

# Distribución de los Peces de Agua Dulce en el Neotrópico

**Región Neotropical:** una de las mayores concentraciones de diversidad orgánica del planeta: plantas vasculares, macrófitas acuáticas, insectos, anuros, aves, mamíferos y peces.



Image Landsat  
Data SIO, NOAA, U.S. Navy, NGA, GEBCO  
Image IBCAO

- >5600 especies de peces: 10% de todos los vertebrados, 20% del total de las especies de peces del mundo; 43 familias endémicas

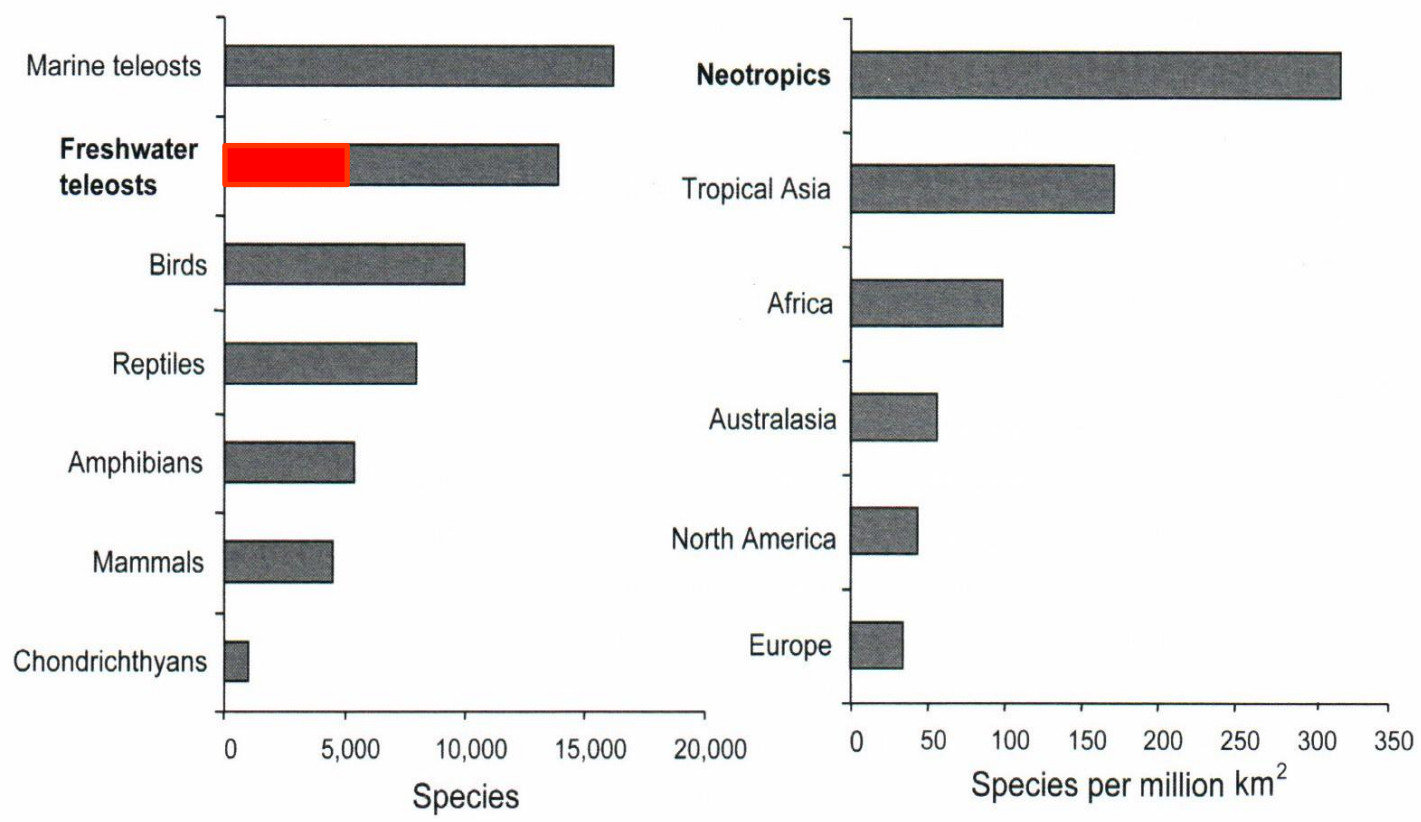


FIGURE 1.1 Species richness of Neotropical freshwater fishes among the vertebrates. *Left:* Comparisons with other major vertebrate groups. Note that many of these groups are not monophyletic. *Right:* Comparisons with freshwater fish faunas of other global biogeographic regions. Diversity estimates as species per million km<sup>2</sup>.



# De donde surge esta diversidad?

Factores **Ecológicos**:

Amplias regiones tropicales.

Sistema Hídrico muy desarrollado.

Heterogeneidad de hábitat (gradientes altitudinales).

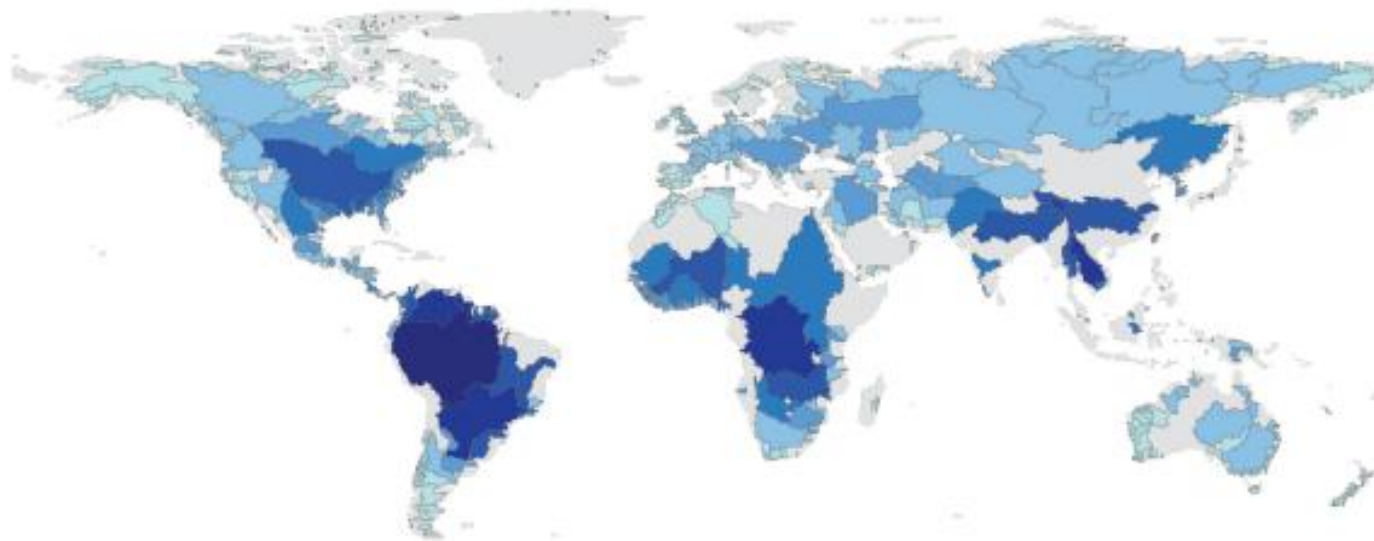


# Amplias regiones tropicales

Research Article

## Global and Regional Patterns in Riverine Fish Species Richness: A Review

Thierry Oberdorff,<sup>1</sup> Pablo A. Tedesco,<sup>1</sup> Bernard Hugueny,<sup>1</sup> Fabien Leprieur,<sup>2</sup>  
Olivier Beauchard,<sup>3</sup> Sébastien Brosse,<sup>4</sup> and Hans H. Dürr<sup>5</sup>



Total species richness



FIGURE 1: Global freshwater fish species richness patterns at the drainage basin grain.

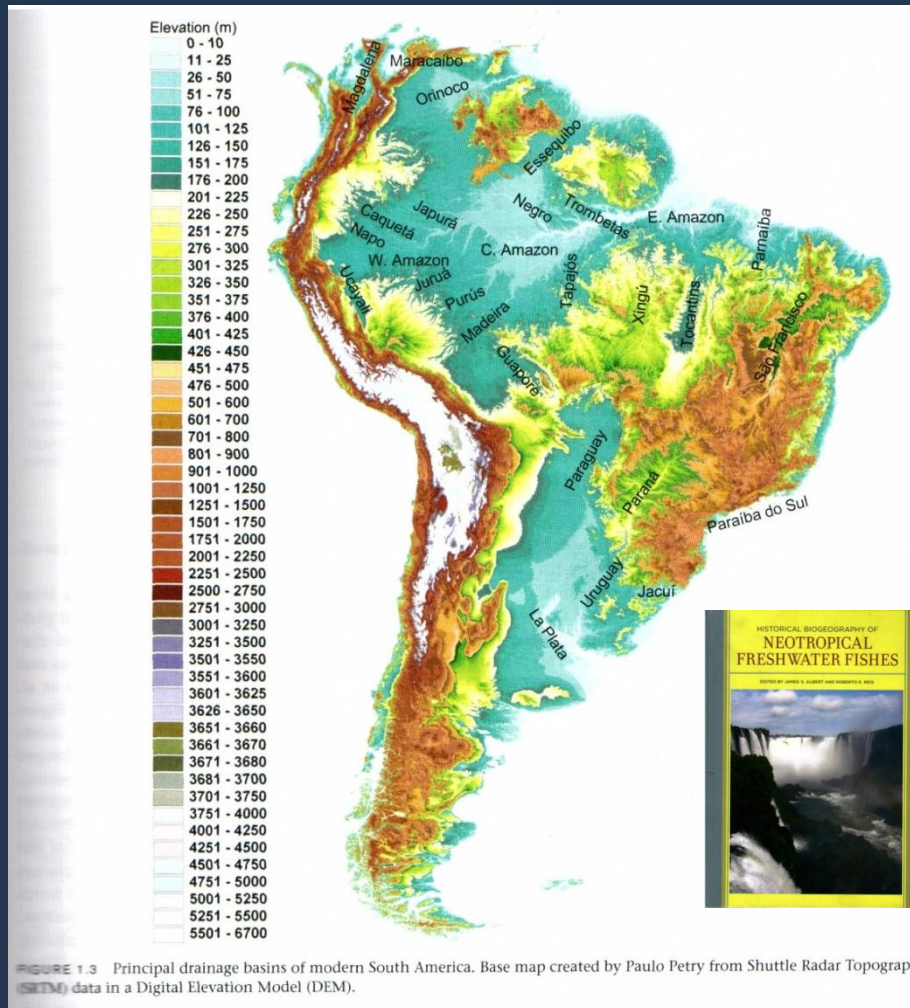
Sistema Hídrico muy desarrollado.  
Heterogeneidad de hábitat  
(gradientes altitudinales)

## Cuenca del Amazonas:

7 millones de km<sup>2</sup>

175mil m<sup>3</sup>/sec.

20% del agua dulce vertida al O. Atlántico.



### Además:

- Paraná: 5ta en extensión en el planeta
- Casiquire: conexión Amazonas-Orinoco
- Titicaca: Lago endoreico
- Magdalena: trasandina
- Cuencas costeras Atlánticas

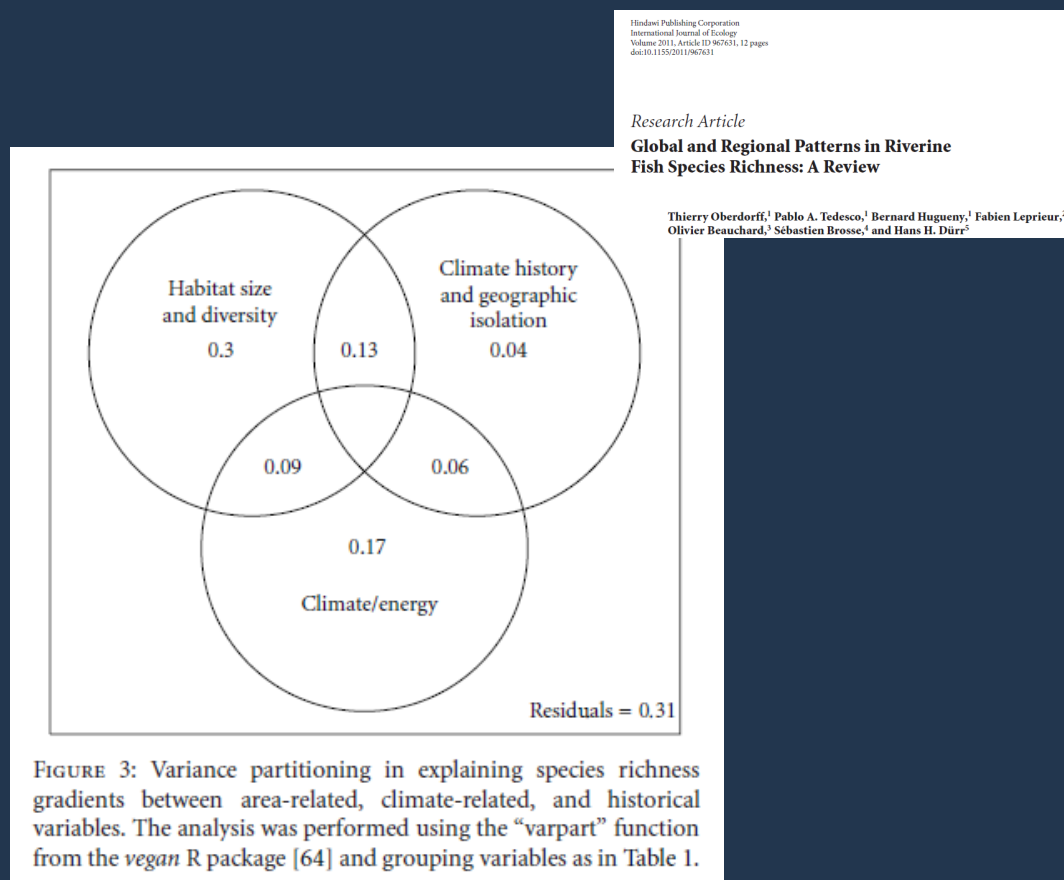
# De donde surge esta diversidad?

## Factores **Ecológicos**:

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De donde surge esta diversidad?

Factores **Ecológicos**:

Amplias regiones tropicales.

Sistema Hídrico muy desarrollado.

Heterogeneidad de hábitat (gradientes altitudinales).

Factores **Históricos**:

Compleja historia geológica.

Cambios en los niveles del Mar



## Factores Históricos:

- Aislamiento creciente de Africa
- **Formación de los Andes:** La mayor fuerza activa formadora de patrones de drenaje.
- Unión con Centroamérica
- Escudos
- Arcos estructurales (barreras subsuperficiales)
- Cambios Climáticos y Cambios en los niveles del mar

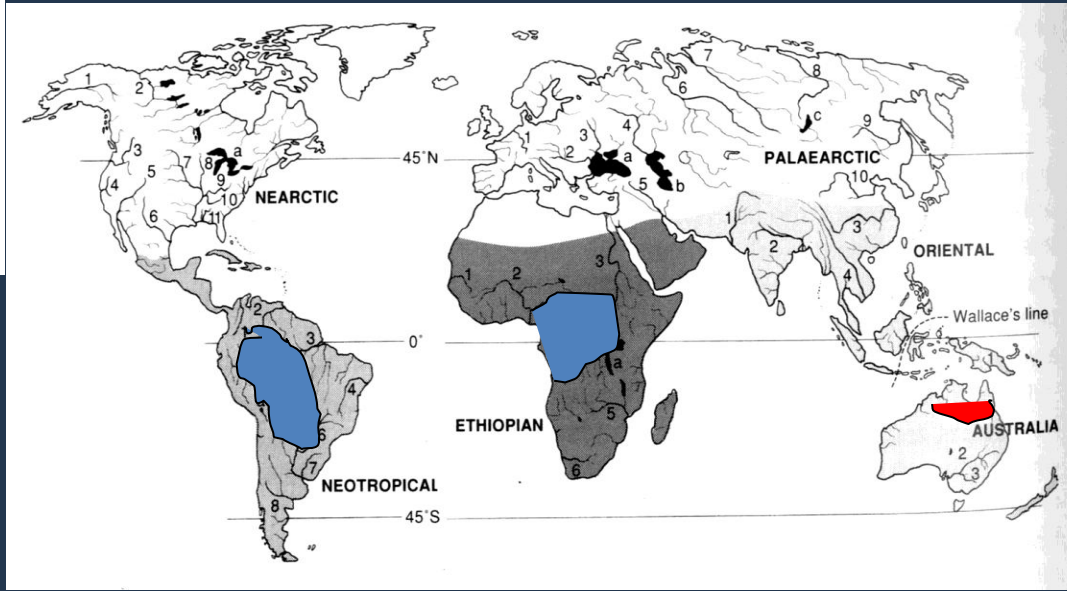
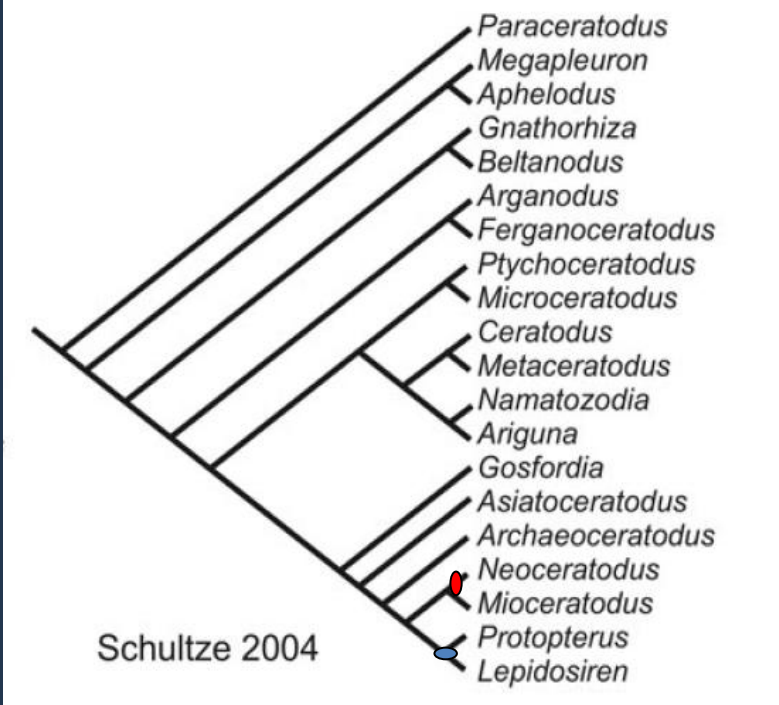
Diversificación de organismos acuáticos Neotropicales en los dinámicos y cambiantes ríos y cuencas de drenaje durante el Cretácico tardío y el Cenozoico (90 millones de años AP).

# Afinidades de la Ictiofauna Neotropical con otras Grandes Áreas de Endemismo

Clase Sarcopterygii; Orden Ceratodontiformes; Familia Lepidosirenidae

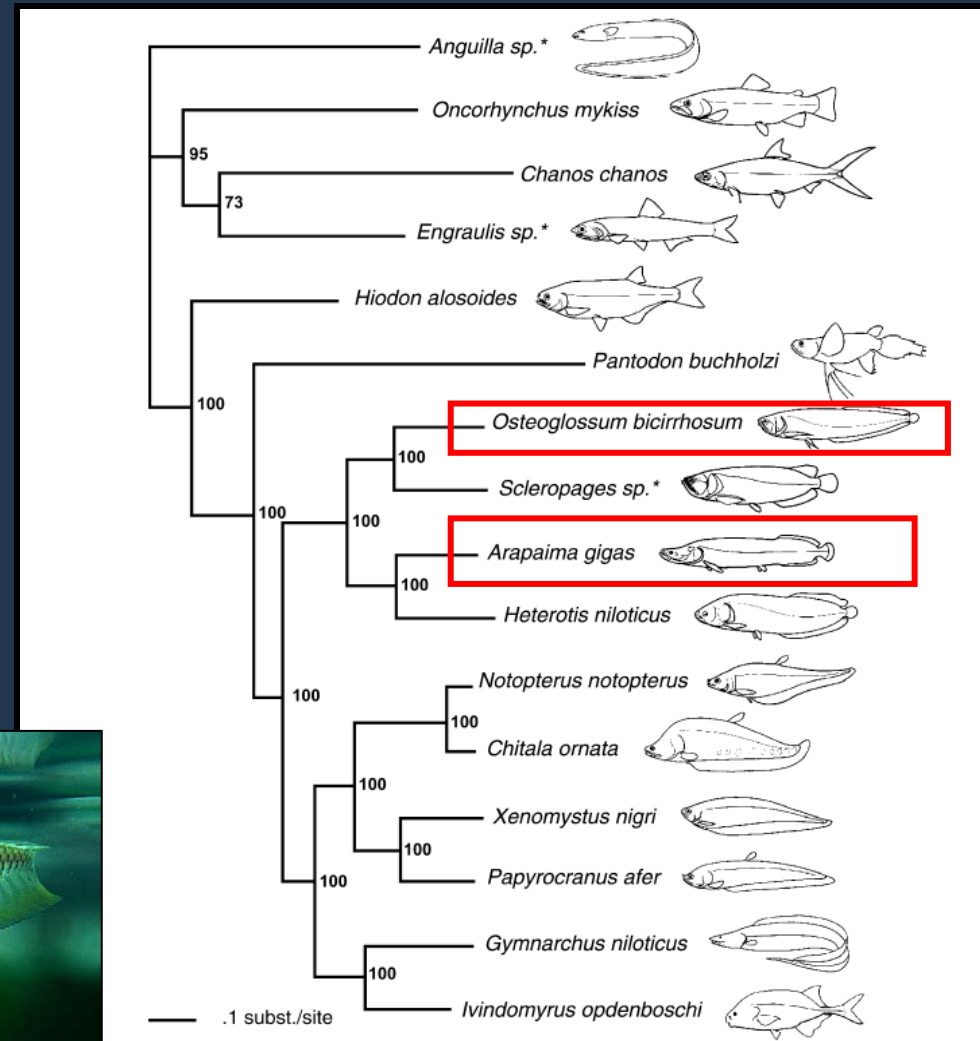
*Lepidosiren paradoxa*, distribuída en las cuencas del Amazonas y Paraná-Paraguay (hasta 35° lat S).

Registro Fósil: Cretácico tardío (70 ma)



Division Teleostei; Orden Osteoglossiformes; Familia Osteoglossidae (4 géneros y 7 especies)  
Cretácico tardío (70 ma)

2 especies del género *Osteoglossum* y *Arapaima gigas* (pirarucú)







# Siluriformes

35 familias, 446 géneros, 2867 especies. Distribución Global  
Origen?: Cretácico tardío (70 ma)

Fósiles de grupos vivientes: Paleoceno-Oligoceno (60-30 ma): Pimelodidae,  
Callichthyidae

PROCEEDINGS OF THE ACADEMY OF NATURAL SCIENCES OF PHILADELPHIA 156: 39-53

JUNE 2007

## Discovery of African roots for the Mesoamerican Chiapas catfish, *Lacantunia enigmatica*, requires an ancient intercontinental passage

JOHN G. LUNDBERG, JOHN P. SULLIVAN

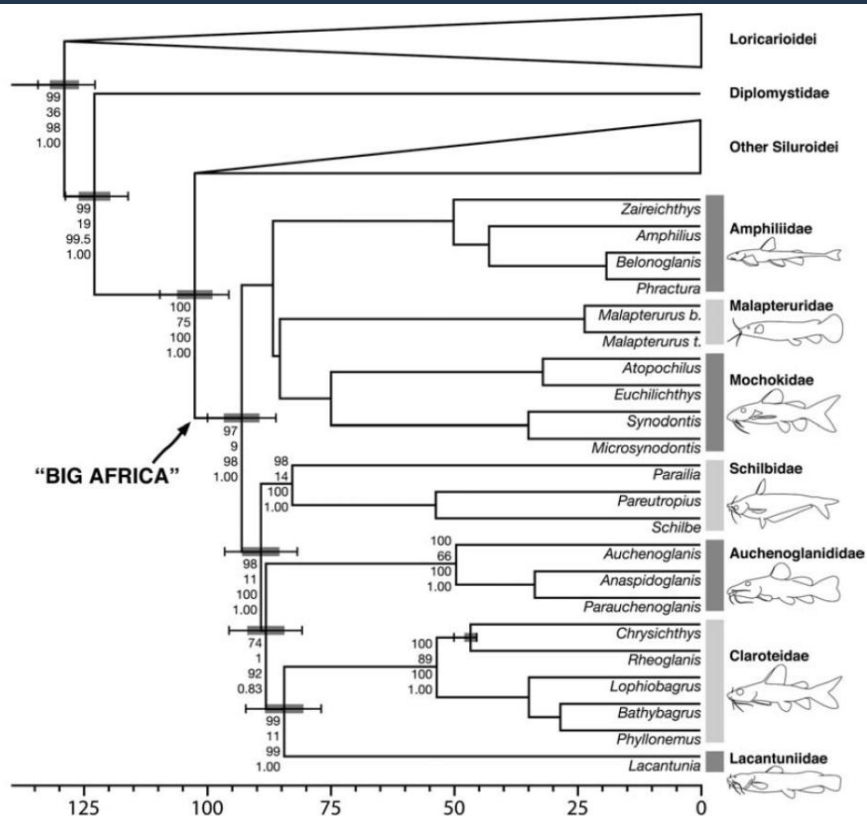


Fig. 4. Schematic alternative hypotheses for freshwater dispersion from Africa to Mesoamerica. 1) Pangean: Africa to North America before opening of the Central Atlantic and then to Mesoamerica, 2) Gondwana: Africa to South America before opening of the South Atlantic and then to Mesoamerica, 3) Bering land bridge: Africa to Asia to North America during Late Cretaceous to Late Miocene warm climate and then to Mesoamerica, 4) North Atlantic land bridge: Africa to Europe to North America during Late Cretaceous to Late Paleogene warm climate and then to Mesoamerica. Freshened surface waters of the Arctic and adjacent northern oceans during the middle Eocene raises a possibility of direct open-water dispersion from Europe or Asia to North America.

# Orden: Cyprinodontiformes; Suborden: Aplocheiloidei

10 familias, 109 géneros, 1013 especies



Rivulidae



Aplocheilidae

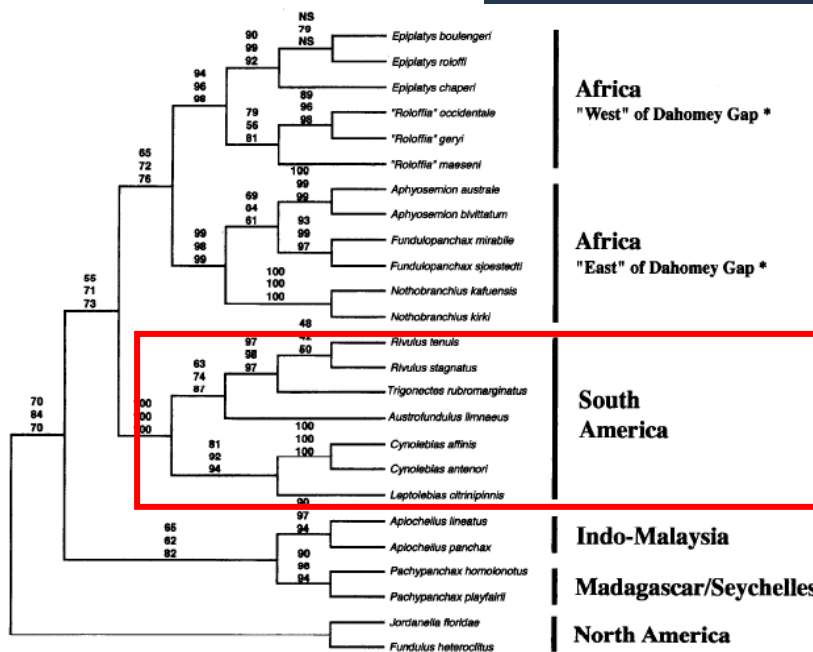


FIG. 4.—Phylogenetic hypothesis for the Aplocheiloidei based on parsimony analysis of the total data set. Bootstrap values (500 replicates) are listed above the branches in descending order for: equal-weighted MP, MP using conservative substitutions for *cytb* (see *Materials and Methods*) and all sites for the 12S and 16S rRNAs, and MP with  $T_v$  weighted three times  $T_s$ . The latter analysis did not support the shown relationships within *Epiplatys*, instead grouping *E. boulengeri* and *E. chaperi* (78% of replicates). Asterisks marking the labels "West" and "East" of the Dahomey Gap indicate general distributions of sampled taxa, but note exceptions to these definitions in the *Discussion*.



# Orden Cichliformes: 1300 especies

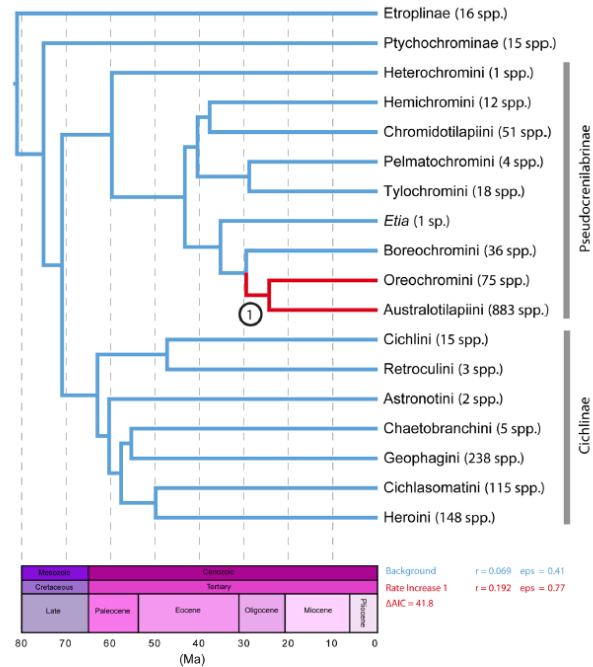
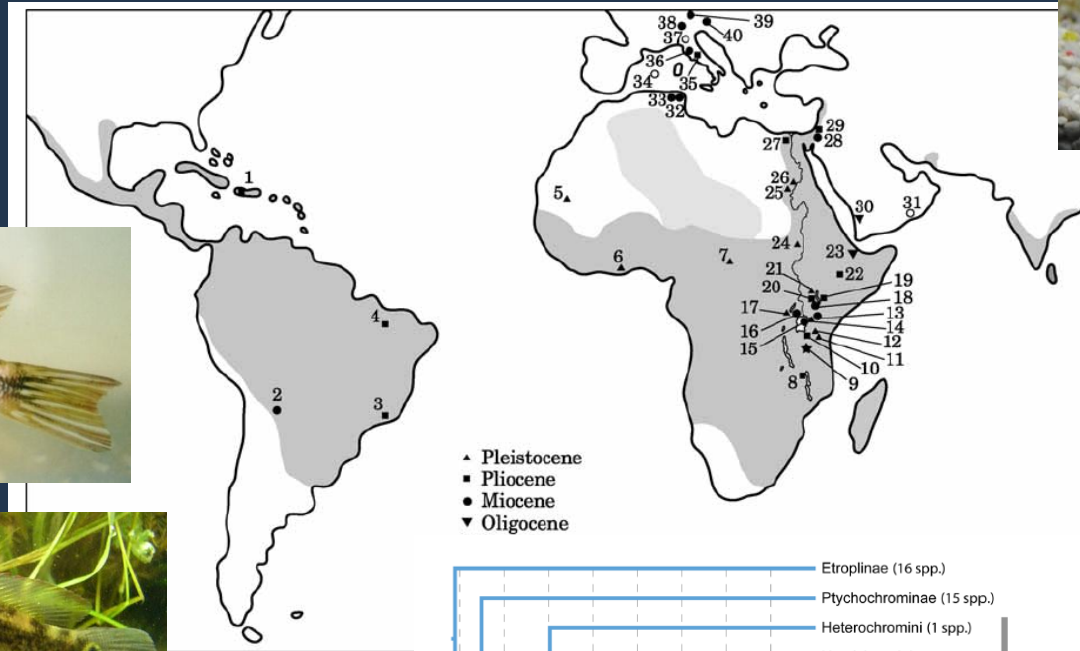


Figure 2. Temporal phylogeny of cichlids pruned to subfamily for Ptychochrominae, Etroplinae, tribes for Pseudocrenilabrinae, Cichlinae. Red clades indicate rate shifts in diversification, with lineages in blue undergoing a background rate of diversification.  
doi:10.1371/journal.pone.0071162.g002



# Orden: Cyprinodontiformes; *Orestias* spp

10 familias, 109 géneros, 1013 especies

Copeia, 1995(1), pp. 8-21

## Molecular Perspective on Evolution and Zoogeography of Cyprinodontid Killifishes (Teleostei; Atherinomorpha)

ALEX PARKER AND IRV KORNFIELD

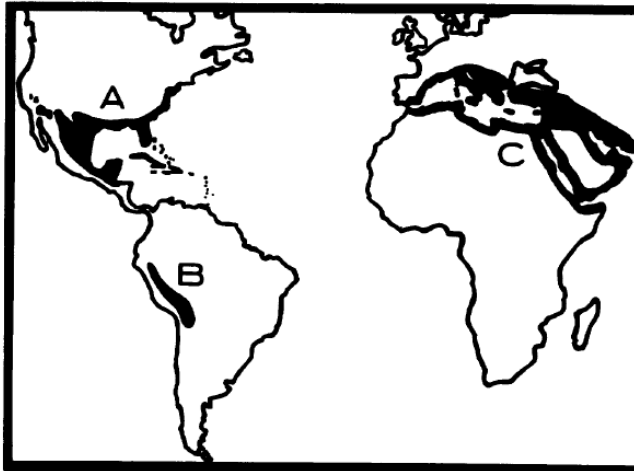


Fig. 1. Distribution of the three groups (sensu Parenti, 1981) comprising Cyprinodontidae: (A) Caribbean cyprinodontids; (B) *Orestias*; and (C) Anatolian cyprinodontids.

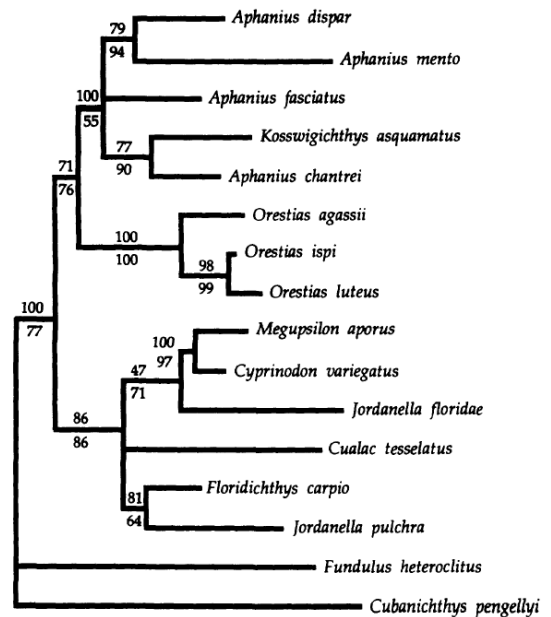


Fig. 2. Consensus (50% majority-rule) tree for 16 cyprinodontid taxa, based on 16s rRNA sequences (102 informative characters). Numbers at nodes indicate percentage of 2000 bootstrap replicates that support each node: maximum-parsimony values are above; neighbor-joining values are below. Branch lengths are proportional to estimated genetic distances. The two shortest trees found by PAUP were 294 steps long (CI = 0.56, RC = 0.33). The  $g_1$  value of the length distribution of 1000 random trees was  $-0.750$  ( $P < 0.01$ ). The same topology was found in maximum-likelihood analysis, where all branch lengths were significant ( $P < 0.01$ ). Compatibility analysis was uninformative (81 equally parsimonious trees). When rearranged to fit Parenti's (1981) hypothesis, the resulting tree was 326 steps long (CI = 0.50, RC = 0.24).

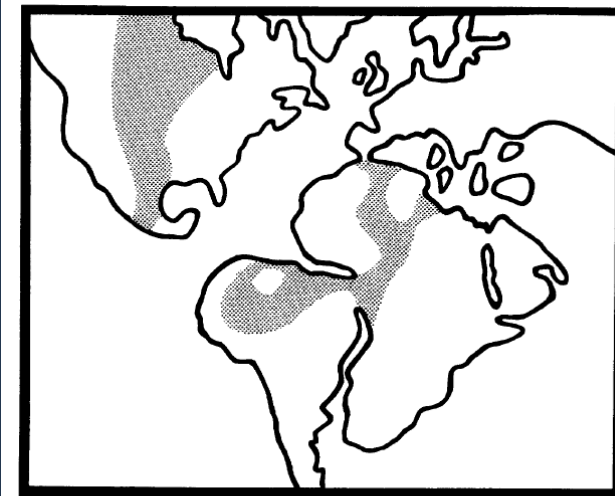
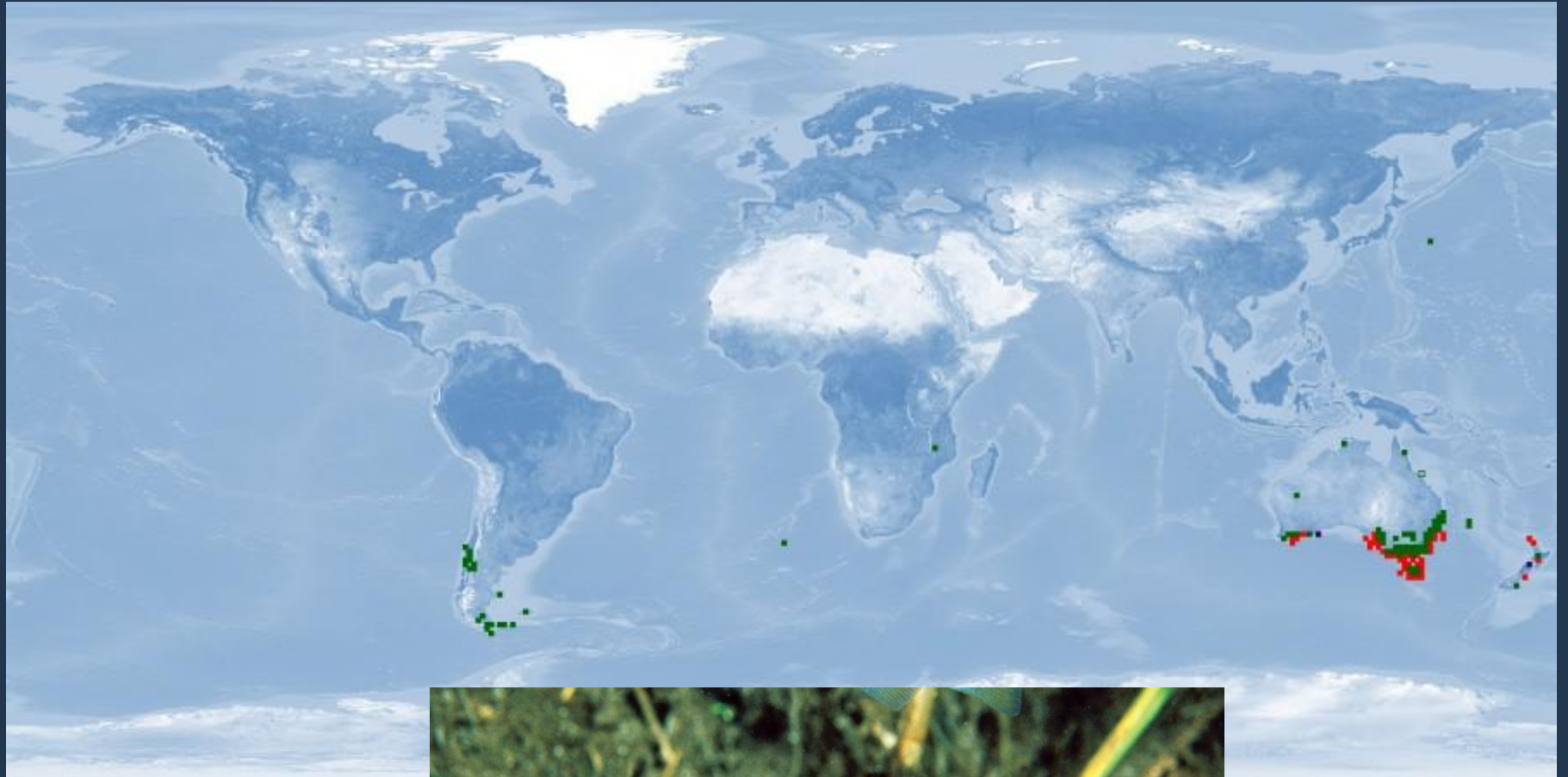


Fig. 5. Hypothesized habitat continuity and range of ancestors to *Orestias* and *Aphanius*. Diagram illustrates position of the South American continent relative to the North American and Eurasian continents and the proto-Atlantic Ocean at the beginning of the Cretaceous eustatic maximum. Shading indicates areas thought to have been covered by epicontinental seas during part or all of this period (adapted from Briggs, 1987; Van der Voo, 1993; and Hallam, 1992).

Orden Osmeriformes; Familia Galaxiidae; *Galaxias maculatus* (Distribución Circumpolar)



# Procesos Históricos del Neotrópico: Geología y Clima

# Procesos geológicos y geomorfológicos: Deriva Continental y Formación de los Andes.

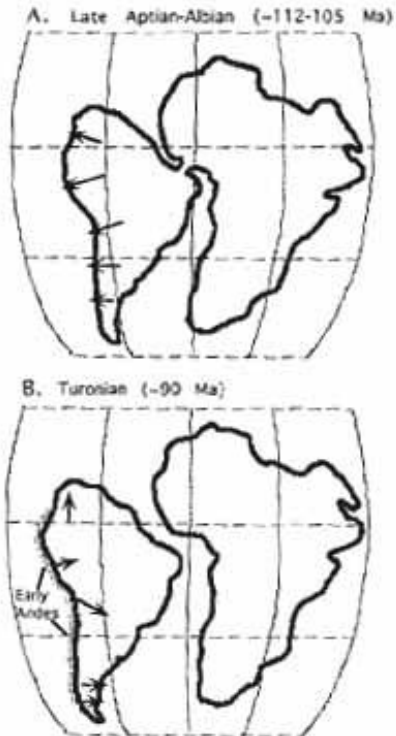


Figure 10. A. South America and Africa at about the time of final separation of the continents in late Aptian-Albian (-112-105 Ma, after Map 16 in Smith *et al.*, 1994). B. South America and Africa in the Turonian (-90 Ma) following complete separation (after Map 14 in Smith *et al.*, 1994).

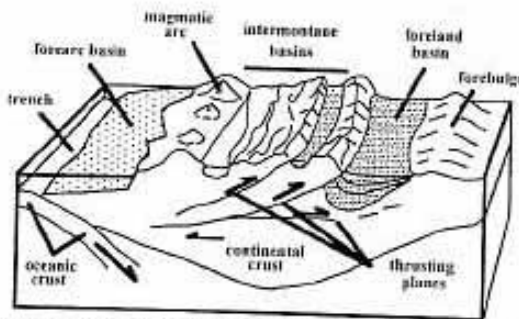


Figure 4. West (left) to east (right) schematic section of the Andes showing geological features associated with mountain building and foreland basin development (modified after Fig. 1 in Marocco *et al.*, 1995 and Fig. 2 in Horton & DeCelles, 1997).

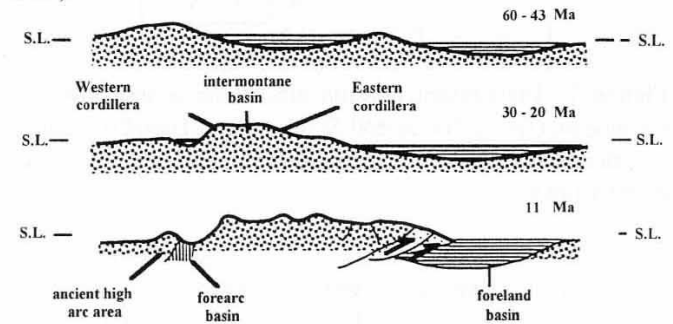
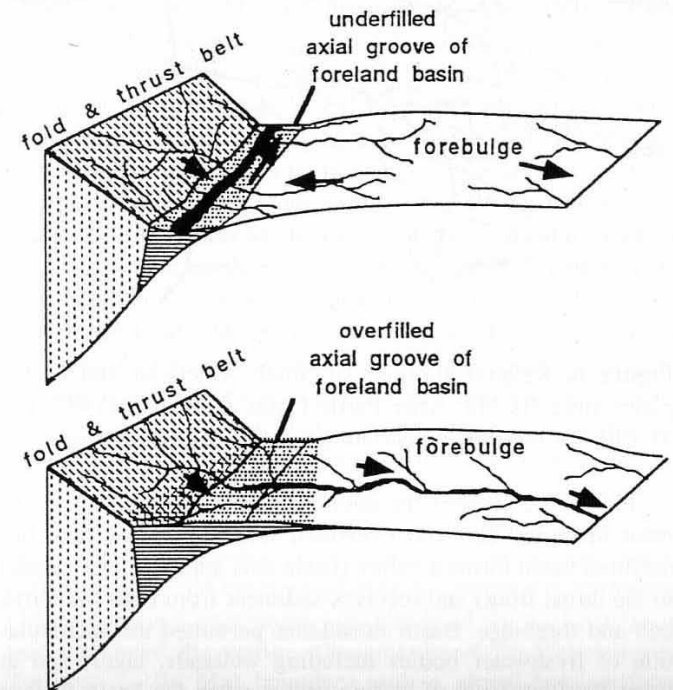
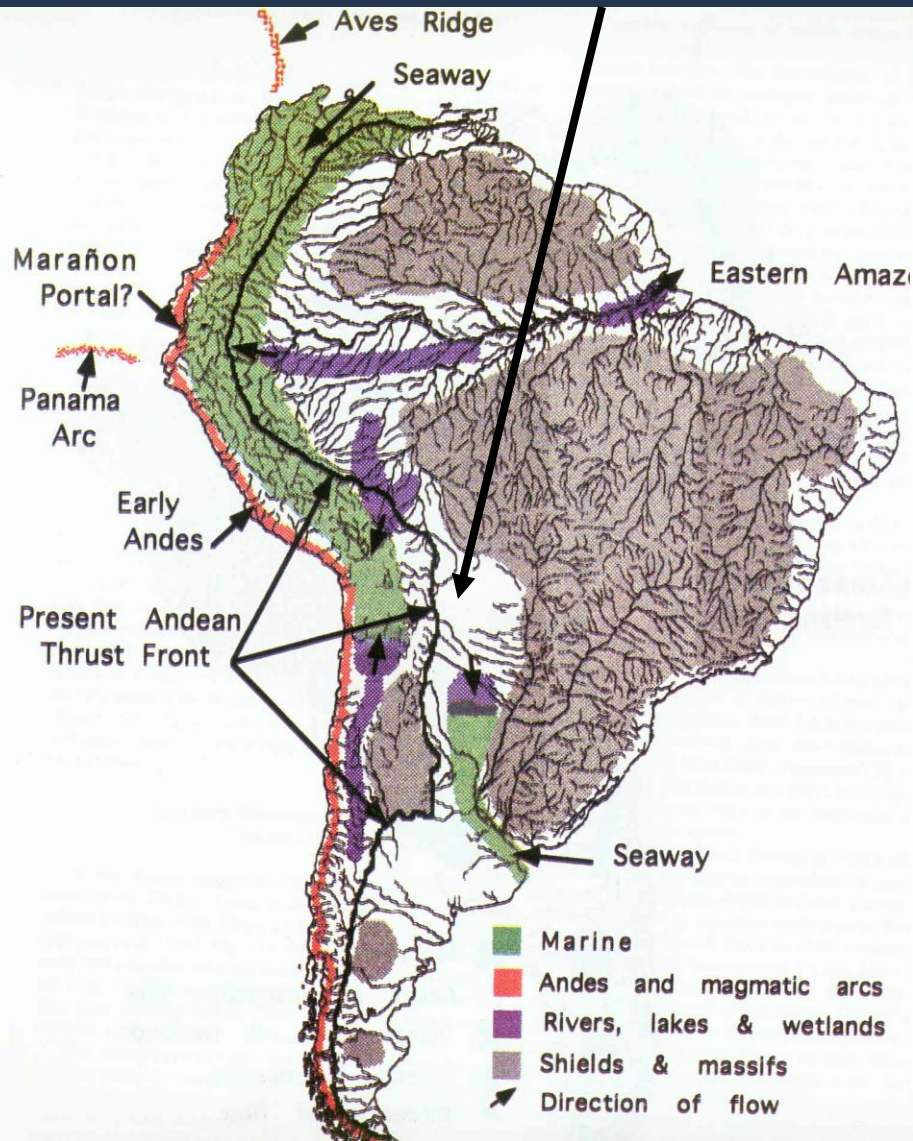


Figure 5. Eastward growth of the orogenic belt, foreland basin and forebulge. Modified after Fig. 7 in Jordan & Alonso (1987). S.L., sea level.

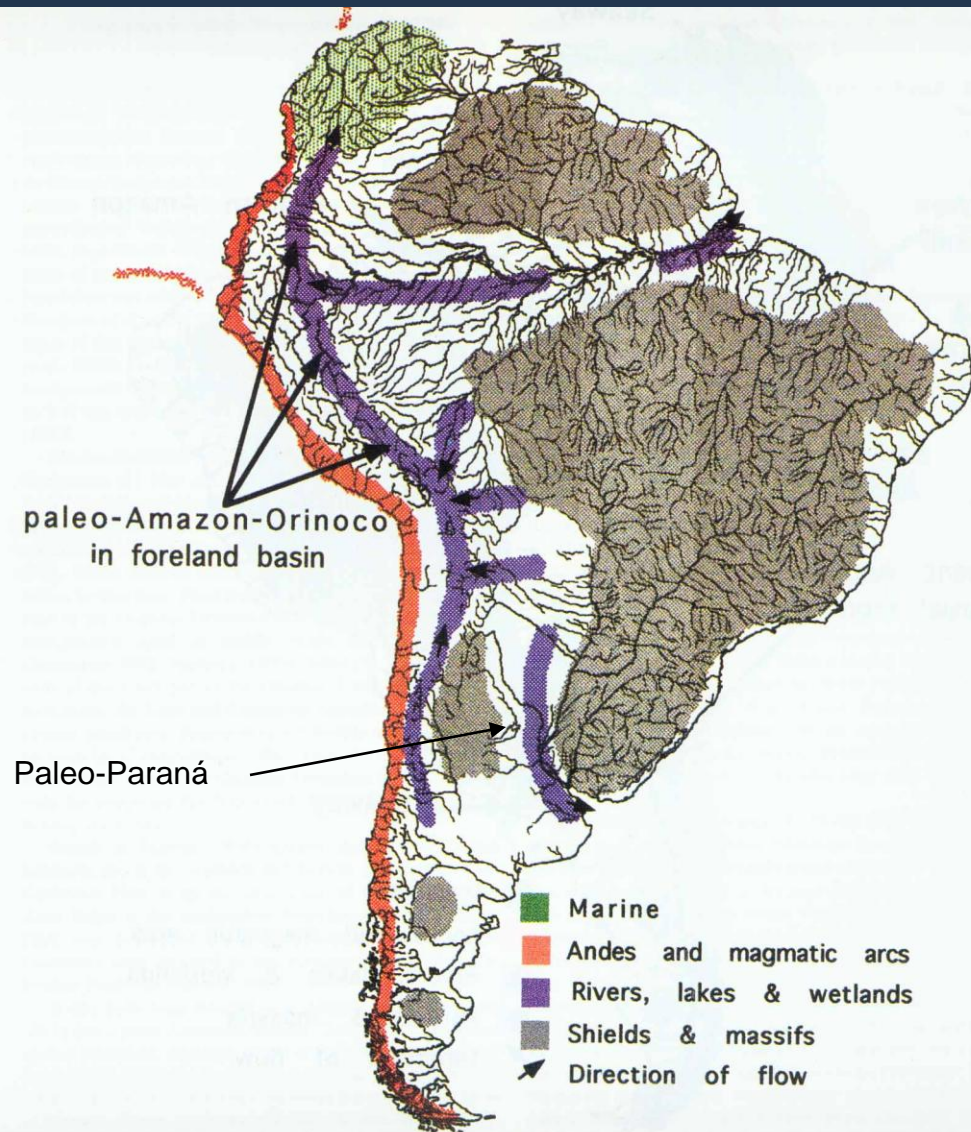




# Fósiles de peces marinos o estuarinos (Gayet et al, 2001)



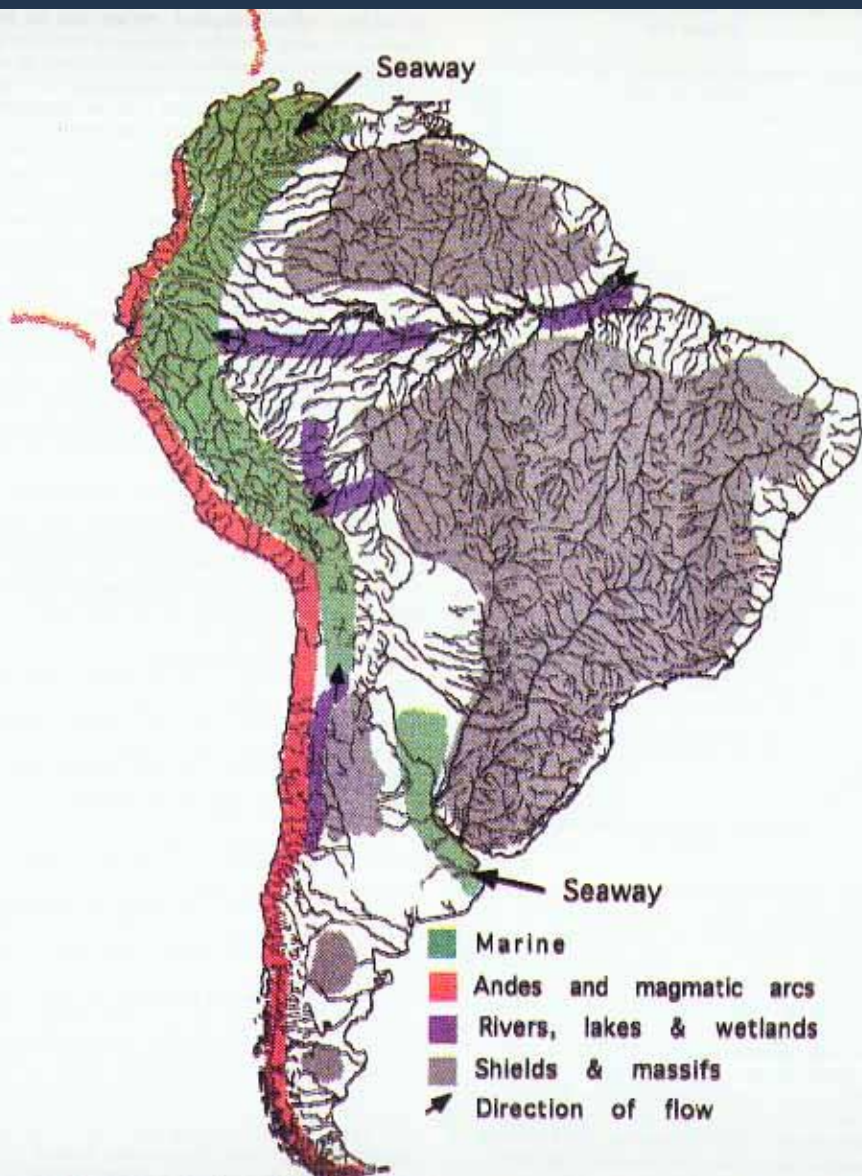
83-73 ma



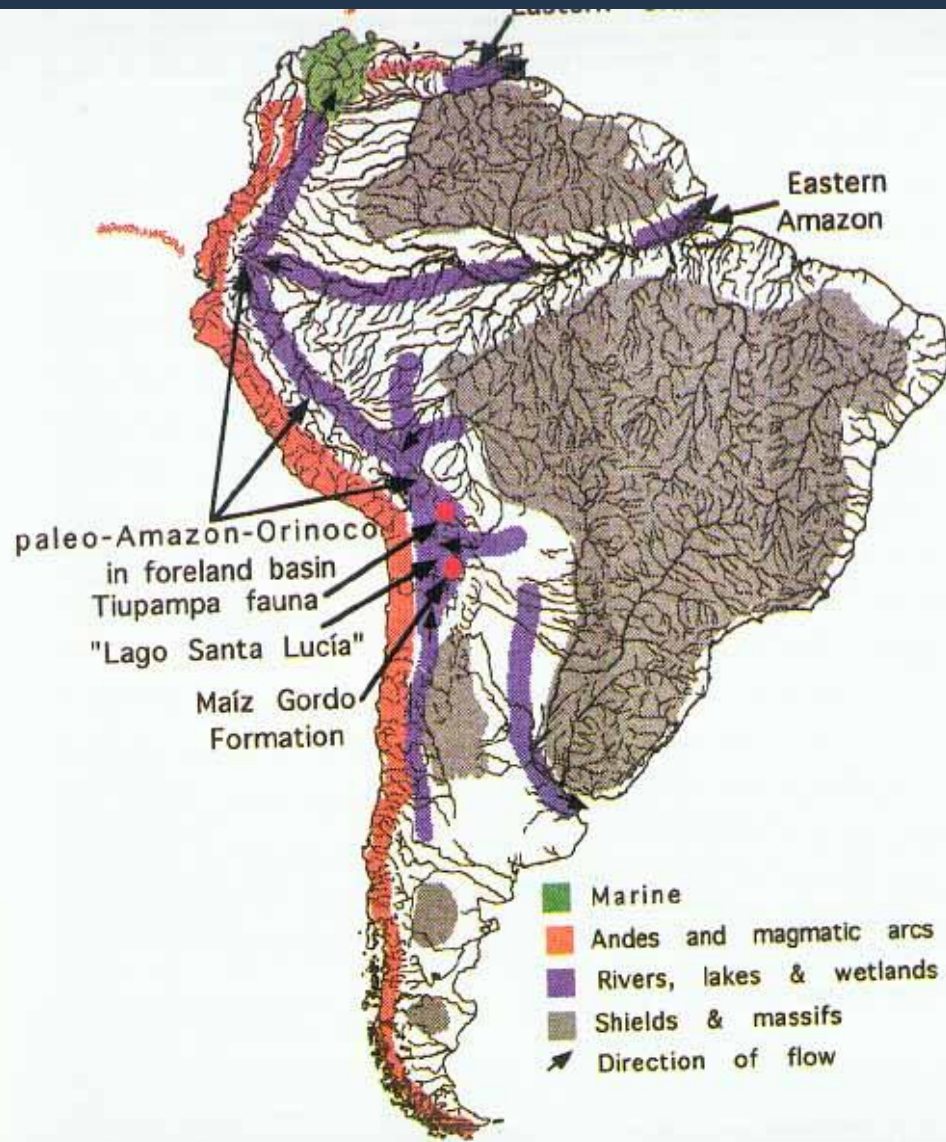
67-61 ma



# Fósiles de género actual: *Corydoras*



61-60 ma



60-43 ma



# Paraná captura Amazonas

# Locura andina

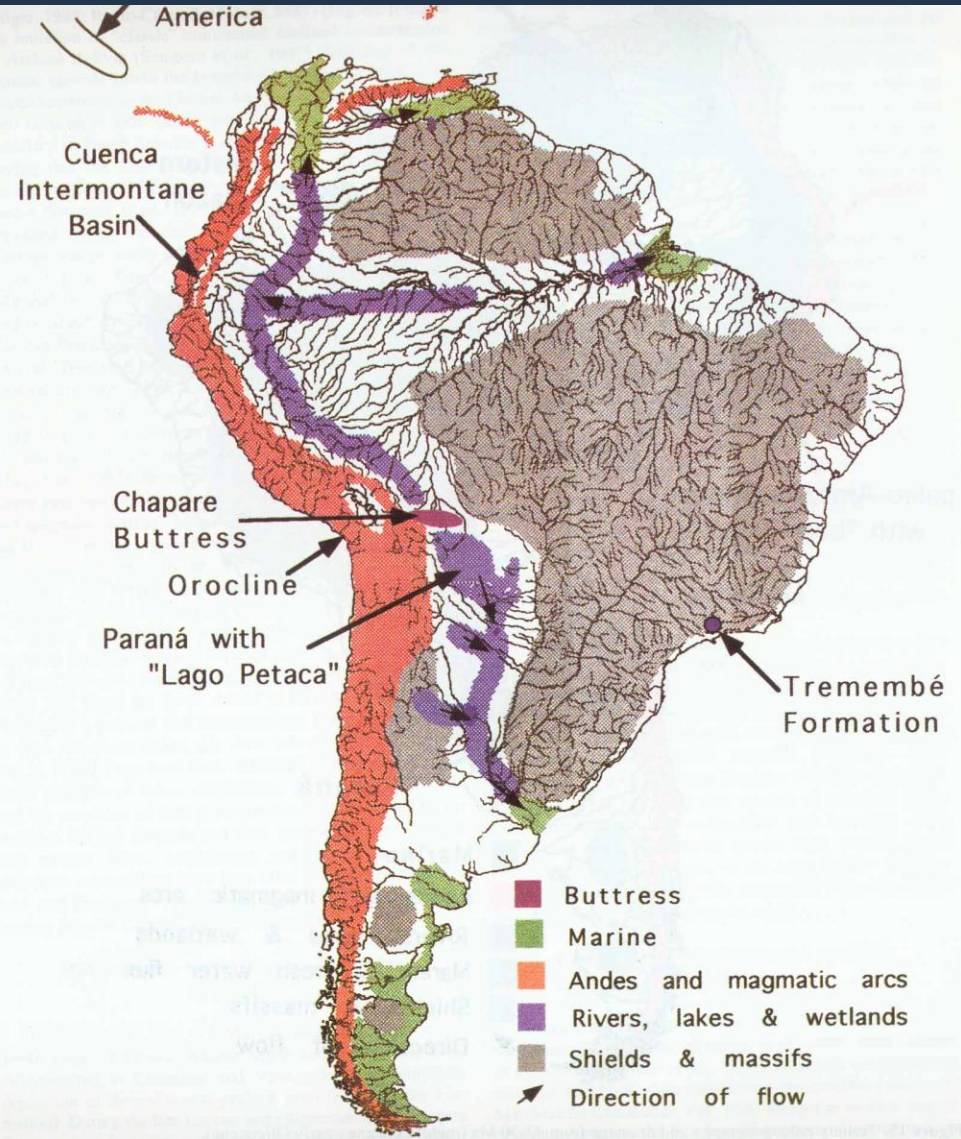
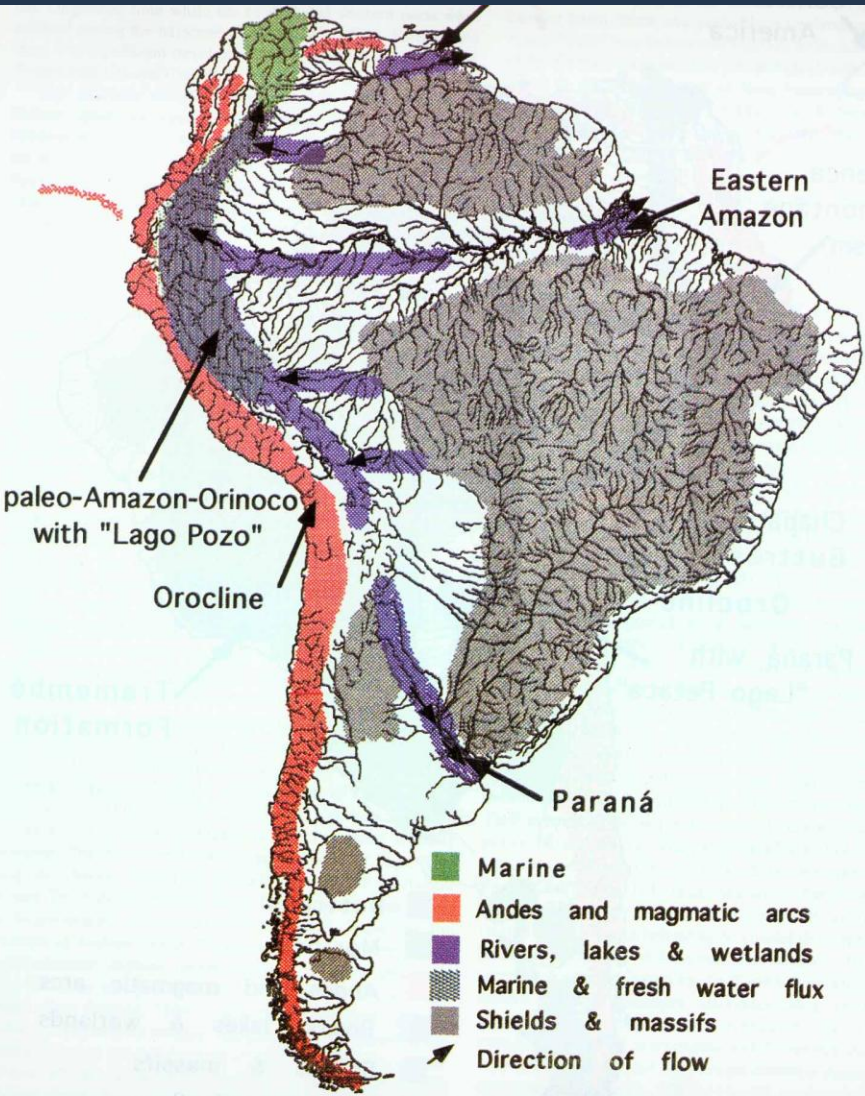


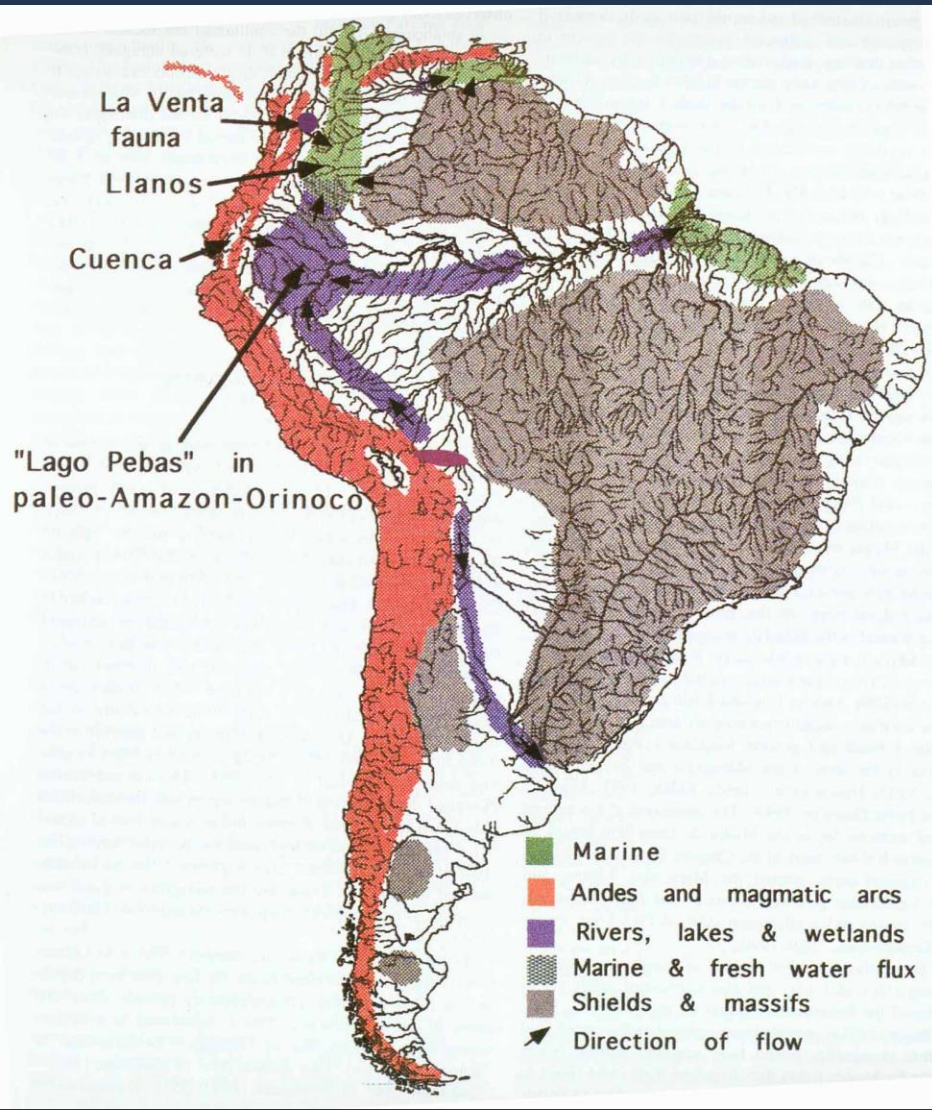
Figure 15. Tertiary paleogeography and drainage from 43-30 ma

43-30 ma

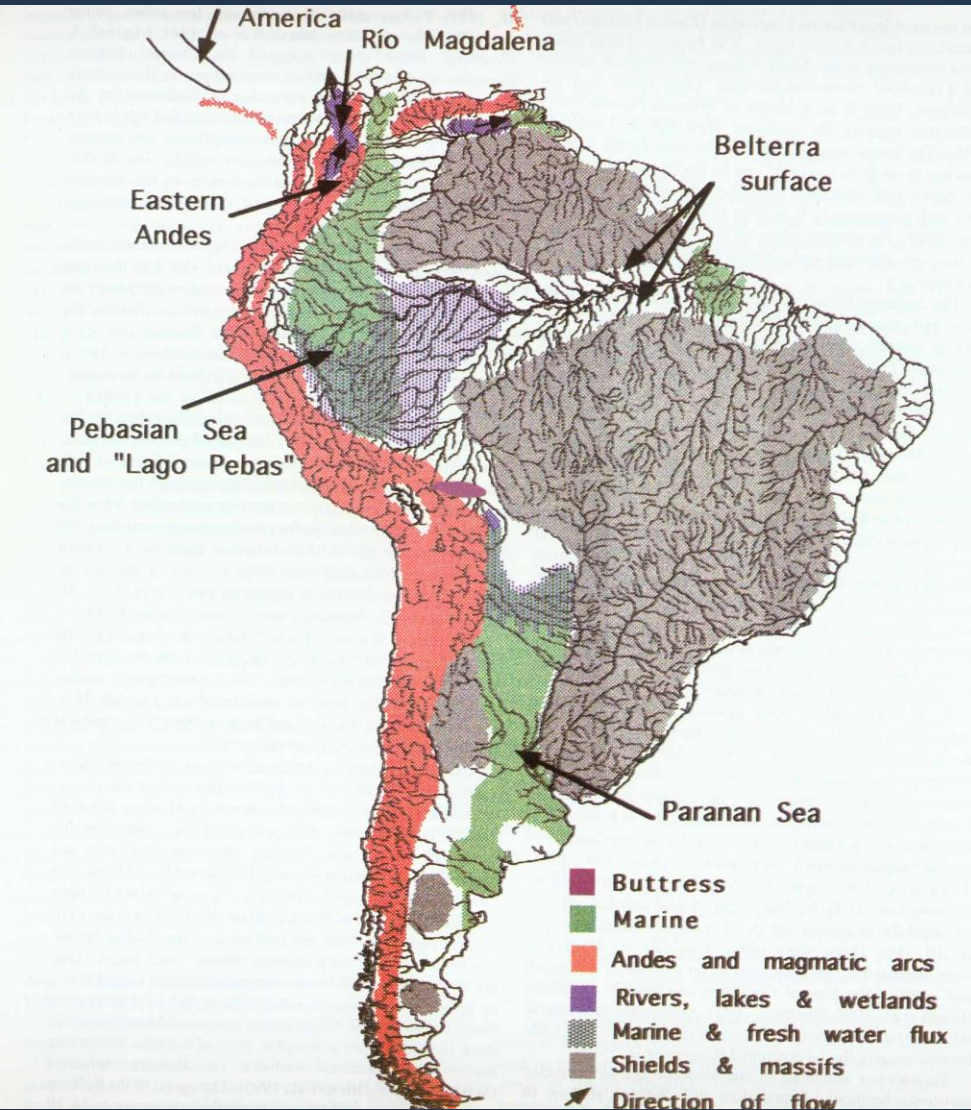
30-20 ma



# Amazonas captura Paraná



20-11.8 ma



11.8-10 ma



# El Lago Pebas



FIGURE 3.1 Paleogeography of northwestern South America during the Oligocene (33–24 Ma). Mountains, river courses, and shorelines are approximate, with conjectural details.



FIGURE 3.2 Paleogeography of northwestern South America during the Early and Middle Miocene (24–11 Ma). This model depicts a sea-level high stand at about 15 Ma. Mountains, river courses, and lake shores are approximate. The shape and connectivity of the Pebas system were very dynamic. Possibly every 20–40 Ka, base-level cycles occurred that increased or decreased the continuity of lacustrine and riverine habitats within this system. The blue stars south of the Maracaibo Basin depict possible lowland aquatic corridors.



FIGURE 3.3 Paleogeography of northwestern South America during the Late Miocene (7–11 Ma). Mountains, river courses, and lake shores are approximate. Landscape structuring and marine connections during deposition of the upper Solimões Formation in the Acre system are poorly understood. The system captured sediments from the emergent Andes, included tides, and was connected at the same time with the present-day Amazon mouth (Figueroa et al. 2009, 2010). There are no indications for marine influence in Amazonia after 7 Ma.

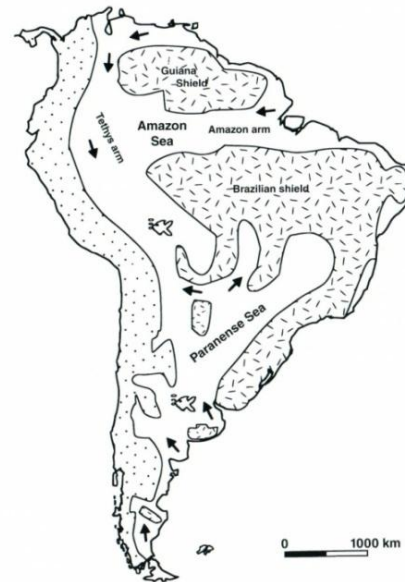
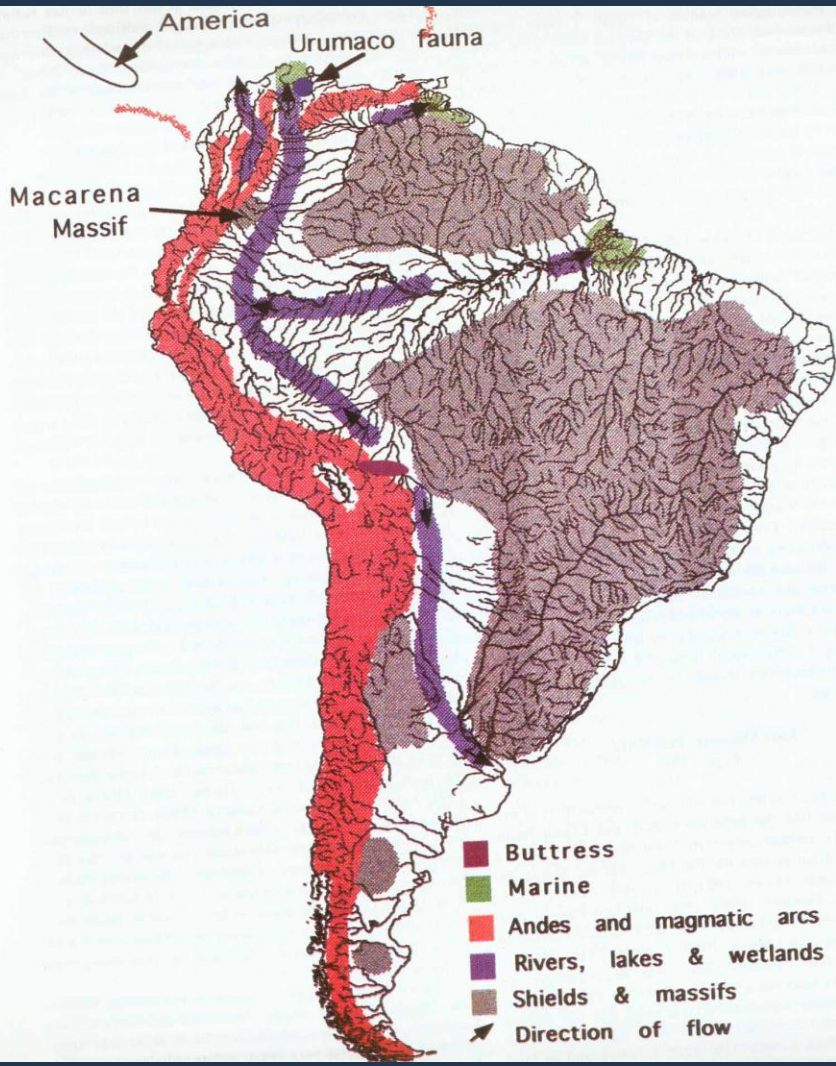
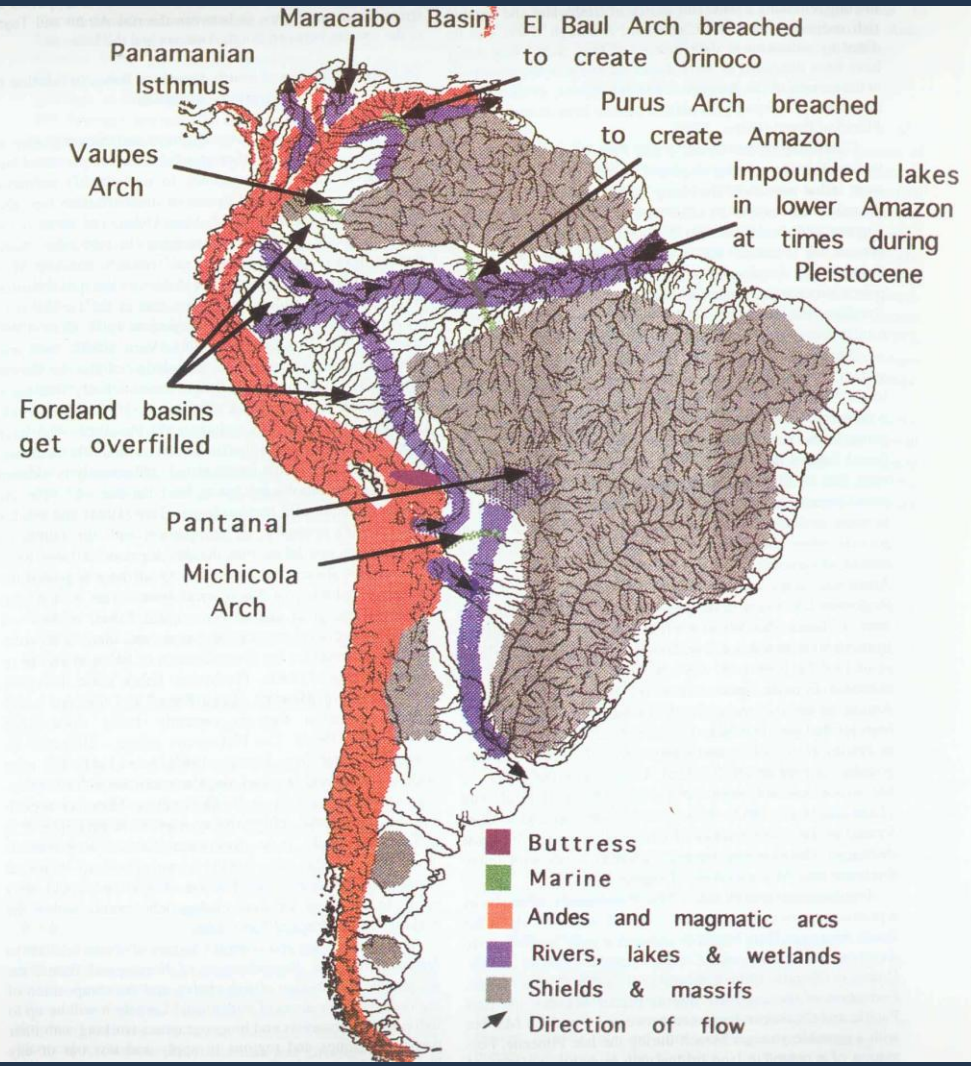


FIGURE 3.4 Possible extension of the Miocene (12 MY) transgression of the Paranaense Sea (modified from V. Ramos and Aleman 2000).

# Dirección actual del Río Amazonas



10-8 ma



8-0 ma



## Cladograma de Areas: Relaciones a gran escala

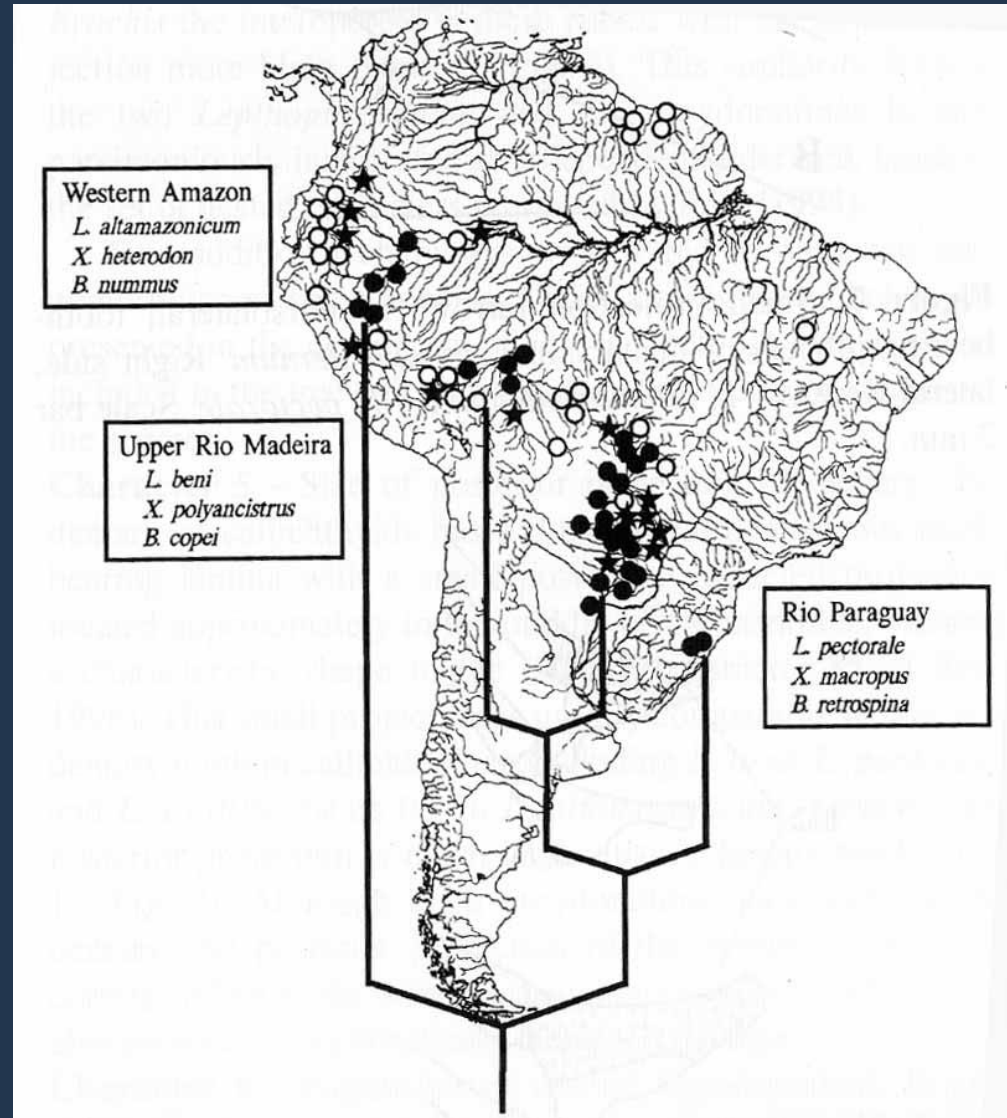
Siluriformes: Callichthyidae:  
*Leptoplosternum*



Characiformes: Characidae  
*Xenurobrycon*



Characiformes: Characidae:  
*Brycochalcinus*









# Invasores Marinos



## Familia Potamotrygonidae

Tres géneros: *Paratrygon*, *Plesiotrygon*, *Potamotrygon*; apróx. 20 especies.

Distribución: Cuencas Atlánticas y Caribe, aunque ausentes de la cuenca San Francisco, ríos costeros Atlánticos, Cuenca alta del Paraná y ríos al Sur de la cuenca del Plata.

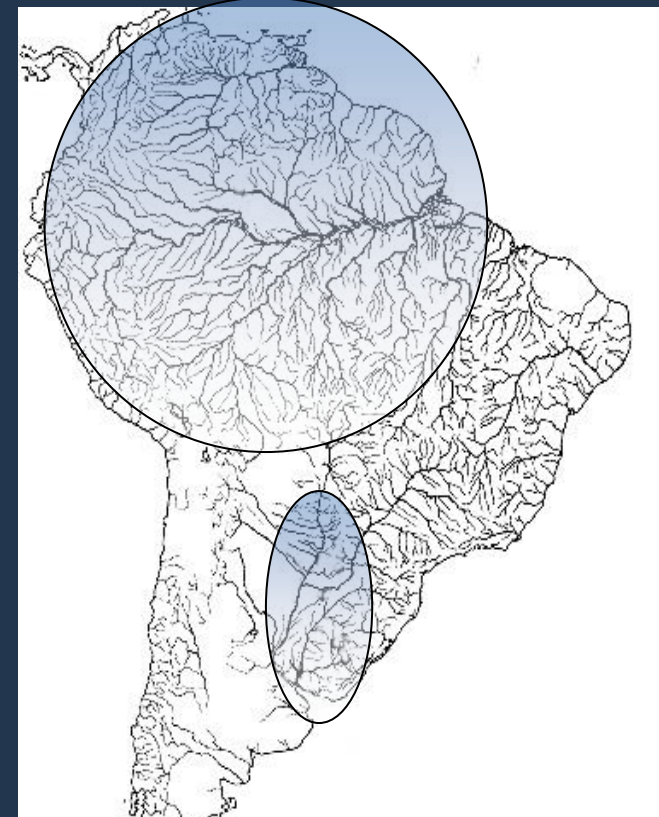
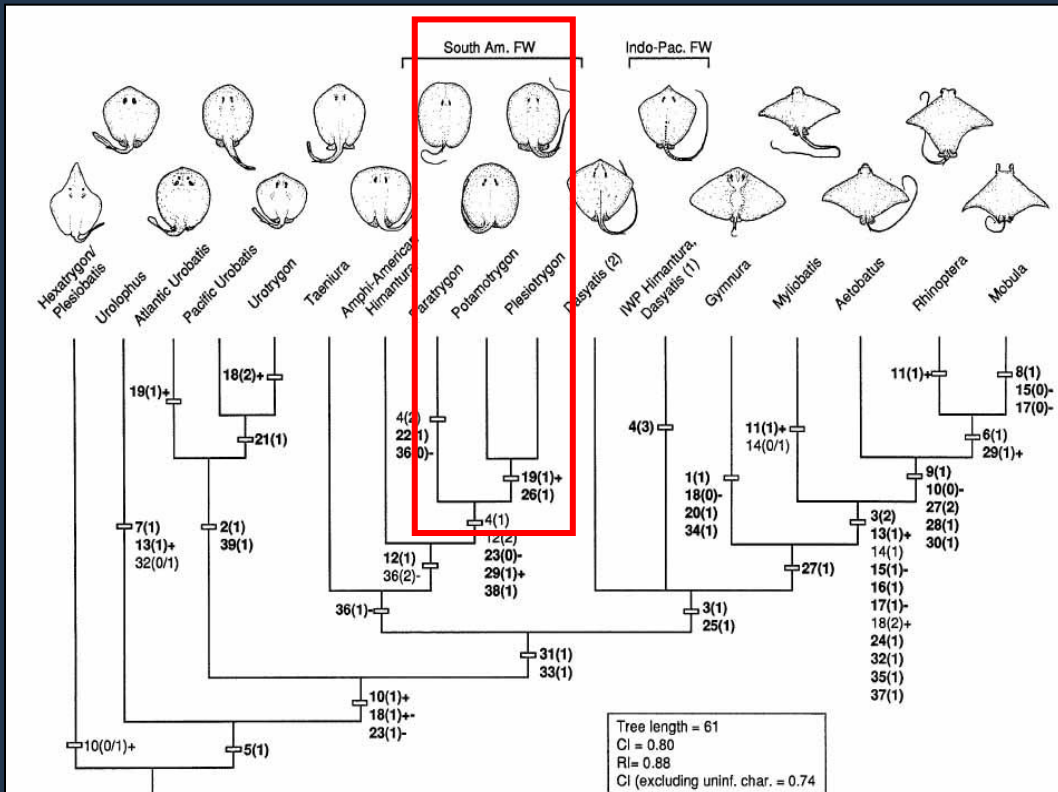
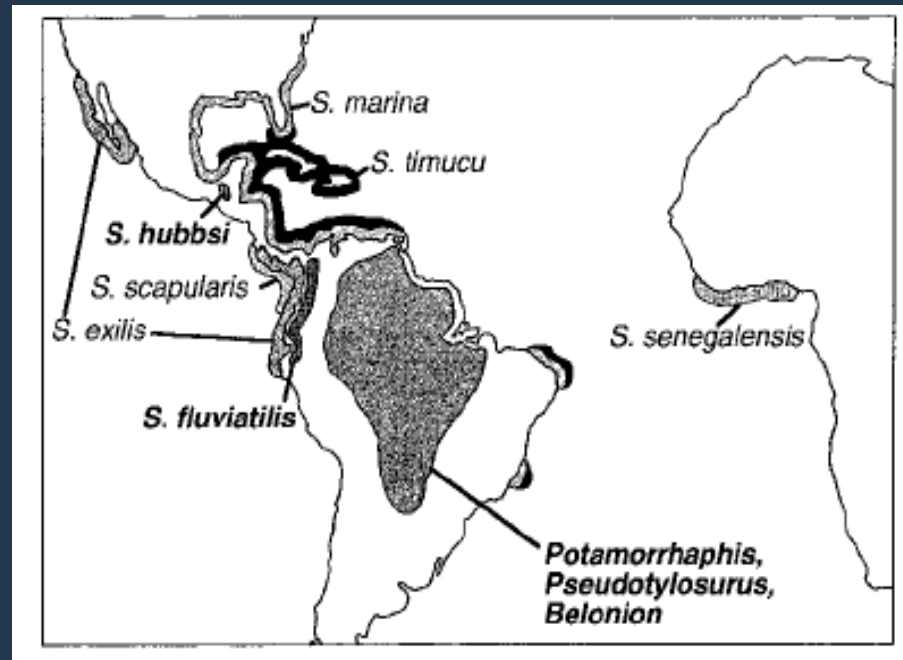
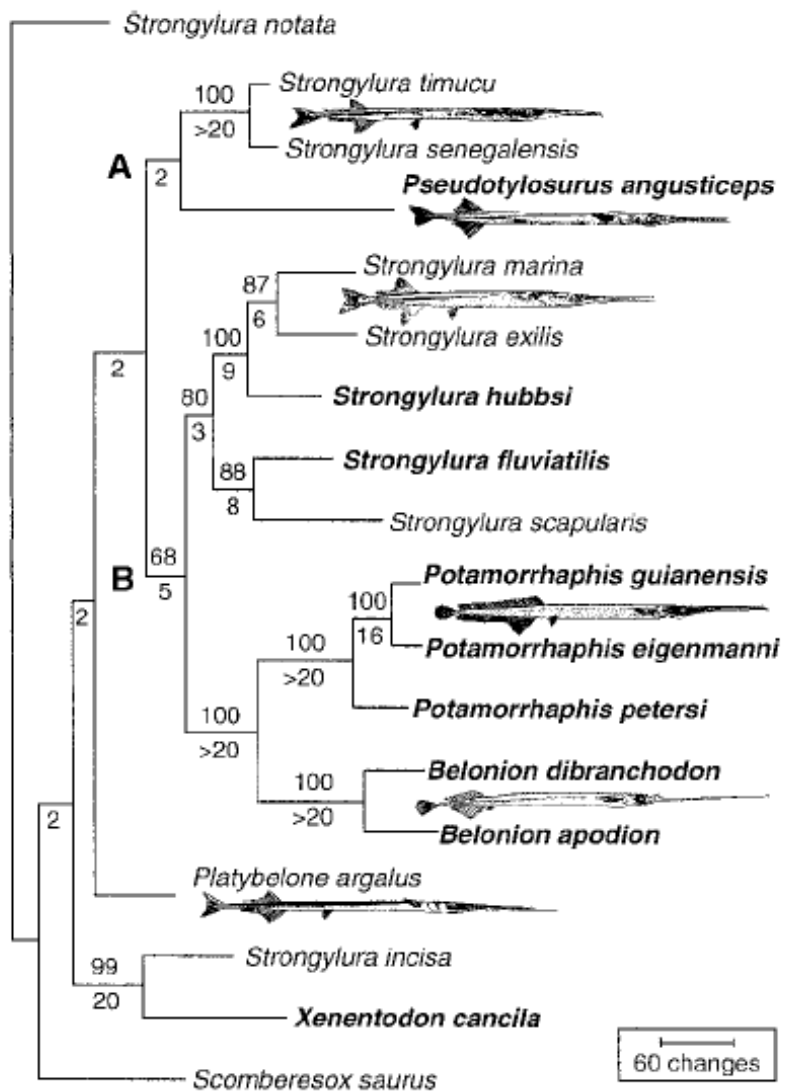


Figure 15. Single most parsimonious tree produced by phylogenetic analysis of stingray taxa. Homoplasy indicated by '+' (independent gain) or '-' (reversal). Some ray silhouettes after Castello & Yagolkowski (1969); Compagno (1977); Heemstra & Smith (1980); McEachran & Capapé (1984).

# Teleostei: Belonidae





## Sistemas costeros del E de Sudamérica: margen continental pasivo



Fig. 4. Geographic location of the Brazilian Atlantic continental margin and of the coastal drainages of eastern Brazil (shaded area) and areas showed in figures 6, 7 and 8 (modified from Hearn *et al.*, 2000).

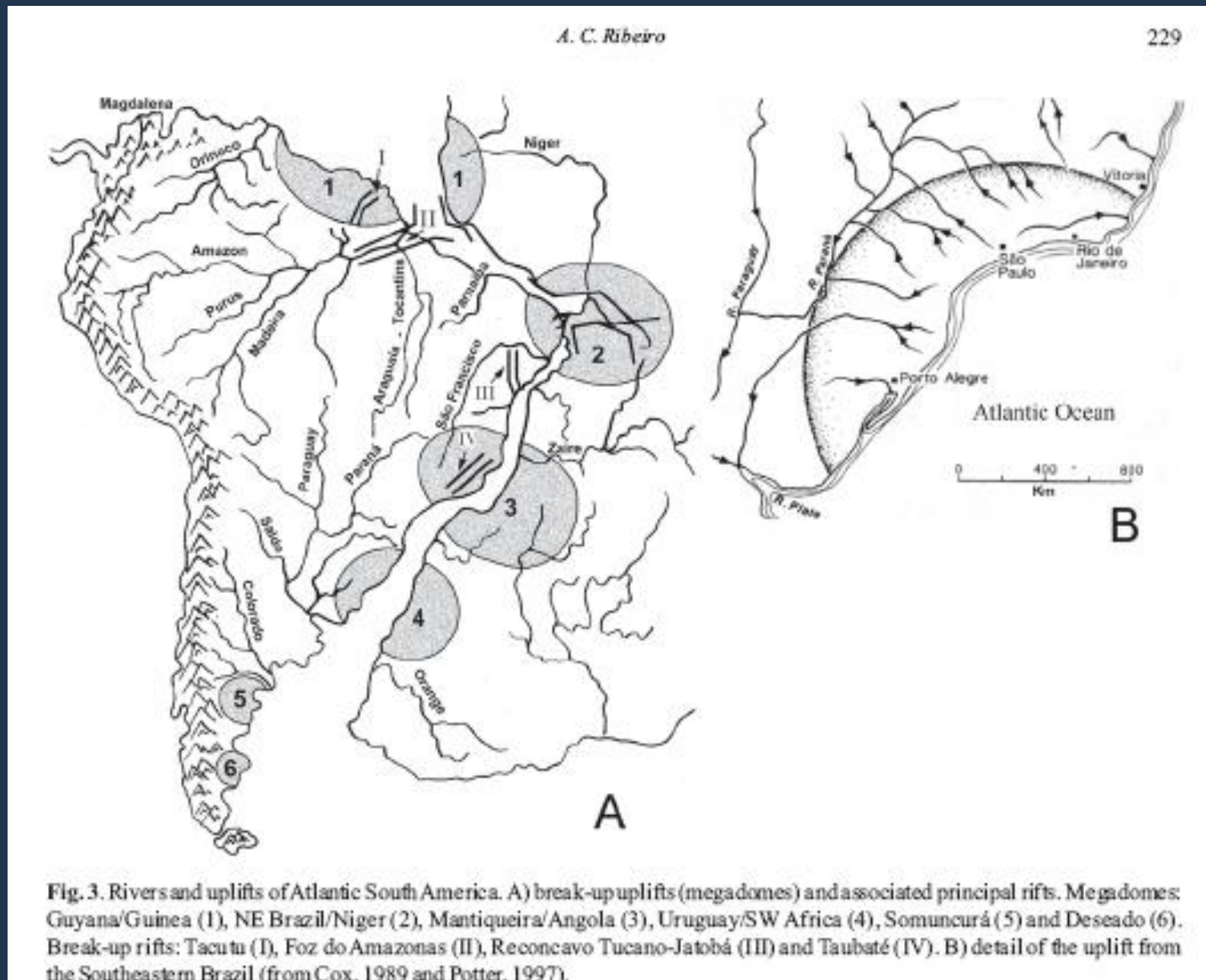
Área con componente biogeográfico antiguo (taxa basales a clados altamente diversificados en restantes las cuencas).

- Eventos cladogenéticos tempranos, asociados al estado inicial de la evolución geomorfológica del este de Sudamerica (procesos tectónicos y erosivos). Procesos activos en la actualidad (litósfera débil en la región).

Ictiofauna con alto grado de endemismos, de un total de 285 especies de peces listadas por Bizerril (1994) para los cursos del sudeste de Brasil: 95% endémicos con 23.4% de géneros endémicos.



- Ruptura con Africa: Megadomos que determinan el patrón de flujo de los cursos de agua.



**Tectonic history and the biogeography of the freshwater fishes from the coastal drainages of eastern Brazil: an example of faunal evolution associated with a divergent continental margin**

Alexandre Cunha Ribeiro

- La acción erosiva continua desde el E provocó la captura de varios ríos del escudo cristalino tierras arriba, haciéndolos parte de las cuencas oceánicas (incluso algunos tan recientes como el cuaternario).
- También el movimiento entre fallas dió lugar a cuencas resultantes de capturas de nacientes circundantes, originando una hidrografía compleja, a veces representadas por sistemas lacustres interconectados (Cretácico-Terciario): captura de las nacientes entre sistemas hidrográficos adyacentes.
- Procesos iniciados en el Cretácico y que se continuaron hasta la actualidad. Ya que está reportada actividad de faulting en el Holoceno de la mayoría de las provincias geológicas de Brasil (Riccomini & Assumpção, 1999, Modenesi-Guattieriet al.,2002).



Siluriformes; Trichomycteridae.

Trichogeninae (*Trichogenes*) SE Brasil

Copionodontinae (*Glaphyropoma*, and *Copionodon*) NE Brasil

Grupos hermanos, basales al resto de la familia.

Taxas reminiscentes de historia biogeográfica antigua (Cretácico)



Siluriformes; Callichthyidae; Aspidoradini.

*Scleromystax*: cuatro especies endémicas de SE y S de Brasil, grupo hermano del más diverso *Aspidoras* ampliamente distribuído tanto en ríos del escudo como en varios sistemas costeros (Reis, 2003).

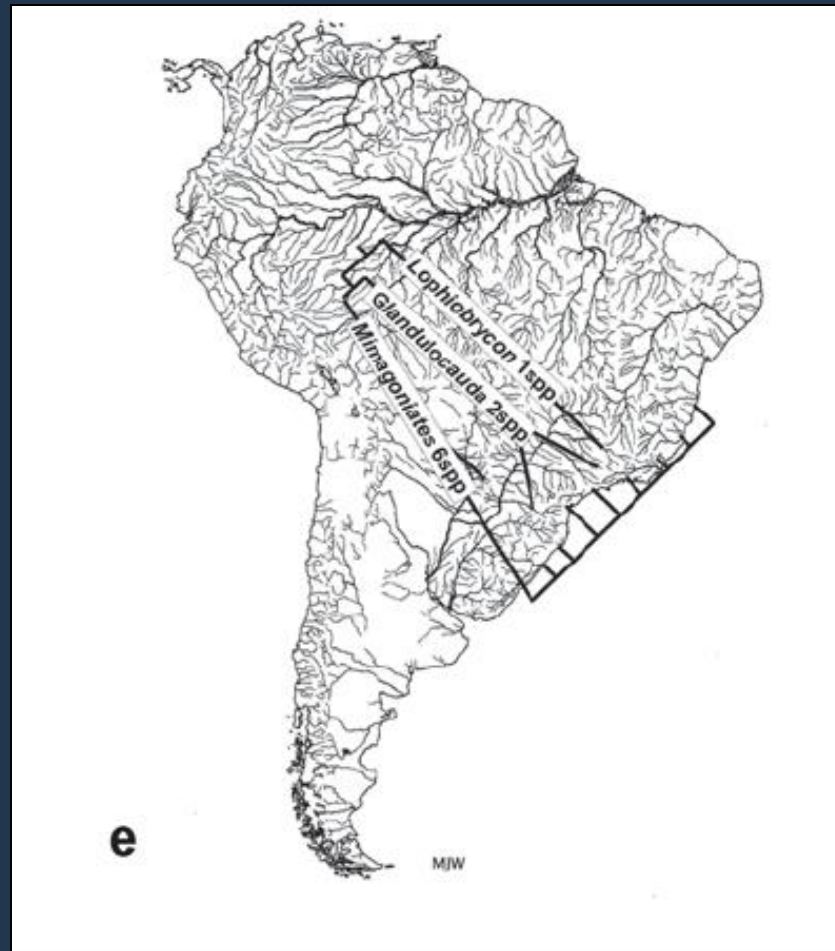
Antigüedad relativa de Callichthyidae corroborada por registro fósil.





Characiformes: Characidae: Glandulocaudinae.

*Mimagoniates*: seis especies ampliamente distribuídas en los sistemas costeros cuyo grupo hermano, *Glandulocauda* (dos especies con caracteres ancestrales), es endémico del escudo cristalino (rios Tietê e Iguaçú).



## New Species of *Jenynsia* (Teleostei: Cyprinodontiformes) from Southern Brazil and Its Phylogenetic Relationships

MICHAEL J. GHEDOTTI, AMY DOWNING MEISNER, AND PAULO H. F. LUCINDA

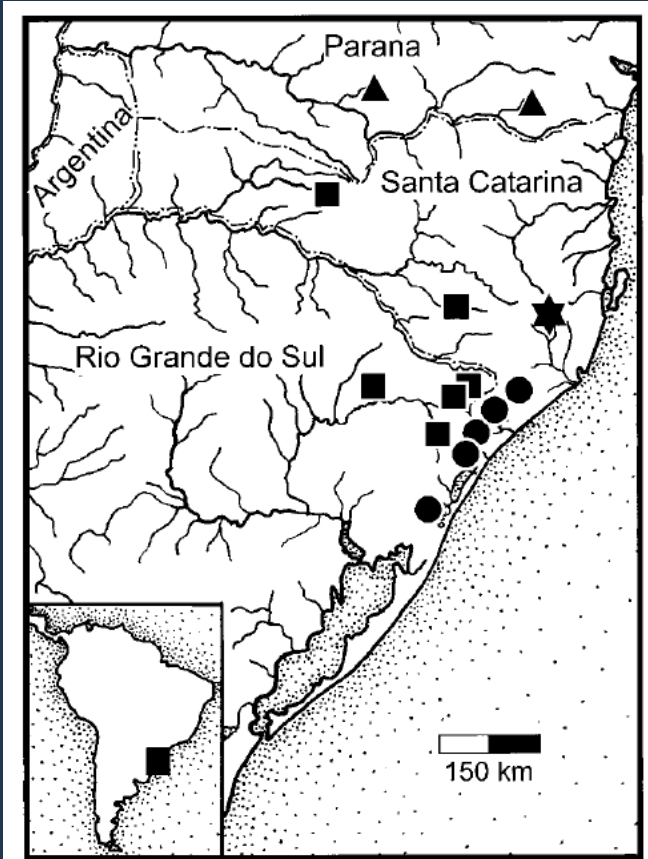


Fig. 4. Distributions of species in the subgenus *Plesiojenynsia*. The type locality of *Jenynsia weitzmani* is indicated by a star. Known distribution of *Jenynsia eigenmanni* shown as triangles. Known distribution of *Jenynsia eirmostigma* shown as squares. Known distribution of *Jenynsia unitaenia* shown as circles.

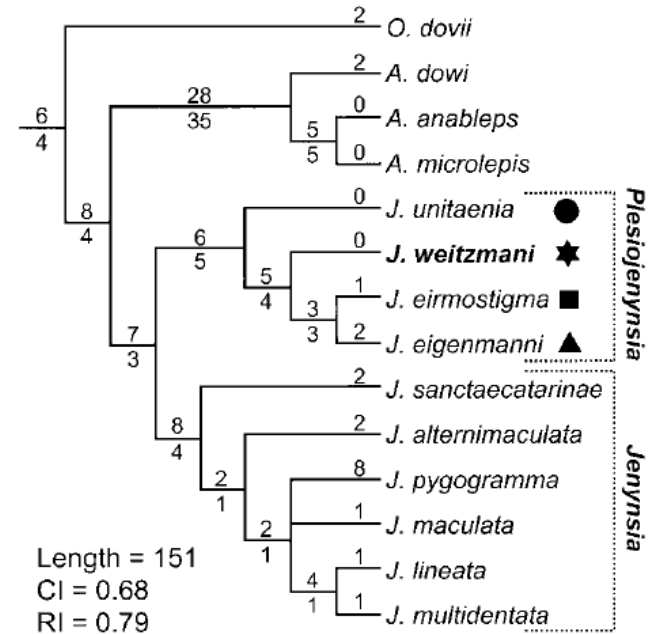
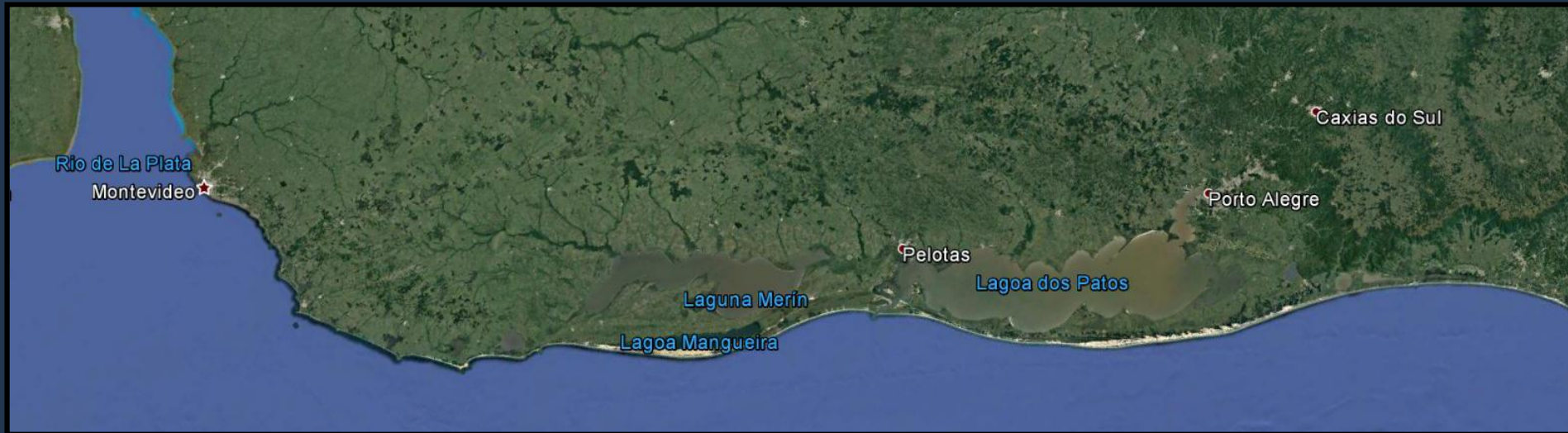


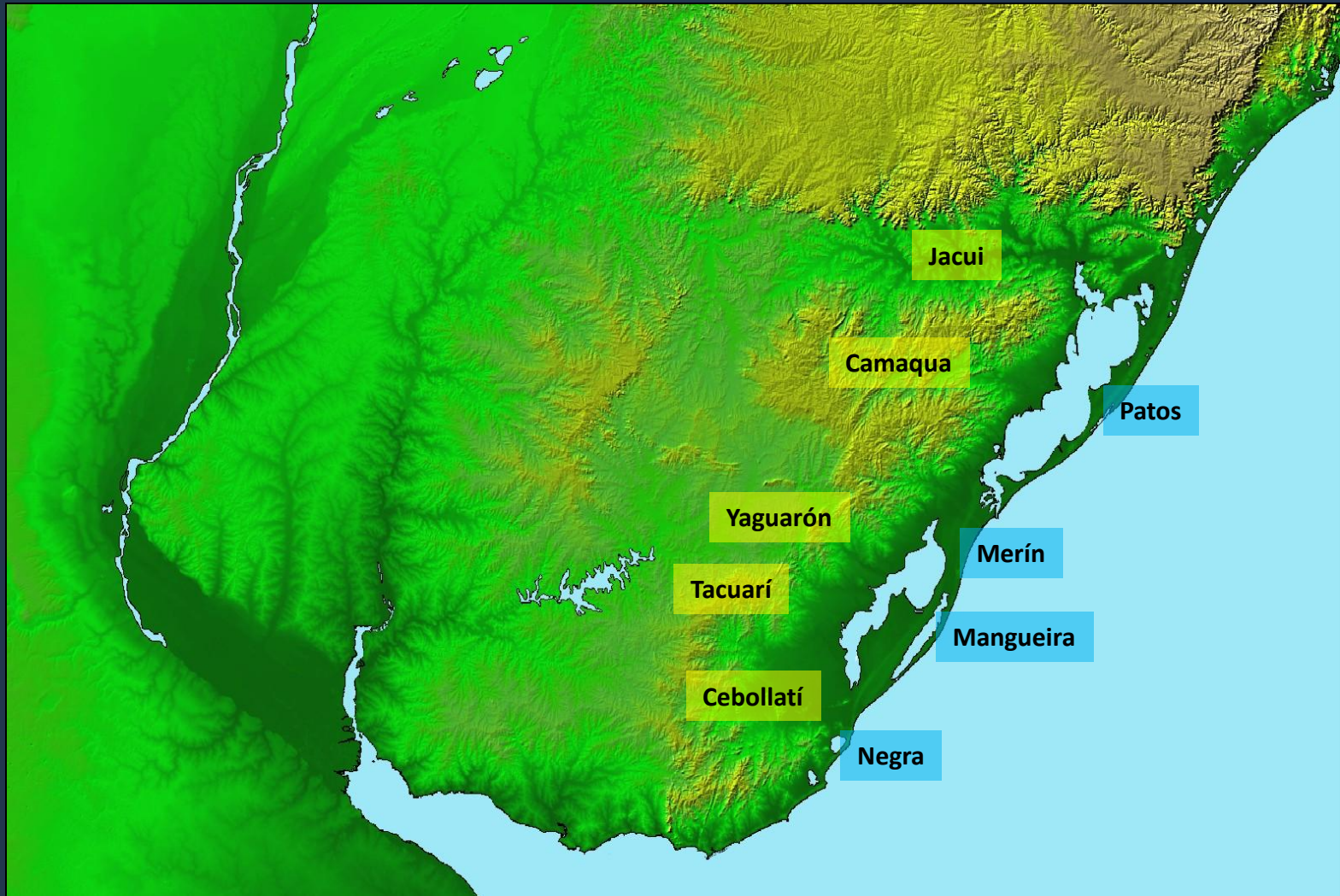
Fig. 3. Strict consensus of three equally most-parsimonious phylogenetic trees. Outgroups not included. Tree statistics based on fundamental trees from the analysis using the outgroup topology proposed by Parenti (1981). Statistics from all analyses presented in text. Branch lengths based on ACCTRAN optimization above branches, Bremer (1988) decay indices below branches. Symbols associated with *Plesiojenynsia* species correspond to those in Figure 4.

## El sistema de drenaje Patos-Merín: Museo de la diversidad biológica





## Patos – Merín: Cuenca Hidrográfica



**Cuenca Hidrográfica:** territorio drenado por un único sistema de drenaje natural, delimitada por la línea de las cumbres, también llamada divisoria de aguas.

# Patos - Merín: Área de Endemismo y Ecorregión

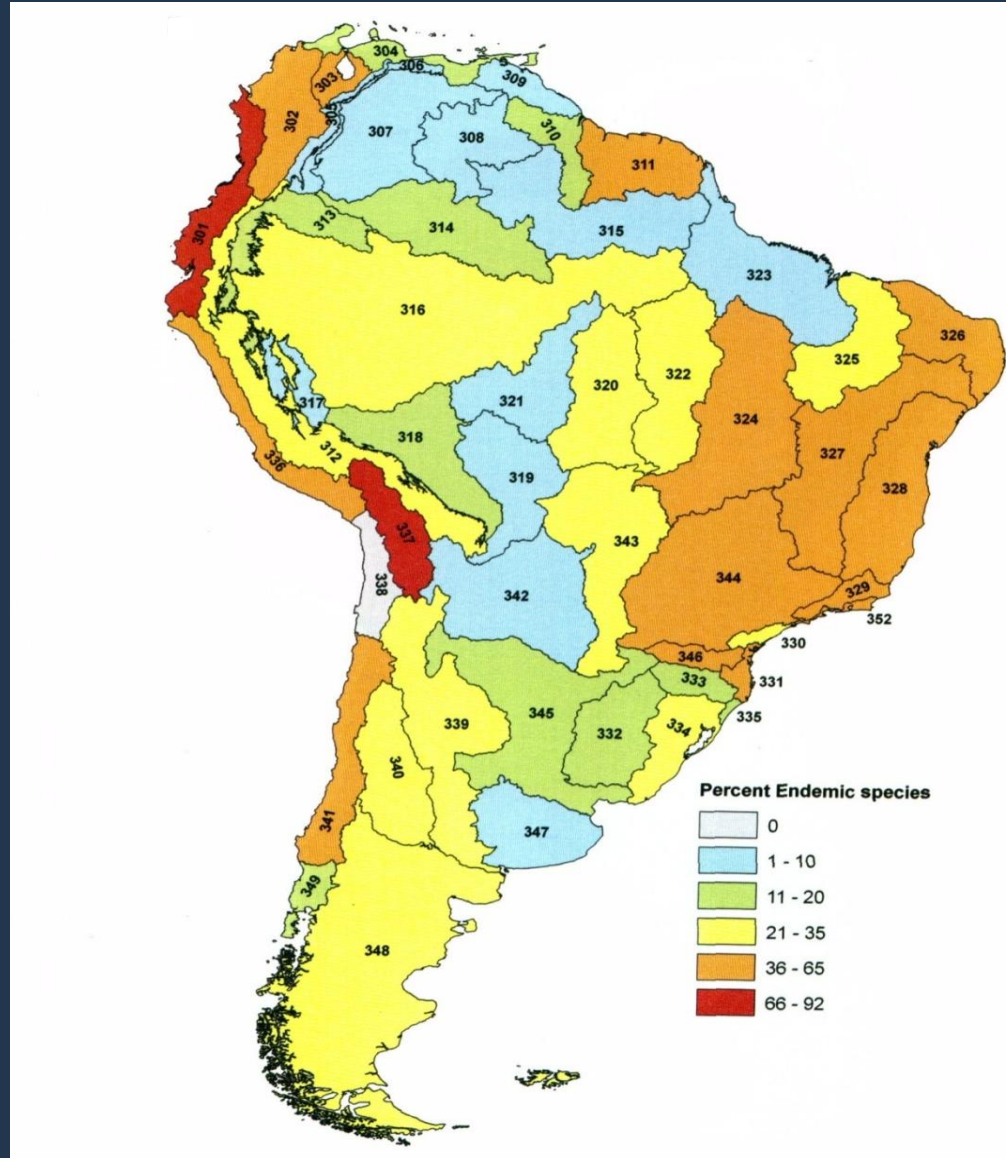


Figura: Albert & Reis (2011)



Patos Merin - Drenajes costeros del SE de Brazil

Characidae: *Mimagoniates* spp







Neotropical Ichthyology, 3(3):373-382, 2005  
Copyright © 2005 Sociedade Brasileira de Ictiologia

## Systematics and biogeography of the genus *Phalloptychus* Eigenmann, 1907 (Cyprinodontiformes: Poeciliidae: Poeciliinae)

Paulo H. F. Lucinda

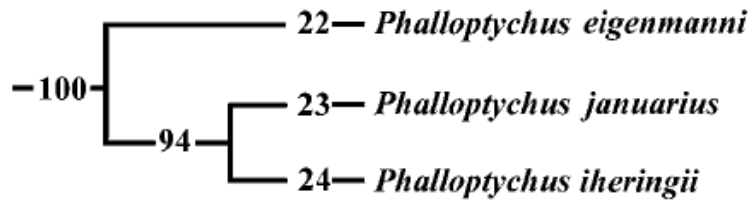


Fig. 2. Intrageneric relationships of *Phalloptychus*. The numbers on the branches refer to the character state transformations series listed by Lucinda & Reis (2005).

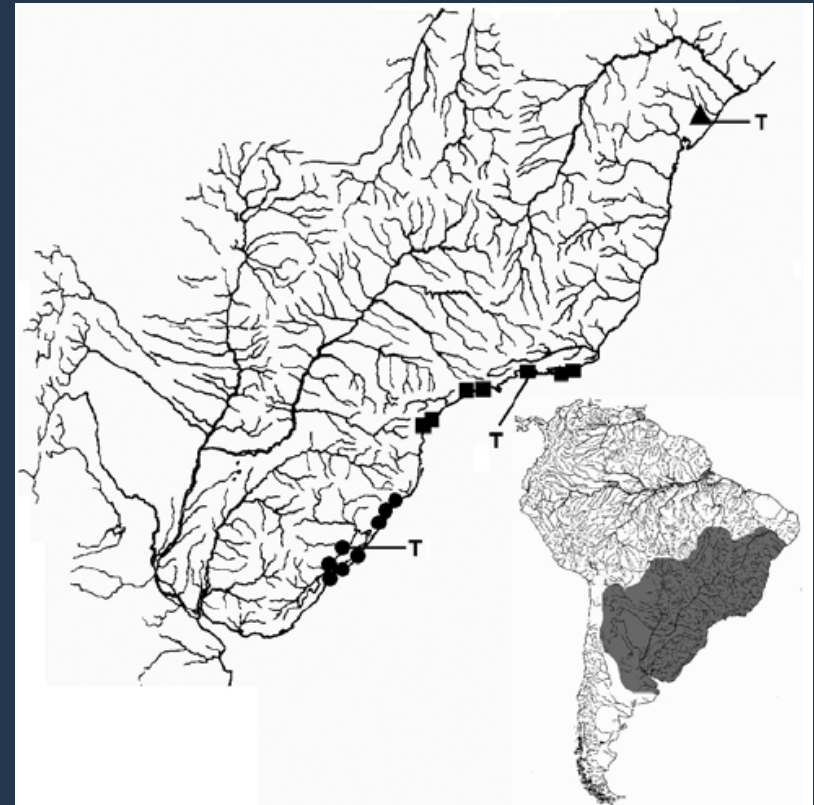


Fig. 1. Coastal drainages from Bahia to Rio Grande do Sul, and Uruguay showing distribution of *Phalloptychus eigenmanni* (triangle), *P. januarius* (squares), and *P. iheringii* (circles). Each symbol may represent more than one lot and/or locality. T = type locality.

# Patos-Merín: Los cambios en el nivel del mar y las Conexiones Costeras

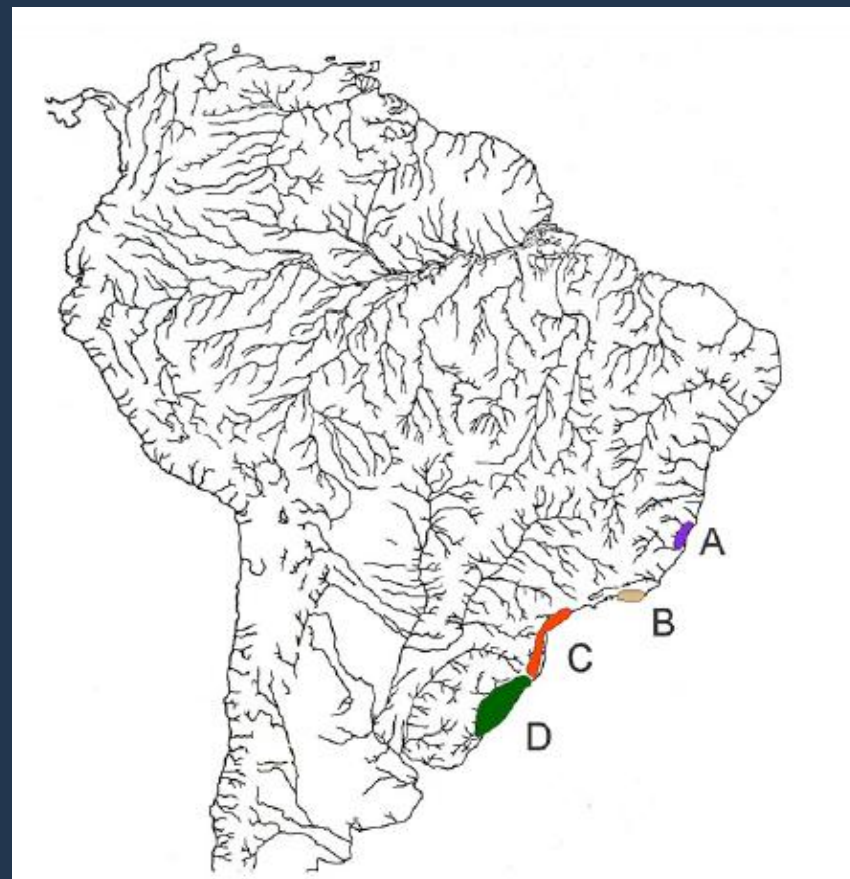
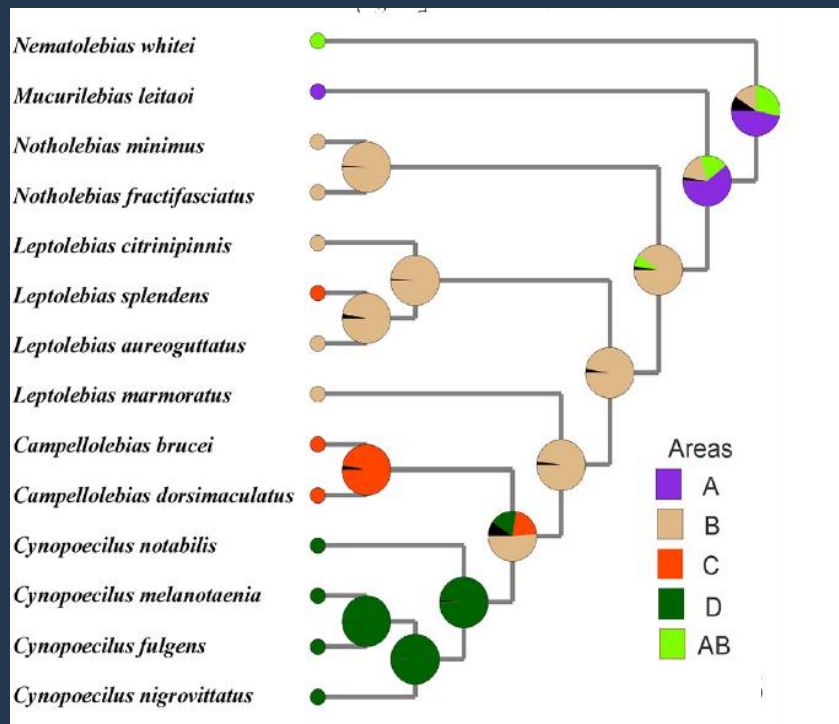


RESEARCH ARTICLE

## Inferring Evolution of Habitat Usage and Body Size in Endangered, Seasonal Cynopoeciline Killifishes from the South American Atlantic Forest through an Integrative Approach (Cyprinodontiformes: Rivulidae)

Wilson J. E. M. Costa\*

Laboratory of Systematics and Evolution of Teleost Fishes, Institute of Biology, Federal University of Rio de Janeiro, Rio de Janeiro, RJ, Brasil

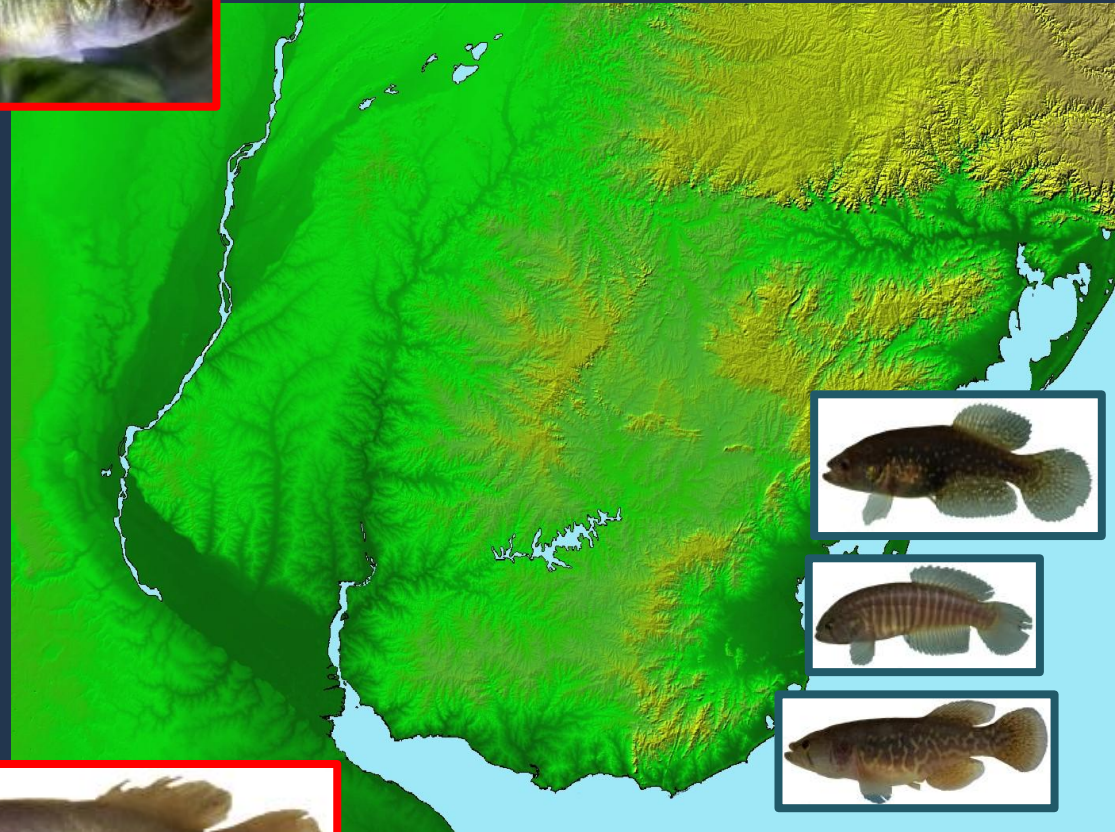
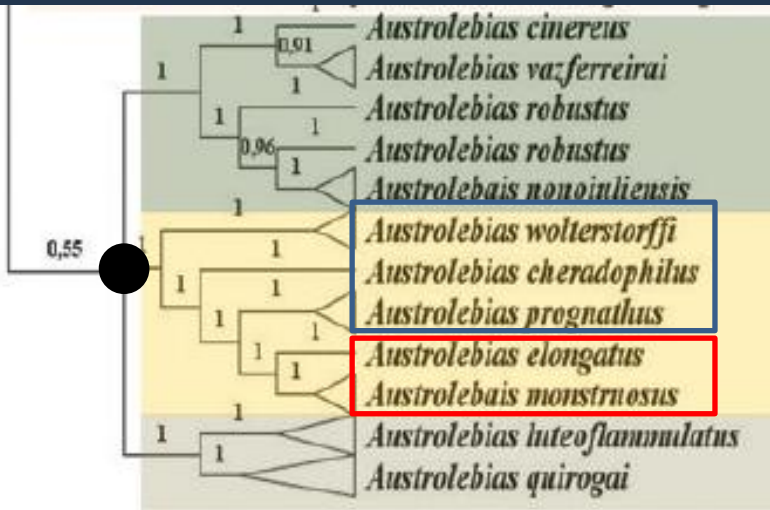




# Patos-Merín: Los cambios en el nivel del mar y las Conexiones Costeras

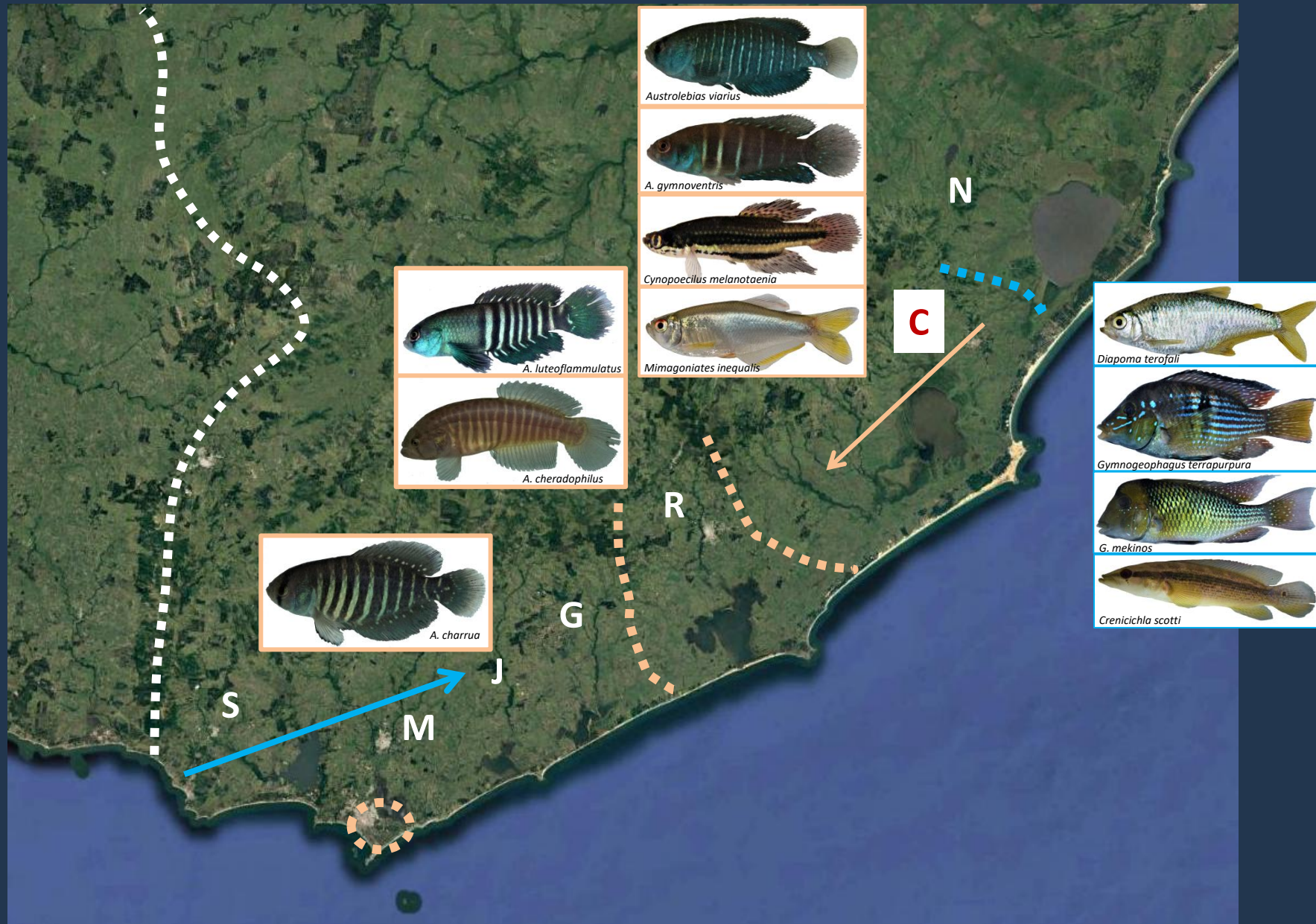


*Austrolebias*: subgénero *Megalebias*





# Patos-Merín: Los cambios en el nivel del mar y las Conexiones Costeras





# Patos-Merín: Cambios en el nivel del mar y la Invasión del pejerrey



*Copeia*, 2000(2), pp. 441–447

Population Genetics of the Silverside *Odontesthes argentinensis* (Teleostei, Atherinopsidae): Evidence for Speciation in an Estuary of Southern Brazil

LUCIANO B. BEHEREGARAY AND JOSÉ A. LEVY



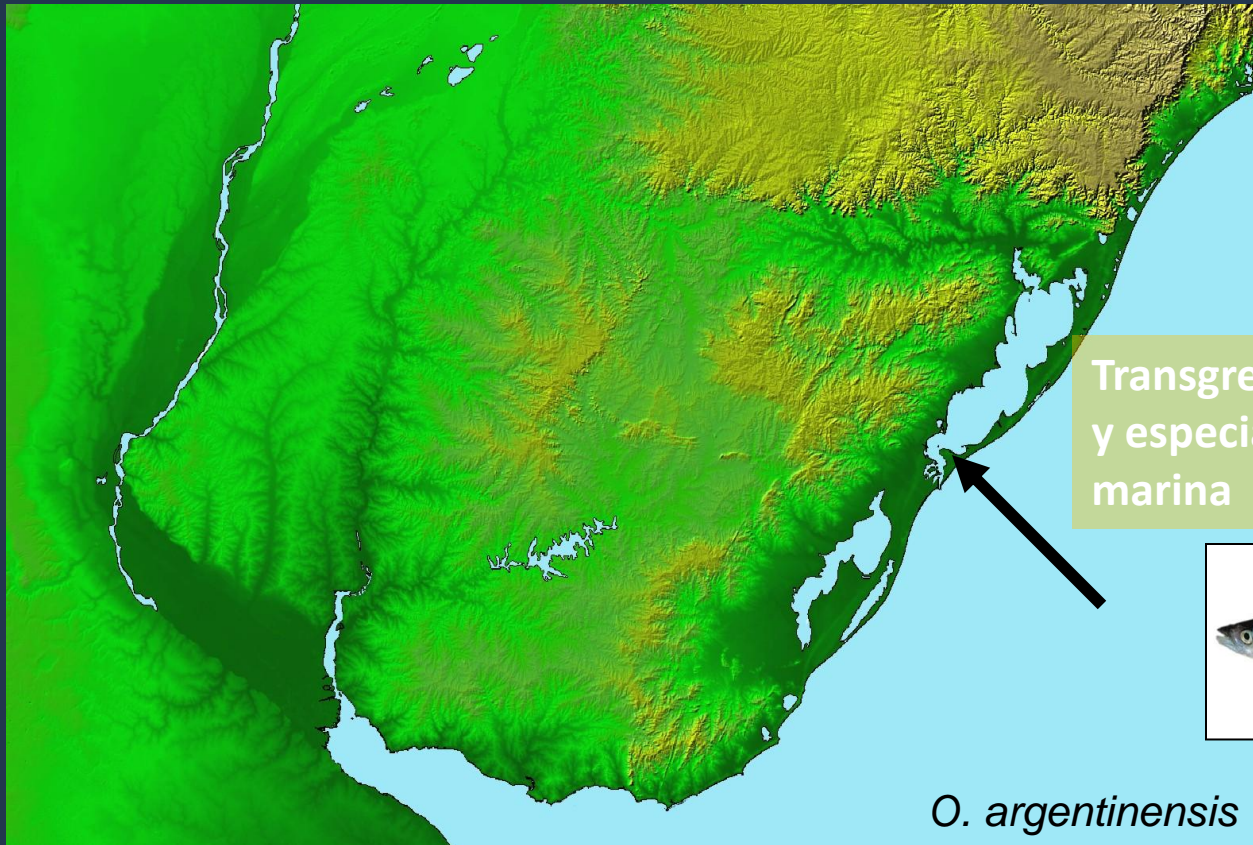
**A rapid fish radiation associated with the last sea-level changes in southern Brazil: the silverside *Odontesthes perugiae* complex**

Luciano B. Beheregaray<sup>1\*</sup>, Paul Sunnucks<sup>2</sup> and David A. Briscoe<sup>1</sup>

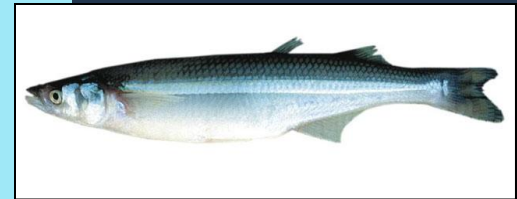
<sup>1</sup>Department of Biological Sciences, Macquarie University, Sydney, NSW 2109, Australia

<sup>2</sup>Department of Genetics, La Trobe University, Melbourne, VIC 3086, Australia

Received 14 May 2000  
Accepted 10 August 2000  
Published online 10 December 2000

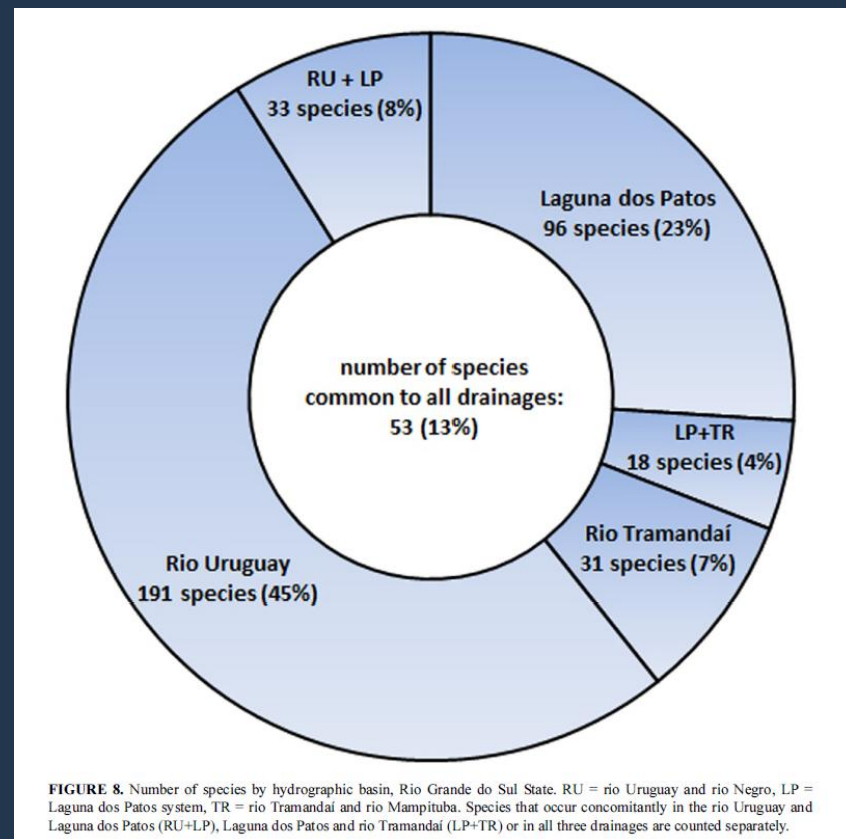


Transgresiones Marinas: Dispersión y especiación reciente de especie marina



*O. argentinensis*

# Patos Merín y cuenca del Río Uruguay: separados al nacer



**FIGURE 8.** Number of species by hydrographic basin, Rio Grande do Sul State. RU = rio Uruguay and rio Negro, LP = Laguna dos Patos system, TR = rio Tramandai and rio Mampituba. Species that occur concomitantly in the rio Uruguay and Laguna dos Patos (RU+LP), Laguna dos Patos and rio Tramandai (LP+TR) or in all three drainages are counted separately.



Zootaxa 4138 (3): 401–440  
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## Article

ISSN 1175-5326 (print edition)  
**ZOOTAXA**  
ISSN 1175-5334 (online edition)

<http://doi.org/10.11646/zootaxa.4138.3.1>

<http://zoobank.org/urn:lsid:zoobank.org:pub:14F318A9-0DCB-4DA9-BB99-65BD71E946D1>

### Inventory of the freshwater fishes from a densely collected area in South America —a case study of the current knowledge of Neotropical fish diversity

VINICIUS A. BERTACO<sup>1</sup>, JULIANO FERRER<sup>2</sup>, FERNANDO R. CARVALHO<sup>3</sup> & LUIZ R. MALABARBA<sup>2</sup>

<sup>1</sup>Museu de Ciências Naturais, Fundação Zoobotânica do Rio Grande do Sul. Av. Dr. Salvador França, 1427, 90690-000 Porto Alegre, RS, Brazil. E-mail: vbertaco@gmail.com

<sup>2</sup>Departamento de Zoologia and Programa de Pós-Graduação em Biologia Animal, Universidade Federal do Rio Grande do Sul. Av. Bento Gonçalves 9500, 90470-430 Porto Alegre, RS, Brazil. E-mail: julianoferre@bol.com.br [JF]; malabarba@ufrgs.br [LRM]

<sup>3</sup>Universidade Federal de Mato Grosso do Sul. Cidade Universitária, 79070-900 Campo Grande, MS, Brazil. E-mail: carvalhofr@gmail.com



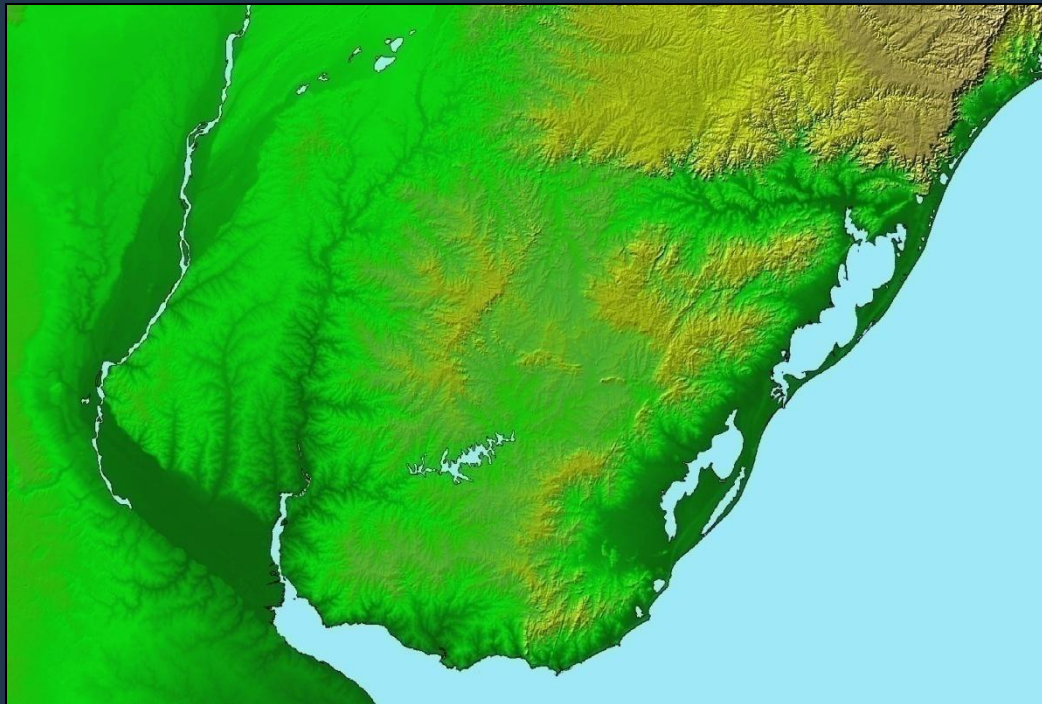
# Patos Merín y cuenca del Río Uruguay: separados al nacer



Grandes migradores actualmente restringidos a cuenca del Río Jacuí:

Si entrada por el Paraná y luego extinción: reciente y asociada a los cambios en los niveles del mar.

Si entrada por el Uruguay medio: antiguo y asociada a baxamiento perisférico del extremo sur del macizo brasileño (Neogeno temprano 20 millones de años)

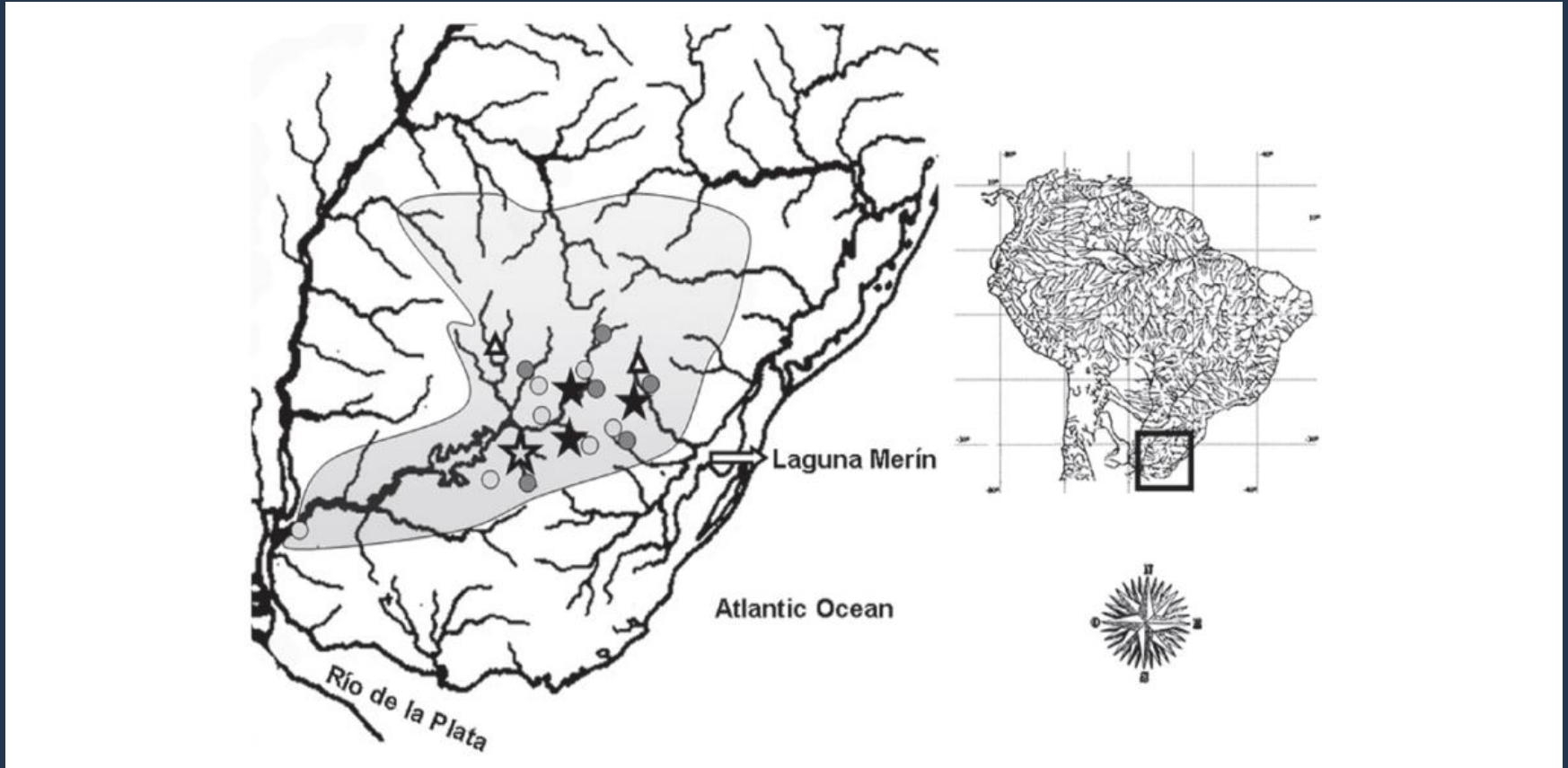


*Salminus brasiliensis*  
*Leporinus obtusidens*  
*Prochilodus lineatus*

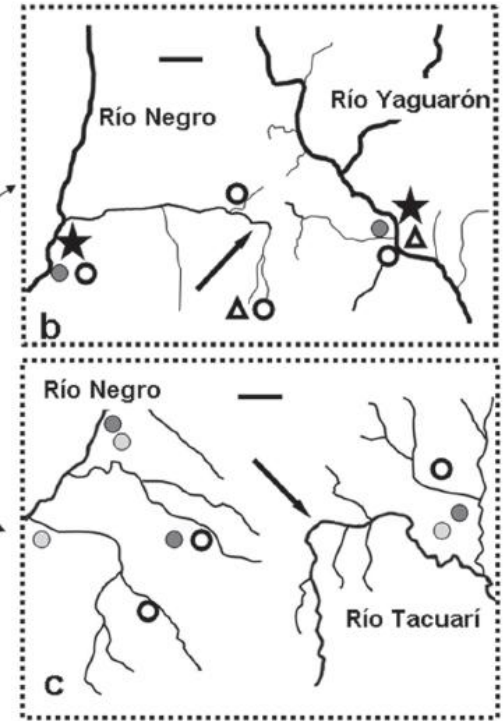
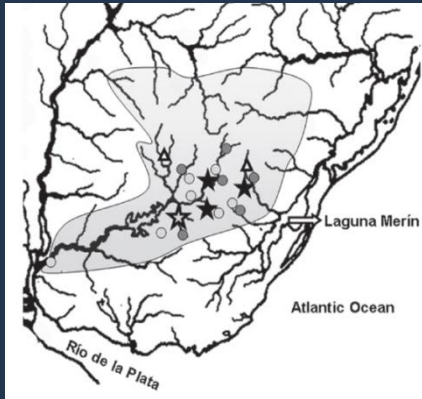
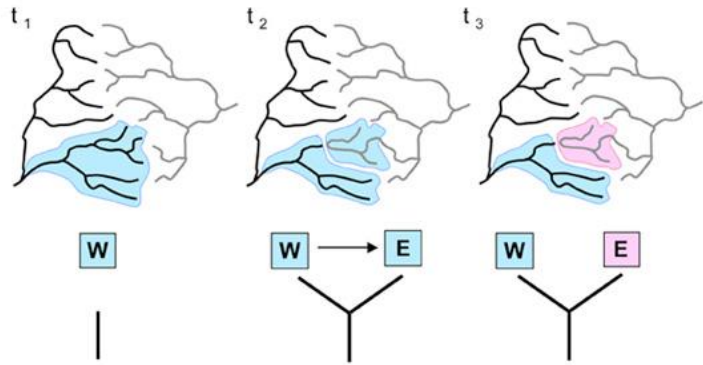




## Distribución de 5 taxa del género *Austrolebias*



# Reordenamiento de los sistemas de drenaje



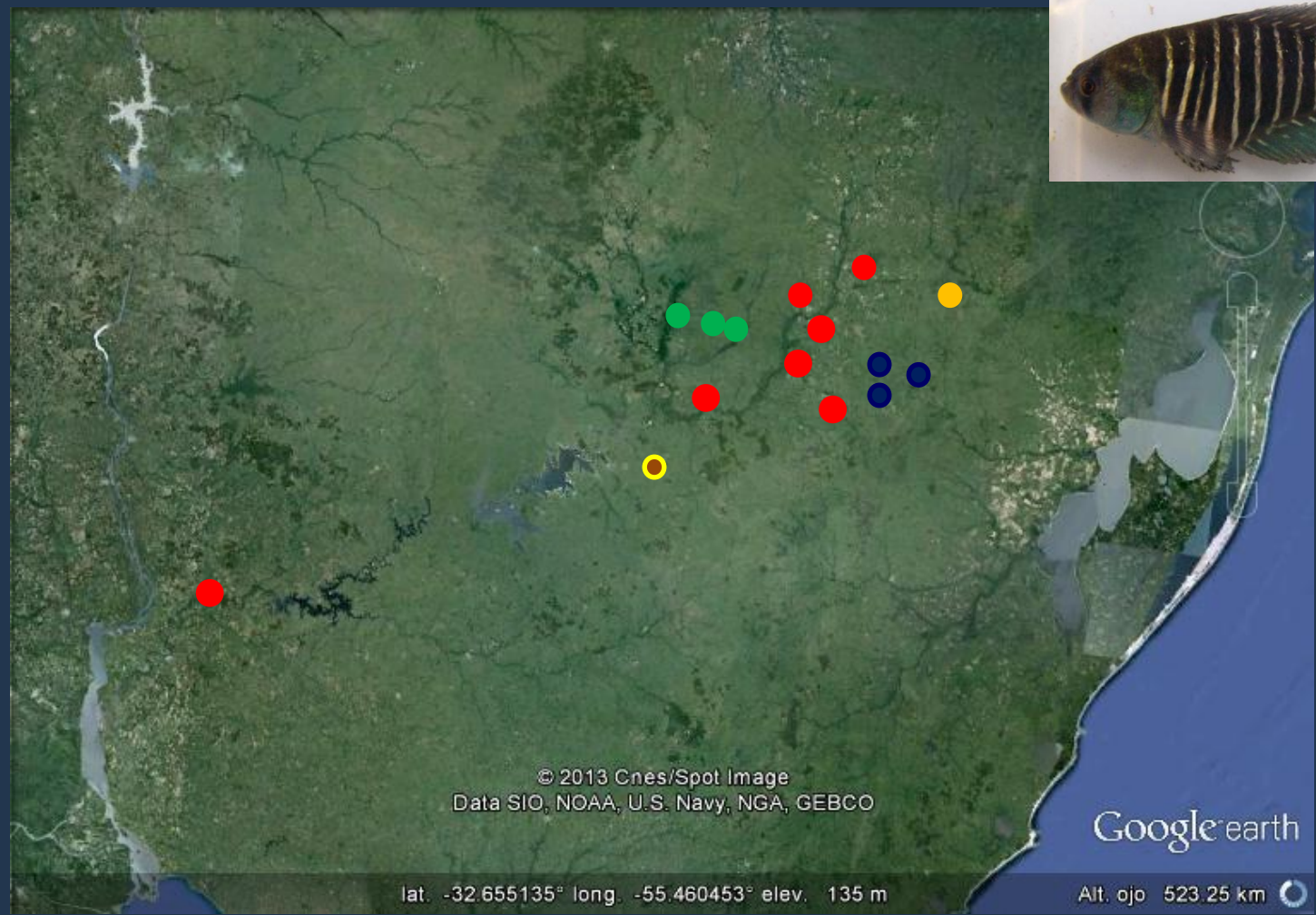
Evidencias biogeográficas, filogenéticas y filogeográficas en el género *Austrolebias* que apuntan a los reordenamientos de los sistemas de drenaje, asociados al margen pasivo de la placa Sudamericana, como responsables de elevar la diversidad en Patos-Merín, y a la cuenca alta del Río Negro (Uruguay medio) como fuente de esa diversidad.



# Patos-Merín: Reordenamiento de los sistemas de drenaje



Filogeografía de *Austrolebias arachan*: Stareczek et al. (en prep)



# Patos-Merín: Reordenamiento de los sistemas de drenaje



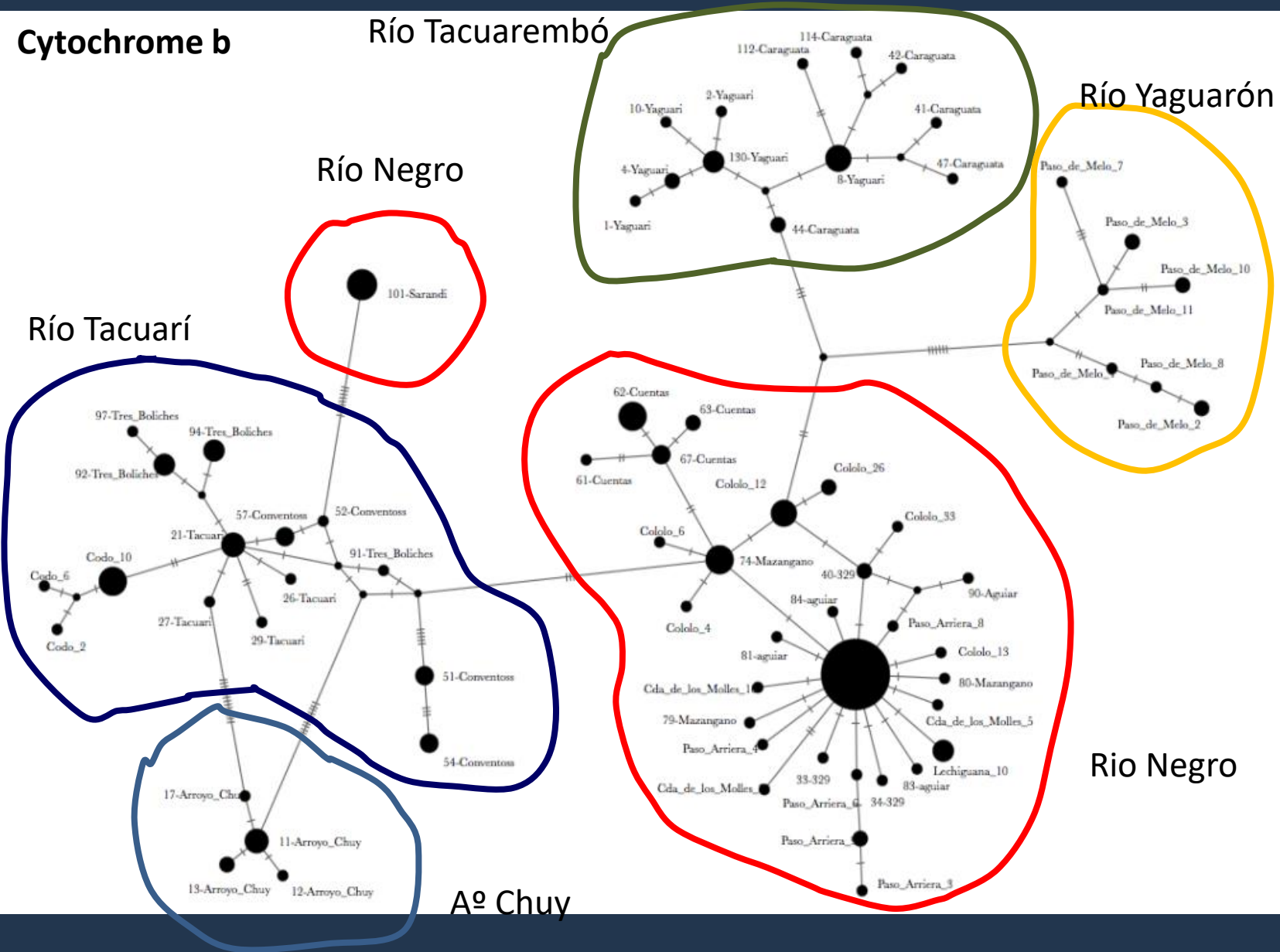
Cytochrome b

Río Tacuarembó

Río Negro

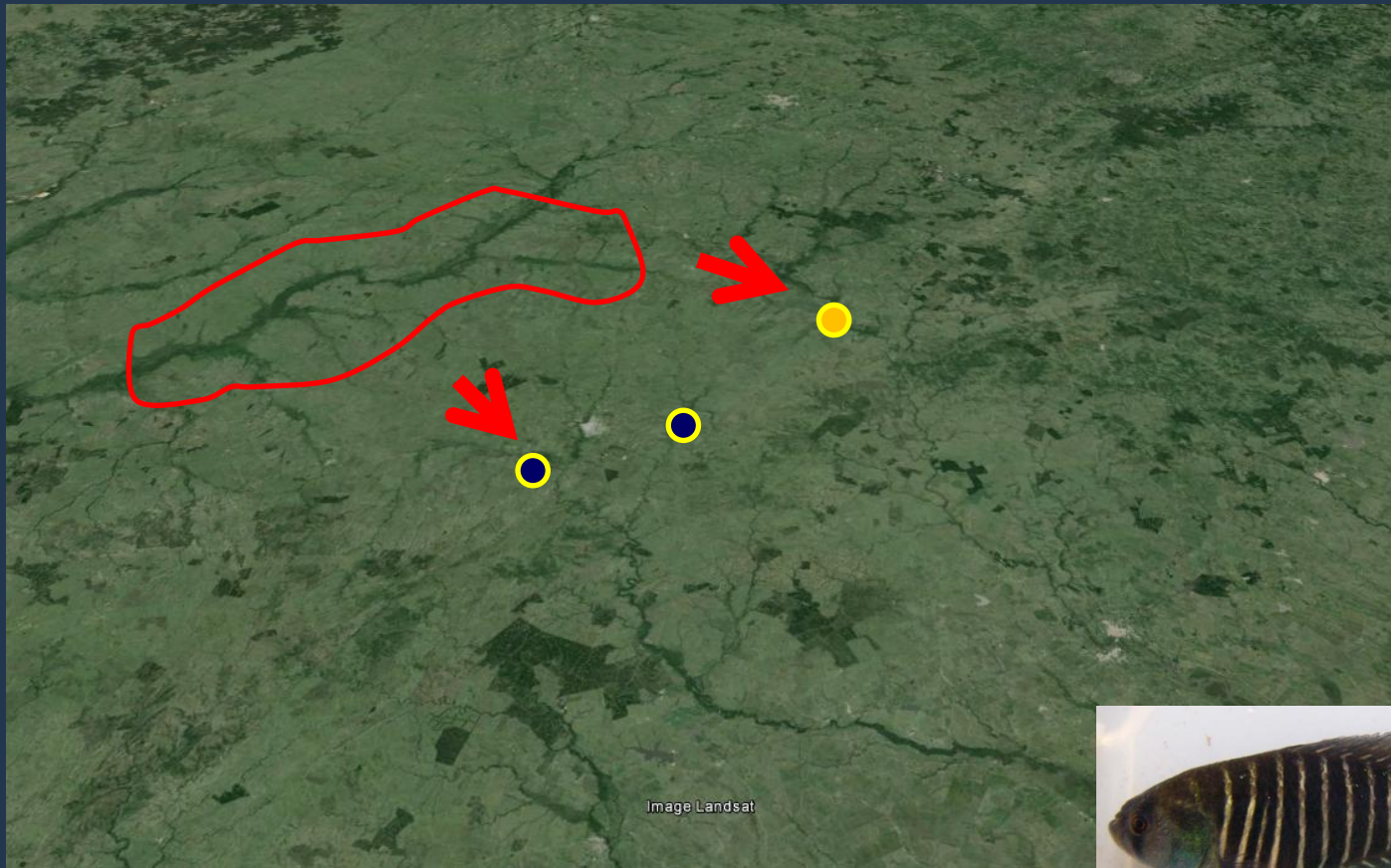
Río Yaguarón

Río Tacuarí





Capturas de cuenca: no solo un corredor sino un generador de diversidad intraespecífica?

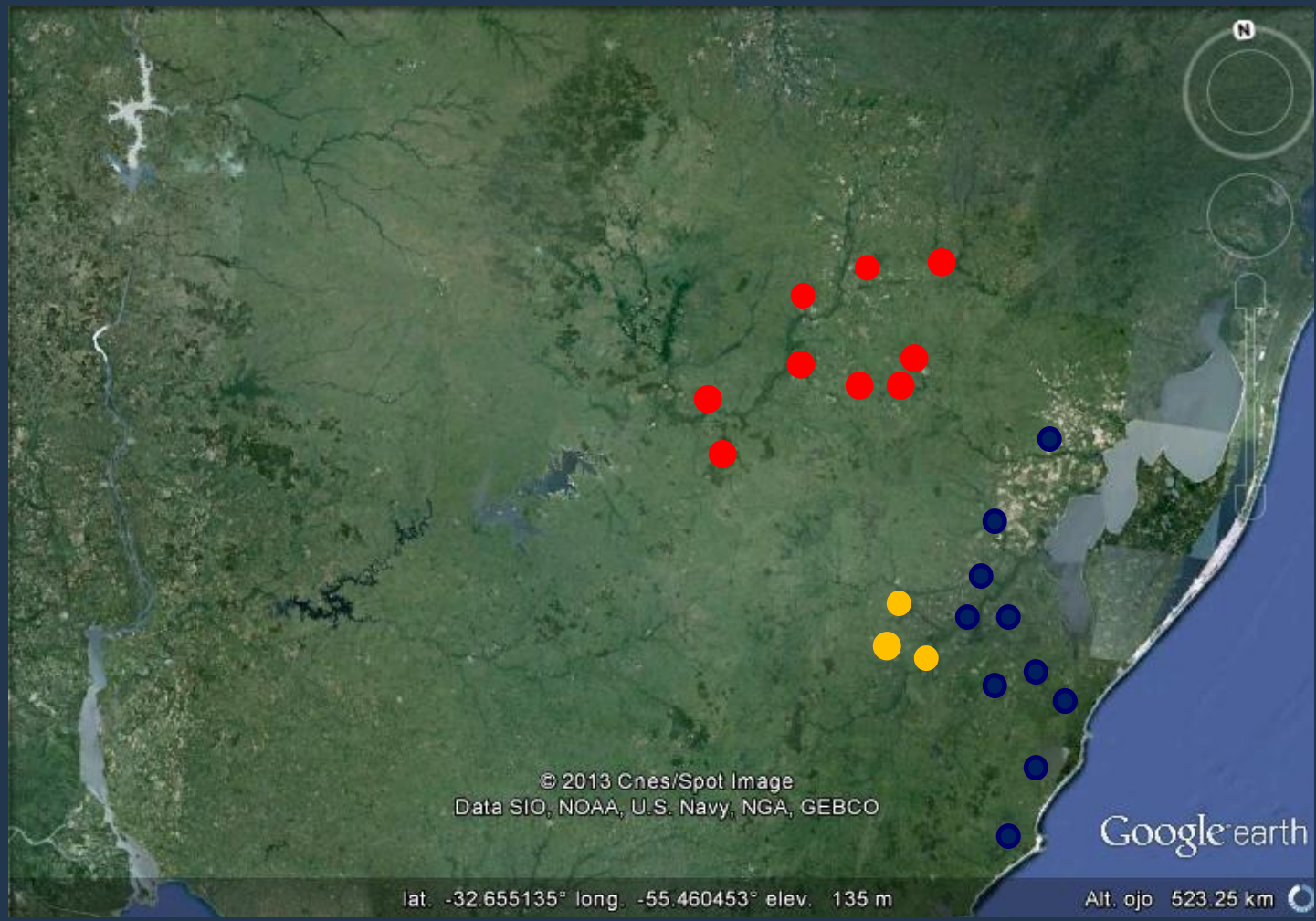




# Patos-Merín: Reordenamiento de los sistemas de drenaje



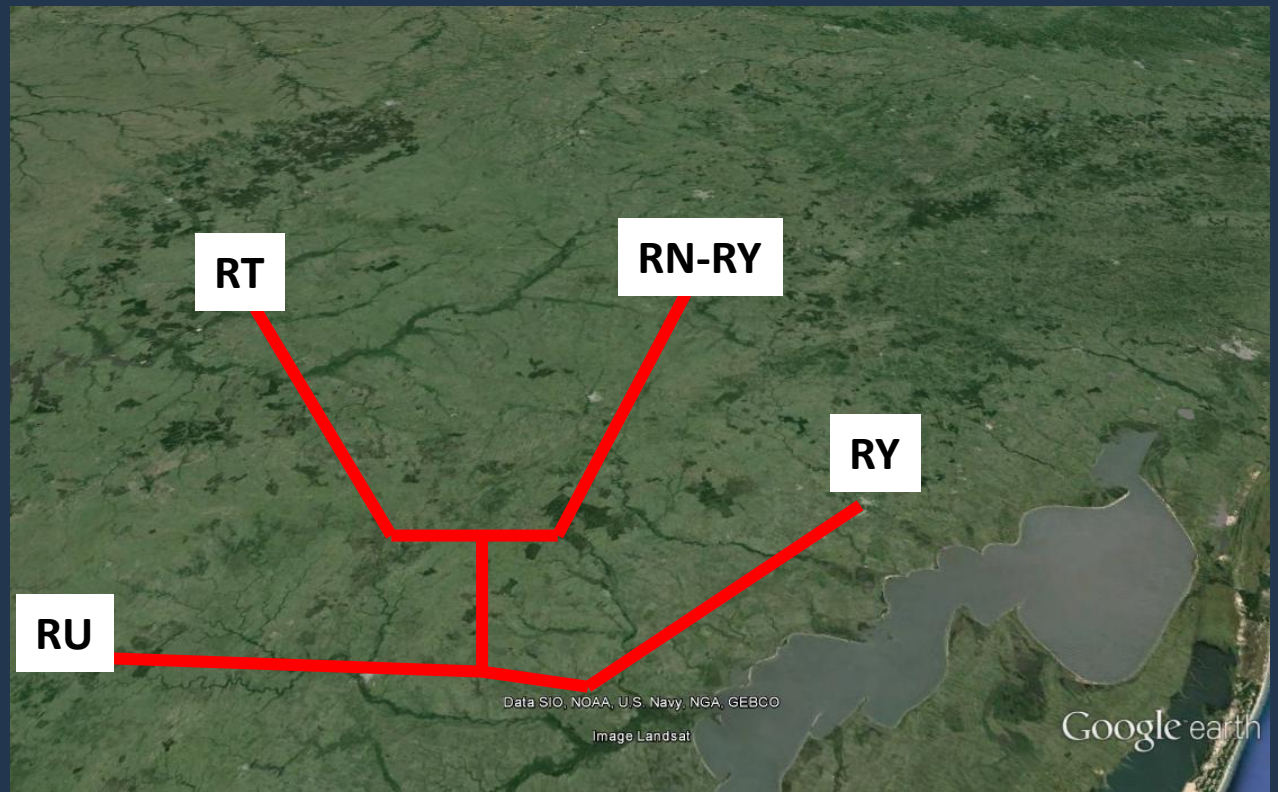
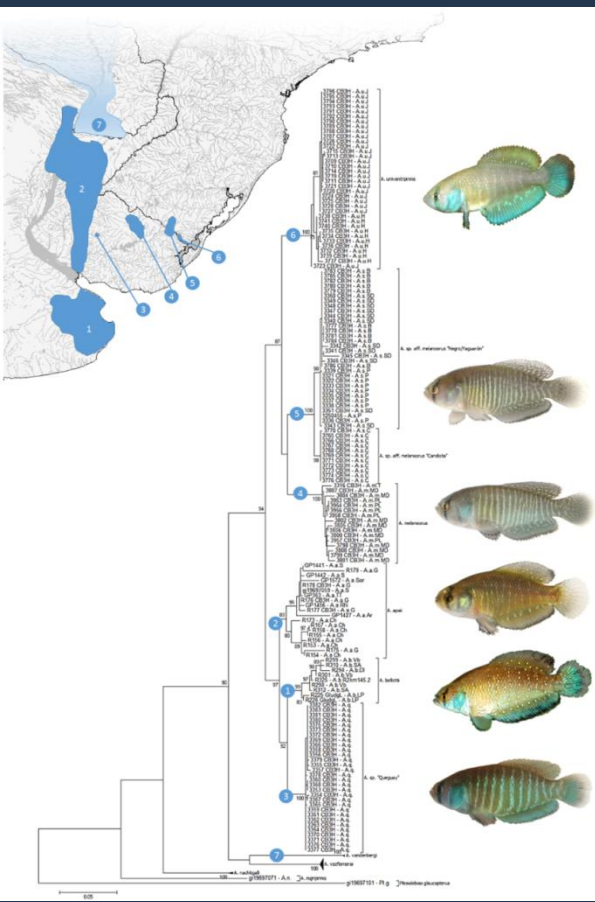
Duarte et al. (en prep) *A. luteoflamulatus*-*A. quirogai*







## Serra et al in prep: grupo de especies “*A. bellotti*”

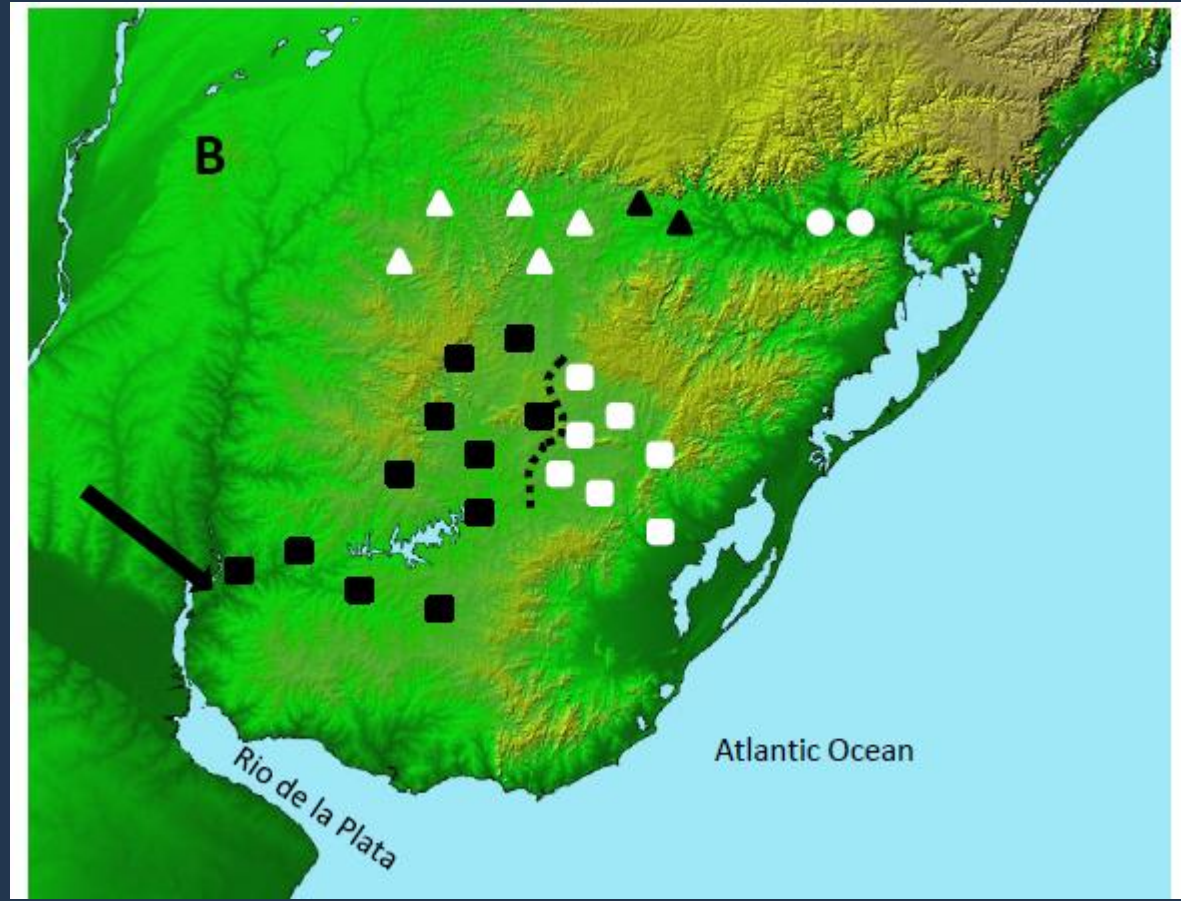




# Patos-Merín: Reordenamiento de los sistemas de drenaje



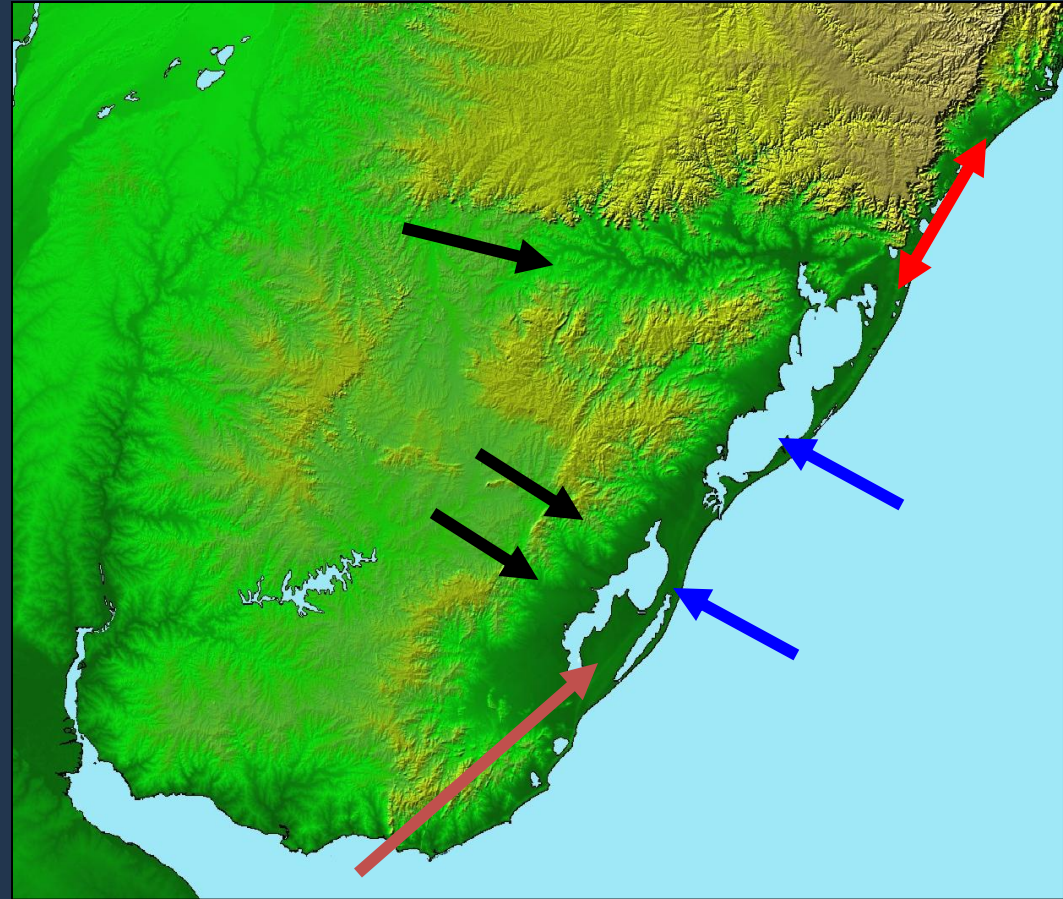
Grupo de especies “*A. affinis*”





## Origen de ictiofauna Patos Merín:

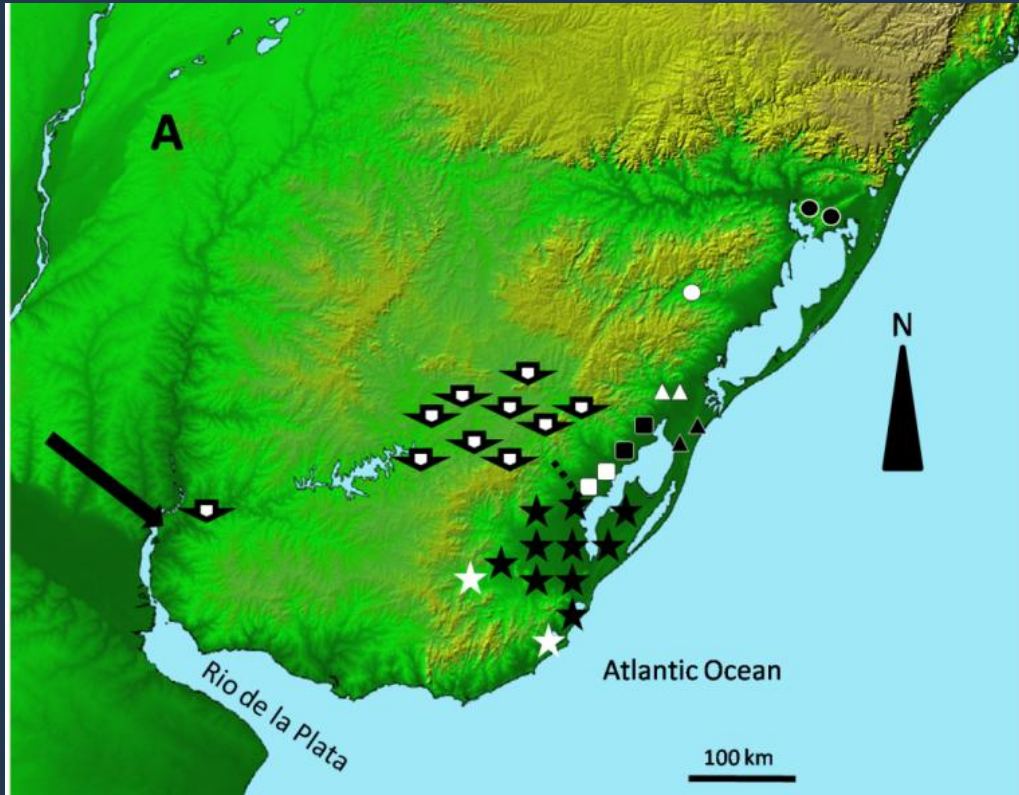
1. Cuenca Río Uruguay-captura de cuencas.
2. Cambios en nivel del mar: conexiones entre cursos costeros.
3. Cambios en nivel del mar: invasión de especies marinas.
4. Procesos internos asociados o no cambios en el nivel del mar.







## *Austrolebias* (Cyprinodontiformes, Rivulidae)



### Grupo de especies “*A. adloffii*”

*A. arachan*

*A. charrua*

*A. reicherti*

*A. natchigalli*

*A. minuano*

*A. nigrofasciatus*

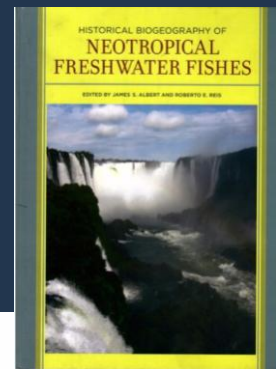
*A. bagual*

*A. adloffii*





# Algunos Patrones Macroecológicos



## Ecoregiones dulceacuícolas (Abell et al. 2008):



FIGURE 2.14 Geographic partitions of the freshwater ecoregions of tropical South America. A. Ecoregions grouped by major river basin and zoogeographic province. B. (on next page). Ecoregions grouped into the Amazon-Orinoco-Guiana (AOG) Core (species-rich, low endemism) and Andean Periphery (species-poor, high endemism).



FIGURE 2.1 Freshwater ecoregions of tropical South America (after Abell et al. 2008). Ecoregion limits delineated primarily by watershed boundaries (hydrogeographic basins). Ecoregions and associated geographic data are listed in Table 2.1.

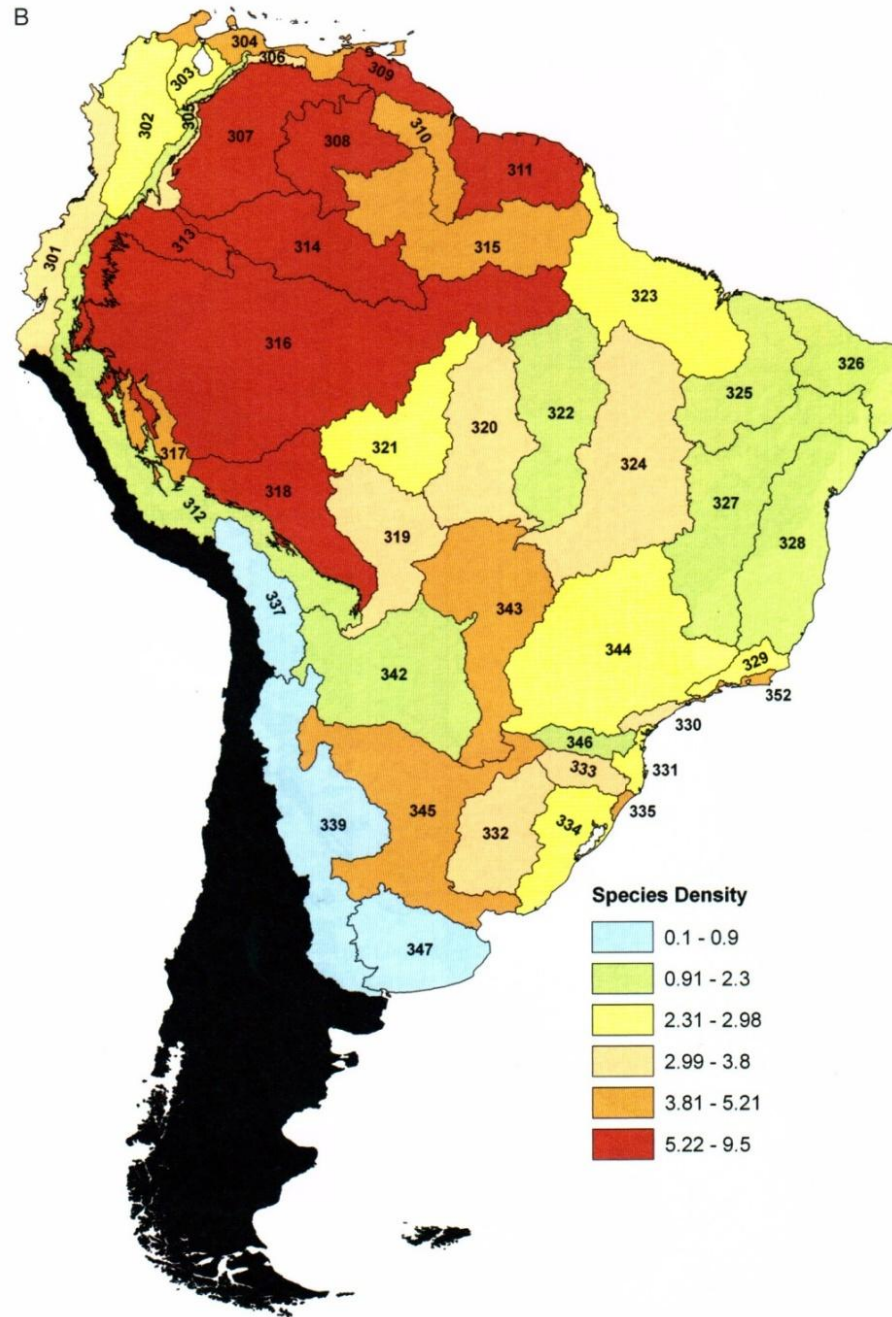
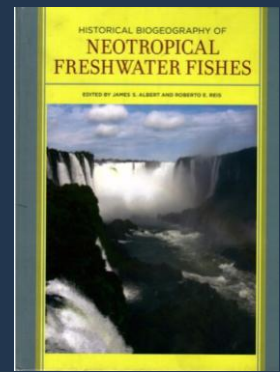


FIGURE 2.7 Continued.



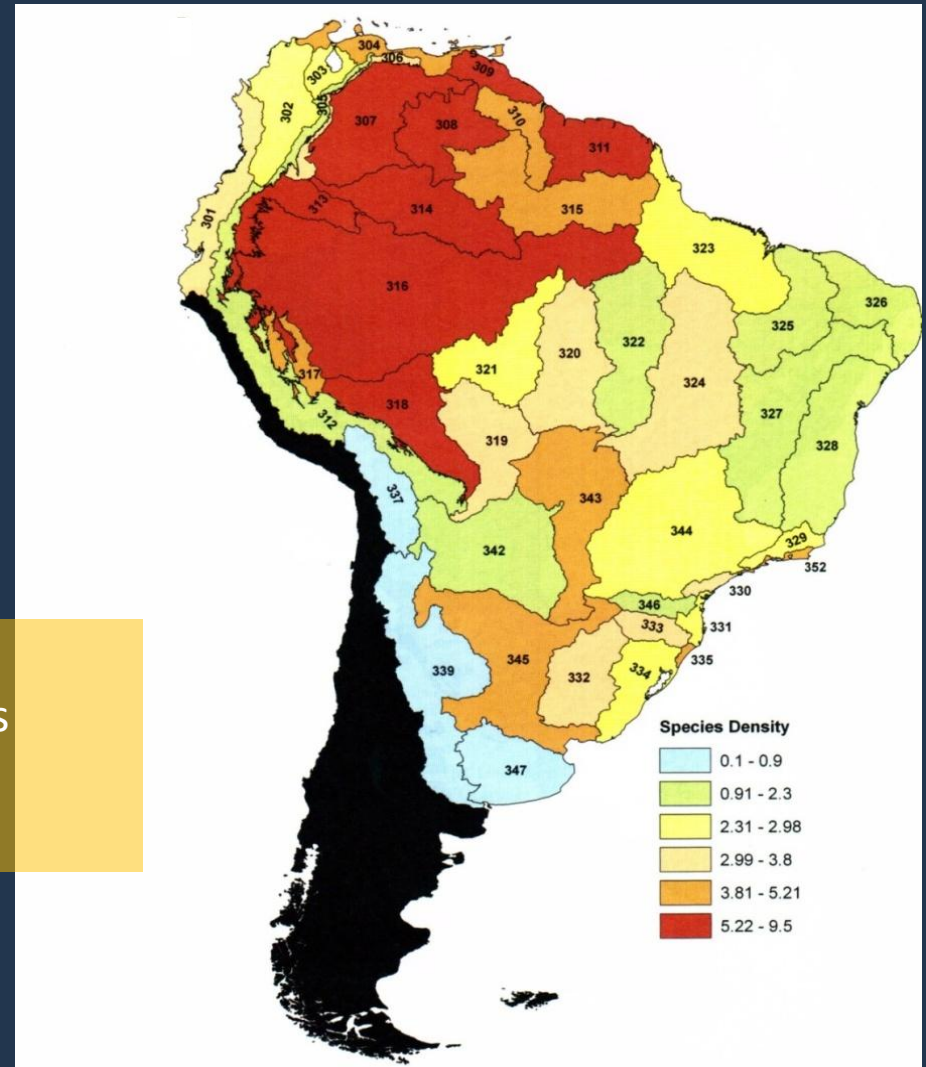


## Patos-Merín: Gradientes de Diversidad

Contrariamente a lo que ocurre a nivel general, donde la densidad total de peces es menor que en áreas adyacentes como el Uruguay medio y el Eje Potámico Subtropical, esta región presenta un mayor número de especies de peces anuales (*Austrolebias* + *Cynopoecilus*).

### *Austrolebias*:

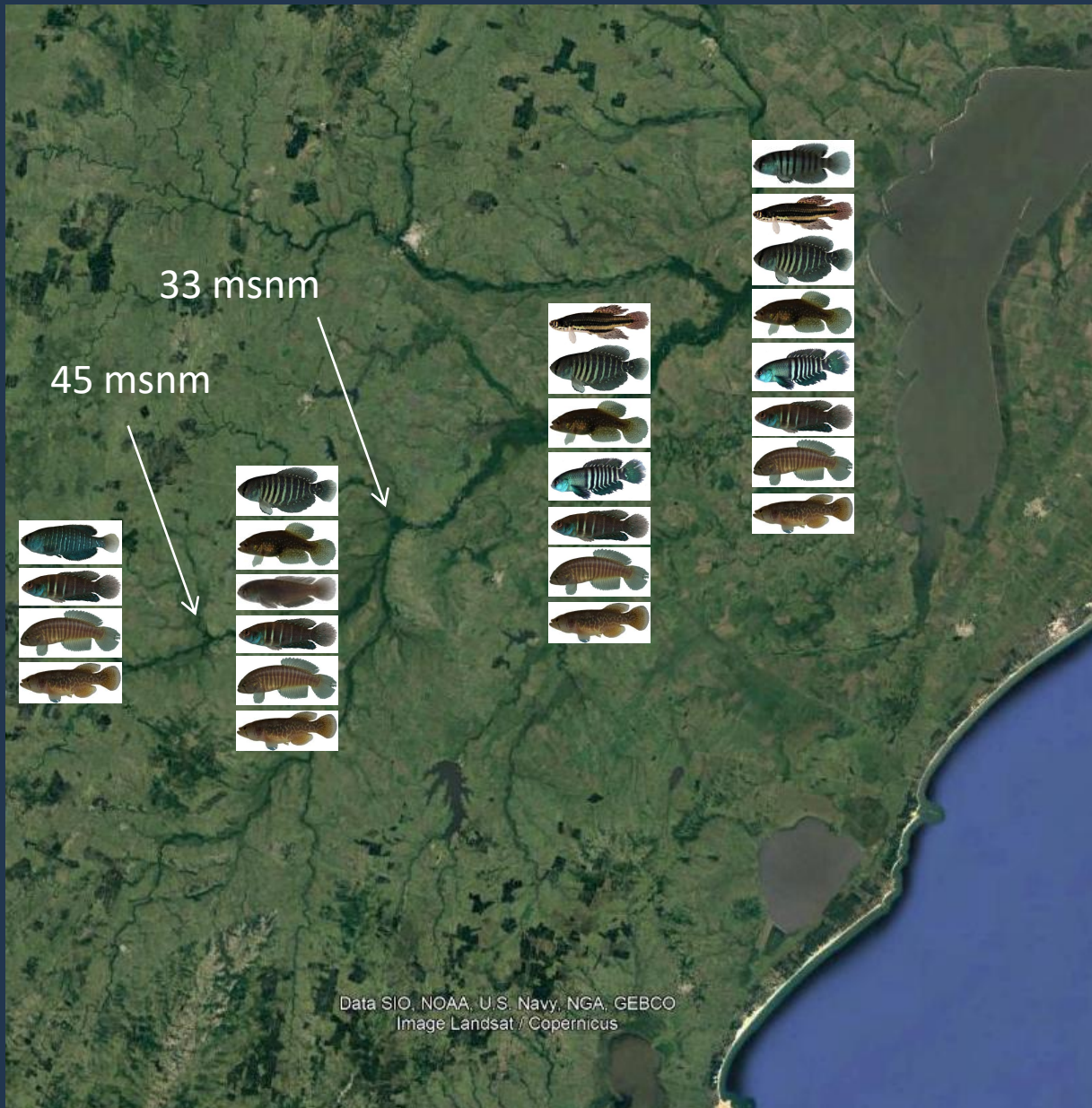
- Eje Potámico Subtropical = 10 especies
- Río Uruguay bajo = 14-15 especies
- Patos-Merín = 21 especies





Cuenca del Río Cebollatí: 10 especies de peces anuales en menos de 20.000 km<sup>2</sup>

- Austrolebias varius*
- Austrolebias gymnoventris*
- Austrolebias cheradophilus*
- Austrolebias prognathus*
- Austrolebias charrua*
- Austrolebias aff quirogai*
- Austrolebias wolterstorffi*
- Austrolebias luteoflammulatus*
- Austrolebias reicherti*
- Cynopocilus melanotaenia*

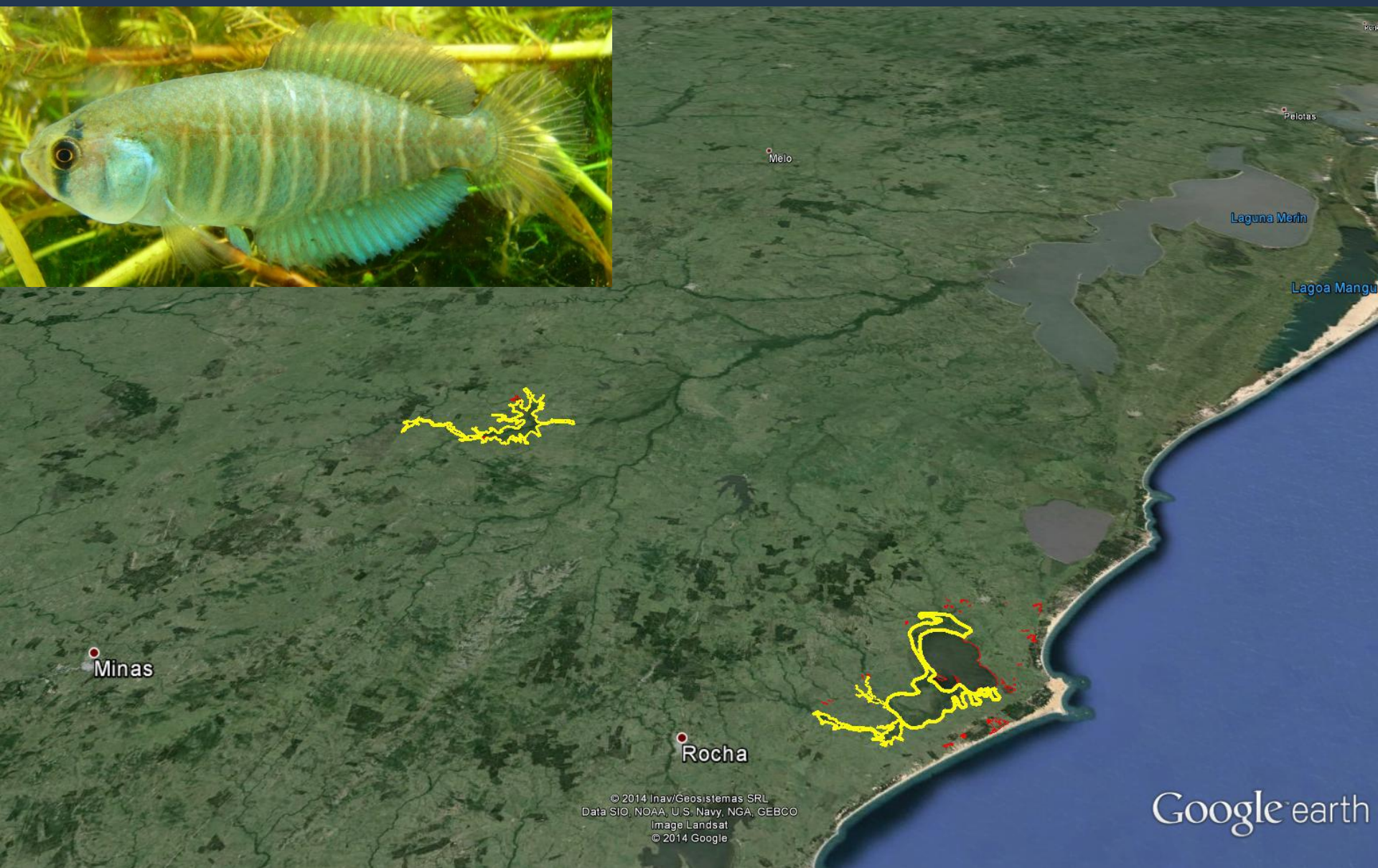




# Patos-Merín: Especies relictuales?



*Austrolebias viarius*

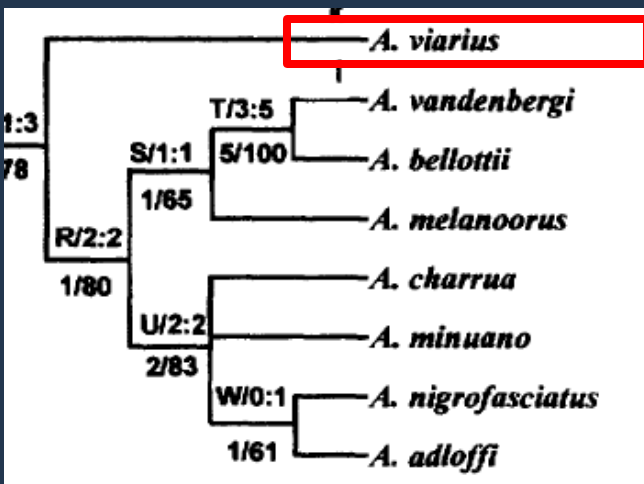


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Data SIO, NOAA, U.S. Navy, NGA, GEBCO  
Image Landsat  
© 2014 Google

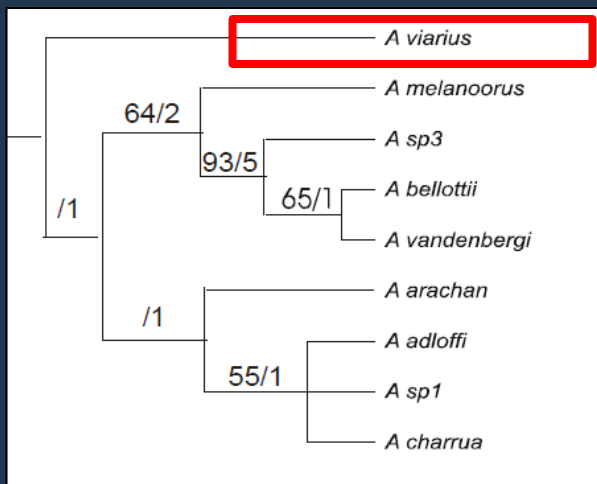
Google earth



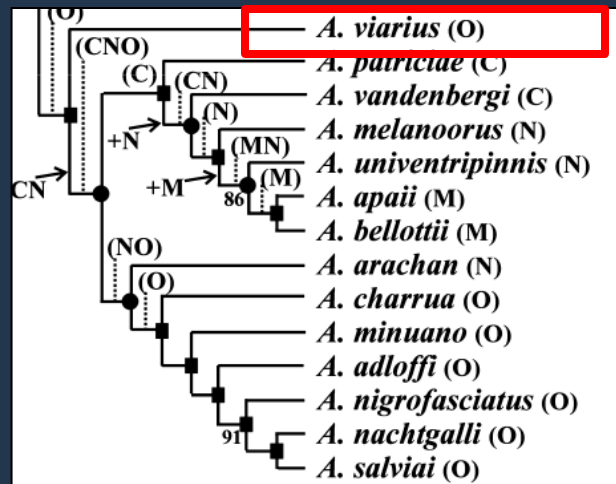
# Patos-Merín: Especies relictuales?



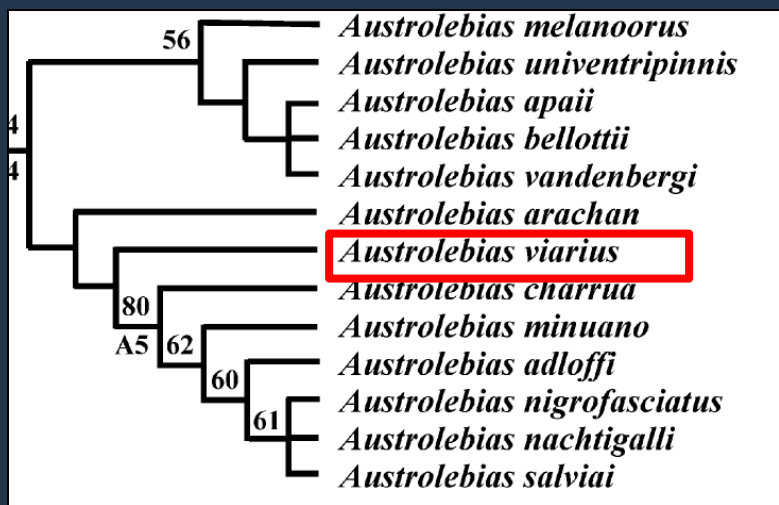
Costa 2002 Morf



Loureiro 2004 Morf



Costa 2006 Morf



Costa 2010 Morf



García et al 2014 Cit b

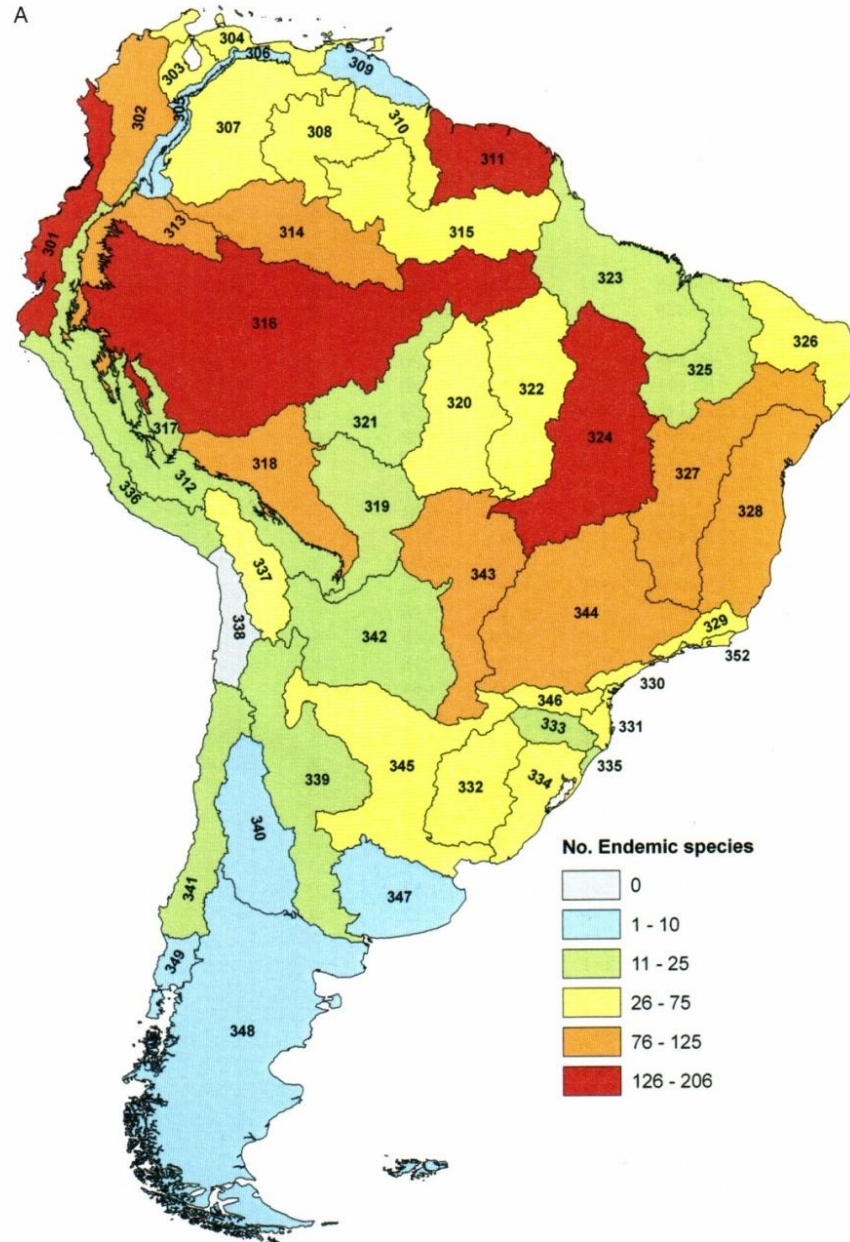


FIGURE 2.8 Patterns of species endemism in South American freshwater fishes. A. Number of species endemic to ecoregions ( $S_e$ ). B. Percent endemism ( $\%S_e$ ) as proportion of total fauna endemic to that ecoregion. Note that percent endemism is highest in the continental periphery.

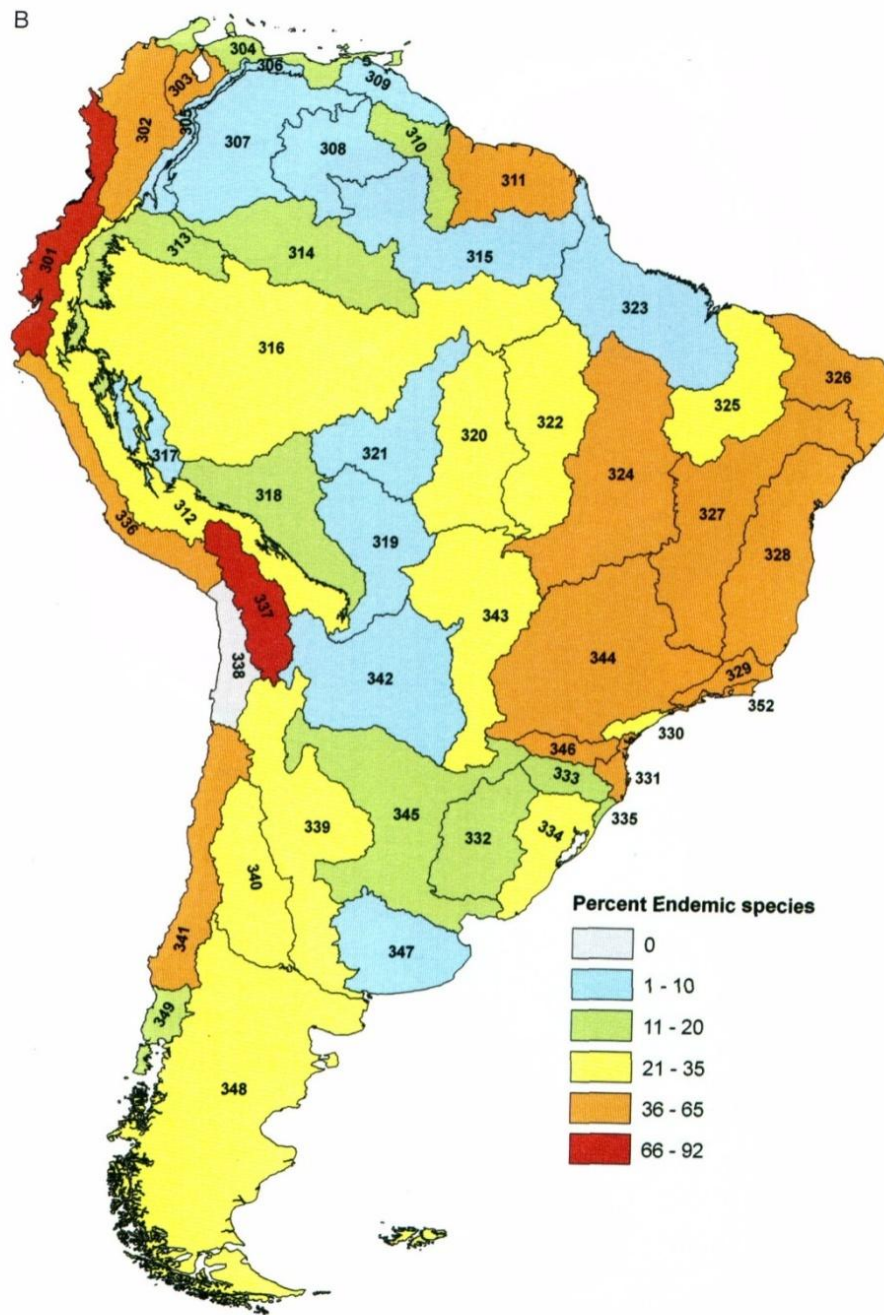
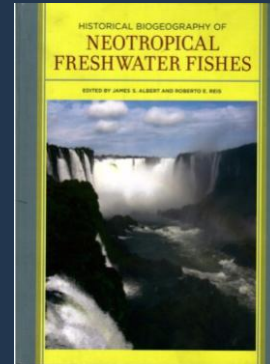


FIGURE 2.8 Continued.





# Patos-Merín: Areas de endemismo anidadas

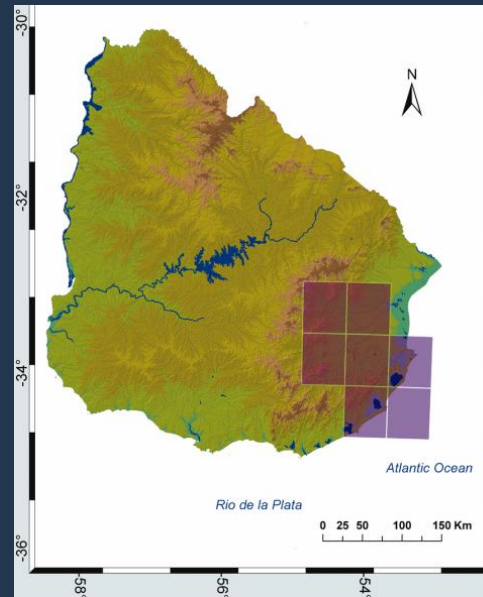
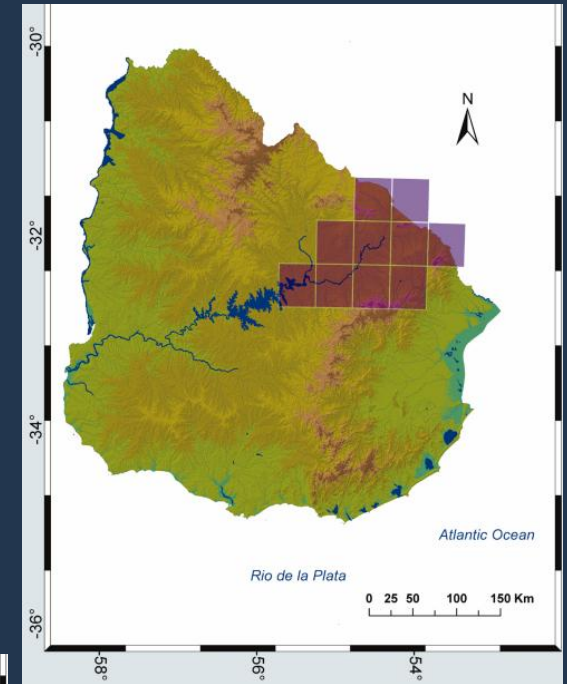


## Bessonart et al (2021)

Análisis NDM/VNDM (Szumik et al. 2002; Goloboff 2004; Szumik & Goloboff 2004, 2007)

Cuadrículas 0.25 x 0.25 de grado

Matriz Presencia Ausencia: Base de datos Colecciones de Peces de Facultad de Ciencias y Museo Nacional de Historia Natural.

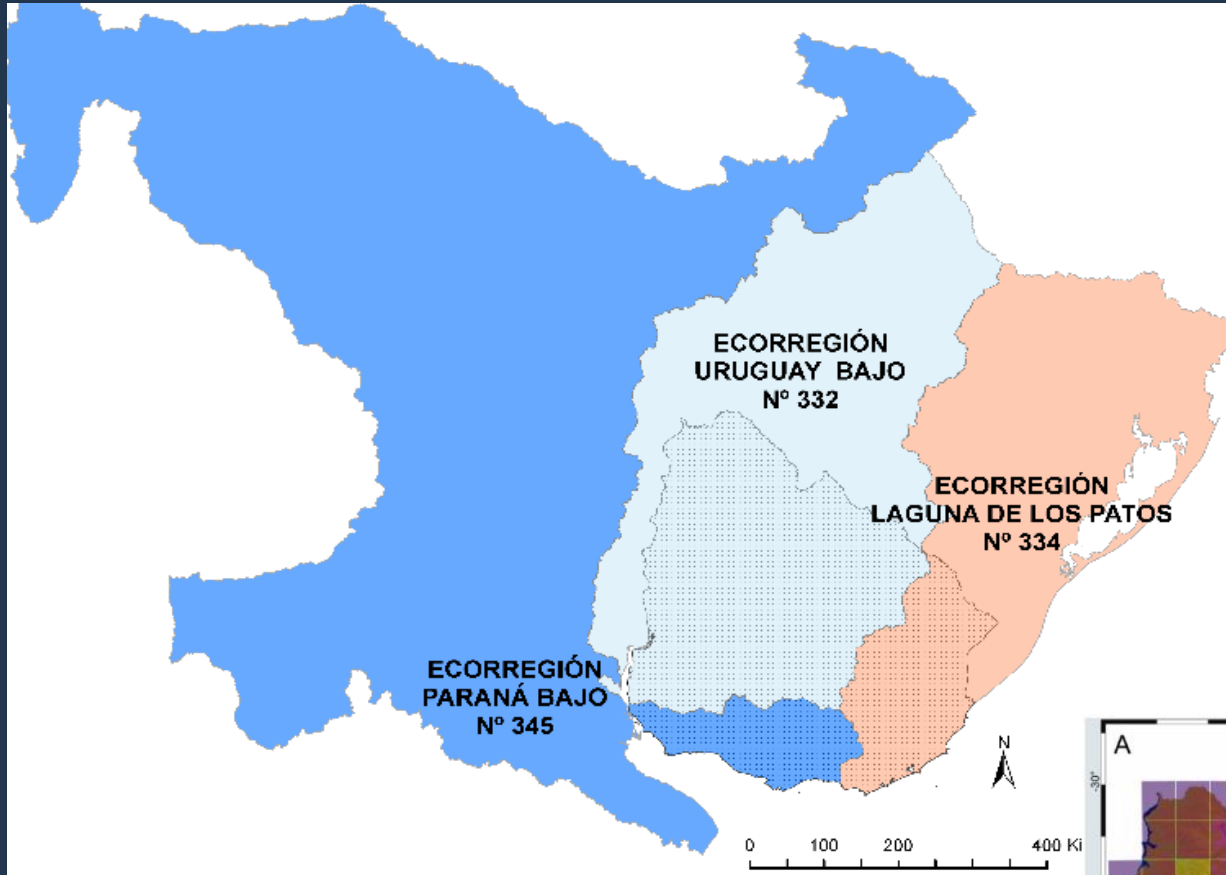


Neotropical Ichthyology Original article <https://doi.org/10.1590/1982-0224-2020-0163>

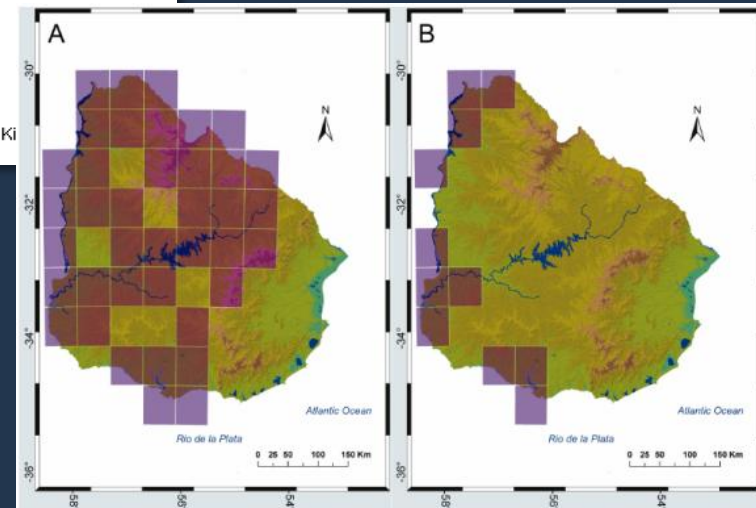
**Distribution of freshwater fish from the Southern Neotropics reveals three new areas of endemism and show diffuse limits among freshwater ecoregions**

Correspondence: José Bessonart<sup>1</sup>, Marcelo Loureiro<sup>1</sup>, José Carlos Guerrero<sup>2</sup> and Claudia Szumik<sup>3</sup>  
marcelo@fciem.edu.uy

Aprox. 270 especies distribuidas en 3 ecorregiones; 3?



	S	"E"
Uruguay	275	3
PB	83	0
UB	229	108
LP	95	38



Neotropical **Ichthyology** Original article <https://doi.org/10.1590/1982-0224-2020-0153>

Distribution of freshwater fish from the Southern Neotropics reveals three new areas of endemism and show diffuse limits among freshwater ecoregions

Correspondence: José Bessonart<sup>1</sup>, Marcelo Loureiro<sup>1</sup>, José Carlos Guerrero<sup>2</sup> and Claudia Szumik<sup>3</sup>  
marcelo@fciem.uba.uy



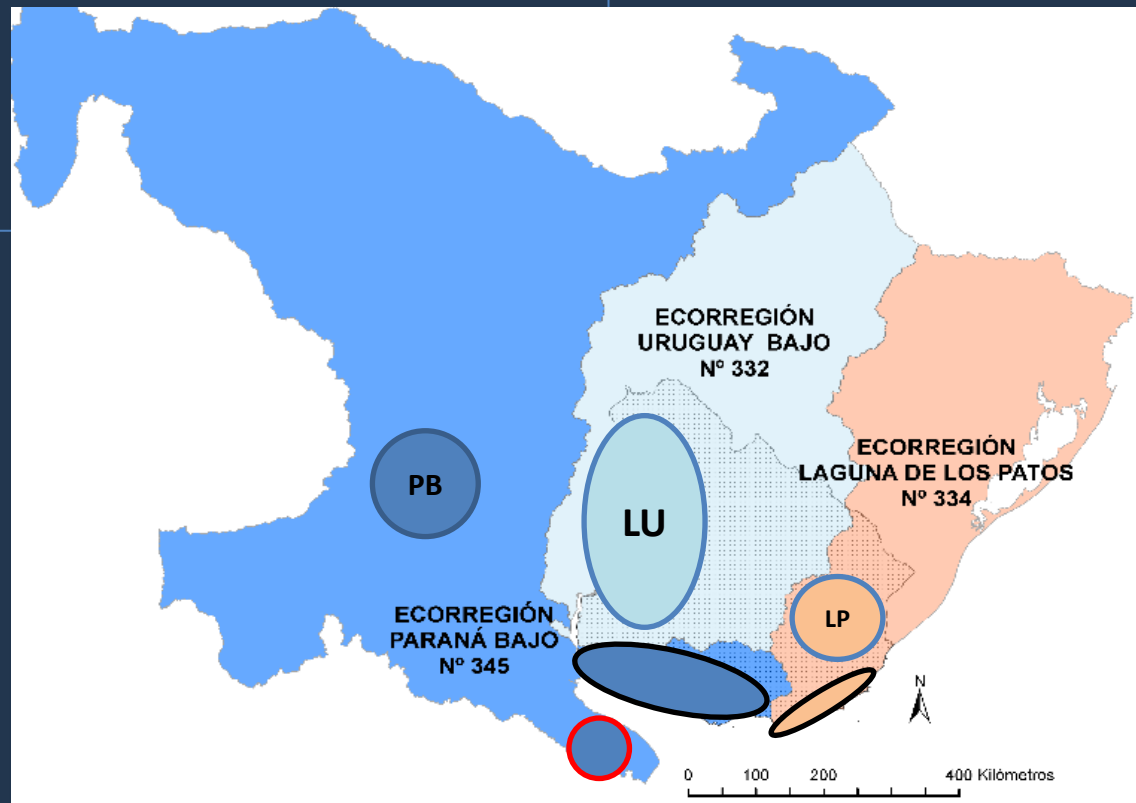
Cluster analyses based on collection records from Uruguay and literature records from Argentina (Demonte & Arias, 2005; Paracampo et al., 2015; Bértora et al., 2018) show some clues about the nature of these limits and the internal structure of the area.

## Cluster Analysis

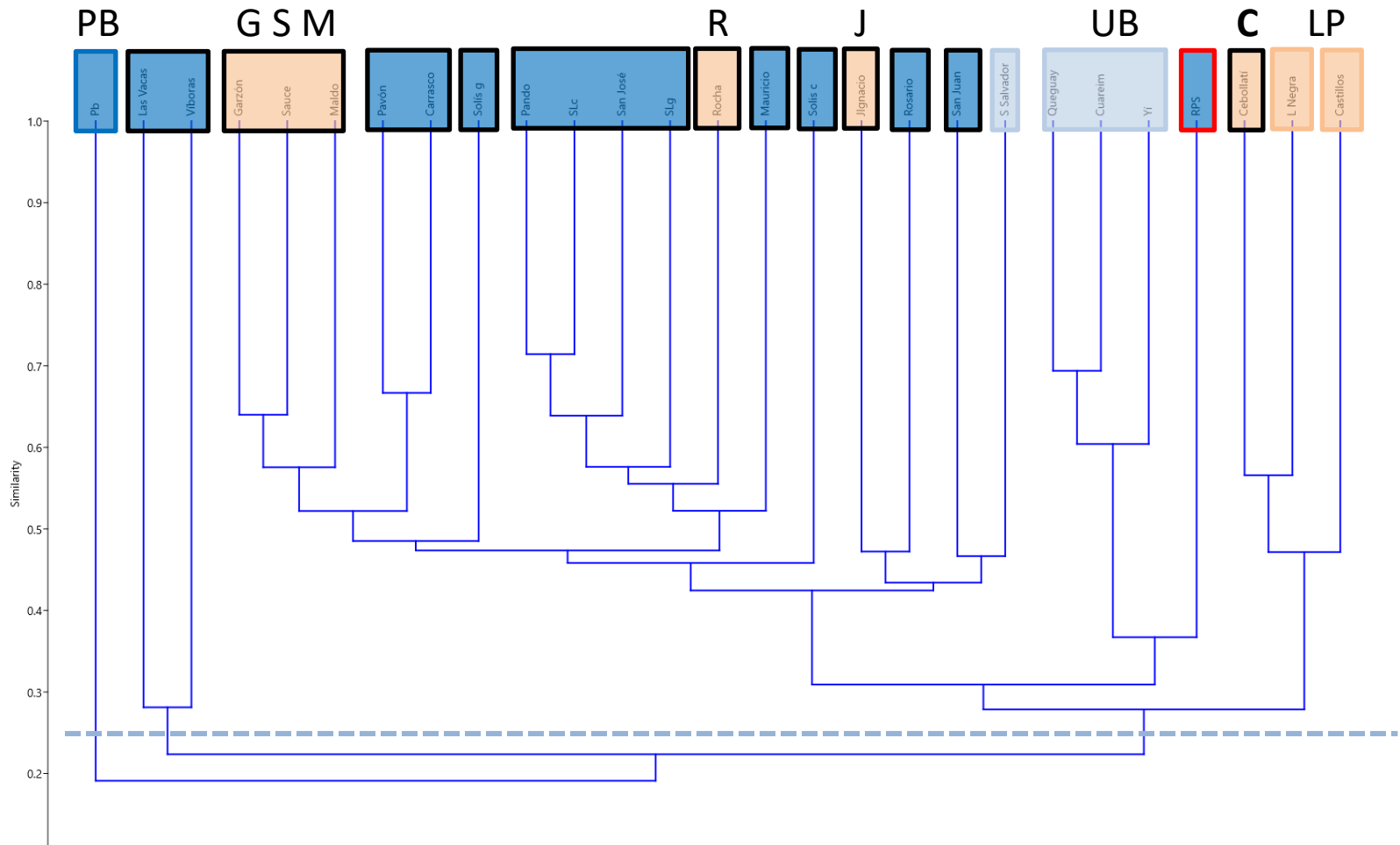
Precense-Absence matrix of 7000 records (147 spp in 27 basins from the three ecoregions):

- 1 Lower Paraná (Paraná river PB)
- 1 Lower Paraná (southern Río de la Plata tributaries, Argentina)
- 13 Paraná bajo (northern Río de la Plata tributaries, Uruguay)
- 4 Lower Uruguay (UB)
- 2 Laguna dos Patos (Merín lagoon LP)
- 6 Laguna dos Patos (Atlántic Ocean tributaries)

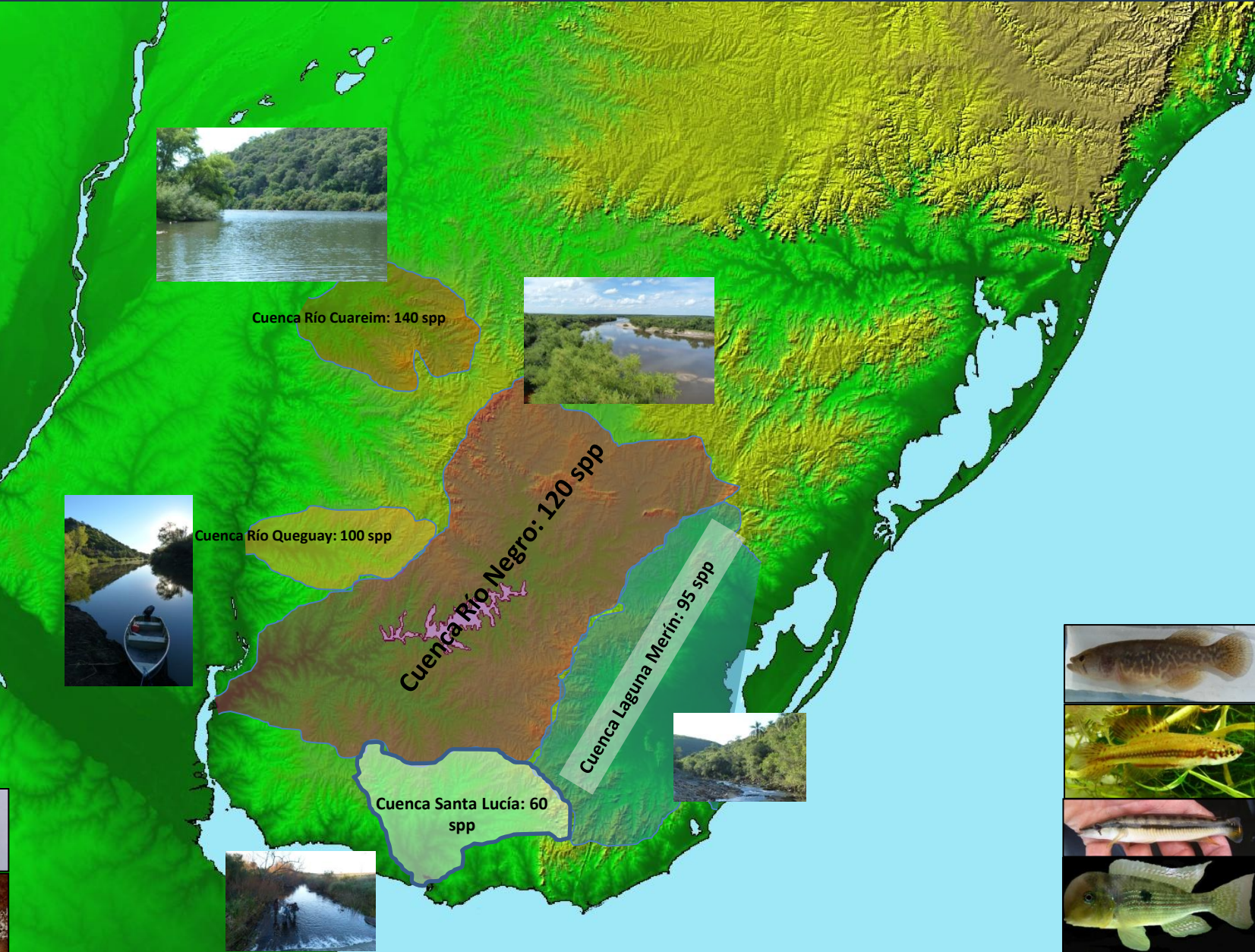
Grouping algorithm= UPGMA  
Similarity Index = Jaccard







# En base a investigaciones de campo y la base de datos de las colecciones de Peces de la Facultad de Ciencias y Museo Nacional de Historia Natural



Cuenca Río Cuareim: 140 spp

Cuenca Río Queguay: 100 spp

Cuenca Río Negro: 120 spp

Cuenca Laguna Merín: 95 spp

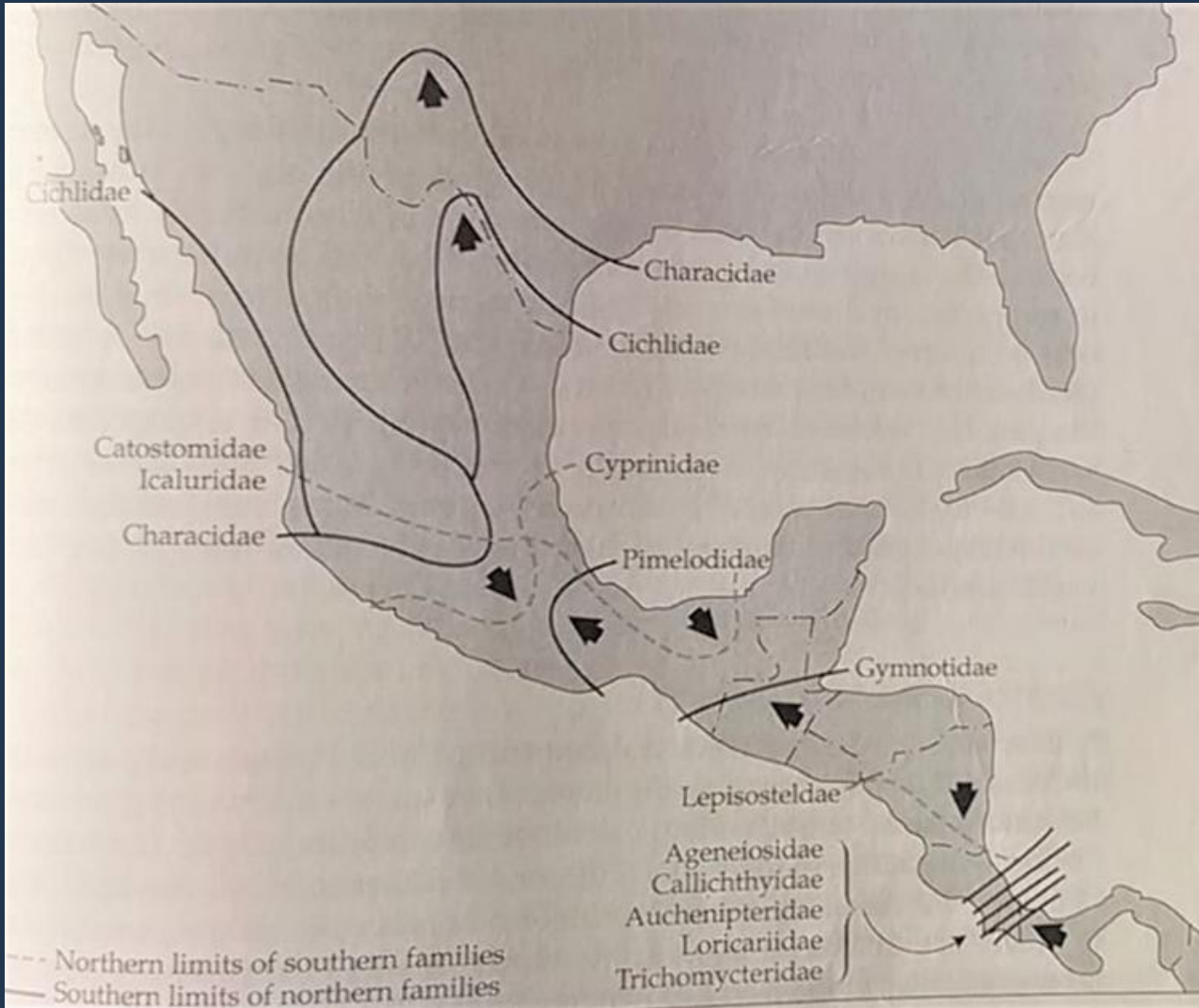
Cuenca Santa Lucía: 60 spp



# Mesoamérica



# Intercambio Biótico



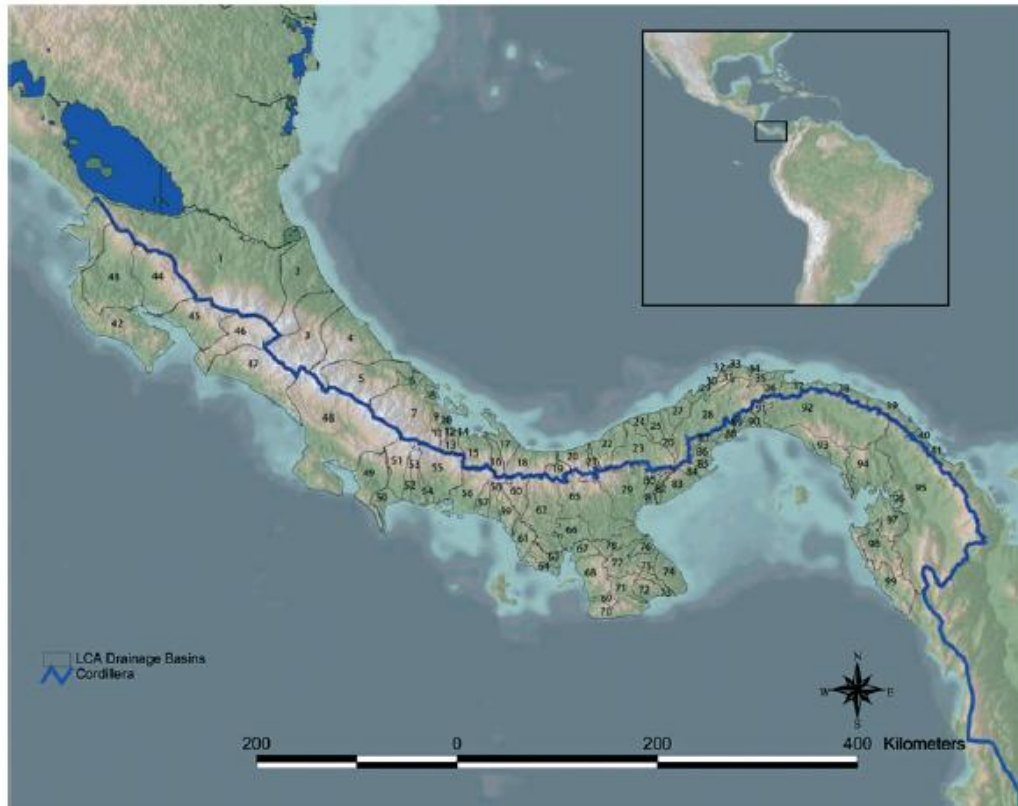
**FIGURE 10.15** Distributional limits of freshwater fish families of South American (dashed lines) and North American (solid lines) origin. Only two species of obligately freshwater fishes of South American origin have reached the United States, and North American forms extend no farther south than Costa Rica. Note that, as in the case of the mammals shown in Figure 10.14, no single line can be drawn to separate unambiguously the Neotropical and Nearctic faunas. (After Miller 1966.)



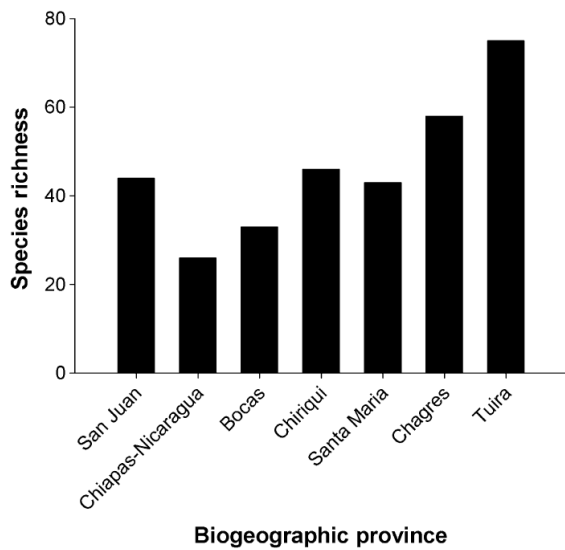
# The biogeography of lower Mesoamerican freshwater fishes

Scott A. Smith<sup>1,2,\*</sup> and Eldredge Bermingham<sup>1,2</sup>

170 especies  
(85% endémicas)

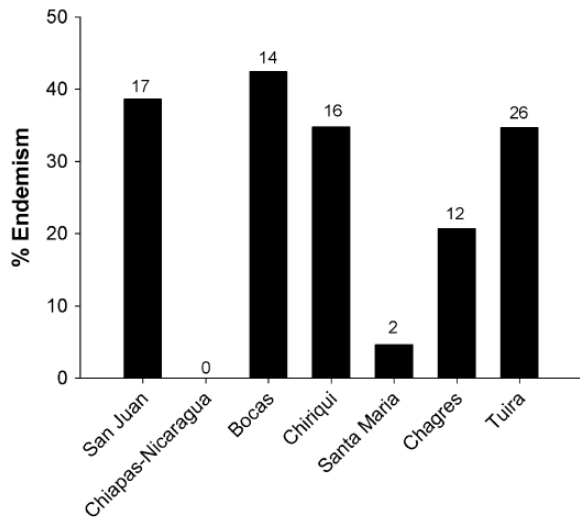


**Figure 1** Drainage basins of lower Mesoamerica. 1, Rio San Juan; 2, Rio Tortuguero; 3, Rio Parismina; 4, Rio Matina; 5, Rio Sixaola; 6, Rio San San; 7, Rio Changuinola; 8, International Cuenca no. 91; 9, Rio Uyama; 10, Quebrada Cilico Creek and Quebrada Marin; 11, Rio Robalo; 12, Quebrada La Gloria; 13, Rio Guarumo; 14, Quebrada La Margarita; 15, Rio Guanaviara; 16, Rio Cricamolá; 17, Rio Canaveral; 18, International Cuenca no. 95; 19, Rio Calovebora; 20, International Cuenca no. 99; 21, Rio Veraguas; 22, International Cuenca no. 103; 23, Rio Codel Norte; 24, International Cuenca no. 107; 25, Rio Miguel de la Borda; 26, Rio Indio; 27, International Cuenca no. 113; 28, Rio Chagres; 29, Rio Piedras; 30, Rio Cuanche; 31, Rio Cascajal; 32, Rio Claro; 33, Rio Pina Pina; 34, Rio Frio; 35, Rio Cuango; 36, Rio Mandinga; 37, International Cuenca no. 121; 38, Rio Azucar; 39, Rio Playon Chico; 40, Rio Cuadi; 41, Rio Acla; 42, Rios of the Nicoya Peninsula; 43, Rio Tempisque; 44, Rio Bebedero; 45, Rio Barranca; 46, Rio Tarcoles; 47, Rio Pirris; 48, Rio Terraba; 49, Rio Coto; 50, Rio Palo Blanco; 51, Rio Chiriqui Viejo; 52, Rio Escareca; 53, Rio Chico; 54, Rio Platanal; 55, Rio Chiriqui; 56, Rio Estero Salado; 57, Rio San Juan; 58, Rio San Felix; 59, Rio Santiago; 60, Rio Tabasara; 61, Rio Bubi; 62, Rio San Pablo; 63, Rio Cate; 64, Quebrada Seca; 65, Rio Santa Maria; 66, Rio San Pedro; 67, Rio Ponuga; 68, Rio Tebario; 69, Rio Pavo; 70, Rio Playita; 71, Rio Tonosi; 72, Rio Cana; 73, Rio Ora; 74, International Cuenca no. 126; 75, Rio Guarare; 76, Rio Honda; 77, Rio La Villa; 78, Rio Parita; 79, Rio Codel Sur; 80, Rio Chorrera; 81, Rio Estancia; 82, Rio Anton; 83, Rio Farallon; 84, Rio Chame; 85, Rio Sajalices; 86, Rio Capira; 87, Rio Caimito; 88, Rio Grande; 89, Rio Juan Diaz; 90, Rio Cabra; 91, Rio Pacora; 92, Rio Bayano; 93, International Cuenca no. 150; 94, Rio Lara; 95, Rio Tuira; 96, Rio Iglesia; 97, International Cuenca no. 160; 98, Rio Samba; 99, International Cuenca no. 164.



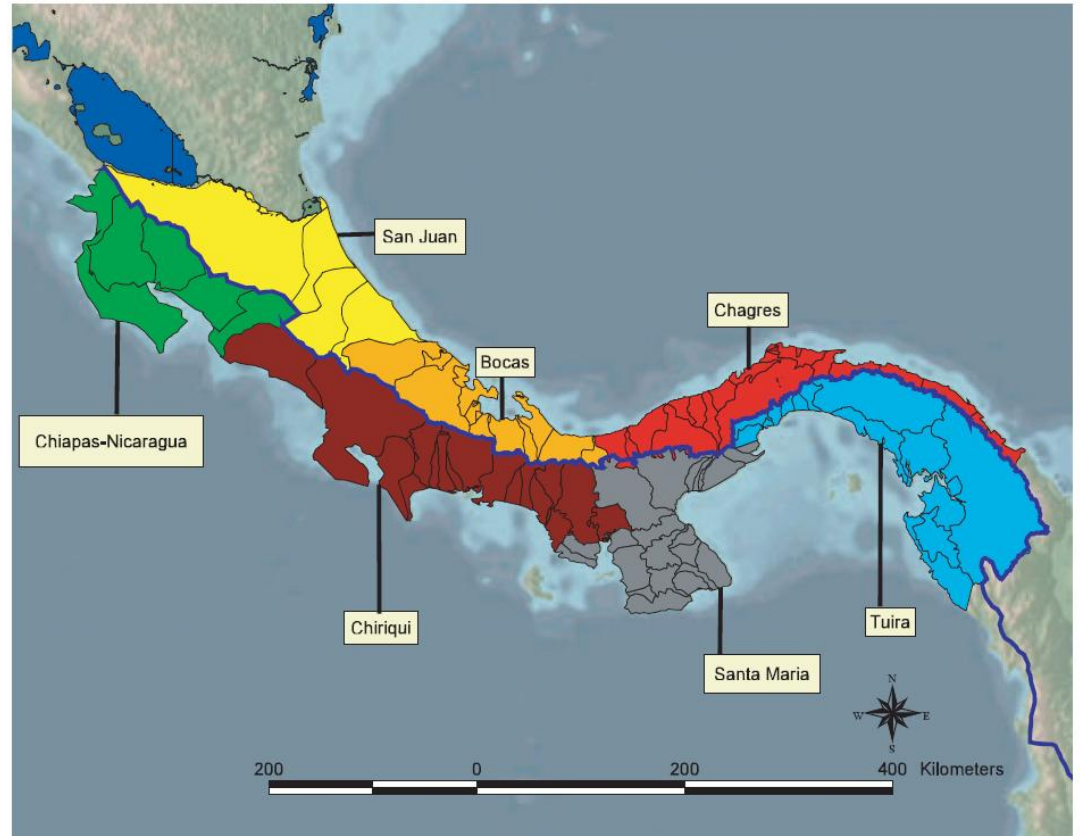
**Biogeographic province**

**Figure 6** Species richness of the biogeographical provinces of LMA.

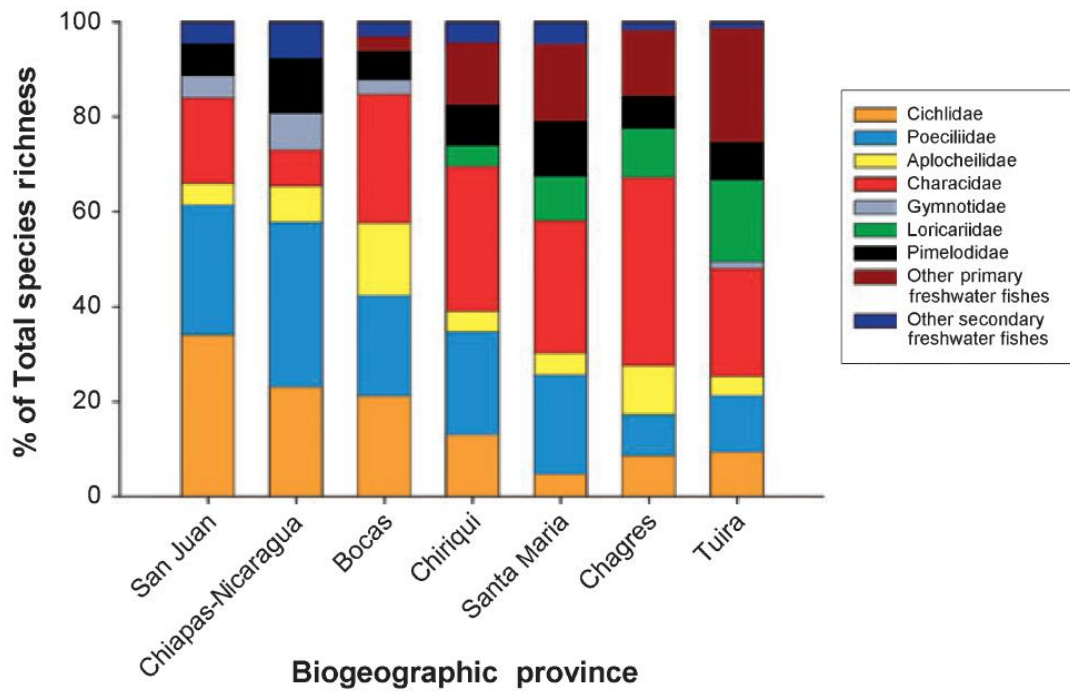


**Biogeographic province**

**Figure 8** Patterns of endemism in the LMA biogeographical provinces. The number of endemic species for each biogeographical province was divided by the species richness of the province to obtain a measure of the relative degree of endemism of each biogeographical province. The number above each of the bars indicates the number of endemic species located in each province.







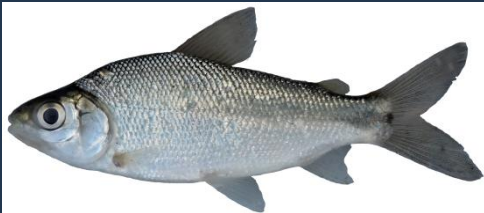
**Figure 5** The relative contributions of selected LMA freshwater fish families to the species richness of the LMA biogeographical provinces.

## Colonization, population expansion, and lineage turnover: phylogeography of Mesoamerican characiform fish

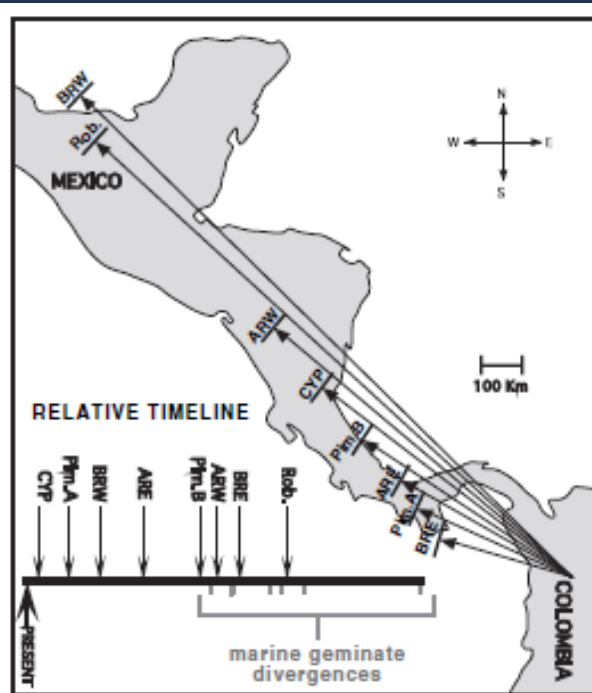
R. GUY REEVES<sup>1,2†</sup> and ELDREDGE BERMINGHAM<sup>1\*</sup>

<sup>1</sup>Smithsonian Tropical Research Institute, Apto. 2072, Balboa, Republic of Panamá

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## Colonizaciones independientes desde la conexión del Istmo de Panamá



**Figure 4.** Inferred timing and geographical limit of initial waves of Mesoamerican primary freshwater fish expansion out of South America. Arrows mark the most westerly extent of waves of expansion, estimated from contemporary species distributions. The timeline represents an approximate reconstruction of the relative temporal sequence of waves of expansion based on the relative phylogenetic depth of observed polytomies for each lineage (see Results for details). Below the line are divergence estimates of marine fish geminate pairs (unlabelled lines). For the lineages *Pimelodella* A and CYP in which no polytomy between operational taxonomic units was observed the maximum observed divergence estimate among Mesoamerican taxa was used to estimate the relative timing of their expansion. Major-lineage abbreviations are as described in the text.

# Región Austral



ORIGINAL  
ARTICLE



# Biogeographical revision of Argentina (Andean and Neotropical Regions): an analysis using freshwater fishes

Hugo L. López<sup>1\*</sup>, Roberto C. Menni<sup>2</sup>, Mariano Donato<sup>3</sup> and Amalia M. Miquelarena<sup>2</sup>



**Figure 4** Ichthyological provinces of Argentina resulting from a parsimony analysis of endemicity (PAE) 50% majority-rule consensus tree of a matrix of 52 localities by 440 species. Numbers of localities correspond to lists in the text. Areas in white correspond to unresolved localities.

# Región Patagónica

29 especies, 22 nativas

*Diplomystes*, *Percichthys trucha*, *Galaxias* spp

## Distribution patterns of native freshwater fishes in Patagonia (Argentina)

Claudio Baigún<sup>1\*</sup>, Ricardo Ferriz<sup>2</sup>

<sup>1</sup> Centro Nacional Patagónico, Puerto Madryn, Chubut, Argentina  
<sup>2</sup> Museo Argentino de Ciencias Naturales "B. Rivadavia", Buenos Aires, Argentina

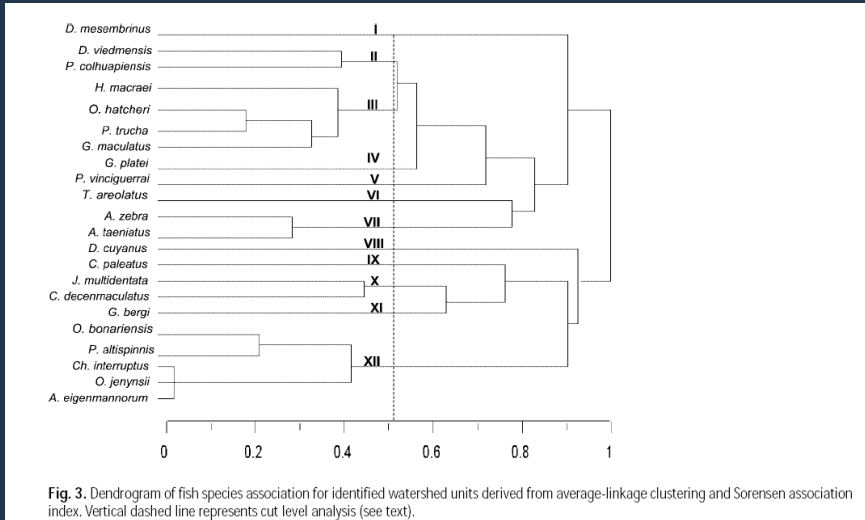


Fig. 3. Dendrogram of fish species association for identified watershed units derived from average-linkage clustering and Sorensen association index. Vertical dashed line represents cut level analysis (see text).

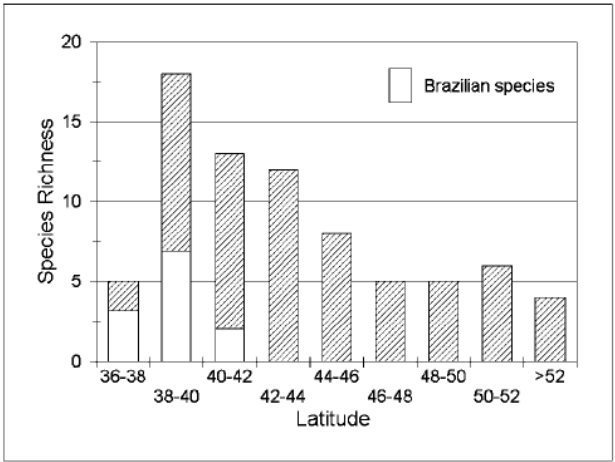


Fig. 2. Variation of species richness along latitude.

## Tropical freshwater teleosts from Miocene beds of eastern Patagonia, southern Argentina

### Téléostéens d'eau douce brésiliens dans des couches d'âge miocène dans le nord-est de la Patagonie, Argentina

Alberto Luis Cione <sup>a,\*</sup>, María de las Mercedes Azpelicueta <sup>b</sup>,  
Jorge Rafael Casciotta <sup>b</sup>, María Teresa Dozo <sup>c</sup>

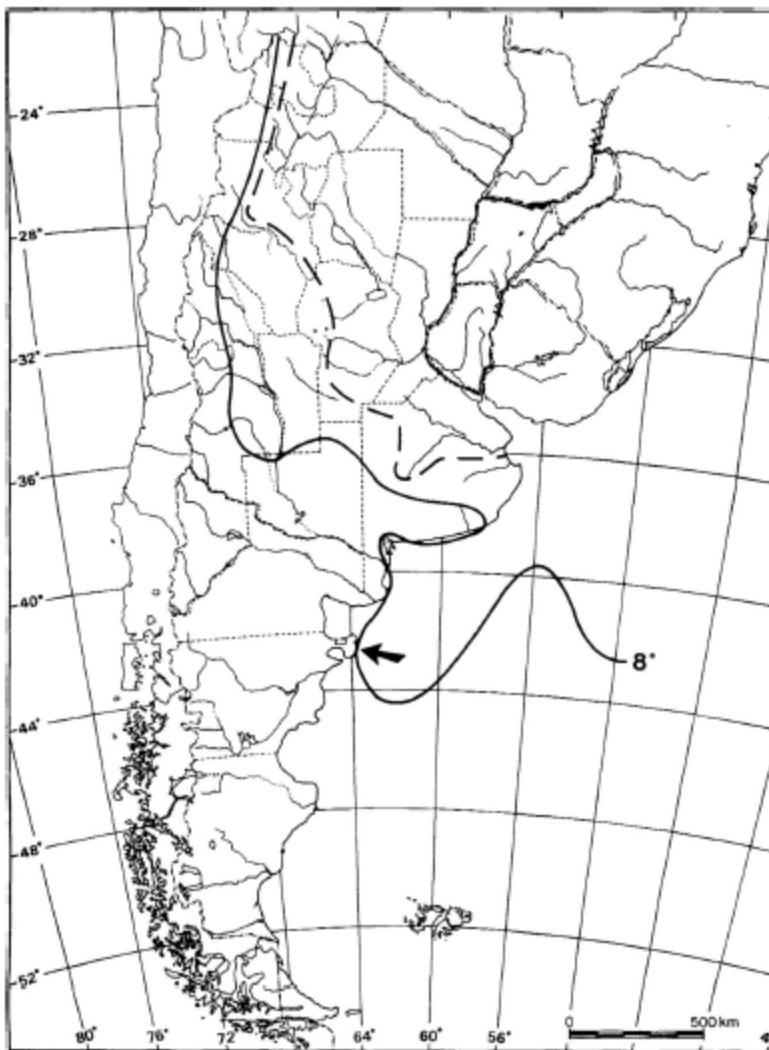


Fig. 9. Solid line indicates the boundary between Brazilian and Austral subregions. Dashed line indicates the present distribution of Loricariidae. The arrow indicates Puntavala Valdés. The isotherm of 8 °C in winter is depicted according to Garcia (1992).

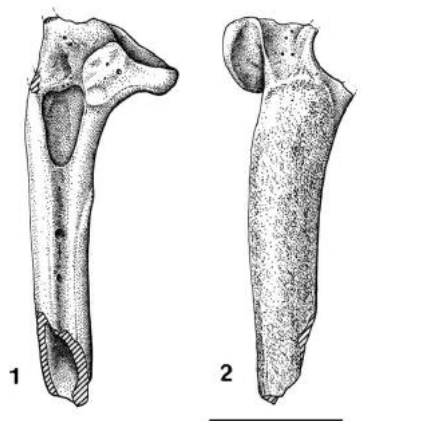


Fig. 4. Pectoral spine of Loricarioidei, MPEF-PV 2505-1. 1. Posterior view showing the large foramen, and the sulcus. 2. Dorsal view showing numerous odontode bases. Scale bar = 1 cm.

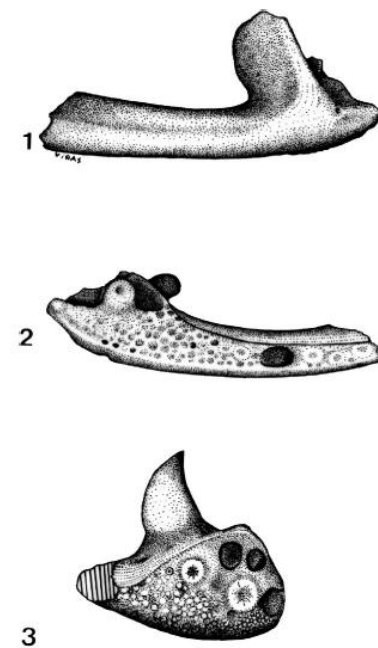


Fig. 8. Percomorpha, premaxillae. 1, 2. MPEF-PV 2519-1, lateral and occlusal views. 3. MPEF-PV 2519-2, occlusal view showing several rows on the symphysis. Scale bars = 1 cm.