

# Speciation

Speciation is the evolution of more than one species (or, at least, a single different species) where previously there was only one.

=> species are the unit of evolution

Yesterday we spoke about the problems with defining a species and went through 7 different species concepts.

## Some general problems with defining species

### 1. Polymorphism

Variation within a population. Different individuals in the population have distinctly different structures, colors, biochemistry, etc. but clearly belong to the same population since they reproduce with one another.

e.g. *Himantura uarnak*

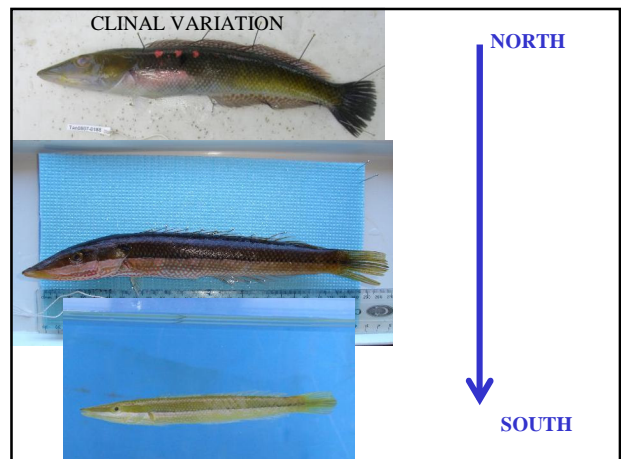


### 2. Geographic variation

Refers to variation over geography

populations in different areas look different from each other.

One common pattern of geographic variation is **clinal variation**. **Clinal variation** refers to a gradual change in some feature across geography.



### 3. Hybrid zones

Geographic areas where two distinctly different forms of organism contact each other and interbreed.

Outside this zone, the two forms retain distinct differences from one another but within the zone intermediate forms between the two occur as a result of interbreeding.

e.g. *O. niloticus* in southern Africa

## 4 TEST CASES FOR SPECIES BY DIFFERENT DEFINITIONS:

#### Fish:

1. Blacktail - *Diplodus capensis* (SA), *Diplodus capensis* (Angola)
2. Leervis - *Lichia amia* (SA), *Lichia amia* (Angola)

#### Reptiles:

3. Little striped whiptail - *Cnemidophorus inornatus* (USA)
- New Mexico whiptail - *Cnemidophorus neomexicanus* (USA/MEXICO)
- Desert whiptail - *Cnemidophorus tigris* (MEXICO)

#### Insects:

4. Two barred flasher - *Astraptus fulgurator* (USA - ARGENTINA)

## *Diplodus capensis*



RSA

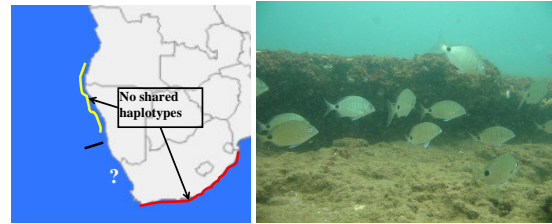


Angola

Distribution



## GENETIC ANALYSIS

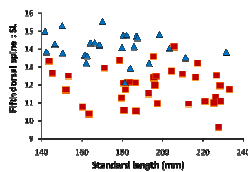


The lack of shared haplotypes (combination of DNA sequences) shows that they are reproductively isolated. The CO-1 gene was 2.5% different between populations (2% is normally the cut off value for a species).

## Morphometric comparison

	ANGOLA (n=36)			South Africa (n=42)		
	Mode	Min	Max	Mode	Min	Max
Dorsal Fin Spine Count	12	12	13	12	11	13
Dorsal Fin Ray Count	14	12	15	14	13	16
Anal Fin Spine Count	3	3	3	3	2	4
Anal Fin Ray Count	14	13	14	13	12	15
Pectoral Fin Ray Count	16	15	18	16	15	17
Lateral Line Scale Count	70	66	75	74	64	79

The meristic characters (primitive) overlap so there is no clear separation



The measurements (derived characters) look different and the majority of measurements can be grouped by species suggesting that their shape has changed.

While the meristic characters are the same, the morphological differences suggest that these populations may have diverged into different species (by some definitions) since they became isolated.

## 1. Morphological Species concept

A species is the smallest group of individuals that are distinct and distinguishable from all others



## 2. Biological Species concept

A species is a group of interbreeding natural populations that are reproductively isolated from other such groups



## 3. Evolutionary Species concept

An evolutionary species is a lineage (an ancestral-descendant sequence of populations) which maintains its **identity** evolving separately from others and with its own unitary evolutionary role and tendencies



## 4. Phylogenetic Species Concept

a species is a "tip" on a phylogeny, that is, the smallest set of organisms that share an ancestor and can be distinguished from other such sets.



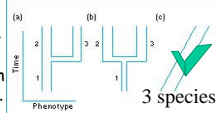
## 5. Recognition Species Concept

A species is the most inclusive population of biparental organisms that share a common fertilization system



## 6. Cladistic Species concept

A species is a set of organisms (an evolutionary lineage) between two branch points or between one branch point and an extinction event or a modern population (Ridley 1993).



## 7. Cohesive Species concept

A species is the most inclusive group of organisms having the potential for genetic and/or demographic exchangeability. (Templeton, 1989)



## *Lichia amia*



RSA

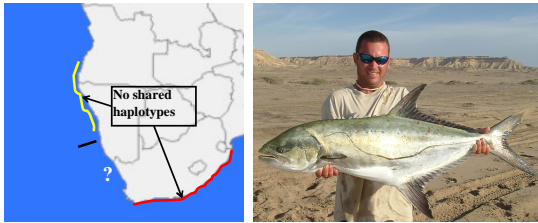


Angola

Distribution



## GENETIC ANALYSIS

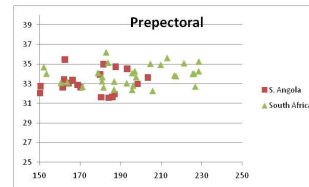


The lack of shared haplotypes (combination of DNA sequences) shows that they are reproductively isolated. The CO-1 gene was 1.1% different between populations (2% is normally the cut off value for a species).

## Morphometric comparison

	ANGOLA (n=36)			South Africa (n=42)		
	Mode	Min	Max	Mode	Min	Max
Dorsal Fin Spine Count	7	6	8	7	6	8
Dorsal Fin Ray Count	18	17	19	18	17	19
Anal Fin Spine Count	3	3	3	3	3	3
Anal Fin Ray Count	19	17	21	19	17	21

The meristic characters (primitive) are identical so there is no separation



The measurements (derived characters) look different and the majority of measurements can be grouped by species suggesting that their shape has changed.

While the meristic characters are the same, the morphological differences suggest that these populations may have diverged into different species (by some definitions) since they became isolated.

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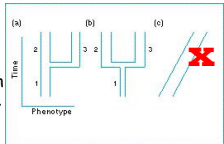
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Not sure?

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## Whiptail lizards

*Cnemidophorus inornatus* (left)  
*Cnemidophorus neomexicanus* (center)  
*Cnemidophorus tigris* (right)



Distribution: *Cnemidophorus inornatus* – southern states of USA  
*Cnemidophorus tigris* – northern Mexico  
*Cnemidophorus neomexicanus* - where the above two overlap

### Morphologically different:

*C. tigris* - attains a larger size, different colour patterns  
*C. inornatus* - smaller size, striped pattern  
*C. neomexicanus* - larger size, striped pattern

### Reproduction:

*Cnemidophorus neomexicanus* (center) only found where the other two species overlap and hybridise. It is parthenogenic with only females in the population.



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A species is the smallest group of individuals that are distinct and distinguishable from all others

3 species ✓

### 2. Biological Species concept

A species is a group of interbreeding natural populations that are reproductively isolated from other such groups

2 species ✗

### 3. Evolutionary Species concept

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1 species ✗

### 4. Phylogenetic Species Concept

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3 species ✓

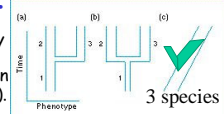
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✗

## *Astraptes fulgerator*

First described in 1775, is a common and widely distributed neotropical skipper butterfly (Lepidoptera: Hesperidae).



### Distribution

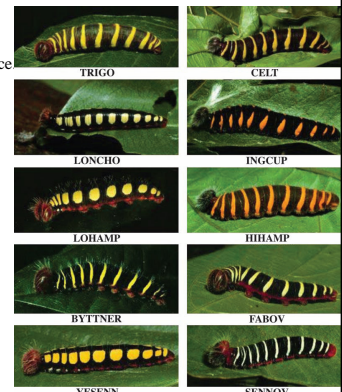
Far southern United States to northern Argentina, from the near desert to deep rain forest, from lowlands to middle elevations, and from urban gardens to pristine habitats.

Hebert et al 2004

A recent morphological and DNA barcoding study showed that *A. fulgerator* has at least 10 sympatric populations (could be species).

### Morphological differences:

None in adults – no genitalic divergence  
morphology of the caterpillars is different.



**Ecological differences:** Somewhat different ecosystem preferences

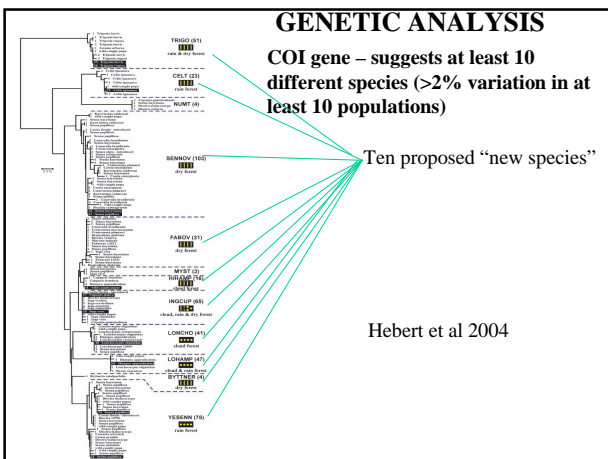
Hebert et al 2004

## GENETIC ANALYSIS

COI gene – suggests at least 10 different species (>2% variation in at least 10 populations)

Ten proposed "new species"

Hebert et al 2004



### 1. Morphological Species concept

A species is the smallest group of individuals that are distinct and distinguishable from all others

10 sp caterpillars  
1 sp adult ✓

### 2. Biological Species concept

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10 species ✓

### 3. Evolutionary Species concept

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1 species ✗

### 4. Phylogenetic Species Concept

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10 species ✓

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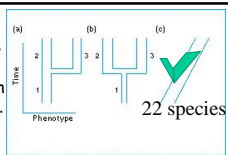
10 species ✓

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10 species