OF ISLANDS AND CONTINENTS: THE STORY OF FRESHWATER FISHES

Caribaea Initiative

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St Kitts & Nevis

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THE UNIVERSITY OF THE WEST INDIES
AT ST. AUGUSTINE, TRINIDAD AND TOBAGO

Fishes

- Represent over 50% of all vertebrates
- About 250 new species are described every year
- Final number will exceed 31 000 species (Eschmeyer) other estimates are similar at about 32 000 species
- The freshwater fishes are one of the most important groups in the study of zoogeography
- The highest level of endemism in freshwater fishes is in the Neotropics (~69% of the families are not found elsewhere)

Freshwater fish diversity in the Caribbean islands

In ~228 980 km^2 of land

- 188 species of freshwater fishes
  - 16 orders
  - 38 families
  - 96 genera
- Of these, 51 (27%) of are exotics
- Of the 137 native species, 66 (48%) are endemics

http://www.paradise-islands.org/CaribbeanMapLarge.jpg

Freshwater fishes

Meyers (1938, 1949, 1951) classification as modified by Darlington (1957)

- Peripheral – some families with members confined to fresh waters; others may spend a significant part of their lives in fresh water. In both cases, they are derived from marine families that dispersed via the sea
  - Generally tolerant of marine conditions; secondarily derived from marine ancestors
  - Found on all Caribbean islands
  - Includes: Anguillidae, Gobiidae, Eleotridae, Gobiesocidae, Mugiliidae
- Secondary division – usually confined to fresh water; disperal along coastal waters or across short stretches of sea
  - Tolerant enough of salt water to survive in the sea for short periods
  - Found on almost all Caribbean islands
  - Includes: North American garpikes, synbranchid eels, cichlids, topminnows, cyprinodonts
- Primary division – members are confined to fresh water. Their dispersal is over land
  - Limited tolerance to estuarine conditions
  - Found on very few Caribbean islands
  - Includes: Characiformes, Siluriformes

Relevance of Myers' classification

- Primary freshwater fishes
  - salt water represents a major barrier to their dispersal (though this varies among families)
  - distribution not usually dependent on sea crossings
- Secondary freshwater fishes
  - have some salt tolerance
  - distribution may reflect dispersal along coastlines or over short distances across the sea
- Though conceptually useful, there are problems with the generalisations
  - Some taxa classified as primary, have members with good salt tolerance, *e.g.*, some characins (see Lasso *et al*. 2010)
  - Some taxa classified as secondary have only a handful of members that show salt tolerance, *e.g*., the cichlids

Freshwater fishes of the Caribbean

Overview (excludes T&T; includes T&T; exotics)

No. of

- 'freshwater' fishes = ~152 spp. (in 24 families; 14 orders); 188 spp. (in 37 families; 16 orders)
- 1° division freshwater fishes = 26 (26); 55
- 2° division freshwater fishes = 95 (26); 104
- N. American origin = 27
- S. American origin = 39
- Exotics = 53 (9 families; 4 orders have no natural Caribbean members); 52
- Peripheral = 25 (1); 29
- Endemics = 59; 60

Why are true (1°) freshwater fishes particularly important in zoogeography?

The importance of fresh-water fishes to students of zoogeography depends primarily on two facts

- certain families of fishes possess an ancient physiological inability to survive in salt sea water, which binds them to the land as securely as any known terrestrial animals
- on the land, they are inescapably confined to their own particular drainage systems and can migrate from one isolated stream basin to the next only through the slow physiographical change of the land itself (stream capture, *etc*.)

Why are true (1°) freshwater fishes important in zoogeography?

- Migration of freshwater fishes over land (*i.e.*, from one drainage basin to the next) is extremely slow
- Migration across saline water is almost impossible
- Therefore their distribution reflects geological history

Caribbean distribution native primary freshwater fishes

Several genera only in Trinidad

Caribbean distribution of garpikes

(also found in North and Central America)

1 species in Cuba *Atractosteus tristoechus*

Secondary freshwater fishes of the WI

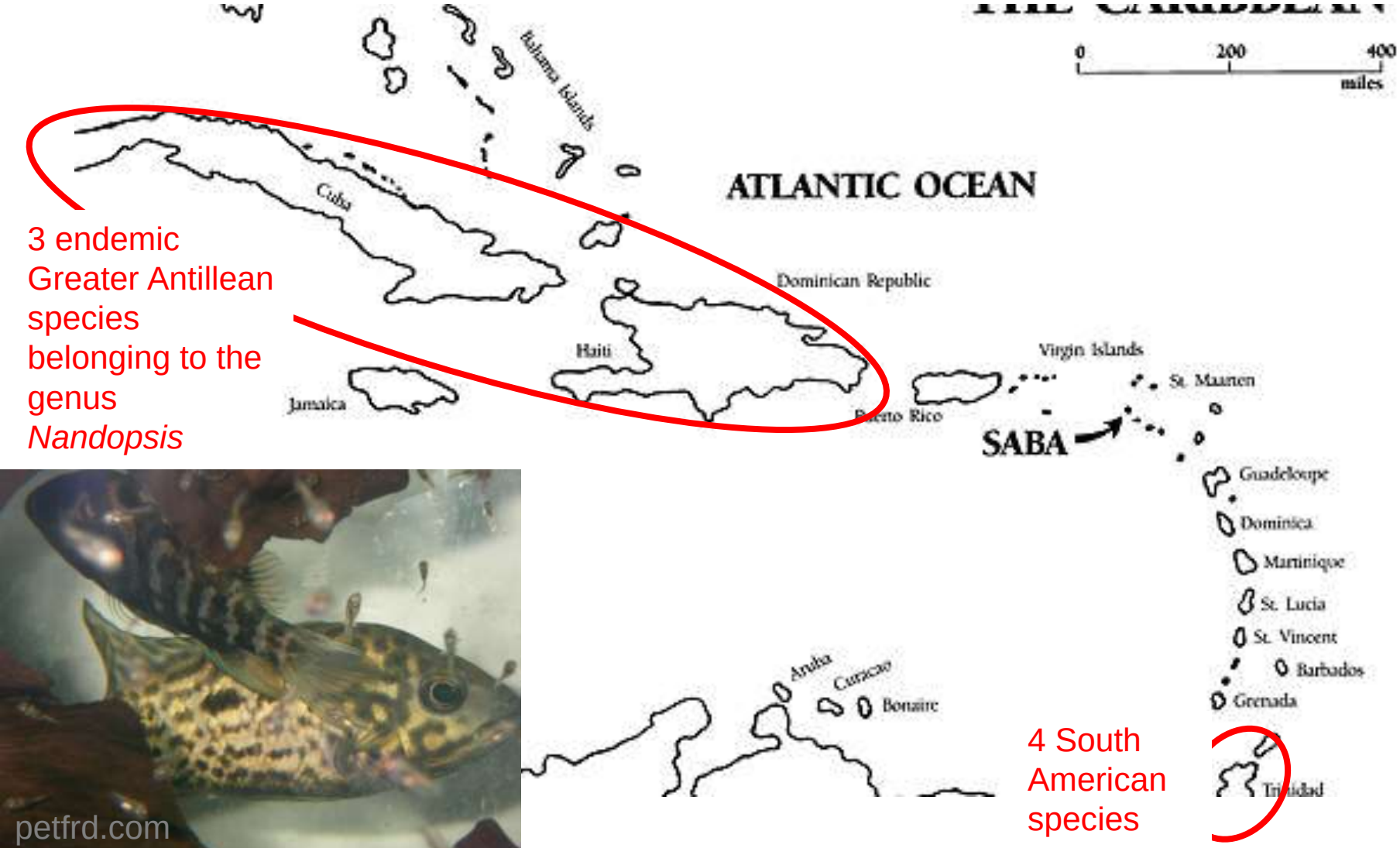
Nine families, including

- Synbranchidae – swamp eels
- Cyprinodontidae - pupfishes
- Fundulidae – topminnows and killifishes
- Poeciliidae – live-bearing tooth carps
- Rivulidae – rivulines, formerly joined with the Poeciliidae
- Cichlidae – cichlids

Caribbean distribution Synbranchidae

2 species, both found in Cuba and Trinidad

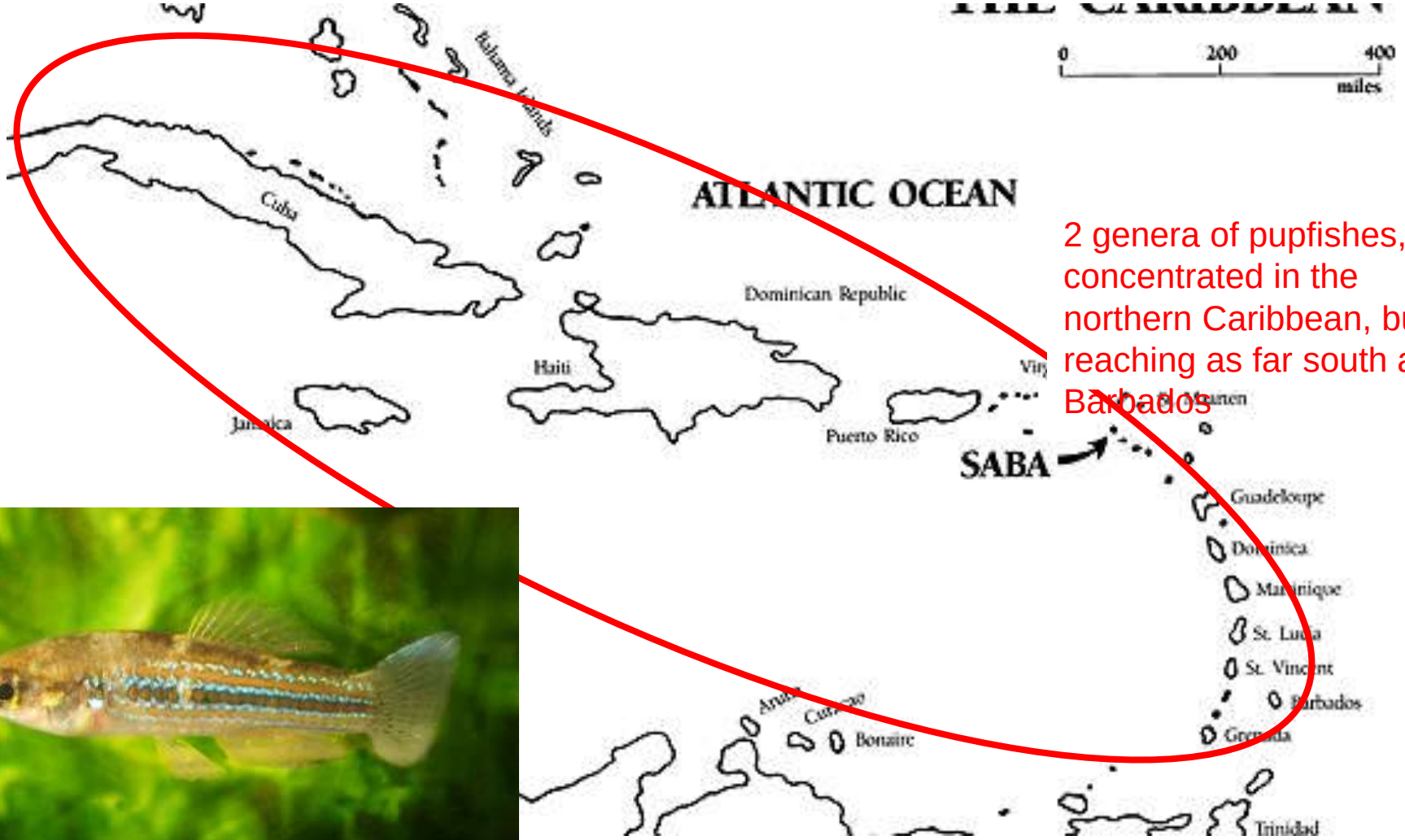
Caribbean distribution of Cichlidae



3 endemic Greater Antillean species belonging to the genus *Nandopsis*

4 South American species

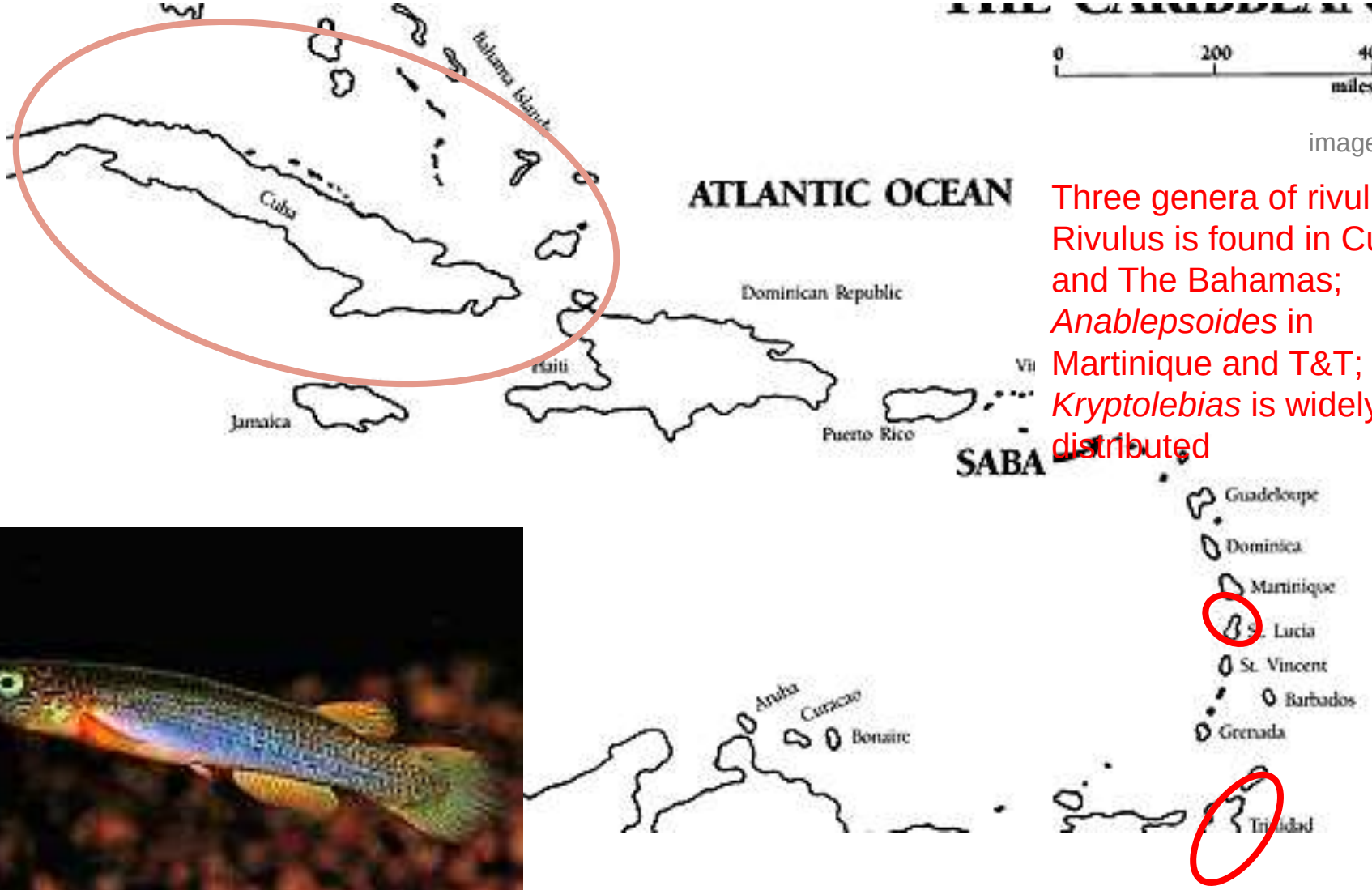
Caribbean distribution Cyprinodontidae



2 genera of pupfishes, concentrated in the northern Caribbean, but reaching as far south as Barbados

Source: Wikipedia

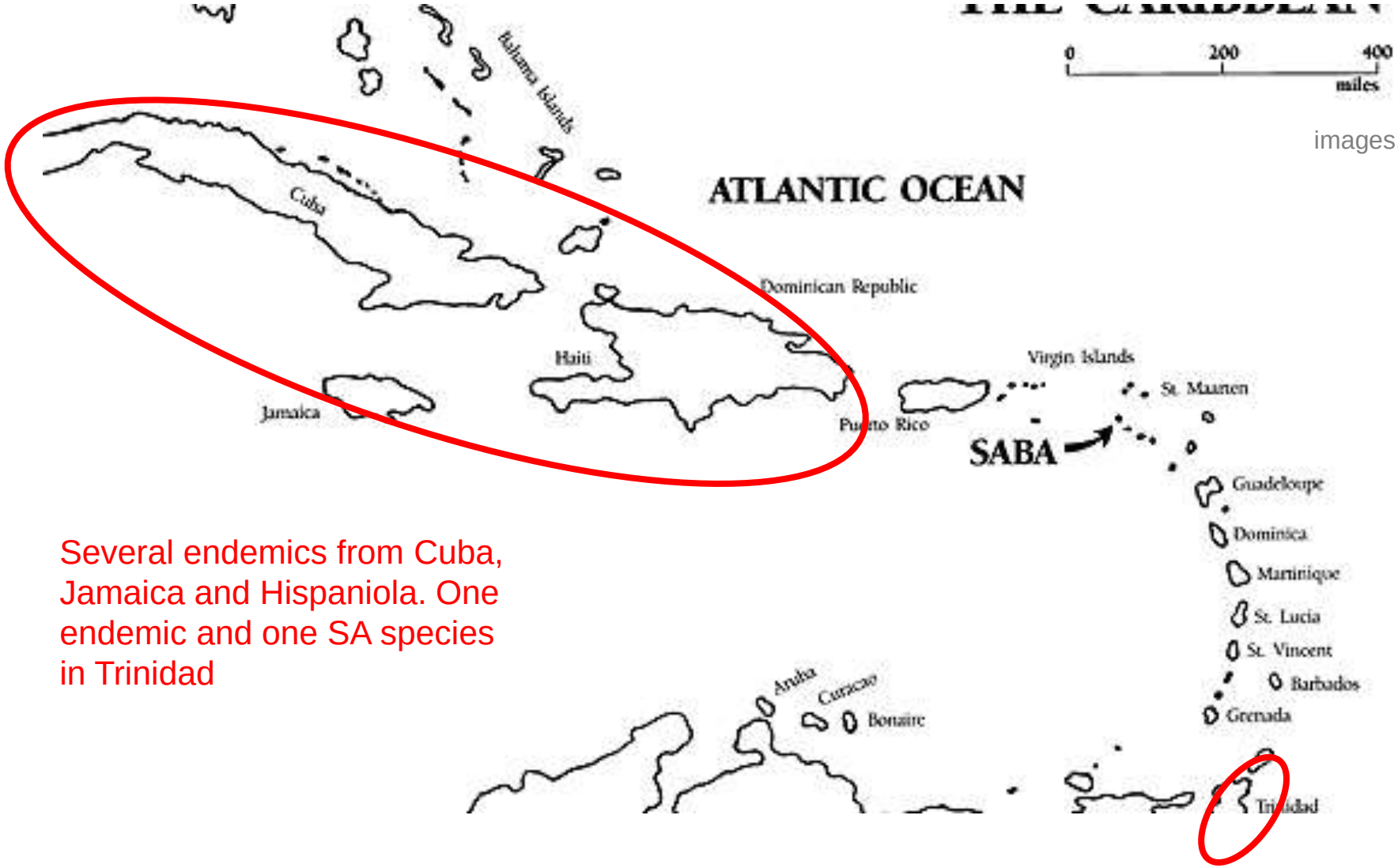
Caribbean distribution Rivuliidae



images.killi.net

Three genera of rivulines: Rivulus is found in Cuba and The Bahamas; *Anablepsoides* in Martinique and T&T; and *Kryptolebias* is widely distributed

Caribbean distribution Poeciliidae



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Several endemics from Cuba, Jamaica and Hispaniola. One endemic and one SA species in Trinidad

Hypotheses to explain these occurrences

1. Marine dispersal from North, South or Central America to the islands. The islands, in particular those of the Lesser Antilles, are true oceanic islands, and were colonised by chance – *i.e*., by waif fauna or vagrants
2. Land bridges linking the continents to the islands
3. Drift vicariance: the islands, in particular Trinidad & Tobago and the Greater Antilles, are not true oceanic islands, but once were connected to continental North, Central or South America

North American origin

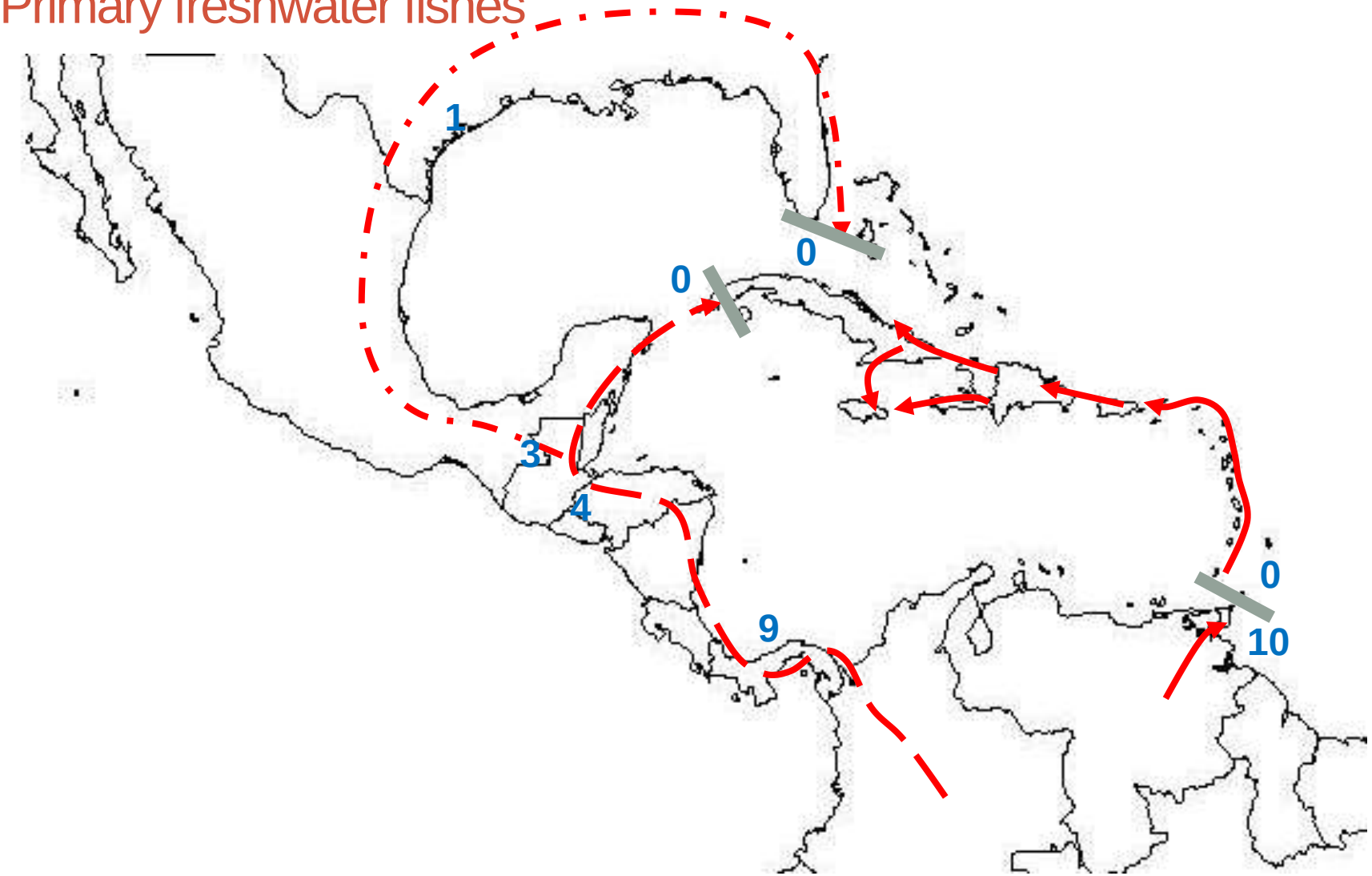
Adapted from schools.look4.net.nz

Central American origin

Adapted from schools.look4.net.nz

South American origin

Primary freshwater fishes



Adapted from schools.look4.net.nz

Central American Origin

Secondary freshwater fish genus *Rivulus* (Murphy & Collier 1996)

Adapted from schools.look4.net.nz

Importance to Caribbean Societies

Traditional fisheries, for example:

- *A. rostrata* elver fishery (Puerto Rico, Jamaica)
- 'Tri tri' fishery for mixed species shoals of larval returns migrating upstream (St Vincent)
- *Hoposternum littorale* (Trinidad)
- Aquarium species such as *Corydoras aeneus* (Trinidad)

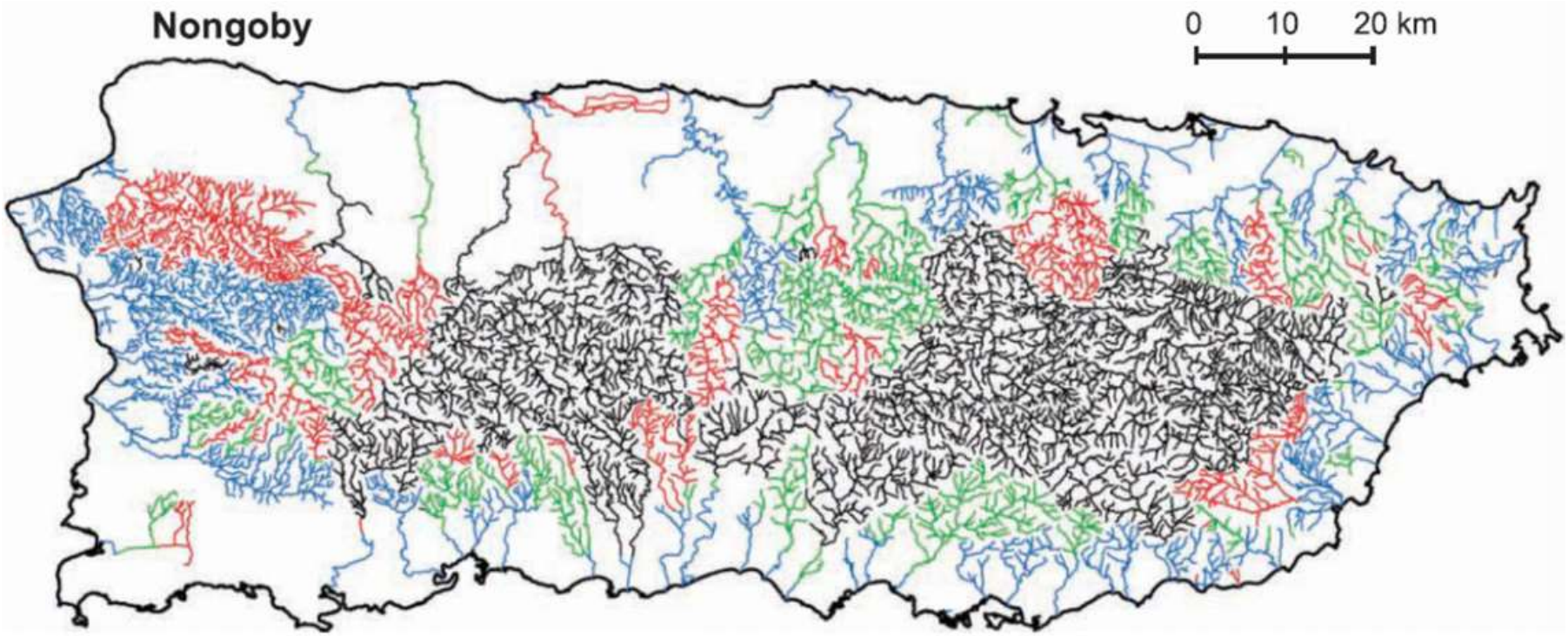
Threats

- The non-goby fish assemblage has been extirpated from large areas of Puerto Rico (Cooney & Kwak 2013)
- Dams block up to 95% of *A. rostrata* migration in Puerto Rican streams (Cooney & Kwak 2013)
- Other threats include
  - Culverts
  - Erosion
  - Industrial and domestic pollution
  - Dredging
  - Stream channelisation
  - Water extraction

    – Hemphil & Garcia 2002
  - Deforestation
  - Agricultural pollution

    – Pringle *et al*. 2000a

Accessibility of stream reaches to non-goby diadromous fishes in Puerto Rico



Cooney & Kwak 2013

A. rostrata in other islands

Guadeloupe

- Dam construction resulted in reduced densities of eels and other diadromous fishes in lower stream reaches
  - Fievert *et al*. (2001b)

Trinidad

- Extirpated from the Caroni River basin
- Kenny (1995) blamed industrial and domestic pollution
- Phillip (1998) found *A. rostrata* only in streams unaffected by pollution or perturbation (*e.g*., dams)

Threats: organochlorine (OC) pollution

- Levels in aquatic habitats in Martinique and Guadeloupe were among the highest in the world (Coat *et al*. 2006, 2011, respectively)
  - β-HCH 386 µg kg^{-1}-1 w.w. in freshwater (Martinique)
  - chlordecone 219 µg kg^{-1} w.w. for fishes (Guadeloupe)
  - The legal limit is 20 µg kg^{-1} w.w.
- Pollution due primarily to the use of pesticides

Threats: policy directions and cultural attitudes

- Development policies that promote urbanisation, industrialisation
- The use of criteria such as economic importance, endemicity and IUCN conservation assessments as the sole determinants for prioritising protection (*e.g.*, in EIAs)
- The continued ‘invisibility’ of fresh water and freshwater biota

Conservation status

IUCN ranking	Native (N = 135)		Introduced (N = 53)		Total (N = 188)
	No.	(%)	No.	(%	
Critically endangered	1	(1)	0	(0	1
Endangered	1	(1)	0	(0	1
Vulnerable	2	(1)	2	(4	4
Near threatened	0	(0)	2	(4	2
Least concern	20	(15)	21	(40	41
Data deficient	3	(2)	1	2	4
Not evaluated	108	(80)	27	51	135

Threats: lack of information/understanding of the biology of many of these species

- Benchetrit & McCleave (2016) *Anguilla rostrato*'s biology is based on research done in North America
- Very little is known of its biology and ecology in the Caribbean region
- IUCN status: **endangered**
- For management and conservation, greater efforts are needed in research on the' basic ecology of this species in the wider Caribbean

Threats: lack of information/understanding of the biology of many of these species

- *Sicydium* populations have been on the decline
- Several studies done on various aspects of the biology and ecology of the members of the genus in the Caribbean
- Yet …

Aiken undated

What are the consequences of species loss?

Future needs - research

- not much is known about the freshwater fish assemblages in the Caribbean
  - Taxonomic issues
  - Basic biology
  - Functional roles
  - Status
  - Population trends
  - Threats
- capacity and other resources issues
- Need to monitor biodiversity

Future needs

- Training and capacity building
- Is it possible to have citizen-science surveys throughout the islands – like the annual Christmas bird surveys?
- Strengthened regional cooperation for research and collaboration on conservation
- Funding is a major limitation

Future needs

- In addition to international measures (*e.g.*, IUCN Red List) we need to also use regional and local criteria for determining species conservation priorities
  - local considerations need to be taken into account
- Stronger, better policies to protect fresh water and freshwater resources

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