Aquatic Insect Functional Diversity Along Canopy Coverage, Elevation and Water Temperature Gradients In Rocky Mountain Streams

Carolina Gutiérrez, Rachel Harrington, Boris Kondratieff, Colleen Webb, Cameron Ghalambor and N. LeRoy Poff

Functional Diversity (FD)

What is it?

Broadly defined as:

The value, range, distribution and relative abundance of the functional traits in a given ecosystem

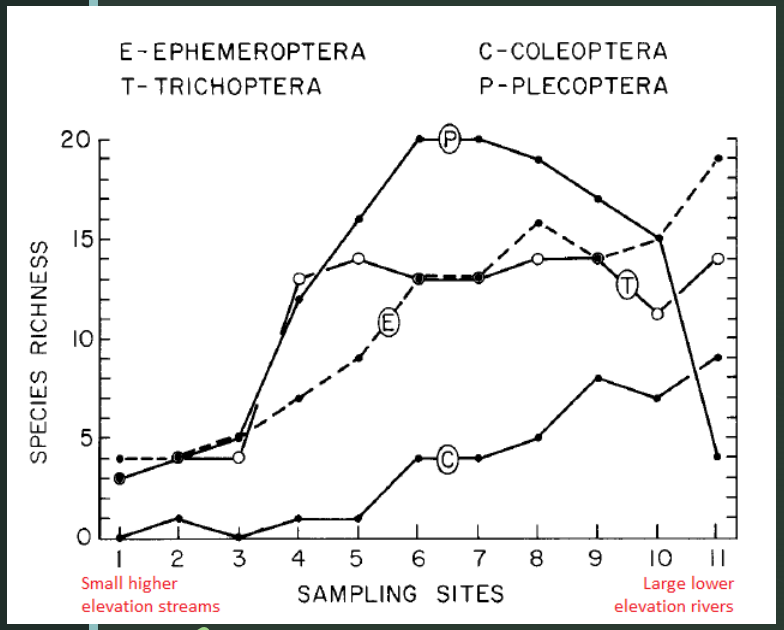
(Díaz *et al.,* 2007)

Why should we be interested?

- Quantify the value and range of organismal traits
- Influence of traits in organismal performance in ecosystem
- Rather than species diversity, FD enhances insight into ecosystem functions.

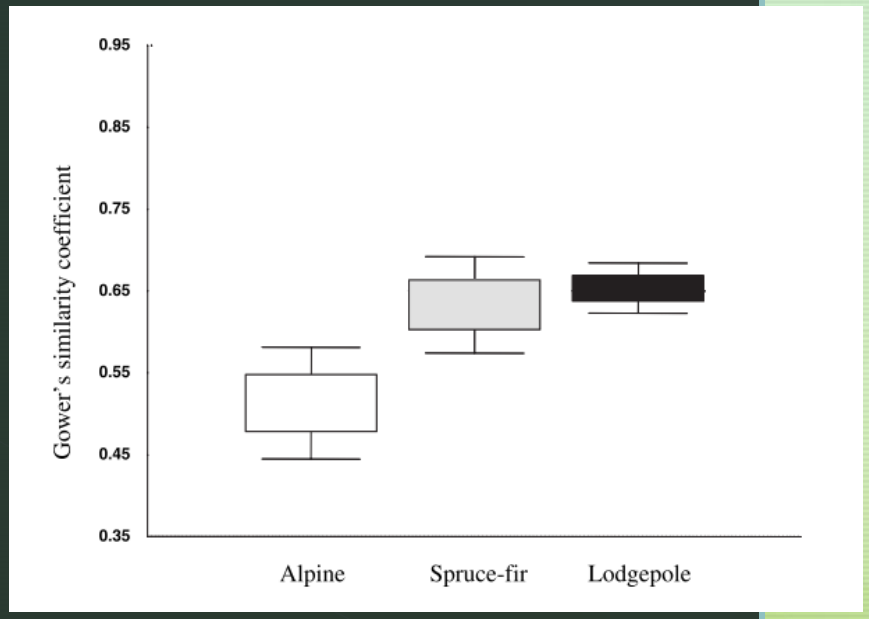
Why measure Diversity along environmental gradients?

- Less consideration given to elevation gradients than to longitudinal gradients
- Abiotic conditions change rapidly over small spatial scales



Elevation

Ward (1986)



Elevation

Finn & Poff (2005)

Higher elevations = lower richness, less similarity

Resources change along gradients…

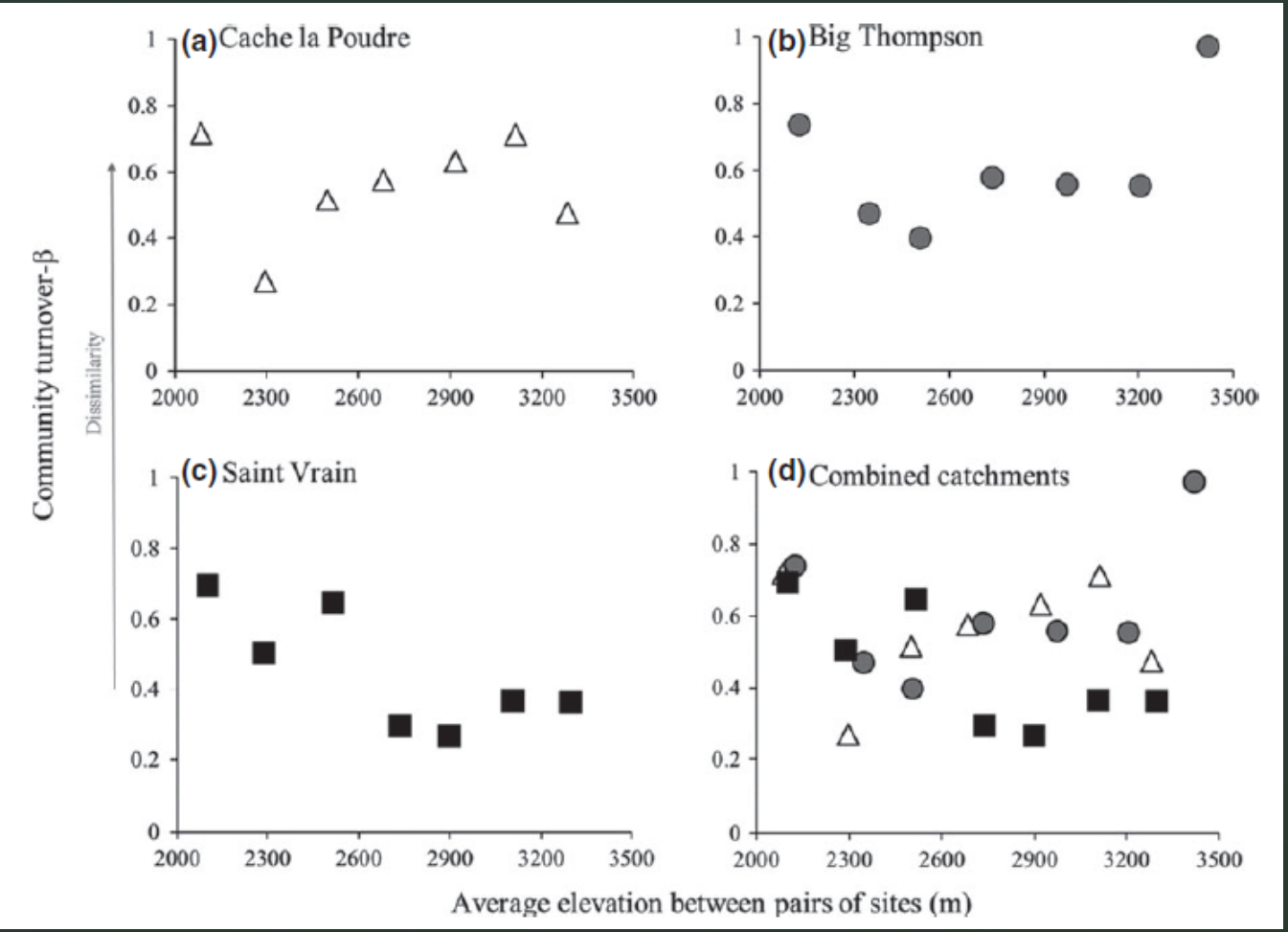
Physical conditions

- Temperature
- Flow regime
- Light availability/cover

Resources

- Benthic Organic Matter
- Algae (chlorophyll a)
- Prey density

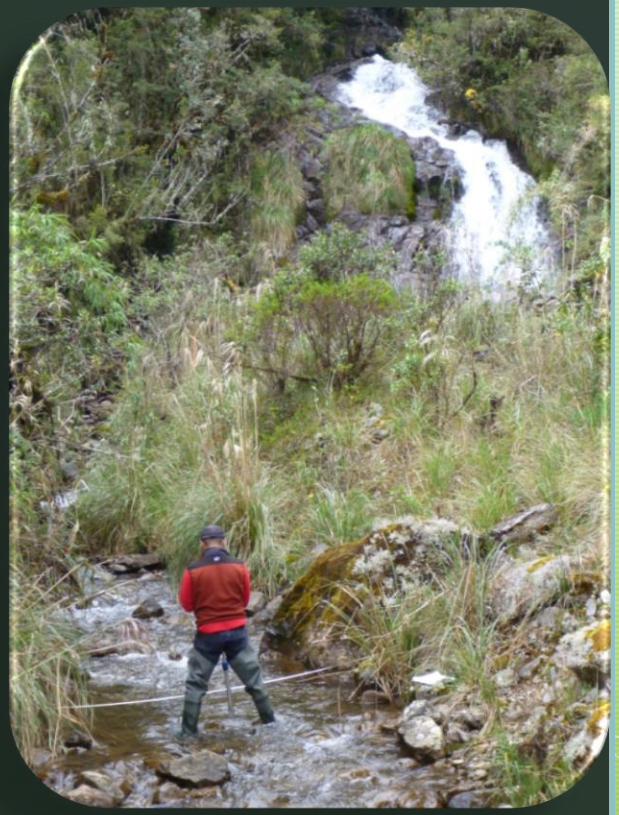
Recent background



Source: Harrington et al. (2016)

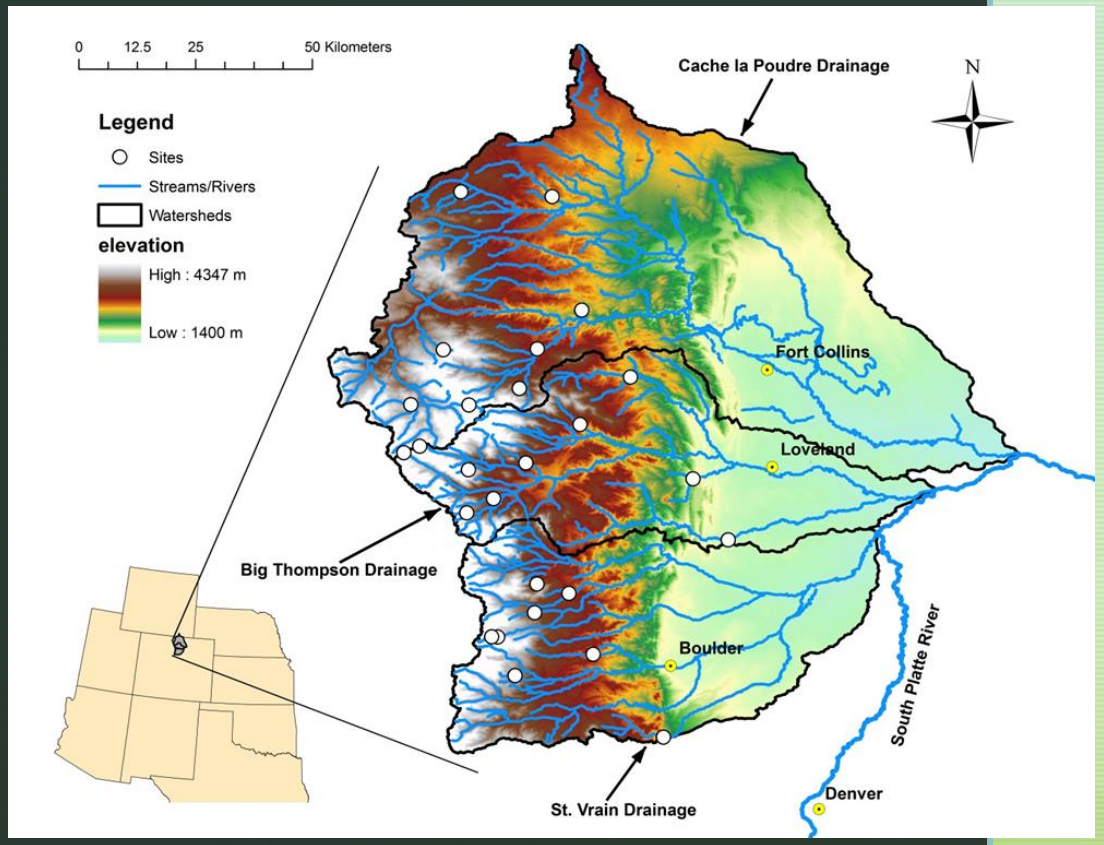
Question:

Does the functional diversity (FD) of aquatic insect communities change along environmental gradients in Rocky Mountain Streams? If so, how?



METHODS: Field locations

- 24 streams total
- 200 meter elevation bands ranging from 1500m-3500m
- Replicated in 3 different drainages



Elevation

Source: Harrington (2014)

METHODS: Insect collection

RESOURCES: Chlorophyll *a*

In situ filtration of rock slurry using glass fiber filters at both open and closed replicate sites.

Freeze preservation of filters to perform chl *a* extraction in the laboratory.

Chl *a* extraction and concentration measured using a Turner Designs *Aqua*Fluor Handheld Fluorometer.

Methods: 20 traits used

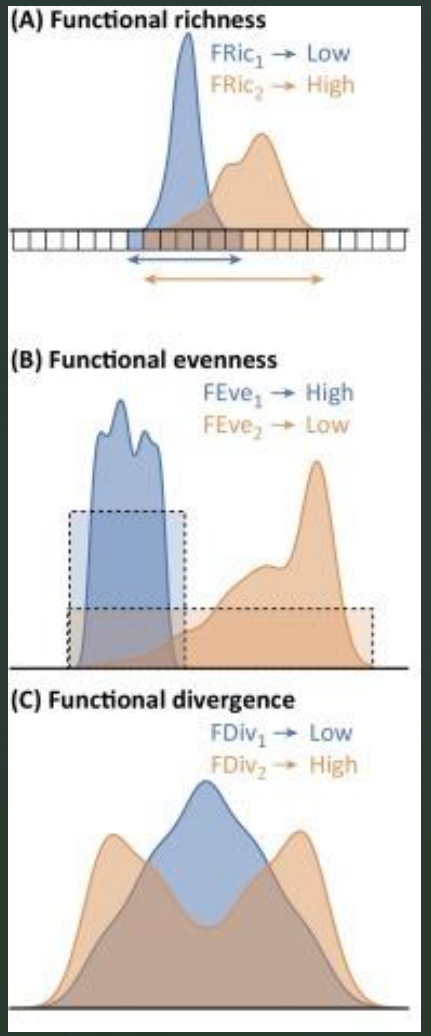
Traits	Trait States (#)
Life history	
Ability to survive desiccation	2
Adult ability to exit	2
Adult life span	3
Development	3
Synchronization of emergence	2
Voltinism	3
Mobility	
Adult flying strength	2
Female dispersal	2
Maximum crawling rate	3
Occurrence in drift	3
Swimming ability	3
Morphology	
Armoring	3
Attachment	3
Respiration	3
Shape	2
Size at maturity	3
Ecology	
Habit (in ecosystem)	6
Rheophily	3
Thermal preference	3
Trophic Habit	5

Source: Adapted for use from Poff *et al*. (2006)

How to measure FD?

Multidimensional framework: 3 facets of FD

- **Functional richness (FRic)**
  - Volume of multidimensional space
  - All species in a community within functional space.
- **Functional evenness(FEve)**
  - Regularity of trait distribution
  - Relative abundance of species in functional space for a given community.
- **Functional divergence (FDiv)**
  - Proportion of total abundance
  - Supported by species with the most extreme trait values within a community.



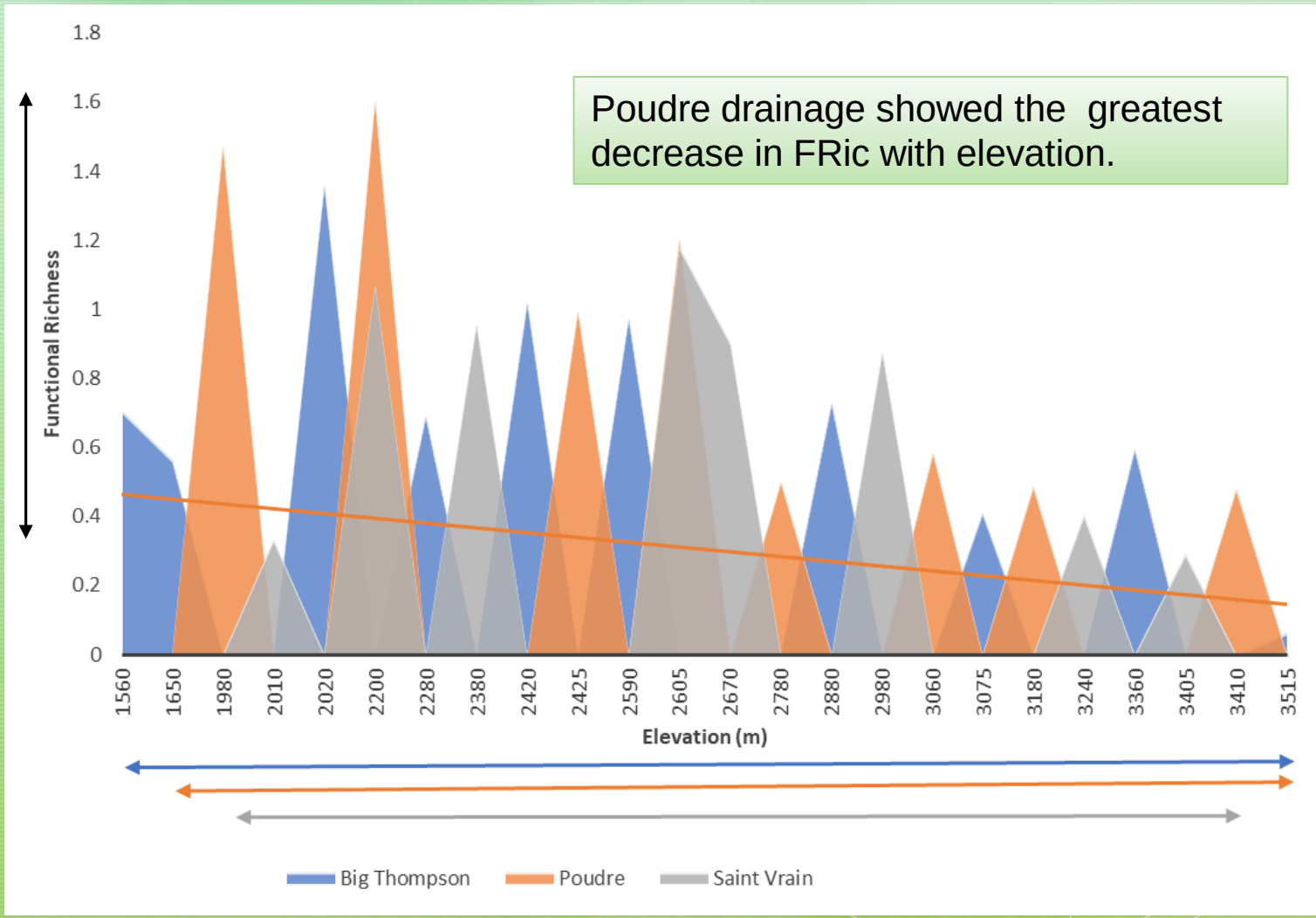
Source: Adapted from Villéger *et al*., 2008 & Carmona *et al.,* 2016; Mouillot *et al*., 2013.

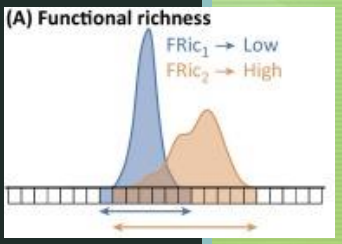
Statistical analysis

- Taxonomic richness and community structure analysis
- Functional Richness, Evenness & Divergence Indexes analysis
- ANOVA on indexes' values to test the hypothesis of variation along environmental gradients
- Ordination Analysis on Traits' distribution
- Analysis of Chl *a* concentration along the elevation gradient.

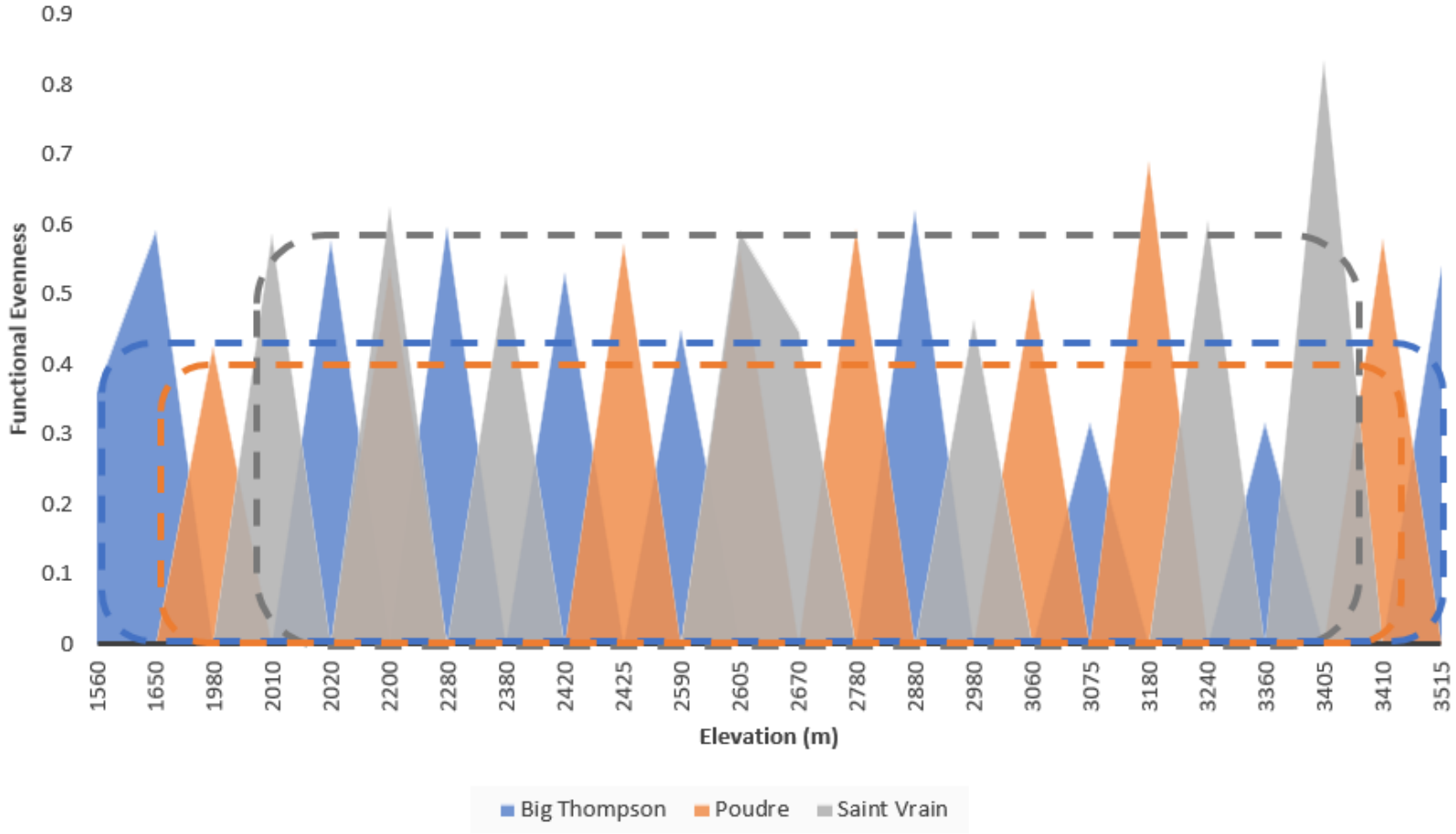
Results

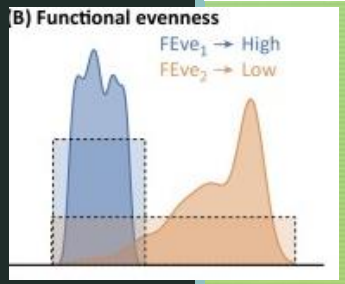
Results: Functional Richness*



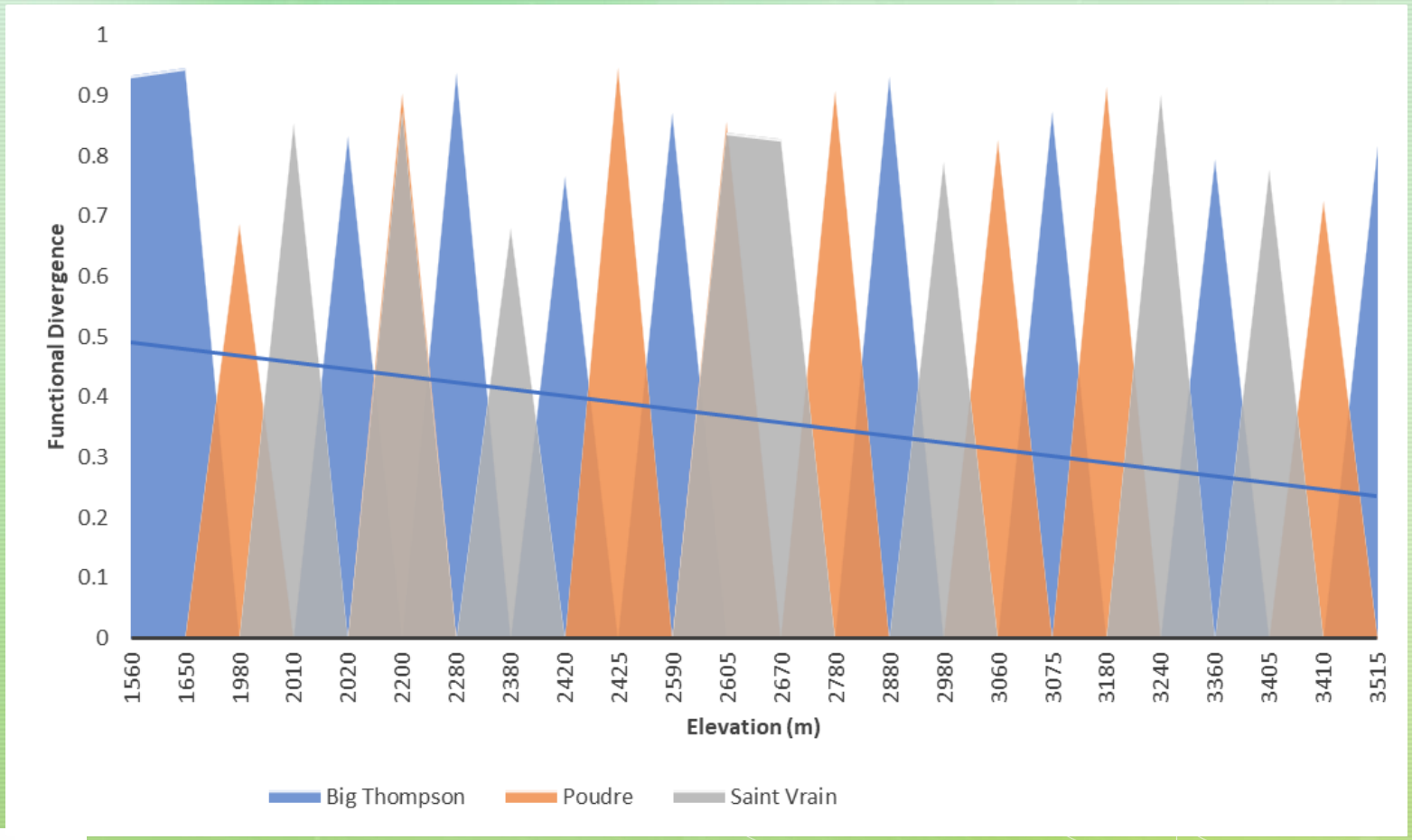


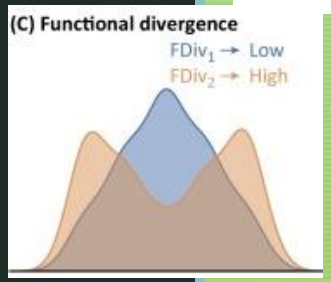
Results: Functional Evenness



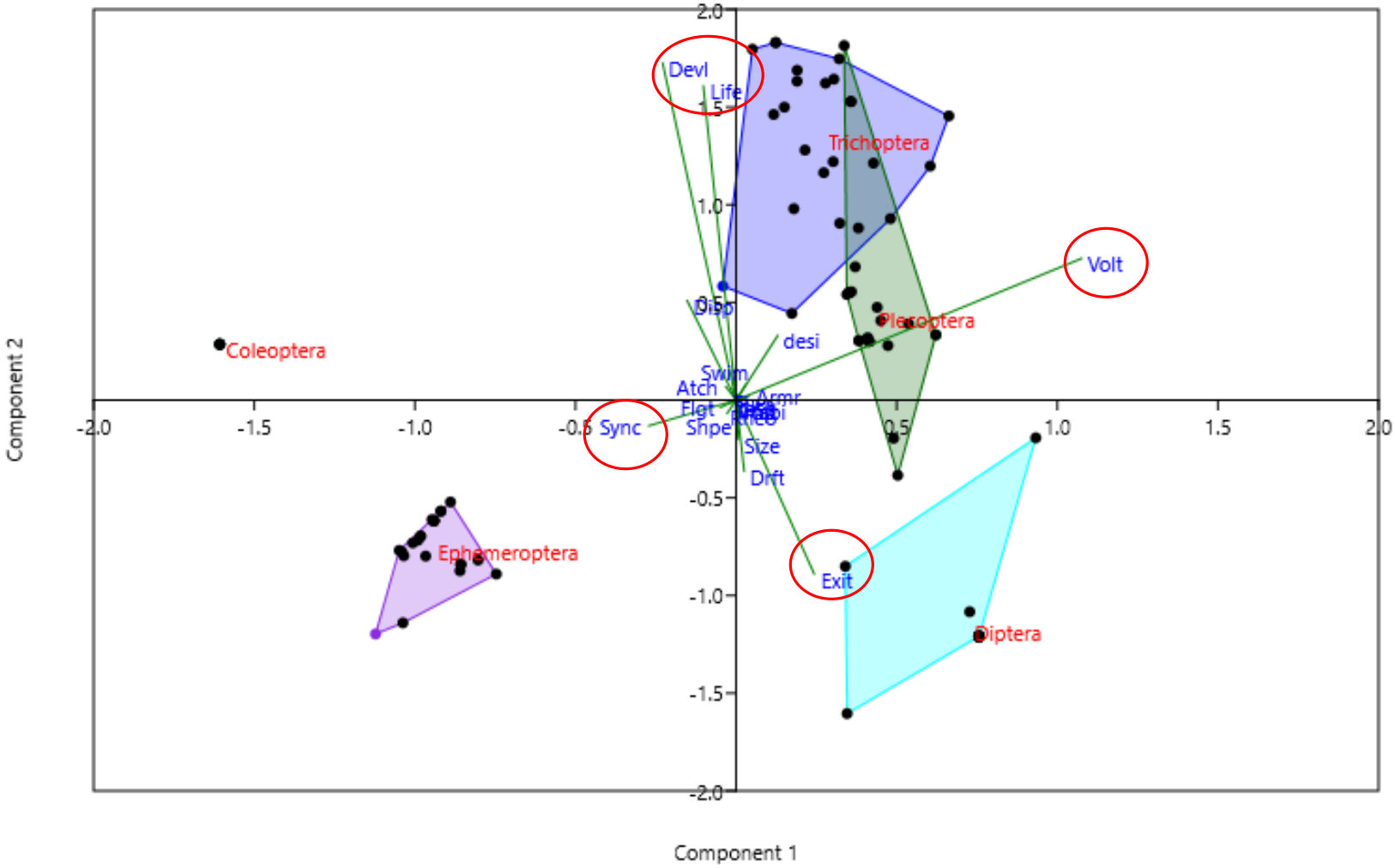


Results: Functional Divergence

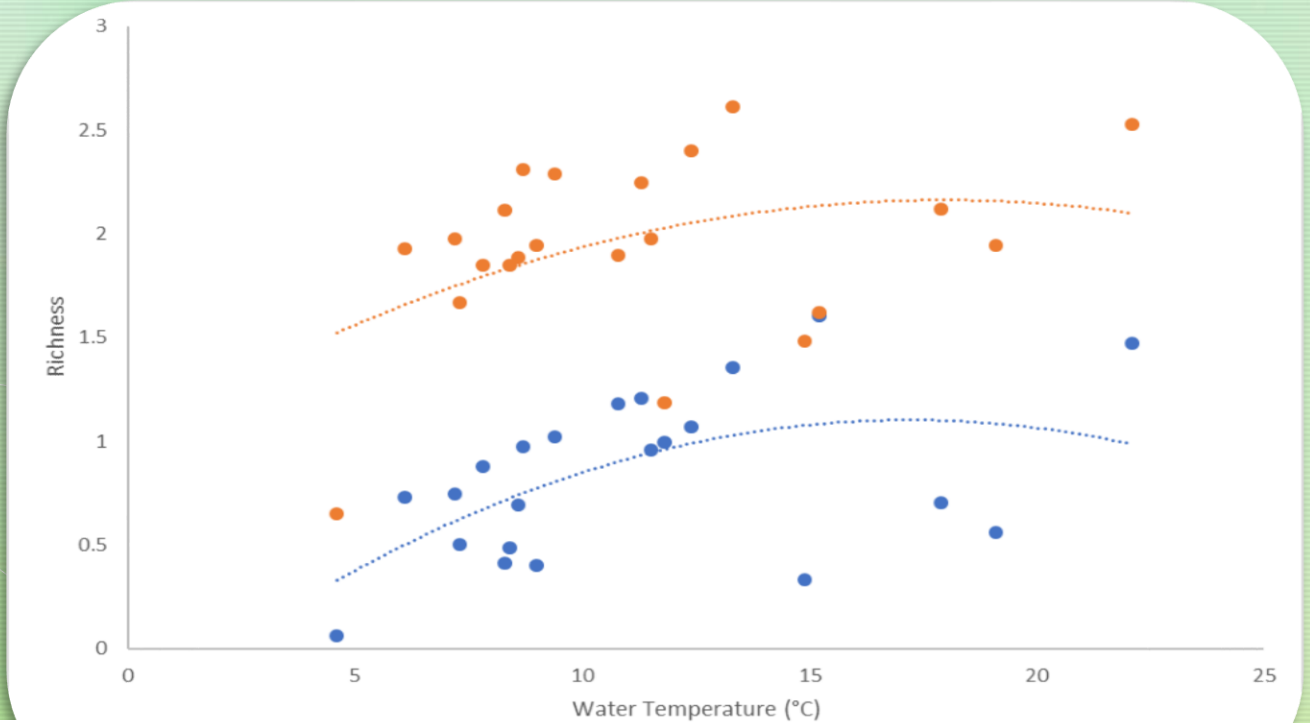


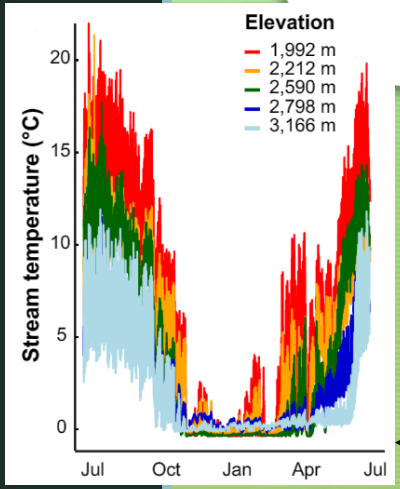


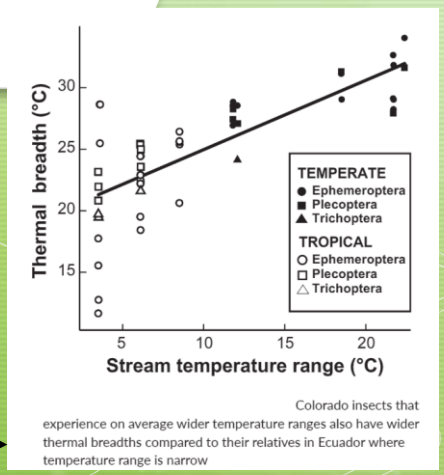
What is the traits' distribution?



What about Water temperature?

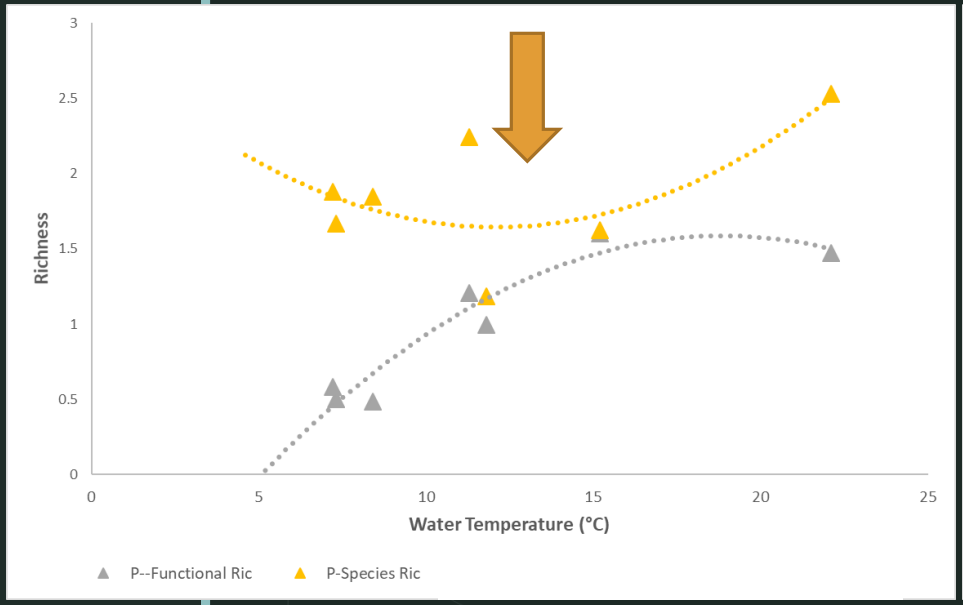


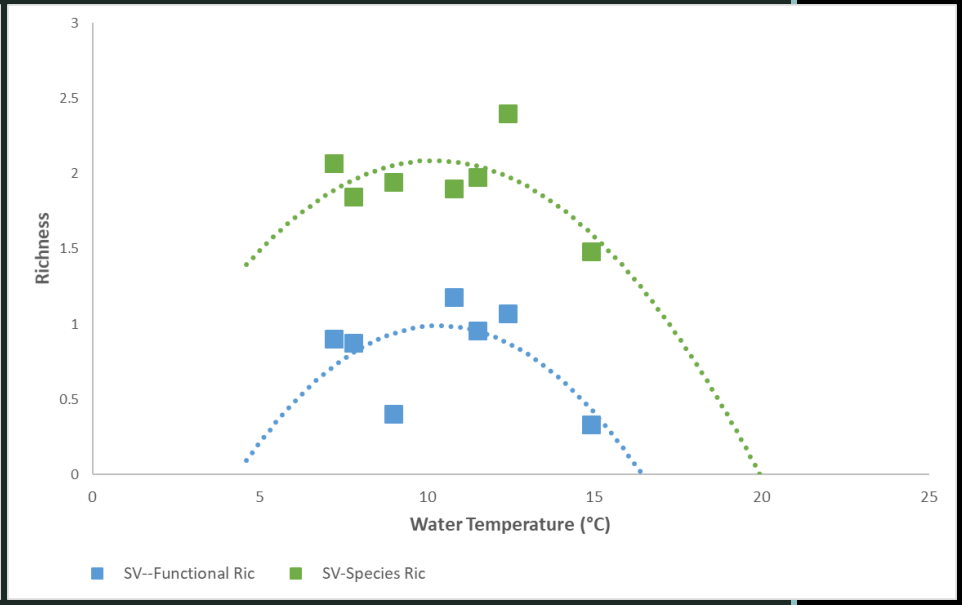


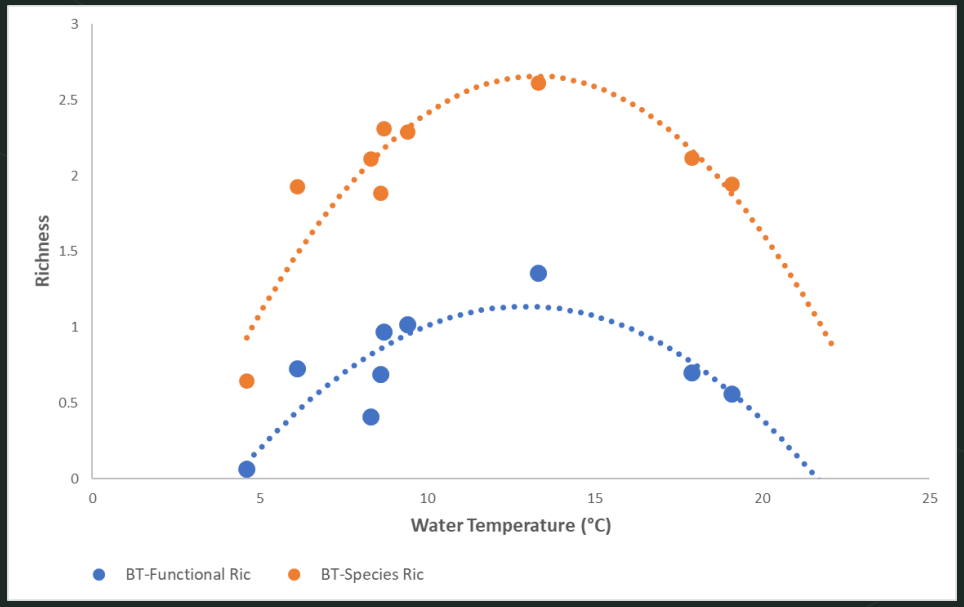


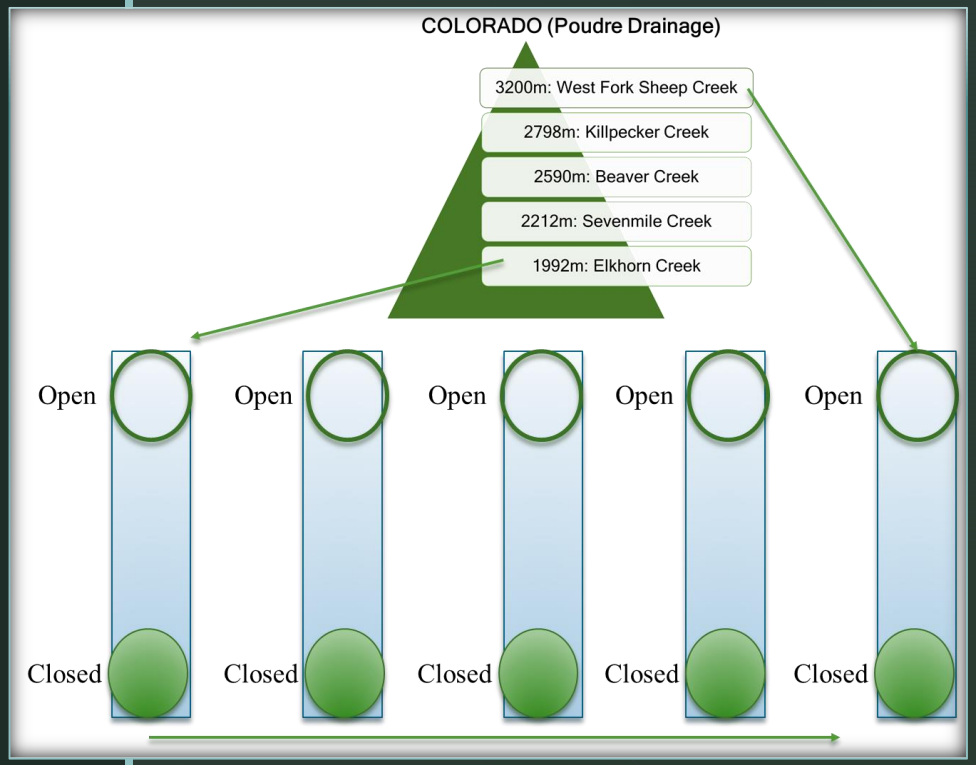
Colorado insects that experience on average wider temperature ranges also have wider thermal breadths compared to their relatives in Ecuador where temperature range is narrow

Source: Shah et al. (2017)

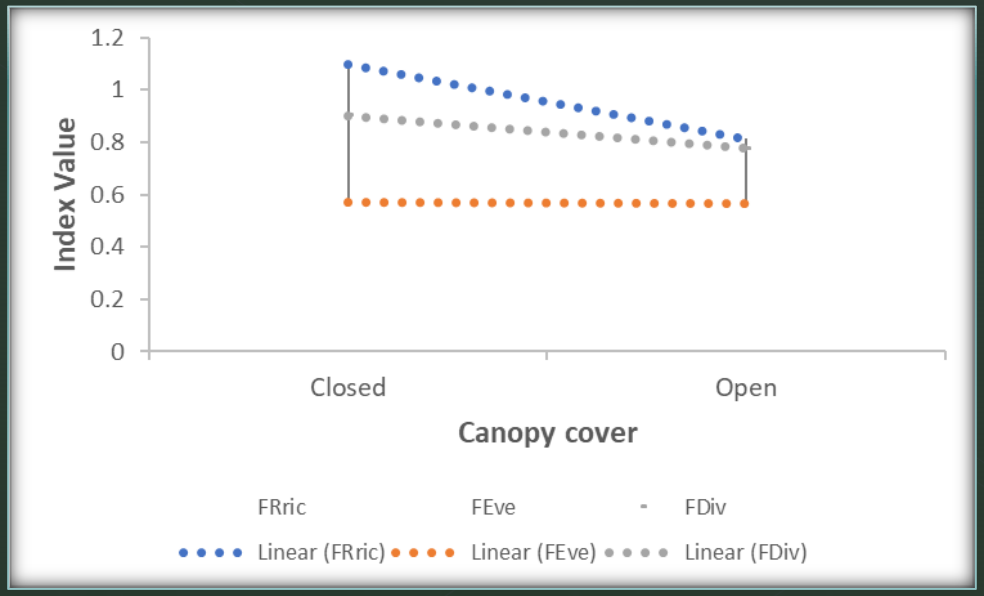

Richness
Water Temperature (°C)
P--Functional Ric
P-Species Ric


Richness
Water Temperature (°C)
SV--Functional Ric
SV-Species Ric

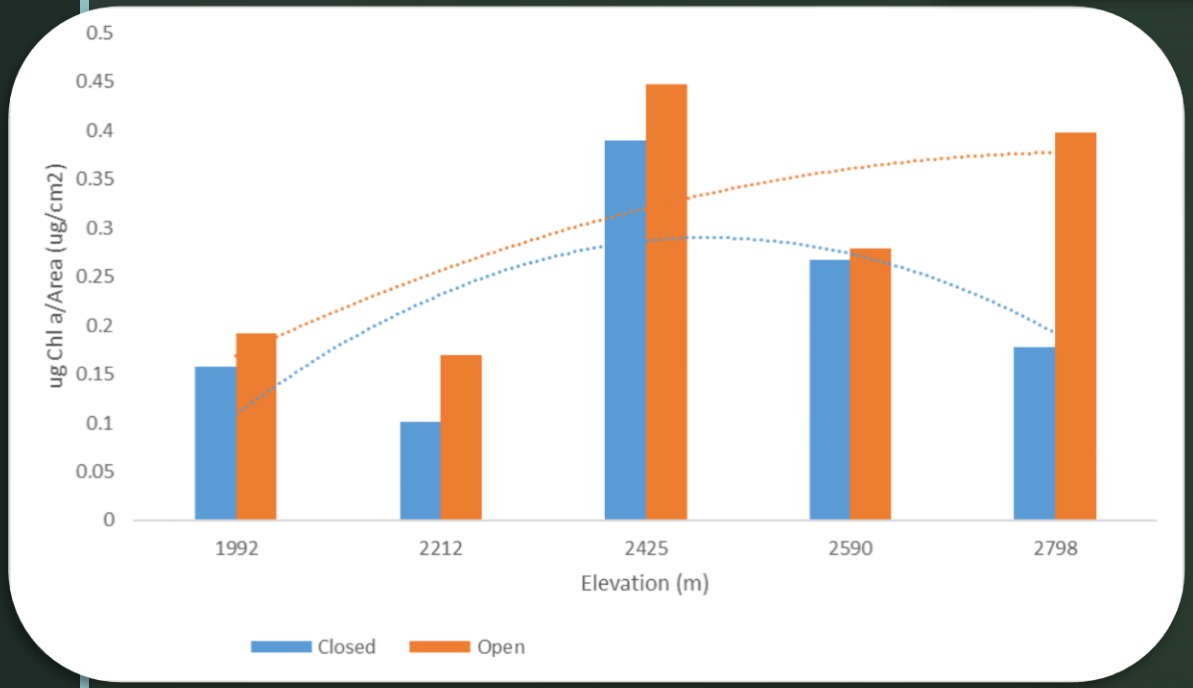

Richness
Water Temperature (°C)
BT-Functional Ric
BT-Species Ric



What about canopy cover?



What about resources?: Chl *a*



Chl *a* concentracion increases with elevation in open canopy areas

In summary:

- Functional Richness of the aquatic insect community decreased significantly with increasing elevation in RMS.
- Highest Functional Richness in two out of our three drainages of study (Big Thompson and Saint Vrain) was observed between 8ºC and 15ºC.
- Preliminary results suggest highest Functional Richness and Diversity on closed canopy areas, since open canopy open canopy areas offer less diversity of resources for the community (mostly for algal consumers measured by Chl *a*).
- Traits with the highest influence on variability in the community of insects in the RMS studied were those related to:
  - Voltinism
  - Adult life span
  - Synchronization of emergence
  - Adult ability to exit
  - Development
  - Ability to survive desiccation
  - Female dispersal

Future work

- Completing analysis on relationship to canopy cover and water temperature.
- Changes in FD along the gradient of other resources such as algal biomass.
- Context of results along gradients comparing mountain temperate streams vs. tropical mountainous streams in the Ecuadorian Andes.
- Functional Feeding Group proportions analysis along environmental gradients.
- Implications for headwater stream ecosystem management and conservation in lieu of vulnerabilities of the functional structure of aquatic insect communities.

Acknowledgements…

EVOTRAC

Evolutionary and Ecological
Variability in
Organismal
Trait
Response with
Altitude and
Climate

- **Boris Kondratieff**
- **Cameron Ghalambor**
- **Alex Flecker**
- **Steve Thomas**
- **Andrea Encalada**
- **Scott Morton**
- **Ryan McShane**
- **Whitney Beck**
- **Holly Lafferty**
- **David Martin**
- **Monica Paez**
- **Alisha Shah**
- **Brian Gill**
- **Erin Larson**
- **Amanda Rugenski**
- **Carla Atkinson**
- **Poff Lab members since 2011 to date!**

Thanks for listening!

Questions?