemiptera (alóct.)				5,9				7,7	6,2		
Hemiptera (autóct.)**				5,9							
Trichoptera	8,3										
Larva **						8,3					
Thysanoptera		8,3	14,3	11,7				30,7	15,6	5,7	8,6
Thysanura								7,7	3,1		
Lepidóptera (larva)			2,8								
Blattodea											2,8
Plecoptera						8,3					
Psocoptera								15,4			
Ephemeroptera						16,6		7,7	3,1		
Naiade**	2,8		2,8								
Odonata (naiade)**			2,8						3,1		
Orthoptera										2,8	
Hymenoptera	2,8	19,4	11,4	23,5		16,6	20	76,9	12,5	8,6	5,7
Microhymenoptera		5,5	14,3						21,9		25,7
Formicidae	5,7	8,3	8,6	23,5	20	8,3		23	6,2	5,7	11,4
Diptera		19,4	5,7	17,6		8,3		15,4	9,4	8,6	2,8
Brachycera	2,8	8,3	8,6	17,6		25		15,4	3,1		5,7
Nematocera	5,7	50	14,3		20	41,6	20	23	25	14,3	25,7
Larva ñ id.**	2,8	2,8	2,8	5,9		8,3		7,7	3,1		5,7
Chironomidae**									6,2		5,7
Simullidae**	2,8										
Cullicidae**										2,8	
Homoptera	5,7	16,7	20	41,2		33,3					20
Pupa		2,8									
Ninfa		2,8	8,6								5,7
Inseto ñ id.*	8,6	38,9	42,8	17,6	20	33,3		23	31,2	20	48,6
Larva de inseto ñ id.*	17,1		2,8		20	8,3		7,7	12,5	5,7	11,4
Ovos de inseto	25,7	44,4	62,8	41,2	20	25	20	23	18,7	34,3	11,4
Collembola	8,6	25	54,3	41,2		33,3	20	30,7	37,5	20	25,7
Acarina	17,1	36,1	48,6	41,2	20		20	7,7	34,4	22,8	20
Araneae		13,9	5,7	17,6		8,3		30,7	25	8,6	5,7
Microcrustáceos						16,6	60	23	6,2		
Cladocera	37,1	11,1	11,4		20	58,3		7,7	15,6	20	2,8
Artrópodes ñ id.*	14,3	13,9	31,4	11,7	40	33,3		7,7	40,6		34,3
Molusco			2,8								
MVS	17,1	47,2	54,3	5,9	40			7,7	12,5	5,7	5,7
Matéria Orgânica	65,7	55,5	54,3	64,7	80	83,3	60	92,3	90,6	37,1	54,3
Sedimento	48,6	50	62,8	41,2	60	41,6	40	69,2	50	25,7	54,3
indiv. analisados	35	36	35	17	5	12	5	13	32	35	35

Tabela 2. Índice de Importância Alimentar (IIA) total de *Mimagoniates microlepis* no canal de ligação das lagoas Emboaba e Emboabinha, RS.

Categorias Alimentares	Jan	Mar	Abr	Mai	Jun	Jul	Ago	Set	Out	Nov	Dez
insetos alóctones	0,71	0,87	0,79	0,8	0,55	0,75	0,75	0,59	0,76	0,90	0,96
insetos autóctones	0,02	0	0,03	0,03	0	0,04	0	0	0,03	0,02	0,04
aracnídeos	0,04	0,11	0,13	0,12	0,05	0,02	0,05	0,08	0,12	0,07	0,07
microcrustáceos	0,10	0,03	0,03	0	0,05	0,40	0,30	0,08	0,05	0,05	0,01
ovos de insetos	0,07	0,13	0,16	0,10	0,05	0,06	0,05	0,06	0,05	0,09	0,03
outros invertebrados	0,10	0,12	0,23	0,12	0,15	0,13	0,05	0,10	0,14	0,05	0,12
matéria vegetal superior	0,04	0,12	0,14	0,02	0,10	0	0	0,02	0,03	0,02	0,02
matéria orgânica	0,38	0,19	0,27	0,32	0,65	0,38	0,25	0,57	0,44	0,15	0,16
sedimento	0,13	0,13	0,16	0,10	0,15	0,10	0,10	0,17	0,12	0,07	0,14

Tabela 3. Índice de Importância Alimentar (IIA) por classes de comprimento padrão (CCP) de *Mimagoniates microlepis* no canal de ligação das lagoas Emboaba e Emboabinha, RS.

Categorias Alimentares	CCP 1	CCP 2	CCP 3	CCP 4
insetos alóctones	0,65	0,81	0,86	0,90
insetos autóctones	0,01	0,22	0,03	0,02
aracnídeos	0,09	0,10	0,09	0,05
microcrustáceos	0,14	0,06	0,03	0,01
ovos de insetos	0,09	0,11	0,04	0,10
outros invertebrados	0,16	0,15	0,10	0,06
matéria vegetal superior	0,03	0,07	0,04	0,04
matéria orgânica	0,41	0,30	0,29	0,10
sedimento	0,09	0,13	0,12	0,13

Tabela 4. Índice de Importância Alimentar (IIA) por sexo de *Mimagoniates microlepis* no canal de ligação das lagoas Emboaba e Emboabinha, RS.

Categorias Alimentares	Machos	Fêmeas
insetos alóctones	0,88	0,83
insetos autóctones	0,02	0,03
aracnídeos	0,05	0,10
microcrustáceos	0,02	0,05
ovos de insetos	0,08	0,09
outros invertebrados	0,09	0,13
matéria vegetal superior	0,18	0,05
matéria orgânica	0,25	0,30
sedimento	0,12	0,12

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GEOGRAPHICAL DISTRIBUTION OF CHROMATIC PATTERNS IN ELAPOMORPHINE SNAKES (COLUBRIDAE), AND SPECIES GROUPS

*Thales De Lema**

RESUMO

As serpentes fossorias da subfamília Elapomorphinae estão distribuídas pela América do Sul cisandina. Elas apresentam diversos padrões de coloração e cada padrão é próprio de uma região específica em um determinado domínio morfoclimático. As regiões com determinado domínio morfoclimático e determinado padrão cromático, definem diferentes regiões de espécies: (1) Região Amazônica, com espécies de padrão estriado sobre cor dorsal de fundo castanho rosada e ventre imaculado; (2) Região Cerrado, com padrão dorsal vermelho sem estrias ou com duas estrias e o ventre imaculado ou manchado de preto; (3) Região Argentina com padrão dorsal de duas a três estrias sobre fundo pardo amarelado, ventre com manchas pretas; (4) Região Meridional – três a duas estrias sobre fundo vermelho, ventre com manchas pretas; (5) Região Atlântica – cinco, três ou nenhuma estrias sobre fundo pardo-amarelado ou vermelho, com ventre imaculado. Há pequenas áreas com padrões especiais como o Chaco em que as espécies são vermelhas, uniforme ou com duas estrias, ventre imaculado ou com manchas parcadas; outra é a região Subandina (Oeste da Argentina) onde as espécies são pardo amareladas a avermelhadas sem estrias ou manchas. As espécies de cada Região apresentam semelhanças entre si que permitem distribuí-las em grupos de espécies afins pela cor e morfologia no sentido de norte a sul: Gênero *Apostolepis* – (a) grupo *A. quinquelineata* na Região Amazônica e em alguns enclaves na Caatinga. (b) grupo *A. tenuis* na Amazônia meridional contatando com o Cerrado florestado (Cerradão); (c) grupo *A. flavotorquata* no Cerrado. (d) grupo *A. assimilis* no Cerrado para Caatinga e para o Chaco; (e) grupo *A. lineata* no Cerrado contato Chaco; (f) grupo *A. polylepis*, endêmico em en Caatinga; (g) grupo *A. dimidiata* no Cerrado para o Chaco; Gênero *Phalotris* – (h) grupo *P. spegazzinii* – Pampas da Argen-

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tina; (i) grupo *P. tricolor* – Subandina para o Chaco; (j) grupo *P. lemniscatus* – Pampa do Brasil para o Planalto meridional do Brasil; (l) grupo *P. nasutus* – Cerrado meridional a setentrional e uma ocorrência no contato Cerrado-Chaco; (m) grupo *P. mertensi* – Cerrado Central; Gênero *Elapomorphus* – (n) grupo *Elapomorphus quinquelineatus* – Floresta Atlântica.

Palavras-chave: Serpentes, Elapomorphinae, padrões cromáticos regionais, grupos de espécies, América do Sul.

ABSTRACT

The fossorial snakes of subfamily Elapomorphinae are distributed in cisandine South America. They have several color patterns, and each pattern is present in a particular region with a specific morphoclimatic region. Different species regions are recognized each with its own pattern: (1) Amazonian Region – species with striped pattern on pinkish brown background color, venter immaculate; (2) Cerrado Region – uniformly red or two-striped, venter immaculate or with paired black blotches; (3) Argentinian Region – two or three striped pattern on a yellowish ocher background color, venter immaculate or with single black blotches; (4) Southern Region – three or two striped pattern on a red background color, venter with single black blotches; (5) Atlantic Forest Region: with 5, 5/3, 3 or none stripe, with immaculate venter. Smaller areas with unique patterns can be recognized as Chaco with uniformly red dorsal color, or two-striped with or without black ventral blotches, head entirely black; and the Subandean area, western Argentina, with uniformly yellowish ocher dorsal pattern, and immaculate venter. The species can be grouped in closely related species groups according to distribution and color pattern (north to south): Genus *Apostolepis* – (a) *A. quinquelineata* group – Amazonian region and Caatinga enclaves; (b) *A. tenuis* group – Southern Amazonia, contacting Cerradão; (c) *A. flavotorquata* group – Cerrado; (d) *A. assimilis* group – Cerrado to Caatinga, and to Chaco; (e) *A. lineata* group – Cerrado, contact with Chaco; (f) *A. polylepis* group – Enclave within Caatinga; (g) *A. dimidiata* group – Cerrado to Chaco; Genus *Phalotris* – (h) *P. spegazzinii* group – Argentinian Pampa; (i) *P. tricolor* group – Subandean to Chaco; (j) *P. lemniscatus* group – Brazilian Pampa to Southern Brazilian Plateau; (k) *P. nasutus* group – Southern Cerrado, contacting Chaco; (l) *P. mertensi* group – Southern Cerrado; Genus *Elapomorphus* – (m) *E. quinquelineatus* group – Atlantic Forest region.

Key words: Serpentes, Elapomorphinae, regional color patterns, species group, South America.

INTRODUCTION

The subfamily Elapomorphinae Jan 1862 is formed by fossorial snakes that inhabit cisandine South America comprising three genera: *Apostolepis* Cope 1861, *Elapomorphus* Wiegmann 1843, and *Phalotris* Cope 1861. *Apostolepis* is the most derived taxon (Ferrarezzi, 1993c), characterized by two prefrontal plates lacking internasals and presence of black blotch on end of tail. It is composed by many species distributed in northern and central South America, in the morphoclimatic domains Amazonia, Cerrado, Caatinga, and Chaco (northern and central Brazil, Guianas, Bolivia, Paraguay, and northern Argentina). (Lema, 2001b). *Elapomorphus* is the most basal taxon (Ferrarezzi, 1993c), characterized by presence of two prefrontral and two internasal plates. The species are endemic to the Atlantic Forest (eastern Brazil, from Bahia to Rio Grande do Sul States) (Lema & Deiques, 1995). *Phalotris* is an intermediate taxon among *Elapomorphus* and *Apostolepis* (Ferrarezzi, 1993c) with species related to the former and others related to the later; it comprises several species with medium to small size characterized by two internasals and single prefrontal plate; species inhabiting open areas in southern South America from the Pampean Region to Chaco and Central Brazil (Argentina to Maranhão, Brazil) (Lema, 1984a). The Elapomorphinae possesses several shared characters with African species of families Atractaspididae and Elapidae (Savitzky, 1979; Underwood & Kochva, 1993; Ferrarezi, 1993c). Many characters present in these those species are due to fossorial life adaptations, although a few may be derived from a common ancestor.

This study focuses the distribution of the color patterns in relation to the species suggesting the existence of species groups according the different morphoclimatic domains.

METHODS AND MATERIAL

Coloration – The color pattern is examined by different aspects: (a) generalized for ecophysiographic regions, (b) in different species, (c) in relation to distribution, (d) with comparison among different areas, and (e) synthesized in geographical patterns. The color nomenclature follows Smithe (1975). Maps – Areas of pattern distribution outlined by specimen origins from museum collections (See data sources). Morphoclimatic domains and ecophysiographical regions follow Ab'Saber (1977) and Duellman (1979): equatorial forests of Amazonian Region (Hylaea), Cerrados (including Cerradões), Caatinga (including Amazonian enclaves within it), Chaco, Paraná Region (including highlands of Serra do Mar, Serra Geral, and Serra do Sudeste, with Paraná Basin), Pampas (savannahs), and Monte (mesophytic). Data Sources – This paper represents a synthesis of the majority of published contributions on elapomorphine snakes, as well as some my submitted manuscript Lema, T. & Albuquerque, N. R. (submitted) and Lema (2002). Therefore, I do not present complete list of specimens examined because of space limitations, and this material is available in other sources. Much of the information contained herein is taken from the my doctoral thesis (Lema, 1977), master dissertations of Clarice Hoffstadler Deiques (Deiques, 1991), and Hebert Ferrarezzi (Ferrarezzi, 1993c). Other sources are from Ferrarezzi (1993a, 1993b, 1993c), Lema (1970, 1977, 1978a, 1978b, 1978c, 1979a, 1979b, 1982, 1984a, 1984b, 1992, 1993, 1994, 1997, 1999), Savitzky (1979), Rodrigues (1993), Lema & Deiques (1995), Lema & Renner (1998), Zamprogna *et al.* (1998) and Harvey (1999).

RESULTS

Coloration aspects: (A) general dorsal ground color, independent of pattern; (B) ventral color; (C) dorsal pattern. The distribution of these three color variables shows particular chromatic groups (Figs. 1 to 4), and combination of the patterns of these aspects shows following distribution of phenotypes:

A. Ground dorsal color:

AA – Buff: Northern region at Amazonia and enclaves into Caatinga in northeastern Brazil; distributed southward to Goiás and Mato Grosso. Species: *A. arenaria, A. gaboi, A. goiasensis, A. intermedia, A. lineata, A. niceforoi, A. nigrolineata, A.nigroterminata, A. phillipsi, A. pymi, A. tenuis, A. vittata, Apostolepis sp., E. wuchereri* (young).

AB – Yellow ocher: Eastern region, Atlantic Forest region. Species: *E. wuchereri* (adult), *E. quinquelineatus.*

AC – Scarlet: Central region into northeastern Brazil (Caatinga region) and into Paraguayan and Argentinian Chaco. Species: *A. ambiniger, A. assimilis, A. breviceps, A. cearensis, A. dorbignyi, A. flavotorquata, A. multicincta, P. concolor, P. labiomaculatus, P. mertensi, P. nasutus, P. punctatus, P. tricolor, Phalotris sp.*

AD – Yellowish buff: Argentina (Monte formations) to Chaco of Argentina and Paraguay, to Cerrado in southwestern Brazil (Mato Grosso do Sul and São Paulo). Species: *P. cuyanus*, *P. lativittatus*, *P. spegazzinii*, *P. suspectus*, *P. trilineatus*.

AE – Geranium pink: Southern Brazil and Uruguay (Pampa region) to Chaco (Paraguay, adjacent Brazil), Cerrado (São Paulo), and Atlantic Forest (Brazil). Species: *A. albocolaris*, *A. dimidiata* (non melanistic morphs), *A. quirogai*, *E. lepidus* (adult), *P. lemniscatus*.

AF – Melanistic (sides and/or venter): Southern Brazilian Plateau from São Paulo to northern Rio Grande do Sul, and from eastern Mato Grosso to Misiones, Argentina, through Paraguay. Species: *A. dimidiata* (melanistic morph), *P. iheringi*, *P. multipunctatus*, *P. nigrilatus*.

B. Ventral color pattern:

BA – Yellowish white (paraventral stripe continuous or dotted): Amazonian and Atlantic forests (some species). Species: *A. gaboi*, *A. goiasensis*, *A. nicerofoi*, *A. nigrolineata* (young), *A. pymi*, *E. quinquelineatus*.

BB – Immaculate: All species with this ventral color pattern occur north of Tropic of Capricorn and some species from southwestern Brazil and adjacent countries. Species: *A. arenaria*, *A. cearensis*, *A. dorbignyi*, *A. flavotorquata*, *A. gaboi*, *A. goiasensis*, *A. intermedia*, *A. lineata*, *A. longicaudata*, *A. multicincta*, *A. niceforoi*, *A. nigrolineata*, *A. nigroterminata*, *A. phillipsi*, *A. polylepis*, *A. pymi*, *A. sanctaeritae*, *A. tenuis*, *A. vittata*, *Apostolepis sp.*, *E. lepidus*, *E. quinquelineatus*, *E. wuchereri*, *P. concolor*, *P. labiomaculatus*, *P. mertensi*, *P. nasutus*, *P. punctatus*.

BC – Yellowish white with a pair of black blotches on each ventral and subcaudal plates: Cerrado to Chaco. Species: *A. albocolaris*, *A. dimidiata*, *A. quirogai*, *P. nigrilatus*.

BD – Cream with a single black blotch on each ventral and subcaudal plates: All species with this ventral color pattern occur south of the Tropic of Capricorn (southern region). Species: *P. divittatus*, *P. iheringi*, *P. lemniscatus*, *P. multipunctatus*, *P. spegazzinii*, *P. suspectus*, *P. trilineatus*.

C. Dorsal Pattern:

CA – Five longitudinal dark stripes, usually (seven rarely): Northern region (Amazonian region), with some enclaves into northeastern region (Caatinga); dispersing to south and to southwest, reaching northern Goiás, and Mato Grosso do Sul (Brazil). Species: (a) *A. gaboi, A. niceforoi* (7-striped); (b) *A. intermedia, A. lineata, A. nigrolineata, A. nigroterminata, A. phillipsi, A. quinquelineata, A. vittata, Apostolepis sp.*, (5-striped).

CB – Five to three dark longitudinal stripes: Eastern Amazonia to south, one from Atlantic Forest. Species: *A. albocolaris, A. goiasensis, A. nigrolineata, A. tenuis, A. pymi, E. quinquelineatus.*

CC – Three dark longitudinal stripes/ to uniformly: Eastern (northern to southeastern) species in Atlantic Forest (Brazil). Species: *E. wuchereri, E. lepidus.*

CD – Two striped (if three striped, the vertebral is stripe thin or vestigial): Central to southern species. Species: *A. albocolaris, A. dimidiata, A. quirogai, P. iheringi, P. lativittatus, P. lemniscatus, P. nigrilatus, P. spegazzinii, P. suspectus, P. trilineatus.*

CE – Uniformly dorsal coloration: Cerrado and Caatinga, with dispersal to Chaco. Species: *A. ambiniger, A. assimilis, A. breviceps, A. cearensis, A. dorbignyi, A. flavotorquata, A. multicincta, A. sanctaeritae, P. cuyanus, P. labiomaculatus, P.mertensi, P. punctatus, P. tricolor, Phalotris sp.*

CF – Melanistic with/or without red vertebral zone: Species from Brazilian Southern Plateau, from São Paulo to northern Rio Grande do Sul, and from eastern Mato Grosso to Misiones, Argentina. Species: *A. dimidiata* (melanistic morph), *P. iheringi, P. multipunctatus.*

CONCLUSION

The distribution of different color patterns and the distribution of different species allows to recognize five regions of different fauna of Elapomorphinae: Amazonian, Cerrado, Argentinean, Southern Region (Pampa and Monte) and Atlantic Forest Region. The species inhabiting each from these regions present some chromatic characters identifying an ecotone in that physiographic region (Table 1, Fig. 5).

Table 1. Chromatic variation of the Elapomorphinae by geographical regions of species, and combination of patterns by regions according the text. The letters A, B, and C indicate the dorsal background color, ventral pattern, and presence of dorsal stripes, respectively

Regions	Phenotypes
Amazonian	AA—BA—CA
Cerrado	AA—BB—CB
	AC—BB—CE
	AD—BC—CD
Argentinean	AD—BC—CD
	AE—BD—CC
	AE—BB—CE
Southern	AD—BD—CD
	AD—BD—CF
	AE—BD—CD
Atlantic Forest	AB—BA—CB
	AD—BB—CC

Characterization of the Regions

Amazonian Region. In northern South America. It is dominated mainly by Amazonian Forest. The principal pattern is five-stripes becoming seven-stripes in extreme western Amazonia (*A. niceforoi*, Colombia and Ecuador) and enclaves in Caatinga, dunnes of São Francisco River (*A. arenaria*). In western Amazonia occurs *Apostolepis quinquelineata* and in eastern Amazonia occurs *A. nigrolineata* (Para State east to south) with transitional pattern from five-to three-stripes during development. Pattern with three stripes occurs with *A. goiasensis*. The back ground color is a buff to Pratt's rufous above, and yellow ventrally. This area is occupied only by the genus *Apostolepis*. In enclaves within Caatinga occurs endemic species (*A. longicaudata, A. arenaria, A. gaboi, A. polylepis*, all with five stripes except the later that have four to two stripes). Western to south occurs *A. nigroterminata*. For southern Amazonia occur *A. goiasensis* and *A. tenuis* with three stripes, but the later has a black lateral band that may be fusion of the paravertebral, lateral and paraventral stripes. At southern border of this area, there are a population of small species with five-stripes in the are of contact of Cerrado with Chaco (Goiás, Mato Grosso, and Mato Grosso do Sul).

Cerrado Region. Comprises all the Cerrado region with dispersal to Caatinga into northeast, and to Chaco into southwest. Caatinga has xerophytic vegetation, usually in open areas; Cerrado varies from forested areas in the north ("Cerradão") to open areas at center and southwest, at Chaco that has just open areas. The dominant pattern is uniformly scarlet color, without stripes, varying to geranium pink from center to south, according to the species. Another pattern is the yellowish buff in some species at the border of this area (eg. *Phalotris lativittatus*). The dominant ventral color is yellowish-white with some species having black blotches in two series or the venter entirely black by fusion of the blotches among them. This region is occupied by two genera, *Apostolepis* and *Phalotris*, but mainly for the former; the latter is from southern South America, and it disperses toward Cerrado. The Cerrado is the domain of the unicolor pattern.

Argentinean Region. This center is located in Argentina, with dispersal of some species to the Paraguayan Chaco. The back ground color is yellowish buff, with dorsal striped pattern (three-to-two striped) in northeastern Argentina, and uniform from west to Chaco. Another back ground color is geranium pink with yellowish white belly, from western Argentina to Paraguay, Bolivia, and southwestern Brazil. *A. dimidiata, A. quirogai, P. spegazzinii* and *P. suspectus* from Argentina, have two or three stripes with black blotches ventrally. *P. punctatus* and *P. cuyanus* have uniform coloration.

Southern Region. Comprises the Pampean region of Brazil (Rio Grande do Sul) and Uruguay, reaching the southern Brazilian plateau. The basic pattern is striped, three-to-two striped (as in Argentine Center), but the background dorsal color is a geranium pink with the venter strongly blotched with black bars (*P. lemniscatus, P. divittatus*). One phenotype is melanist and occurs on the highlands of southern plateau reaching the west of Mato Grosso (*P. iheringi, P. multipunctatus*). In coastal sandy Atlantic plains from southeastern Uruguay to Santa Catarina (Brazil), occurs a species (*P. trilineatus*) with yellowish buff as the primary dorsal color, mimics with the sandy soil. The species from Southern Center are derived from the Argentine Region (Lema, 1977).

Atlantic Forest Region. Some time ago Atlantic Forest extended from northeastern Brazil to southern Brazil, but now it is reduced to isolated forests in the extremes and southeastern Brazil; where remnants are the gallery forests along river basins that run from east to west flowing in the Paraná river. This event is due to the human action by Brazilian colonization mainly on Atlantic coast. There are two basic patterns in this region: (a) one is five striped in the young becoming three striped in adult (*Elapomorphus quin-*

quelineatus); (b) another with three stripes in young becoming uniform in adult. The primary dorsal color varies from yellow ocher (*Elapomorphus wuchereri*) to geranium pink (*Elapomorphus lepidus*). The ventral color is whitish yellow with or without lateral dots. This region is the domain of genus *Elapomorphus* that has primitive characters in relation to other genera (Lema & Deiques, 1995).

Northeastern Enclaves. There are aberrant species captured into Caatinga in small forested areas that are relict of Amazonian Forest remaining after last glaciation ("refugia"). They are endemic species in small areas. In southern Piauí, were found *A. longicaudata*, and *A. polylepis* only at a single local (Engenheiro Dodt). The former is very similar to *A. nigrolineata*, and the latter presents a regression in the dorsal number of scales (17 rows instead 15), beyond to have an aberrant dorsal pattern (four stripes, one becoming dotted for rear, and divergent of the other (autapomorphy). *Apostolepis arenaria* and *A. gaboi*, have similarities with *A. quinquelineata*, and both are endemic in very small areas at the dunes of the São Francisco river in northern Bahia and is probable the occurrence of other endemic relict species in that area because is very poor explored (Rodrigues, 1992). All species (except *A. polylepis*), have strong similarities with *A. nigroleneata*, a true model species of Amazonian; *A. polylepis* is similar to *A. ambiniger*, a Chacoan species.

Distribution of back ground color

The generalization of the distribution is schematic and is used the dominant back ground color. In the Argentine region there are not species with back ground color red, but only yellowish ocher. In the Chacoan region appears species with the back color red, but similar to the color brick. In Cerrado-Caatinga, the dominant color is red, or orange-tasting or brilliant. In the Amazonian to south, and in eastern Atlantic forest, there are many species with the dominant back color brown, yellowish or pinkish tonality. In the Atlantic forest area, the dominant back color varies of yellowish brown or reddish brown to yellow or red (Fig. 1).

Final Comments

The analysis of color pattern in correlation with age showed that the multilineate pattern is reduced during ontogenic development in several species. The Amazonian species have snout not projected beyond jaws (plesiomorphy according Ferrarezzi (1993c)), and the number of stripes reducing north to south and the stripes disappearing in the central region (Cerrado). In southern border of Amazonia occurs phenotypes with three or five stripes, from east to west. In Southern regions the stripes varies two to three desapearing to western semi arid areas. *Apostolepis* (striped pattern) is northern, and *Phalotris* (striped to uniform), is southern. The seven-striped pattern is derived from the five srtiped because some five striped species have black dots on paraventral zones that usually are continuos, forming stripe. The five striped or seven striped occurring in Caatinga enclaves, are remnants from Amazonian forest that covered all the northern part of the continent. The two striped pattern is obviously a derived of the three striped because specimens of two striped pattern present vestiges of the vertebral dark stripe in the black nuchal collar, and some specimens present vestiges of the vertebral stripe as dots, or feeble line. Likewise, some species of uniformly pattern present vestiges of the stripes in the same black nuchal collar, as it is well visible in *Apostolepis ambiniger e.g.* Vestiges of dark dorsal stripes are visible in many specimens of uniform color species, or in the neck, or in the trunk, or in the tail (*e.g. A. ambiniger, A. dimidiata, P. concolor*).

The color pattern of the different species and population are the expression of the basic genetic patterns of the elapomorphines presenting different phenotypes by different morphoclimatic domains and/or particular habitats. In several species, or specimens, it is possible to visualize vestiges of a different pattern from the basic, *e.g.*, *Apostolepis ambiniger*, that has uniform pattern, presents vestiges of the black dorsal longitudinal stripes at the posterior margin of the black cervical collar, and there are specimens of this species that present segments of the stripes isolated along the back. Several species with uniform dorsal pattern can be present vestiges of dorsal stripes.

The black blotches on ventral sides is own from southern species of *Phalotris* and some *Apostolepis* from Cerrado and Chaco. In the later species (*dimidiata* Group) the black blotches tending to disappears in the extreme of area, at Chaco domain.

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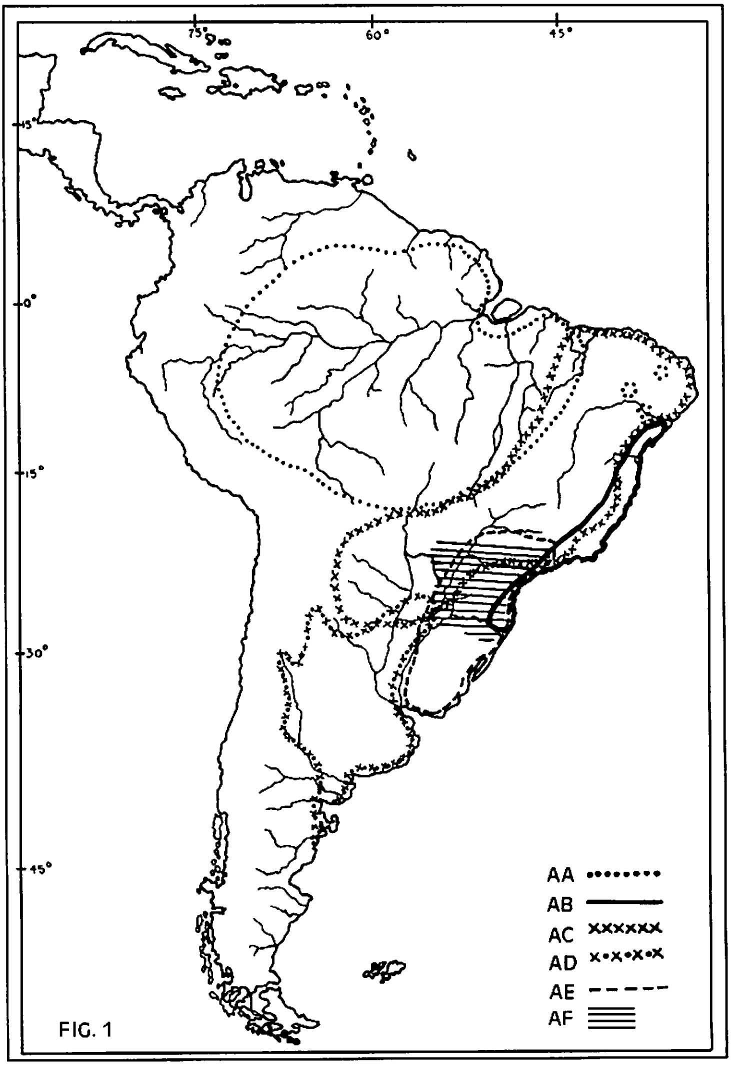

FIG. 1

Figura 1. Distribution of the primary dorsal color of Elapomorphinae (A). Combinations: AA, buff (= reddish brown); AB, yellow ocher (=yellowish brown); AC, scarlet (= coral red); AD, yellowish buff (= sand color); AE, geranium pink (= cinnabar red); AF, Melanistic (total or partial). (Schematic).

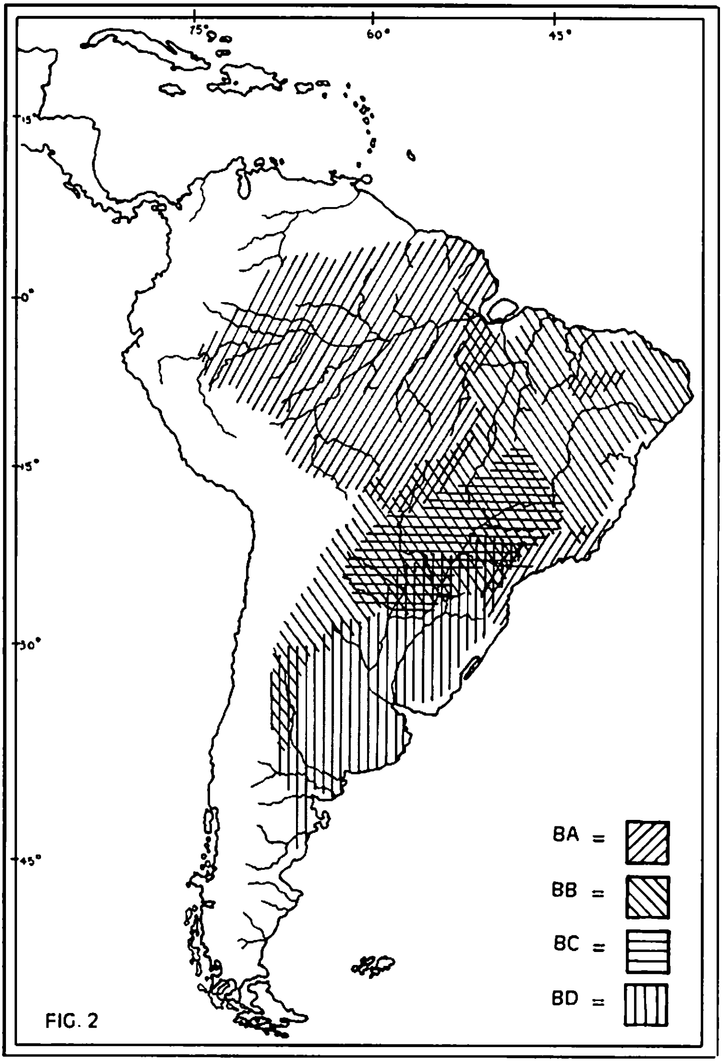

FIG. 2

Figura 2. Distribution of ventral color pattern (B). Combinations: BA, yellowish white usually with paraventral dotted stripe; BB, yellowish white immaculate; BC, one pair of black blotches by each ventral scale; BD, single black blotch by every ventral scale. (Schematic).

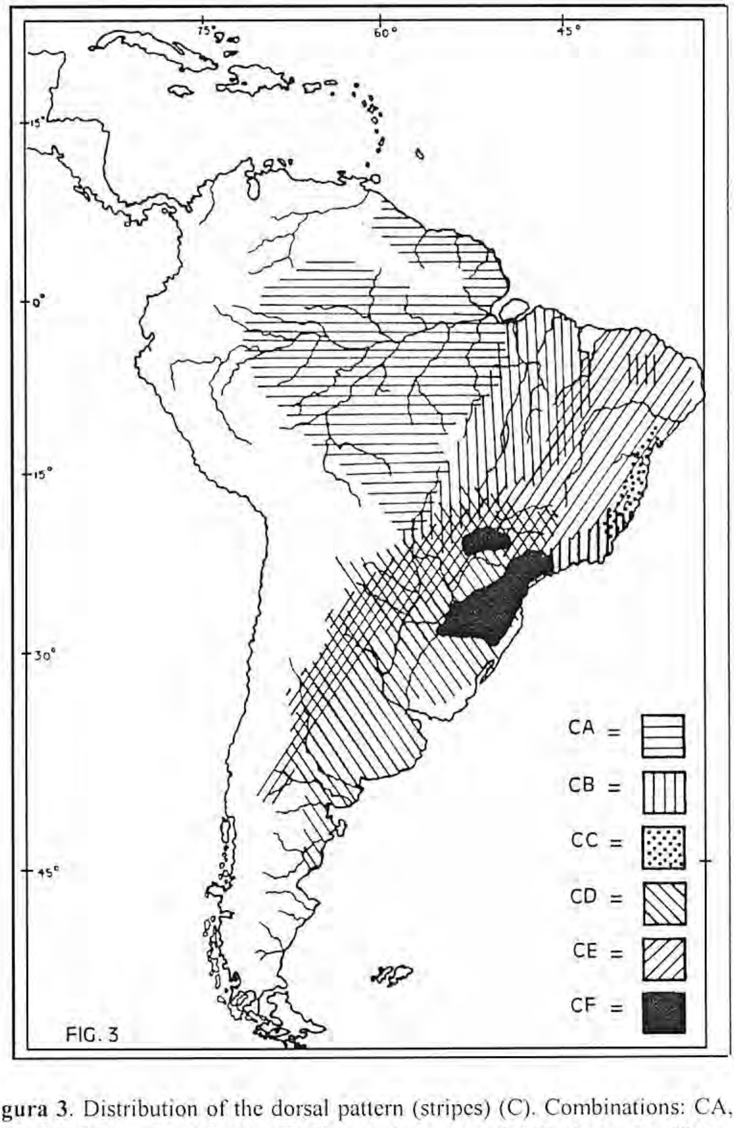

FIG. 3

Figura 3. Distribution of the dorsal pattern (stripes) (C). Combinations: CA, five striped (a few seven striped); CB, five-to-three striped; CC, three to uniform; CD, tri-to-two striped; CE, uniform; CF, melanistic. (Schematic).

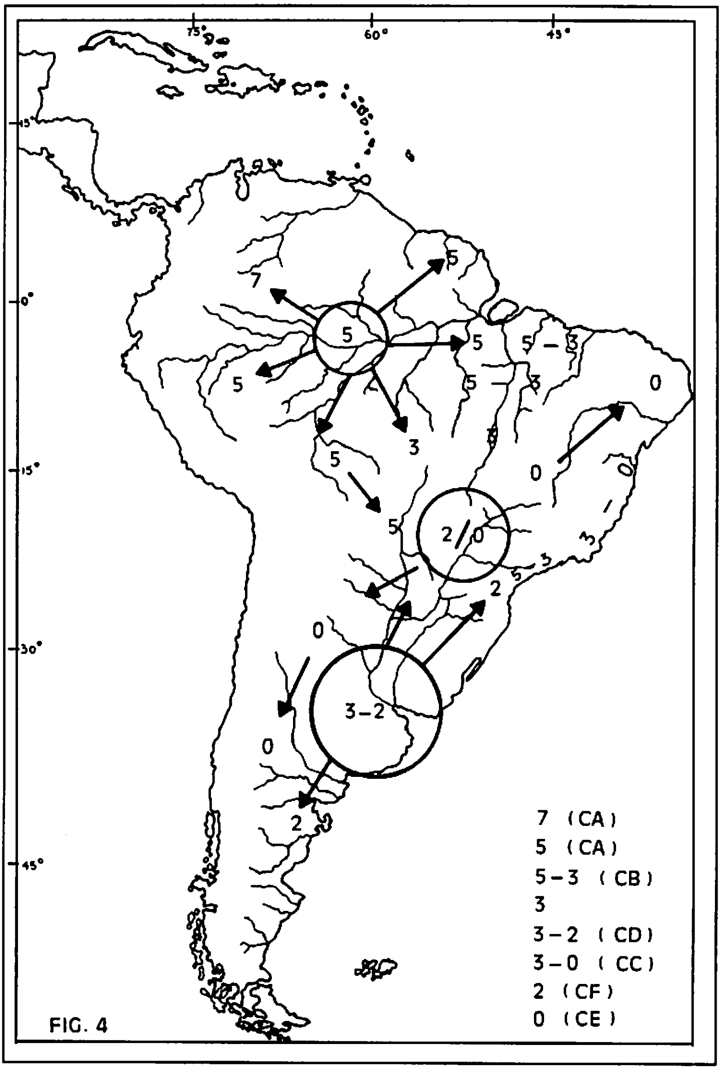

FIG. 4

Figura 4. Distribution of the dorsal pattern using only by the number os stripes. (Complementary map of the Figure 3). 7 Seven striped (CA): 5 five striped (CA); 5-3: young (5) to adult (3) (CB); 3 three striped; 3-2 vertebral distinct or vestigial in the same species (CD); 3-0: young (3) to adult (0) (CC): 2 two striped red or melanistic (CF); 0 uniforme red to brown along the distribution NE/SW (CE).

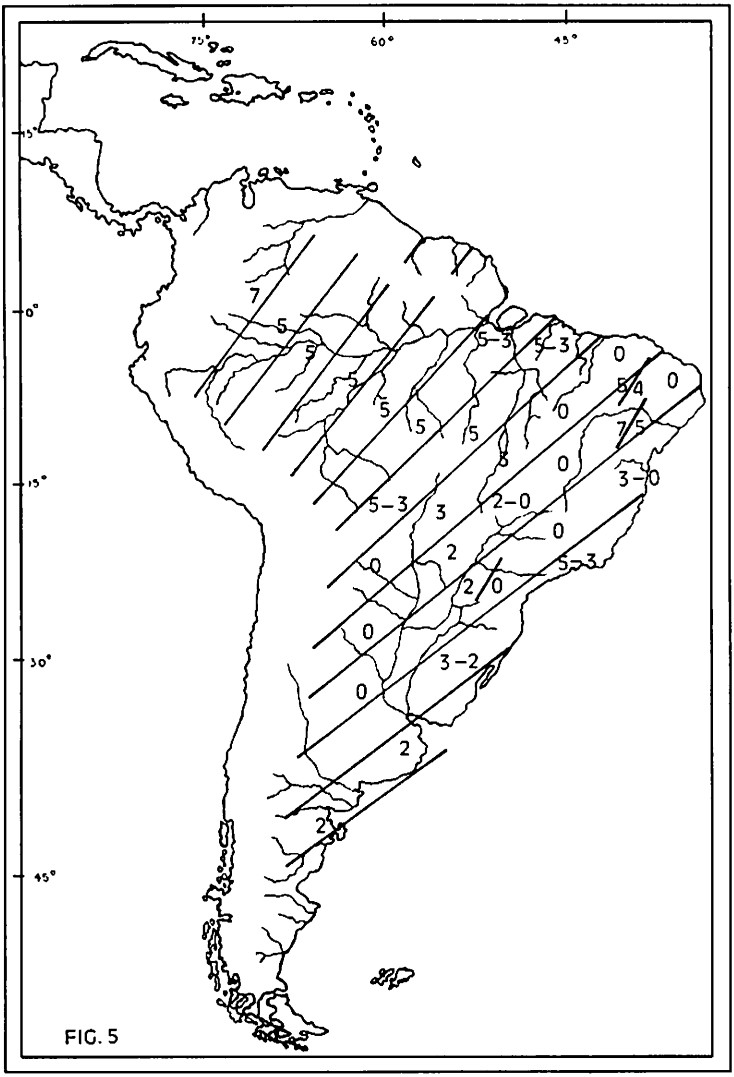

FIG. 5

Figura 5. Distribution of the dorsal pattern of Elapomorphinae showing decreasing grades of the number of stripes from the North, or from the South, all for to central region (Cerrados). (Another view of the Fig. 4)

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Appendix

Systematic list of the species (Lema, 1984, 2001b; Ferrarezzi, 1993c; Lema & Deiques, 1995)

Elapomorphinae Jan, 1862
1. Elapomorphini
1.1. *Elapomorphus* Wiegmann, 1843
1.1.1. *E. lepidus* (Reinhardt, 1861): Easthern Brazil (Espírito Santo to Bahía).
1.1.2. *E. quinquelineatus* (Raddi, 1820): Southeastern Brazil (Espírito Santo to Rio Grande do Sul).
1.1.3. *E. wuchereri* Günther, 1861: Eastern Brazil (Espírito Santo to Bahía). (Revalidated by Lema and Albuquerque, submitted).
2. Phalotriini
2.1. *Phalotris* Cope, 1861
2.1.1. Group *P. spegazzinii* (= *P. bilineatus* according Ferrarezzi, 1993a)
2.1.1.1. *P. spegazzinii* (Boulenger, 1913): Northeastern to central Argentina (Corrientes to Buenos Aires Provinces) (= *Elapomorphus bilineatus* Duméril, Bibron & Duméril, 1854, part).
2.1.1.2. *P. suspectus* (Amaral, 1924): Western Argentina (Corrientes to Chubut) (= *Elapomorphus bilineatus* Duméril, Bibron & Duméril, 1854, part).
2.1.2. Group *P. lemniscatus* (= Group *P. bilineatus,* Ferrarezzi, 1993a, part)
2.1.2.1. *P. divittatus* (Lema, 1984): Highlands of southern Brazil to Uruguay (Santa Catarina to Montevideo).
2.1.2.2. *P. iheringi* (Strauch, 1885): Brazilian Southern Plateau (São Paulo to Rio Grande do Sul; Brazil; and Misiones, Argentina) (= *Elapomorphus reticulatus* Peters, 1860, part).
2.1.2.3. *P. lemniscatus* (Duméril, Bibron & Duméril, 1854): Southern Brazil (Rio Grande do Sul) to Uruguay
2.1.2.4. *P. multipunctatus* Puorto & Ferrarezzi, 1993: Southwestern Brazil (São Paulo to eastern Mato Grosso).
2.1.2.5. *P. trilineatus* (Boulenger, 1889): Eastern district of southern Brazil and Uruguay (Rio Grande do Sul, Brazil, to Punta del Este, Uruguay).
2.1.3. Group *P. nasutus*
2.1.3.1. *P. concolor* Ferrarezzi, 1993: Eastern Brazil (Minas Gerais State).
2.1.3.2. *P. labiomacultaus* Lema, 2002: Northern Brazil (Maranhão State)
2.1.3.3. *P. lativittatus* Ferrarezzi, 1993: Central Brazil (São Paulo to Santa Catarina).
2.1.3.4. *P. nasutus* (Gomes, 1915): Central Brazil (Goiás, Minas Gerais, São Paulo and Mato Grosso States).
2.1.3.5. *P. nigrilatus* Ferrarezzi, 1993: Eastern Paraguay.
2.1.4. Group *P. tricolor*

2.1.4.1. *P. cuyanus* (Cei, 1984): Southwestern Argentina (San Juan to Mendoza).

2.1.4.2. *P. punctatus* (Lema, 1979): Western, Bolivia to northern Argentina (Santa Cruz to Misiones and Córdoba Provinces).

2.1.4.3. *P. tricolor* (Duméril, Bibron & Duméril, 1854): Western region, from Bolivia to Brazil and Paraguay (Santa Cruz de la Sierra, Bolivia, attaining southwestern Brazil at Mato Grosso and Mato Grosso do Sul States and adjacent lands of Paraguay).

2.1.5. Group *P. mertensi* (Several characters shared with *Apostolepis*)

2.1.5.1. *P. mertensi* (Hoge, 1958); Central to southwestern Brazil (Minas Gerais and Mato Grosso to Paraná).

3. Apostolepidini

3.1. *Apostolepis* Cope, 1861

3.1.1. Group *A. nigrolineata*

3.1.1.1. *A. longicaudata* Gomes, 1921: Northeastern Brazil (enclave in southern Piaui State).

3.1.1.2. *A. niceforoi* Amaral, 1935: Amazonian Colombia and Ecuador.

3.1.1.3. *A. nigrolineata* (Peters, 1869): Western Amazonia (Guyanas to southern Amazonas in Brazil).

3.1.1.4. *A. nigroterminata* Boulenger, 1896: Eastern Ecuador and Peru to Bolivia and Brazil.

3.1.1.5. *A. pymi* Boulenger, 1896: Eastern Amazonia (Pará to Rondônia, and enclaves in northeastern Brazil).

3.1.2. Group *A. tenuis*

3.1.2.1. *A. arenaria* Rodrigues, 1993: Northeastern Brazil (Bahia).

3.1.2.2. *A. gaboi* Rodrigues, 1993: Northeastern Brazil (Bahia).

3.1.2.3. *A. tenuis* Ruthven, 1927: Andes of Bolivia.

3.1.3. Group *A. flavotorquata*

3.1.3.1. *A. dorbignyi* (Schlegel, 1837): Bolivia.

3.1.3.2. *A. flavotorquata* (Duméril, Bibron & Duméril, 1854): Central Brazil.

3.1.4. Group *A. assimilis*

3.1.4.1. *A. assimilis* (Reinhardt, 1861): Central Brazil to Paraguay.

3.1.4.2. *A. cearensis* Gomes, 1915: Northeastern Brazil.

3.1.4.3. *A. multicincta* Harvey, 1998: Santa Cruz Department, Bolivia.

3.1.4.4. *A. sanctaeritae* Werner, 1924: Central Brazil (Bahia State).

3.1.5. Group *A. lineata*

3.1.5.1. *A. intermedia* Koslowsky, 1889: Southwestern Brazil (Mato Grosso do Sul).

3.1.5.2. *A. lineata* Cope, 1887: Western Brazil (Mato Grosso).

3.1.5.3. *A. phillipsi* Harvey, 1998: Santa Cruz, Bolivia.

3.1.5.4. *A. vittata* (Cope, 1887): Western Brazil (Mato Grosso).

3.1.6. Group *A. dimidiata*

3.1.6.1. *A. albocolaris* Lema, 2002: Central Brazil (Goiás) at Cerrado.

3.1.6.2. *A. ambiniger* (Peters, 1869): Paraguay to southwestern Brazil and to northern Argentina.

3.1.6.3. *A. breviceps* Harvey, Gonzalez-A. & Scrocchi, 2001: Bolivian Chaco.

3.1.6.4. *A. dimidiata* (Jan, 1862): Central Brazil to Paraguay and northern Argentina.

3.1.6.5. *A. goiasensis* Prado, 1942: Central Brazil (Goiás).

3.1.6.6. *A. polylepis* (Amaral, 1921): Northeastern Brazil (enclave at Piaui).

3.1.6.7. *A. quirogai* Giraudo & Scrocchi 1998: Northeastern Argentina to adjacent Brazil (Misiones Province, Rio Grande do Sul State).

PADRÕES DE VOCALIZAÇÃO DE ANÚNCIO EM CINCO ESPÉCIES DE HYLIDAE (AMPHIBIA: ANURA) DO BRASIL CENTRAL

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RESUMO

O objetivo central deste trabalho foi descrever os padrões de vocalização de anúncio de cinco espécies de hilídeos: *Hyla albopunctata*, *H. cruzi*, *H. goiana*, *H. nana* e *Scinax fuscomarginatus*, verificando se há correlação entre os parâmetros acústicos (duração do canto, taxa de repetição e freqüência dominante) e comprimento rostro-anal (CRA)/massa dos machos cantores ou com a temperatura do ar. As observações de campo foram realizadas em três localidades do Estado de Goiás: (a) Fazenda Lagoa Grande, município de Pontalina, (b) Floresta Nacional, município de Silvânia e (c) Sítio dos Pinheiros, município de Palmeiras. As espécies foram encontradas vocalizando, principalmente, em ambientes de áreas abertas. As vocalizações de anúncio das cinco espécies foram analisadas e descritas. Foram detectadas correlações significativas entre os seguintes pares de variáveis: taxa de repetição de canto e temperatura; freqüência dominante e o comprimento rostro-anal e freqüência dominante e a massa dos machos cantores.

Palavras-chaves: vocalização de anúncio, Hylidae, Brasil Central, Anura.

ABSTRACT

Patterns of advertisement calls in five species of Hylidae (Amphibia: Anura) from Central Brazil.

This aim of this work was to analyze some acoustic parameters of advertisement calls in the following hylids species: *Hyla albopunctata*, *H. cruzi*, *H. goiana*, *H. nana* and *Scinax fuscomarginatus*. The field work was carried out from March

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1999 to April 2001, at three localities in the State of Goiás: Fazenda Lagoa Grande, municipality of Pontalina; Floresta Nacional (FLONA), municipality of Silvânia, and Sítio dos Pinheiros, municipality of Palmeiras. Open areas were the main sites of vocalization. Advertisement calls of five species were analyzed and described. We detected significant relationships between the following pairs of variables: call repetition rate and temperature; dominant frequency and snout-vent length; and dominant frequency and mass of the calling males.

Key words: advertisement call, Central Brasil, Anura, Hylidae.

INTRODUÇÃO

A emissão de sinais sonoros é de ocorrência quase universal nos anuros, sendo provável que tenha surgido no início da história evolutiva do grupo (Salthe & Mecham, 1973). Em várias espécies de anfíbios anuros são observadas correlações significativas entre os parâmetros acústicos e CRA/massa do emissor ou com a temperatura (*e.g.* Giacoma *et al.*, 1997; Given, 1988; Howard & Young, 1998).

Em algumas espécies de anuros, as variações nos parâmetros da vocalização de anúncio (ex.: freqüência dominante, número de pulsos, duração, taxa de repetição) estão relacionadas com os padrões de escolha realizada pelas fêmeas (*e.g.* Lea *et al.*, 2000; Wollerman, 1998).

O objetivo deste estudo foi verificar os padrões das vocalizações de anúncio em 5 espécies de Hylidae: *Hyla albopunctata* (Spix, 1824), *H. cruzi* Pombal & Bastos, 1998; *H. goiana* B. Lutz, 1968, *H. nana* Boulenger, 1889 e *Scinax fuscomarginatus* (A. Lutz, 1925), verificando se há correlação entre os parâmetros acústicos (duração do canto, taxa de repetição e freqüência dominante) e o comprimento rostro-anal (CRA)/massa dos machos cantores ou com a temperatura do ar.

MATERIAL E MÉTODOS

As observações de campo foram realizadas em três localidades do Estado de Goiás: (a) Fazenda Lagoa Grande, município de Pontalina (17°31'23"S; 49°26'49"W: 640 m de altitude), cerca de 124 km de Goiânia, (b) Floresta Nacional (FLONA), localizada no município de Silvânia (16°39'26"S; 48°36'16"W; 900 m de altitude) a qual está sob a responsabilidade do IBAMA e (c) Sítio dos Pinheiros, município de Palmeiras (19°80'50"S; 49°92'58"W; 596 m de altitude).

As observações de campo foram iniciadas na estação chuvosa (novembro) de 2000 e foram finalizadas em dezembro de 2001. Cada turno de observação foi iniciado aproximadamente entre 18h00min e 19h00min, terminando conforme diminuísse o número de indivíduos ou a atenção dos observadores. Não foi considerada alteração estabelecida pelo horário de verão. A temperatura do ar foi obtida através de Termo-Higrômetro digital Minipa.

Os anuros foram coletados e observados utilizando-se lanterna manual de luz branca, porém quando necessário foi utilizado filtro vermelho para diminuir o estresse nos animais (*e.g.* Robertson, 1990). Para tais observações, foi utilizado o método de *animal focal* (Martin & Bateson, 1986), sendo que todos os dados foram registrados em fita cassete em um gravador Casio.

As gravações dos machos, foram realizadas com gravador digital DAT TCD-D100 com microfone direcional Sony ECM-MS907 ou DAT TASCAM DAP1 e microfone Sennheiser ME66. Os indivíduos gravados ou que tiveram a taxa de repetição dos cantos foram coletados, pesados com dinamômetro Pesola (precisão de 0,05 g) e CRA foi medido com paquímetro de plástico (precisão de 0,1 mm).

A análise bioacústica das diferentes vocalizações foi realizada em computador Pentium PC com o programa Avisopht-Sonograph light e Cool Edit. Cinco variáveis acústicas foram tomadas: duração do canto, número de notas, número de pulsos, taxa de repetição de cantos e freqüência dominante. No total, foram gravados 116 indivíduos, sendo 25 de *Hyla albopunctata*, 16 de *Hyla cruzi*, 21 de *Hyla goiana*, 15 de *Hyla nana* e 39 de *Scinax fuscomarginatus*.

Os resultados são apresentados como $\bar{\chi} \pm$ DP. Para a análise estatística dos dados foi utilizado o coeficiente de correlação de Pearson (r). O nível de significância considerado foi de $P \leq 0{,}05$ (Zar, 1996).

RESULTADOS

Hyla albopunctata somente foi observada em Silvânia, com indivíduos agregando-se ao redor de corpos de água permanentes localizados em áreas abertas ou próximos de Matas de Galerias. Como sítios de vocalização, os machos de *H. albopunctata*, ocuparam ramos das vegetações arbustivas ou emergentes e o solo. Os machos vocalizavam em duetos, trios ou quartetos, com o corpo em posição horizontal ou com a cabeça levemente voltada para cima. Os machos emitiam o canto de anúncio (Fig. 1A) a uma taxa média de

9,80 ± 10,21 cantos por minuto (variação de 1 a 42 cantos), sendo correlacionada significativamente com a temperatura do ar (*r* = 0,42; *n* = 25 indivíduos; *P* = 0,036; Tab. 1). A duração média deste canto foi de 0,476 ± 0,091 s (variação de 0,281 a 0,643 s). A correlação entre a duração média do canto e o CRA/massa dos machos não foi significativa. Em média, os cantos apresentaram 63 ± 15 pulsos (variação de 40 a 92). A freqüência dominante foi de 2202,74 ± 159,21 Hz (variação de 1710,80 a 2491,00 Hz), sendo negativamente correlacionada com o CRA (*r* = -0,56; *n* = 22 indivíduos; *P* = 0,007) e com a massa dos machos vocalizantes (*r* = -0,73; *n* = 17 indivíduos; *P* = 0,0009). Além do canto de anúncio, foi registrado a vocalização territorial.

Indivíduos de *Hyla cruzi* formavam leques (arenas de exibição) e vocalizaram, nas três localidades estudadas, em ramos de vegetação marginal de corpos de água permanentes ou temporários, localizados em áreas abertas. A vocalização de anúncio (Fig. 1B) foi constituída por 1 a 5 pulsos. A duração total média deste canto foi de 0,011 ± 0,0026 s (variação de 0,008 a 0,017 s), não sendo correlacionada com o CRA ou massa dos machos (Tab. 1). A taxa de repetição média foi de 62,75 ± 20,93 cantos por minuto (variação de 38 a 82), sendo positivamente correlacionada com a temperatura do ar (*r* = 0,44; *n* = 20 indivíduos; *P* = 0,05). A freqüência dominante média foi de 6322,58 ± 408,81 Hz (variação de 5194,3 a 7002,00 Hz), estando correlacionada negativamente com o CRA (*r* = -0,66; *n* = 16 indivíduos; *P* = 0,005) e a massa (*r* = -0,59; *n* = 16 indivíduos; *P* = 0,016) dos machos vocalizantes.

Machos de *Hyla goiana* foram observados somente em Silvânia e vocalizavam desde o solo até 2 m de altura e desde próximo à margem de corpos permanentes de água até 6 m de distância. O canto de anúncio (Fig. 1C) apresentou estrutura harmônica e duração média de 0,29 ± 0,082 s (variação de 0,16 a 0,41 s). A correlação de Pearson entre a duração do canto de anúncio e o CRA não foi significativa, bem como a correlação entre este parâmetro acústico e o peso dos machos (Tab. 1). Em média, o canto de anúncio foi constituído por 4 ± 1 notas (variação de 2 a 5), cada uma com duração média de 0,023 ± 0,007 s (variação de 0,01 a 0,05). A taxa de repetição foi de 14 ± 3 cantos por minuto (variação de 1 a 20) e não foi significativamente correlacionada com a temperatura do ar (Tab. 1). A freqüência dominante média foi de 3228,99 ± 113,38 Hz (variação de 2984,6 a 3468,3 Hz), estando correlacionada negativamente com o CRA (*r* = -0,50; *n* = 21 indivíduos; *P* = 0,02) e peso (*r* = -0,64; *n* = 19 indivíduos; *P* = 0,003) dos machos cantores.

Machos vocalizantes de *Hyla nana* foram encontrados, nos municípios de Palmeiras e Pontalina, formando leques e vocalizavam sobre gramíneas de ambientes abertos e também em vegetação marginal de corpos permanentes de água de áreas abertas. A vocalização de anúncio (Fig. 1D) apresentou duração média de 0,031 ± 0,009 s (variação de 0,016 a 0,048 s) e não foi significativamente correlacionada com o CRA ou peso dos machos (Tab. 1). Cada canto foi constituído, em média, por 8,79 ± 3,26 pulsos (variação de 3,4 a 14,6). A taxa de repetição foi de 57,39 ± 27,32 cantos por minuto (variação de 24 a 105), estando correlacionada positivamente com a temperatura do ar (r = 0,57; n = 21 indivíduos; P = 0,007). A freqüência dominante média foi de 4180,93 ± 405,80 Hz (variação de 3446,30 a 4684,3 Hz), sendo correlacionada negativamente com o CRA (r = -0,68; n = 15 indivíduos; P = 0,005) e peso (r = -0,58; n = 15 indivíduos; P = 0,02) dos machos cantores.

Indivíduos de *Scinax fuscomarginatus* foram observados formando leques, nas três localidades estudadas, em corpos permanentes ou temporários de água. Os machos podiam vocalizar em locais abrigados sobre ramos de vegetação arbustiva ou emergente, ou em locais mais expostos como vegetação rasteira de gramíneas e elevações do solo. A posição dos indivíduos e a altura do substrato foram bastante variáveis. O canto de anúncio (Fig. 1E), apresentou duração média de 0,525 ± 0,076 s (variação de 0,379 a 0,826 s), não estando correlacionada com o CRA e peso (Tab. 1). Cada canto apresentou, em média, 98,1 ± 11,00 pulsos (variação de 76,2 a 125,8). A taxa de repetição foi de 11,49 ± 4,71 cantos por minuto (variação de 1 a 21) e a correlação de Pearson entre esse parâmetro acústico e a temperatura do ar não foi significativa (Tab. 1). A freqüência dominante média foi de 4017,33 ± 347,94 Hz (variação de 3512,7 a 4940,9 Hz), sendo negativamente correlacionada com o CRA (r = -0,37; n = 39 indivíduos; P = 0,02) e com o peso (r = -0,34; n = 39 indivíduos; P = 0,03) dos machos cantores.

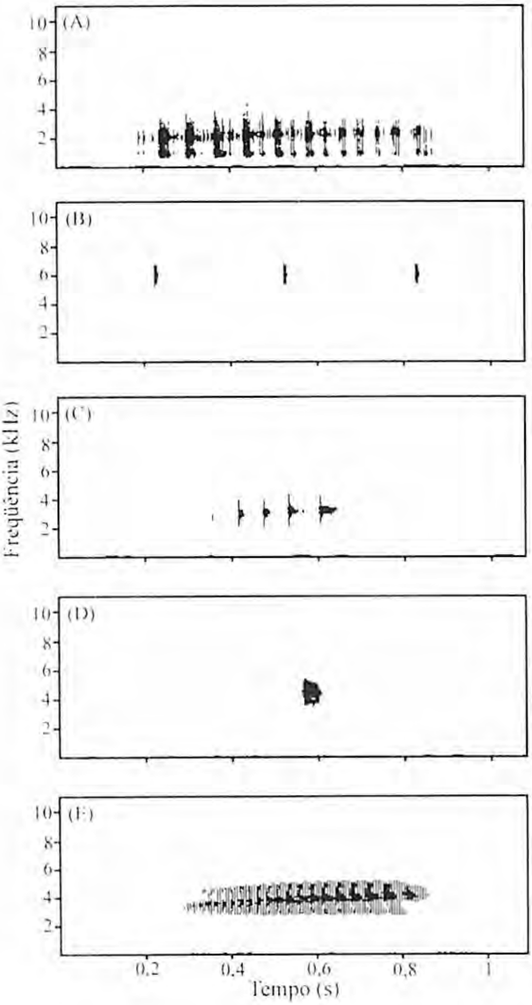

Figura 1. Sonogramas do canto de anúncio de: (A) *Hyla albopunctata*; (B) *Hyla cruzi*; (C) *Hyla goiana*; (D) *Hyla nana* e (E) *Scinax fuscomarginatus*.

DISCUSSÃO

As vocalizações de anúncio das espécies analisadas são similares às descritas por outros pesquisadores: *Hyla albopunctata* (Cardoso, 1986; de la Riva *et al.*, 1997; Heyer *et al.*, 1990; Straneck *et al.*, 1993); *Hyla cruzi* (Pombal & Bastos, 1998); *Hyla goiana* (Guimarães *et al.*, 2001); *Hyla nana* (Márquez *et al.*, 1993; Straneck *et al.*, 1993) e *Scinax fuscomarginatus* (Bokermann, 1967; Pombal, 1995; Pombal *et al.*, 1995).

As principais diferenças verificadas, aparentemente, podem decorrer do uso de técnicas diversas de gravação, análise, variações de nomenclaturas ou diferenças populacionais. Por exemplo, gravações realizadas a diferentes distâncias, do animal que vocaliza, podem ocasionar perda de harmônicos, perda de parte da freqüência (Pombal, 1995) ou artefatos podem ser produzidos pelo uso de diferentes tipos de filtros (Vielliard, 1993).

O canto de anúncio *H. albopunctata* foi considerado como sinônimo das notas "a", "b" e "c" de Cardoso (1986), o que não invalida a hipótese de existir uma diferença a nível populacional. Para *H. albopunctata*, talvez ocorra o aumento do número de notas por unidade de tempo, como em *Hyla minuta* (Haddad, 1987), devido ao incremento do número de machos no coro, que, nestes casos, são mutuamente estimulados. O número de pulsos registrado para *Hyla cruzi* foi maior do que aquele apresentado por Pombal & Bastos (1998), para indivíduos de Silvânia (GO). Deste modo, a amplitude de variação deste parâmetro acústico, para *Hyla cruzi*, é maior do que o anteriormente reportado (Pombal & Bastos, 1998).

Em anuros, algumas características das vocalizações são correlacionadas significativamente com variáveis abióticas ou com a massa e o CRA dos machos cantores, como por exemplo: taxa de repetição de canto e a temperatura do ar (Bastos & Haddad, 1995; Gayou, 1984; Sullivan, 1992), taxa de repetição e CRA/massa (Given, 1988), intensidade sonora e CRA/massa (Arak, 1983; Given, 1988), freqüência e CRA/massa (Crespo *et al.*, 1989; Giacoma *et al.*, 1997; Given, 1987; Howard & Young, 1998).

Neste trabalho, também foram encontradas algumas correlações significativas entre os parâmetros acústicos analisados e temperatura do ar ou características dos machos cantores (CRA e massa). Para todas as cinco espécies foi verificado que a freqüência dominante foi correlacionada negativamente com o CRA e a massa dos machos. Este tipo de resultado é comum entre os anuros (veja referências no parágrafo anterior), pois a freqüência é um parâmetro acústico determinado por componentes estruturais passivos da laringe (Martin, 1972). Dessa forma, machos pequenos têm, em média, freqüências dominantes mais altas que a dos maiores. Os machos, então, poderiam usar esta informação para determinar a habilidade de luta de algum potencial competidor.

Todavia, como a grande maioria das correlações (Tab. 1) não foi significativa, pode-se supor que fatores ecológicos (e.g. densidade de indivíduos, distância para o indivíduo cantor mais próximo, escolha realizada pela fêmea), que não foram analisados neste trabalho, poderiam ter influenciado alguns parâmetros acústicos, como a taxa de repetição ou duração do canto. Assim, à medida que a densidade do coro aumenta ou a distância entre os vizinhos cantores diminui, os machos de determinadas espécies de anuros aumentam a sua taxa de repetição (Wells, 1988; Bastos & Haddad, 1995; Ovaska & Caldebeck, 1997), alteram a complexidade do canto (Rand & Ryan, 1981), modificam a freqüência dominante (Howard & Young, 1998; Witte *et al.*, 2001) e/ou alteram o padrão temporal (Wells & Schwartz, 1984a, b). Por outro lado, em outras espécies, à medida que há um incremento na densidade do coro, a taxa de repetição diminui, mas a duração do canto de anúncio aumenta (Wells & Taigen, 1986). Essas variações nos parâmetros acústicos têm sido interpretadas como estratégias utilizadas pelos machos para diminuir a competição com seus vizinhos coespecíficos (Bee & Perril, 1996; Bosch & Márquez, 1996; Wollerman, 1999) e, conseqüentemente, aumentar suas chances de acasalamento (Wells & Schwartz, 1984a; Wollerman, 1998).

Tabela 1. Valores dos coeficientes de correlação (*r*) obtidos entre os pares de parâmetros acústicos analisados para as cinco espécies de Hylidae. *P* = probabilidade. Valores em negrito são significativos a $P \leq 0,05$.

Correlações entre parâmetros acústicos	Espécies									
	Hyla albopunctata		Hyla cruzi		Hyla goiana		Hyla nana		Scinax fuscomarginatus	
	r	P	*r*	P	*r*	P	*r*	P	*r*	P
Duração do canto x CRA	0,054	0,810	0,028	0,917	-0,087	0,709	-0,215	0,442	0,124	0,453
Duração do canto x massa	-0,046	0,862	0,016	0,954	-0,255	0,293	-0,285	0,302	0,049	0,766
Taxa de repetição x CRA	0,033	0,883	0,111	0,682	-0,150	0,515	0,253	0,363	0,233	0,154
Taxa de repetição x massa	0,158	0,544	0,258	0,335	-0,289	0,231	0,300	0,277	0,168	0,305
Taxa de repetição x temperatura	**0,421**	0,036	**0,444**	0,05	-0,014	0,952	**0,572**	0,007	-0,247	0,119
Freqüência dominante x CRA	**-0,559**	0,007	**-0,662**	0,005	**-0,504**	0,019	**-0,684**	0,005	**-0,370**	0,020
Freqüência dominante x massa	**-0,723**	0,001	**-0,592**	0,016	**-0,643**	0,003	**-0,581**	0,023	**-0,339**	0,035

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UMA NOVA ESPÉCIE DE *Piabina* REINHARDT, 1867 (TELEOSTEI: OSTARIOPHYSI: CHARACIDAE) PARA O ALTO RIO TIETÊ, SÃO PAULO, BRASIL

*José Francisco Pezzi da Silva**
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RESUMO

Uma nova espécie de caracídeo, *Piabina anhembi*, é descrita para o alto rio Tietê, Estado de São Paulo, Brasil. A nova espécie diferencia-se de *P. argentea* pelo menor comprimento da cabeça (20,6-24,5% do CP, média 22,4% versus 22,2-27,5% do CP, média 24,7% na população do alto rio Paraná e 22,6-25,0% do CP, média 23,7% na população do rio São Francisco); menor largura da boca (5,0-6,3% do CP, média 5,6% versus 6,1-8,4% do CP, média 7,07% na população do alto rio Paraná e 6,3-7,9% do CP, média 6,97% na população do rio São Francisco) e diferenças na posição dos dentes do pré-maxilar, dente anterior da tríade parcialmente inserido entre o primeiro e o segundo dente da primeira série em *P. anhembi* (dente anterior da tríade nunca inserido no espaço entre o primeiro e o segundo dente da primeira série em *P. argentea*).

Palavras-chave: *Piabina*, Characidae, sistemática, alto rio Tietê.

ABSTRACT

A new species of *Piabina* Reinhardt, 1867 (Teleostei: Ostariophysi: Characidae) from upper rio Tietê, São Paulo, Brazil

A new characid species, *Piabina anhembi*, is described from the upper rio Tietê, São Paulo State, Brazil. The new species differs from *P. argentea* by the relative head length (20.6-24.5% of SL, average 22.4% versus 22.2-27.5% of SL, average 24.7% in the upper rio Paraná population and 22.6-25.0% of SL, average 23.7% in the rio São Francisco population); mouth width (5.0-6.3% of SL, average 5.6% versus 6.1-8.4% of SL, average 7.07% in the upper rio Paraná population and

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6.3-7.9% of SL, average 6.97% in the rio São Francisco population) and by differences in the position of the premaxillary teeth (anterior teeth of triad partially inserted between first an second tooth of the first series in *P. anhembi* versus anterior teeth of triad not inserted between first an second tooth of the first series in *P. argentea*).

Key words: *Piabina*, Characidae, systematics, upper rio Tietê.

INTRODUÇÃO

O gênero *Piabina* e a espécie-tipo, *P. argentea*, foram descritos por Reinhardt (1867:49) de Lagoa Santa, Minas Gerais, Brasil. Recentemente, Vari & Harold (1998; 2001) discutiram exaustivamente as relações filogenéticas de *Creagrutus* e *Piabina* e concluíram que *Piabina* é um gênero monofilético com uma única espécie, *P. argentea*, e essa forma o grupo irmão de *Creagrutus*. As outras duas espécies descritas do gênero *Piabina*, *P. analis* e *P. beni*, pertencem, respectivamente, aos gêneros *Piabarchus* e *Creagrutus* (= *C. pearsoni*). De acordo com Vari & Harold (2001), *P. argentea* ocorre na bacia do alto rio Paraná no nordeste do Paraguai e sudeste do Brasil, acima de salto Guaíra, e no rio São Francisco, rio Itapicuru, rio Paraíba do Sul e rio Itapemirim, bacias do leste do Brasil. Em recente coleta nas cabeceiras do rio Tietê, São Paulo, foram capturados exemplares de um lambari, que identificamos como uma espécie nova de *Piabina* e que descrevemos no presente artigo.

MATERIAL E MÉTODOS

As medidas foram tomadas com paquímetro digital com auxílio de estereomicroscópio. Contagens e medidas foram feitas, sempre que possível, do lado esquerdo do exemplar e seguiram Fink & Weitzman (1974), com exceção da medida Largura da boca, que se refere à distância interna entre os ossos maxilares, no limite superior da boca. Contagens de vértebras, supraneurais, raios procorrentes da nadadeira caudal e dentes foram feitas em exemplares diafanizados e corados (d&c), preparados de acordo com o método de Taylor & Van Dyke (1985). As contagens de vértebras referem-se ao número total, incluindo as quatro primeiras do aparelho de Weber. A delimitação e a nomenclatura das séries de dentes do pré-maxilar seguem Vari & Harold (2001). As abreviaturas utilizadas no texto são: CP, comprimento padrão e CC, comprimento da cabeça e d&c, diafanizados e corados. As comparações estatísticas e a estatística básica dos caracteres foram analisadas através do programa DATAX (versão 4.2) de Reis & Fontoura (1993). Os caracteres morfométricos foram tratados através de retas de regressões e o teste t de *Student* foi aplicado aos coeficientes lineares, angulares ou às médias das relações, seguindo Sokal & Rohlf (1969) e Zar (1974). Para a preparação dos gráficos foi utilizado o programa SigmaPlot 4.0 para windows.

O material examinado pertence às seguintes instituições: MCP, Museu de Ciências e Tecnologia PUCRS, Porto Alegre; MNRJ, Museu Nacional, Rio de Janeiro; MZUSP, Museu de Zoologia da Universidade de São Paulo, São Paulo; USNM, National Museum of Natural History, Washington D. C.

RESULTADOS

Piabina anhembi sp. nov.

(Figura 1; Tabela 1)

Holótipo: Brasil: São Paulo: Salesópolis: MCP 30687 1 (65,3 mm CP, macho) rio Paraitinga na cachoeira da Porteira, afluente do rio Tietê (23°31'37"S-45°45'52"W); 17 de dezembro de 1999; L. R. Malabarba, O. T. Oyakawa, J. C. Nolasco, E. T. Tamura & N. Calette.

Parátipos: MCP 25270, 36, 7 d&c (medidos: 26 ex., 39,53-79,40 mm CP), MZUSP 59144, 37 (medidos: 13 ex., 56,94-76,87 mm CP), MNRJ 23896, 5 (48,51-56,12 mm CP), USNM 372274, 5 (50,65-62,30 mm de CP), coletados junto com o holótipo.

Diagnose. *Piabina anhembi* difere das populações de *P. argentea* do alto rio Paraná e do rio São Francisco por possuir o dente anterior da tríade parcialmente inserido entre o primeiro e o segundo dente da primeira série (Fig. 2A) dente anterior da tríade nunca inserido no espaço entre o primeiro e o segundo dente da primeira série em *P. argentea* (Fig. 2B); apresentar menor comprimento da cabeça em relação ao comprimento padrão (20,6-24,5% do CP, média 22,4% versus 22,2-27,5% do CP, média 24,7% na população do alto rio Paraná e 22,6-25,0% do CP, média 23,7% na população do rio São Francisco) (Fig. 3); e menor largura da boca em relação ao comprimento padrão (5,0-6,3% do CP, média 5,6% versus 6,1-8,4% do CP, média 7,07% na população do alto rio Paraná e 6,3-7,9% do CP, média 6,97% na população do rio São Francisco) (Fig. 4).

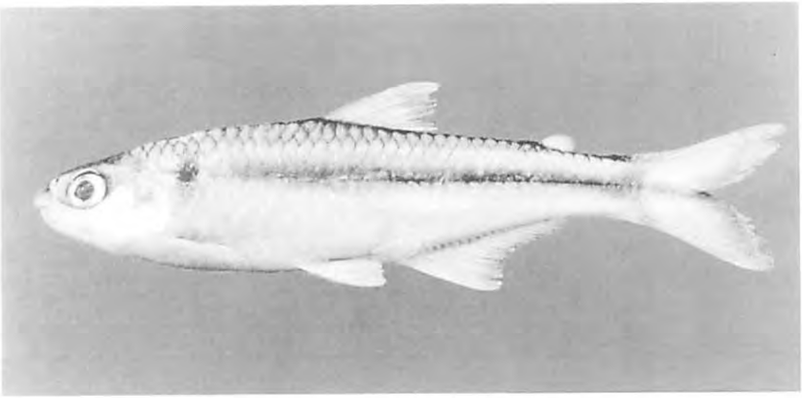

Figura 1. *Piabina anhembi* sp. n., Holótipo, MCP 30687 (65,3 mm de CP).

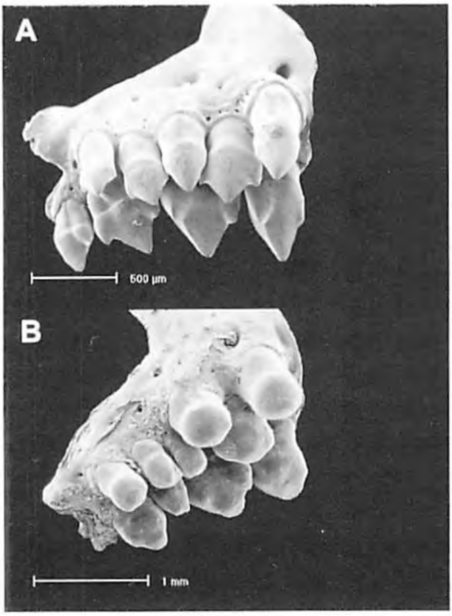

Figura 2. Imagem obtida em Microscópio Eletrônico de Varredura (MEV) do pré-maxilar direito de *Piabina anhembi* (A) e *P. argentea* (B).

Descrição. Dados morfométricos apresentados na Tabela 1. Corpo alongado, comprimido lateralmente, sua maior altura na origem da nadadeira dorsal. Perfil dorsal levemente convexo entre a vertical que cruza sobre as narinas e a origem da nadadeira dorsal; reto da base do último raio da nadadeira dorsal até a origem da nadadeira adiposa, perfil dorsal do pedúnculo caudal ligeiramente côncavo. Perfil ventral do corpo levemente convexo entre o lábio inferior e a origem da nadadeira ventral, reto entre a base da nadadeira ventral e a origem da nadadeira anal; base da nadadeira anal côncava; perfil ventral do pedúnculo caudal levemente côncavo. Focinho acentuadamente convexo; extremidade anterior da maxila superior terminando à frente da mandíbula; boca inferior.

Pré-maxilar com três séries de dentes tricuspidados. Primeira série arqueada, com 5 dentes, com um distinto espaço entre o primeiro e o segundo dente da série, sendo o quarto dente da primeira série distintamente maior que os demais. Dente mais anterior da tríade levemente maior que os dentes da primeira série, parcialmente inserido no espaço entre o primeiro e o segundo dente da primeira série; dentes posteriores da tríade, principalmente o posterolateral, distintamente maiores que os demais dentes do pré-maxilar. Dente simples de forma similar aos da primeira série, localizado na região lateral da área de contato entre o terceiro e o quarto dente da primeira série do pré-maxilar. Maxilar com 2 a 3 dentes tricuspidados. Dentário com 6 a 7 dentes tricuspidados, os três primeiros distintamente maiores que os demais, diminuindo progressivamente de tamanho.

Nadadeira dorsal com ii,8 raios (n = 26), último raio aproximadamente a metade do comprimento do segundo raio não ramificado. Origem da nadadeira dorsal ligeiramente posterior a linha vertical que cruza a origem da nadadeira ventral. Origem da nadadeira adiposa ligeiramente posterior a uma linha vertical projetada sobre a inserção do último raio da nadadeira anal. Nadadeira peitoral com i,10-13 raios (n = 26, média = 11,5), sua margem distal ligeiramente convexa, não alcançando a origem da nadadeira ventral. Nadadeira ventral com i,7-8 raios (n = 26, média = 7,1), sua margem distal reta, não alcançando a origem da nadadeira anal. Origem da nadadeira ventral anterior à origem da nadadeira dorsal. Nadadeira ventral dos machos com ganchos ósseos finos e longos (comparados aos ganchos da nadadeira anal), voltados para a base da nadadeira, ocorrendo um par de ganchos por segmento e até 27 pares de ganchos por raio; ganchos ausentes no raio não ramificado da nadadeira ventral. Nadadeira ventral das fêmeas sem ganchos ósseos. Nadadeira anal com iii,16-19 raios (n = 26, média = 17,1), sua margem distal acentuadamente côncava; último raio não ramificado cerca de 3 vezes mais longo que o último raio ramificado. Origem da nadadeira anal ligeiramente posterior a uma linha vertical que cruza a base do último raio da nadadeira dorsal. Nadadeira anal dos machos com ganchos ósseos finos e curtos (comparados aos ganchos da nadadeira ventral), voltados para a base da nadadeira, ocorrendo um par de gancho por segmento e até 25 pares de ganchos por raio. Nadadeira anal das fêmeas sem ganchos ósseos. Nadadeira caudal bifurcada, os lobos de mesmo tamanho e suas margens ligeiramente convexa. Raios caudais principais: i,17,i (n = 26, 1 exemplar com 16 e 1 exemplar com 18 raios). Dez a 13 raios procorrentes dorsais e 10-11 ventrais (contados em 7 exemplares d&c).

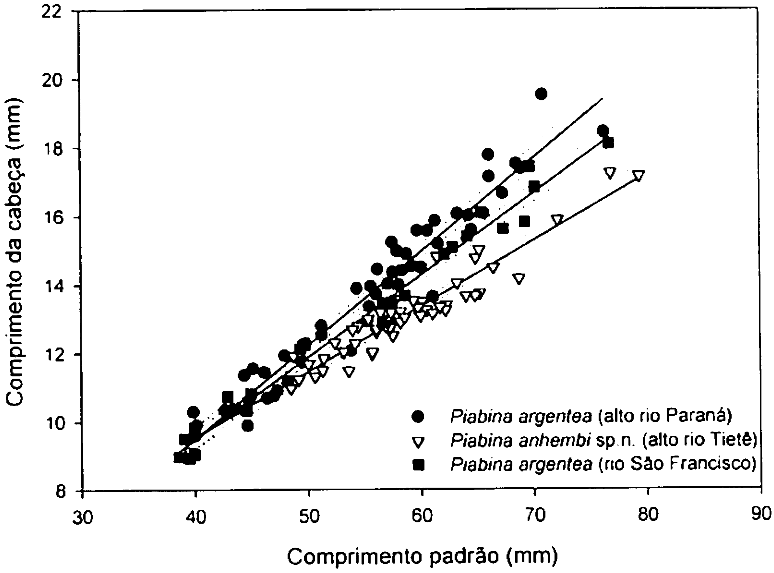

Figura 3. Comprimento da cabeça em função do comprimento padrão de *Piabina anhembi* (a = 1,88; b = 0,19; r^2 = 0,912) e *P. argentea* (população do alto rio Paraná, a = -1,42; b = 0,27; r^2 = 0,936; população do rio São Francisco, a = -0,09; b = 0,24; r^2 = 0,983). Coeficientes angulares significativamente diferentes t(b) = 5,908 (*P. anhembi* e *P. argentea* do alto rio Paraná); e t(b) = 4,330 (*P. anhembi* e *P. argentea* do rio São Francisco). Regressão linear significativamente diferente (P = 0,001).

Escamas ciclóides de mesmo tamanho em todo o corpo; linha lateral completa com 36 a 40 escamas (n = 20, média = 38,5). Séries longitudinais de escamas entre a linha lateral e a origem da nadadeira dorsal 4 a 5 (n = 20, média = 5,0); séries longitudinais de escamas entre a linha lateral e a origem da nadadeira ventral 3 a 5 (n = 25, média = 4,0); escamas pré-dorsais em uma série irregular de 11 a 13 escamas (n = 26, média = 11,6); séries longitudinais de escamas ao redor do pedúnculo caudal 12 a 16 (n = 21, média = 14,0). Nadadeira anal com bainha de 4 a 7 escamas (n = 24, média = 6,0). Vértebras 38 a 39 (n = 7 d&c, média = 38,1), supraneurais 5-6 (n =7 d&c, média = 5,3).

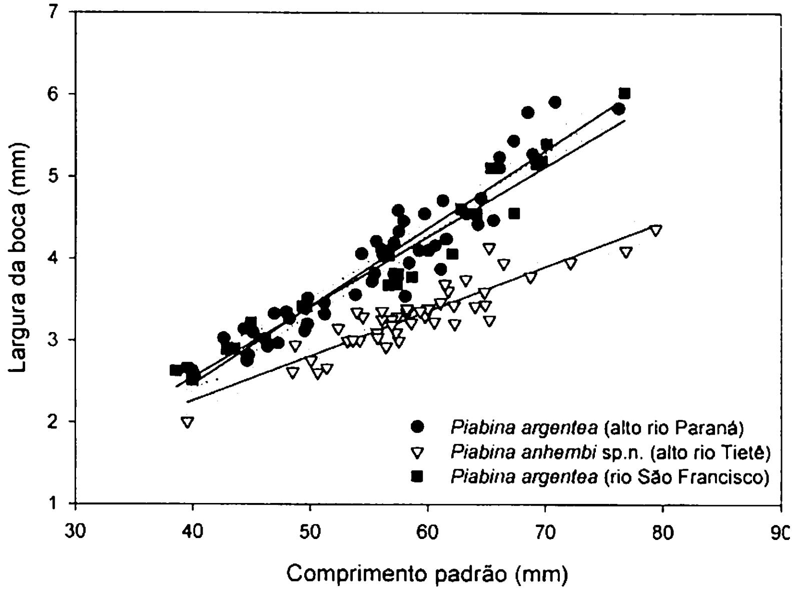

Figura 4. Largura da boca em função do comprimento padrão de *Piabina anhembi* (a = 0,09; b = 0,05; r^2 = 0.829), *P. argentea* (população do alto rio Paraná, a = -1,33; b = 0,10; r^2 = 0,905; população do rio São Francisco, a = -0,87; b = 0,09; r^2 = 0,950). Coeficientes angulares significativamente diferentes t(b) = 3,033 (*P. anhembi* e *P. argentea* do alto rio Paraná); e t(b) = 3,213 (*P. anhembi* e *P. argentea* do rio São Francisco). Regressão linear significativamente diferente (P=0,01).

Colorido em álcool. Coloração geral amarelada, as escamas dorsolaterais com a borda posterior levemente escurecida por cromatóforos, ficando mais evidente a medida que se aproxima da linha médio dorsal. Faixa lateral, escura e larga, localizada uma série de escamas acima da linha lateral, estendendo-se desde a linha vertical projetada sobre a extremidade posterior do último raio da nadadeira peitoral até a base dos raios da nadadeira caudal; mancha caudal escuras de formato triangular, pouco conspícua, não alcançando as superfícies superior e inferior do pedúnculo caudal. Mancha umeral alongada verticalmente, localizada sobre a terceira e quarta escamas da linha lateral, estendendo-se duas séries de escamas acima desta. Nadadeiras pares hialinas; nadadeira dorsal e anal levemente escurecidas por cromatóforos; raios medianos da nadadeira caudal com uma faixa escura pouco conspícua. Região dorsal da cabeça fortemente pigmentada de preto.

Distribuição. Conhecida somente da localidade-tipo (Fig. 5).

Etimologia. O nome específico *anhembi*, tratado como substantivo em aposição, é dado em alusão a área de ocorrência da nova espécie. Anhembi é uma palavra de origem indígena que significa rio das Anhumas ou de Anhimas, aves que desde o início do povoamento da região do alto rio Tietê eram procuradas pelos caboclos, que buscavam nelas o remédio ou preservativo para toda sorte dos males. Este foi o nome do rio Tietê até o ano de 1748.

DISCUSSÃO

Piabina anhembi apresenta o infra-orbital 4, aproximadamente triangular e excluído da margem posterior da série infra-orbital, autapomorfia que define o gênero *Piabina*, como descrito em Vari & Harold (2001:39). Além disso, *Piabina anhembi* compartilha as sete sinapomorfias que são congruentes com a hipótese de que *Piabina* é o grupo irmão de *Creagrutus*. A análise dos caracteres propostos por Vari & Harold (2001) para a hipótese de monofilia de *Piabina* e *Creagrutus* mostra que *Piabina anhembi* apresenta a grande maioria dos caracteres no mesmo estado que *P. argentea*, com exceção dos caracteres 15, 20 e 44 (observados em 2 exemplares d&c da nova espécie). *Piabina anhembi* apresenta o caráter 15 no estado 1, abertura medial do forame dentário localizada imediatamente anterior à ponta da cartilagem mequeliana, enquanto que *P. argentea* apresenta este caráter no estado 0, abertura localizada anterodorsalmente à ponta da cartilagem mequeliana. Dentre as espécies analisadas por Vari & Harold (2001) somente *Creagrutus cracentis* Vari & Harold, 2001, *C. gephyrus* Böhlke & Saul, 1975, e *C. maxillaris* (Myers, 1927), apresentam esse caráter no estado 1, correspondendo ao clado G de Vari & Harold (2001). O caráter 20, margem da porção posterodorsal do ângulo-articular, aparece no estado primitivo em *Piabina argentea* (estado 0) e no estado derivado (estado 1) em *P. anhembi*. Este caráter é uma das cinco sinapomorfias que definem o clado H da árvore de consenso de Vari & Harold (2001), composta por *Creagrutus maxillaris* mais *C. cracentis*. O caráter 44, margem anterior do espinho esfenótico não elaborada (estado 0), aparece em *Piabina argentea*, enquanto *P. anhembi* apresenta a margem anterior do espinho esfenótico com processo lamelar anterior (estado 1). Este estado é compartilhado por três espécies de *Creagrutus* (*C. gyrospilus* Vari & Harold, 2001, *C. hysginus* Harold, Vari, Machado-Allison & Provenzano, 1994 e *C. paralacus* Harold & Vari, 1994), que estão em uma politomia não resolvida de 41 espécies de *Creagrutus* na árvore de consenso de Vari & Harold (2001). Os três caracteres discutidos acima servem adicionalmente à diagnose de *Piabina anhembi* em relação a *P. argentea*, sendo mais parcimonioso assumir que os mesmos surgiram independente em *P. anhembi* e nas espécies de *Creagrutus*.

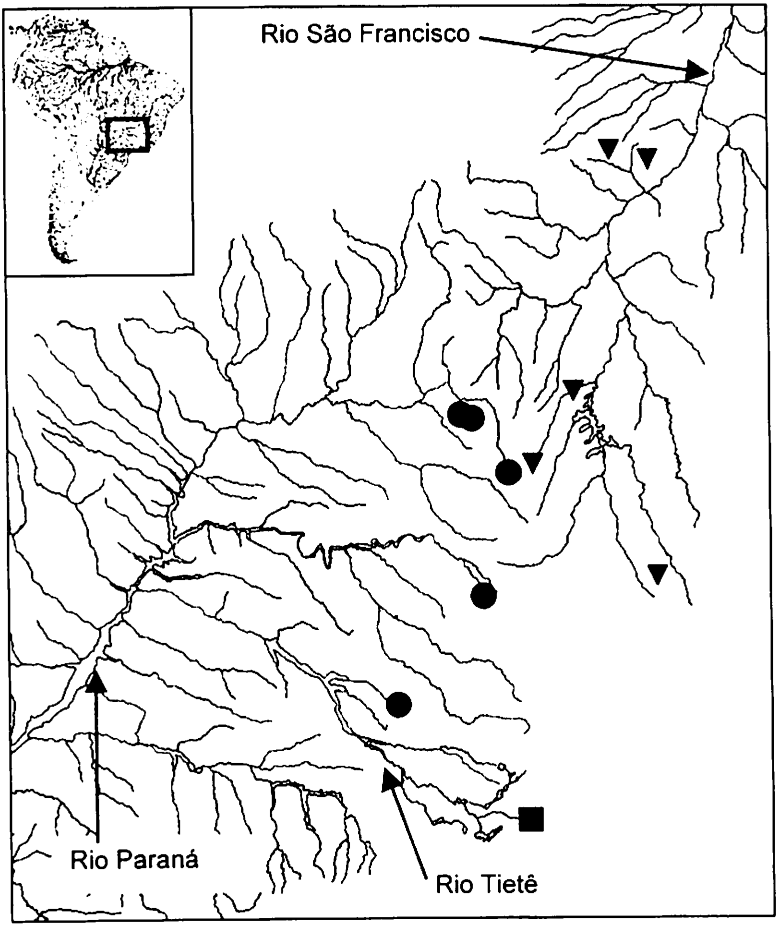

Figura 5. Localidade-tipo de *Piabina anhembi* (quadrado) e distribuição do material comparativo examinado de *P. argentea*, população do alto rio Paraná (círculo) e população do rio São Francisco (triângulo). Um símbolo pode indicar mais de um lote.

Tabela 1. Dados morfométricos de *Piabina anhembi* sp.n. (n= número de exemplares).

Medidas	Holótipo	n	mín.	max.	média
Comprimento Padrão (MM)	65,3	50	39,5	79,4	58,5
Percentagens do comprimento padrão					
1. Distância pré-dorsal	48,3	50	47,3	51,3	49,2
2. Distância pré-ventral	43,7	50	42,8	47,8	44,9
3. Distância pré-peitoral	21,7	50	21,1	24,1	22,4
4. Distância pré-anal	61,1	50	59,4	65,3	61,7
5. Altura do corpo	23,9	50	22,8	28,2	25,0
6. Altura pedúnculo caudal	9,0	50	7,7	10,3	9,1
7. Compr. pedúnculo caudal	11,6	50	10,5	17,3	13,7
8. Base da nadadeira anal	23,8	50	23,8	29,2	26,1
9. Compr. nadadeira dorsal	21,6	50	20,0	24,0	22,1
10. Compr. nadadeira ventral	14,9	50	13,9	16,8	15,3
11. Compr. nadadeira peitoral	18,6	50	17,1	20,9	19,2
12. Compr. cabeça	21,1	50	20,6	24,5	22,4
13. Compr. focinho	6,2	50	5,4	7,0	6,1
14. Compr. maxila	7,9	50	7,9	9,9	8,8
15. Diâm. horiz. órbita	7,4	50	7,4	10,1	8,6
16. Largura interorbital	7,1	50	6,4	8,0	7,2
17. Largura boca	5,0	46	5,0	6,3	5,6

AGRADECIMENTOS

Ao Programa de Apoio a Núcleos de Excelência - CNPq (PRONEX), nº: 661058/1997-2 "Conhecimento, Conservação e Utilização Racional da Diversidade da Fauna de Peixes do Brasil" que financiou os trabalhos de campo e laboratório. Ao Centro de Microscopia e Microanálises - CEMM, PUCRS pelas imagens em Microscópio Eletrônico de Varredura (MEV). A Osvaldo T. Oyakawa (MZUSP) pelo empréstimo de material. A Luiz Roberto Malabarba (MCP) pela revisão, críticas e sugestões ao manuscrito.

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Apêndice

Material comparativo examinado de *Piabina argentea*:

Sistema do alto rio Paraná: Brasil: Minas Gerais: Abadia dos Dourados: MCP 27884, 5 de 15 (59,72-70,85 mm CP) córrego na estrada Davinópolis/Douradoquara, cerca de 5 km da balsa do rio Paranaíba, localidade de Palmito (18°12'47"S-47°27'57"W). MCP 27795, 8 de 78 D&C, 20 de 78 (51,49-68,93 mm CP) córrego na estrada Abadia dos Dourados/Coromandel, afluente do rio Dourados (bacia do rio Paranaíba) (18°29'0"S-47°12'28"W). Rio Paranaíba: MCP 27878, 9 de 98 (49,81-65,61 mm CP) Ribeirão de Fora, estrada Rio Paranaíba/Serra do Salitre (bacia do rio Paranaíba) (19°11'58"S-46°21'49"W). Fortaleza de Minas: MZUSP 35394, 8 de 23 (44,63-61,08 mm CP) riacho afluente do rio São João, próximo a estrada de ferro Minas-Perobas (bacia do rio Grande). Goiás: Davinópolis: MCP 27876, 13 de 200 (39,74-76,28 mm CP) córrego na estrada Davinópolis em direção a balsa do rio Paranaíba, cerca de 6 km de Davinópolis (18°9'37"S-47°30'41"W). São Paulo: Corumbataí: MZUSP 16756, 5 de 66 (40,12-49,77 mm CP) rio Corumbataí (bacia do rio Tietê). MZUSP 16857, 2 de 25 (55,48-64,53 mm CP) rio Corumbataí (bacia do rio Tietê). *Sistema do rio São Francisco*: Brasil: Minas Gerais: Moeda: MZUSP 37153, 14 de 100 (49,32-76,76 mm CP) ribeirão afluente do rio Paraopeba, Pedra Vermelha, Km 10 da BR 040. Major Porto: MZUSP 39625, 5 de 21 (39,97-56,67 mm CP) córrego Capivara, rio Abaeté. Três Marias: MZUSP 39704, 3 de 81 (39,93-38,56 mm CP) córrego Carapi. Montalvânia: MZUSP 54620, 2 de 37 (39,10-44,57 mm CP) rio Poções, em Poções, 11 km as S de Montalvânia. Januária: MCP 16862, 5 de 30 D&C) rio Peru-Açu em Fabião (15°11' 0"S-44°12'30"W).

DESCRIPTION OF A NEW GENUS WITH SIX NEW SPECIES FROM SOUTHERN BRAZIL, URUGUAY AND ARGENTINA, WITH A DISCUSSION OF A PUTATIVE CHARACID CLADE (TELEOSTEI: CHARACIFORMES: CHARACIDAE)

*Luiz R. Malabarba**
*Stanley H. Weitzman***

RESUMO

Descrição de um gênero novo e de seis espécies novas do sul do Brasil, Uruguai e Argentina, com a discussão sobre um clado hipotético de caracídeos. (Teleostei: Characiformes: Characidae)

O novo gênero *Cyanocharax* é descrito com seis espécies novas conhecidas das drenagens costeiras do Atlântico no sul do Brasil, nos estados do Rio Grande do Sul e Santa Catarina, e da bacia do rio Uruguai, no sul do Brasil, Uruguai e Argentina. Formula-se a hipótese de que *Cyanocharax* pertence a um grupo monofilético de caracídeos que compartilham a presença de uma nadadeira dorsal derivada, com dois raios não ramificados e oito raios ramificados, enquanto outros caracídeos têm dois raios não ramificados e nove raios ramificados e em alguns casos derivados contagens maiores. Este clado hipotético é também definido pela presença de quatro dentes na série interna da pré-maxila, incluindo, além dos Glandulocaudinae, a maioria das espécies de Characidae com boca ventral. A presença de ganchos ósseos nas nadadeiras também é avaliada com relação a sua distribuição em Characiformes, e é considerada uma sinapomorfia de um clado monofilético que inclui Gasteropelecidae e a maioria das espécies atualmente referidas na família Characidae. As espécies do novo gênero incluem *Cyanocharax*

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alburnus nova combinação, e as espécies novas *C. itaimbe*, do rio Mampituba, rio Tramandaí e rio Araranguá, *C. dicropotamicus* e *C. tipiaia* do rio Jacuí, *C. lepiclastus*, *C. alegretensis* e *C. macropinna* do rio Uruguai.

Palavras-chaves: *Cyanocharax*, Glandulocaudinae, filogenia, Hemibryconini, ganchos.

ABSTRACT

Cyanocharax, new genus, is described with six new species, known only from the Atlantic coastal drainages of Southern Brazil, in the states of Rio Grande do Sul and Santa Catarina, and from the rio Uruguay drainage in Southern Brazil, Uruguay and Argentina. *Cyanocharax* is hypothesized to belong to a monophyletic group of characid fishes that share the derived possession of a dorsal fin with two unbranched and eight branched rays whereas other characids have two unbranched and nine branched rays or in a few derived cases a higher number of rays. This putative clade is also defined by the presence of four teeth in the inner series of the premaxilla and in addition to glandulocaudines includes most of the characid species with ventral mouths. The distribution of bony hooks on the fins among Characiformes is also evaluated and is hypothesized to be a putative synapomorphy for a monophyletic clade including Gasteropelecidae, and most of the species currently placed in Characidae. Species of the new genus include *Cyanocharax alburnus* new combination, *C. itaimbe* new species, from rio Mampituba, rio Tramandaí and rio Araranguá drainages, *C. dicropotamicus* new species and *C. tipiaia* new species from rio Jacuí drainage, *C. lepiclastus* new species, *C. alegretensis* new species and *C. macropinna* new species from rio Uruguay drainage.

Key words: *Cyanocharax*, Glandulocaudinae, phylogeny, Hemibryconini, fin-hooks.

INTRODUCTION

Cyanocharax, new genus, comprises a group of small characid fishes most readily recognized in the field by the blue color of mature specimens. To date the species of *Cyanocharax* are known only from the Atlantic coastal drainages of Southern Brazil, in the states of Rio Grande do Sul and Santa Catarina, and from the rio Uruguay drainage in Brazil, Uruguay and Argentina (Fig. 1). The new species described herein, although relatively abundant in recent collections, remained unknown to the scientific community for more than a century, since the initial collections made in the area by Reinhold F. Hensel (1863-1868), Brazilian Emperor Dom Pedro II (1865 – donated to Louis Agassiz, Thayer Expedition), Hermann von Ihering (1880-1898), and Herbert H. Smith (1881-1882) (Malabarba, 1989). Jorge Casciotta (Museo de La Plata) joined us in the description of one of these new species concomitantly discovered in Argentina and Brazil.

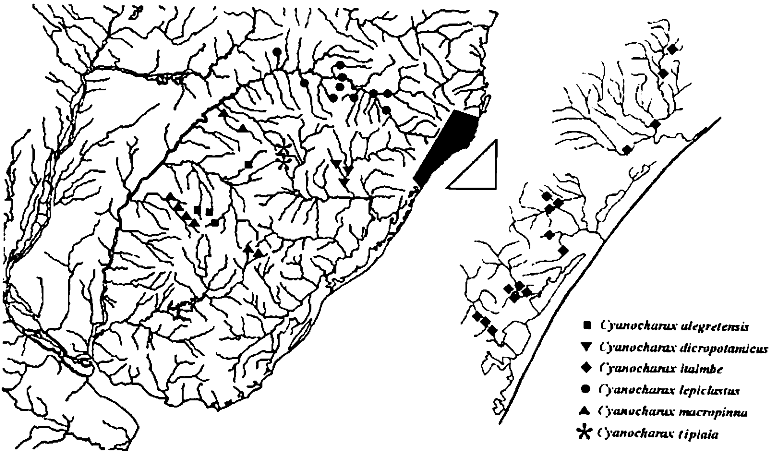

Figure 1. Map of southern Brazil, Uruguay and eastern Argentina, showing the distribution of examined specimens of *Cyanocharax alegretensis*, *C. dicropotamicus*, *C. itaimbe*, *C. lepiclastus*, *C. macropinna*, and *C. tipiaia*. The detailed portion of the map includes, from North to South, the rio Araranguá, rio Mampituba, rio Três Forquilhas, and rio Maquiné drainages.

The relationships of *Cyanocharax* may be among the so-called Characidae, in a more restricted concept of that family than those of Greenwood *et al.* (1966) and Géry (1977). Such a restricted Characidae excludes the Cynodontidae containing the subfamilies Cynodontinae (*Cynodon* Spix, *Rhaphiodon* Agassiz, *Hydrolycus* Müller & Troschel) and Roestinae (*Gilbertolus* Eigenmann, *Roestes* Günther), and Acestrorhynchidae (*Acestrorhynchus* Eigenmann & Kennedy), as defined by Lucena & Menezes (1998). It also excludes the Crenuchidae with the subfamilies Crenuchinae and Characidiinae and the latter's several genera, as diagnosed by Buckup (1998).

Weitzman & Malabarba (1998) pointed out that the members of the Agoniatinae, Aphyocharacinae, Characinae, Cheirodontinae, Glandulocaudinae, Paragoniatinae, Rhoadsiinae, Stethaprioninae, and Tetragonopterinae, as recognized in Géry (1977) may possibly form a monophyletic Characidae. They differ from *Brycon* Müller & Troschel, and its putative relatives (*Salminus* Agassiz, *Triportheus* Cope, and *Lignobrycon* Eigenmann & Myers), as well as from *Bryconops* Kner, *Clupeacharax* Pearson, and *Engraulissoma* Castro, by lacking a supraorbital bone. *Cyanocharax* also lacks a supraorbital bone, a putative reductive character that may possibly group it with the subfamilies listed above in a monophyletic Characidae.

Such a restricted Characidae, however, has yet to be diagnosed as monophyletic based on additional putative synapomorphies (Weitzman & Malabarba, 1998), but contains a few phylogeneticaly diagnosed groups to which *Cyanocharax* can be compared. Although we will treat these characid subgroups as subfamily or tribal groups in our discussion, it must remain clear that this assignment of group names is a nomenclaturally conservative approach. A hypothesis of the relationships among the several characid subgroups and genera based on synapomorphies must be developed before it is appropriate to assign taxonomic rank to monophyletic subtaxa in the Characidae.

Among the Characidae, as diagnosed by Weitzman & Malabarba (1998), *Cyanocharax* species lack the synapomorphies described by Reis (1989) diagnosing the Stethaprioninae, those described by Malabarba (1998) diagnosing the Cheirodontinae, and those of Weitzman & Menezes (1998) diagnosing the Glandulocaudinae. *Cyanocharax* also lacks the apomorphies described by Vari (1977) as diagnosing the Iguanodectinae, ranked as a tetragonopterine tribe (Iguanodectini) by Géry (1977). Even though not presented as a formal phylogenetic diagnosis for the Characinae, Lucena (1998) listed a series of characters hypothesizing the relationships of *Charax* Scopoli to eleven other characid genera (including those of the Cynopotaminae of Menezes, 1976), which are also not shared with *Cyanocharax* species. The relationships hypothesized by Lucena may be expressed as follows: (*Priocharax* ((*Gnathocharax* (*Hoplocharax* (*Heterocharax*, *Lonchogenys*))) (*Phenacogaster* ((*Cynopotamus* (*Acestrocephalus*, *Galeocharax*)) (*Acanthocharax* (*Charax*, *Roeboides*)))))).

Although not hypothesized as monophyletic based on putative apomorphies, some of the remaining suprageneric groups are distinguished by apparently derived characters that are absent in *Cyanocharax*. The Aphyocharacinae possess a large fourth infraorbital, a character that possibly indicates a monophyletic clade including all the species of *Aphyocharax* Günther. This feature excludes *Cyanocharax*. Finally, the Rhoadsiinae form a group of characid fishes of uncertain relationships, but diagnosed by a peculiar ontogenetic development of teeth and jaws that includes changes in tooth shape, number of tooth series in the premaxilla and extension of toothed portion of the premaxilla not shared with *Cyanocharax* species.

Thus, *Cyanocharax* appears to be excluded as a member of any of the suprageneric taxa listed above, but this does not eliminate the possibility of its being the sister clade to one or more of those taxa. Among the remaining characids, investigations concerning the relationships of *Cyanocharax* must be directed to the species currently placed in the possibly both polyphyletic and paraphyletic Tetragonopterinae, as well as to a number of incertae sedis characid genera and species.

METHODS AND MATERIAL

Counts and measurements follow Fink & Weitzman (1974:1-2). For counts recorded in the descriptions of the new species the observed range is followed in parentheses by the mean (= $\bar{x}$) and total number of specimens counted. Total vertebral counts include the four vertebrae of the Weberian apparatus. The terminal "half centrum," usually designated as PU_1+U_1, but not necessarily consisting only of those elements, was counted as one vertebral element. Vertebral counts were taken from radiographs and from cleared Alizarin red and Alcian blue counter stained preparations (c&s), prepared according to Taylor & Van Dyke (1985). Morphometric data for holotypes are presented separately in the tables. All measurements other than standard length (SL) are expressed as a percentage of SL except subunits of the head, which are recorded as a percentage of head length (HL).

The following acronyms are used for institutions and collections: MCP, Museu de Ciências e Tecnologia, Pontifícia Universidade Católica do Rio Grande do Sul, Porto Alegre; AI, Asociación Ictiológica, La Plata, Argentina; MNRJ, Museu Nacional, Rio de Janeiro, Brazil; MZUSP, Museu de Zoologia da Universidade de São Paulo, São Paulo; USNM, former United States National Museum, now the National Museum of Natural History, Smithsonian Institution, Washington D.C. Data in the list of examined specimens of each species is presented in the following order: catalog number; total number of specimens of each lot, number of specimens cleared and/or stained - c&s, collecting locality, date of collection.

Phylogenetic analysis and terms

In our discussions, comments on phylogeny are based on the concepts of phylogenetic systematics as reviewed and discussed by Wiley (1981). The term diagnostic character in a diagnosis is used to designate one or a series of synapomorphies or autapomorphies that are characteristic of a particular taxon. Distinguishing characters help in distinguishing one taxon from others, but have no phylogenetic implications (Weitzman *et al.*, 1994:48). We confine the use of autapomorphies to species, thus avoiding the confusion that arises when a character is considered an autapomorphy for a genus and a synapomorphy for its included species. Thus, we use the term synapomorphy at all levels other than species and autapomorphies for characters that diagnose only one species.

Ingroup and outgroup taxa and investigative approach

The discussion of the relationships of the species herein described in *Cyanocharax* with various tetragonopterine taxa is difficult, since there are no hypotheses of relationships among tetragonopterine genera supported by cladistic analyses, or even evidence that the Tetragonopterinae form a monophyletic group among characids. The Tetragonopterinae embraces 30-40 poorly defined genera and more than 250 valid species. Most of its genera are not diagnosed as monophyletic, and at least some of the largest genera are undoubtedly polyphyletic and paraphyletic, such as *Astyanax* Baird & Girard (86 spp.), *Hyphessobrycon* Durbin (97 spp.), and *Hemigrammus* Gill (43 spp.) (Weitzman & Malabarba, 1998). This is probably the same situation for *Bryconamericus* Eigenmann (51 spp.), *Hemibrycon* Günther (19 spp.), *Knodus* Eigenmann (16 spp.) and *Moenkhausia* Eigenmann (58 spp.; specific counts taken from Reis *et al.*, 2003).

Few of the genera assigned to the Tetragonopterinae have been cladistically hypothesized to be monophyletic, and *Cyanocharax* lacks all apomorphies diagnosing those genera. Cladistically diagnosed genera include: *Creagrutus* Günther and *Piabina* Reinhardt by Vari & Harold (1998); *Paracheirodon* Géry by Weitzman & Fink (1983); *Hypobrycon* Malabarba & Malabarba (1994) and Silva & Malabarba (1996); *Jupiaba* Zanata, 1997 (21 sp.); *Caiapobrycon* Malabarba & Vari, 2000 (1 sp.), and *Attonitus* Vari & Ortega, 2000 (3 sp.).

Most of the several remaining tetragonopterine or *incertae sedis* characid genera, not listed above (41 of the 63) are monotypic. Some of these, although not formally proposed in a cladistic manner, were diagnosed by apomorphic traits, also not shared with *Cyanocharax* species.

Considering (1) the physical overall similarities among the new species herein described, (2) their shared possession of an intense silvery light blue color in mature specimens in life, and finally (3) the lack of evidence grouping any of these species to any other characid genus, our investigation was directed to testing the monophyly of a hypothetical clade formed by these six new species by investigating the relationships of this clade with characid species or genera currently assigned to the Tetragonopterinae, and testing the possible relationships of this new putative clade with the hypothesized monophyletic characid sub-clades in the restricted sense of Weitzman & Malabarba (1998). These include the Cheirodontinae as diagnosed by Malabarba (1998); the Glandulocaudinae of Weitzman & Menezes (1998); the Stethaprioninae of Reis (1989); the Iguanodectinae of Vari (1977); the *Charax* Clade of Lucena (1998), and the putative monophyletic Aphyocharacinae containing *Aphyocharax* and the Rhoadsiinae. The resulting phylogenetic character analyses using these groups as outgroups to *Cyanocharax* are based on hypothetically plesiomorphic species of those outgroups, not derived species within these outgroups (*Odontostilbe* for the Cheirodontinae; *Diapoma* for the Gladulocaudinae; *Poptela* for Stethaprioninae; *Phenacogaster* for *Charax* and related genera). For additional outgroup comparison we choose *Brycon* and *Bryconops*, for the reasons explained in the introductory section.

RESULTS

Cyanocharax Relationships

The phylogenetic analysis presented below is not an in-depth phylogeny of characid species. Instead, it is an up-dated presentation of previously published hypotheses of relationships among characids plus their relationships with *Cyanocharax*. Only characters found to be consistent in hypothesizing relationships and diagnosing monophyletic groups among characids are discussed. This excludes several ambiguous characters presented in the hypotheses of Lucena (1993) and Buckup (1998:125-134). The simplified cladogram presented in Fig. 2 summarizes current knowledge about characid phylogeny, with the addition of a few characters we found informative.

1) The presence of hooks on fin rays. The presence of hooks on the anal-and pelvic-fin rays of males, often on the caudal fin and rarely on the dorsal and/or pectoral fins has been described in Gasteropelecidae (Weitzman, 1954; Collette, 1977), Serrasalminae (Jégu et al., 1989:56, Fig. 8) and in several representatives of the Characidae such as Cheirodontinae (Malabarba, 1998; Malabarba & Weitzman, 1999, 2000), Glandulocaudinae (Weitzman & Fink, 1985; Menezes & Weitzman, 1990; Weitzman *et al.*, 1988; Géry, 1977; Nelson, 1964, Weitzman & Thomerson, 1970; Weitzman & Menezes, 1998), Stethaprioninae (Reis, 1989), *Charax* and related genera (*Charax*, Lucena, 1987; *Phenacogaster*, Malabarba & Lucena, 1995; *Priocharax*, Weitzman & Vari, 1987; *Roeboides*, Lucena 2000a, 2000b), Aphyocharacinae (*Aphyocharax*, Wiley & Collette, 1970), Iguanodectinae (Böhlke, 1954), Rhoadsiinae (pers. obs.), and several Tetragonopterinae and *incertae sedis* characid genera (the literature cited is not exhaustive): *Astyanax*, Garutti (1990); *Attonitus*, Vari & Ortega (2000); *Aulixidens*, Böhlke (1952); *Bario*, Wiley & Collette (1970); *Boehlkea*, Géry (1966); *Bramocharax* (pers. obs.); *Bryconexodon*, Jégu et al. (1991:780, Fig. 7); *Brittanichthys*, Malabarba & Weitzman (1999); *Brycon* (Flávio Lima, pers. comm. and unpublished M.Sc. thesis); *Bryconamericus*, Malabarba & Kindel (1995); *Bryconops*, Wiley & Collette (1970); *Caiapobrycon*, Malabarba & Vari (2000); *Creagrutus*, Vari & Harold (2001); *Eretmobrycon* (pers. obs.); *Genycharax* (pers. obs.); *Gymnocorymbus* (pers. obs.); *Hemibrycon*, Wiley & Collette (1970); *Hemigrammus*, Wiley & Collette (1970); *Hollandichthys* (pers. obs.); *Hyphessobrycon*, Wiley & Collette (1970); *Jupiaba*, Zanata (1997); *Knodus* (pers. obs.); *Lignobrycon*, M. Malabarba (1998); *Microschemobrycon*, Böhlke (1953), Géry (1973); *Moenkhausia*, Wiley & Collette (1970); *Nematocharax*, Weitzman et al. (1986); *Odontostoechus* (pers. obs.); *Oligosarcus*, Wiley & Collette (1970; as *Acestrorhamphus bolivianus*); *Paracheirodon*, Weitzman & Fink (1983); *Petitella* (pers. obs.); *Piabarchus* (pers. obs.); *Piabina*, Vari & Harold (2001); *Prionobrama* (pers. obs.); *Rachoviscus*, Weitzman & Cruz (1981); *Rhinobrycon* (pers. obs.); *Rhinopetitia* (pers. obs.); *Salminus*, Morais-Filho & Schubart (1955, figs. 2-3), *Tyttobrycon*, Géry (1973).

Although the fin-ray hooks, almost always secondary sexual characters of males, may greatly differ in shape, position and possibly function among the species of these groups, they are always observed to be a bony spiny process developed on the surface of individual segments of lepidotrichia. We hypothesize that these hooks represent an expression of a gene or genes absent in other American or African characiforms, namely the Distichodontidae, Citharinidae, Parodontidae, Curimatidae, Prochilodontidae, Anostomidae, Chilodontidae, Crenuchidae, Hemiodontidae, Alestidae, Acestrorhynchidae, Erythrinidae, Lebiasinidae, Ctenoluciidae and Hepsetidae. Fin-ray hooks are also absent in siluriforms and cypriniforms, suggesting that the presence of fin hooks is a derived character synapomorphic for certain subgroups of characiforms (Fig. 2), consisting of the Gasteropelecidae and a large part of the Characidae. Outside of these groups, hooks were found only in *Gilbertolus* (pers. obs.) and *Roestes* (Lucena, pers. com.) of the subfamily Roestinae of the Cynodontidae, but are absent in *Cynodon*, *Rhaphiodon* and *Hydrolycus* (Toledo-Piza, pers. com.) of the subfamily Cynodontinae. Based on the uniqueness of this character among ostariophysans and the apparent homology between the fin hooks in Roestinae and the groups listed above, we suggest that a re-analysis of Roestinae and Cynodontinae relationships is needed.

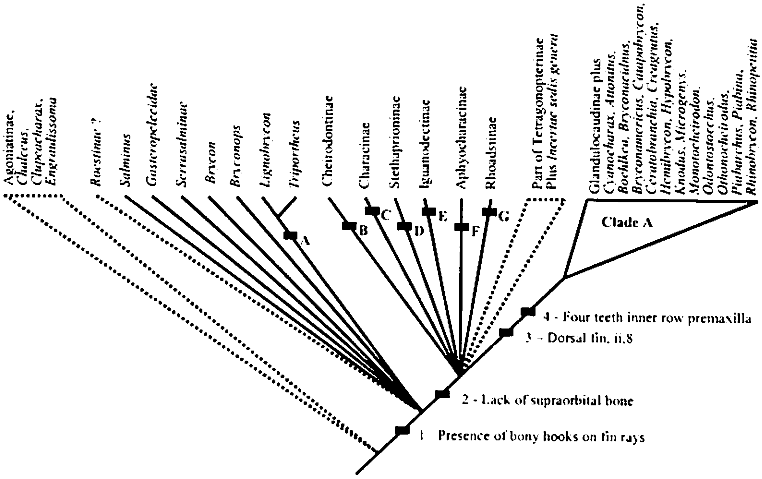

Figure 2. Cladogram summarizing present knowledge on the relationships of characids, gasteropelecids and roestines. Lettered boxes A through E represent hypotheses supported by characters presented by A – M. Malabarba (1998); B – Malabarba (1998); C – Lucena (1998); D – Reis (1989) and E – Vari (1977). Lettered boxes F and G are characters putatively derived that represent possible synapomorphies for the corresponding groups (F – the large fourth infraorbital in all *Aphyocharax* species; G – a peculiar ontogenetic development of teeth and jaws that includes changes in tooth shape, number of tooth series in the premaxilla and extension of toothed portion of the premaxilla in the Rhoadsiinae). Numbered boxes represent characters discussed herein (see under "***Cyanocharax* relationships**").

Among the remaining so-called characid fishes, the presence of hooks on the fins is to date unknown in the Agoniatinae, and the following genera: *Aphyocharacidium*, *Aphyodite*, *Astyanacinus*, *Atopomesus*, *Axelrodia*, *Bryconacidnus*, *Bryconella*, *Ceratobranchia*, *Chalceus*, *Clupeacharax*, *Coptobrycon*, *Deuterodon*, *Engraulisoma*, *Exodon*, *Grundulus*, *Gymnocharacinus*, *Gymnotichthys*, *Hasemania*, *Leptagoniates*, *Leptobrycon*, *Lobodeuterodon*, *Markiana*, *Microgenys*, *Mixobrycon*, *Monotocheirodon*, *Nematobrycon*, *Oligobrycon*, *Othonocheirodus*, *Oxybrycon*, *Paragoniates*, *Parapristella*, *Parecbasis*, *Phenagoniates*, *Pristella*, *Probolodus*, *Psalidodon*, *Psellogrammus*, *Pseudochalceus*, *Roeboexodon*, *Schultzites*, *Scissor*, *Serrabrycon*, *Stichonodon*, *Stygichthys*, *Tetragonopterus*, *Thayeria*, *Thrissobrycon*, *Tucanoichthys*, and *Xenagoniates*.

Since hooks are usually sexually dimorphic features and in most species are observed only in mature males, we reserve judgment about the lack of hooks in the genera listed above, most of which are represented by a few lots in collections and in which positive identification of the presence of sexually mature males is lacking. However, hooks were consistently reported as absent in *Inpaichthys kerri* (by Géry & Junk, 1977), *Hypobrycon maromba* and *H. leptorhynchus* (by Silva & Malabarba, 1996), and *Triportheus* (M. Malabarba, 1998). We have examined mature males of *Carlastyanax* with enlarged fin rays that lack hooks.

Among these genera, *Inpaichthys*, *Carlastyanax* and *Hypobrycon* also lack a supraorbital bone (see character 2), and *Carlastyanax* and *Hypobrycon* have dorsal-fin rays reduced to two unbranched plus eight branched elements (see character 3) suggesting that the lack of fin hooks on these genera is probably a reversal. *Triportheus* has been hypothesized as closely related to *Lignobrycon* and *Brycon* (M. Malabarba, 1998), and since both of these genera have bony hooks, it is suggested that the absence of bony hooks in *Triportheus* is also a reversal.

Cyanocharax species have pelvic- and anal-fin hooks (Figs. 3-8), suggesting they belong to a clade of South American characiforms with fin hooks.

2) Absence of a supraorbital. Among Characiformes, the absence of a supraorbital is found only in the clade formed by Erythrinidae and Lebiasinidae (Weitzman, 1964:141), and in the Characidae members of the Aphyocharacinae, Characinae, Cheirodontinae, Glandulocaudinae, Paragoniatinae, Rhoadsiinae, Stethaprioninae, and Tetragonopterinae, as defined by Géry (1977). *Cyanocharax* also lacks a supraorbital bone, a reductive character that may possibly group it with the subfamilies listed above (Fig. 2) in a monophyletic Characidae (Weitzman & Malabarba, 1998; note that we failed to cite the presence of a supraorbital in Agoniatinae that paper). The lack of supraorbital in the clade Erythrinidae and Lebiasinidae is clearly homoplastic with respect to the absence of that bone in the *Cyanocharax* and the other groups listed for the Characidae, according to the hypotheses of relationships relating the Erythrinidae and Lebiasinidae to the Ctenoluciidae and Hepsetidae presented by Vari (1995) and Buckup (1998).

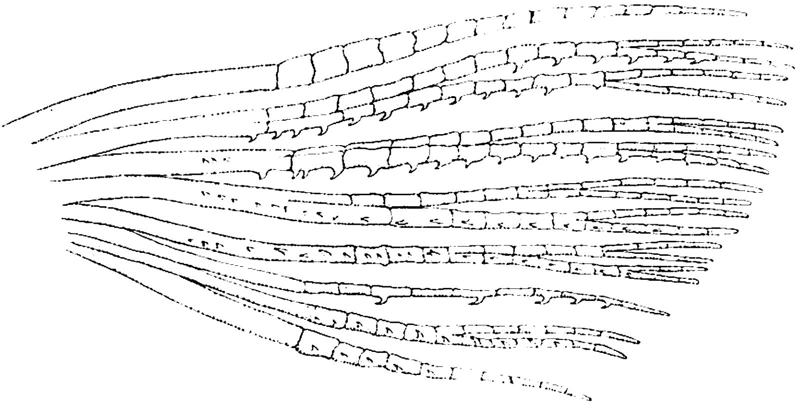

Figure 3. Ventral view of the left pelvic fin of a male of *Cyanocharax dicropotamicus* showing the distribution of the pelvic-fin hooks (MCP 19510, 41.9 mm SL).

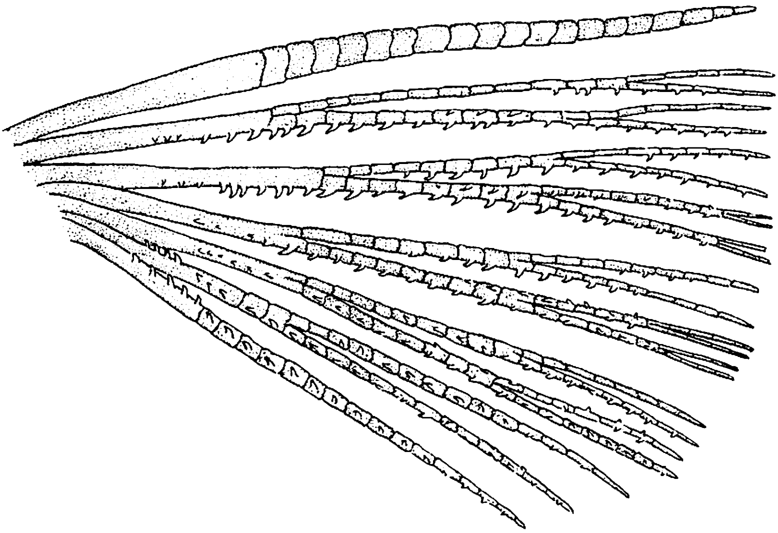

Figure 4. Ventral view of the left pelvic fin of a male of *Cyanocharax alegretensis* showing the distribution of the pelvic-fin hooks (MCP 11232, 39.7 mm SL).

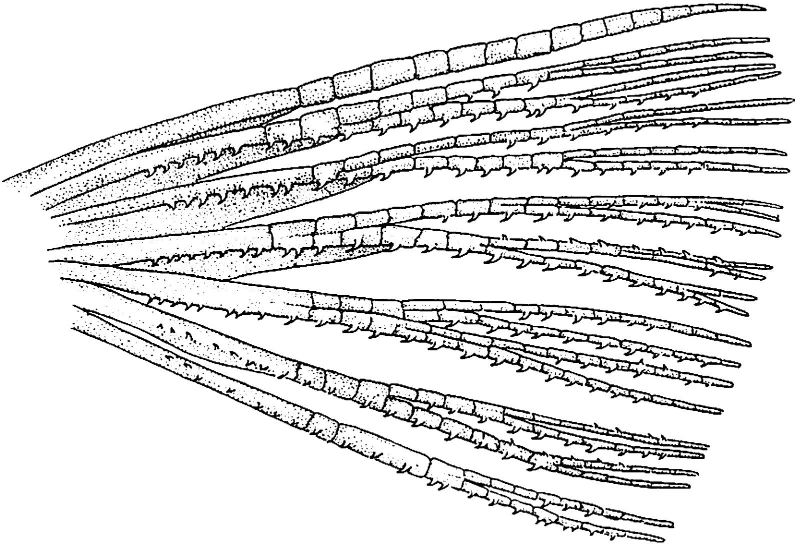

Figure 5. Ventral view of the left pelvic fin of a male of *Cyanocharax macropinna* showing the distribution of the pelvic-fin hooks (MCP 16382, 46.4 mm SL).

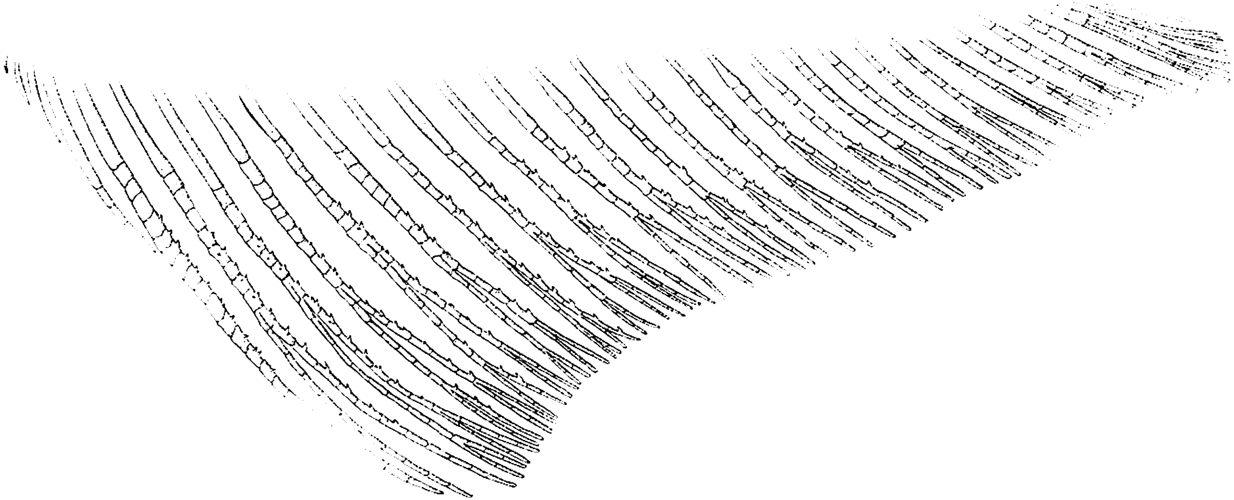

Figure 6. Left view of the anal fin of a male of *Cyanocharax dicropotamicus* showing the distribution of the anal-fin hooks (MCP 19510, 41.9 mm SL).

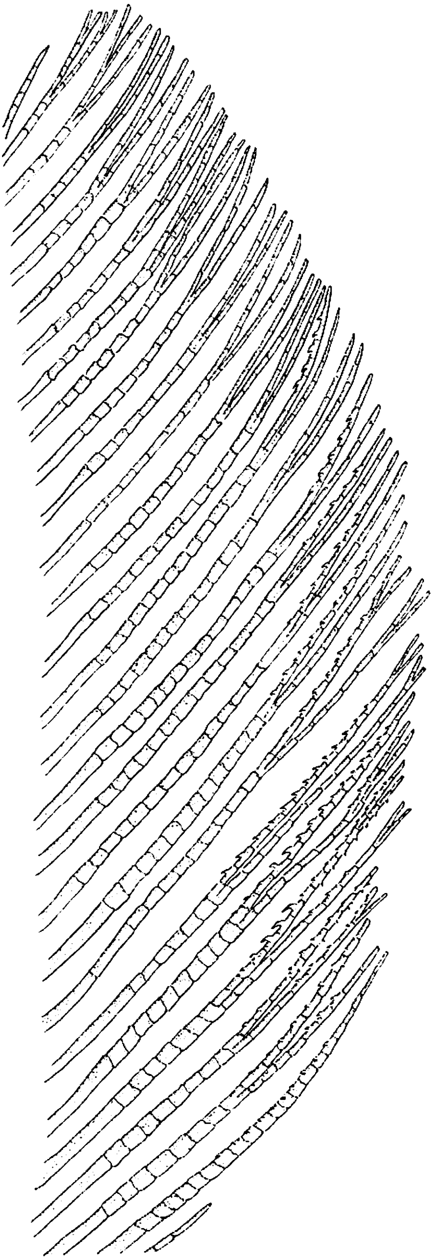

Figure 7. Left view of the anal fin of a male of *Cyanocharax alegretensis* showing the distribution of the anal-fin hooks (MCP 11232, 39.3 mm SL).

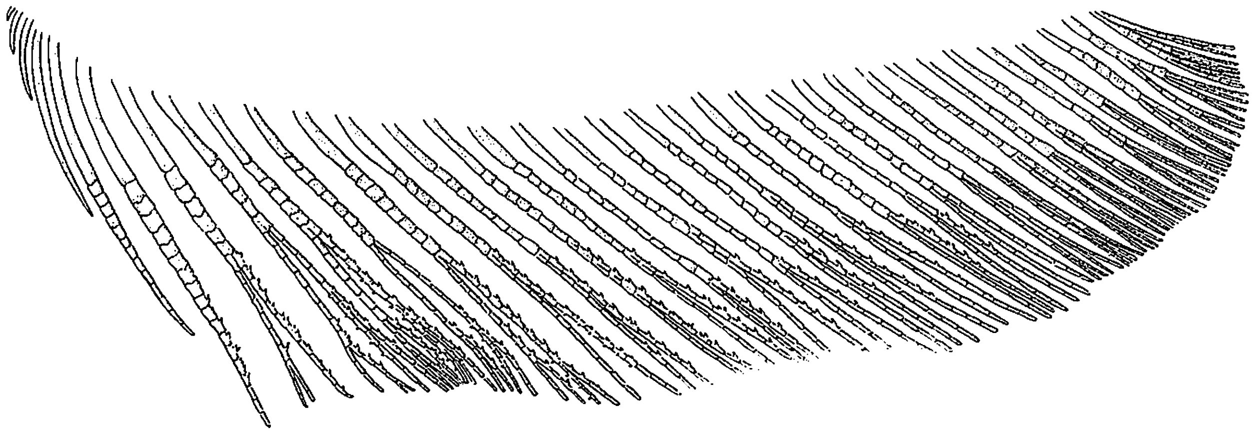

Figure 8. Left view of the anal fin of a male of *Cyanocharax macropinna* showing the distribution of the anal-fin hooks (MCP 16382, 43.5 mm SL).

3) Dorsal-fin rays reduced to two unbranched plus eight branched elements. The number of elements in the dorsal-fin skeleton of characid fishes rarely varies. The usual characid fin-ray count is two anterior unbranched rays plus nine branched rays. This putative primitive number (ii,9) is found among all the species of the so-called Characidae that bear fin-ray hooks and retain a supraorbital bone (the species of *Brycon*, *Bryconops*, *Lignobrycon*, *Salminus*), with the exception of the Serrasalminae which has higher counts and the Gasteropelecidae in which the number of rays may vary from ii,6-8 or iii,5-7 to ii,10-15 or iii,9-14 among the three genera (Weitzman, 1960). Among species that bear no hooks on fins, the Agoniatinae and *Triportheus* also have ii,9 rays; *Chalceus* ii,10; and the genera *Clupeacharax* and *Engraulisoma* ii,8.

Among characid fishes lacking the supraorbital, the apparently primitive dorsal-fin ray number is equal to ii,9 in all the examined species of the Cheirodontinae (genera *Cheirodon*, *Nanocheirodon*, *Heterocheirodon*, *Spintherobolus*, *Serrapinnus*, *Megacheirodon*, *Compsura*, *Saccoderma*, *Macropsobrycon*, *Acinocheirodon*, *Kolpotocheirodon*, *Odontostilbe*, *Prodontocharax*, *Cheirodontops*, *Aphyocheirodon*, and *Pseudocheirodon*), the Stethaprioninae (ii,9-ii,10), the Iguanodectinae (ii,9 in *Iguanodectes* and *Piabucus*; ii,8-9 in some *Piabucus* species), the "Characinae" (*Charax* Clade of Lucena, 1998), Aphyocharacinae (*Aphyocharax*), and the Rhoadsiinae (*Carlana*, *Rhoadsia* and *Parastremma*).

We found two states of this character among genera of the so-called Tetragonopterinae, as well as among the Glandulocaudinae: the putative primitive state (ii,9), and a hypothesized derived condition of two anterior unbranched rays plus eight branched rays (ii,8).

The primitive state (ii,9) is found among the examined species of the tetragonopterine or incertae sedis characid genera *Aphyocharacidium*, *Aphyodite*, *Astyanacinus*, *Astyanax*, *Atopomesus*, *Aulixidens*, *Axelrodia*, *Bario*, *Bramocharax*, *Brittanichthys*, *Bryconella*, *Bryconexodon*, *Coptobrycon*, *Ctenobrycon*, *Deuterodon*, *Eretmobrycon*, *Exodon*, *Genycharax*, *Grundulus*, *Gymnocharacinus*, *Gymnocorymbus*, *Gymnotichthys*, *Hasemania*, *Hemigrammus*, *Hollandichthys*, *Hyphessobrycon*, *Inpaichthys*, *Jupiaba*, *Leptobrycon*, *Markiana*, *Microschemobrycon*, *Mixobrycon*, *Moenkhausia*, *Nematobrycon*, *Nematocharax*, *Oligobrycon*, *Oligosarcus*, *Oxybrycon*, *Paracheirodon* (ii,8 or ii,9), *Parapristella*, *Parecbasis*, *Petitella*, *Pristella*, *Probolodus*, *Psalidodon*, *Psellogrammus*, *Pseudochalceus*, *Roeboexodon*, *Schultzites*, *Scissor*, *Serrabrycon* (ii,8 or ii,9), *Stichonodon*, *Stygichthys*, *Tetragonopterus*, *Thayeria*, *Thrissobrycon*, *Tucanoichthys*, *Tyttobrycon* (ii,8 or ii,9).

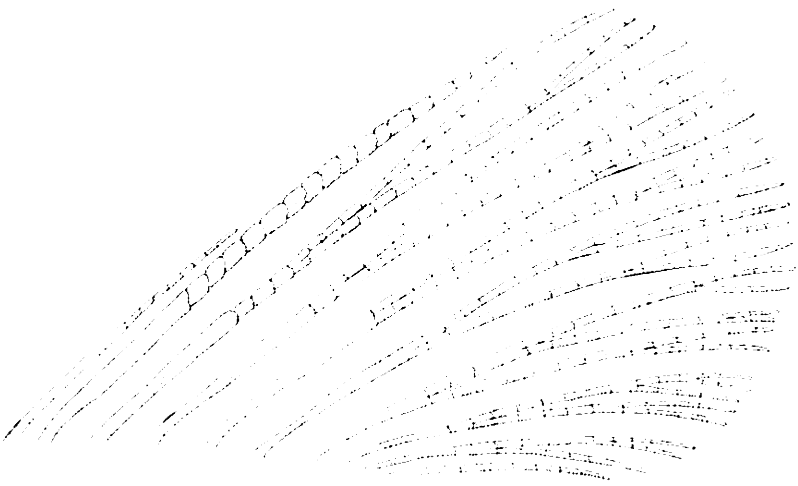

Figure 9. Left view of the dorsal fin of male *Cyanocharax alegretensis* (MCP 11232, 39.7 mm SL) showing the two unbranched plus eight branched dorsal-fin rays shared with other *Cyanocharax* species and putatively related genera.

The derived condition (ii,8) is found among all the examined species of the genera of Géry (1966)'s Hemibryconini (*Boehlkea*, *Bryconacidnus*, *Bryconamericus*, *Ceratobranchia*, *Hemibrycon*, *Knodus*, *Microgenys*, and *Rhinobrycon*), and Géry (1966)'s Creagrutini (*Creagrutus*, *Creagrudite* (= *Creagrutus*), *Piabarchus*, and *Piabina*). A number of other genera were referred by Géry (1966) as possibly belonging to his Hemibryconini, or to the group called "*Hemibrycon* and allied genera" (Géry, 1977). Among these genera, only *Carlastyanax* and *Rhinopetitia* have ii,8 dorsal-fin rays. A number of ii,8 dorsal-fin rays is also present in *Attonitus*, *Caiapobrycon*, *Hypobrycon*, *Monotocheirodon*, *Odontostoechus*, *Othonocheirodus*, "*Astyanax*" *alburnus* and the species of the new genus *Cyanocharax* (Fig. 9).

Among characid fishes lacking a supraorbital, only glandulocaudines share the derived presence of ii,8 dorsal-fin rays with the taxa listed in the preceding paragraph. Glandulocaudines, however, also show the largest variability in dorsal-fin ray number when compared to other characid subgroups, as such cheirodontines, characines, aphyocharacines, iguanodectines, rhoadsiines and stethaprionines. The ii,8 dorsal-fin ray formula is present in all genera of the Diapomini (*Diapoma*, *Planaltina* and *Acrobrycon*) and Corynopomini (*Gephyrocharax*, *Pterobrycon* and *Corynopoma*). Among the Hysteronotini, both species of *Hysteronotus* and *Pseudocorynopoma* have ii,8 or ii,9, (e.g. ii,8 in *Pseudocorynopoma heterandria* and ii,9 in *P. doriae*). In the Glandulocaudini, the basal genus *Glandulocauda* (see Menezes & Weitzman, 1990) and most species of *Mimagoniates* (e. g. *M. microlepis* and *M. sylvicola*) have ii,8 dorsal-fin rays, but one of the most derived species of the tribe, *M. rheocharis*, has an increased number of dorsal-fin rays and an intraspecific range from ii,8 to ii,12. Xenurobryconins have two unbranched and a highly variable number of branched dorsal-fin rays, ranging from 6-7, rarely 8 in the small sized species of *Xenurobrycon*; 7 or 8 in *Tyttocharax*; 8 in the relatively basal genera *Iotabrycon* and *Argopleura*; 9 in *Ptychocharax*, and 9 or 10 in *Chrysobrycon* that includes the largest species of the tribe.

The increased dorsal-fin ray number is apparently secondary in glandulocaudines, as exemplified by *Mimagoniates rheocharis* and *Chrysobrycon myersii*. In both cases, these species correspond to derived taxa of their tribes (Glandulocaudini and Xenurobryconini), while basal species have ii,8 dorsal fin rays. The increased dorsal-fin ray number in Glandulocaudinae may be related to the elaborate courtship behavior of these fishes (Nelson, 1964). A dorsal-fin with 9 branched rays also occurs in the only species of the Landonini, *Landonia latidens* and the Phenacobryconini, *Phenacobrycon henni*.

Hypotheses of affinities between the Glandulocaudinae and some members of the Tetragonopterinae were mentioned by Böhlke (1954) and Géry (1966). However, those hypotheses were weakly defended and mostly based on superficial similarities among the species of those groups. Further evidence of possible relationships between glandulocaudines and the genera listed above are related to the presence of insemination in *Attonitus*, *Monotocheirodon*, and some species of the genera *Creagrutus*, *Knodus* and at least one species currently assigned to *Bryconamericus*, a derived feature among Characidae.

4) Presence of four teeth in the inner series of the premaxilla. The presence of four teeth in the inner series of the premaxilla (Fig. 10), *versus* the presence of five or more teeth, has long been used since Eigenmann (1917) to diagnose some genera among tetragonopterine characids. No evidence has been presented before, however, to identify any of these states as derived and thus informative for the diagnosis of monophyletic groups within the Characidae. We found, however, the presence of four teeth in the inner premaxillary tooth row in some tetragonopterine genera and basal glandulocaudines consistently associated with the derived presence of a reduced number of dorsal-fin rays (ii,8). The hypothesis of relationships supported by the preceding characters 1, 2 and 3 and presented in the cladogram of Fig. 2, also parsimoniously supports the recognition of the presence of four teeth in the inner series of the premaxilla as derived, and as an additional synapomorphy for Clade A characids, versus the presence of five or more teeth in the inner series of the premaxilla in all other taxa bearing at least two tooth rows. *Cyanocharax* species have four teeth in the inner series of the premaxilla (four or five in four of the species of *Cyanocharax*), which supports its inclusion among Clade A characids.

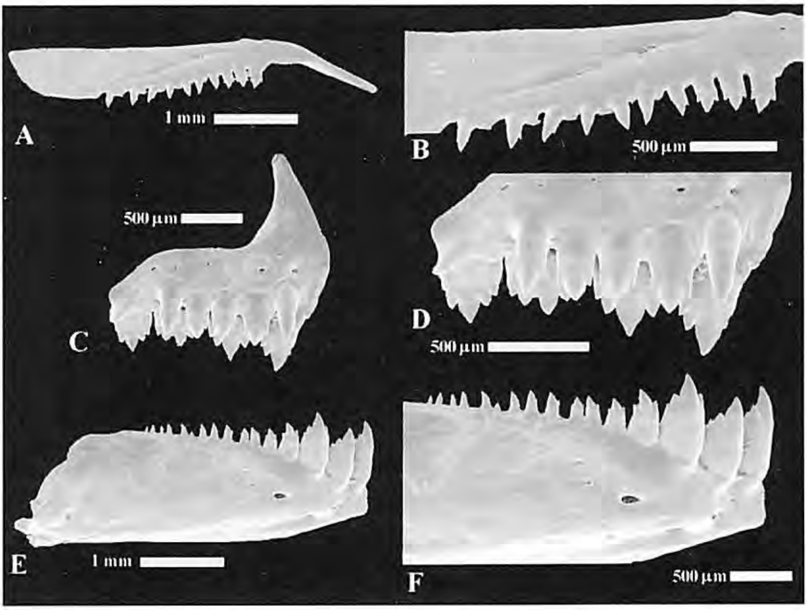

Figure 10. Jaws and teeth of *Hemibrycon dariensis* (MCP 27072, 47.0 mm SL). A-B – Maxilla and detailed view of teeth; C-D – Premaxilla and detailed view of teeth; E-F – Dentary and detailed view of teeth.

The presence of four teeth in the inner series of the premaxilla, along with the presence of a large infraorbital 3 (designated the "second suborbital") in contact with the preopercle below, has been used by Eigenmann (1917:51) to diagnose a group of tetragonopterines in his key. Based on the same characters, Géry (1966) proposed the recognition of a subtribe named Hemibryconini as "... a group of tetragonopterine characids which seem (remotely) [sic] monophyletic and curiously well delimited, despite the apparently insignificant common characters of the forms, i. e. the presence of *only four inner premaxillary teeth* [italicized by Géry], frequently associated with a great development of the third suborbital [infraorbital 3], and, quite often, the irregular implantation of the outer premaxillary row of teeth." Géry's Hemibryconini consisted of *Hemibrycon*, *Knodus*, *Bryconacidnus*, *Bryconamericus*, *Boehlkea*, *Microgenys*, *Ceratobranchia* and *Rhinobrycon*; along with the genera then classified in the Stevardiidi (= Glandulocaudinae), *Glandulocauda* ("at least the type species *melanogenys*"), *Phenacobrycon*, *Argopleura*, *Planaltina*, *Acrobrycon*, *Pterobrycon*, and *Stevardia* (= *Corynopoma*); and the genera of a "Tetragonopteridi" subtribe named the Creagrutini that included *Piabarchus*, *Creagrudite*, *Creagrutus*, and *Piabina*. Further in the text, he mentioned some additional genera or species for the Hemibryconini, including: *Nematobrycon*, *Coptobrycon*, *Rhinopetitia*, *Hyphessobrycon melanopleurus* (= *Glandulocauda melanogenys*, Weitzman & Menezes, pers. comm.), *Landonia* and *Gephyrocharax* (the last two genera now referred to Glandulocaudinae, Weitzman & Menezes, 1998). It is noteworthy the similarities in genera composition of the group proposed by Géry and the hypothesized monophyletic Clade A proposed herein (Fig. 11).

Chernoff & Machado-Allison (1990:266), while discussing the relationships of *Ceratobranchia*, pointed out that Géry's hypothesis of relationships among those genera were difficult to accept, since it was based on characters not unique for the group in question (the large infraorbital 3 is present in other tetragonopterine genera), or difficult to polarize (the number of inner premaxillary teeth). They additionally disagree with Géry's statement that the outer premaxillary teeth in *Ceratobranchia*, *Knodus*, *Bryconamericus* or *Hemibrycon* are irregularly placed, and different from those non-Hemibryconini genera.

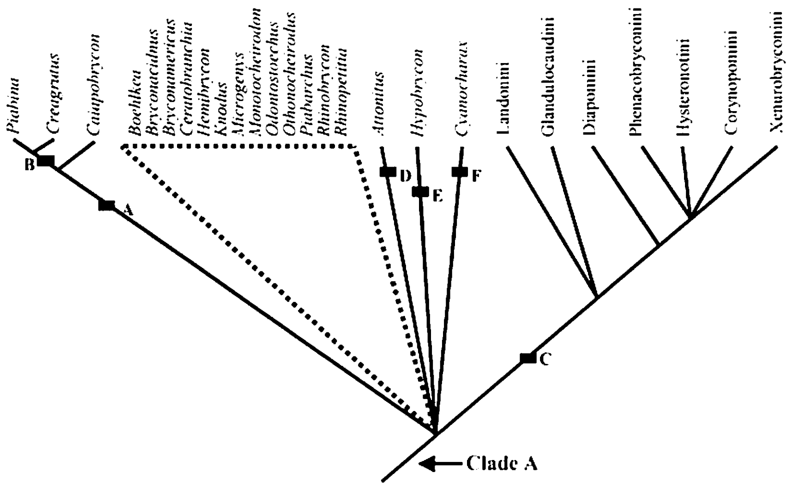

Figure 11. Cladogram depicting known relationships of the clade A of Fig. 2, including *Cyanocharax*. Lettered boxes A through E represent hypotheses supported by characters presented by A – Malabarba & Vari (2000); B – Vari & Harold (1998, 2001); C – Weitzman & Menezes (1998); D – Vari & Ortega, 2000; E – Malabarba & Malabarba (1994) and Silva & Malabarba (1996); and F – present hypothesis.

We do not challenge the Chernoff & Machado-Allison (1990) arguments regarding the variability in size of the infraorbital 3 and outer premaxillary tooth arrangement in tetragonopterine fishes for using these as characters defining a clade among characid genera. We hypothesize, however, the presence of four teeth in the inner premaxillary tooth row in some tetragonopterine genera and basal glandulocaudines as derived and a synapomorphy for Clade A characids, through the most parsimonious analysis of distribution of characters 1, 2, 3 and 4.

Comparisons of the number of teeth in the inner series of the premaxilla of the Clade A characids must be made with species in the basal glandulocaudine tribes and genera. The species of the genera *Planaltina* (N. A. Menezes, pers. commun.) and *Diapoma* (Malabarba, 1983) of the basal glandulocaudine tribe Diapomini and *Landonia latidens* of the basal tribe Landonini have premaxillary teeth with similar arrangement and number (usually four teeth in the inner series) to those observed for most *Bryconamericus* or *Knodus* species. Among xenurobryconins, one of its basal genera, *Argopleura* (Weitzman & Fink, 1985:42, Fig. 66) also has similar tooth arrangement, but other genera of this tribe and also the putatively basal genus *Ptychocharax* (Weitzman et al., 1994:59, Fig. 12) has 5 teeth in the inner series. The genera *Iotabrycon*, *Scopaecharax*, *Tyttocharax* and *Xenurobrycon*, all with derived and paedomorphic species, have completely different and specialized tooth number and arrangements (Weitzman & Fink, 1985:40-41, Figs. 59-64). Therefore, the species of these genera are not actually pertinent to this particular problem.

Cyanocharax definition

The cladogram of Fig. 11 depicts the hypothesized relationships among the genera included in the putative monophyletic Clade A of Fig. 2, that is characterized by the possession of ii,8 dorsal-fin rays and four teeth in the inner series of the premaxilla. Considering the presented hypothesis of monophyly of Clade A characids, *Cyanocharax* differs from *Hemibrycon* and *Boehlkea* by the presence of an incompletely toothed maxilla, with 2 to 8 teeth (Figs. 23, 28, 32, 38, 44, 49, 51) whereas *Boehlkea* has an almost to completely toothed maxilla with 11-21 teeth, and *Hemibrycon* 6-20 maxillary teeth (Fig. 10).

Figure 11 also illustrates hypotheses of the monophyly and/or relationships previously proposed by Weitzman & Menezes (1998) for the Glandulocaudinae; Malabarba & Malabarba (1994) and Silva & Malabarba (1996) for *Hypobrycon*; Vari & Harold (1998, 2001) for *Piabina* and *Creagrutus*; Malabarba & Vari (2000) for *Caiapobrycon*, *Piabina*, and *Creagrutus*; and Vari & Ortega (2000) for *Attonitus*. *Cyanocharax* species do not share any of the apomorphies described for those clades or genera and are therefore excluded from all of them.

Clade A encompasses most of the known inseminating species of the Characidae, including all species of Glandulocaudinae, all species of the genera *Attonitus* and *Monotocheirodon* and a few species currently placed in *Creagrutus*, *Bryconamericus*, and *Knodus* (J. R. Burns, pers. commun.). *Cyanocharax* species are not inseminating, thus lacking any further evidence to group them with the inseminating species listed above.

It is notable that the genera grouped in Clade A (Figs. 2 and 11) include most of the tetragonopterine species with ventrally-located mouths (*Attonitus*, *Bryconacidnus*, *Caiapobrycon*, *Ceratobranchia*, *Creagrutus*, *Hypobrycon*, *Microgenys*, *Piabarchus*, *Piabina*, *Rhinobrycon*, *Rhinopetitia*, and part of *Bryconamericus* and *Knodus*) suggesting a possible close relationship among them or at least part of them. Three unlisted characid genera with ventrally-located mouths (*Monotocheirodon*, *Odontostoechus* and *Othono-*

cheirodus) were previously included in Cheirodontinae (Géry, 1977) and moved to incertae sedis in Characidae by Malabarba (1998). Species of these genera have a single series of teeth in the premaxilla and thus cannot be characterized by the presence of "four teeth in an inner tooth series". Species of those genera, however, have ii,8 dorsal-fin rays suggesting their inclusion among Clade A characids. In *Odontostoechus* there is a single series, but Malabarba (1998) reported an undescribed species, closely related to *Odontostoechus lethostigmus*, in which young individuals have two series of teeth in the premaxilla with four teeth in the inner row, and "an arrangement similar to that of *Bryconamericus*," corroborating their inclusion in Clade A. In *Monotocheirodon* there is a single series of four teeth, suggesting that the absence of an anterior series is a secondary loss, and that the remaining tooth series is homologous to the inner tooth series of the other Clade A genera, but such a hypothesis needs further support.

Hypothesis of relationships among genera with ventrally-located mouths have already been discussed by Vari & Harold (1998, 2001) for *Piabina* and *Creagrutus* and by Malabarba & Vari (2000) for *Piabina*, *Creagrutus*, and *Caiapobrycon*. Malabarba & Vari (2000) have further discussed the possible relationships among tetragonopterines with ventrally-located mouths that share a reduced anal-fin ray number, as found in *Caiapobrycon*, *Attonitus*, *Ceratobranchia*, *Rhinobrycon*, *Bryconacidnus* and *Creagrutus*. *Cyanocharax* species do not share any of the specialized jaw bones and teeth such as observed in *Attonitus*, *Bryconacidnus*, *Caiapobrycon*, *Ceratobranchia*, *Creagrutus*, *Hypobrycon*, *Microgenys*, *Piabarchus*, *Piabina*, *Rhinobrycon*, *Rhinopetitia*, *Bryconamericus*, *Knodus*, *Monotocheirodon*, *Odontostoechus* and *Othonocheirodus* or the reduced anal-fin ray number that would support the inclusion of the species described herein in any of those genera.

Although we cannot phylogenetically diagnose *Cyanocharax* based on exclusively derived features, the synapomorphies diagnosing the internal clades within that genus and which are discussed below further support the close relationships among included species. Characters that allow the recognition of the *Cyanocharax* species are listed under "**Distinguishing characters.**"

Relationships among *Cyanocharax* species (Note: characters used in a cladistic analysis of the species included in the discussion below are numbered and presented in the cladogram of Fig. 12)

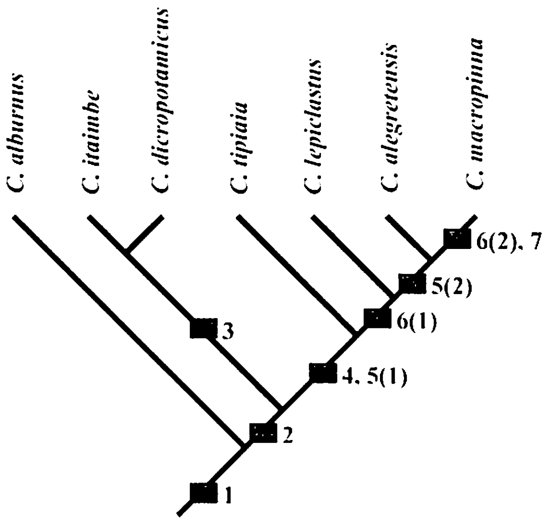

Figure 12. Hypothesized relationships among *Cyanocharax* species based on the characters described under "**Relationships among *Cyanocharax* species**".

Possible derived features diagnosing *Cyanocharax* among Clade A characids are: (1) A maxilla with an incomplete dentition consisting of 2-8 teeth that occupy less than half the length of the maxilla or the anteriormost portion of this bone (Figs. 23, 28, 32, 38, 44, 49, 51). *Hemibrycon* and *Boehlkea* (with 11-21 maxillary teeth) are apparently the most basal genera in Clade A, lacking all specializations related to insemination, development of caudal and/or anal glands or the jaw and teeth modifications related to a ventral mouth, as observed in the remaining genera and species of Clade A. Compared to *Cyanocharax*, the genera *Hemibrycon* and *Boehlkea* basically differ in the longer toothed portion of the maxilla (Fig. 10) that extends beyond its half-length. Although we can hypothesize the condition found in *Cyanocharax* as derived compared to the long toothed portion of the maxilla as found in the outgroup characid genus *Brycon*, such a character is also found in several representatives of Clade A characids, and cannot be assumed as a synapomorphy for *Cyanocharax* until the relationships among the members of Clade A are better hypothesized. However, the facts above do allow a diagnosis of *Cyanocharax* that distinguishes it from *Hemibrycon* and *Boehlkea*.

(2) The presence of an intense blue color in sexually mature specimens somewhat similar to that observed in *Mimagoniates* is also hypothesized to be derived (Figs. 20A, 47). This color has been observed in *C. itaimbe*, *C. dicropotamicus*, *C. lepiclastus*, *C. alegretensis*, and *C. macropinna*. No mature specimens of *C. tipiaia* were available for evaluation of this character and such coloration is absent in *C. alburnus*. The latter species' systematic position, formerly placed in *Astyanax*, has long been problematic due to the variable presence of four or five teeth in the inner series of the premaxilla. It has consequently been described in the literature as *Bryconamericus alburnus* and *Astyanax hasemani*, and lately referred as *A. alburnus*. Its relationships were briefly discussed by Malabarba (1983), who pointed out a possible relationship to *Bryconamericus* or to the glandulocaudine species *Diapoma speculiferum* and *Glandulocauda terofali* (now = *Diapoma terofali*), instead of *Astyanax*.

We hypothesize that "*Astyanax alburnus*" belongs to Clade A characids on the basis of its possession of ii,8 dorsal-fin rays and the presence of a variable number of four or five teeth in the inner series of the premaxilla. It furthermore lacks the derived features diagnosing most of the other genera of Clade A and has a short section of the maxilla toothed, a feature that excludes it from *Hemibrycon* and *Boehlkea*, but is congruent with a hypothesis of a relationship to *Cyanocharax*. This species, now referred to as *C. alburnus*, a new combination, would seem to be basal among the species of *Cyanocharax*. It lacks the intense blue color of sexually mature specimens, a putative derived feature grouping the remaining *Cyanocharax* species, and, in addition, the derived features discussed below that define internal *Cyanocharax* subclades. *Cyanocharax alburnus* also has the largest geographical distribution among *Cyanocharax* species, occurring in all river systems where the remaining species of the genus are found, although not necessarily syntopic.

(3) Among the remaining *Cyanocharax* species, *C. itaimbe* and *C. dicropotamicus* are hypothesized to constitute a clade defined by the presence of a black pigmented adipose fin, that is absent in all other *Cyanocharax* species and outgroup taxa.

(4) *Cyanocharax lepiclastus*, *C. alegretensis*, *C. macropinna*, and *C. tipiaia* share the presence of an interrupted lateral line or an alternating series of perforated and non-perforated lateral line scales. Although the presence of a complete or reduced lateral line is a character highly variable among Clade A species and thus difficult to polarize for the species of *Cyanocharax*, the hypothesis supported by character 2 that places all

Cyanocharax species as a sister group to *C. alburnus*, allows the use of the last species as a functional outgroup to polarize this character among the remaining *Cyanocharax* species. Such a procedure supports the recognition of the reduced lateral line as derived and as a synapomorphy for *C. lepiclastus*, *C. alegretensis*, *C. macropinna*, and *C. tipiaia*.

Further supporting this hypothesis is a series of modifications of the anal fin of males and females. The anal-fin shape is variable in *Cyanocharax*, with the adult males of the putative basal species, *C. alburnus* plus *C. itaimbe* (Figs. 13, 17) and *C. dicropotamicus* (Figs. 6, 24), having (5) an anal fin with a concave distal border (5 state 0), whereas *C. tipiaia* and *C. lepiclastus* (Fig. 33) have a nearly straight distal anal-fin margin (5 state 1) and *C. alegretensis* (Figs. 7, 15, 39-40) and *C. macropinna* (Figs. 8, 16, 45) a deeply convex margin (5 state 2). By parsimony, a nearly straight anal fin distal border is derived and a synapomorphy supporting a clade formed by *Cyanocharax lepiclastus*, *C. alegretensis*, *C. macropinna*, and *C. tipiaia*, and, in a transformation series, the deeply convex anal fin distal border a synapomorphy for the subclade *C. macropinna* and *C. alegretensis*.

All *Cyanocharax* species have a (6) scale sheath covering the basal portions of the anal-fin rays. The extension of this scale sheath over the basal fin rays varies according to the species. In the putative basal species *C. alburnus* as well as in *C. itaimbe* (Fig. 13), *C. dicropotamicus* (Fig. 14) and *C. tipiaia* we found the scales forming a sheath in each species to vary from 7 to 13 scales (6 state 0) covering the bases of the anterior branched anal-fin rays. *Cyanocharax lepiclastus* and *C. alegretensis* (Fig. 15) have a greater series with 12 to 20 scales (6 state 1), while *C. macropinna* (Fig. 16) have a greater series of 20 to 30 scales (6 state 2) covering the base of most anal-fin rays. Again, comparing to the most basal species, the larger series of scales covering anal-fin rays bases is considered apomorphic and a synapomorphy within a clade consisting of *C. lepiclastus*, *C. alegretensis* and *C. macropinna* (6 state 1). The highest number observed in *C. macropinna* is also apomorphic in a transformation series and an autapomorphy of this species (6 state 2).

Finally, *C. macropinna* is hypothesized to have the most derived anal fin among all *Cyanocharax* species. The number of branched anal-fin rays (7) in *C. macropinna* varies from 29-35 ($\bar{x}$ = 31.0, n = 120), while all other *Cyanocharax* species have smaller counts of branched anal-fin rays, as follows: *C. alburnus*, 20-23; *C. itaimbe*, $\bar{x}$ = 23.9, n = 88; *C. dicropotamicus*, $\bar{x}$ = 24.6, n = 130; *C. tipiaia*, $\bar{x}$ = 22.3, n = 15; *C. lepiclastus*, $\bar{x}$ = 26.2, n = 133; *C. alegretensis*, $\bar{x}$ = 26.6, n = 185. The higher count observed in *C. macropinna* is considered derived and an autapomorphy for this species.

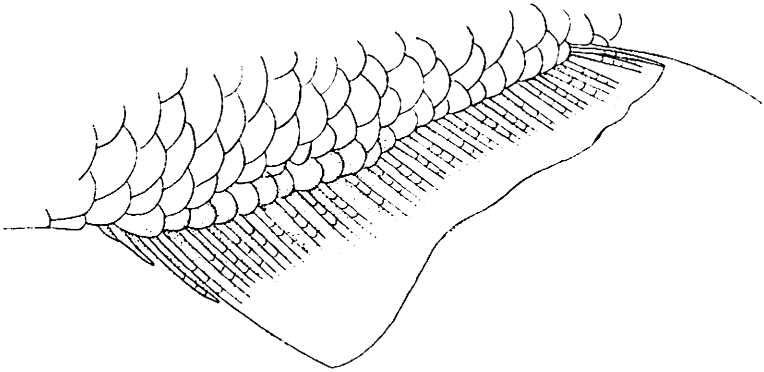

Figure 13. Left view of the anal fin of male *Cyanocharax itaimbe*, showing the sheath of scales covering the base of the anterior anal-fin rays (USNM 323415, 45.3 mm SL).

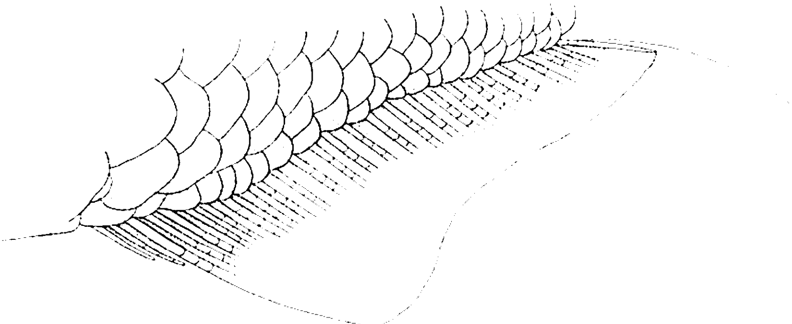

Figure 14. Left view of the anal fin of male *Cyanocharax dicropotamicus*, showing the sheath of scales covering the base of the anterior anal-fin rays (USNM 337612, 40.8 mm SL).

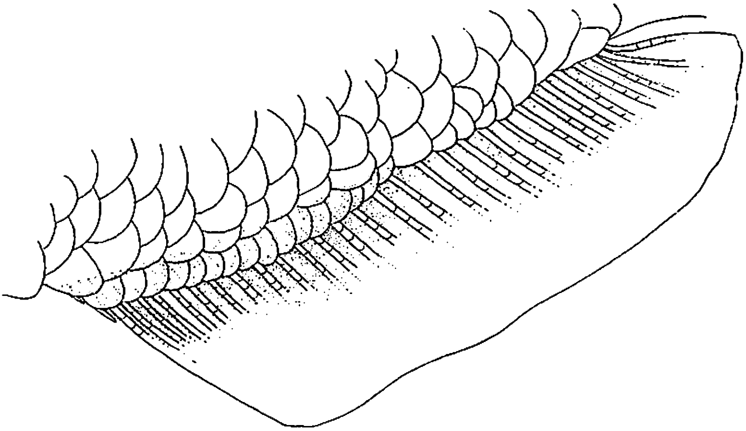

Figure 15. Left view of the anal fin of male *Cyanocharax alegretensis*, showing the sheath of scales covering the base of the anterior anal-fin rays (USNM 357245, 39.3 mm SL).

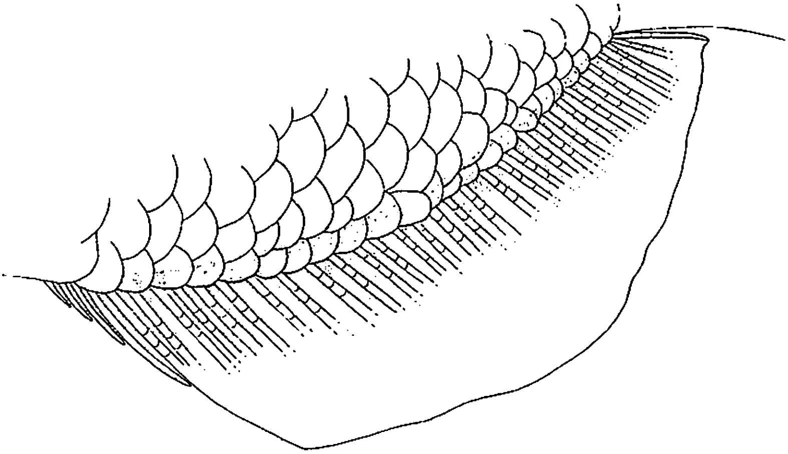

Figure 16. Left view of the anal fin of male *Cyanocharax macropinna*, showing the sheath of scales covering the base of the anterior anal-fin rays (USNM 319750, 43.5 mm SL).

Cyanocharax, new genus

Type species: *Cyanocharax macropinna*, new species

Distinguishing characters. Characters that allow the recognition of *Cyanocharax* are summarized as (1) the presence of two unbranched and eight branched dorsal-fin rays; (2) absence of insemination; (3) absence of caudal- and anal-fin glands or specialized organs; (4) the presence of one unbranched and six branched pelvic-fin rays; (5) presence of a clearly anterior mouth with unspecialized teeth, as well as the absence of a ventrally-located mouth with modified maxilla, premaxilla and dentary bones; (6) the number of branched anal-fin rays, ranging from 21 to 35; and (7) the incompletely toothed maxilla, with 2 to 8 teeth.

Cyanocharax is distinguished from most characid genera (except *Attonitus*, *Boehlkea*, *Bryconacidnus*, *Bryconamericus*, *Caiapobrycon*, *Ceratobranchia*, *Creagrutus*, *Hemibrycon*, *Hypobrycon*, *Knodus*, *Microgenys*, *Monotocheirodon*, *Odontostoechus*, *Othonocheirodus*, *Piabarchus*, *Piabina*, *Rhinobrycon*, and *Rhinopetitia*), by the presence of a derived dorsal fin with ii,8, instead of ii,9 or higher number of rays.

Cyanocharax species can be recognized and distinguished from glandulocaudines, *Attonitus* and *Monotocheirodon* by the absence of the insemination, that is present in those taxa, as well as by the lack of modified caudal organs as described for the glandulocaudine tribes (Weitzman & Menezes, 1998).

A reduced number of pelvic-fin rays (i,6) differentiate *Cyanocharax* from *Attonitus*, *Bryconacidnus*, *Bryconamericus*, *Ceratobranchia*, *Creagrutus*, *Hemibrycon*, *Hypobrycon*, *Odontostoechus*, *Othonocheirodus*, *Piabina*, *Rhinobrycon* and *Rhinopetitia*, all of which have i,7 pelvic-fin rays.

The presence of a clearly anterior mouth with unspecialized teeth, as well as the absence of modified maxilla, premaxilla, and dentary bones distinguishes *Cyanocharax* from *Attonitus* (as diagnosed by Vari & Ortega, 2000), *Caiapobrycon* (as diagnosed by Malabarba & Vari, 2000), *Ceratobranchia* (as diagnosed by Chernoff & Machado-Allison, 1990), *Creagrutus* and *Piabina* (as diagnosed by Vari & Harold, 1998), and *Hypobrycon* (as diagnosed by Malabarba & Malabarba, 1994; and Silva & Malabarba, 1996). Although not cladistically diagnosed, the genera *Bryconacidnus*, *Microgenys*, *Monotocheirodon*, *Odontostoechus*, *Othonocheirodus*, *Piabarchus*, *Rhinobrycon*, and *Rhinopetitia* are all characterized by the specialized mouth placed anteroventrally or ventrally with modified teeth and maxilla, premaxilla and dentary bones, features not shared with the species of *Cyanocharax*.

Cyanocharax is further distinguished from *Monotocheirodon*, *Odontostoechus*, and *Othonocheirodus* by the presence of two tooth series in the premaxilla (versus one in *Monotocheirodon*, *Odontostoechus* and *Othonocheirodus*).

The 21 to 35 branched anal-fin rays further distinguish *Cyanocharax* from *Caiapobrycon* (8 to 10 branched anal-fin rays), *Attonitus* (11-17), *Ceratobranchia* (11-19), *Rhinobrycon* (11-14), *Bryconacidnus* (total of 14-17 anal-fin rays), and *Creagrutus* (8-18) (Malabarba & Vari, 2000).

Cyanocharax is distinguished from *Boehlkea* and *Hemibrycon* by the incompletely toothed maxilla, with 2 to 8 teeth (versus almost to completely toothed in *Boehlkea*, with 11-21 teeth, and 6-20 teeth in *Hemibrycon*). It is distinguished from *Knodus* by the absence of scales covering the proximal region of the caudal-fin rays.

The genera *Bryconamericus* – 51 species, *Hemibrycon* – 19 species and *Knodus* – 16 species lack a diagnosis based on putatively apomorphic characters, and their species are so morphologically diverse that the limits among those genera have long been considered uncertain. Although the characters given to distinguish *Cyanocharax* from the above three genera apply for most of their species, our comparisons herein were primarily concerned with distinguishing *Cyanocharax* from the type species of each genus.

Key to the species of *Cyanocharax*

1 – Lateral line usually complete. Anal-fin origin clearly posterior to vertical through dorsal-fin origin. Anal-fin distal border concave in males. 2

1' – Lateral line never complete (interrupted, or with alternated series of perforated and non perforated scales). Anal-fin origin nearly along vertical through dorsal-fin origin. Anal-fin distal border convex or nearly straight in mature males. 4

2 – Anal fin black pigmented, with distal tip of anterior lobe unpigmented. Adipose fin black in preserved mature males and females. 3

2' – Anal fin unpigmented, without distinctive marks. Adipose fin not pigmented in preserved mature males and females. . . . . *C. alburnus*

3 – Eleven to 13 scale rows between dorsal-fin origin and pelvic-fin origin. . . . . *C. itaimbe*

3' – Ten to 11 scale rows between dorsal-fin origin and pelvic-fin origin. . . . . *C. dicropotamicus*

4 – Anal fin with one row of 7-13 small scales covering basal part of unbranched anal-fin rays and anterior 7-13 branched anal-fin rays. . . . . *C. tipiaia*

4' – Anal fin with one row of more than 12 small scales covering basal part of unbranched anal-fin rays and anterior 12-20 branched anal-fin rays or all branched anal-fin rays. 5

5 – Distal border of anal fin in mature males nearly straight. Body scales in longitudinal series 37-39 (usually 37-38). . . . . *C. lepiclastus*

5' – Distal border of anal fin in mature males strongly convex (Figs. 7, 8). Body scales in longitudinal series 36-38 (usually 36-37). 6

6 – Branched anal-fin rays, 23-30 (usually 25-28). Anal fin with basal sheath of scales, consisting of 1 row with 12-18 small scales, covering bases of unbranched rays and first 12 to 18 branched rays. . *C. alegretensis*

6' – Branched anal-fin rays, 28-35 (usually 29-33). Anal fin with basal sheath of scales, consisting of one row with 20-28 small scales, covering anterior 22 branched rays, to all anal-fin base . . . . *C. macropinna*

Cyanocharax itaimbe Malabarba & Weitzman, new species

(Figs. 1, 13, 17-23, Tables 1 and 2)

Diagnosis. The strongly pigmented adipose fin (dark in alcohol preserved specimens) distinguishes *C. itaimbe* from *C. alburnus*, *C. lepiclastus*, *C. macropinna*, and *C. alegretensis*. *Cyanocharax itaimbe* differs from *C. dicropotamicus* by the larger eye diameter (43.0-50.0% versus 37.8-46.8% of HL), and higher number of longitudinal series of scale rows (11-13 scale rows between dorsal-fin origin and pelvic-fin origin versus 10-11, respectively). The completely perforated lateral line separate *C. itaimbe* from *C. tipiaia* that has 7-11 perforated lateral-line scales. The unpigmented tip of the anterior lobe of the anal fin, and the concave distal border of the anal fin of mature males further distinguishes *C. itaimbe* from *C. lepiclastus*, *C. macropinna* and *C. alegretensis*, which have a pigmented anal fin and convex or nearly straight distal border of the anal fin.

Figure 17. *Cyanocharax itaimbe* new species, **holotype**, male, 49.6 mm SL, arroio Facão at Mãe dos Homens, tributary of rio Canoas – rio Mampituba, Praia Grande, Santa Catarina, Brazil (MCP 25972).

Figure 18. *Cyanocharax itaimbe* new species, female, 45.4 mm SL, same locality as in Fig. 17 (MCP 14788).

Figure 19. *Cyanocharax itaimbe*, 40.4 mm SL, rio Jordão, Jordão Alto, Nova Veneza, Santa Catarina, Brazil (USNM 319746).

Description. Based on specimens from rio Mampituba drainage only – see discussion under Distribution and Geographical Variation. Morphometric data given in Table 1. Body moderately elongate and compressed. Dorsal and ventral profiles nearly equally convex from head to caudal peduncle. Greatest depth at dorsal-fin origin, or somewhat anterior of that point if belly expanded. Body profile along anal-fin base nearly straight. Caudal peduncle slightly longer than deep. Dorsal and ventral profiles of caudal peduncle slightly concave.

Head small (21.8-24.8% of SL). Eyes large (43.0-50.0% of HL). Maxilla positioned at approximately 45 degrees angle relative to long body axis. Posterior tip of maxilla reaches or passes vertical through anterior border of pupil.

Premaxilla with two series of teeth. Teeth of outer series 3 to 5, usually tricuspid and smaller than inner series. Inner series with 4 or 5 teeth with 3 to 5 cusps. Teeth with 4 or 5 cusps with fourth and fifth cusps very small, almost imperceptible. Maxilla with 5 to 7 teeth usually ranging from 3 cusps anteriorly to conical posteriorly, rarely with 5 cusps anteriorly. Dentary with 4 large anterior dentary teeth followed posteriorly by series of 9 to 13 much smaller ones teeth. Dentary teeth ranging from 3 cusps anteriorly to conical posteriorly. Anterior large dentary teeth with 3 to 5 cusps. Those teeth with 4 or 5 cusps with fourth and fifth cusps usually very small, almost imperceptible. Second dentary tooth relatively short and inserted at more ventral position on bone such that tip of tooth reaches only as high as tip of second largest cusp of first and third dentary teeth (Fig. 23).

Dorsal-fin rays ii,8 (n = 29). First unbranched ray about one-half length of second ray. Dorsal-fin origin at, or slightly posterior to, midlength of body. Adipose-fin origin just dorsal to vertical through insertion of posteriormost anal-fin ray.

Anal-fin rays iii-v (usually iv or v), 22-27 ($\bar{x}$ = 23.9, n = 88). Anal-fin origin clearly posterior to vertical through dorsal-fin origin. Distal border of anal fin concave in both sexes, with anterior 3-4 branched rays longer, forming prominent anterior lobe. One mature male (Fig. 17 – holotype) with long unbranched and first and second branched rays longer than usual, with anterior lobe of anal fin reaching further posteriorly than longest dorsal-fin rays, possibly a secondary sexual feature. Anal-fin rays of males with small retrorse bony hooks present on longest unbranched ray and usually 8 anteriormost branched rays. Hooks present on distal 2/3 of longest unbranched ray, first 4 branched rays, and usually distal one-half length of branched rays 5 to 8. Minute hooks distributed along third distal portion of some remaining rays. Hooks mostly present on posterior branches of rays. Usually one pair of bony hooks per ray segment; two pair rarely occur on anterior branched rays.

Pectoral-fin rays i,9-11 ($\bar{x} = 10$, n = 29). Tips of longest rays extend to or close to pelvic-fin origin. Pelvic-fins i,6 (n = 29; i,7 in 2 specimens). Pelvic-fin origin anterior to vertical through dorsal-fin origin. In females longest ray reaches or falls short of anal-fin origin. In males longest pelvic-fin ray reaches anal-fin origin. Pelvic fins with ventromedial, usually unpaired retrorse bony hooks on branched rays only. Principal caudal-fin rays 10/9.

Figure 20A-B. *Cyanocharax itaimbe*, Balneário Maquiné, rio Maquiné, Maquiné, Rio Grande do Sul, Brazil (UFRGS 4998). A – Photograph taken just after fixation in formalin, showing the blue color pattern. B – Photograph of a second specimen collected with specimen above after losing the blue color pattern.

Scales cycloid. Lateral line usually complete. Of 22 specimens counted, one with an alternate series of 25 perforated, 11 non-perforated and 4 perforated scales and one specimen with incomplete lateral line having 29 perforated scales. Total number of scales in lateral-line row, including perforated and non-perforated scales, 37-40 ($\bar{x}$ = 38.2, n = 22). Scale rows between dorsal-fin origin and lateral line 6 to 7 ($\bar{x}$ = 6.7, n = 27). Scale rows between lateral line and pelvic-fin origin 4-5 ($\bar{x}$ = 4.1, n = 29). Predorsal scales 11-15 ($\bar{x}$ = 13.0, n = 16), usually irregularly arranged. Males and females with scale sheath on anal-fin base consisting of one row with 7 to 13, usually 9 to 10, small scales covering bases of unbranched rays and first 7 to 11 branched rays.

Vertebrae 35-38 ($\bar{x}$ = 36.8, n = 61), including vertebrae of Weberian apparatus and posterior half centrum (counts taken from radiographs of USNM 323414 and USNM 323416).

Color in alcohol. Figs. 17-19 and 22. Body pale brownish yellow in specimens preserved in formalin long enough to destroy guanine pigment. Lateral body stripe broad and dark posteriorly, becoming pale and narrow anterior to dorsal-fin origin. Dark humeral spot vertically elongate, centered on fourth and fifth scales of scale row just dorsal to lateral line. Caudal fin remarkably darkly pigmented in mature males, primarily along middle caudal-fin rays and extending to termination of those rays. Branched rays of ventral caudal-fin lobe also darkly pigmented. Dorsal caudal-fin lobe not pigmented basally, and weakly pigmented distally. Dorsal and anal fins darkly pigmented, except for a distinct unpigmented area at tip of dorsal fin and tip of anterior lobe of anal fin. Adipose fin very darky pigmented. Head black to gray dorsally, especially dark near nape. Sides of head and opercle silvery where guanine pigment not destroyed by formalin; otherwise whitish yellow. Exposed borders of scales of dorsal part of body delineated by dark chromatophores. Specimens collected during late spring and summer, presumably corresponding to reproductive period (Figs. 17, 18, 20, 22), more strongly pigmented than those collected during fall and winter months (Figs. 19, 21).

Color in life. Field observations show that specimens collected during late spring and summer, presumably corresponding to the reproductive period, have intense blue pigmentation, mostly along midbody, as shown in Fig. 20A. Specimens collected during fall and winter months and presumably not in reproductive mode, are whitish, with more intense yellow pigmentation on caudal fin (Fig. 21).

Sexual dimorphism. Males with hooks on anal and pelvic fins. Also, mature males with slightly longer pelvic fins than females (Table 1).

Etymology. Itaimbé, meaning precipice, comes from the Tupi-Guarani language of Brazilian Amerindians. In reference to the most popular of the deep canyons of the Parque Nacional de Aparados da Serra, Cânion do Itaimbezinho, at the border of the states of Rio Grande do Sul and Santa Catarina. All deep canyon rivers flowing from the Parque Nacional de Aparados da Serra are tributaries to the rio Mampituba drainage, the type locality of *C. itaimbe*.

Figure 21A-B. *Cyanocharax itaimbe*, rio Itoupava, near Ermo, Santa Catarina, Brazil (MCP 25437). Specimens collected in non-reproductive period (May 2000). Note that the white tips of the anal, dorsal and caudal fins are clearly seen in the black background (Fig. 21A) but not apparent in a white background (Fig. 21B).

Figure 22. *Cyanocharax itaimbe*, creek crossing the road from Terra de Areia to Vila Itati, Vila Nova, Rio Grande do Sul, Brazil (MCP 25308). Specimen collected in reproductive period (December 1999). Note the dark pigmentation on fins.

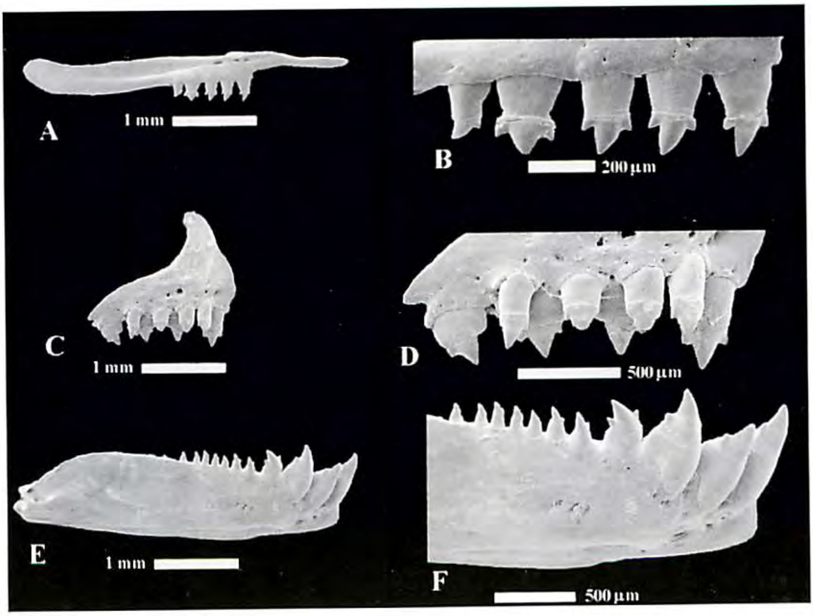

Figure 23A-F. Jaws and teeth of *Cyanocharax itaimbe* (USNM 323409, 48.5 mm SL). A-B – Maxilla and detailed view of teeth; C-D – Premaxilla and detailed view of teeth; E-F – Dentary and detailed view of teeth.

Ecological notes. *Cyanocharax itaimbe*, although until recently apparently absent in fish collections, seems to be a relatively common fish species in mainstream clear and cold waters of the small rivers draining from Serra Geral formation. Twenty of the 22 MCP lots originated in clear waters, with the bottom covered with rocks and stones in all 22 samples, and with some areas of sand and mud in 7 of these 22 samples. All sited had a low to medium speed water currents.

Distribution and geographical variation. The description of *C. itaimbe* is based exclusively on population samples collected from the rio Mampituba drainage; however, two other geographically isolated population samples were tentatively identified as *C. itaimbe*. One occurs in the Atlantic drainage immediately to the North, the rio Araranguá and its tributaries. The second in the immediately southern drainage of the rio Tramandaí. In this latter drainage, *C. itaimbe* was found in rio Maquiné and rio Três Forquilhas valleys of the Serra Geral, that are partially connected in the coastal plain through lagoa dos Quadros and lagoa Itapeva, but was absent in fish samples taken on the coastal plain itself (Fig. 1).

We found no clear differences among these populations (see Tables 1 and 2), except for different ranges and means in anal-fin ray counts. *Cyanocharax* specimens from the rio Araranguá drainage have a relatively low number of anal-fin rays (21-25, median = 23, $\bar{x}$ = 22.9, n = 104) compared to the *Cyanocharax* populations from the coastal drainages of the rio Mampituba (22-27, median = 24, $\bar{x}$ = 23.9, n = 88), and rio Tramandaí (rio Três Forquilhas, 22-27, median = 25, $\bar{x}$ = 24.6, n = 76; rio Maquiné, 22-27, median = 25, $\bar{x}$ = 24.7, n = 121). The parametric t-test used for comparing these four samples, showed the differences in the mean values between the rio Araranguá population and each of the three remaining populations are greater than would be expected by chance (P = 0.001). Because these population samples did not have a normal distribution, we subjected them to non-parametric Mann-Whitney Rank Sum Tests, and found a statistically significant difference in the median values between the rio Araranguá population and each of the three remaining populations (P = 0.001). The type series from rio Mampituba also was statistically significantly different from the rio Maquiné and rio Três Forquilhas means (P = 0.01), and medians (P = 0.001 and P = 0.002, respectively), but a comparison between the rio Três Forquilhas and rio Maquiné populations (both from rio Tramandaí drainage) showed no statistically significant differences in both tests. According to these statistical results for anal-fin ray counts, we could recognize two (rio Araranguá and rio Mampituba + Três Forquilhas + Maquiné) or three (rio Araranguá, and rio Mampituba, and rio Três Forquilhas + Maquiné) different species among these *C. itaimbe* populations. However, we found no additional characters supporting the recognition of different species and consequently prefer not to describe more than one species for these populations.

Additionally we tested statistical differences among population samples from the same drainage taken at different tributaries on the same date (tributaries of the rio Mampituba drainage, 15 Jan 1991: USNM 323414, rio dos Mengue; USNM 323410, arroio Facão) and among samples taken in the same tributary at different years (rio Jordão, rio Araranguá tributary: USNM 319746, 2 Dec 1977; MCP 15000, 7 Jun 1985). We found that the statistical differences in the mean and median values between samples taken at the same tributary in different years, MCP 15000 (range 22-25, median = 24, $\bar{x}$ = 23.4, n = 21) and USNM 319746 (range 21-25, median = 23, $\bar{x}$ = 22.7, n = 83), are also greater than would be expected by chance (P = 0.003 for means and P = 0.003 for medians), as well as differences between samples taken at different tributaries of the same drainage on the same date USNM 323414 (range 22-27, median = 24, $\bar{x}$ = 24.4, n = 31) and USNM 323410 (range 22-26, median = 24, $\bar{x}$ = 23.6, n = 48), (P = 0.001 for means and P = 0.005 for medians). This seems to show that, at least for *C. itaimbe*, slight changes in the range, mean and median of anal-fin rays counts observed within drainages are influenced by unknown factors affecting sample composition, and may not be appropriate for species recognition.

Although the three isolated population samples of *C. itaimbe* may constitute more than one species, in view of the small differences discussed so far, these populations samples are considered as constituting a natural assemblage comparable to the remaining *Cyanocharax* species. This is additional support for the recognition of an area of endemism in some of the small Atlantic coastal drainages of Southern Brazil, first proposed to include the rio Maquiné, rio Três Forquilhas, and rio Mampituba by Malabarba & Isaia (1992), and later extended to the rio Araranguá by Reis & Schaefer (1999).

Table 1. Morphometrics of *Cyanocharax itaimbe*, new species. Standard length is expressed in mm; other measurements through head length are percentages of standard length; the last four entries are percentages of head length. Described ranges include measurements of the holotype MCP 25972, male, and paratypes from rio Mampituba drainage (MCP 14710, 8; MCP 14838, 6; MCP 14707, 9; MCP14788, 12); and comparative material from rio Tramandaí drainage (MCP 13604, 9; MCP 14856, 3; MCP 14795, 8; MCP13697, 7; MCP 14791, 8; MCP 14263, 13) and rio Araranguá drainage (MCP 15000, 20; USNM 326248, 5; USNM 326249, 3; USNM 323413, 2).

		holotype + paratypes rio Mampituba				rio Tramandaí				rio Araranguá			
Character	holotype	n	low	high	$\bar{x}$	n	low	high	$\bar{x}$	n	low	high	$\bar{x}$
Standard length (mm)	49.6	35	28.4	49.6	38.8	48	29.4	52.6	40.3	30	29.0	51.4	38.2
Snout to anal-fin origin	60.1	35	54.2	61.2	57.2	48	55.7	59.9	57.7	30	55.4	60.5	58.6
Snout to dorsal-fin origin	53.0	35	50.3	55.5	53.2	48	51.1	55.5	53.3	30	50.8	55.5	53.3
Snout to pelvic-fin origin	42.3	34	40.4	45.6	43.0	48	41.0	46.6	43.3	30	41.2	46.1	43.4
Dorsal-fin base length	12.1	35	9.7	12.8	11.4	48	10.1	13.1	11.7	30	9.1	13.2	11.4
Anal-fin base length	31.9	35	30.4	36.0	33.2	48	29.6	37.1	33.0	30	28.2	34.2	31.4
Caudal peduncle length	13.3	35	11.4	15.2	13.1	48	11.0	16.2	13.1	30	9.6	16.2	13.1
Caudal peduncle depth	11.1	35	9.2	11.4	10.3	48	9.9	12.2	11.0	30	8.6	11.0	10.2
Depth at dorsal-fin origin	32.1	34	27.0	35.0	30.0	48	26.1	36.9	31.6	29	24.6	33.2	28.6
Dorsal-fin height	28.2	35	21.8	28.6	24.4	46	21.9	27.2	23.9	29	21.2	27.4	23.8
Pelvic-fin length males	17.9	21	13.4	17.9	15.0	18	12.8	17.1	15.6	11	14.8	17.4	16.1
Pelvic-fin length females		13	12.5	15.1	13.9	29	12.2	15.8	14.0	13	13.5	15.7	14.4
Pectoral-fin length	22.0	34	18.8	23.6	20.7	46	18.6	23.1	21.0	29	18.2	23.8	21.1
Bony head length	23.2	35	21.8	24.8	23.3	48	21.8	24.2	23.0	30	21.0	24.4	23.4
Snout length	21.7	35	20.7	23.1	21.9	48	19.3	25.0	22.0	29	18.8	23.3	21.1
Upper jaw length	36.5	35	36.2	43.9	39.8	48	33.8	42.0	38.5	30	32.5	44.7	39.4
Horizontal eye diameter	43.5	35	43.0	50.0	46.0	48	38.5	48.1	44.1	30	41.6	48.3	45.3
Least interorbital width	33.9	35	31.5	36.6	33.7	48	31.0	37.3	34.4	30	30.2	37.4	33.9

Table 2. Counts of *Cyanocharax itaimbe*, new species. Described ranges include counts of the holotype MCP 25972, male, and paratypes from rio Mampituba drainage (MCP 14710, 8; MCP 14838, 6; MCP 14707, 5; MCP 14798, 5; MCP 14788, 5), and comparative material from rio Tramandaí drainage (MCP 14791, 8; MCP 14263, 13; MCP 14290, 7; MCP 13604, 9; MCP 14856, 3; MCP 14795, 8) and rio Araranguá drainage (MCP 15000, 14; MCP 15089, 14). Branched anal-fin rays counts taken from x-rays of USNM 323410, USNM 323414 and USNM 323416 (rio Mampituba), MCP 13604, USNM 323409 and USNM 323412 (rio Tramandaí), and USNM 319746 and MCP 15000 (rio Araranguá).

		holotype + paratypes rio Mampituba				rio Tramandaí				rio Araranguá			
Character	Holotype	n	low	high	$\bar{x}$	n	low	high	$\bar{x}$	n	low	high	$\bar{x}$
Unbranched anal-fin rays	3	29	3	5	4.4	48	3	5	4.4	27	4	5	4.6
Branched anal-fin rays	23	88	22	27	23.9	197	22	27	24.7	104	21	25	22.9
Branched dorsal-fin rays	8	29	8	8	8.0	48	7	9	8.0	26	8	8	8.0
Branched pelvic-fin rays	6	29	6	7	6.1	48	5	7	5.9	26	6	6	6.0
Branched pectoral-fin rays	10	29	9	11	10.0	48	9	11	9.7	26	9	11	10.0
Principal caudal-fin rays	19	29	19	19	19.0	48	17	20	19.0	25	19	19	19.0
Lateral line perforated scales	38	22	25	40	37.1	40	4	41	37.1	19	15	40	36.1
Longitudinal scales at lateral line series	38	22	37	40	38.2	39	37	41	38.5	19	38	40	38.4
Scales between lateral line and dorsal-fin origin	6	27	6	7	6.7	43	6	7	6.7	24	6	7	6.3
Scales between lateral line and pelvic-fin origin	4	29	4	5	4.1	42	4	6	4.6	25	4	5	4.4
Number of predorsal scales	15	16	11	15	13.0	27	11	16	13.1	9	11	15	13.0

Taxa with a geographical distribution identical to *Cyanocharax itaimbe* are the characids *Mimagoniates rheocharis* Menezes & Weitzman (1990), and *Deuterodon stigmaturus* (Lucena & Lucena, 1992; Reis & Schaefer, 1999); the loricariid *Epactionotus*, with three species, one in the rio Maquiné plus rio Três Forquilhas, one from the rio Mampituba, and one from rio Araranguá drainage (Reis & Schaefer, 1999); an undescribed species of *Rineloricaria* (Reis & Schaefer, 1999), and two monophyletic groups of *Hemipsilichthys* species (Edson H. L. Pereira, pers. comm., and Reis & Schaefer, 1999). The characid *Odontostoechus lethostigmus* Gomez is also endemic to the rio Tramandaí and rio Mampituba drainages, and is putatively closely related to an undescribed species from the rio Araranguá drainage (Malabarba, 1998). The pimelodid *Microglanis cibelae* Malabarba & Mahler (1998) has been found only in the rio Maquiné, rio Três Forquilhas and rio Mampituba drainages, but no other species of this genus have been collected as yet in the rio Araranguá drainage.

Holotype: MCP 25972, male, 49.6 mm SL, arroio Facão at Mãe dos Homens, tributary rio Canoas – rio Mampituba, Praia Grande, Santa Catarina, Brazil; 15 Jan 1991.

Paratypes: Rio Mampituba drainage: Santa Catarina, Brazil: MCP 14788 (46: 10 c&s, 28.0-45.8 mm SL), USNM 323410 (51), MZUSP 43549 (50, 29.3-47.0 mm SL), MNRJ 23841 (15, 31.4-45.8 mm SL), collected with holotype. MCP 14707 (9, 31.7-42.9 mm SL), rio Canoas, between Praia Grande and Mãe dos Homens, 8 km from Praia Grande, Praia Grande; 16 Jan 1991. Rio Grande do Sul, Brazil: MCP 14838 (13, 12.5-35.1 mm SL), USNM 323416 (10), MZUSP 43544 (10, 25.2-30.1 mm SL), rio das Pacas, near Morro Azul, tributary of lagoa Jacaré, Três Cachoeiras; 15 Jan 1991. MCP 14710 (47, 14.3-37.3 mm SL), USNM 323414 (41), MZUSP 43548 (40, 14.1-33.0 mm SL), rio dos Mengue, between Morro Azul and Rua Nova, tributary of lagoa Jacaré, Torres; 15 Jan 1991.

Non-type specimens). Rio Araranguá drainage, Santa Catarina, Brazil: MCP 15000 (21: 4 c&s), rio Jordão, Siderópolis; 2 Dec 1977. MCP 15089 (85: 5 c&s), MZUSP 44136 (79), USNM 319746 (85), rio Jordão, Jordão Alto, Nova Veneza; 7 Jun 1985. USNM 323413 (15), USNM 326248 (6), USNM 326249 (20), rio Pique, Morro Cortado, road off Meleiro, near Limeira, turn off at Km 407, BR 101; 22 Sep 1977. MCP 25437 (13), rio Itoupava, nearly 3 Km W of Ermo; 5 Jan 2000. Rio Mampituba drainage, Santa Catarina, Brazil: MCP 15091 (70), MZUSP 44137 (68), USNM 319747 (68), rio Faxinalzinho at Mãe dos Homens, Praia Grande; 9 Jun 1985. MCP 14798 (18), USNM 323411 (10), creek tributary of rio Canoas, between Praia Grande and Mãe dos Homens, about 2 km from Praia Grande, Praia Grande; 16 Jan 1991. Rio Três Forquilhas drainage, Rio Grande do Sul, Brazil: MCP 14819 (260), USNM 323408 (100), rio Três Pinheiros, 8 km from BR 101 on road to Itati, Terra de Areia; 15 Jan 1991. MCP 14796 (130), USNM 323412 (80), rio Mitmann, Vila Nova, 10 km from BR 101 on road to Itati, Terra de Areia; 15 Jan 1991. MCP 14791 (8), USNM 323415 (8), rio do Padre, Itati, Osório; 15 Jan 1991. MCP 14569 (6), rio Três Forquilhas, Porto Alágio, Torres; 25 May 1986. MCP 14290 (21: 6 c&s), rio Três Forquilhas, on road Três Forquilhas-Itati, Torres; 12 Dec 1989. MCP 14237 (6), rio Três Forquilhas, on road Três Forquilhas-Itati, 100 m from bridge, Tôrres; 12 Dec 1989. MCP 15404 (121), USNM 319749 (120), MZUSP 44138 (71), Chapéu, Torres; 25 May 1986. MCP 14263 (13: 4 c&s;), rio Três Forquilhas, at second dam after bridge, Torres; 12 Dec 1989. MCP 25308 (105), creek on road Terra de Areia to Itati, nearly 8 Km from BR 101 highroad, Vila Nova; 29 Dec 1999. Rio Maquiné drainage, Rio Grande do Sul, Brazil: MCP 14856 (3), arroio Água Parada, Maquiné; 14 Jan 1991. MCP 14549 (9), arroio Água Parada, Maquiné; 25 May 1986. MCP 13697 (7), arroio Água Parada, Maquiné, Osório; 1 Oct 1989. MCP 14795 (8), USNM 323409 (10: 5 c&s), rio Pinheiro, Maquiné; 14 Jan 1991. MCP 14562 (27), rio Maquiné, Maquiné; 25 May 1986. MCP 15088 (99), USNM 319748 (95), MZUSP 44139 (95), rio Maquiné, 2 km above Maquiné; 25 May 1986. MCP 13604 (9), rio Maquiné, near Maquiné; 1 Oct 1989. UFRGS 4998 (4), Balneário Maquiné, rio Maquiné, Maquiné; 25 Jan 2001.

Cyanocharax dicropotamicus Malabarba & Weitzman, new species
(Figs. 1, 3, 6, 14, 24-28, Table 3)

Diagnosis. *Cyanocharax dicropotamicus* differs from *C. itaimbe* by the smaller eye diameter (37.8-46.8 versus 43.0-50.0% of HL, respectively); and smaller number of longitudinal scale rows between dorsal-fin origin and pelvic-fin origin (10-11 versus 11-13, respectively). Although available specimens are not intensely pigmented, the chromatophore distribution of *C. dicropotamicus* indicates that the species has the tip of the anal-fin lobe unpigmented, and the adipose fin is darkly pigmented. This distinguishes *C. dicropotamicus* from *C. alburnus, C. lepiclastus, C. macropinna*, and *C. alegretensis* that have the adipose fin not black pigmented and the anal and dorsal-fins distal portions darkly pigmented. The concave distal profile of the anal fin of males also distinguishes *C. dicropotamicus* from *C. lepiclastus, C. macropinna,* and *C. alegretensis* that have a straight or convex anal-fin margin. The complete lateral line (37-39 perforated scales) and the higher number of branched anal-fin rays (22-26, rarely 27 or 28; $\bar{x}$ = 24.6) differentiate *C. dicropotamicus* from *C. tipiaia* (7-11 perforated scales and 21-23, $\bar{x}$ = 22.3 branched anal-fin rays).

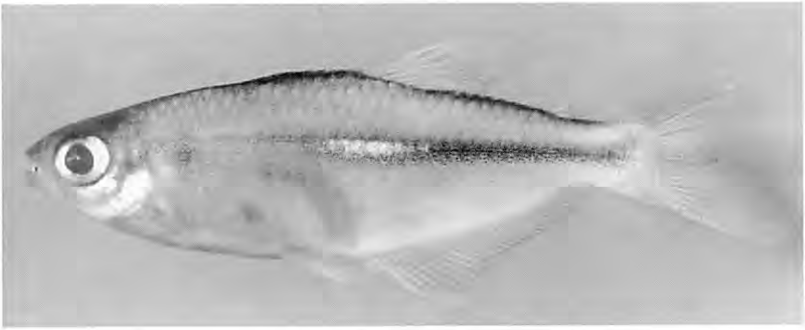

Figure 24. *Cyanocharax dicropotamicus*, new species, **holotype**, male, 42.5 mm SL, rio Forqueta, Marquês de Souza, Lageado, Rio Grande do Sul, Brazil (MZUSP 18984).

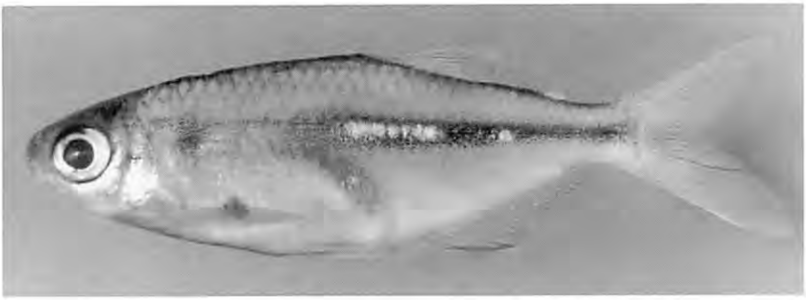

Figure 25. *Cyanocharax dicropotamicus*, new species, female, 41.8 mm SL, same locality as in Fig. 24 (MZUSP 18984).

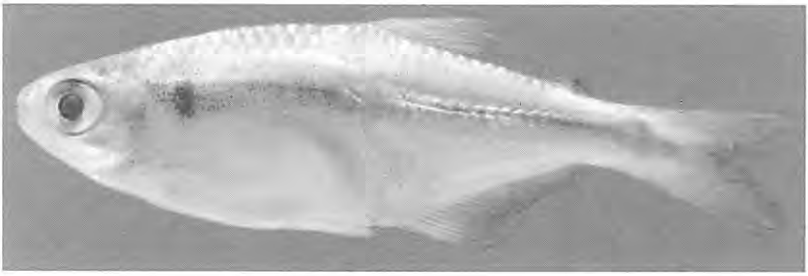

Figure 26. *Cyanocharax dicropotamicus*, new species, male, 37.04 mm SL, rio Taquari, Rio Grande do Sul, Brazil (MCP 19516).

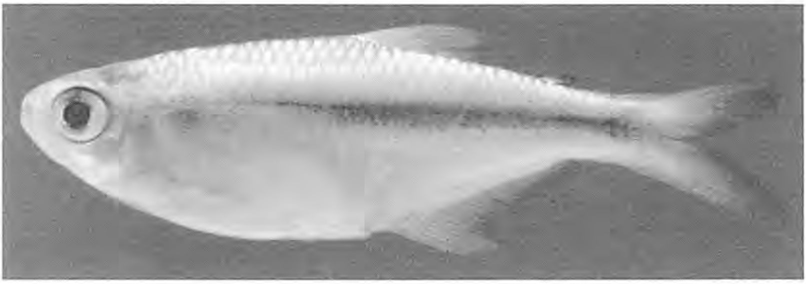

Figure 27. *Cyanocharax dicropotamicus*, new species, female, 33.63 mm SL, rio Taquari, Rio Grande do Sul, Brazil (MCP 19516).

Description. Morphometric data given in Table 3. Body moderately elongate and compressed. Dorsal and ventral body profiles equally convex from snout to dorsal and anal-fin origins, respectively. Dorsal body profile slightly concave near the insertion of the most posterior dorsal-fin rays, and slightly convex from that point to caudal peduncle. Ventral body profile along anal fin nearly straight. Dorsal and ventral profiles of caudal peduncle slightly concave.

Head small (22.1-24.8% of SL). Eyes of moderate size (37.8-46.8% of HL). Maxilla positioned at an angle of 45 degrees or greater, relative to long axis of body. Posterior tip of maxilla usually not reaching further posterior than a vertical line crossing anterior border of pupil.

Two series of premaxillary teeth. Teeth of outer series usually tricuspid, smaller than those of inner series, numbering 3 to 5. Four or 5 teeth with 3, 4 or most rarely 5 cusps in inner series. Those teeth with 4 or 5 cusps with fourth and fifth cusps very small, almost imperceptible. Four to 6 maxillary teeth usually ranging from 3 cusps to conical, from anteriormost to posteriormost teeth. Four large dentary teeth followed by a series of 6 to 10 much smaller ones, ranging from 3 cusps to conical. Anterior large dentary teeth with 3, 4 or 5 cusps. Those teeth with 4 or 5 cusps with fourth and fifth cusps usually very small, almost imperceptible. Second dentary tooth shorter and inserted at a lower position in jaws, in such a way that tip of its longest cusp reaches only as high as tip of second largest cusp of first and third dentary teeth (Fig. 28).

Dorsal-fin rays ii,8 (n = 35). Dorsal-fin origin posterior to mid body length. Adipose-fin origin dorsal to posterior anal-fin ray insertion.

Anal-fin rays iii-v, 22-26, rarely 27 or 28 ($\bar{x}$ = 24.6, n = 130). Anal-fin origin clearly posterior to a vertical line crossing dorsal-fin origin. Distal border of anal fin concave in both sexes, with anterior 3-4 branched rays longer, forming a prominent anterior lobe. Anal-fin rays of males with small retrorse bony hooks present on 2/3 of distal length of longest unbranched ray and usually anterior 8 branched rays (Fig. 6). Minute hooks distributed along distal third of some remaining rays. Hooks mostly present on posterior branches of rays. Usually one pair of bony hooks per ray segment; two pairs rarely occur on anterior branched rays.

Pectoral-fin rays i, 9-11 ($\bar{x}$ = 9.7, n = 35). Distal ends of longest rays extending to or posterior to pelvic-fin origin. Pelvic fins i, 6 (n = 35). Pelvic-fin origin anterior to a vertical passing through dorsal-fin origin. In females longest pelvic-fin ray may or may not reach anal-fin origin. In males longest ray reaches anal-fin origin. Pelvic fins with ventromedial, usually unpaired retrorse bony hooks on branched rays only (Fig. 3). Principal caudal-fin rays 10/9.

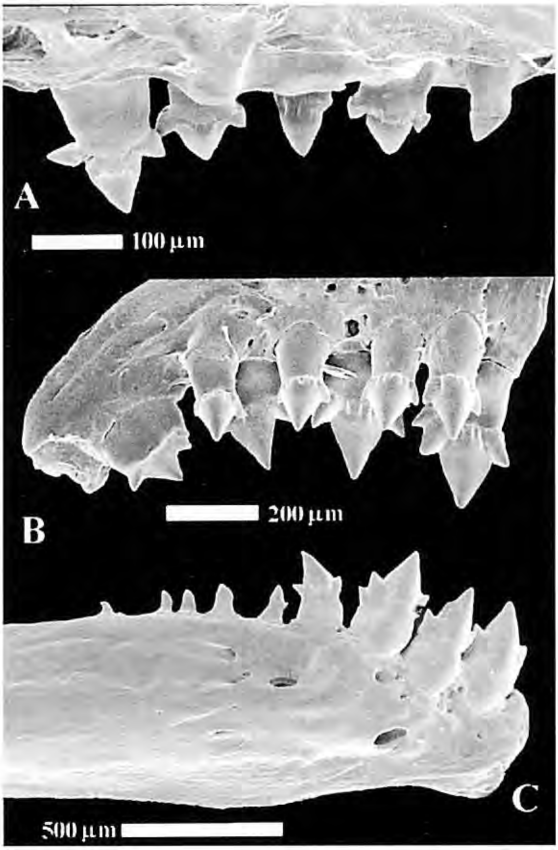

Figure 28. Teeth of *Cyanocharax dicropotamicus* (MCP 19510, 40.0 mm SL). Jaws seem decalcified and deformed. A – Maxilla, B – Premaxilla and C – Dentary teeth.

Scales cycloid. Lateral line complete in all specimens in which scales were counted. Total number of scales in lateral line row, 37-39 ($\bar{x}$ = 37.7, n = 14). Scale rows between dorsal-fin origin and lateral line 5-6 ($\bar{x}$ = 6.0, n = 31). Scale rows between lateral line and pelvic-fin origin 3-4 ($\bar{x}$ = 3.9, n = 35). Predorsal scales 12-15 ($\bar{x}$ = 12.9, n = 15), usually not arranged in one regular series. Males and females with a scale sheath on anal-fin base consisting of one row with usually 9 to 12 small scales covering bases of unbranched rays and first 9 to 12 branched rays.

Vertebrae 36-38 ($\bar{x} = 36.6$, n = 26), including Weberian apparatus and posterior half centrum (counts taken from x-ray negatives from MCP 19510).

Color in alcohol. Available specimens of *Cyanocharax dicropotamicus* (Figs. 24-27) not as heavily pigmented as available specimens of remaining *Cyanocharax* species. All *C. dicropotamicus* specimens were collected during October and December, whereas colorful specimens of *C. itaimbe* were caught during January and February. Pigmentation may be affected by seasonal and reproductive state. Pigmentation pattern of *C. dicropotamicus*, however, with a similar distribution to that described to *C. itaimbe*.

Body pale brownish yellow in specimens preserved in formalin long enough to destroy guanine pigment. Lateral body stripe broad and dark posteriorly, becoming pale and narrow anterior to vertical through dorsal-fin origin. Lateral body stripe remains silvery in some specimens. Dark humeral spot faint, vertically elongate, centered on fourth and fifth scales of scale row just dorsal to lateral line. Middle caudal-fin rays darkly pigmented with pigmentation extending to tips of rays. Exposed borders of scales of back delineated by dark chromatophores. Dorsal and anal fins covered with scattered dark chromatophores, except for distinct unpigmented area at tip of dorsal fin and tip of anterior anal fin lobe. Adipose fin darkly pigmented (most clearly in MCP 19516). Head black to gray dorsally, especially dark near nape. Sides of head and opercles silvery where guanine pigment not destroyed by formalin, sides of head otherwise whitish yellow.

Sexual dimorphism. Males have anal and pelvic fin hooks. Additionally, mature males have slightly longer pelvic fins than females (Table 3).

Etymology. *Dicro* is from the Greek dikros meaning forked and *potamicus* from the Greek potamus meaning river or stream and is reference to the rio Forqueta, the type locality.

Distribution. Known only from northern tributaries of the rio Jacuí, Laguna dos Patos System, draining from Serra Geral formation (Fig. 1).

Holotype: MZUSP 82262, male, 42.5 mm SL, rio Forqueta, Marquês de Souza, Lageado, Rio Grande do Sul, Brazil; 7 Dec 1979.

Table 3. Morphometrics of *Cyanocharax dicropotamicus*, new species. Standard length is expressed in mm; other measurements through head length are percentages of standard length; the last four entries are percentages of head length. All specimens are from laguna dos Patos drainage. Described ranges include measurements of the holotype MZUSP 82262, male, and following paratypes: MZUSP 18984 (35).

Character	holotype	n	low	high	$\bar{x}$
Standard length (mm)	42.5	35	26.3	42.5	32.7
Snout to anal-fin origin	56.0	35	56.0	62.9	58.4
Snout to dorsal-fin origin	54.8	35	52.6	57.1	54.9
Snout to pelvic-fin origin	41.7	35	41.6	45.6	44.0
Dorsal-fin base length	8.7	35	8.7	11.8	10.1
Anal-fin base length	33.4	35	28.8	34.1	31.4
Caudal peduncle length	13.2	35	11.4	14.1	12.8
Caudal peduncle depth	11.3	33	9.1	11.3	10.1
Depth at dorsal-fin origin	30.8	35	26.6	33.1	29.5
Dorsal-fin height	24.2	33	21.6	25.8	23.6
Pelvic-fin length males	15.8	13	14.2	16.5	15.4
Pelvic-fin length females	-	22	12.0	15.2	13.9
Pectoral-fin length	21.2	35	20.3	23.8	21.9
Bony head length	22.6	35	22.1	24.8	23.5
Snout length	22.9	33	19.5	23.5	21.8
Upper jaw length	36.5	34	33.3	41.9	37.6
Horizontal eye diameter	42.7	34	37.8	46.8	42.4
Least interorbital width	34.4	35	31.8	37.3	34.4

Paratypes: all from laguna dos Patos drainage, Rio Grande do Sul, Brazil: MZUSP 18984 (34), USNM 337599 (14), rio Forqueta, Marquês de Souza, Lageado; 7 Dec 1979. MCP 19510 (63: 5 c&s, 22.6-42.6 mm SL), MNRJ 23845 (20, 24.4-30.5 mm SL), USNM 357244 (20), rio Taquari, Cruzeiro do Sul; 29 Oct 1996. MCP 19516 (30, 28.3-40.8 mm SL), rio Taquari, Encantado; 31 Oct 1996.

Cyanocharax tipiaia Malabarba & Weitzman, new species
(Figs. 1, 29-32, Table 4)

Diagnosis. The low number of perforated scales in the lateral line series (7-11) distinguishes *C. tipiaia* from *C. alburnus, C. itaimbe* and *C. dicropotamicus*, which have all scales of the lateral line pored. The low number of scales (7-13) forming a sheath covering unbranched anal-fin rays and anterior 7-13 branched anal-fin rays differs *C. tipiaia* from *C. lepiclastus*, *C. macropinna* and *C. alegretensis* (anal-fin base with a sheath of more than 12 small scales covering unbranched anal-fin rays and anterior 12-20 branched anal-fin rays to all anal-fin base).

Description. Morphometric data given in Table 4. Body elongate and compressed. Dorsal head profile nearly straight to slightly convex. Dorsal body profile from nape to dorsal-fin origin slightly convex, posteroventrally slanted at dorsal-fin base, and nearly straight between dorsal and adipose fins. Ventral body profile convex from lower jaw to pelvic-fin origin, and slightly concave from pelvic to anal-fin origins. Ventral profile along anal-fin base nearly straight to slightly concave. Dorsal and ventral profiles of caudal peduncle nearly straight to slightly concave.

Head small (21.5-23.4% of SL). Eyes relatively large (31.5-37.0% of HL). Maxilla large positioned at an angle of 45 degrees relative to long body axis. Posterior tip of maxilla usually reaching or crossing a vertical line that extends through anterior border of pupil.

Two series of premaxillary teeth. Teeth of outer series tricuspid, smaller than those of inner series, numbering 3 to 4. Four teeth with 3 cusps in inner series. Two to three maxillary teeth, conical or tricuspid. Four anterior dentary teeth larger with 3 cusps followed by a medium size tooth usually with 3 cusps and a series of 6 to 7 much smaller ones, tricuspid or conical. Second dentary tooth inserted at a lower position in jaws, in such a way that tip of its longest cusp reaches only as high as tip of second largest cusp of first and third dentary teeth (Fig. 32).

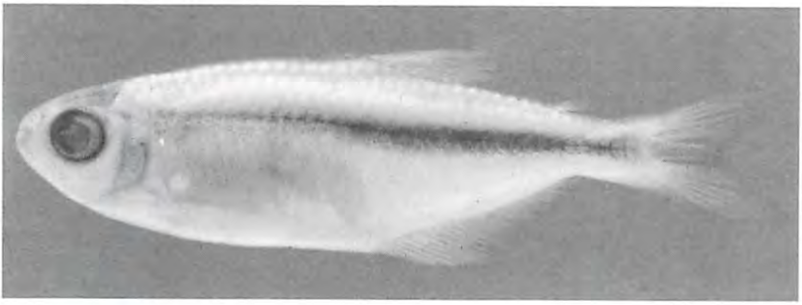

Figure 29. *Cyanocharax tipiaia*, new species, holotype, 36.1 mm SL, arroio Tipiáia, about 13 km N of Júlio de Castilhos, Rio Grande do Sul, Brazil (MCP 30471).

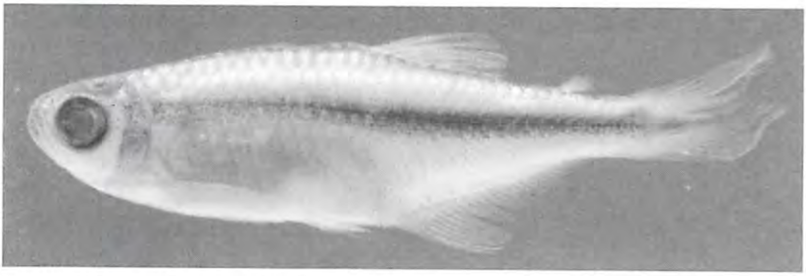

Figure 30. *Cyanocharax tipiaia*, new species, 36.7 mm SL, arroio Felício, about 10 km SSE from Júlio de Castilhos, Rio Grande do Sul, Brazil (MCP 22712).

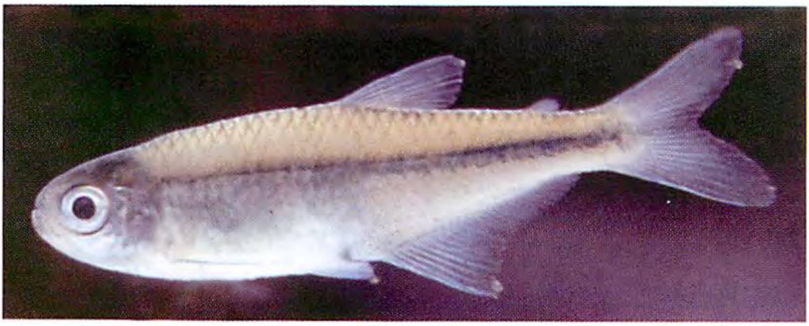

Figure 31. *Cyanocharax tipiaia*, new species, arroio Tipiáia, about 13 km N of Júlio de Castilhos, Rio Grande do Sul, Brazil (MCP 26857). Photograph taken just after fixation in formalin.

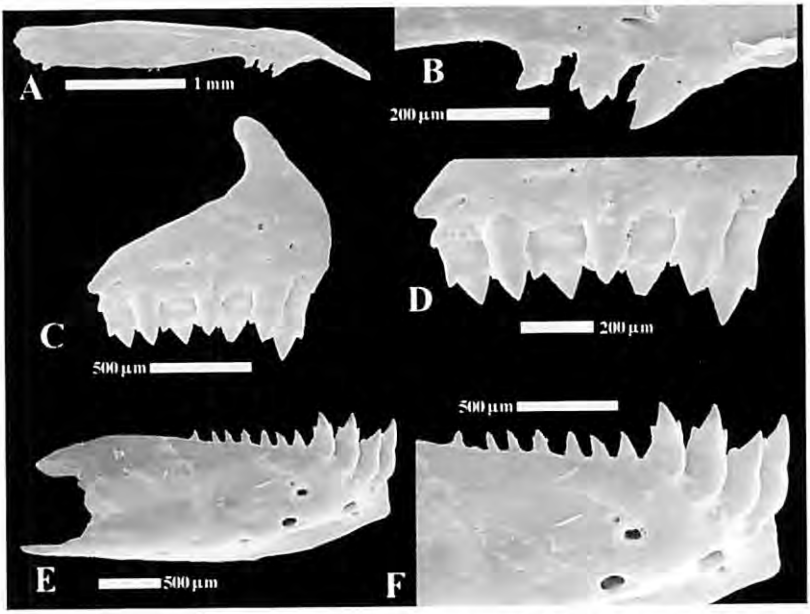

Figure 32. Jaws and teeth of *Cyanocharax tipiaia* (MCP 22712, 38.0 mm SL). A-B – Maxilla and detailed view of teeth; C-D – Premaxilla and detailed view of teeth; E-F – Dentary and detailed view of teeth.

Dorsal-fin rays ii,8 (n = 15). Dorsal-fin origin near middle of body length. Adipose fin dorsal to posteriormost anal-fin ray insertion.

Anal-fin rays iii-v, 21-23 ($\bar{x}$ = 22.3, n = 15). Anal-fin origin ventral to middle dorsal-fin base. Anal-fin distal border slightly concave to nearly straight in all specimens. No mature specimens available to check secondary sexual differences in the anal-fin shape or presence of hooks in mature males.

Pectoral-fin rays i, 9-10 ($\bar{x}$ = 9.6, n = 15). Distal end of longest rays extend posterior to pelvic-fin insertion. Pelvic-fin rays i, 6 ($\bar{x}$ = 6.0, n = 15). Pelvic-fin origin anterior to dorsal-fin origin. Distal end of longest rays not reaching anal-fin origin. Mature specimens unavailable to check the presence of hooks in mature males. Principal caudal rays 10/9.

Scales cycloid. Lateral line incomplete, with 7-11 ($\bar{x}$ = 8.4, n = 15) perforated scales. Total number of scales in the lateral line series 35-38 ($\bar{x}$ = 36.8, n = 11). Scale rows between lateral line and dorsal-fin origin, 4-5 ($\bar{x}$ = 4.7, n = 15). Scale rows between lateral line and pelvic-fin origin, 2-4 ($\bar{x}$ = 3.1, n = 15). Predorsal scales, 12-14 ($\bar{x}$ = 12.9, n = 15), usually in a regular series. Sheath of scales on anal-fin base consisting of one row with 7-10 small scales, covering bases of unbranched rays and at least anterior 8 to 12 branched rays.

Vertebrae 36 (n = 13), including Weberian apparatus and posterior half centrum (counts taken from x-ray negatives from MCP 22712 and 22766).

Color in alcohol. Figs. 29-30. Body pale brownish yellow in specimens preserved in formalin long enough to destroy guanine pigment. Lateral body stripe broad and dark gray posteriorly, becoming pale and narrow anterior to vertical through dorsal-fin origin. Humeral spot not discernible. Dark pigmented area present just posterior to upper opening of opercle. Caudal fin darkly pigmented along middle caudal-fin rays to tip of rays. Exposed borders of scales on dorsal portion of body delineated by dark chromatophores. Dorsal and anal fins without distinct marks. Adipose fin slightly dusky. Head black to gray dorsally, especially dark near nape. Sides of head whitish yellow.

Sexual dimorphism. In the absence of mature specimens it is impossible to determine whether this species demonstrate the secondary sexual differences in the anal-fin shape or the presence of hooks present in congeners.

Etymology. The name *tipiaia* is a reference to the type-locality, arroio Tipiáia.

Ecological notes. The type locality had moderate water velocity, a rocky bottom, and clear to dark water.

Distribution. Known only from the western small tributaries of the rio Jacuí near Júlio de Castilhos, Rio Grande do Sul, Brazil (Fig. 1).

Holotype: MCP 30471, arroio Tipiáia, about 13 km North of Júlio de Castilhos, on road to Cruz Alta, Rio Grande do Sul, Brazil; 1 Apr 1999.

Paratypes, all from laguna dos Patos drainage, Rio Grande do Sul, Brazil: MCP 22766 (90, 12.2-34.9 mm SL), collected with holotype. MCP 22712 (11: 2 c&s, 34.1-38.0 mm SL), arroio Felício, about 10 km SSE from Júlio de Castilhos; 1 Apr 1999.

Non-type specimens. MCP 26857 (11), same locality as holotype; 28 Nov 2000.

Table 4. Morphometrics of *Cyanocharax tipiaia*, new species. Standard length is expressed in mm; other measurements through head length are percentages of standard length; the last four entries are percentages of head length. All specimens are from laguna dos Patos drainage. Described ranges include measurements of the holotype MCP 30741 and following paratypes: MCP 22712.

Character	holotype	n	low	high	$\bar{x}$
Standard length (mm)	36.1	9	35.9	38.4	37.3
Snout to anal-fin origin	59.6	9	57.2	61.3	59.7
Snout to dorsal-fin origin	58.4	9	52.3	58.4	55.0
Snout to pelvic-fin origin	44.6	9	42.3	45.3	44.1
Anal-fin base length	31.3	9	27.9	31.3	29.5
Caudal peduncle length	10.8	9	10.8	13.7	12.3
Caudal peduncle depth	9.4	9	8.8	10.0	9.4
Depth at dorsal-fin origin	31.3	9	28.5	31.3	29.7
Dorsal-fin height	22.4	9	19.9	22.9	21.7
Pelvic-fin length	13.3	9	13.1	14.5	13.9
Pectoral-fin length	22.2	9	19.5	22.9	21.2
Bony head length	22.4	9	21.5	23.4	22.3
Snout length	24.7	9	22.9	27.0	24.9
Upper jaw length	42.0	9	40.5	48.2	43.4
Horizontal eye diameter	37.0	9	31.5	37.0	35.4
Least interorbital width	39.5	9	32.9	39.5	35.7

Cyanocharax lepiclastus
Malabarba, Weitzman & Casciotta, new species
(Figs. 1, 33-38, Table 5)

Diagnosis. *Cyanocharax lepiclastus* is distinguished from *C. dicropotamicus*, *C. itaimbe*, *C. alburnus* and *C. tipiaia* by the greater number of scales covering the basal portion of anal-fin rays (13-20 versus 7-13), greater number of branched anal-fin rays (24-29, $\bar{x}$ = 26.2, n = 133, versus 22-27, $\bar{x}$ = 23.9, n = 88 in *C. itaimbe*; 22-28, $\bar{x}$ = 24.6, n = 130 in *C. dicropotamicus*; 21-23, v = 22.3, n = 15 in *C. tipiaia*; and 20-23 in *C. alburnus*), absence of unpigmented area along distal tip of anal fin anterior lobe (unpigmented area present in *C. dicropotamicus* and *C. itaimbe*), and in having anal-fin origin positioned nearly along vertical through dorsal-fin origin (versus clearly posterior to vertical through dorsal-fin origin in *C. dicropotamicus, C. alburnus* and *C. itaimbe*). The nearly straight distal border of anal fin of mature males of *C. lepiclastus* distinguishes it from *C. dicropotamicus, C. alburnus*, and *C. itaimbe* that have distal border of anal fin concave, and *C. macropinna* and *C. alegretensis* that have distal border of anal fin convex.

Description. Morphometric data given in Table 5. Body moderately elongate and compressed. Predorsal body profile convex, usually with a concavity at nape in large specimens. Dorsal body profile nearly straight from dorsal fin to caudal peduncle. Ventral body profile convex from snout tip to anal-fin origin. Nearly straight in females and slightly convex in mature males along anal-fin base. Ventral and dorsal borders of caudal peduncle slightly concave.

Head small (21.0-24.5% of SL). Eyes large (39.1-48.5% of HL). Maxilla positioned at angle of 45 degrees relative to long body axis. Posterior tip of maxilla usually reaching to vertical through anterior border of pupil.

Two series of premaxillary teeth. Teeth of outer series usually tricuspid, smaller than those of inner series, numbering 3 to 5. Four or five teeth with 3 to 5 cusps in inner series. Three to eight usually tricuspid maxillary teeth. Dentary with three large anterior teeth followed by one medium-sized teeth and 7 to 10 smaller ones, ranging from 3 cusps to conical, from anteriormost to posteriormost teeth. Anterior larger dentary teeth with 3 to 5 cusps. Second dentary tooth shorter and inserted at lower position in jaws, in such a way that tip of its longest cusp reaches only as high as tip of second largest cusp of first and third dentary teeth (Fig. 38).

Dorsal-fin rays ii,7-8 ($\bar{x}$ = 7.9, n = 20). Dorsal-fin origin near middle of body length. Adipose fin dorsal to posterior anal-fin ray insertion.

Anal-fin rays iv-v, 24-29 ($\bar{x}$ = 26.2, n = 133). Anal-fin origin nearly ventral to dorsal-fin origin at middle of body length. Anal-fin distal border concave in females and juveniles, convex or nearly straight in mature males. Anal-fin rays of males with small retrorse bony hooks present on mid distal length of longest unbranched ray and usually anterior 13 to 15 branched rays. Minute hooks may be present along third distal portion of some remaining rays. Hooks mostly present on posterior branches of rays and posterior border of lepidotrichia. Usually one pair of bony hooks per ray segment; two pairs rarely occur on 1, 2 or 3 anterior branched rays.

Pectoral-fin rays i, 9-11 ($\bar{x}$ = 9.6, n = 20). Distal ends of longest rays extend posterior to pelvic-fin insertion in both males and females. Pelvic-fin rays i, 6 (n = 20). Pelvic-fin origin anterior to dorsal-fin origin. In females distal ends of longest rays may or may not reach anal-fin origin. In mature males distal ends of longest rays reach anal-fin origin. Pelvic fins with ventromedial, usually unpaired retrorse bony hooks on first unbranched and all branched rays in sexually mature males. Principal caudal-fin rays 10/9.

Scales cycloid. Lateral line irregular, never complete. Lateral line usually with anterior series of 9 to 14 pored scales ($\bar{x}$ = 10.6, n = 34) followed by a median non-perforated series of 9 to 22 scales, a median posterior perforated series of 3 to 18 scales, and sometimes a posterior non-perforated series of usually 1 or 2 (most rarely 4 to 5) scales. Scale pattern extremely variable, with more than four alternate series of perforated versus non-perforated scales in some specimens. Total number of scales in lateral-line row 37-39 ($\bar{x}$ = 37.8, n = 38). Scale rows between dorsal-fin origin and lateral line 6-7 ($\bar{x}$ = 6.1, n = 33; 5 in one specimen). Scale rows between lateral line and pelvic-fin origin 4-5 ($\bar{x}$ = 4.7, n = 32). Predorsal scales 11-13 ($\bar{x}$ = 12.1, n = 24). Males and females with a sheath of scales on anal-fin base consisting of one row with 13-20 small scales, covering bases of unbranched rays and first 14 to 20 branched rays.

Vertebrae 35-37 ($\bar{x}$ = 36.3, n = 26), including Weberian apparatus and posterior half centrum (counts taken from x-ray negatives from MCP 15200).

Color in alcohol. Figs. 33-34, 36-37. Body pale brownish yellow in specimens preserved in formalin long enough to destroy guanine pigment. Lateral body stripe broad and dark posteriorly, becoming pale anterior to dorsal-fin origin. Lateral body stripe broad and silvery in freshly preserved specimens. Dark humeral spot small, vertically elongated and centered on fourth scale of scale row just dorsal to lateral line. Exposed borders of scales of dorsal portion of body delineated by dark chromatophores. Caudal fin slightly dark pigmented in mature males. Dorsal and anal fins darkly pigmented, except for distinct unpigmented area at tip of dorsal fin. Distal border of anal fin more intensely darkly pigmented. Adipose fin weakly pigmented. Head black to gray dorsally, especially dark near nape. Sides of head and opercles silvery where guanine pigment not destroyed by formalin, sides of head otherwise whitish yellow.

Figure 33. *Cyanocharax lepiclastus*, male, 45.2 mm SL, arroio Lageado União, Linha dos Lima, Palmitinho, Rio Grande do Sul, Brazil (MCP 14557).

Figure 34. *Cyanocharax lepiclastus*, female, 38.5 mm SL, same locality as in Fig. 33 (MCP 14557).

Figure 35. *Cyanocharax lepiclastus*, holotype, male, MCP 16381, rio Dourados, Linha Várzea, on the road between Severiano de Almeida and Aratiba, Severiano de Almeida, Rio Grande do Sul, Brazil. Photograph taken just after fixation in formalin by Peter Wimberger.

Figure 36. *Cyanocharax lepiclastus*, male, 49.5 mm SL, rio Dourado, on the road between Erechim and Dourado, Erechim, Rio Grande do Sul, Brazil (MCP 22686).

Figure 37. *Cyanocharax lepiclastus*, female, 49.5 mm SL, arroio Taquari, about 10 Km S of Vila Kramer, São Francisco de Assis, Rio Grande do Sul, Brazil (MCP 23186).

Color in life. Described from photos taken just after fixation formalin (Fig. 35). Body light pale brownish yellow. Sides of head and belly silvery white. Lateral body stripe broad and silvery light blue from humeral spot to caudal-fin base. Clearly discernible vertical small black humeral spot present. Exposed borders of scales of dorsal portion of body delineated by dark chromatophores. Caudal fin slightly dark pigmented. Dorsal and anal fins dusky, except for distinct unpigmented area at tip of dorsal fin. Narrow portion of distal border of anal fin intensely dark pigmented. Adipose fin weakly pigmented by dark chromatophores.

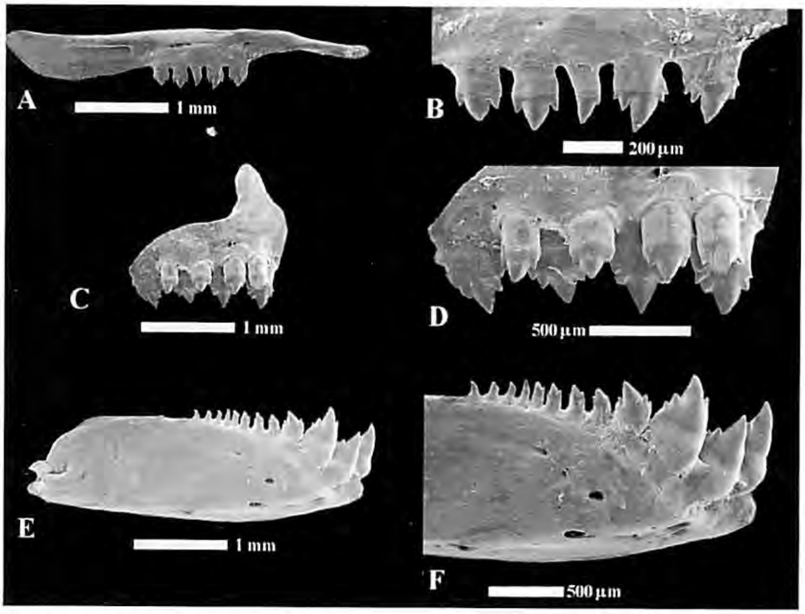

Figure 38. Jaws and teeth of *Cyanocharax lepiclastus* (MCP 16382, 43.2 mm SL). A-B – Maxilla and detailed view of teeth; C-D – Premaxilla and detailed view of teeth; E-F – Dentary and detailed view of teeth.

Sexual dimorphism. Male specimens of *C. lepiclastus* differ from females in the nearly straight distal border of the anal fin (versus concave in females), by the presence of anal and pelvic-fin hooks, and slightly larger pelvic-fin ray lengths (Table 5).

Etymology. *Lepi* is from the Greek lepis meaning scale and *clastus* from the Greek klastos meaning broken in pieces. It is in reference to the unusual irregular alternate sets of pored and unpored scales in the lateral line.

Ecological notes. MCP 25751, MCP 16381, and MCP 14557 were collected in clear turbid water, with rocks, stones, sand and mud on the bottom, in both medium water velocities and still waters.

Distribution. This species occurs in the uppermost section of the rio Uruguay from the headwaters of rio Pelotas and rio Canoas to arroio Lageado União in Brazil, and in the eastern portion of Misiones Province in the North-East of Argentina (Fig. 1).

Table 5. Morphometrics of *Cyanocharax lepiclastus*, new species. Standard length is expressed in mm; other measurements through head length are percentages of standard length; the last four entries are percentages of head length. All specimens are from upper rio Uruguay. Described ranges include measurements of the holotype MCP 25751, male, and following paratypes: MCP 12373 (2); MCP 12374 (6); MCP 12470 (3); MCP 12790 (2); MCP 12924 (9); MCP 12972 (1); MCP 12977 (8); MCP 13313 (6); MCP 13362 (15); MCP 14550 (4); MCP 14557 (26); MCP 15200 (21).

Character	holotype	n	low	high	$\bar{x}$
Standard length (mm)	44.5	103	26.3	46.3	37.6
Snout to anal-fin origin	52.1	103	52.1	58.8	55.4
Snout to dorsal-fin origin	53.0	103	50.6	57.9	53.5
Snout to pelvic-fin origin	41.6	103	38.6	44.6	42.0
Dorsal-fin base length	11.9	103	8.6	12.1	10.4
Anal-fin base length	36.9	103	32.8	40.0	35.9
Caudal peduncle length	12.4	103	10.0	13.9	12.1
Caudal peduncle depth	10.8	101	9.2	12.2	10.6
Depth at dorsal-fin origin	31.7	103	27.6	37.7	31.9
Dorsal-fin height	23.4	94	21.8	29.0	24.5
Pelvic-fin length males	13.5	43	13.2	16.6	14.6
Pelvic-fin length females		54	11.1	15.0	13.1
Pectoral-fin length	20.7	97	19.1	24.8	21.6
Bony head length	20.9	103	20.9	24.5	22.6
Snout length	21.5	103	18.9	26.2	22.2
Upper jaw length	34.4	102	34.1	44.2	38.6
Horizontal eye diameter	44.1	103	39.1	48.5	44.6
Least interorbital width	36.6	103	32.0	39.3	35.3

Holotype: MCP 25751, male, 44.5 mm SL, rio Dourados, Linha Várzea, on road between Severiano de Almeida and Aratiba, Severiano de Almeida, Rio Grande do Sul, Brazil; 12 Dec 1992.

Paratypes, all from rio Uruguay drainage, Santa Catarina, Brazil: MCP 12972 (3, 36.5-39.5 mm SL), rio Jacutinga, on road Seara – Concórdia (BR 283), Concórdia; 8 Dec 1988. MCP 12790 (2, 37.6-38.9 mm SL), rio

Canoas, on road Abdom Batista – Anita Garibaldi, Campos Novos; 11 Nov 1988. MCP 12374 (6, 34.3-41.6 mm SL), rio Canoas, on road Abdom Batista-Anita Garibaldi, Campos Novos; 9 Sep 1988. MCP 14550 (4, 32.5-35.1 mm SL), rio Canoas, on road Abdom Batista-Anita Garibaldi, Campos Novos; 29 Jun 1988. MCP 12373 (2 c&s), rio Canoas, Passo do Canoas, on road Tupitinga – Celso Ramos, Campos Novos; 11 Sep 1988. Rio Grande do Sul, Brazil: MCP 16381 (4, 39.8-41.8 mm SL), MCP 16398 (2, 30.7-31.3 mm SL), collected with holotype. MCP 12924 (15: 4 c&s, 23.5-39.5 mm SL), MNRJ 23842 (8, 25.0-37.8 mm SL), rio Pelotas, on road Anita Garibaldi – Pinhal da Serra, Esmeralda; 11 Dec 1988. MCP 13362 (20, 18.5-34.4 mm SL), rio Pelotas, Passo da Pedra da Ovelha, on road Anita Garibaldi-Pinhal da Serra, Esmeralda; 20 Feb 1989. MCP 12977 (14, 25.5-35.6 mm SL), rio Uruguay, mouth of rio Canoas and rio Pelotas; 10 Dec 1988. MCP 12470 (4, 30.9-37.5 mm SL), rio Ligeiro, on road Maximiliano de Almeida – Marcelino Ramos; 3 Oct 1988. MCP 13313 (9, 26.6-35.8 mm SL), rio Ligeiro, on road Maximiliano de Almeida-Marcelino Ramos (RS 127); 17 Feb 1989. MCP 12286 (5, 16.4-32.7 mm SL), rio Uruguay, bridge of road BR 153, limit between Rio Grande do Sul and Santa Catarina; 17 Aug 1988. MCP 15200 (9, 28.4-44.7 mm SL), USNM 357243 (9), MZUSP 82259 (9), creek on road RS 135, between Getúlio Vargas and Erexim; 17 Nov 1983. MCP 14557 (29: 4 c&s, 30.8-43.4 mm SL), arroio Lageado União, Linha dos Lima, Palmitinho; 22 Dec 1985. Misiones, Argentina: AI 103 (5), arroyo Fortaleza, tributary of arroyo Yabotí-Guazú (26°45'S, 54°10'W), February 2001.

Non-type specimens. Rio Grande do Sul, Brazil: MCP 12285 (3), rio Dourados, Mariano Moro, 17 Aug 1988. MCP 22686 (105.), rio Dourados, on road between Erexim and Dourados, Erexim; 8 Apr 1999. MCP 12284 (20), rio Pelotas, Pinhal da Serra, Esmeralda; 20 Aug 1988. MCP 12122 (7), rio Ligeiro, near boat, 15.5 km from São João da Urtiga; 25 May 1988. MCP 12121 (8), rio Ligeiro, on road Maximiliano de Almeida-Marcelino Ramos (RS 127); 18 Feb 1989. MCP 23186 (240), arroio Taquari, about 10 Km South of Vila Kramer, São Francisco de Assis; 8 May 1999.

Cyanocharax alegretensis Malabarba & Weitzman, new species
(Figs. 4, 7, 9, 15, 39-44, Table 6)

Diagnosis. The convexity of both the distal margin of the anal fin and of the body profile along the anal-fin base in mature males distinguish *C. alegretensis* from *C. lepiclastus*, which has both the distal margin of the anal fin and of the body profile along anal-fin base nearly straight, and from *C. dicropotamicus*, *C. itaimbe*, *C. alburnus*, and *C. tipiaia*, that have the distal margin of the anal fin concave, and body profile along anal-fin base nearly straight. A distal margin of the anal fin nearly straight in mature females also distinguishes *C. alegretensis* from *C. lepiclastus*, *C. dicropotamicus*, *C. itaimbe*, *C. alburnus*, and *C. tipiaia* (in which the distal margin of the anal fin is concave in mature females. The number of branched anal-fin rays (23-30, usually 25-27) distinguishes *C. alegretensis* from *C. macropinna* (28-35, usually 29-33 branched anal-fin rays).

Description. Morphometric data given in Table 6. Body moderately elongated and compressed. Dorsal head profile nearly straight, with pronounced concavity at nape in large specimens. Dorsal body profile from nape to dorsal-fin origin convex, and nearly concave between dorsal-fin origin and adipose fin. Ventral body profile from lower jaw to pelvic-fin origin deeply convex, and slightly concave from pelvic- to anal-fin origins. Ventral body profile along anal-fin base nearly straight in young and females to deeply convex in mature males. Dorsal and ventral profiles of the caudal peduncle nearly straight to slightly concave.

Head small (21.5-24.0% of SL). Eyes relatively large (39.3-46.9% of HL). Maxilla large positioned at an angle of 45 degrees relative to long body axis. Posterior tip of maxilla usually reaching or crossing a vertical line that extends through anterior border of pupil.

Two series of premaxillary teeth. Teeth of outer series usually tricuspid, smaller than those of inner series, numbering 3 to 4, most rarely 2 or 5. Four teeth with 5 cusps in inner series, most rarely with 3 cusps. Four to six maxillary teeth usually ranging from 5 cusps to conical. Three large dentary teeth with 5 cusps, followed by a medium size tooth usually with 3 cusps and a series of 6 to 10 much smaller ones, conical or ranging from 3 cusps to conical, from anteriormost to posteriormost teeth. Second dentary tooth inserted at a lower position in jaws, in such a way that tip of its longest cusp reaches only as high as tip of second largest cusp of first and third dentary teeth (Fig. 44).

Dorsal-fin rays ii,8 (n = 36) (Fig. 9). Dorsal-fin origin near middle of body length. Adipose fin dorsal to posterior anal-fin ray insertion.

Anal-fin rays iii-vi, 23-30 ($\bar{x}$ = 26.6, n = 185). Anal-fin origin nearly ventral to dorsal-fin origin at middle of body length. Anal-fin distal border nearly straight in females, and deeply convex in mature males. Anal-fin rays of males with very small retrorse bony hooks, present in largest unbranched ray and anterior 6 to 9 branched rays (Fig. 7). Additional tiny hooks are sometimes present in some of remaining branched rays, until 16th. Hooks usually present on posterior branches and posterior border of lepidotrichia. Usually one pair of hooks per bony ray segment.

Figure 39. *Cyanocharax alegretensis*, holotype, male, 37.5 mm SL, creek on road Santana do Livramento-Alegrete, Alegrete, Rio Grande do Sul, Brazil (MCP 11473).

Figure 40. *Cyanocharax alegretensis*, male, 27.9 mm SL, same locality as Fig. 39 (MCP 11473).

Figure 41. *Cyanocharax alegretensis*, female, 40.1 mm SL, same locality as Fig. 39 (MCP 11473).

Figure 42. *Cyanocharax alegretensis*, male, arroio Ibicuí da Faxina, BR 158, Santana do Livramento, Rio Grande do Sul, Brazil (MCP 26784).

Figure 43. *Cyanocharax alegretensis*, female, same locality as Fig. 42 (MCP 26784).

Pectoral-fin rays i, 9-11 ($\bar{x}$ = 9.8, n = 36). Tip of longest rays extend posterior to pelvic-fin insertion in both males and females. Pelvic-fin rays i, 6 ($\bar{x}$ = 6.0, n = 36, one specimen with i, 5). Pelvic-fin origin anterior to dorsal-fin origin. In females distal end of longest rays may or may not reach anal-fin origin. In mature males distal end of longest rays always reach anal-fin origin. Pelvic fins with ventromedial, usually unpaired retrorse bony hooks on first unbranched and all branched rays in sexually mature males (Fig. 4). Principal caudal rays 10/9.

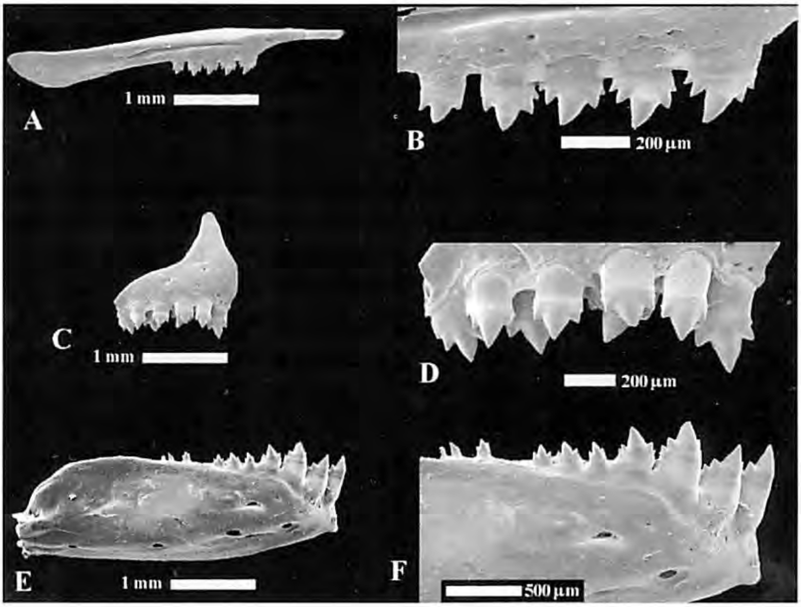

Figure 44. Jaws and teeth of *Cyanocharax alegretensis* (MCP 11232, 44.5 mm SL). A-B – Maxilla and detailed view of teeth; C-D – Premaxilla and detailed view of teeth; E-F – Dentary and detailed view of teeth.

Scales cycloid. Lateral line incomplete, with 5-12 ($\bar{x}$ = 9.0, n = 36) perforated scales (one of 35 specimens counted with alternating series of perforated and non-perforated scales: 9/22/3/4). Total number of scales in the lateral line series 36-38 ($\bar{x}$ = 36.8, n = 23). Scale rows between lateral line and dorsal-fin origin, 5-6 ($\bar{x}$ = 5.9, n = 35). Scale rows between lateral line and pelvic-fin origin, 4-5 ($\bar{x}$ = 4.4, n = 35). Predorsal scales, 11-15

($\bar{x}$ = 12.7, n = 26), usually in an irregular series. Males and females with a sheath of scales on anal-fin base, consisting of one row with 12-18 small scales, covering bases of unbranched rays and first 12 to 18 branched rays.

Vertebrae 35-37 ($\bar{x}$ = 36.1, n = 20), including Weberian apparatus and posterior half centrum (counts taken from x-ray negatives from MCP 11232).

Color in alcohol. Figs. 39-41. Body pale brownish yellow in specimens preserved in formalin long enough to destroy guanine pigment. Midlateral body stripe broad and diffuse. Dark humeral spot small and not clearly delimited from midlateral body stripe. Exposed borders of scales of dorsal portion of body delineated by dark chromatophores. Caudal fin without obvious marks, except for somewhat dark pigmentation that extends along entire length of middle caudal-fin rays in some specimens. Dorsal fin darkly pigmented except for distinct unpigmented area at its tip. Anal fin somewhat dusky, more intensely along distal border. Adipose fin slightly pigmented. Head black to gray dorsally, especially dark at nape. Sides of head whitish yellow.

Color in life. Described from photos taken just after formalin fixation (Figs. 42 and 43). Body light pale brownish yellow. Sides of head and belly silvery white. Lateral stripe on body broad and blue to grayish, from head to caudal-fin base. Humeral spot present. Caudal, dorsal, and anal fins light reddish, except for distinct unpigmented area at tip of dorsal fin. Narrow distal border of anal fin of males intensely pigmented.

Sexual dimorphism. Males of *C. alegretensis* have a convex distal border of anal-fin, contrary to the nearly straight profile of the fin margin in females. Males are also recognized by the presence of anal and pelvic-fin hooks, and longer pelvic and dorsal-fin (Table 6).

Etymology. Alegrete is a traditional county near the type locality of *C. alegretensis*.

Ecological notes. Field notes from MCP 11232 and MCP 11498 register clear water, with a medium speed current and bottom covered with rocks, stones and sand.

Table 6. Morphometrics of *Cyanocharax alegretensis*, new species. Standard length is expressed in mm; other measurements through head length are percentages of standard length; the last four entries are percentages of head length. Described ranges include measurements of the holotype and following paratypes: MCP 11473 (34).

Character	holotype	n	low	high	$\bar{x}$
Standard length (mm)	37.5	34	27.9	40.1	33.5
Snout to anal-fin origin	55.2	34	53.4	58.2	55.6
Snout to dorsal-fin origin	54.1	34	51.2	56.1	53.9
Snout to pelvic-fin origin	41.9	34	38.9	43.5	41.7
Dorsal-fin base length	10.9	34	9.2	12.2	10.8
Anal-fin base length	35.7	34	32.6	38.8	35.9
Caudal peduncle length	13.1	31	10.8	13.2	12.0
Caudal peduncle depth	10.4	34	9.9	11.5	10.5
Depth at dorsal-fin origin	34.9	34	29.8	36.4	32.2
Dorsal-fin height males	27.5	23	24.7	29.2	27.0
Dorsal-fin height females		10	23.0	26.2	24.6
Pelvic-fin length males	14.9	23	14.1	16.4	15.2
Pelvic-fin length females		11	13.2	14.5	13.9
Pectoral-fin length	22.1	34	21.2	23.4	22.3
Bony head length	23.2	34	21.5	24.0	22.7
Snout length	23.0	34	20.3	26.2	22.7
Upper jaw length	44.2	34	36.9	44.6	40.0
Horizontal eye diameter	41.4	34	39.3	46.9	43.9
Least interorbital width	37.9	34	33.3	39.3	36.8

Distribution. This species is known only from the rio Ibicuí tributaries in Rio Grande do Sul state, Brazil (Fig. 1).

Holotype. MCP 25974, creek on road Santana do Livramento-Alegrete, Alegrete, Rio Grande do Sul, Brazil; 13 Nov 1986; C. A. Lucena, L. A. Bergman & P. V. Azevedo.

Paratypes. Rio Grande do Sul, Brazil: MCP 15199 (16, 27.8-37.9 mm SL), rio Jaguarizinho, Florida, Santiago; 8 Jan 1978. MCP 11498 (24, 27.2-43.0 mm SL), tributary of rio Ibirapuitã, São Leandro, Rosário do Sul; 13 Nov 1986. MCP 11232 (83: 10 c&s, 25.9-43.1 mm SL), MZUSP 82260 (25), MNRJ 23843 (25, 27.2-39.7 mm SL), USNM 357245 (25), tributary of rio Ibirapuitã, São Leandro, Rosário do Sul; 13 Nov 1986. MCP 11473 (34, 23.7-38.3 mm SL), collected with holotype.

Non-type specimens. Rio Grande do Sul, Brazil: MCP 26784 (208), arroio Ibicuí da Faxina, BR 158, Santana do Livramento.

Cyanocharax macropinna Malabarba & Weitzman, new species
(Figs. 1, 5, 8, 16, 45-49, Table 7)

Diagnosis. The presence in *C. macropinna* of an anal fin sheath of scales covering all, or nearly all, of the anal fin base (versus anal-fin sheath of scales covering base of a maximum of 18 branched rays in all other species), and the high number of anal-fin rays (28-35, mostly 29-33, mean = 31.0, n = 120) diagnoses that species from all congeners (*C. itaimbe*, 21-27; *C. dicropotamicus*, 22-28; *C. tipiaia*, 21-23; *C. lepiclastus*, 24-29; *C. alegretensis*, 23-30; *C. alburnus*, 20-23).

Description. Morphometric data given in Table 7. Body moderately elongated, compressed. Dorsal head profile nearly straight to slightly convex, with a concavity at nape in larger specimens. Dorsal body profile from nape to dorsal-fin origin convex, and nearly straight between dorsal-fin origin and adipose fin, with a concavity at last dorsal-fin ray base. Ventral body profile convex from lower jaw to pelvic-fin origin, and slightly concave from pelvic-insertion to anal-fin origin. Ventral body profile along anal-fin base nearly straight in young and females to deeply convex in mature males. Dorsal and ventral profiles of the caudal peduncle nearly straight to slightly concave.

Figure 45. *Cyanocharax macropinna*, holotype, male, 44.2 mm SL, arroio Pai-Passo, on the road Santana do Livramento-Alegrete, Quaraí, Rio Grande do Sul, Brazil (MCP 25973).

Figure 46. *Cyanocharax macropinna*, paratype, female, 34.6 mm SL, same locality as Fig. 45 (MCP 15092).

Head small (20.7-25.9 % of SL). Eyes relatively large (38.1-45.0 % of HL). Maxilla large positioned at an angle of 45 degrees relative to long body axis. Posterior tip of maxilla usually reaching or crossing vertical line through anterior border of pupil.

Two series of premaxillary teeth. Teeth of outer series usually tricuspid, smaller than those of inner series, numbering 4 to 5. Four teeth with 5 to 7 cusps in inner series. Four to seven maxillary teeth usually with 3 or 5 cusps. Three large dentary teeth with 5 or 7 cusps, followed by a medium size tooth usually with 3 cusps and a series of 8 to 10 much smaller ones, ranging from 3 cusps to conical, from anteriormost to posteriormost teeth. Second dentary tooth inserted at a lower position in jaws, in such a way that tip of its longest cusp reaches only as high as tip of second largest cusp of first and third dentary teeth (Fig. 49).

Dorsal-fin rays ii,8 (n = 28). Dorsal-fin origin near middle of body length. Adipose fin dorsal to posterior anal-fin ray insertion.

Anal-fin rays iv-vi, 29-35 ($\bar{x}$= 31.0, n = 120, one specimen from MCP 11340 numbering 26). Anal-fin origin nearly ventral to dorsal-fin origin at middle of body length. Anal-fin distal border nearly straight in females. Anal-fin distal border deeply convex in mature males, with the anal-fin rays of the posterior half of anal fin longer. Anal-fin rays of males with small retrorse bony hooks, present in largest unbranched ray and along most anal fin in well developed males (Fig. 8). Hooks usually present on posterior branches and posterior border of lepidotrichia. Usually one pair of hooks per bony ray segment.

Pectoral-fin rays i, 9-11 ($\bar{x} = 9.9$, n = 28). Distal end of longest rays extend posterior to pelvic-fin insertion in both males and females. Pelvic-fin rays i, 6 ($\bar{x} = 6.0$, n = 36, one specimen with i, 5). Pelvic-fin origin anterior to dorsal-fin origin. Distal end of longest rays reach anal-fin origin. Pelvic fins with ventromedial, usually unpaired retrorse bony hooks on first unbranched and all branched rays in sexually mature males (Fig. 5). Principal caudal rays 10/9.

Figure 47. *Cyanocharax macropinna*, male, rio Sarandi III, on the road Santana do Livramento to Quaraí, Rio Grande do Sul, Brazil (MCP 16382).

Figure 48. *Cyanocharax macropinna*, male, 44.5 mm SL, arroio Sarandi, on road Santana do Livramento to Quaraí (MCP 22685).

Scales cycloid. Lateral line incomplete, with 8-12 ($\bar{x}$ = 9.7, n = 26) perforated scales. Seven of 26 specimens with alternated series of 8-12 perforated, 16-23 non-perforated, 3-9 perforated and 1-4 non-perforated scales. Total number of scales in the lateral line series 36-38 ($\bar{x}$ = 37.2, n = 19). Scale rows between lateral line and dorsal-fin origin, 5-7 ($\bar{x}$ = 6.0, n = 26). Scale rows between lateral line and pelvic-fin origin, 4-5 ($\bar{x}$ = 4.6, n = 25). Predorsal scales, 11-14 ($\bar{x}$ = 12.4, n = 16), usually in an irregular series. Males and females with a sheath of scales on anal-fin base, consisting of one row with 20-30 small scales, covering bases of unbranched rays and at least anterior 22 branched rays, to all anal-fin base.

Vertebrae 36-37 ($\bar{x}$ = 36.2, n = 19), including Weberian apparatus and posterior half centrum (counts taken from x-ray negatives from MCP 14291 and 15092).

Color in alcohol. Figs. 45-46. Body pale brownish yellow. Lateral body stripe black, broad, and diffuse along borders in specimens preserved in formalin long enough to destroy guanine. Specimens retaining guanine with lateral body stripe dark silvery and much broader in males than females. Dark humeral spot small. Exposed borders of scales of dorsal portion of body delineated by dark chromatophores. Caudal fin without perceptible marks except for slightly dark pigmentation that extends along entire length of middle caudal-fin rays in some specimens. Dorsal darkly pigmented except at its tip. Anal fin slightly darkly pigmented, more so along distal border (their pigmentation not obvious in the black and white photos; Figs. 45-46). Adipose fin slightly pigmented. Head black to gray dorsally, especially dark at nape. Sides of head whitish yellow or silvery where guanine still present.

Color in life. Described from photos of a male taken just after formalin fixation (Fig. 47). Sides of head and belly silvery white. Dorsal portion of body dark brown. Midlateral body stripe very broad and light blue from head to caudal-fin base, diffuse in humeral area. Humeral spot present and clearly discernible. Median caudal-fin rays slightly darkly pigmented. Caudal, dorsal, and anal fins light reddish, except for a distinct unpigmented area at tip of dorsal fin. Narrow distal border of anal fin intensely pigmented.

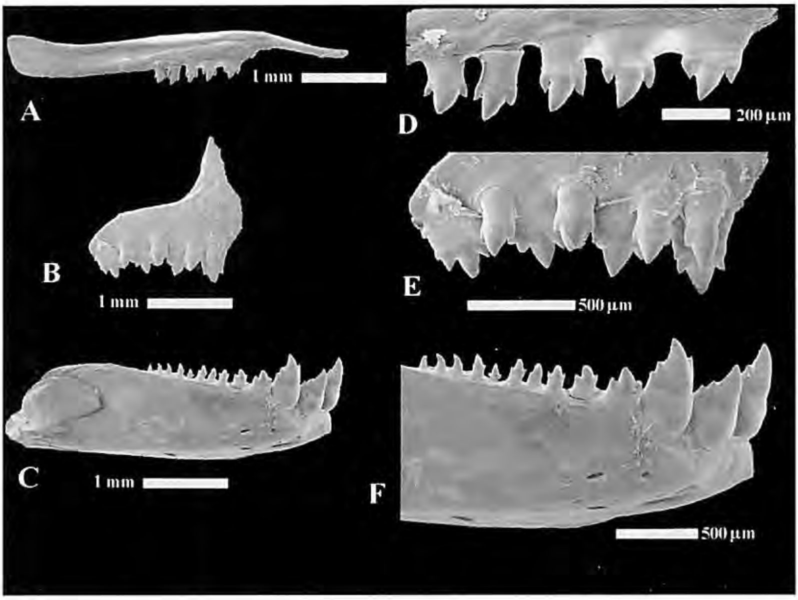

Figure 49. Jaws and teeth of *Cyanocharax macropinna* (MCP 16382, 43.1 mm SL). A-D – Maxilla and detailed view of teeth; B-E – Premaxilla and detailed view of teeth; C-F – Dentary and detailed view of teeth.

Sexual dimorphism. Males of *C. macropinna* have a deeply convex distal border of anal-fin instead of the nearly straight profile in females. Males also have anal and pelvic-fin hooks, and longer pelvic and dorsal-fins (Table 7).

Etymology. *Macro* is from the Greek makros meaning long and *pinna* is from the Greek pinna meaning fin, in reference to its long anal fin base.

Ecological notes. Eleven lots of MCP were collected in clear to slightly turbid waters, usually in low to moderate velocity water current. All localities had rocks and stones on the bottom and with alternating areas of sand and mud in four of these locations.

Table 7. Morphometrics of *Cyanocharax macropinna*, new species. Standard length is expressed in mm; other measurements through head length are percentages of standard length; the last four entries are percentages of head length. Described ranges include measurements of the holotype and following paratypes: MCP 11340 (25), MCP 12622 (28), MCP 14291 (11), MCP 14589 (16), MCP 15092 (10).

Character	holotype	n	low	high	$\bar{x}$
Standard length (mm)	44.2	90	24.9	47.2	33.9
Snout to anal-fin origin	51.8	88	50.4	57.9	54.2
Snout to dorsal-fin origin	53.2	90	51.5	57.0	54.2
Snout to pelvic-fin origin	38.5	90	38.5	45.3	41.6
Dorsal-fin base length	10.6	88	9.0	12.7	10.8
Anal-fin base length	39.4	90	33.2	43.1	37.3
Caudal peduncle length	11.8	87	10.3	15.2	12.5
Caudal peduncle depth	10.9	89	9.4	12.2	10.5
Depth at dorsal-fin origin	33.9	90	29.4	39.3	33.6
Dorsal-fin height males	23.8	42	23.4	29.3	26.3
Dorsal-fin height females		44	21.8	28.0	24.5
Pelvic-fin length males	14.3	43	12.3	15.8	14.0
Pelvic-fin length females		45	11.2	14.1	12.7
Pectoral-fin length	21.0	88	19.0	25.2	21.7
Bony head length	21.7	89	20.7	25.9	23.2
Snout length	21.9	84	17.9	25.0	22.3
Upper jaw length	38.5	85	31.9	43.2	38.3
Horizontal eye diameter	41.7	88	38.1	45.0	41.5
Least interorbital width	36.5	88	30.7	38.8	35.2

Distribution. *Cyanocharax macropinna* is known from the middle tributaries of rio Uruguay, in the Brazil, Argentina and Uruguay border regions, and from the headwaters of rio Negro along the Uruguay and Brazil borders. No samples of *Cyanocharax* are available from lower portions of rio Uruguay and rio Negro (Fig. 1).

Holotype. MCP 25973, arroio Pai-Passo, on road Santana do Livramento – Alegrete (RS 183), Quaraí, Rio Grande do Sul, Brazil; 12 Nov 1986.

Paratypes. Rio Uruguay basin. Misiones, Argentina: MCP 13350 (8), arroio Santa Maria, 8 km from Santa Maria, between Santa Maria and Itacaruare, Santa Maria, Missiones; 28 Jun 1989. Rio Grande do Sul, Brazil: MCP 12622 (125, 22.1-43.7 mm SL), MZUSP 82261 (25), MNRJ 23844 (25, 26.7-35.9 mm SL), USNM 319750 (50), arroio Canoin, on road Pirapó-São Nicolau, São Nicolau; 2 Nov 1988. MCP 15092 (9, 24.5-38.2 mm SL), collected with holotype. MCP 11340 (33, 20.3-42.7 mm SL), arroio Quaraí-Mirim, on road Quaraí-Alegrete, Quaraí; 12 Nov 1986. MCP 11341 (4, 23.8-36.2 mm SL), creek flowing into arroio Garupá, Quaraí; 12 Nov 1986. MCP 11401 (2, 30.2-30.3 mm SL), arroio Garupá, border between Quaraí and Uruguaiana, Quaraí; 11-12 Nov 1986. MCP 15081 (4, 22.9-29.6 mm SL), arroio Garupá, limit between Quaraí and Uruguaiana, Quaraí; 22 Jul 1986. MCP 15099 (5, 22.5-36.4 mm SL), rio Cati, on road Quaraí-Santana do Livramento, Santana do Livramento; 23 Jul 1986. MCP 16382 (16: 4 c&s, 36.5-46.4 mm SL), MCP 16384 (10: 2 c&s, 26.2-38.8 mm SL), rio Sarandi III, on road Santana do Livramento to Quaraí; 10 Dec 1992. Rio Negro basin, Rio Grande do Sul, Brazil: MCP 9057 (2, 26.9-31.6 mm SL), arroio Valente, BR 153, on road Bagé-Aceguá, Bagé; 25 Oct 1982. MCP 14291 (11; 7c, 27.6-35.0 mm SL), rio Negro, on road Bagé-Aceguá, Bagé; 14 Dec 1989. MCP 14589 (19; 7c, 25.0-34.9 mm SL), rio Negro, on road Bagé-Pinheiro Machado; 22 Dec 1982.

Non-types: rio Uruguay basin: Misiones, Argentina: MCP 13350 (8, 12.5-37.2 mm SL), 8 km from Santa Maria, between Santa Maria and Itacaruare, Santa Maria, Misiones; 28 Jun 1989. Rio Grande do Sul, Brazil: MCP 25752 (185 collected with MCP 12622), arroio Canoin, on road Pirapó-São Nicolau, São Nicolau; 2 Nov 1988. MCP 16385 (86), arroio Ximbocuzinho, on road São Luiz Gonzaga to Boçoroca, 4 km from access to Sao Luiz Gonzaga; 11 Dec 1992. MCP 22685, arroio Sarandi, on road Santana do Livramento to Quaraí; 6 Apr 1999. Rio Negro basin, Rio Grande do Sul, Brazil: MCP 16383 (43), rio Piraizinho on road Bagé-Dom Pedrito; 9 Dec 1992. MCP 16380 (8), rio Negro, on road from Bagé to Aceguá, 14 km from Bagé, 9 Dec 1992.

Cyanocharax alburnus (Hensel, 1870)
Figs. 50-51

Tetragonopterus alburnus Hensel, 1870: 85. Type locality: Rio Cadea [rio Cadeia, tributary of rio Caí, Rio Grande do Sul, Brazil]. Holotype: ZMB 7477.

Bryconamericus alburnus. – Eigenmann, 1910 (new combination).

Astyanax hasemani Eigenmann in Eigenmann, Henn & Wilson, 1914: 10. Type locality: Porto Alegre [Brazil]. Holotype: FMNH 56659 [ex CM 5476]. – Géry, 1977 (discussion of the generic position). – Malabarba, 1983 (Redescription, discussion of possible relationships and figures). – Malabarba, 1987 (placed as junior synonym of *Astyanax alburnus* (Hensel); holotype figured).

Astyanax alburnus. – Malabarba, 1987: valid, placed as senior synonym of *Astyanax hasemani* Eigenmann.

Diagnosis. The presence of a complete series of 36-39 perforated scales in the lateral line differentiate *C. alburnus* from *C. tipiaia*, *C. lepiclastus*, *C. alegretensis*, and *C. macropinna* all of which have interrupted lateral lines. The unpigmented adipose fin of *C. alburnus* distinguishes it from *C. itaimbe* and *C. dicropotamicus*.

Description. A description of this species is given in Malabarba (1983) and it is not repeated here.

Figure 50. *Cyanocharax alburnus*, arroio Tipiáia, Júlio de Castilhos, Rio Grande do Sul, Brazil (MCP 26852).

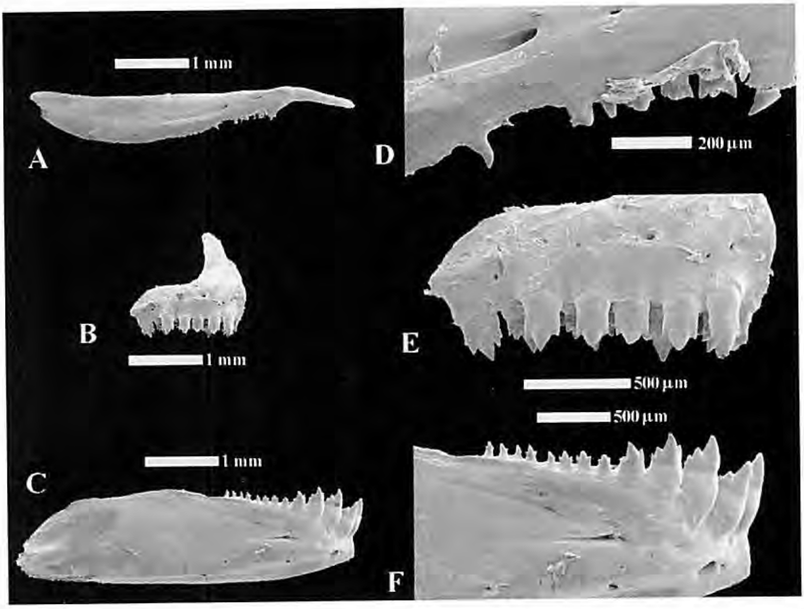

Figure 51. Jaws and teeth of *Cyanocharax alburnus* (MCP 9100, 55.0 mm SL). A-D – Maxilla and detailed view of teeth; B-E – Premaxilla and detailed view of teeth; C-F – Dentary and detailed view of teeth.

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APPENDIX

List of the comparative material checked for the characters discussed in the text: *Acestrorhynchus falcatus* – USNM 331164 (1 c&s), USNM 225614 (1 c&s). *Acrobrycon tariga* – USNM 325995 (3). *Agoniates anchovia* – MZUSP 20130 (1 c&s). *Agoniates halecinus* – MZUSP 34332 (1 c&s). *Alestes leuciscus* – USNM MCP 17116 (1). *Alestes longipinnis* – USNM 285665 (3). *Aphyocharax erythrurus* – USNM 263650 (5). *Aphyocharax rubropinnis* – USNM 232289 (11). *Aphyodite* sp. – USNM uncat. (2); USNM 304808 (3). *Argopleura chocoensis* – CAS 39030 (1). *Astyanax mexicanus* – USNM 214146 (3). *Astyanax sp.* – USNM 279262 (5). *Attonitus bounites* – USNM 349715 (4). *Aulixidens eugeniae* – USNM 157368 (paratype). *Axelrodia risei* – USNM 207923, holotype. *Bario steindachneri* – IUM 15750 (3). *Boehlkea fredcochui* – USNM uncat. (2). *Bramocharax caballeroi* – USNM 325997 (2) paratypes. *Brittanichthys axelrodi*: USNM uncat. (15). *Brittanichthys* – USNM 332486 (3). *Brycon argenteus* – USNM 293136 (1). *Brycon falcatus* – USNM 226161 (2). *Brycon meeki* – CAS 12983 (2). *Brycon melanopterus* – USNM 307073 (4). *Bryconacidnus ellisi* – USNM 117544, cotype. *Bryconamericus alfredae* – ANSP 143357. *Bryconamericus alpha* – USNM 285343. *Bryconamericus brevirostris* – USNM 311329 (12). *Bryconamericus deuteronoides* – USNM 349407. *Bryconamericus eigenmanni* – USNM 176067. *Bryconamericus exodon* – USNM 232402 (7). *Bryconamericus hyphessus* – USNM 225745 (2). *Bryconamericus iheringii* – USNM 285884 (1). *Bryconamericus meridae* – USNM 121469 (4), USNM 310358 (1). *Bryconamericus pachacuti* – MUSM 12149. *Bryconamericus pectinatus* – USNM 303442, 303441. *Bryconamericus peruanus* – MCZ 48719 (2), IUM 15176 (2). *Bryconamericus stramineus* – USNM 232201. *Bryconella pallidifrons* – USNM 216205 (6). *Bryconexodon juruenae* – USNM 194333 (4 parátipos). *Bryconops affinis*, USNM 225968 (2 c&s). *Carlana* – USNM 289105 (1); USNM 074240. *Carlastyanax aurocaudatus* – IMCN 891. *Catoprion mento* – USNM 257547 (1 c&s). *Ceratobranchia binghami* – USNM 345887 (2) USNM 345887 (2). *Chalceus macrolepidotus* – USNM 231547 (1). *Chrysobrycon hesperus* – USNM 236105 (1). *Clupeacharax* – MZUSP 49672 (1 c&s). *Colossoma edulis* – MZUSP 19584 (1 c&s). *Corynopoma riisei* – USNM uncat. (1). *Creagrutus mucipu* USNM 350449. *Creagrutus zephyrus* ANSP 161236. *Crenuchus spilurus* – RPV 84 – 22 (4c&s). *Ctenobrycon sp.* – IUM 17294 (11 c&s). *Ctenobrycon spilurus* – USNM 331166 (1). *Diapoma terofali* – USNM 237957 (1). *Engraulissoma* – MZUSP 49724 (2 c&s). *Eretmobrycon bayano* – USNM 214006 (1). *Exodon paradoxus* – USNM 191574 (21). *Genycharax tarpon* – USNM 120152 (1). *Gephyrocharax* sp. – USNM 236085 (3). *Gilber-*

tolus atratoensis – USNM 120170 (14) parátipos *G. alatus atratoensis*. *Glandulocauda melanogenys* – USNM 236093 (2). *Grundulus* – USNM 079212 (17), USNM 360016 (82). *Gymnocharacinus bergii* – USNM 313878 (2 of 7) USNM 313878 (3 c&s). *Gymnocorymbus ternetzi* – USNM 326533 (2), USNM 331165 (1). *Gymnocorymbus thayeri* – USNM 317778 (3). *Hemibrycon dariensis* – MCP 27072 (1 c&s), USNM 293245. *Hemibrycon dentatus* – USNM 132593. *Hemibrycon huambonicus* – USNM 167814 (9). *Hemigrammus rhodostomus* – USNM 269338 (21). *Hemigrammus* sp. – USNM 221671 (3). *Hemiodus unimaculatus* – MZUSP 32501 (1 c&s). *Hepsetus odoe* – USNM 179331 (1 c&s). *Hollandichthys multifasciatus* – USNM 320271 (7). *Hoplias microlepis* – MZUSP 19584 (1 c&s). *Hyphessobrycon compressus* – FMNH 4642 (1). *Hyphessobrycon erythrostigma* – USNM uncat. (1). *Hyphessobrycon flameus* – USNM uncat. (1). *Hyphessobrycon heterohabdus* – USNM 221679 (18). *Hyphessobrycon loretoensis* – USNM 216700 (8). *Hyphessobrycon reticulatus* – USNM uncat. (2). *Hyphessobrycon rosaceus* – USNM uncat. (1). *Hyphessobrycon socolofi* – USNM 327704 (2). *Hysteronotus megalostomus* – MCP 16410 (4). *Iguanodectes spilurus* – USNM 272294 (4); USNM uncat (2 c&s). *Inpaichthys kerri* – USNM 356516 (3). *Iotabrycon precox* – USNM 216802 (2). *Knodus beta* – USNM 311347 (2), USNM 361471. *Knodus breviceps* – USNM 086793 (1 of several). *Knodus gama* – USNM 311358 (2). *Knodus megalops* – USNM 335179. *Knodus meridae* – USNM 310358. *Knodus savanensis* – USNM 196088. *Knodus septentrionalis* – USNM 328109, USNM 329803 (1 of several). *Knodus* sp. – USNM 175976. *Landonia latidens* – USNM 345402 (16). *Lebiasina* sp., USNM uncat. (1 c&s). *Lepidarchus adonis* – USNM 267290 (5). *Leptobrycon* – USNM 222012 (3). *Lignobrycon myersi* – USNM 304497 (1). *Lonchogenys ilisha*: USNM uncat. (3). *Markiana geayi* – USNM 258527 (47), USNM 233394 (14). *Microschemobrycon* sp. – USNM uncat. (7), USNM uncat. (6). *Mimagoniates inequalis* – USNM 236090. *Mixobrycon ribeiroi* – CAS 59778 (holótipo). *Moenkhausia oligolepis* – USNM 331167 (2). *Monotocheirodon pearsoni* – MUSM 11082 (7). *Nematobrycon lacortei* – USNM 310896 (8). *Nematocharax venustus* – USNM 320347 (4). *Odontostoechus lethostigmus* – MCP 26965 (3). *Oligosarcus hepsetus* – USNM 278988 (1). *Othonocheirodus eigenmanni* – CAS 17946 (4). *Oxybrycon parvulus* – MHNG 2150.18 – 27 parátipos. *Paragoniates alburnus* – SU 50670 (1), USNM 348692 (3). *Parastremma sp.* – UNC 1598 (1 of 4). *Parecbasis* – USNM 307418 (11). *Parodon affinis* – MCP 11062. *Petitella* – USNM 273481 (40). *Phenacobrycon henni* – MCZ 48661 (22, rx). *Phenacogaster calverti* – MCZ 40770 (4). *Phenacogrammus pabrensis*,USNM 326209 (2 c&s). *Phenagoniates macrolepis* – USNM 121351 (18); 078665 (3), USNM 310898 (2), USNM 348919 (3). *Pia-*

barchus analis – USNM 326513 (6). *Piabarchus torrenticola* – USNM 326536 (74). *Poptella compressa* – USNM 300997 (2). *Priocharax* – MCNG 12253 (1). *Prionobrama filigera* – USNM 263971 (18), USNM 301924 (8), USNM 307174 (1). *Prionobrama paraguayensis* – USNM 232407 (15). *Pristella riddlei* – USNM uncat. (2). *Psellogrammus* – USNM 325682 (6). *Pseudochalceus bohlkei* – USNM 327402 (1). *Pseudochalceus lineatus* – MCZ 48730 (2). *Pseudocorynopoma doriae* – USNM 313995, 313996, 287144, 287141, MZUSP 53234. *Pseudocorynopoma heterandria* – MZUSP 53229, 53227; USNM 313999, 287142. *Pterobrycon myrnae* – USNM 236067 (1). *Rhinobrycon negrensis* – USNM 270186 (7). *Rhinopetitia* – USNM 313079. *Rhoadsia* – USNM 280682 (20). *Roeboexodon guianensis* – USNM 225627 (1); 225238 (1); 221179 (1). *Salminus hilarii* – MZUSP 45257 (1 c&s). *Salminus maxillosus* – MZUSP 19439 (1 c&s). *Serrabrycon magoi* – USNM 309191 (17). *Serrasalmus rhombeus* – MZUSP 56425 (1 c&s). *Tetragonopterus argenteus* – MZUSP 18798 (1c&s). *Tetragonopterus sp.* – IUM 17261 (1) . *Thayeria boehlkei* – USNM 311082 (+10). *Thayeria obliqua* – USNM 270234 (+30). *Thrissobrycon pectinifer* – USNM 269896 (25). *Triportheus sp.* – USNM 331163 (1). *Tucanoichthys* – USNM uncat – rio Tea, Caranã (4). *Tyttocharax atopodus* – MCZ uncat. (3). *Tyttocharax* sp. – USNM 12041 (3). *Xenagoniates bondi* – USNM 163154 (3), USNM 348709 (12). *Xenurobrycon* sp. – SU 53679 (1). Undescribed Tetragonopterinae – MCP 12638 (146: 4 c&s).

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