

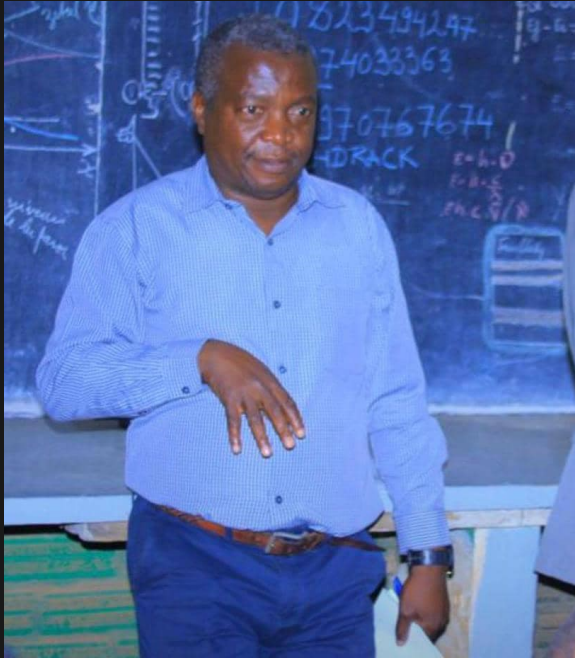
# Adaptive evolution of parasite stress response genes aligns with host niche diversity

*ASP Meeting, 17/06/2024*

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Lutz Bachmann, Christoph Hahn, Philipp Resl,  
Nikol Kmentová  
armando.cruzlaufer@uhasselt.be*



# Dedication



Prof. Auguste Chocha Manda

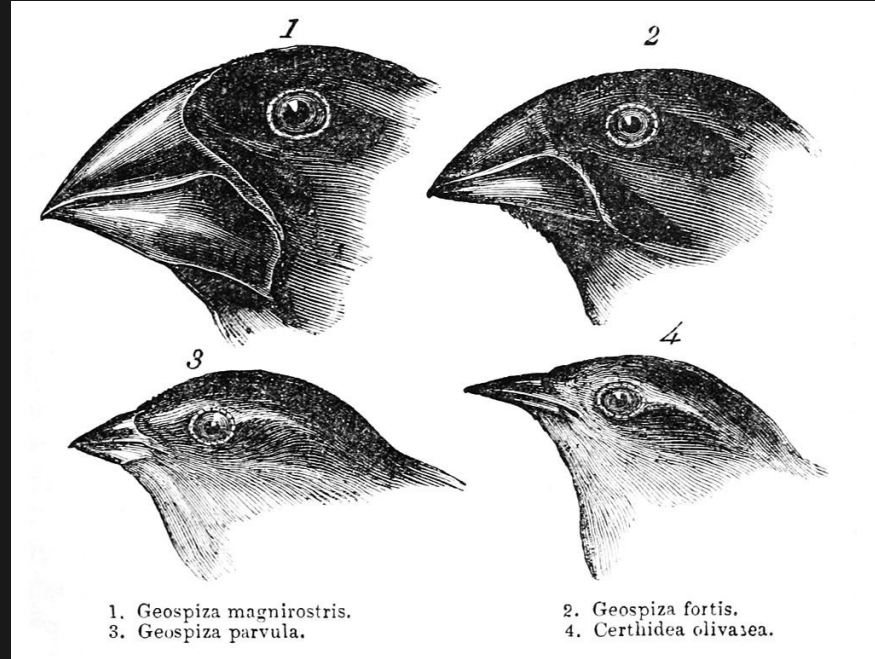


Prof. Charles F. Bilong Bilong

# Adaptive radiation

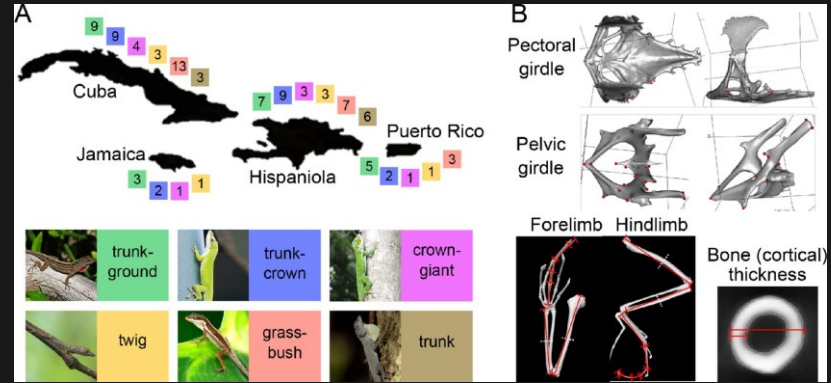
*“Seeing this gradation and diversity of structure in one small, intimately related group of birds, one might really fancy that from an original paucity of birds in this archipelago, one species has been taken and modified for different ends” (Darwin 1845: 380)*

**“Explosive” speciation, with an adaptive component**



# Key innovation

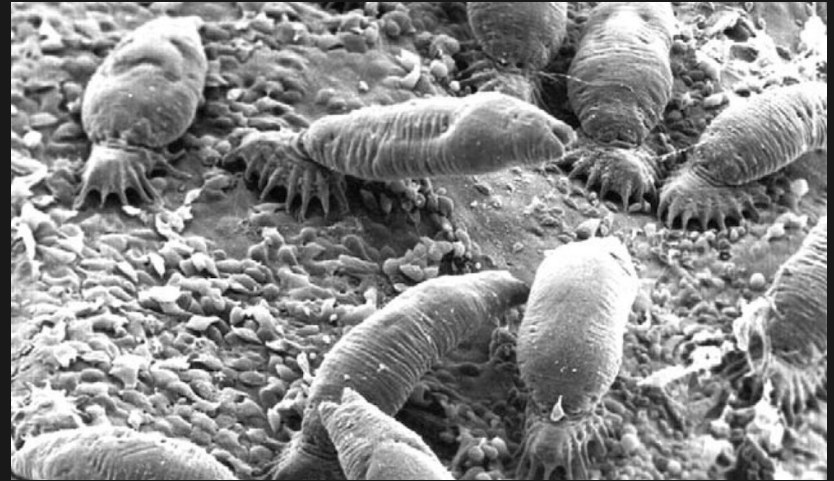
What character(s) allow a lineage to radiate?



# Key innovations in parasites?

Two problems:

- Radiations in parasites are understudied
- Parasite adaptation is understudied



# Biological stress



# Parasites also experience stress

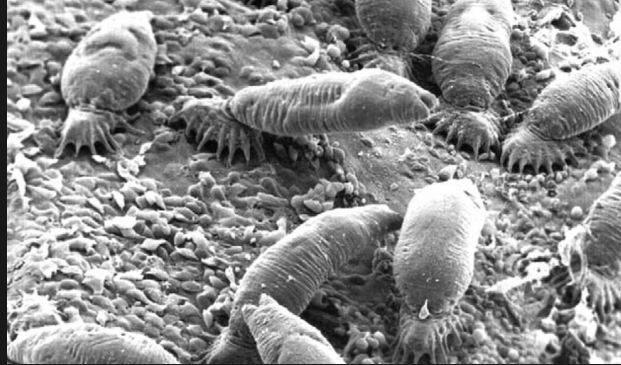
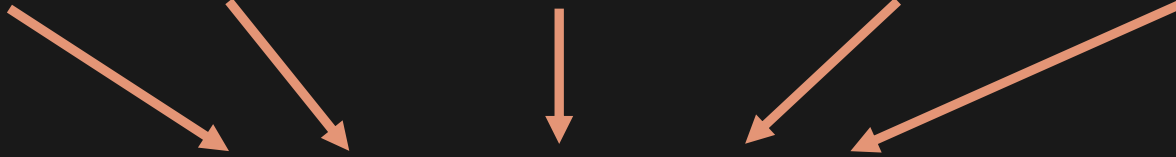
Temperature

pH

Osmotic pressure

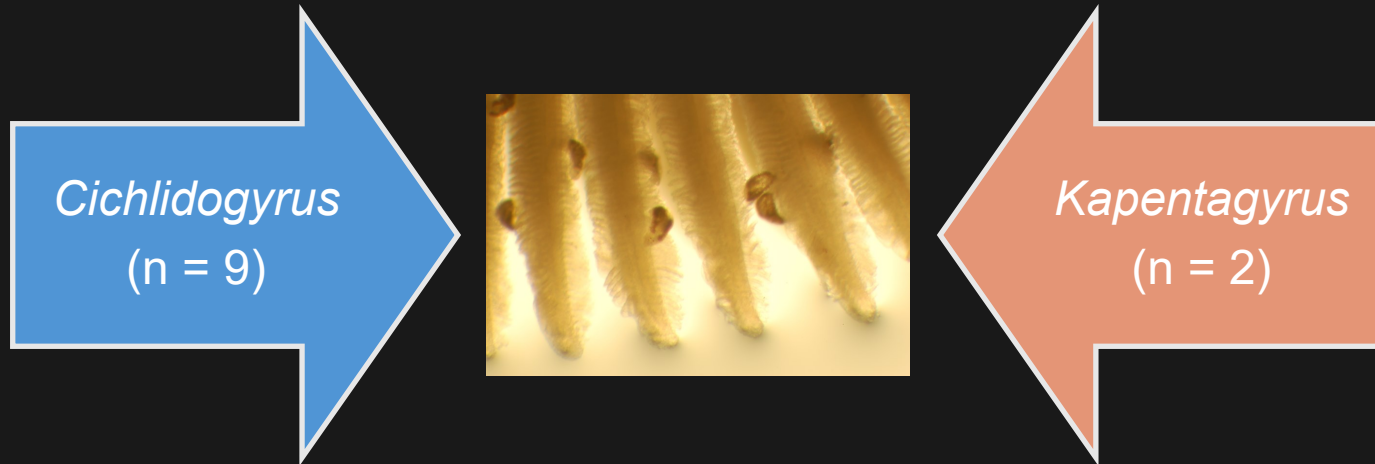
Pollution

Host defences



# *Our study system*

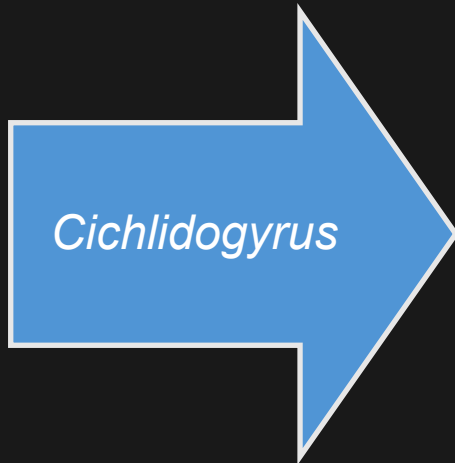
**Contrast in host niche diversity**  
→ **Difference in evolution of stress genes?**





# *Our study system*

**Contrast in host niche diversity  
→ Difference in evolution of stress genes?**



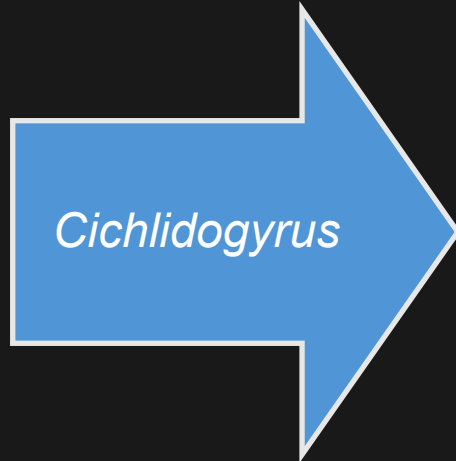
**African cichlid fishes**

**Model system of  
adaptive evolution**

**Species-rich**

# *Our study system*

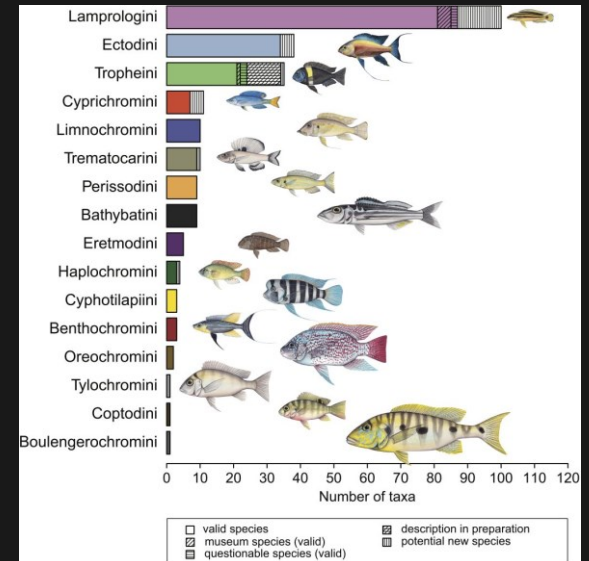
**Contrast in host niche diversity  
→ Difference in evolution of stress genes?**



**African cichlid fishes**

**Model system of  
adaptive evolution**

**Host radiation in Lake  
Tanganyika (LT)**



# *Our study system*

**Contrast in host niche diversity  
→ Difference in evolution of stress genes?**



**African freshwater  
clupeid fishes**

**Conserved host niche  
(open-waters of rivers  
and lakes)**

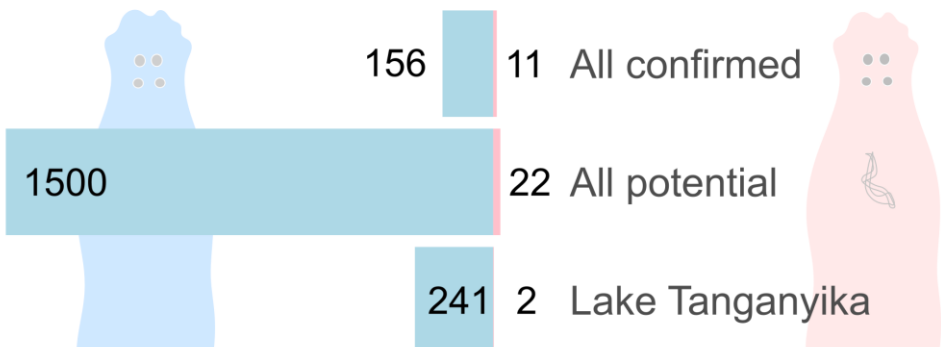
**Species-poor**

*Kapentagyris*

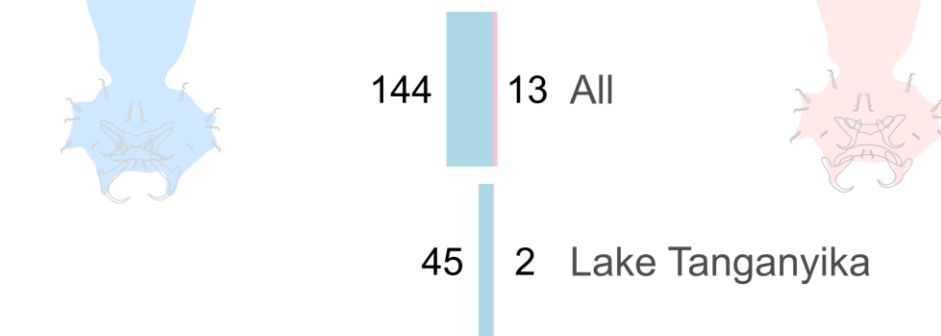
*Cichlidogyrus*

*Kapentagyrus*

How many host species?



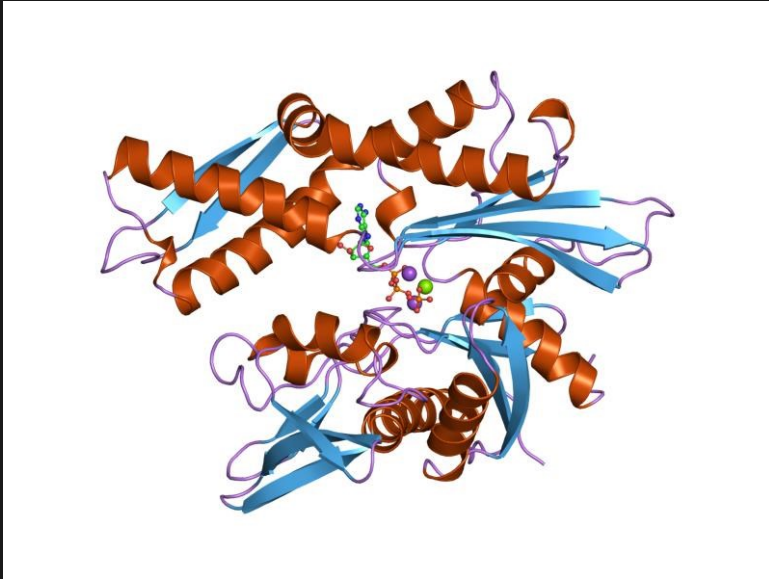
How many parasite species?



↓  
Ecologically diverse?

↓  
Ecologically conserved?

# Methodology: indicators



## Copy numbers

→ Does *Cichlidogyrus* have more copies of stress genes?

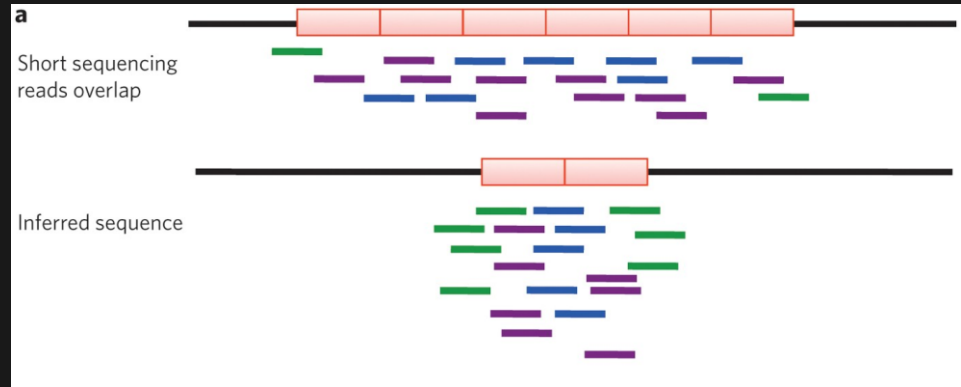
## Substitution rates (dN/dS)

→ Positive selection of gene sites  
→ adaptive evolution

# Methodology: genomics

## Whole-genome sequencing (Pool seq) + exon bait capture

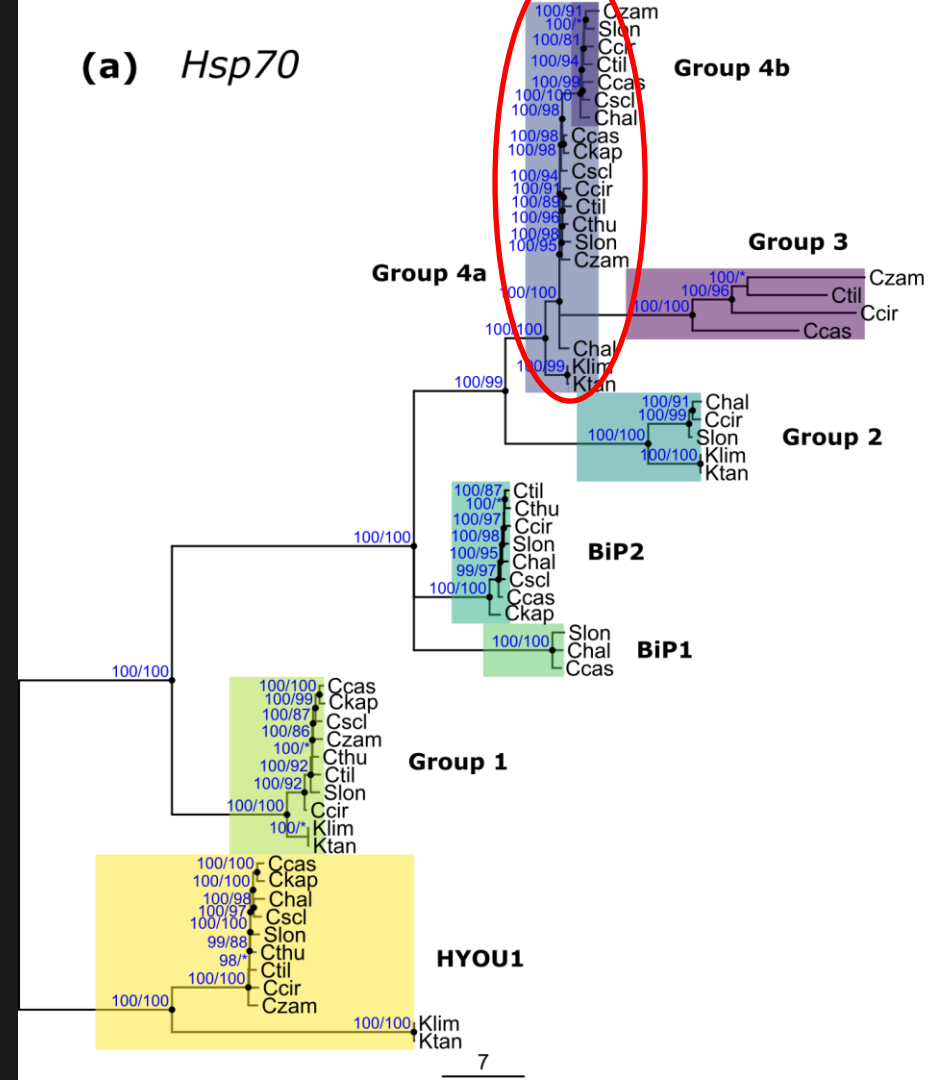
- **Stress gene sequences  
(48)**
- **Phylogenetic markers  
(363)**



# Copy number differences

*Cichlidogyrus* has more

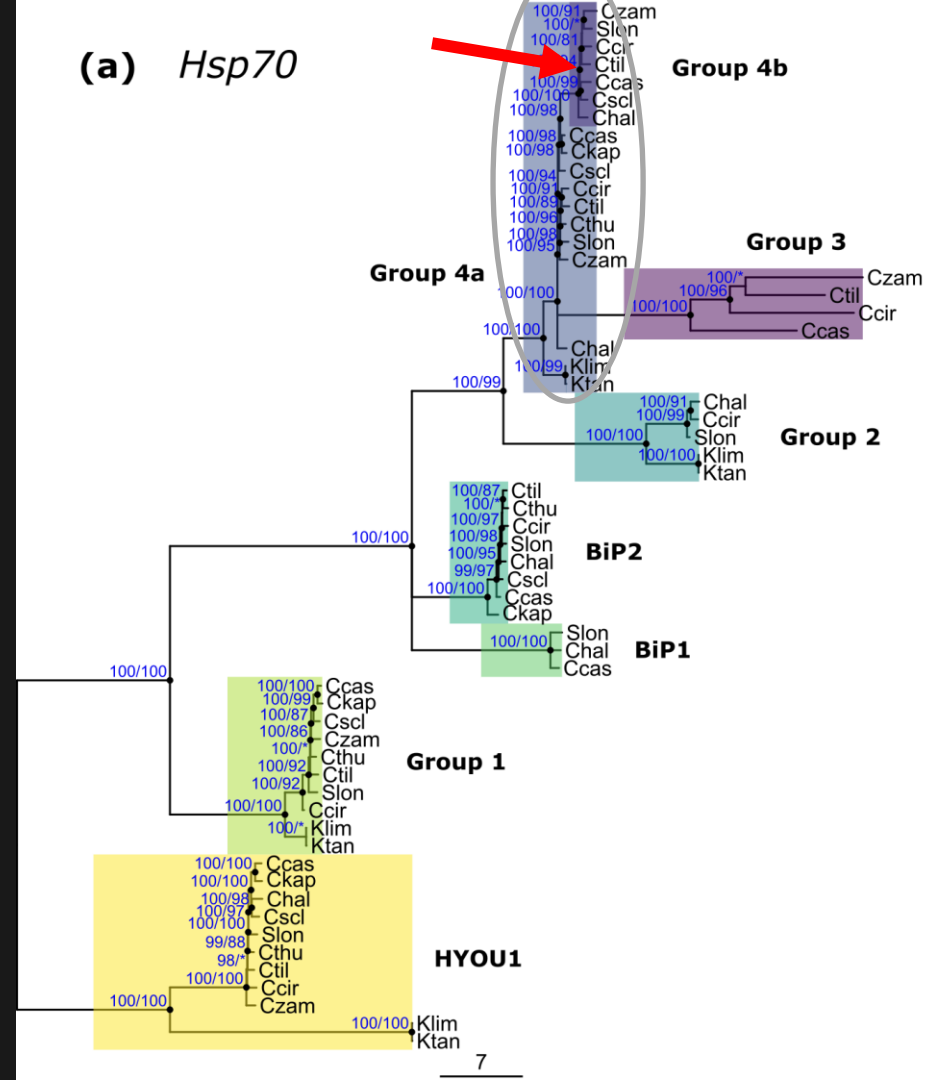
- Heat shock protein 70 kDa (HSP70)
- Glutathione *S*-transferase mu-class (GSTM)



# Copy number differences

*Cichlidogyrus* has more

- Heat shock protein 70 kDa (HSP70)
- Glutathione *S*-transferase mu-class (GSTM)

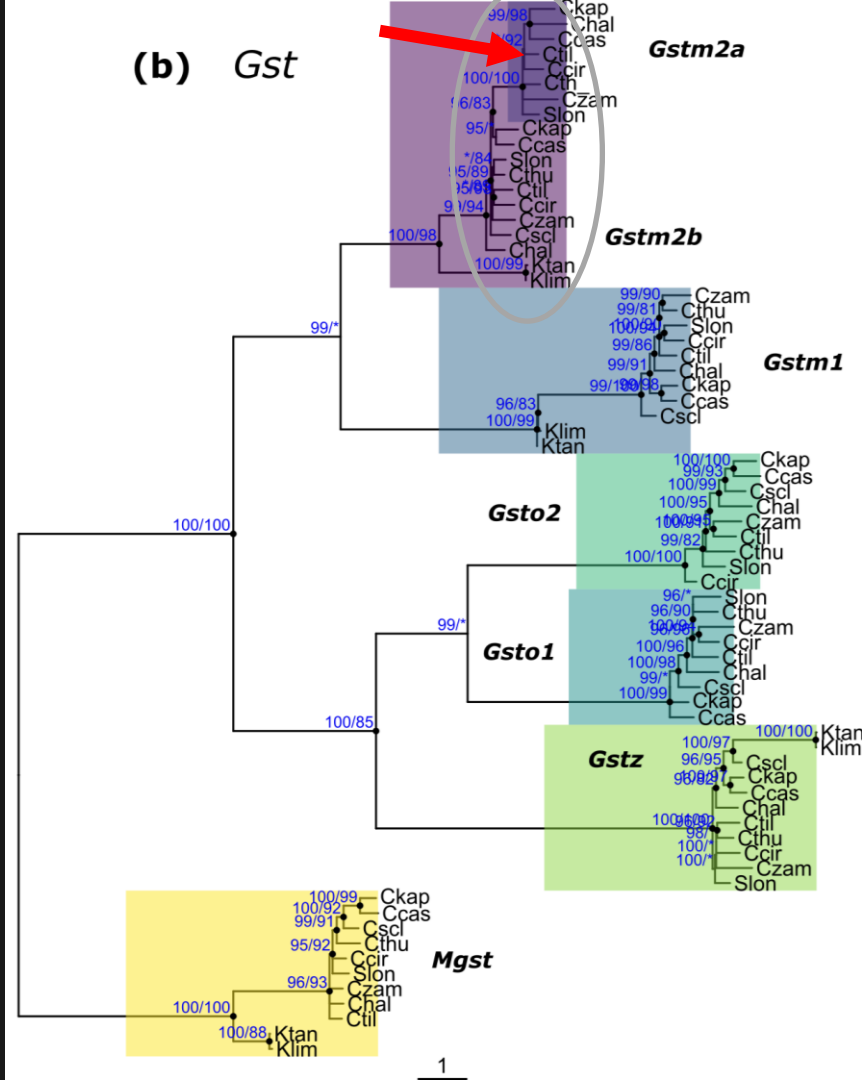




# Copy number differences

*Cichlidogyrus* has more

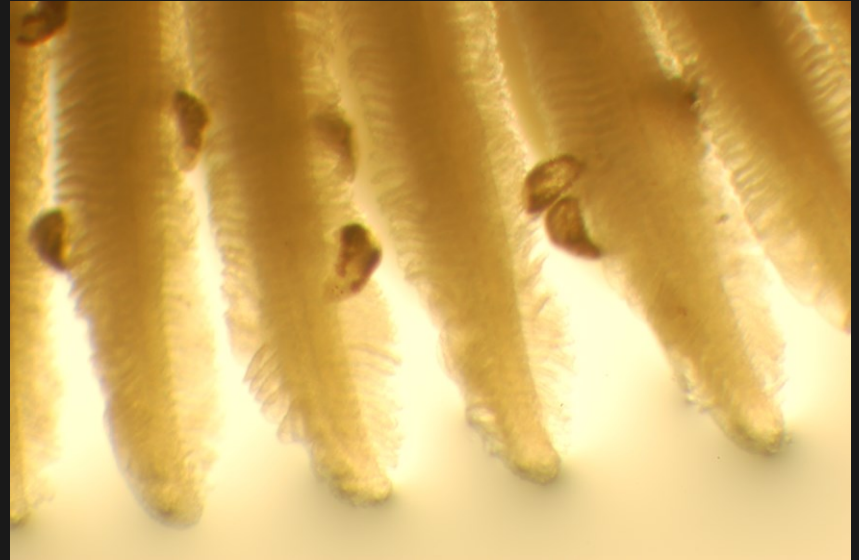
- Heat shock protein 70 kDa (HSP70)
- Glutathione *S*-transferase mu-class (GSTM)



# *Cichlidogyrus* vs. *Kapentagyrus*

*Cichlidogyrus* has more copies  
of specific stress genes  
→ Link with adaptive  
potential?

We need a better  
understanding gene functions  
→ transcriptomics  
→ gene expression analyses

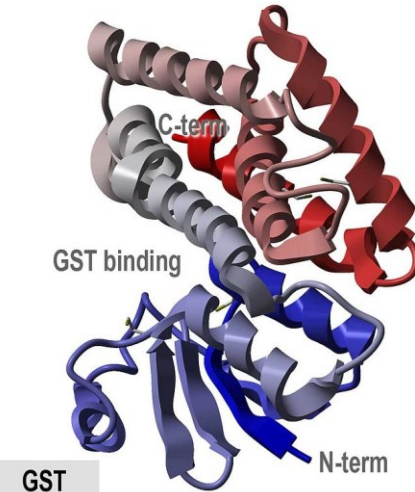
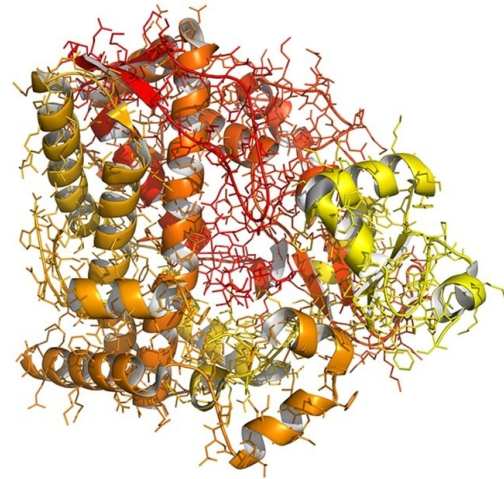


# Note: “monogenean” stress genes

Cytochrome P450 (CYP) and  
multiple GST classes (sigma, kappa)  
missing in both groups

Some of these genes are almost  
ubiquitous in all organisms

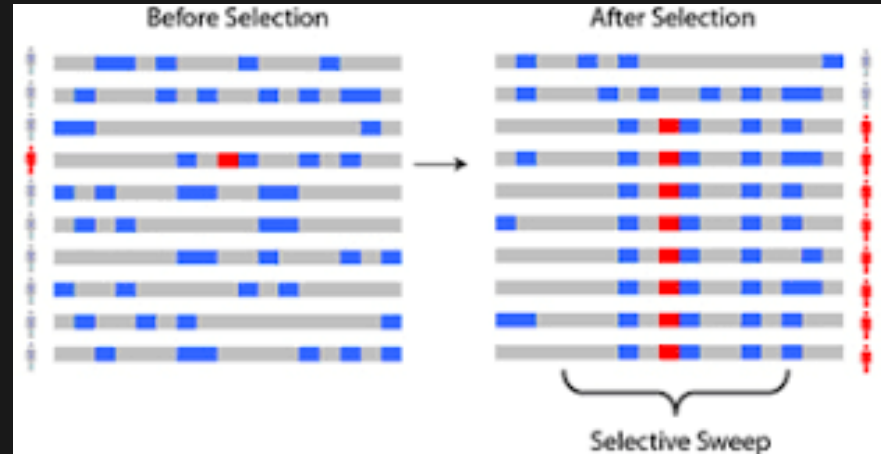
- Missing in monogeneans?
- strongly derived?



# Adaptive evolution = positive selection

*Ratio of synonymous vs. non-synonymous substitution in codons ( $dN/dS$ ): CODEML*

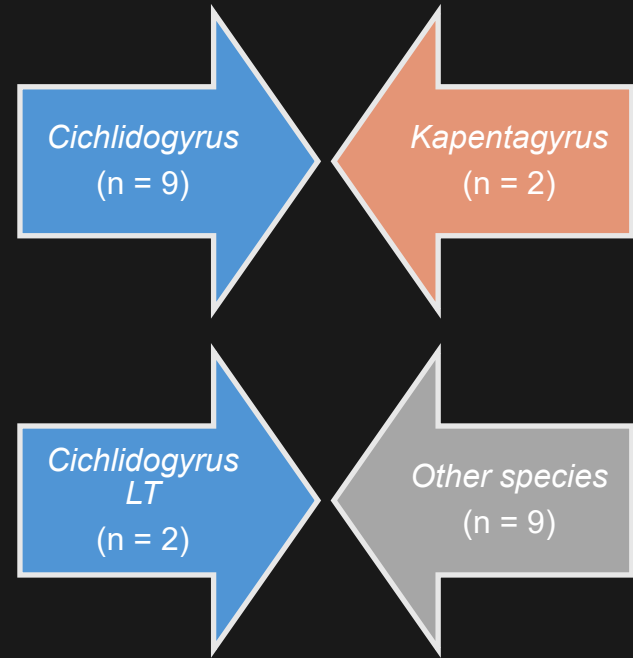
→ Branch-site model: which genes have positively selected sites in specific clades (*Cichlidogyrus*, *Cichlidogyrus*-LT only)



# Adaptive evolution = positive selection

*Ratio of synonymous vs. non-synonymous substitution in codons ( $dN/dS$ ): CODEML*

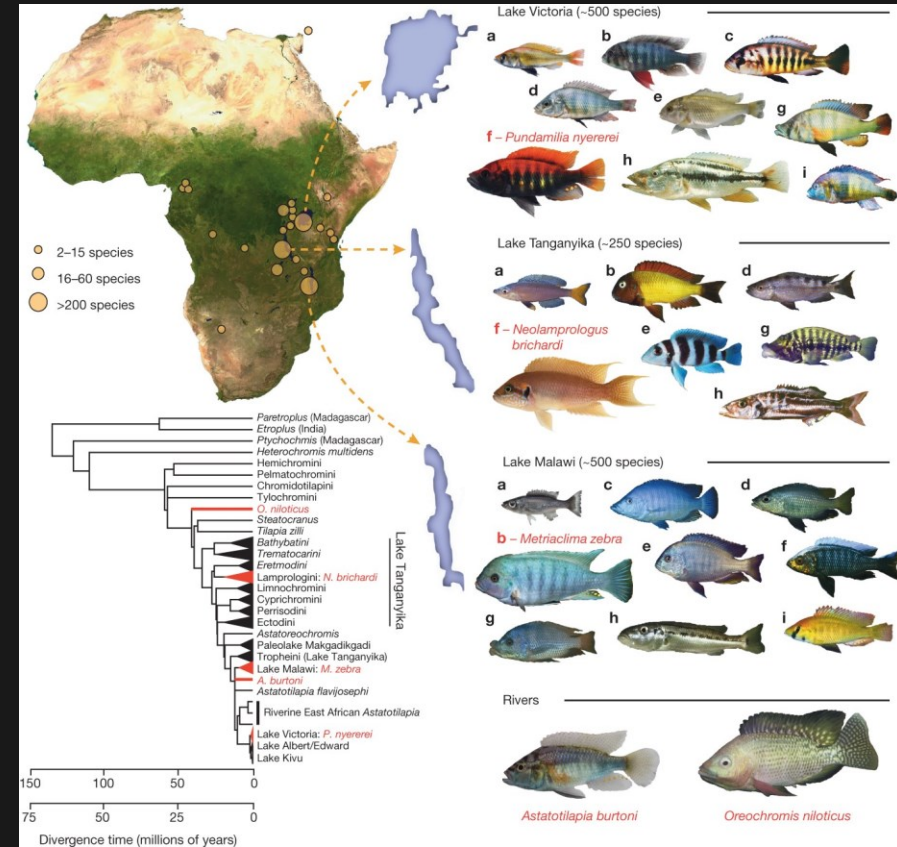
→ **Branch-site model: which genes have positively selected sites in specific clades (*Cichlidogyrus*, *Cichlidogyrus-LT* only)**



# Adaptive evolution = positive selection

*Ratio of synonymous vs. non-synonymous substitution in codons (dN/dS): CODEML*

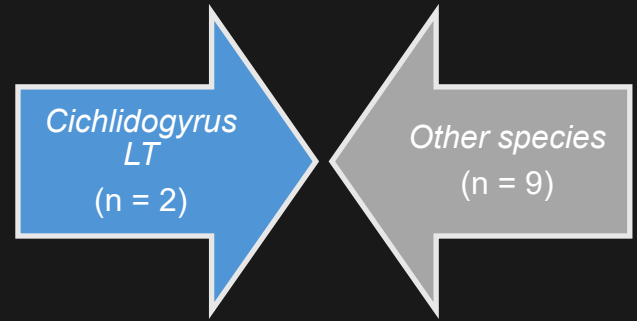
➔ **Branch-site model: which genes have positively selected sites in specific clades (*Cichlidogyrus*, *Cichlidogyrus*-LT only)**



# Adaptive evolution = positive selection

Branch-site model: *hsp60*, 1x *hsp40*  
(LT vs. others)

- ***HSP60***: mitochondrial chaperonin → folding of imported proteins
- ***HSP40***: *DNAJA1* → protein import into mitochondria



**Adaptive evolution = positive selection**

**Why is mitochondrial protein import evolving adaptively in LT? → key innovation**

**First evidence for “*adaptive*” radiation of *Cichlidogyrus* in Lake Tanganyika?**



# Thank you!

Maxwell Barson  
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Samuel Njom  
Karen Smeets  
Fidel Muterezi Bukinga  
Natascha Steffanie  
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of Washington)



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