



TEXAS A&M UNIVERSITY
SAN ANTONIO

INSIGHTS INTO SUBTERRANEAN CONNECTIVITY WITHIN THE AQUIFER OF THE YUCATÁN PENINSULA: POPULATION GENETICS AND DISTRIBUTION OF *TYPHLATYA* SPECIES

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Efrain Chavez-Solis, Fernando Calderón- Gutiérrez,
Tom Iliffe, Nuno Simões, and Elizabeth Borda

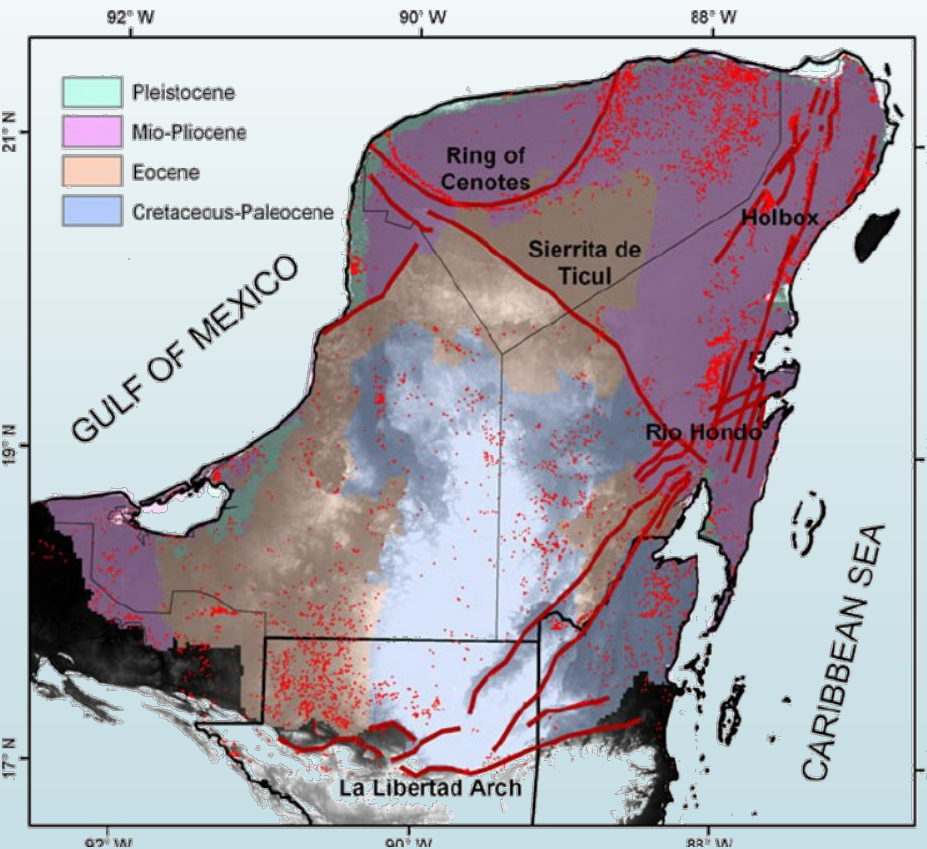
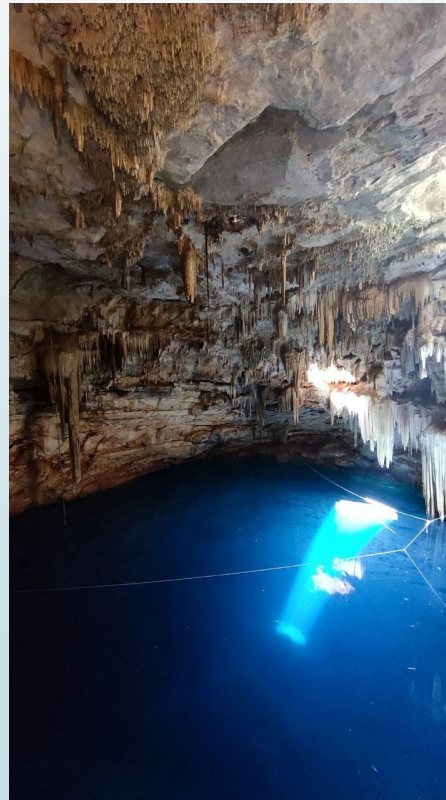
Department of Natural Sciences, Texas A&M
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Texas Groundwater Invertebrate Forum 2024



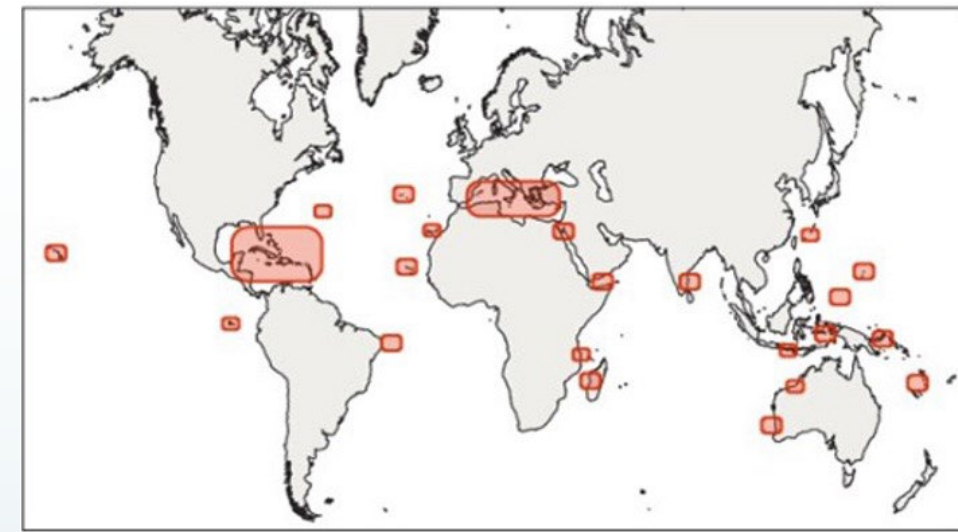
The Yucatán Peninsula

- No major lakes or rivers
- Extensive karst aquifer ecosystems
- ~80 stygobiont species (>70% crustaceans)
 - High endemism
 - Low abundance

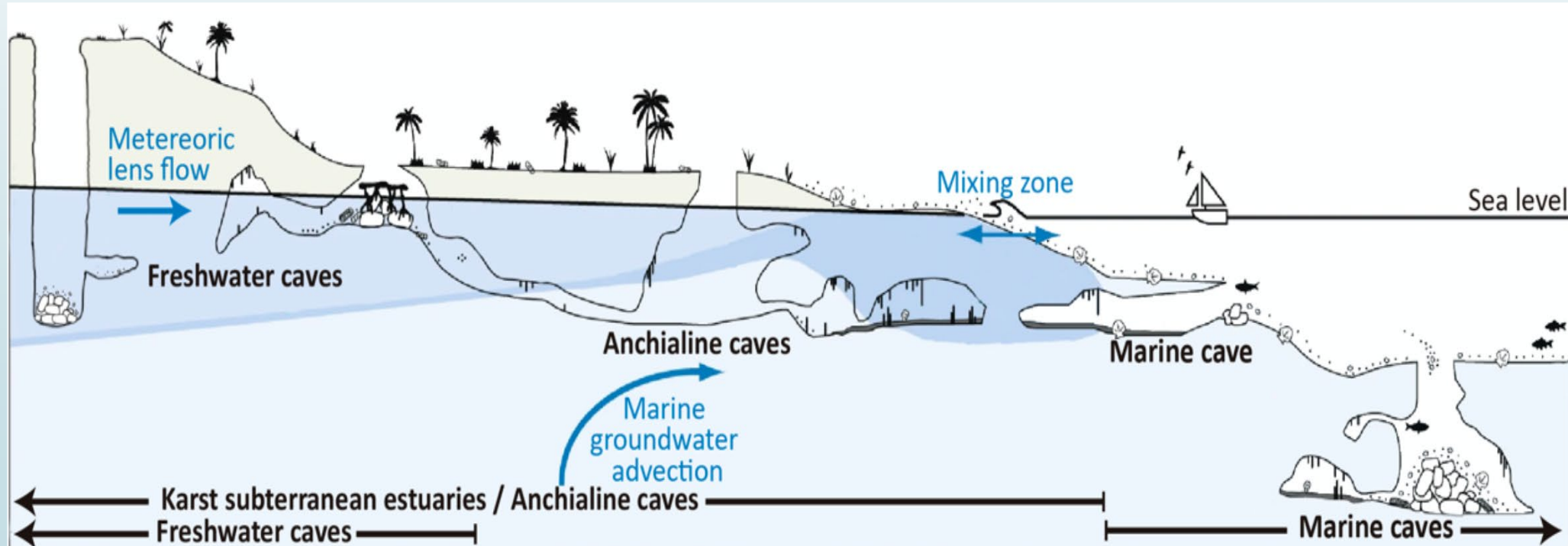


Anchialine Caves

- Karst subterranean estuaries
- Stratified salinity (fresh – saline), separated by a halocline
- Transient ecosystems relative to sea level rise and fall

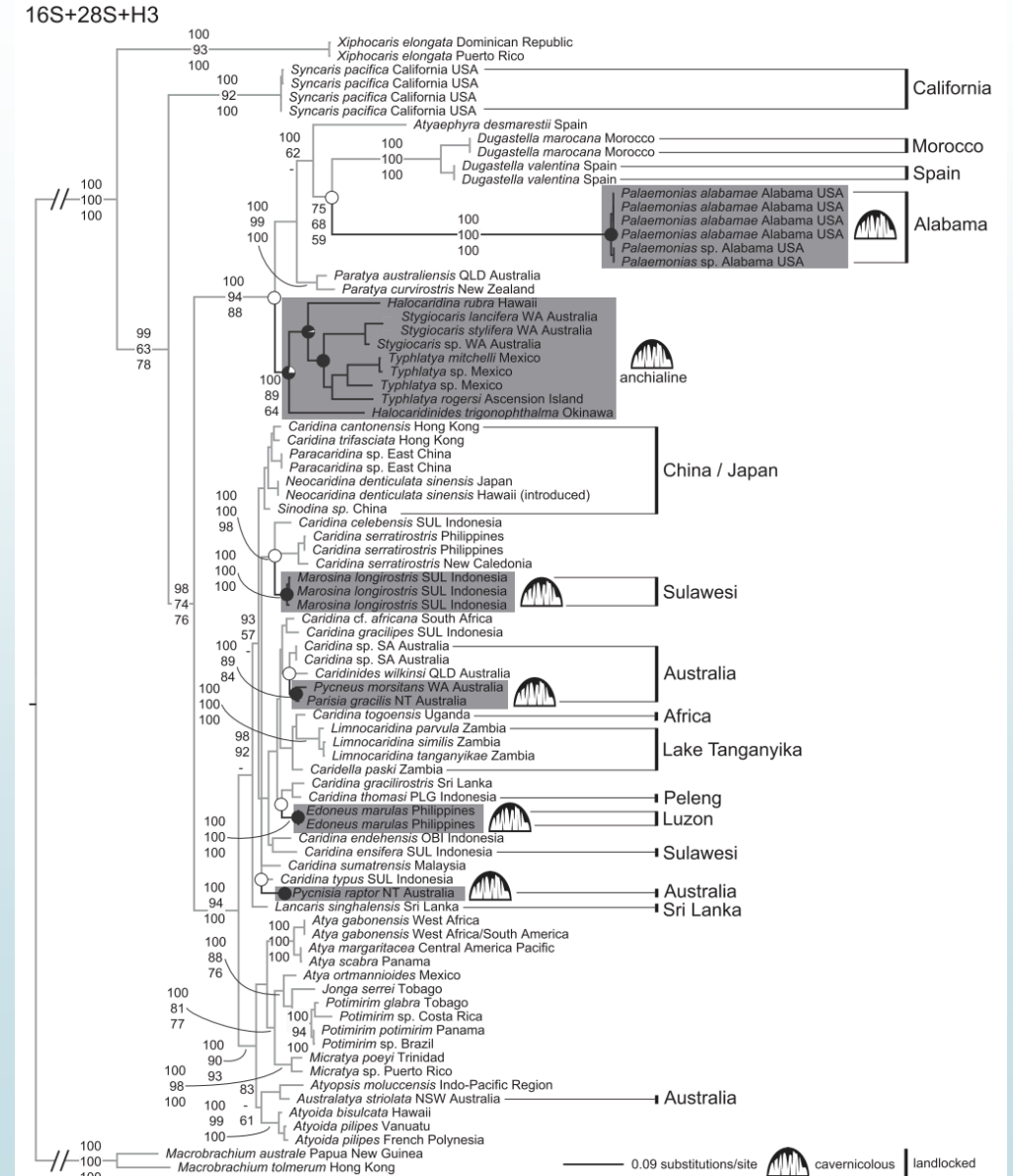


Iliffe and Kornicker 2009, Martinez et al. 2018

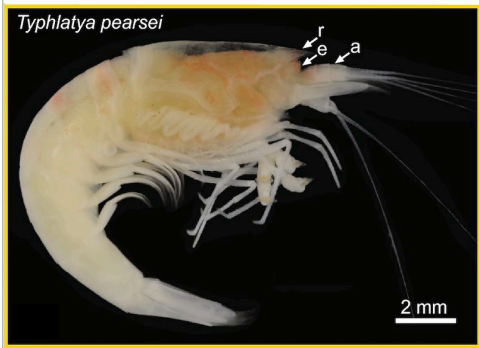


Atyidae

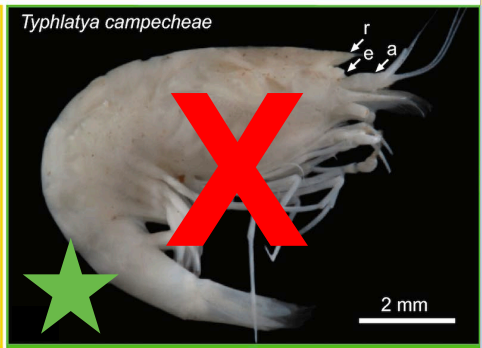
- 450 species, 40 genera
- Freshwater family
- Convergent cave adaptations
- Single anchialine adapted clade
 - Fresh $\leftrightarrow$ Saline
- Not recorded in the open ocean



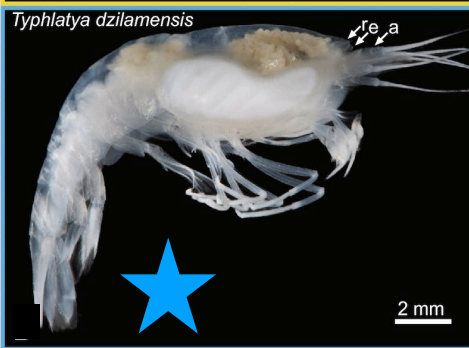
Typhlatya in the Yucatán Peninsula



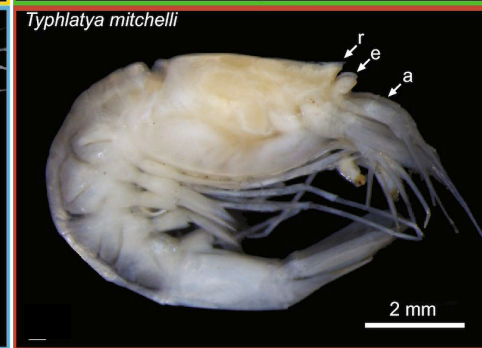
Typhlatya pearsei
Creaser, 1936



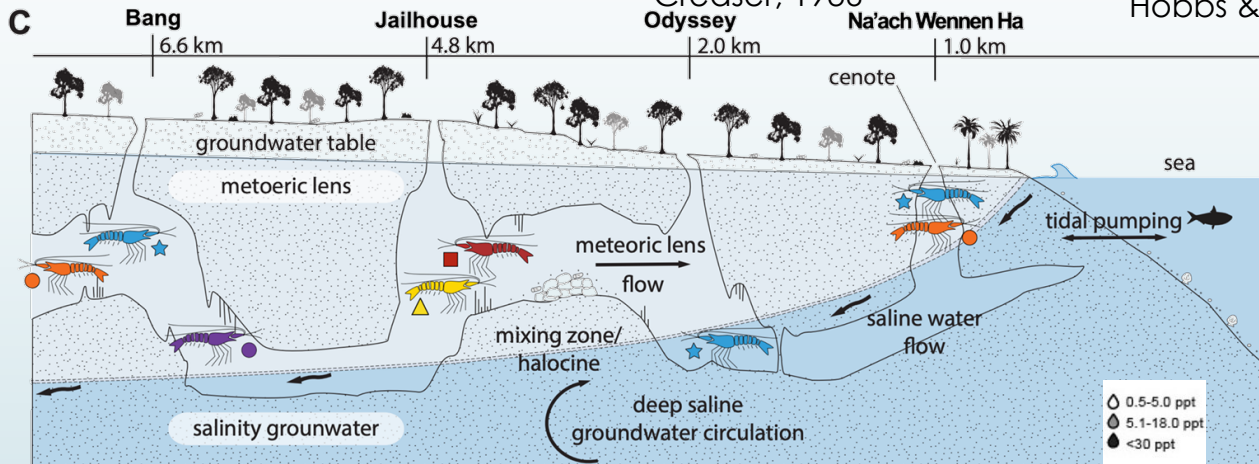
Typhlatya campecheae
Hobbs & Hobbs, 1976



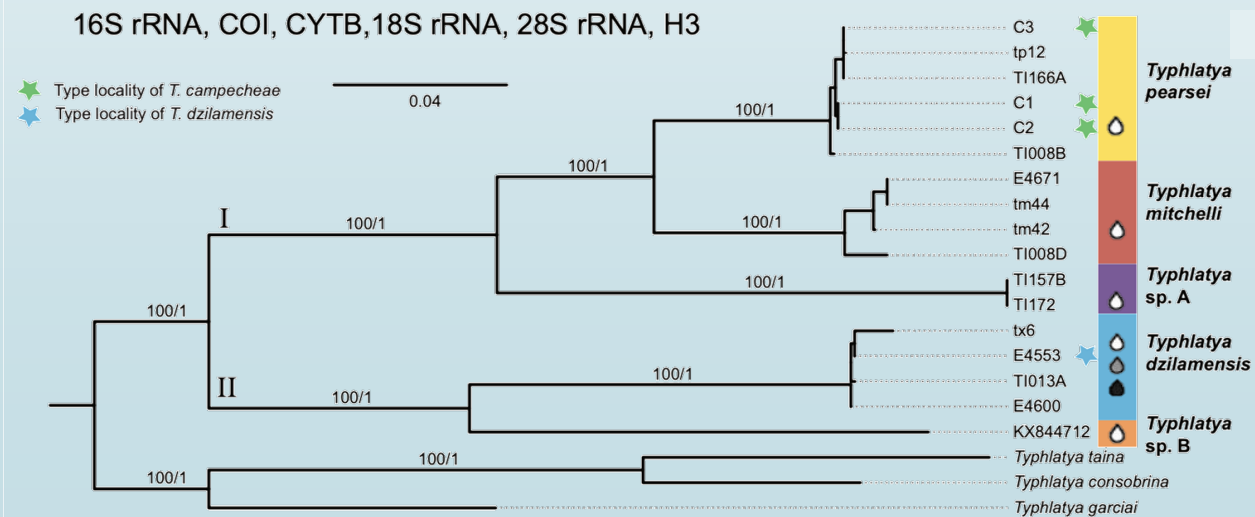
Typhlatya dzilamensis
Alvarez et al., 2005



Typhlatya mitchelli
Hobbs & Hobbs, 1976



- Endemic
- Evidence of syntopy
- Coastal euryhaline *Typhlatya dzilamensis* demonstrate phenotypic plasticity (e.g., salinity tolerance)



Research Questions

- What is the distribution of the *Typhlatya* species within the Yucatán Peninsula?
- Can the distribution and population genetics of *Typhlatya* species provide insights into connectivity between and among cave systems within the Yucatán Peninsula?



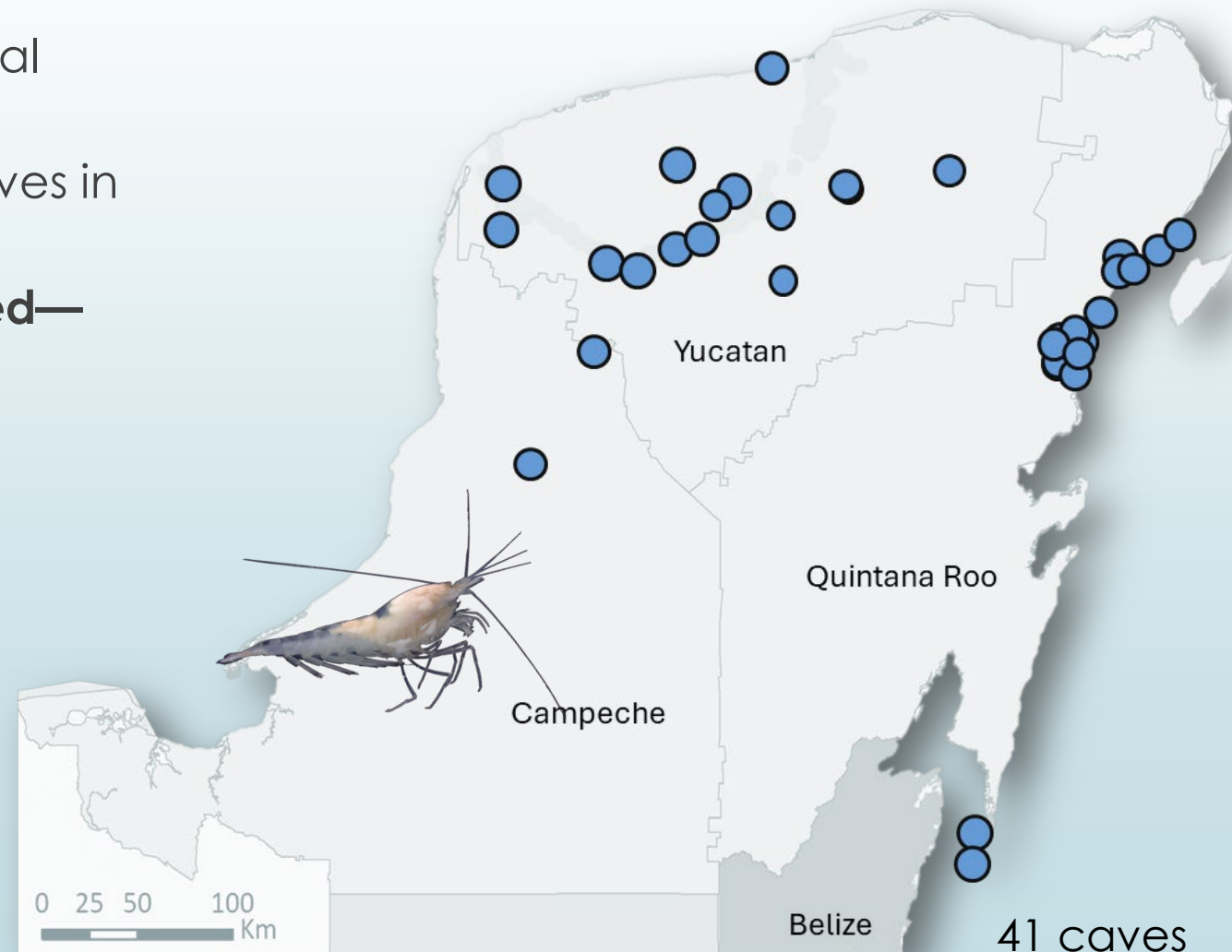
Methods

Sampling—

- ~41 inland and coastal caves
- Includes 2 marine caves in Belize

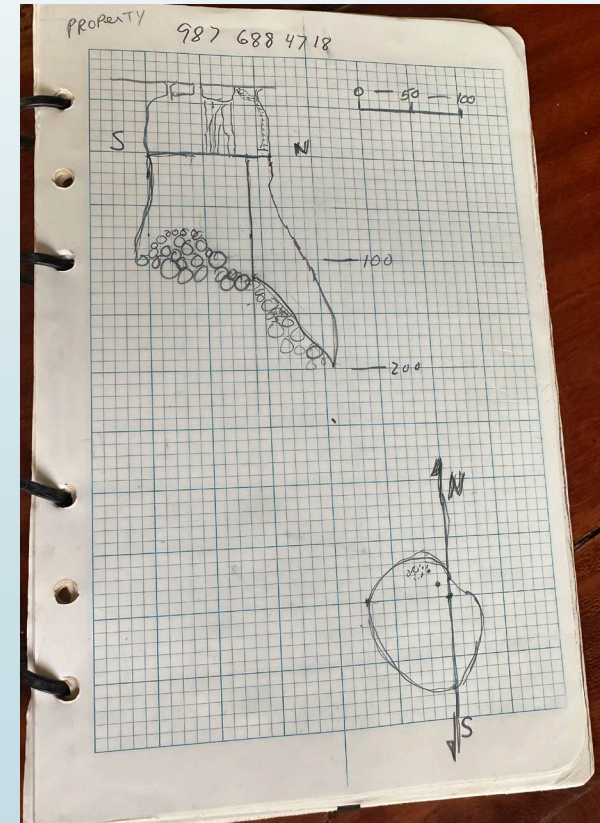
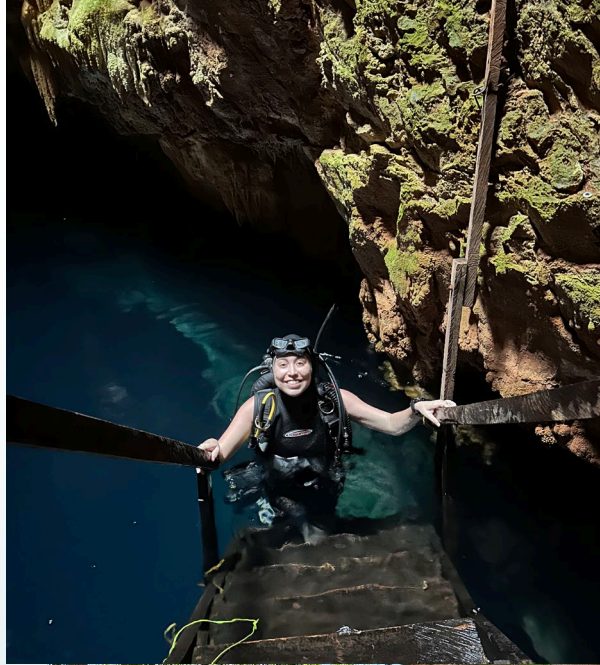
Molecular Data extracted—

- Mitochondrial genes
 - 16S rRNA
 - CO1
 - CYTB
- Nuclear genes
 - 28S rRNA
 - ITS



Methods— Sampling in SOTUTA, YP

- 10-day fieldwork expedition
- Exploration and mapping of unmapped cenote, 'Tres Rayos'
 - Courtesy of Imelda & Steve Moon
- Specimen collection
 - Only one *T. mitchelli* was collected ☹
 - Low abundance!



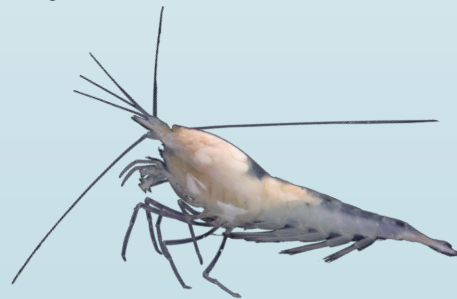
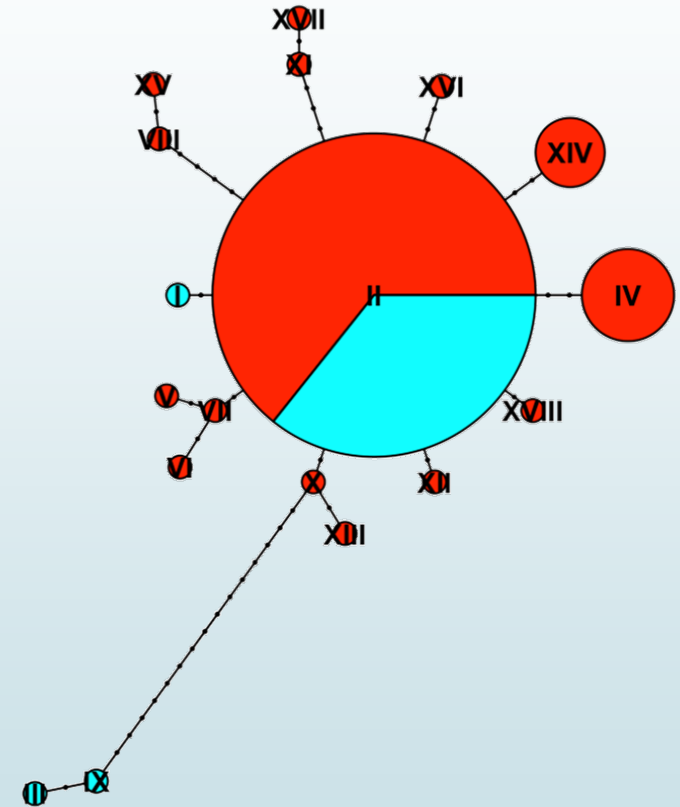
Methods

Population Genetics—

- Haplotype Network Reconstruction
- Population structure
- Connectivity

Statistical Analysis—

- Genetic diversity
- Isolation by distance (IBD)
- F_{ST}



Results

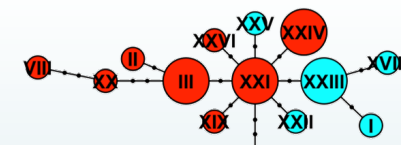


Typhlatya pearsei

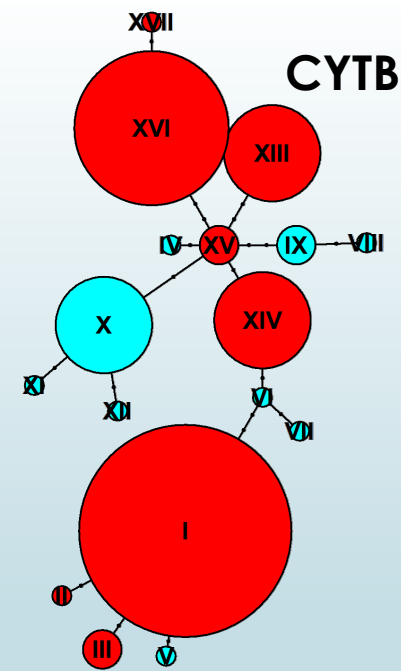
12 Caves



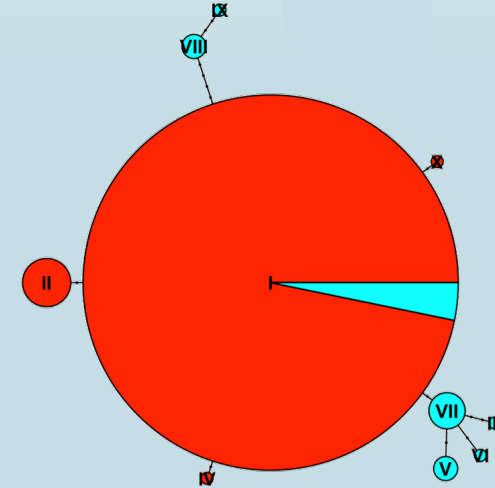
COI



CYTB



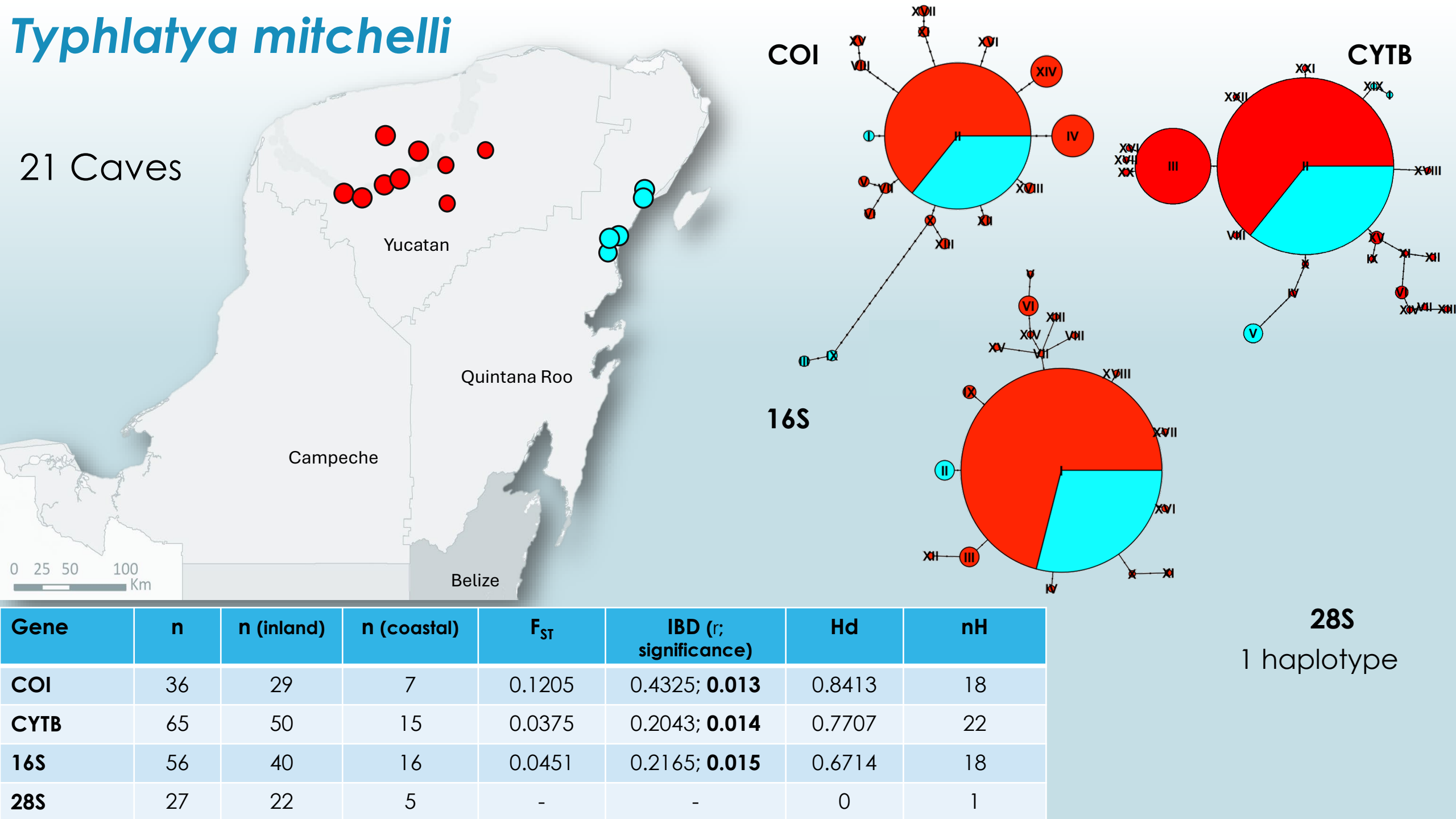
16S

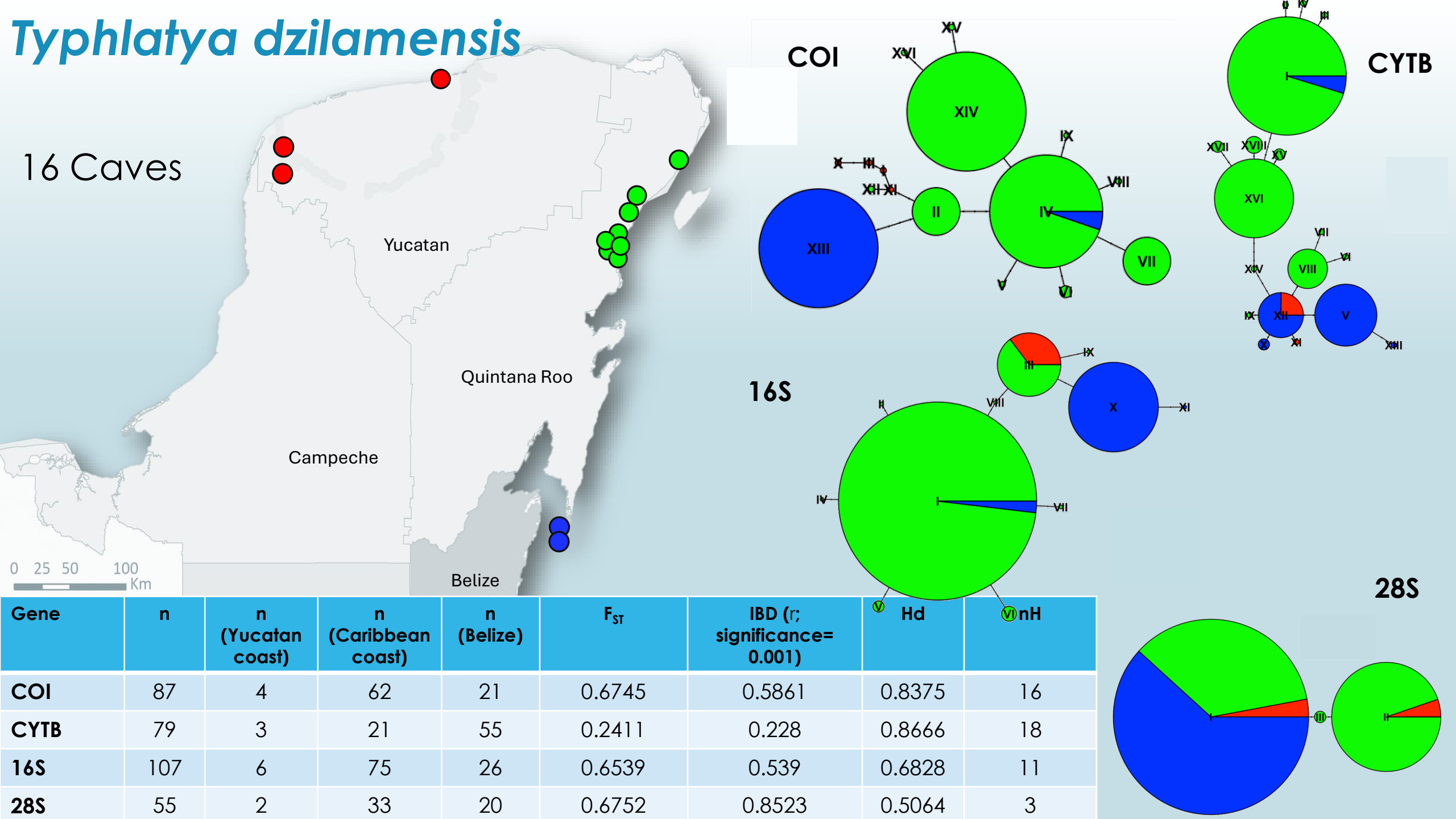


28S

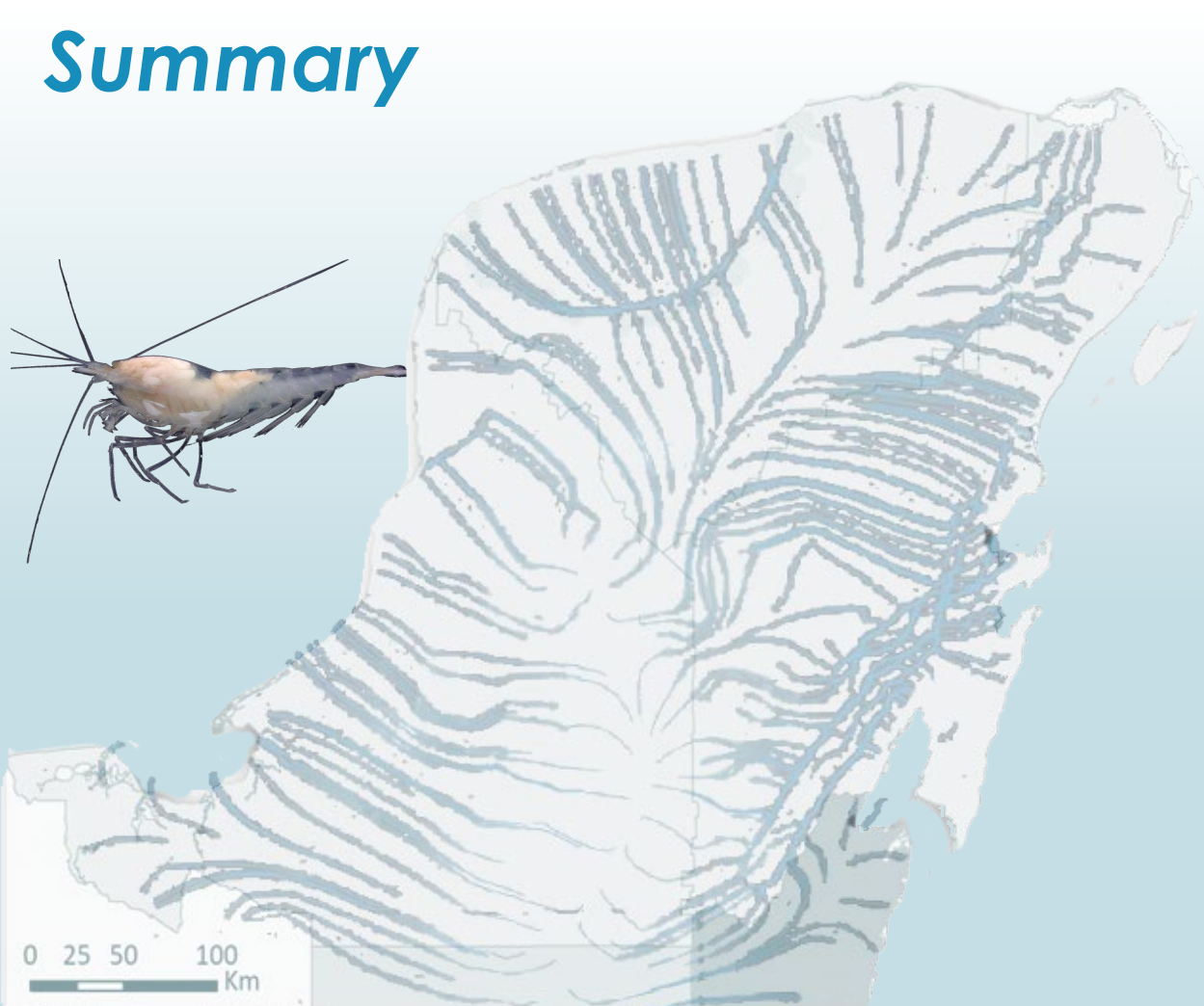
1 haplotype

Gene	n	n (inland)	n (coastal)	F _{ST}	IBD (r; significance)	Hd	nH
COI	34	24	10	0.4234	0.1534; 0.021	0.9857	27
CYTB	49	35	14	0.1677	0.0907; 0.036	0.9014	17
16S	47	36	11	0.2612	0.4095; 0.001	0.5597	10
28S	27	16	11	0	-	0	1



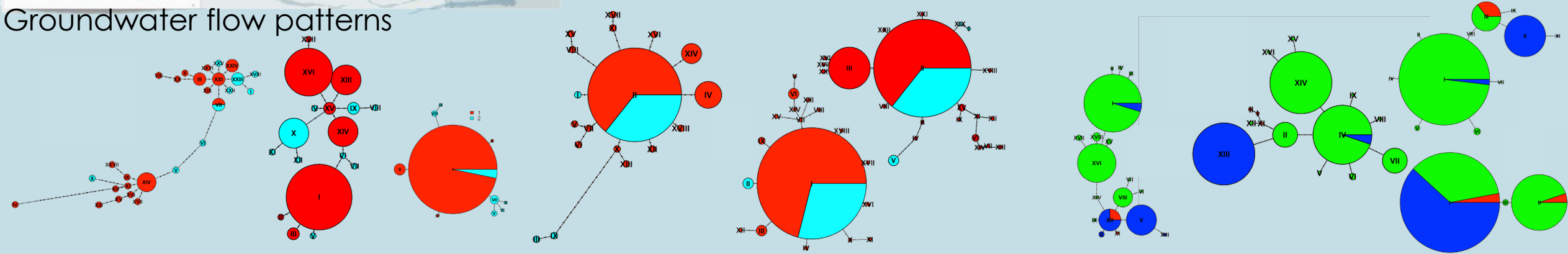
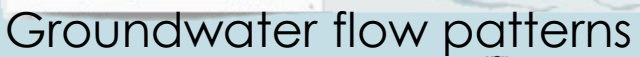
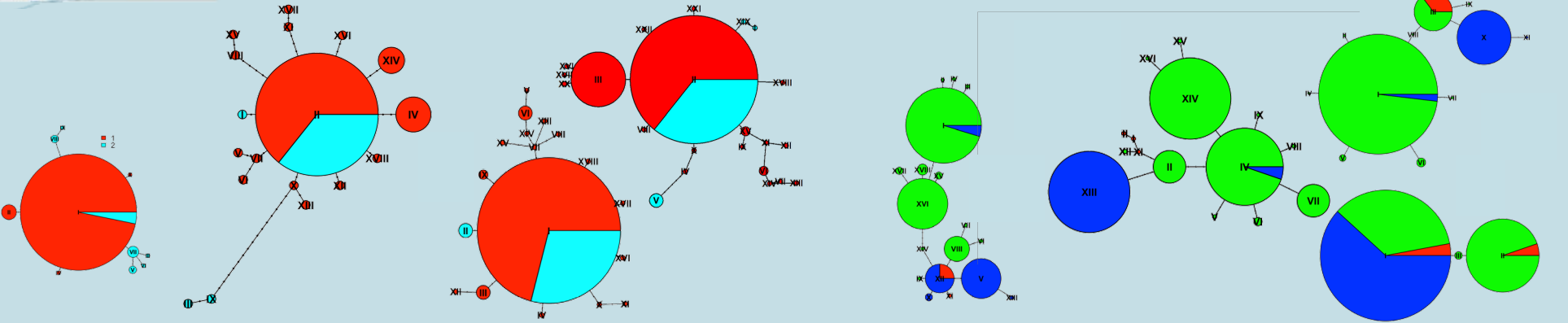
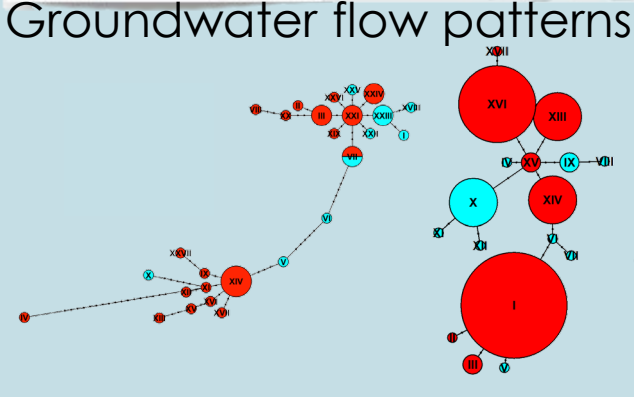


Summary



- Importance of molecular tools towards more **accurate identification of populations** within Yucatán Peninsula aquifer
- Provide insights into the
 - Potential **connections between / among** inland and coastal cave systems
 - Potential connections between / among proximal and distant cave systems
 - Distributional ranges
- **Subterranean caves are NOT isolated**

Groundwater flow patterns



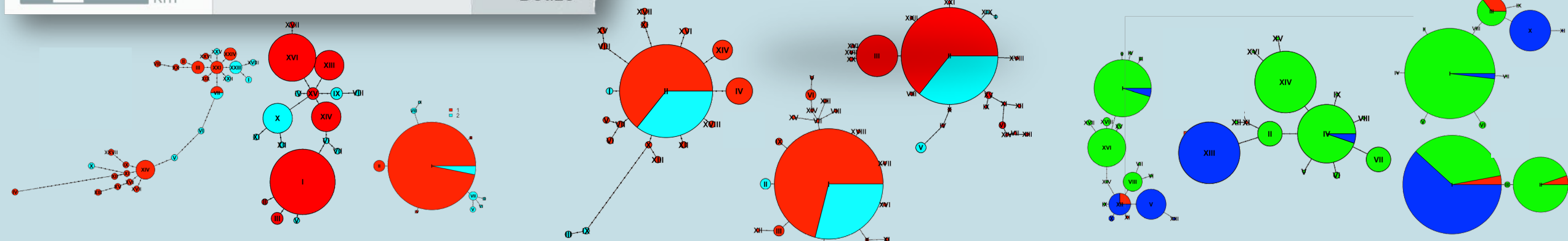
Discussion

The map displays the Yucatán Peninsula with sampling locations marked by blue dots. The locations are distributed across the states of Yucatán, Quintana Roo, Campeche, and Belize. A scale bar indicates distances of 0, 25, 50, and 100 Km. Two circular insets provide close-up views of the shrimp: one showing a shrimp with a yellowish body and numerous yellow eggs, and another showing a shrimp with a dark, patterned body.

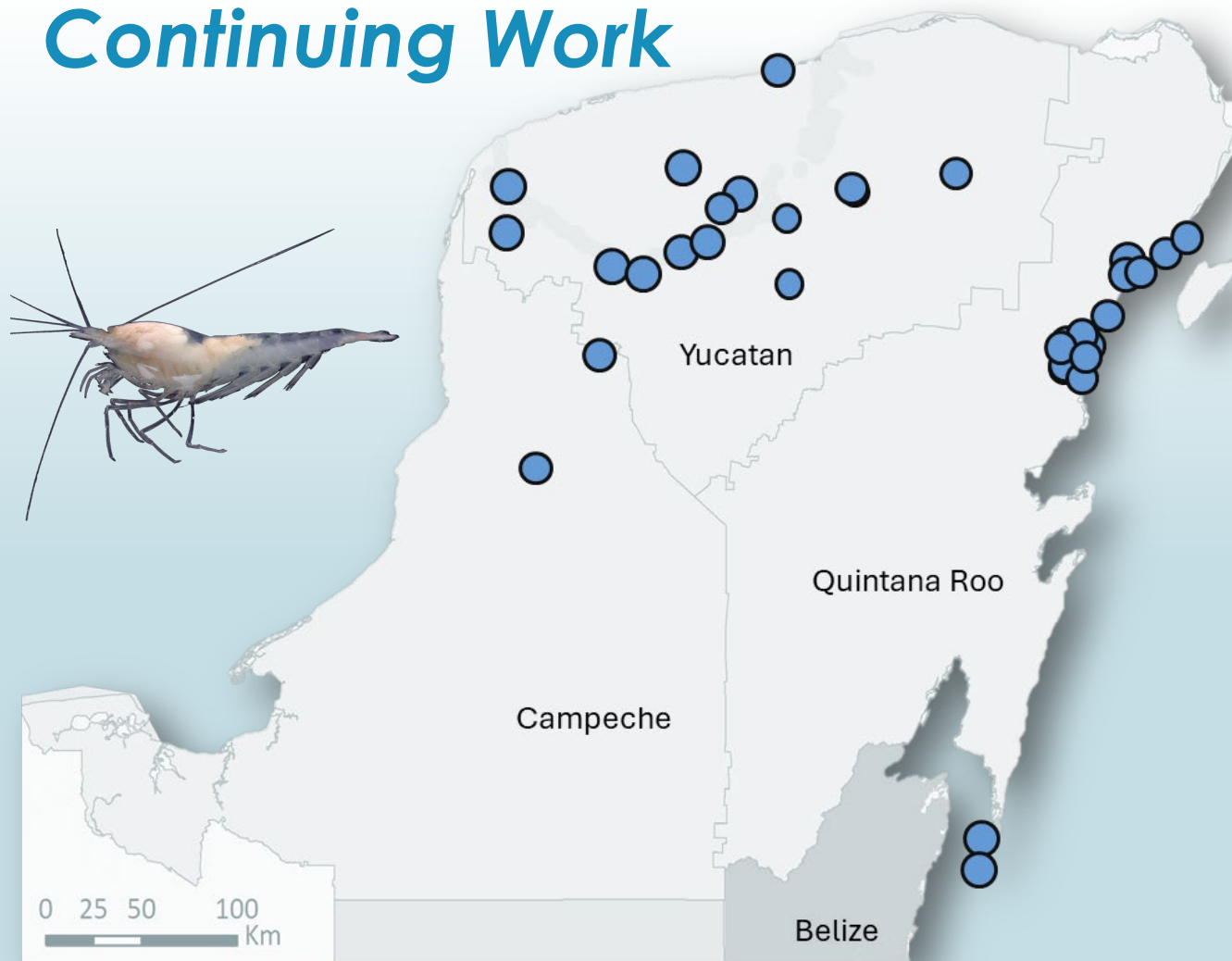
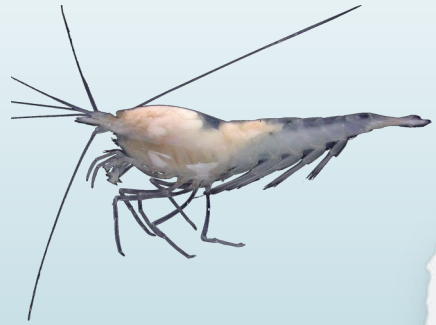
Mitochondrial vs. Nuclear diversity

- nucDNA

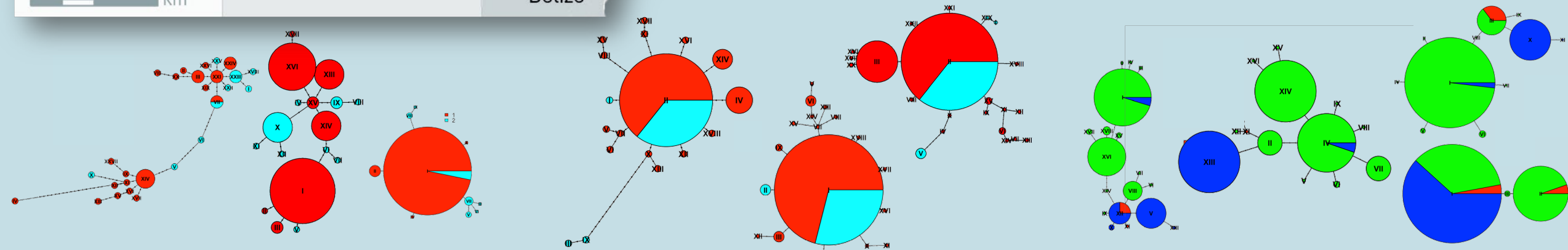
- Different patterns
- Moving males



Continuing Work



- Evaluation of the population connectivity by cave
- Linking environmental data with population structure
- Increase sample sizes
- Decrease geographic sampling gaps
- Inclusion of ITS (In progress) will provide added insight among populations of *Typhlatya* species
- Setting the stage for ongoing work to integrate genomic data



Acknowledgements



Advisor/Mentor: Dr. Elizabeth Borda

Borda lab

Co-authors: Lauren Ballou, David Brankovits, Efrain Chavez-Solis, Fernando Calderón- Gutiérrez, Tom Iliffe and Nuno Simões

Imelda & Steve Moon, Danielle Bragg

KISS Rebreather team

Research funding:

Texas A&M University San Antonio Research Council & Summer Research Grants

NSF Biological Oceanography (#2136322)



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Questions?