Is sympatric speciation more important in the ocean?

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UROP Online Symposium
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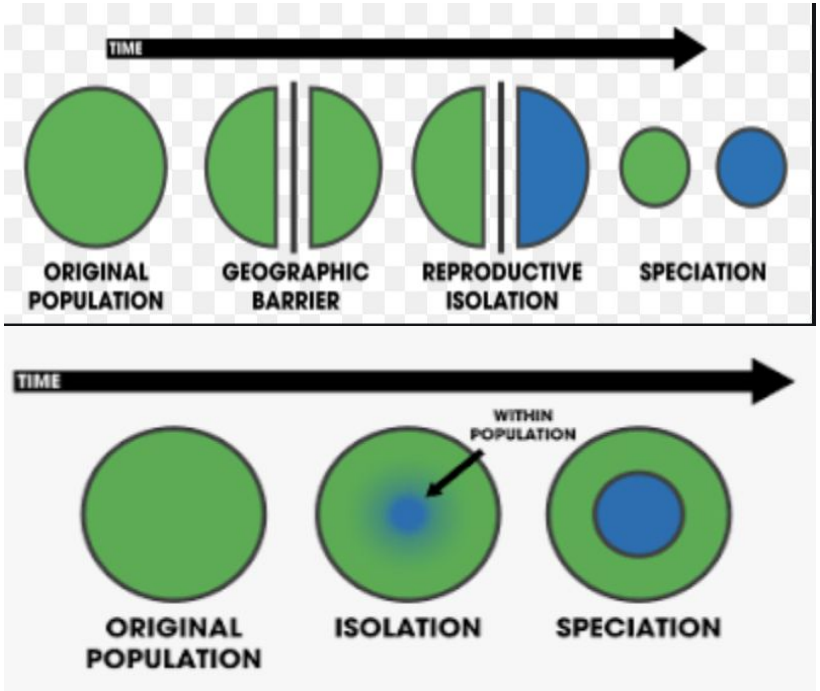
Introduction & Background

- ***Terrestrial environment***:
  - existence of hard barriers
  - geographical isolation
  - rich resources,
  - high complexity
  - ...
- ***Marine environment***:
  - lack of absolute barriers
  - dispersal ability of many larvae of invertebrates
  - importance of ocean current
  - ...
- ***It's reasonable to expect more sympatry in the ocean.***

Allopatric vs. Sympatric Speciation

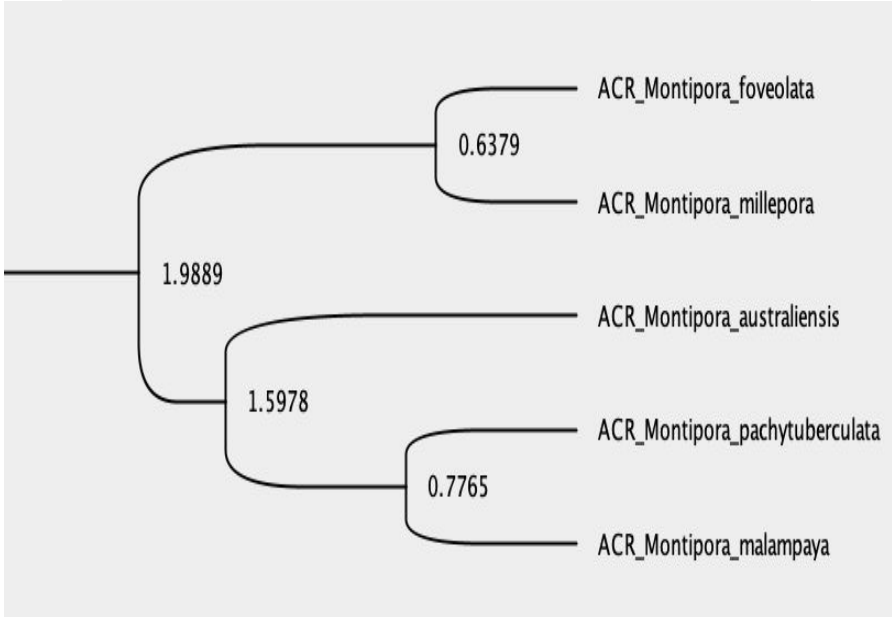
- ***Allopatric Speciation***: speciation that happens when two populations of the same species become isolated from each other due to geographic changes.
- ***Sympatric speciation***: speciation that occurs when two groups of the same species live in the same geographic location. (high range overlap）
- ***Other Concepts***: node age, sister species pairs, etc.



Top: allopatric speciation vs. Bottom: sympatric speciation

What are in our dataset?

- ***Sister species pairs*** and **age** of species pairs are obtained by interpreting phylogenetic tree.
    - ***Example***: M. foveolata & M. millepora are species pairs, while 0.6379 myr is their age.
- Range data of species are retrieved from OBIS open dataset, which records the occurrence of almost all known species.

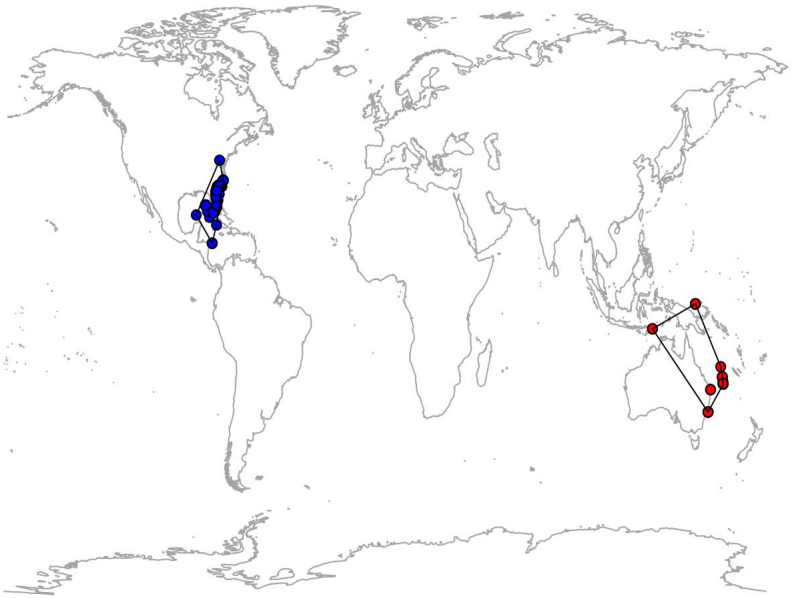


Example of Evolutionary tree. The numbers above represent the age of the node in the tree.

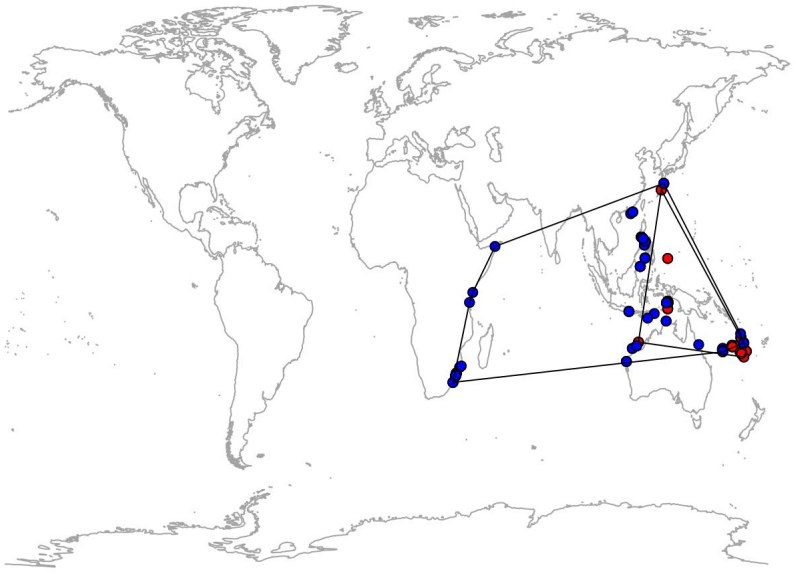
Methodology

- Build a dataset of marine species with their phylogenetic and range information (including marine mammals and invertebrates).
- Compute the ***range overlap*** and examine the pattern of speciation
  a) Identify and discard Outliers
  b) We compute range overlap by computing the convex hull of data points and the intersected areas of two species.
  c) Formula: ***range overlap = areai / min(area1,area2)***, where ***areai*** is the area of intersection of ranges of two species.
- Examine the relationship between range overlap and node age (i.e. age of the species)

Example: How we compute range overlap



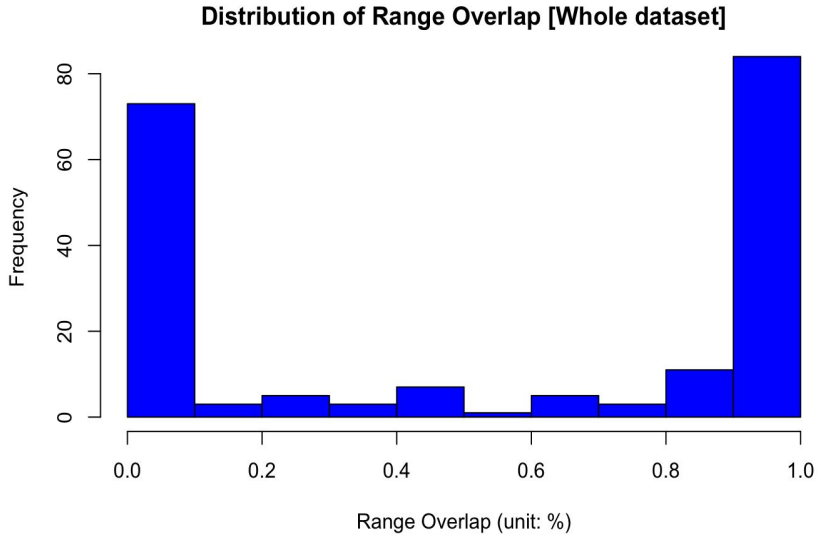
Ex 1: Species pairs with overlap of 0%
(Thecopsammia elongata vs. Thecopsammia socialis)

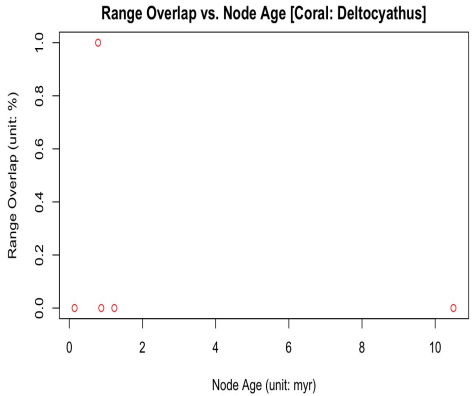


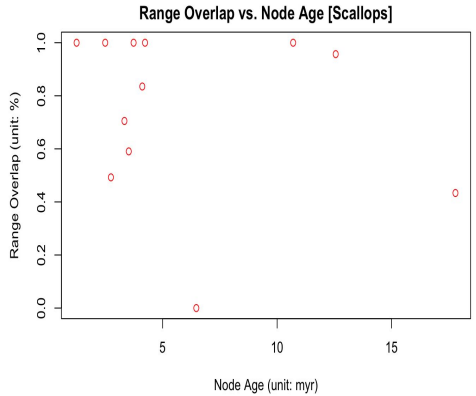
Ex 2. Species pairs with overlap of 0.97
(Tropidocyathus labidus vs. Tropidocyathus lessonii)

Results & Discussion

- ***In general, ≈ 47% species pairs have range overlap > 0.8, while 54% have range overlap > 0.5.***
    - Allopatry and sympatry both exist but no one dominates.
- Pattern of speciation ***depends on species.*** The relationship between range overlap and node age also varies across species.

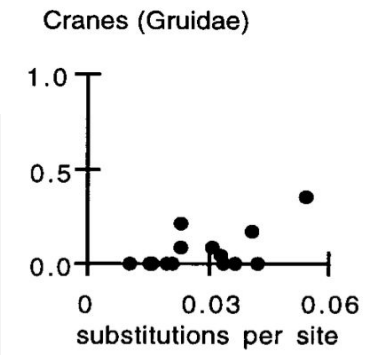


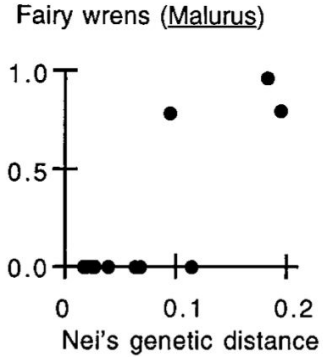


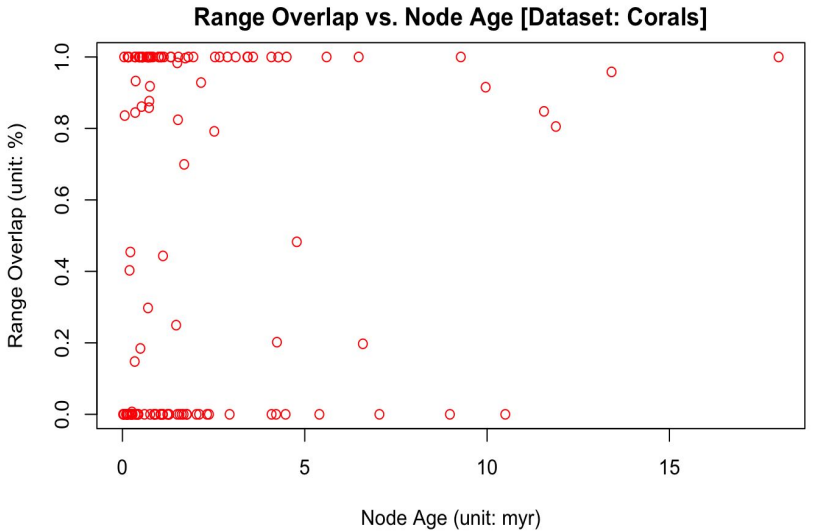


Comparison & Discussion

- ***Barraclough & Vogler (2000)*** tried to determine the speciation mechanisms for some birds and vertebrates using ***range overlap*** and ***age node.***
  - Example: Highly ***allopatry*** for Cranes & Malurus.
  - Quite ***different*** from results obtained in our study. (sympatry)
- ***Perfect overlap*** for really old species.
  - Time is long enough for real speciation signal to disappear.
  - Influence of migration, ocean current, etc.







Explanation

- Many marine species have strong dispersal ability, lack of barrier of gene flow -> ***sympatry***
- Instead of geographic factors (allopatry), ***ecological factors*** (sympatry) are argued as the main driven force in the ocean. (Bowen et al., 2013) Speciation occurs under various conditions:
    - Biodiversity hotspot -> intense competition
    - Depauperate region -> lack of competition
- Sympatric speciation is sometimes ***faster than*** allopatric speciation since selection can establish reproductive barrier more rapid than genetic drift.

Conclusion

- ***Sympatric speciation*** *is indeed the hidden speciation mechanisms for many invertebrates and mammals in the ocean, and it happens for many marine species.*
  - *However, speciation mechanism for old species remains* ***unknown****.*
  - ***Random distribution of range overlap*** *is expected for old species.*
- *The increasing importance of sympatry may lead to* ***more frequent speciation****, which contradicts with the fact that ocean has lower biodiversity than the land.*
  - *We may infer that speciation mech*anism is not the dominant factor that influences biodiversity.

Thanks!