



Patterns and drivers of beta diversity across geographic scales and lineages in the Macaronesian flora

Lea Mouton, Jairo Patiño, Mark Carine, Fred Rumsey, Miguel Menezes de Sequeira, Juana María González-Mancebo, Rosalina Maria de Almeida Gabriel, Olivier. J. Hardy, Manuela Sim-Sim, J. Alfredo Reyes Betancort, Flavien Collart, Alain Vanderpoorten



Jardin botanique
Meise

Introduction : Macaronesia



Μακάρων νησοι = « islands of the blessed »

4 archipelagos

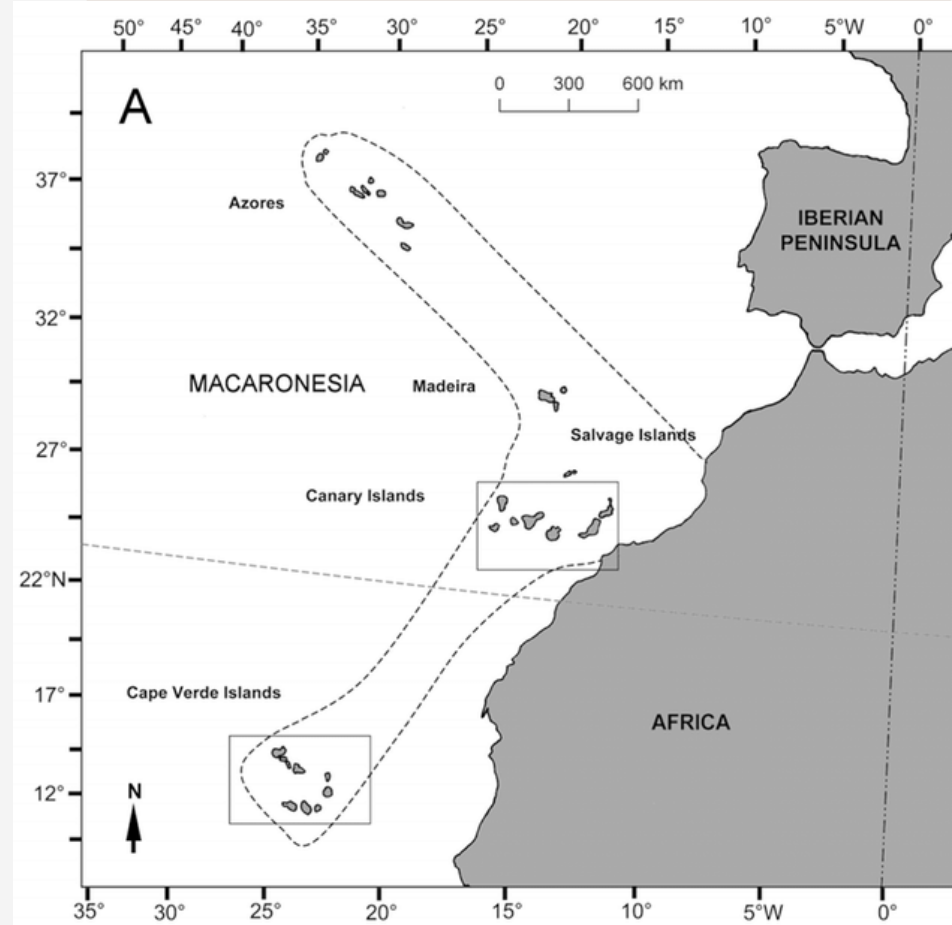
North Atlantic Ocean

Oceanic islands - Volcanic islands

Various climates, habitats, sizes and ages.

4 archipelagos:

- Azores including 9 islands
- Madeira including 3 islands
- Canaries including 7 islands
- Cape Verde including 10 islands

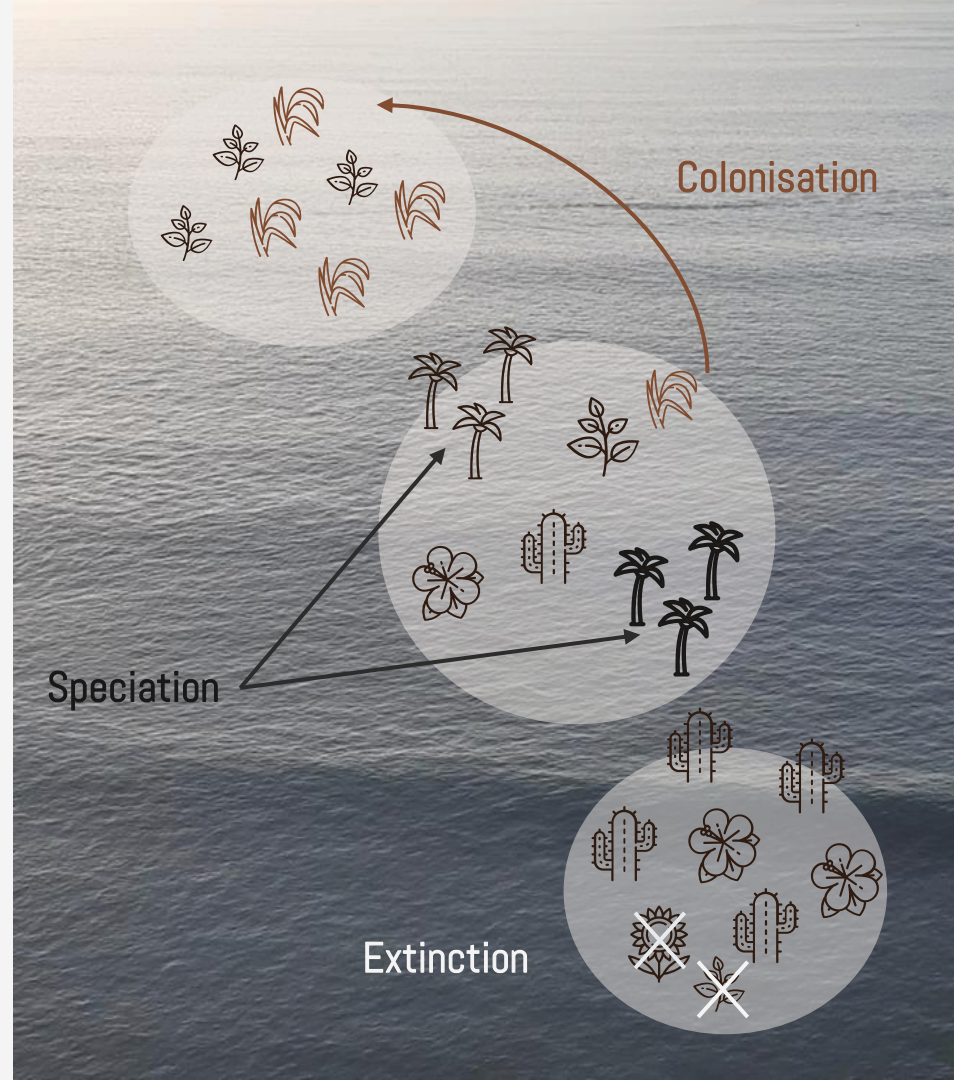


Introduction : island system

Déterminants of the variation in species composition among islands :

- Geographic distance
- Dispersal capacities
- Environment heterogeneity
- Geographic isolation
- Island size

What drivers explain the variation of floristic composition among islands and lineages in Macaronesia ?



Beta Diversity β



Turnover

Rate of species replacement



Geographic scale, extrinsic and intrinsic factors

Varying with scale

Depending on environmental and biological factors
such as : niche breadth and dispersal capacities

Main lineages of land plants



MOSSES

- Spores (10-30 μ m)
- No roots, no vascular system
- Endemics: 9% and 1% SIE



LIVERWORTS

- Spores (10-30 μ m)
- No roots, no vascular system
- Endemics : 7% and 2% SIE



PTERIDOPHYTES

- Spores (50 μ m)
- Vascular system and roots
- Endemics: 21% and 5% SIE



SPERMATOPHYTES

- Seeds (0,1mm to +10cm)
- Vascular system and roots
- Endemics: 43% and between 4 and 70%SIE

Objectives



1

To assess whether beta diversity varies among land plant lineages (Liverworts, Mosses, Pteridophytes and Spermatophytes) and with scale.



Variations of Beta with scale and among lineages

2

To assess biogeographic affinities among islands based on floristic composition among lineages.



Variations of Beta among islands

3

To identify the mechanisms behind beta diversity variations across lineages.



Drivers of Beta among lineages

Method



- Species checklist per island for each lineage.
- Beta
- Scales

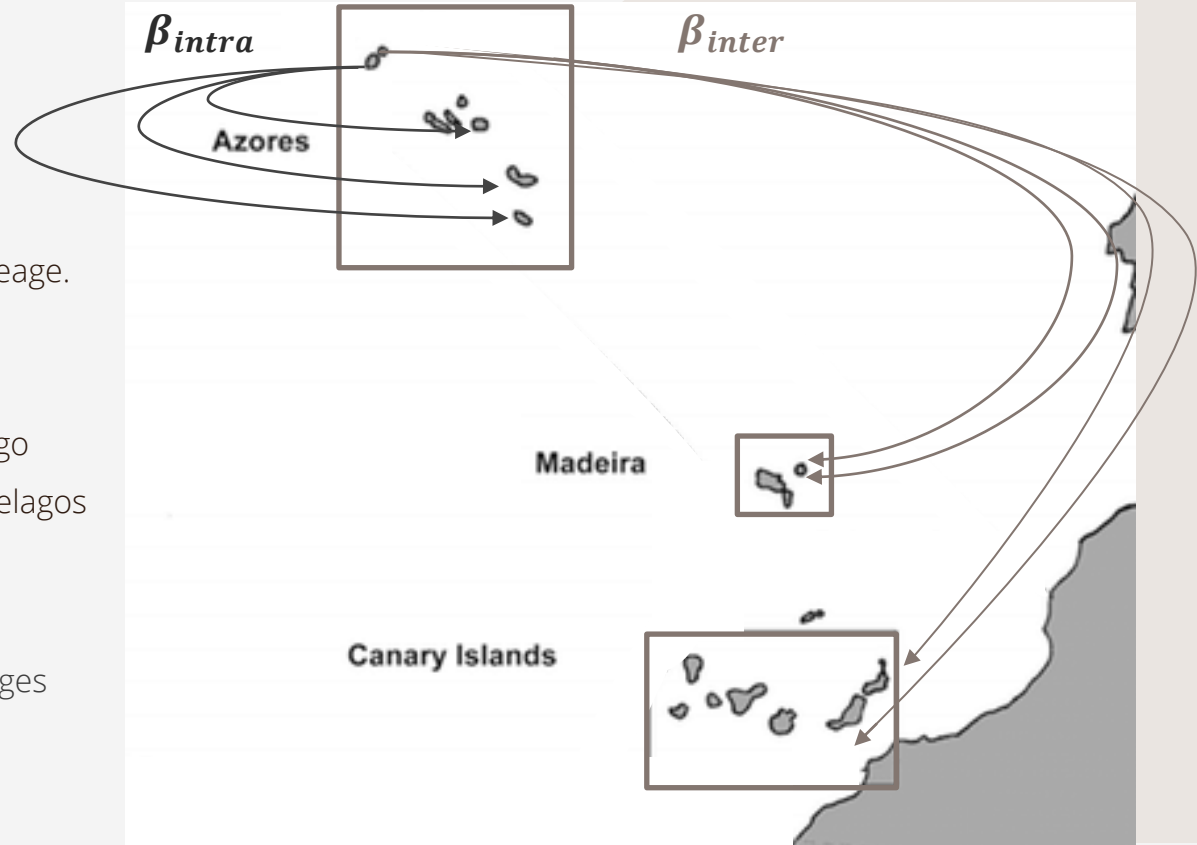
β_{intra} Among islands from same archipelago

β_{inter} Among islands from different archipelagos

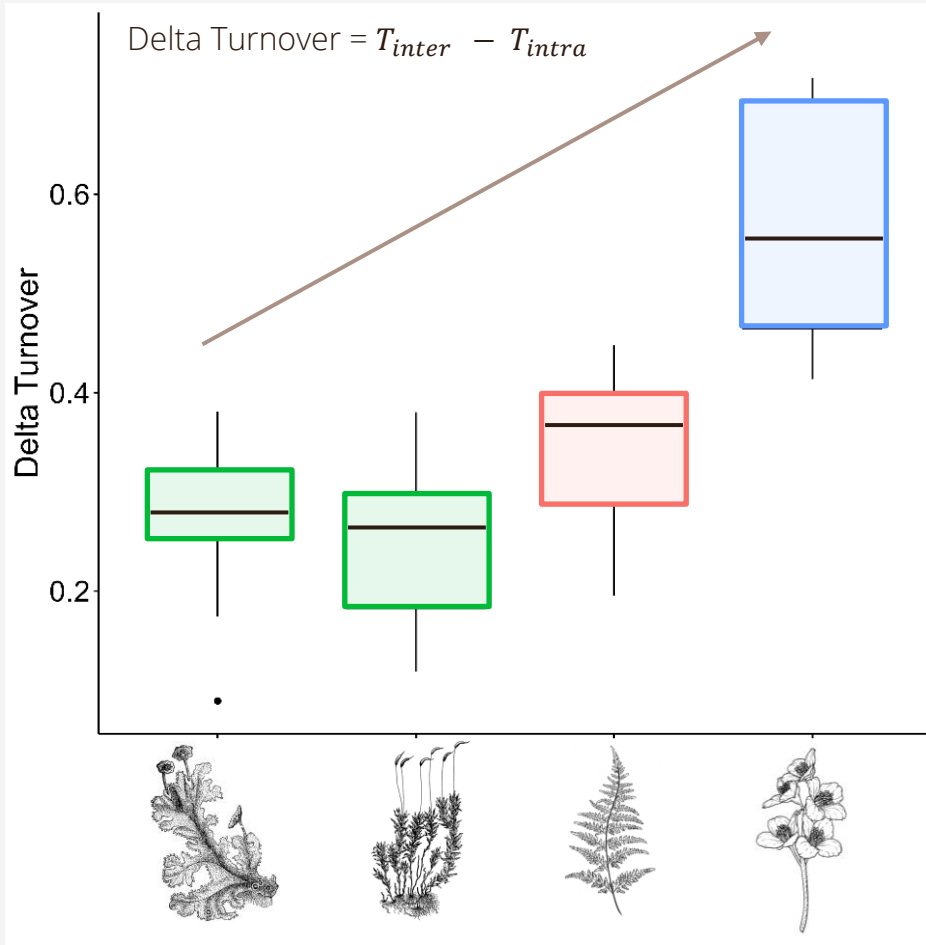
$$\text{Delta Beta} = \beta_{inter} - \beta_{intra}$$

- Comparison β_{intra} with β_{inter}
- Comparison of Delta Beta among lineages

Beta diversity



Results and Discussion

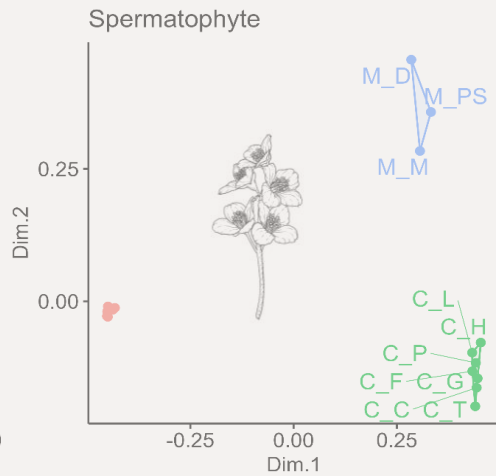
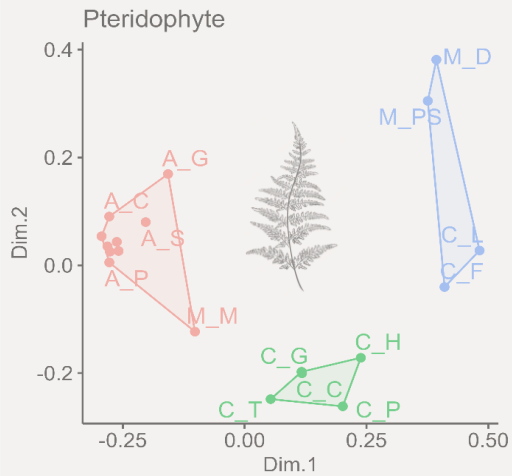
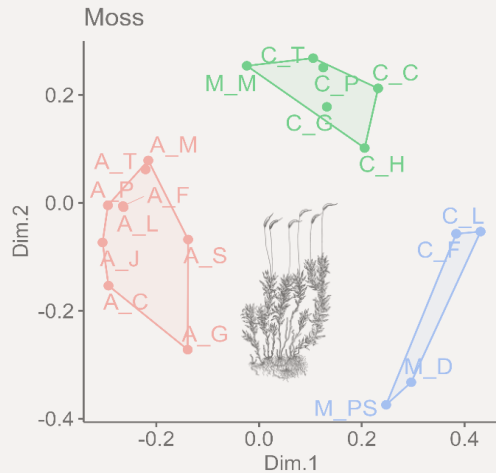
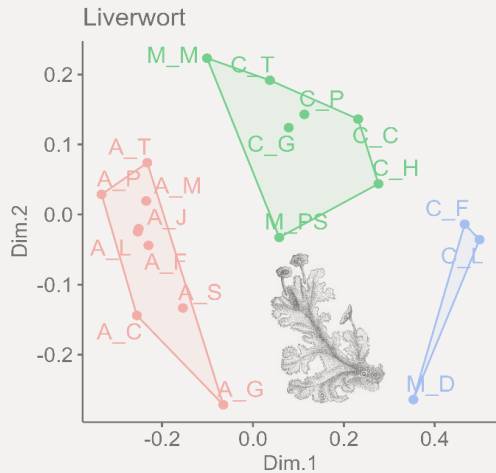


Among scales

Inter, Intra and Delta Turnover

- $T_{intra} < T_{inter}$ for all lineages.
→ Turnover increases with scale.
- Delta Turnover of spermatophytes higher than pteridophytes than bryophytes.
→ Following dispersal capacities
→ High endemism rates in Spermatophytes

Method



Clustering

Similarities of islands according to floristic composition

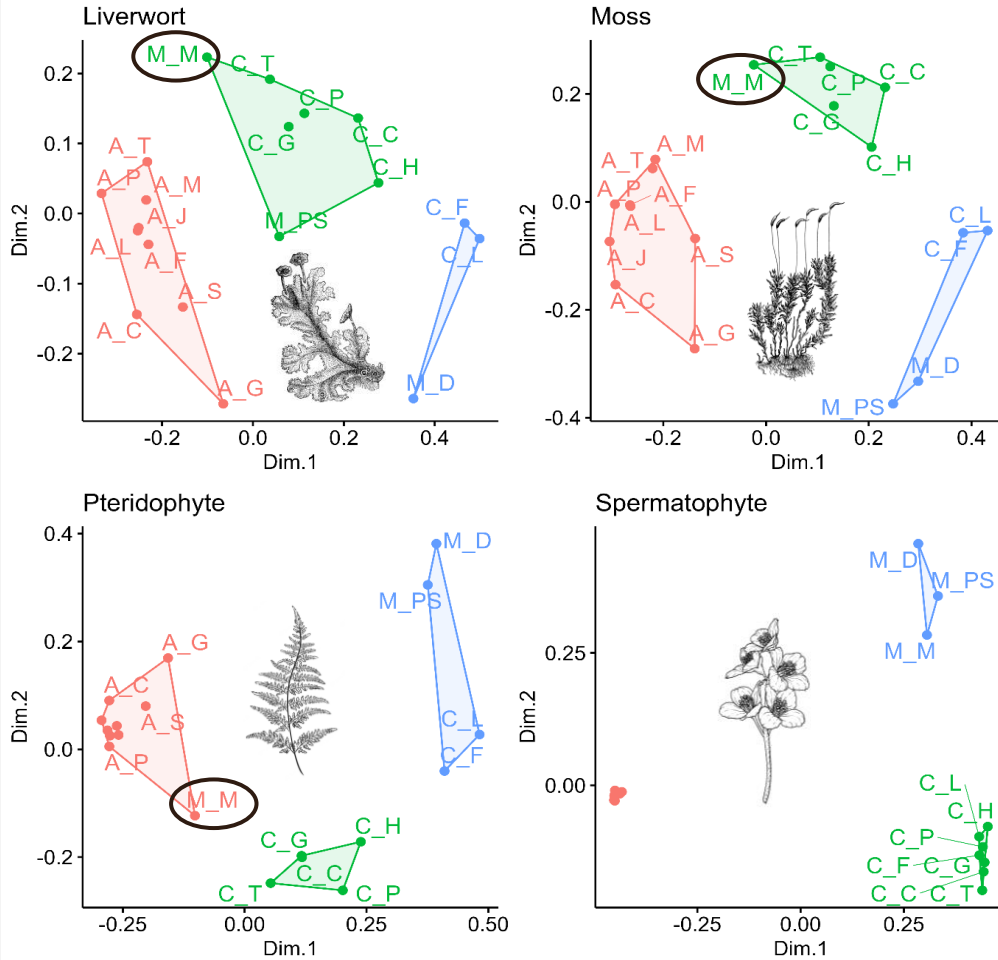


Clustering method based on Sørensen

→ Comparison among lineages

Clustering

Similarities of islands according to floristic composition



Spermatophytes group according to archipelago.

- Spore producing plants cluster by environmental factors due to high dispersal capacities.
- Seed plants are limited by geographical distance and historical factors.

Method

Liverworts



Mosses



Pteridophytes



Spermatophytes



Drivers of Beta by GDM

Generalized Dissimilarity Model



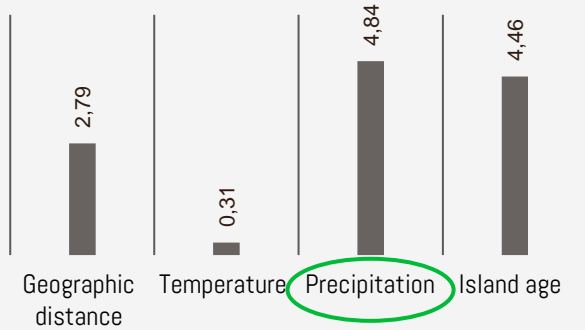
- ◆ Intra-Turnover among islands
- ◆ Environmental and geographic variables:

Altitude, archipelago structure, area, elevation, geographic distance, island age, precipitation and temperature

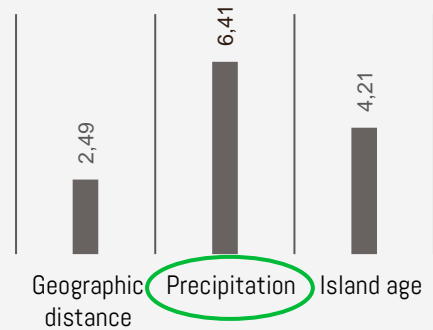
→ Comparison among lineages



Liverworts



Mosses



Drivers of Beta by GDM

Generalized Dissimilarity Model

● Spore plants : Precipitation > age.

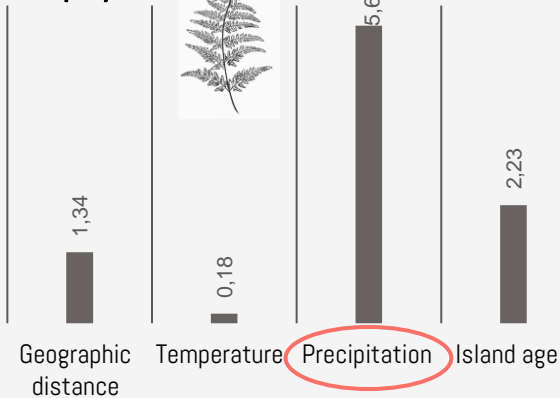
● Spermatophytes : Age > precipitation.

● Archipelago structure selected only for spermatophytes.

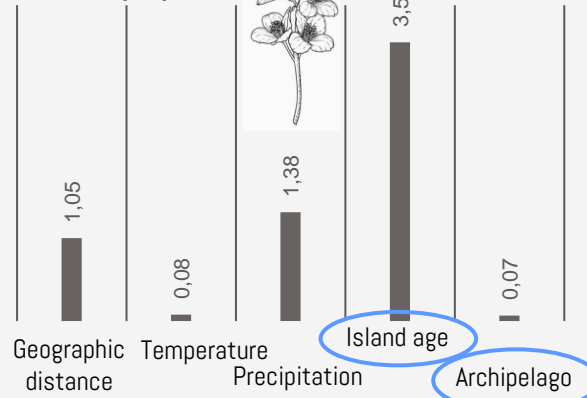
→ In line with the Clustering result

→ Island age reflects time, evolution and endemism.

Pteridophytes



Spermatophytes





Conclusion

Dispersal capacity

Significantly contributes to the Macaronesian flora distribution.

Endemism

High endemism rates in Spermatophyte, especially Single Island Endemics.



Questions ?



Endemism

Lineage	Species total	Endemic MAC	SIE AZO	SIE MAD	SIE CAN	SIE tot
Liverworts	228	20	0	2	0	2
Mosses	519	37	3	7	2	12
Pteridophytes	91	19	0	5	0	5
Spermatophytes	1816		4%		70%	

Carine & Schaefer (2010)

Introduction : Macaronesia



Μακάρων νήσοι = « islands of the blessed »

Ocean

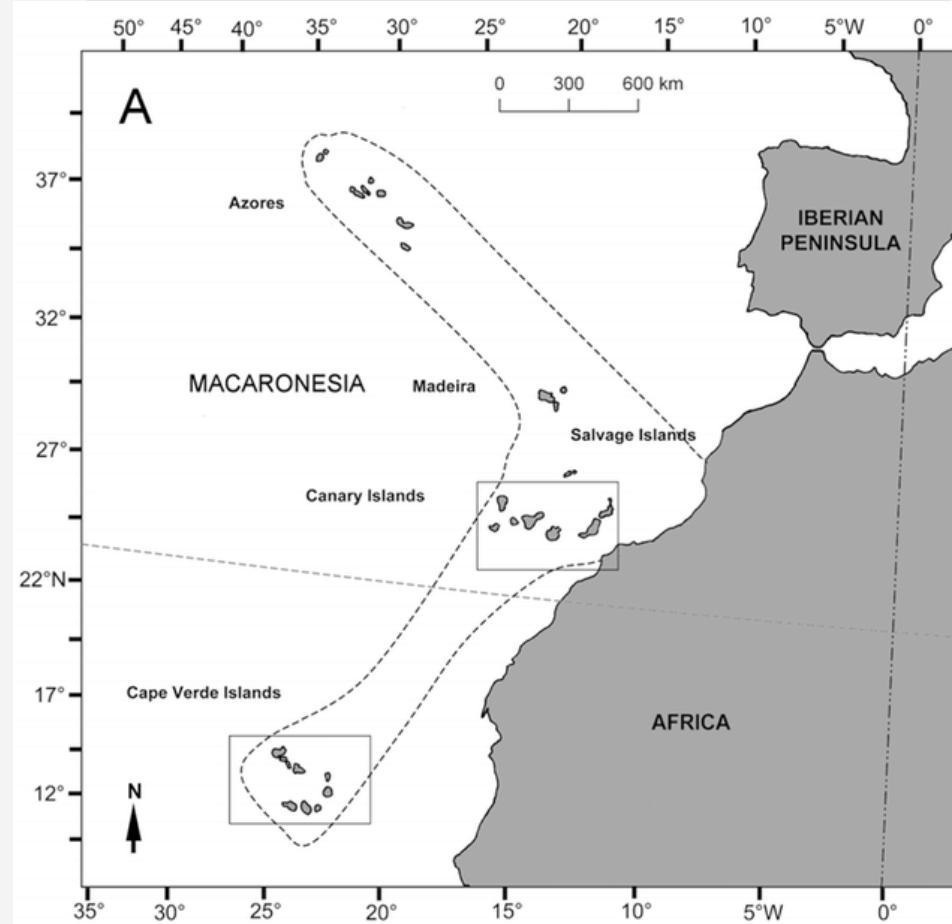
Latt long

Various

Age : 0,7-20 Ma

4 archipelagos:

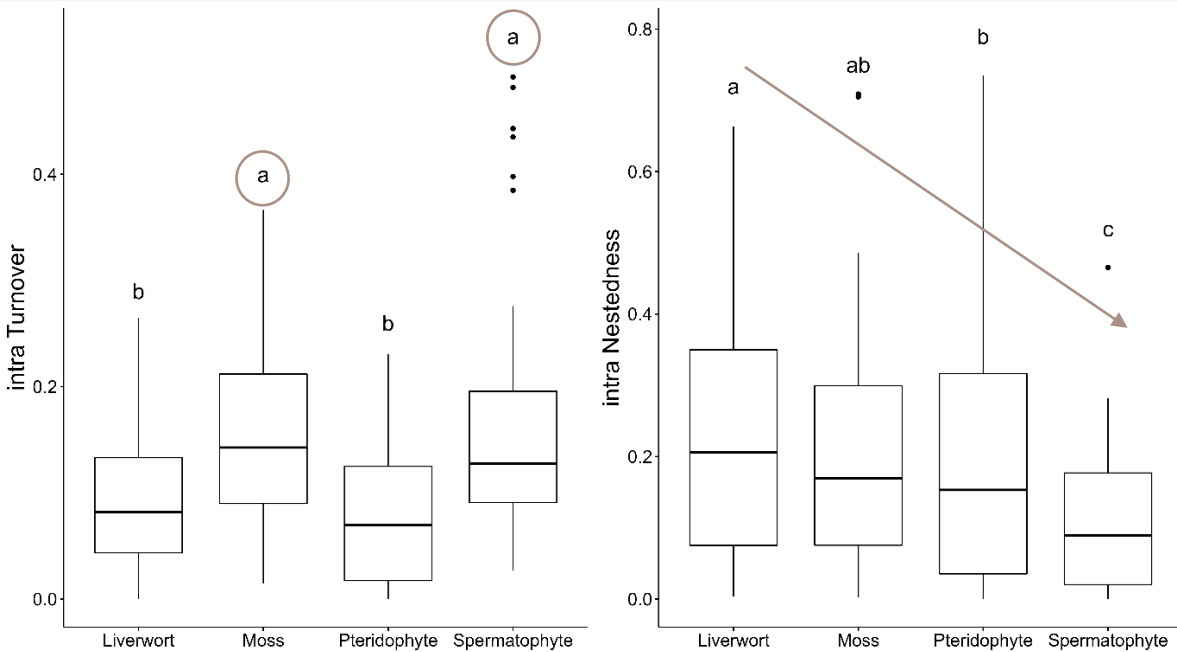
- Azores including 9 islands
- Madeira including 3 islands
- Canaries including 7 islands
- Cape Verde including 10 islands



Results and Discussion

Among taxa

intra -Turnover and Nestedness

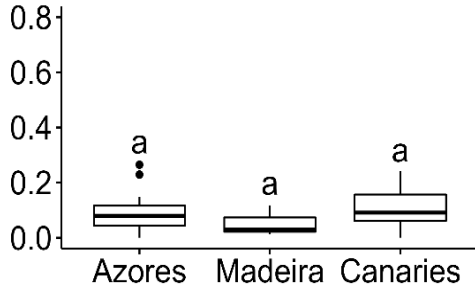


- Intra-Turnover higher in mosses and spermatophytes than pteridophytes and liverworts.
- Many elevation-specialists and a higher species richness of the high-altitude in moss
- Intra-Nestedness of spermatophytes smaller than spore producing plants one.
- The progressive decrease of turnover and increase of nestedness from spermatophytes to bryophytes reflects their differences in dispersal capacities.

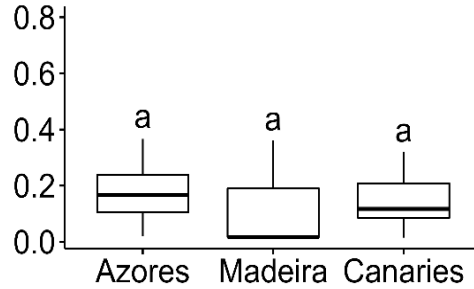
Results

intra Turnover

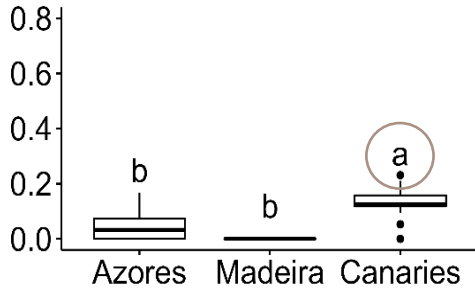
Liverwort



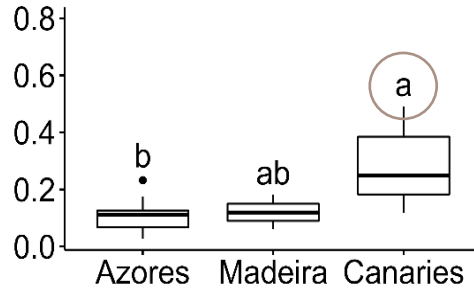
Moss



Pteridophyte



Spermatophyte

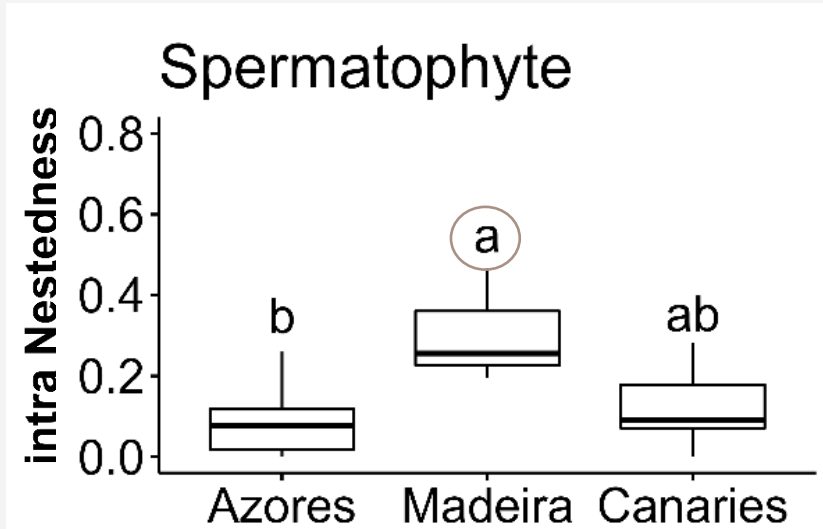


Among archipelagos

intra-archipelago Turnover

- For pteridophytes and spermatophytes the turnover in the Canaries is greater than in the Azores.
- Stronger environmental and altitudinal gradient in the Canaries than the Azores.
- Canarian endemics being SIEs whereas Azorean endemics tend to be MIEs.

Results



Among archipelago

intra -Turnover and Nestedness

- Nestedness in Madeira was higher than in other archipelagos.
- Madeira island very different in species richness.

Beta Diversity β



Nestedness

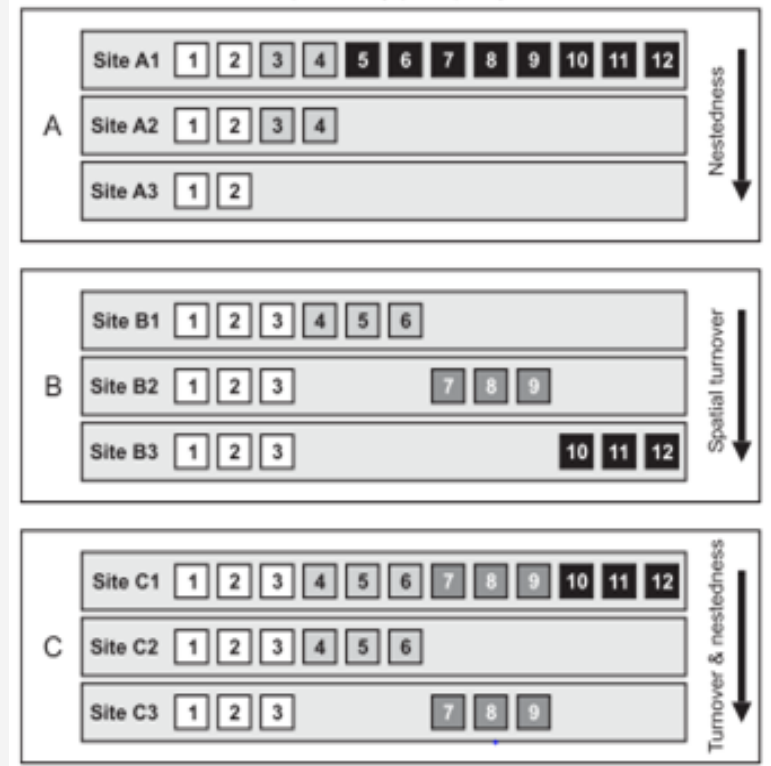
poorer systems are included in richer system, depends on specific richness and number of common species

→ Factors of dispersion
colonization delay, geographical isolation, time, dispersive limits

Turnover

Rate of species replacement

Facteurs of selection ←
niche differentiation, environmental gradient

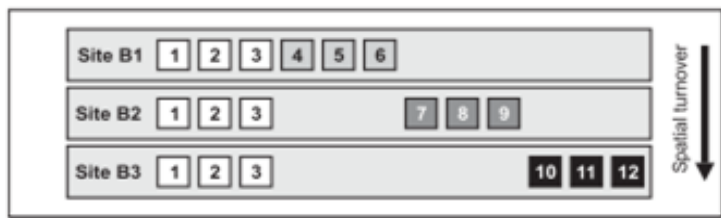


Beta Diversity β



1 Turnover

Rate of species replacement



2 Nestedness

Difference of richness

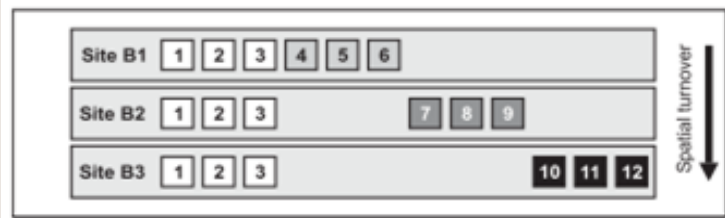


Beta Diversity β



1 Turnover

Rate of species replacement



2 Nestedness

Difference of richness

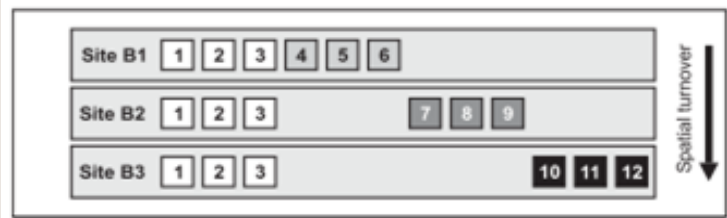


Beta Diversity β



1 Turnover

Rate of species replacement



2 Nestedness

Difference of richness



Geographic scale, extrinsic and intrinsic factors

Varying with scale

Depending on environmental and biological factors such as : niche breadth and dispersal capacities

Beta Diversity β



Geographic scale

Varying with scale according to the strength of the environmental gradients

- Turnover increases with scale
- Nestedness controversial

Extrinsic and intrinsic factors

Depending on environmental and biological factors, related to species niche breadth and dispersal capacities

- High turnover for low dispersive organisms ←
- High turnover with strong gradient ←
- High nestedness for high dispersive ←

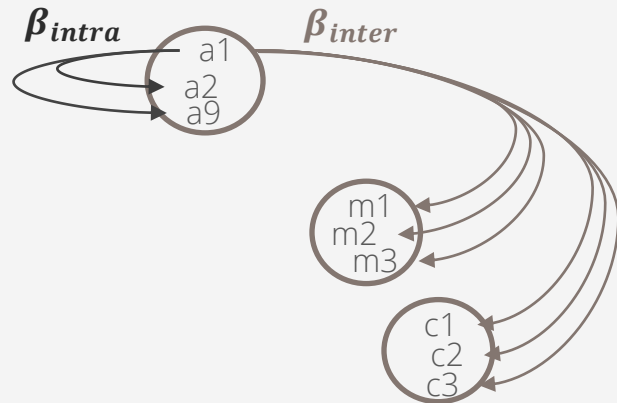


Method



1 Beta diversity

- Species checklist per island for each lineage.
- Beta
- Scales



2 Clustering

- Clustering method based on β_{intra}
- Comparison among lineages

3 Generalized Dissimilarity Model

- Intra-Turnover among islands
- Environmental and geographic variables

Altitude, archipelago structure, area, elevation, geographic distance, island age, precipitation and temperature.

→ Comparison among lineages

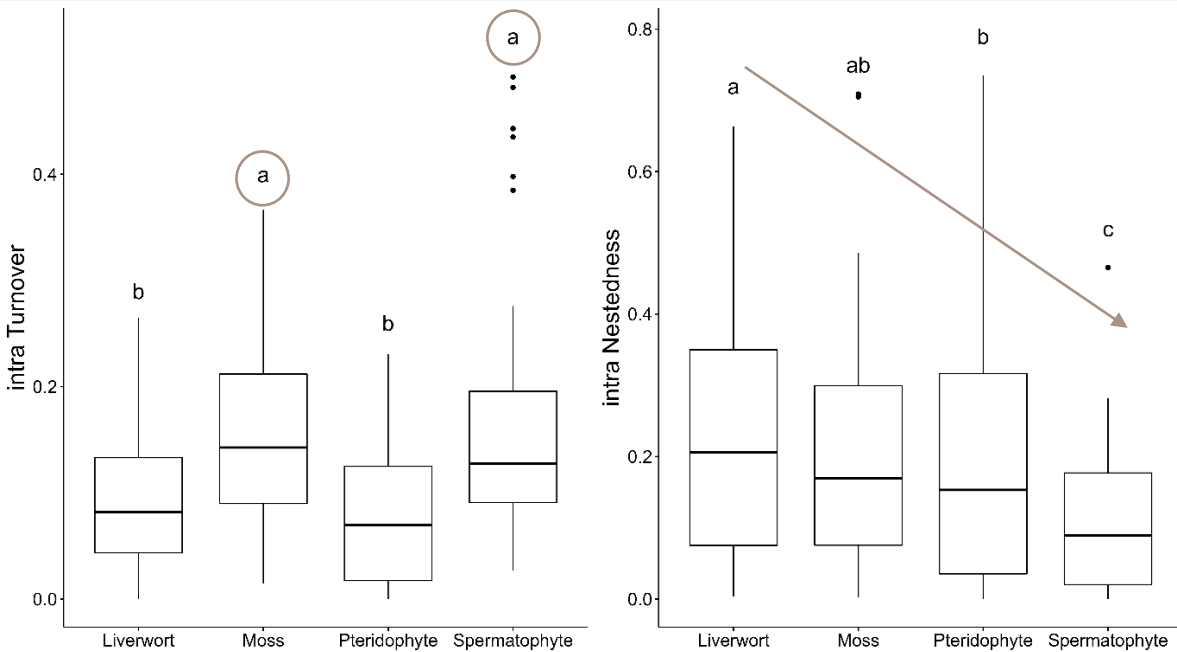
$$\text{Delta Beta} = \beta_{inter} - \beta_{intra}$$

- Comparison β_{intra} with β_{inter}
- Comparison of Delta Beta among lineages

Results and Discussion

Among taxa

intra -Turnover and Nestedness

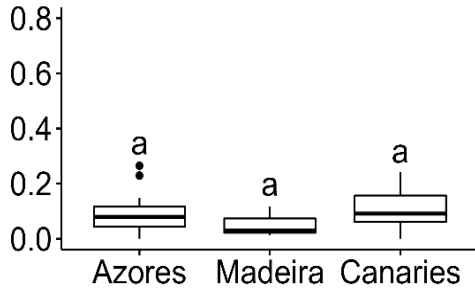


- Intra-Turnover higher in mosses and spermatophytes than pteridophytes and liverworts.
- Many elevation-specialists and a higher species richness of the high-altitude in moss
- Intra-Nestedness of spermatophytes smaller than spore producing plants one.
- The progressive decrease of turnover and increase of nestedness from spermatophytes to bryophytes reflects their differences in dispersal capacities.

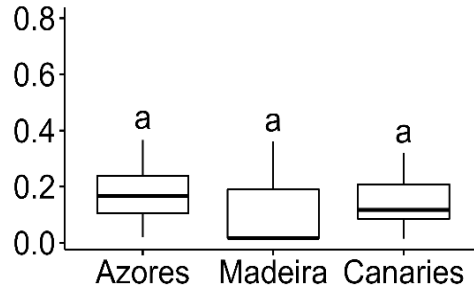
Results

intra Turnover

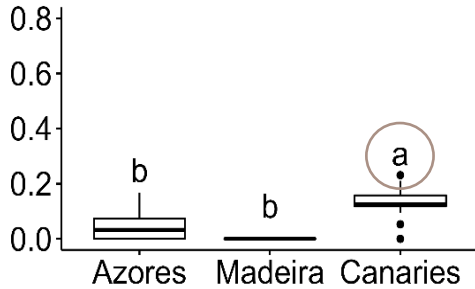
Liverwort



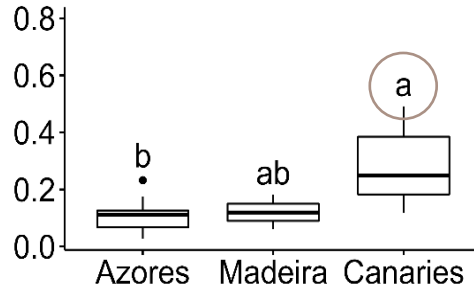
Moss



Pteridophyte



Spermatophyte

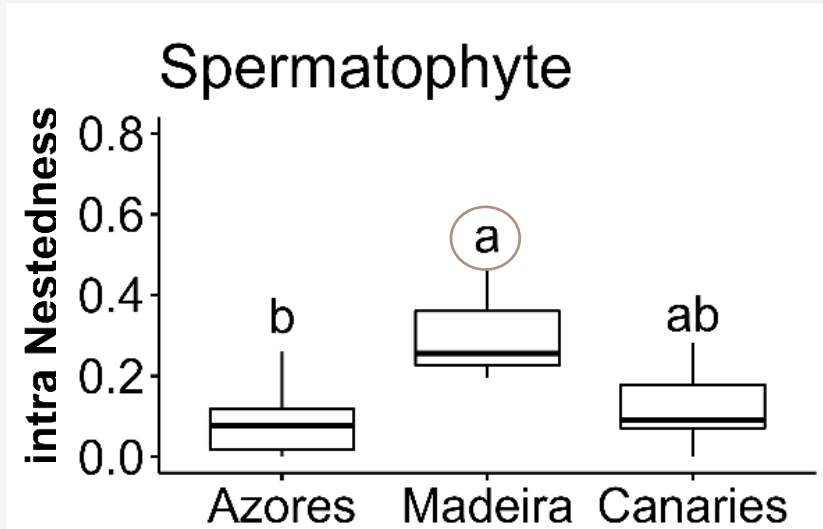


Among archipelagos

intra-archipelago Turnover

- For pteridophytes and spermatophytes the turnover in the Canaries is greater than in the Azores.
- Stronger environmental and altitudinal gradient in the Canaries than the Azores.
- Canarian endemics being SIEs whereas Azorean endemics tend to be MIEs.

Results



Among archipelago

intra -Turnover and Nestedness

- Nestedness in Madeira was higher than in other archipelagos.
- Madeira island very different in species richness.