

Lichen phycobionts of the Canary Islands



Lucie Vančurová^{1*}, Jiří Malíček², Jana Steinová¹ & Pavel Škaloud¹

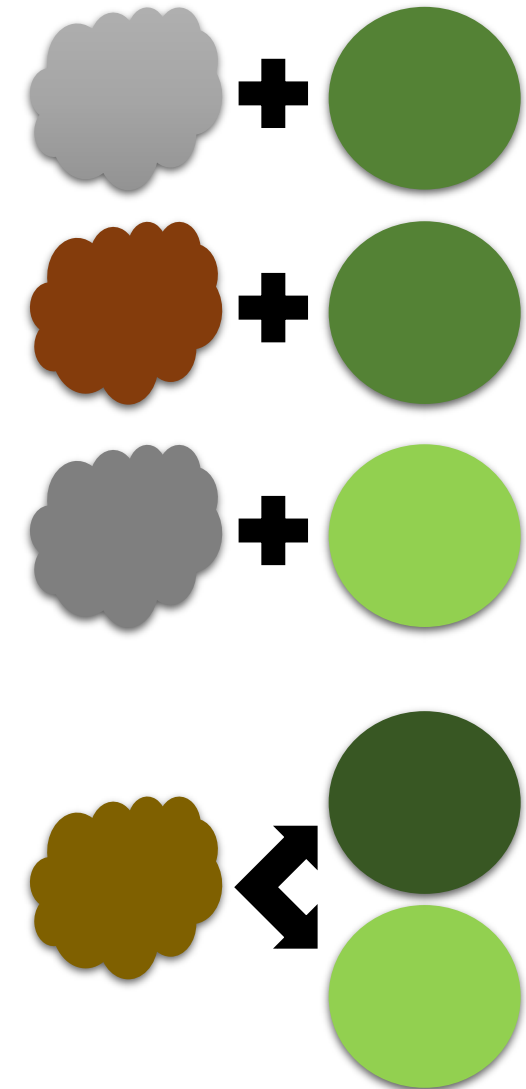
¹ Charles University, Faculty of Science, Department of Botany, Benátská 2, 128 01 Prague 2, Czech Republic

² The Czech Academy of Sciences, Institute of Botany, Zámek 1, 252 43 Průhonice, Czech Republic

* lucie.vancurova@natur.cuni.cz

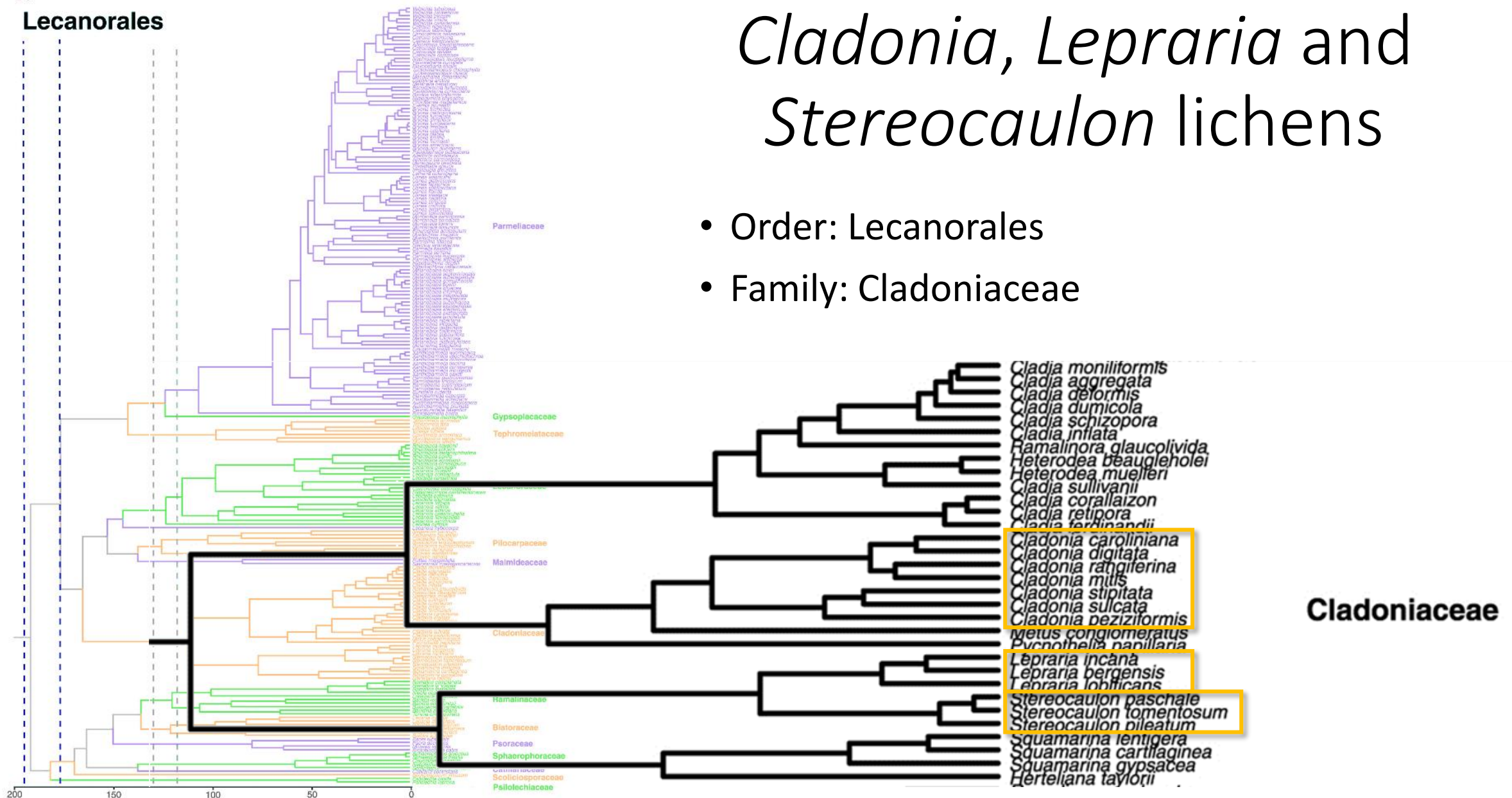
Phycobiont diversity

- Mycobionts generally associate with a single phycobiont genus, e. g.:
 - **Trebouxia** + **Protoparmelia**, **Rhizoplaca**, **Tephromela**, **Xanthoparmelia**, **Xanthoria**, and **Xanthomendoza** (Leavitt et al., 2016, 2013; Muggia et al., 2013; Muggia et al., 2018; Nyati et al., 2013)
 - **Asterochloris** + **Cladonia** (Bačkor et al., 2010; Beiggi & Piercey-Normore, 2007; Piercey-Normore & DePriest, 2001; Škaloud & Peksá, 2010; Yahr et al., 2004) and **Lepraria** (Nelsen & Gargas, 2006, 2008; Peksá & Škaloud, 2011; Škaloud & Peksá, 2010)
- A few other mycobionts associate with **different Trebouxiophycean genera** (**Lepraria borealis**, Engelen et al., 2010; **Micarea**, Yahr et al., 2015; **Bagliettoa** and **Verrucaria nigrescens**, Thüs et al., 2011, Voytsekhovich & Beck, 2015; **Diploschistes muscorum**, Wedin et al., 2015; **Stereocaulon**, Vančurová et al., 2018, 2020)



A

Lecanorales

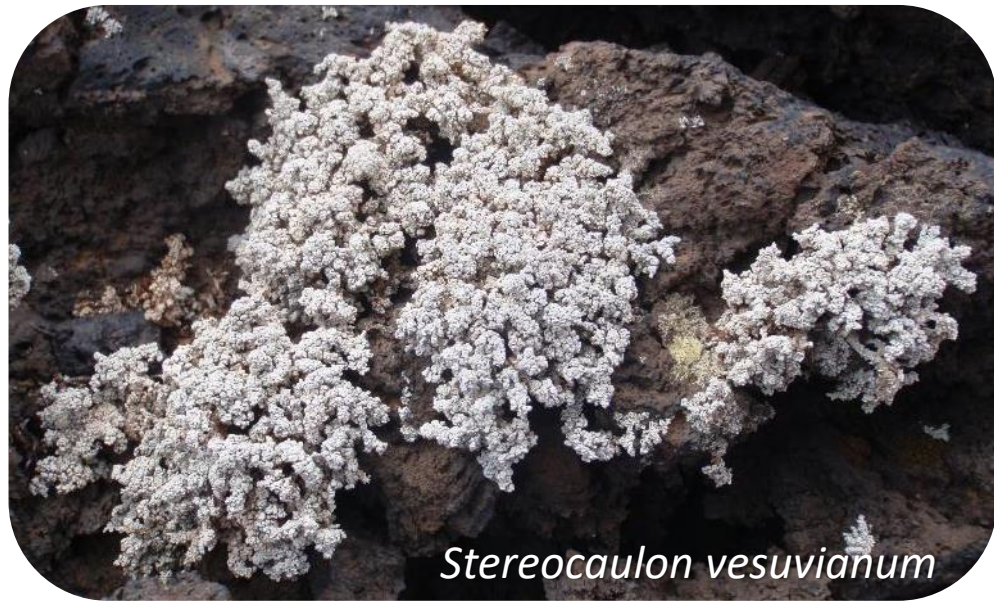


Cladonia, Lepraria and Stereocaulon lichens

- Order: Lecanorales
- Family: Cladoniaceae

Chronogram illustrating relationships among the taxa in Lecanorales using the temporal banding-based classification. The colours of branches represent families. The scale below represents the time scale in million years (modified from Kraichak et al., 2018).

Cladonia,
Lepraria and
Stereocaulon
lichens



Stereocaulon vesuvianum

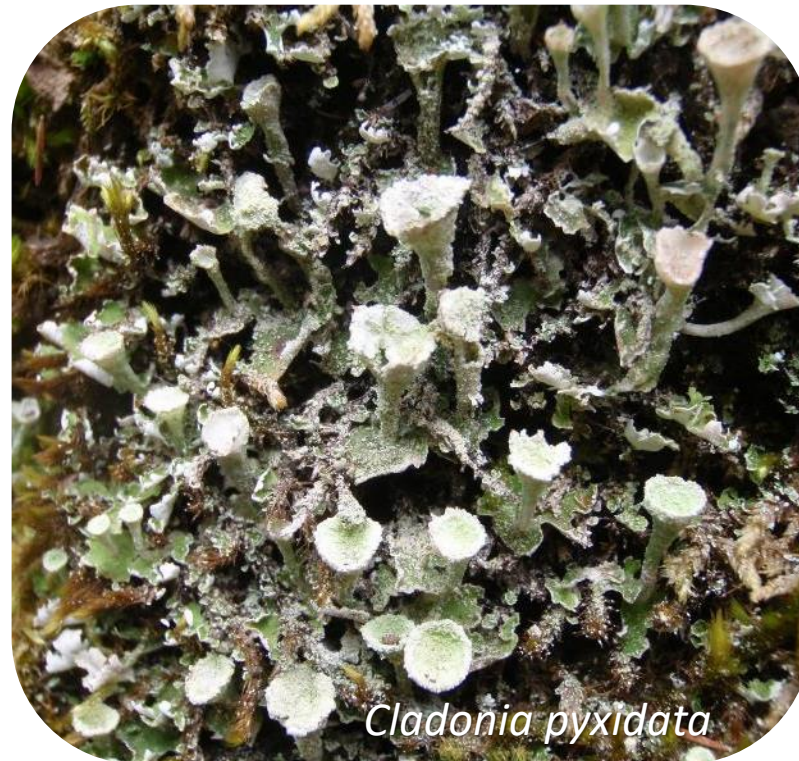


Lepraria borealis

www.lichenology.info



Stereocaulon azureum



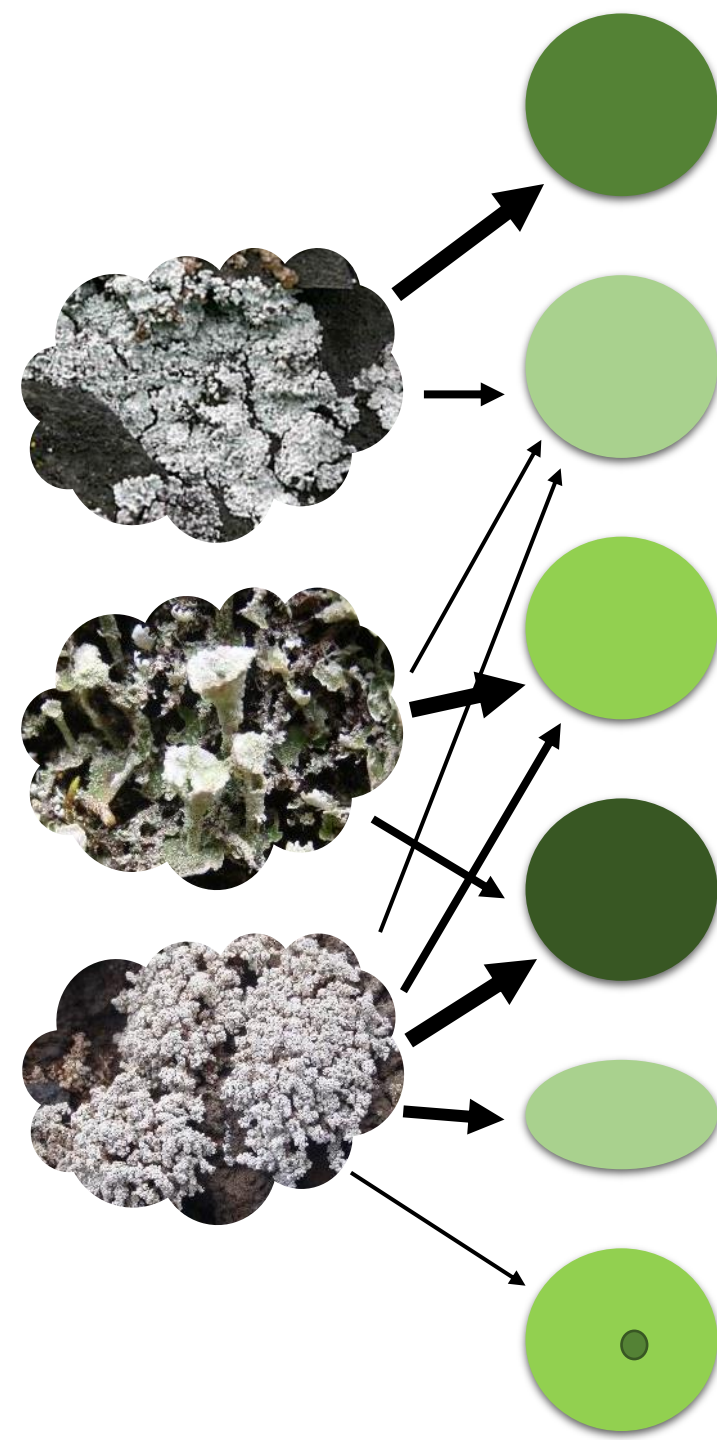
Cladonia pyxidata



Cladonia rangiformis

Specificity and selectivity

- The term **specificity** delimits the taxonomic range of acceptable partners, whereas **selectivity** refers to the preference for a certain group of partners (Rambold *et al.* 1998; Yahr *et al.* 2004, 2006).
- ***Cladonia*** and ***Lepraria***
 - specific towards ***Asterochloris*** phycobionts on the genus level
 - selective towards certain species-level lineages (Peksa & Škaloud, 2011; Steinová *et al.*, 2019; Škaloud *et al.* 2015)
- ***Stereocaulon***
 - ***Asterochloris*, *Chloroidium*, *Vulcanochloris*** and several other Trebouxiophycean algae (Vančurová *et al.*, 2015, 2018, 2020)
 - Specificity/selectivity on the species level

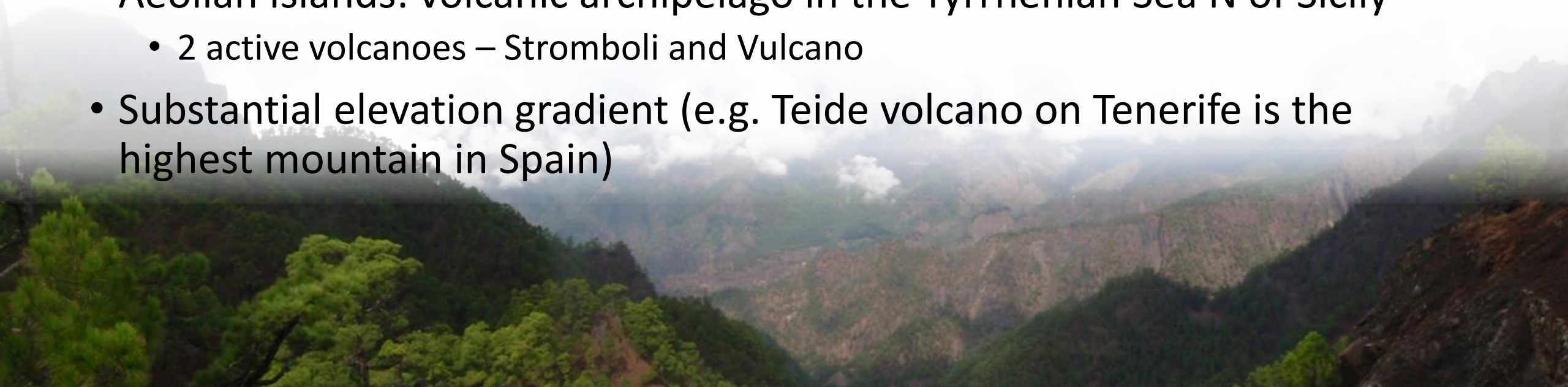


Study area



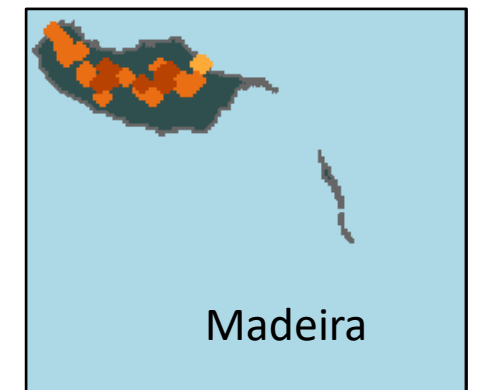
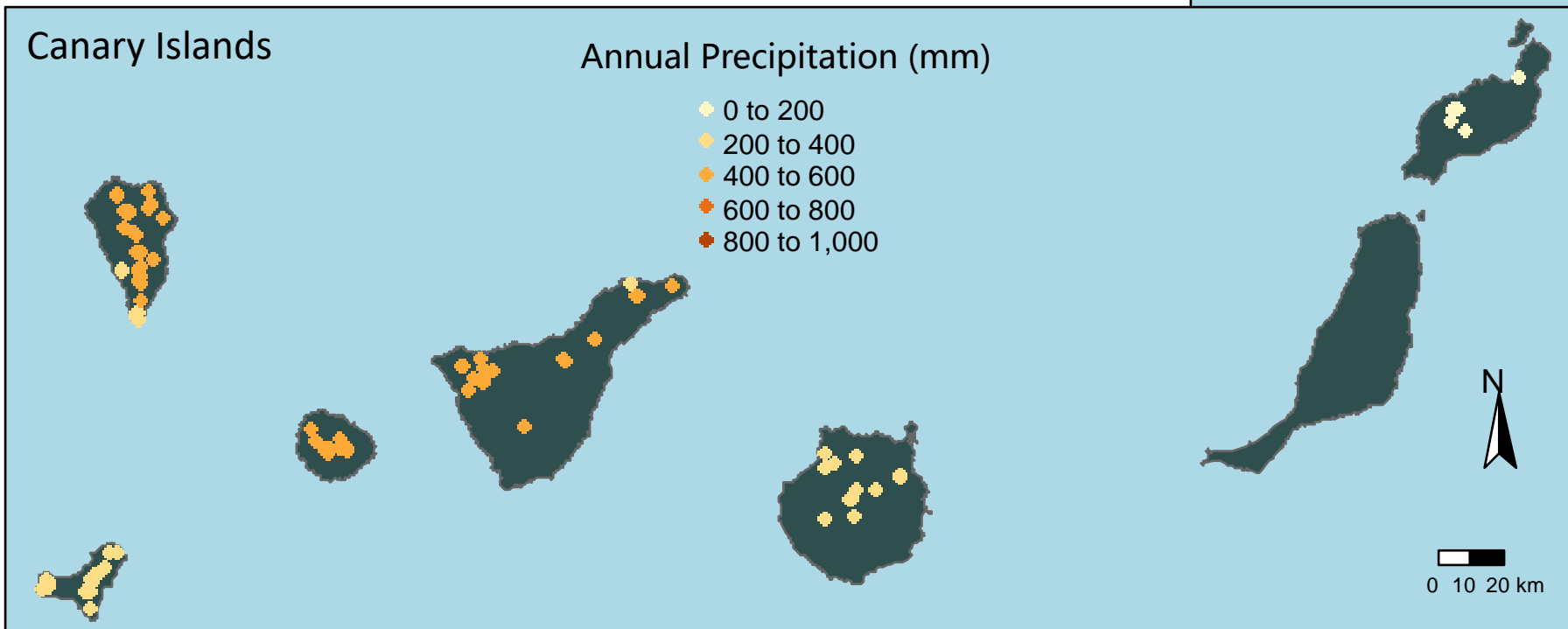
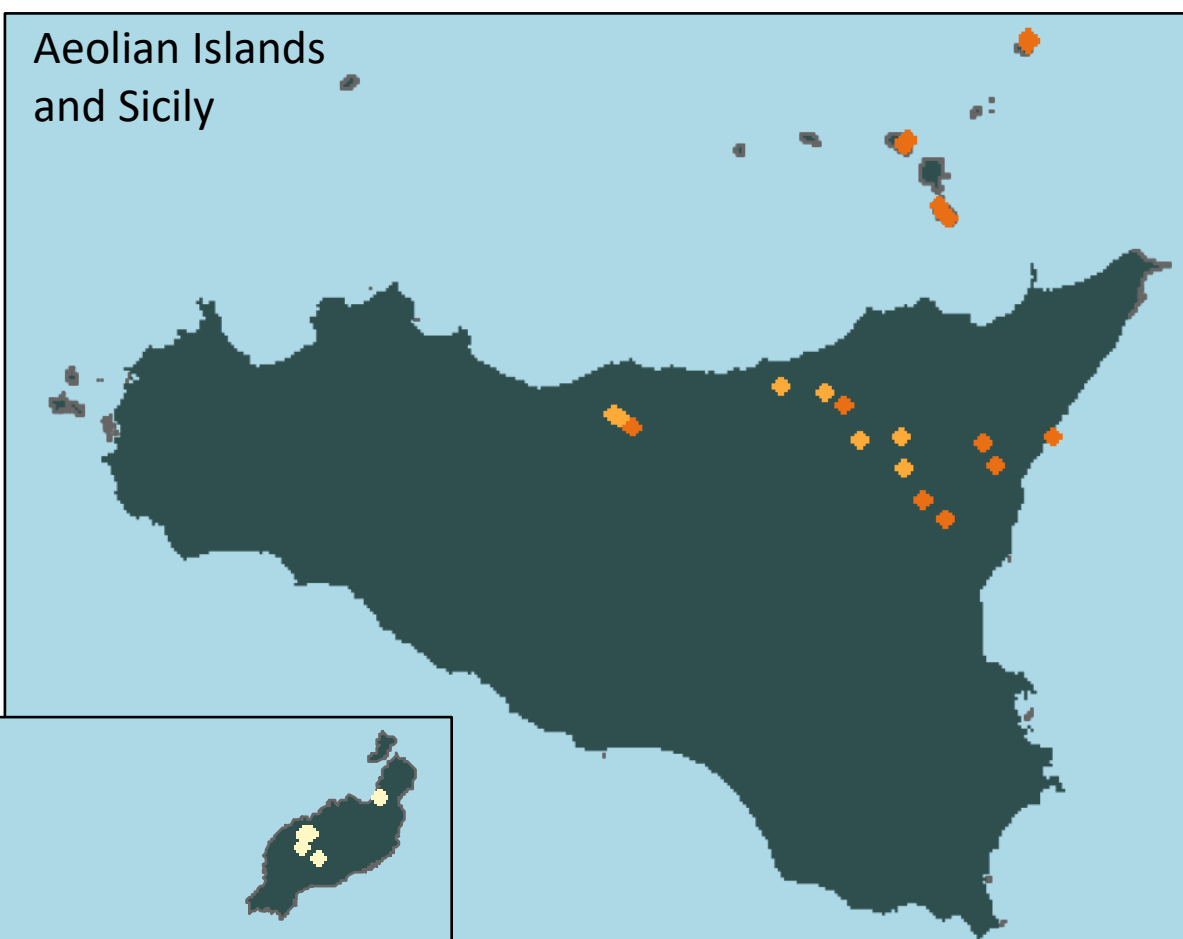
Study area

- Canary Islands: volcanic islands in Macaronesia, 100 km W of Morocco
 - 4 islands (Lanzarote, Tenerife, La Palma and El Hierro) have historical records of eruptions since European discovery
- Madeira: volcanic island in Macaronesia, 400 km N of Canary Islands
- Aeolian Islands: volcanic archipelago in the Tyrrhenian Sea N of Sicily
 - 2 active volcanoes – Stromboli and Vulcano
- Substantial elevation gradient (e.g. Teide volcano on Tenerife is the highest mountain in Spain)



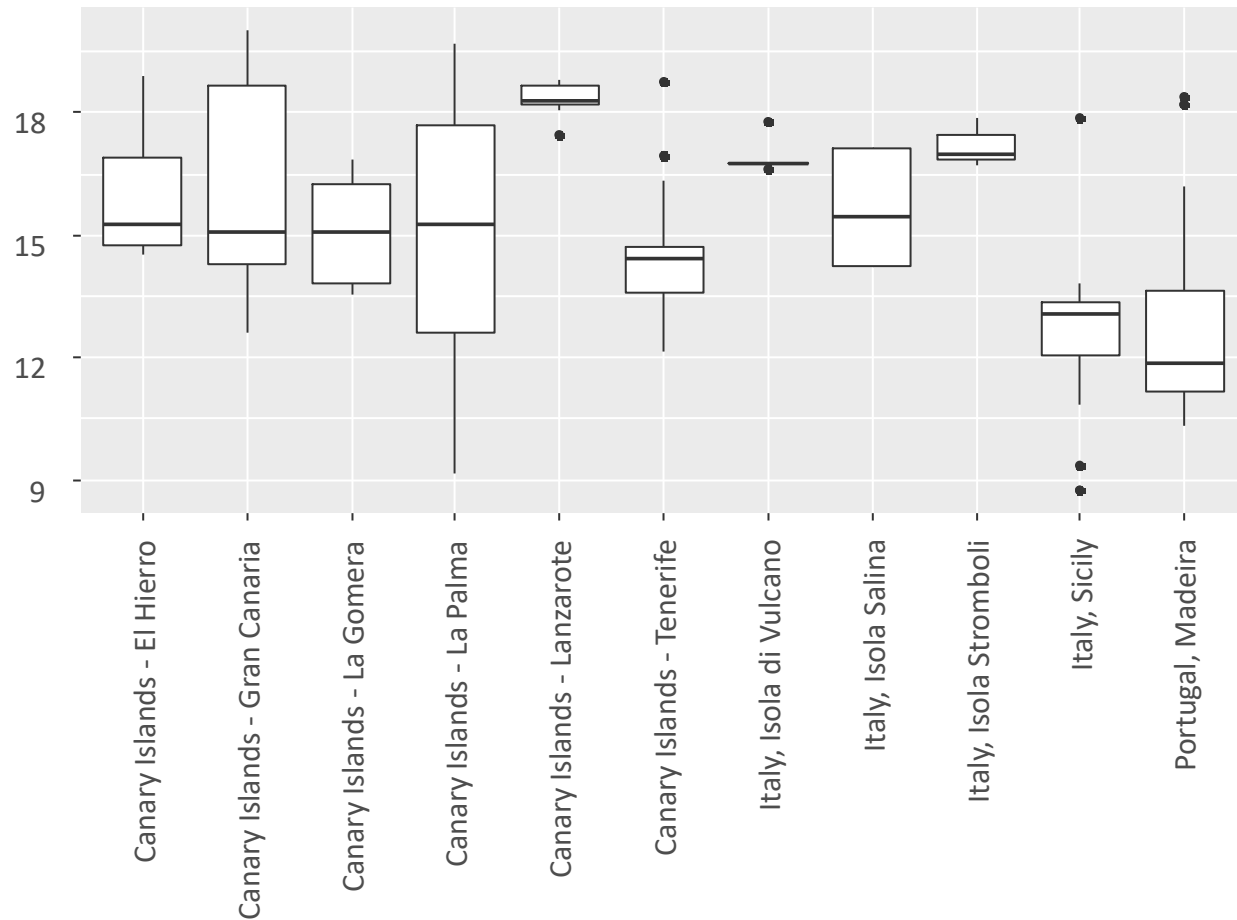
Sampling sites

- El Hierro, La Palma, La Gomera, Tenerife, Gran Canaria, Lanzarote (on Fuerteventura none of the three lichen genera was found)
- Sicily, Salina, Vulcano, Stromboli
- Madeira

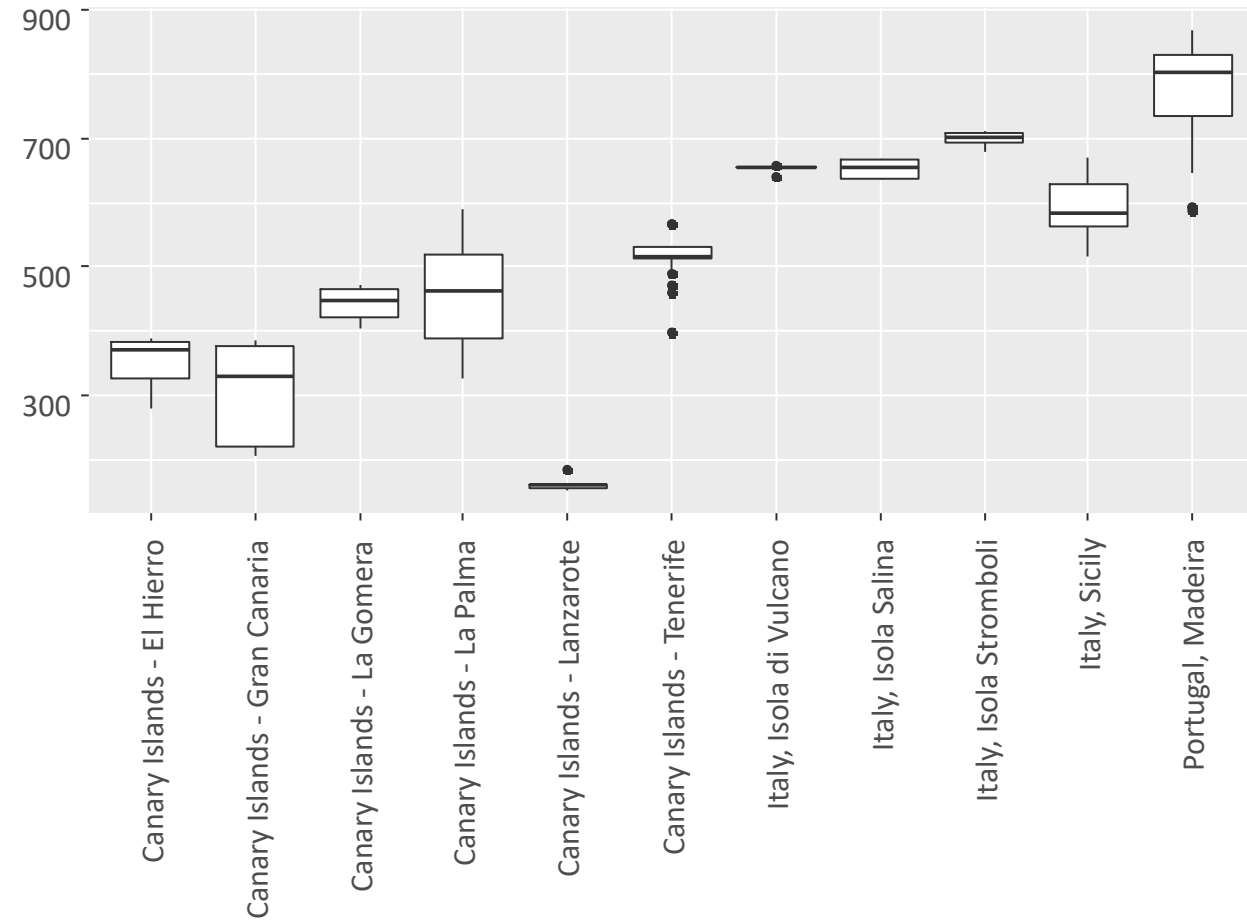


Climate at localities

Annual Mean Temperature (°C)



Annual Precipitation (mm)

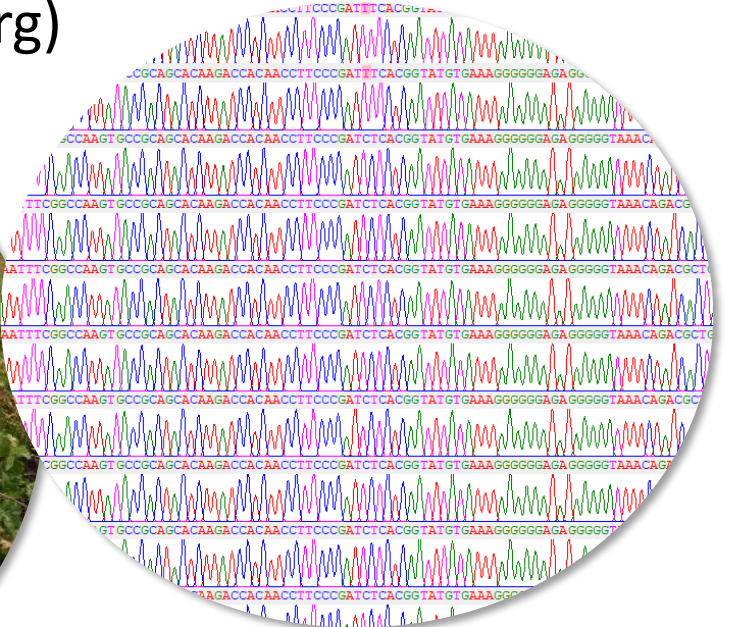


Questions

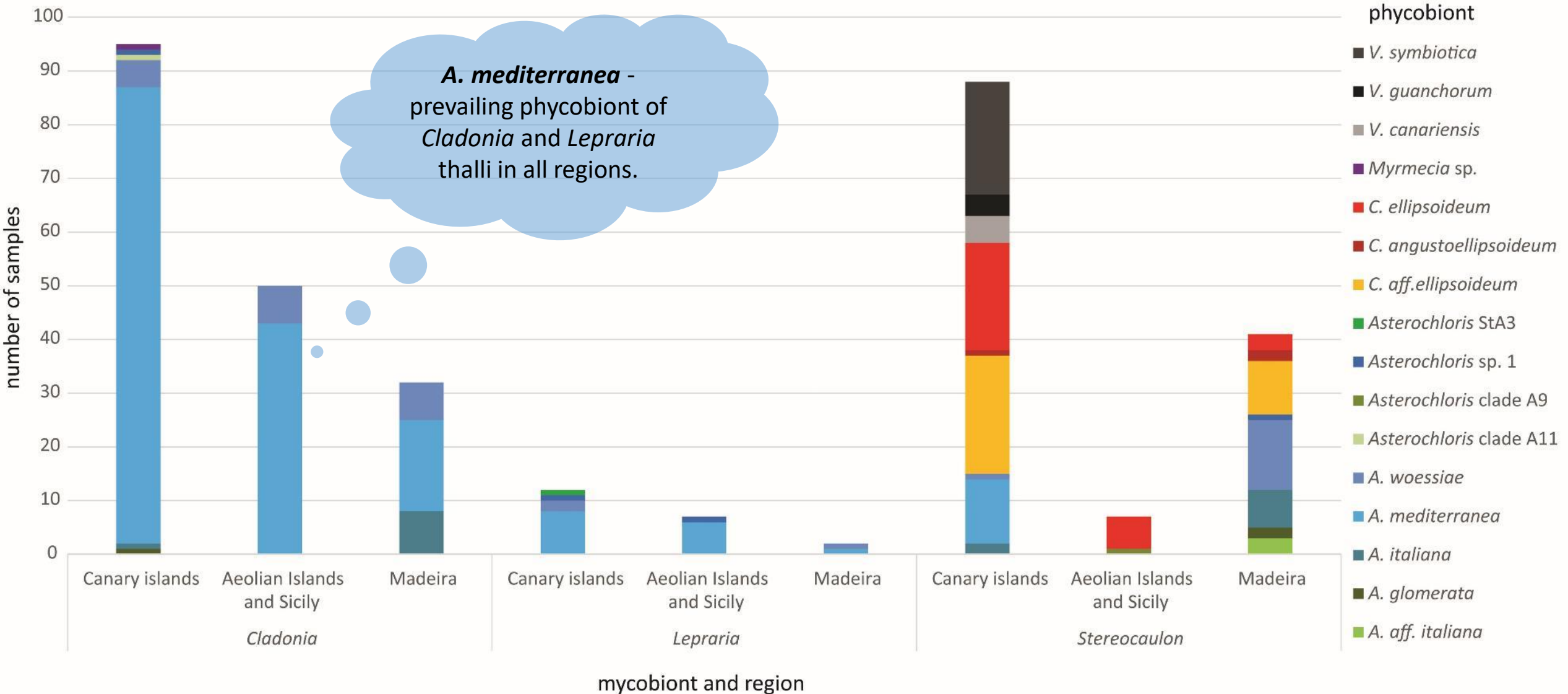
- What is the diversity of phycobionts associated with the lichen-forming genera *Stereocaulon*, *Lepraria*, and *Cladonia* in the study area?
- Do closely related mycobionts *Stereocaulon*, *Lepraria*, and *Cladonia* share the same pool of phycobionts?
- Which factors drive the distribution of phycobionts?

Methods

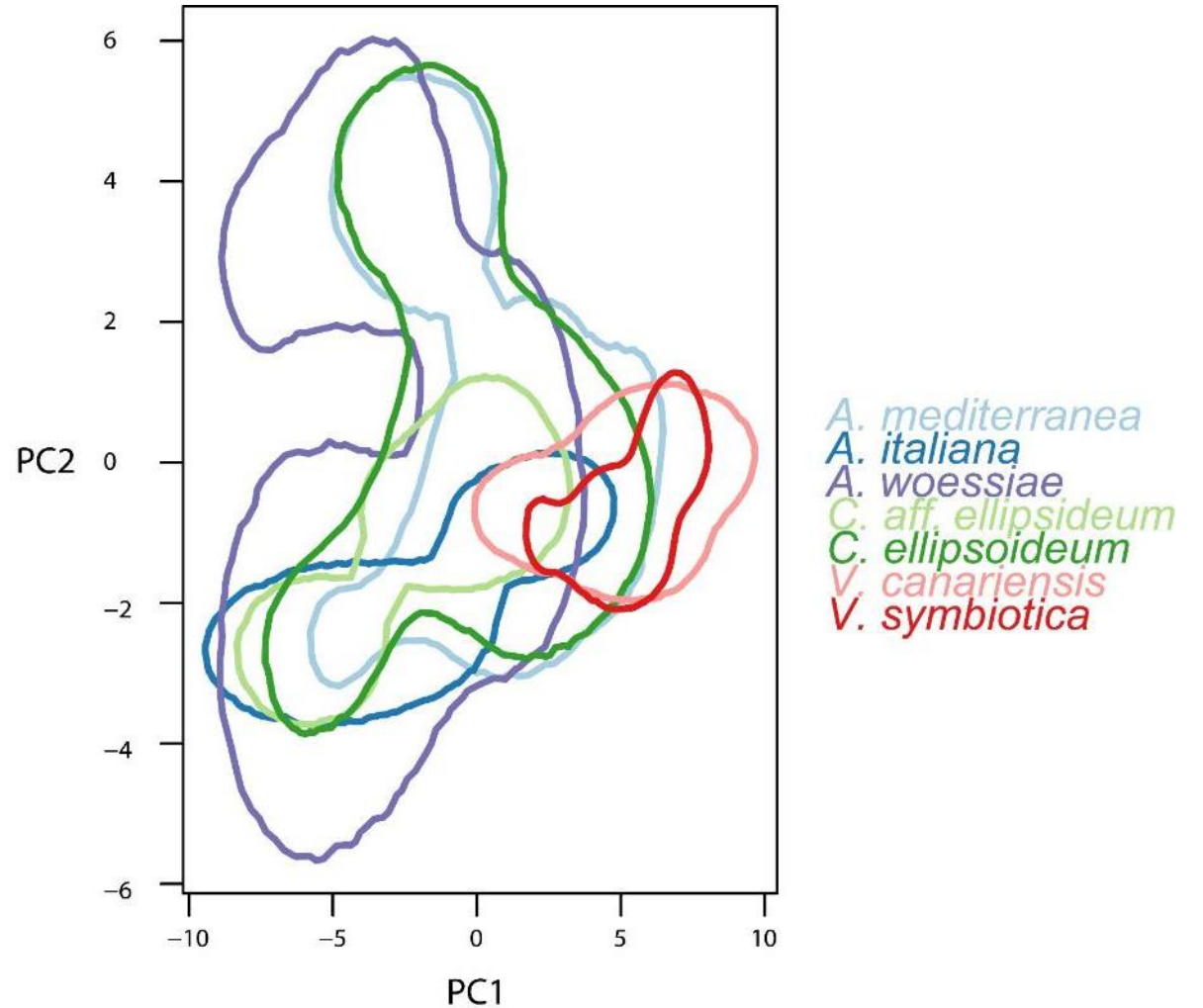
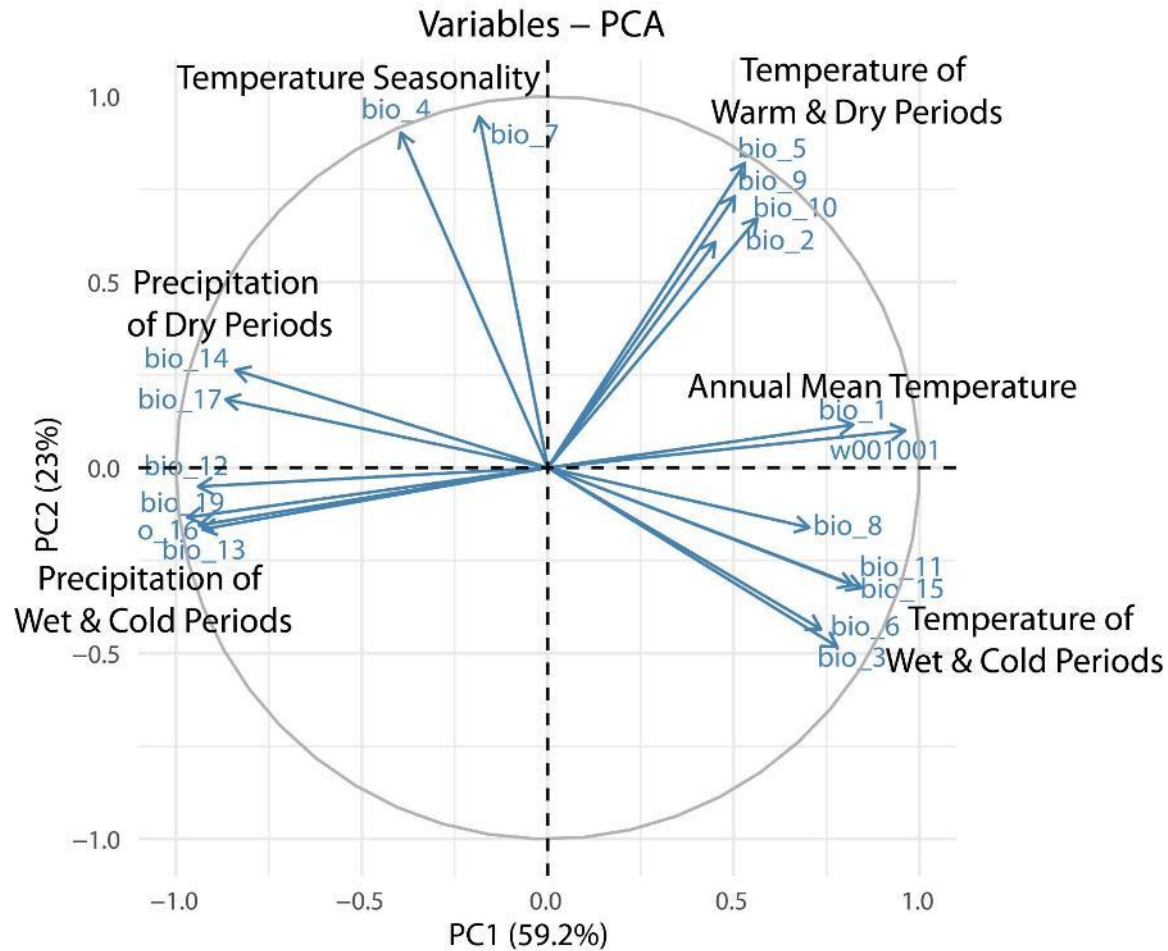
- DNA extracted directly from lichen thalli (total lichen DNA)
- phycobiont and mycobiont ITS rDNA
- niche hypervolumes: 19 WorldClim variables (<http://www.worldclim.org>)



Phycobionts of *Cladonia*, *Lepraria* and *Stereocaulon*

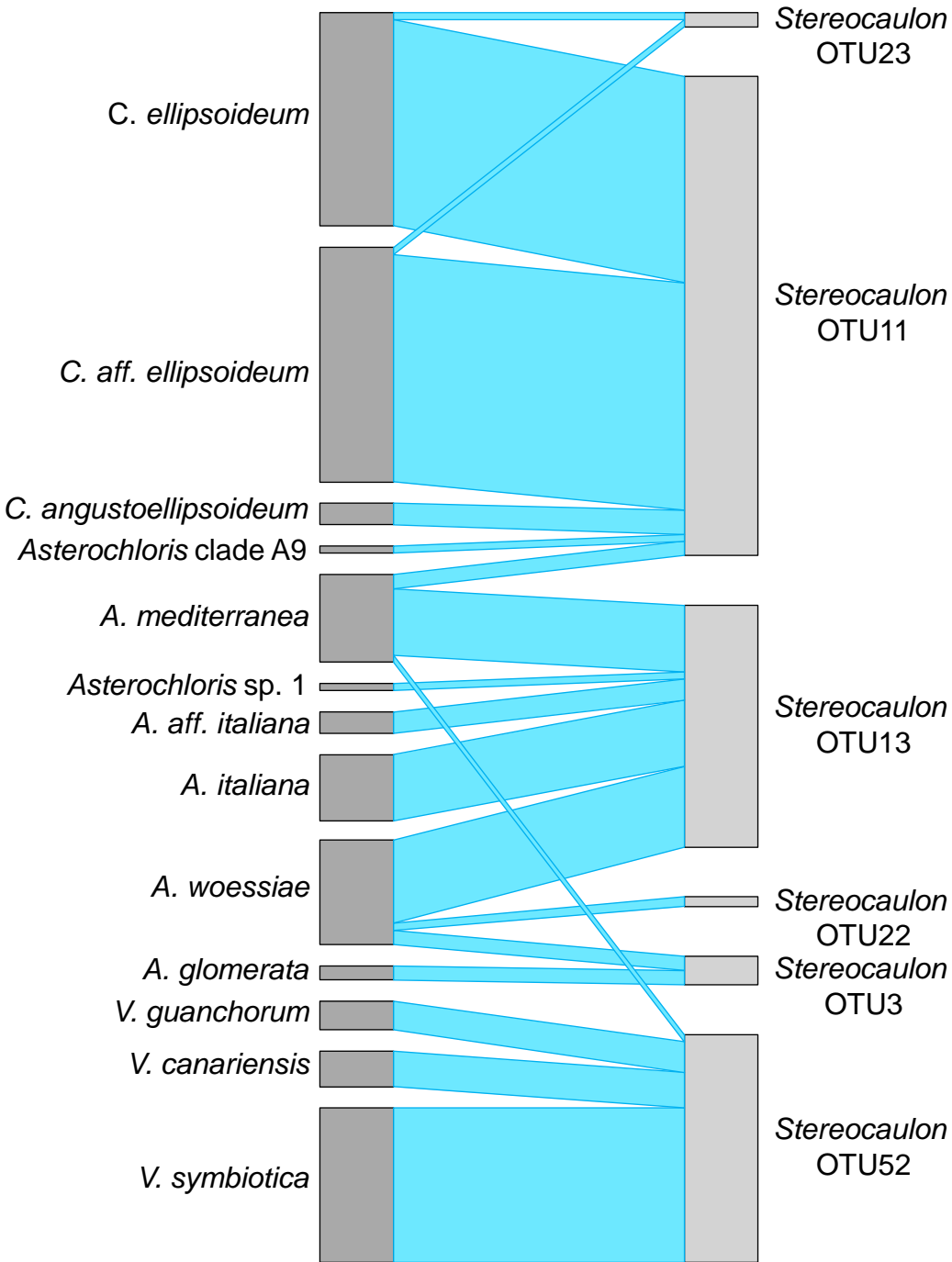


Climatic hypervolumes of phycobionts

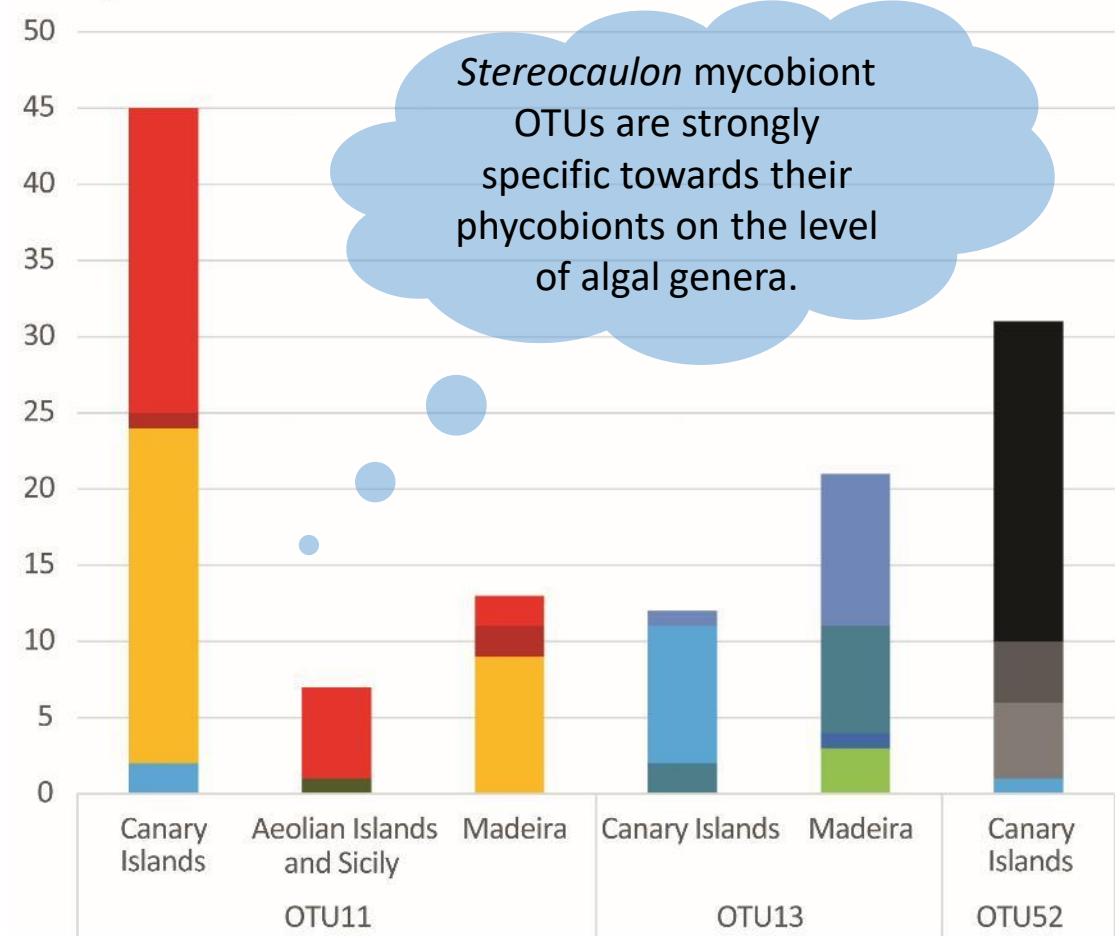


Climatic niche hypervolumes for seven most abundant phycobiont species-level lineages based on climatic PC1–PC2 axes (explaining 82.2% of variation).

Phycobionts of *Stereocaulon* lichens



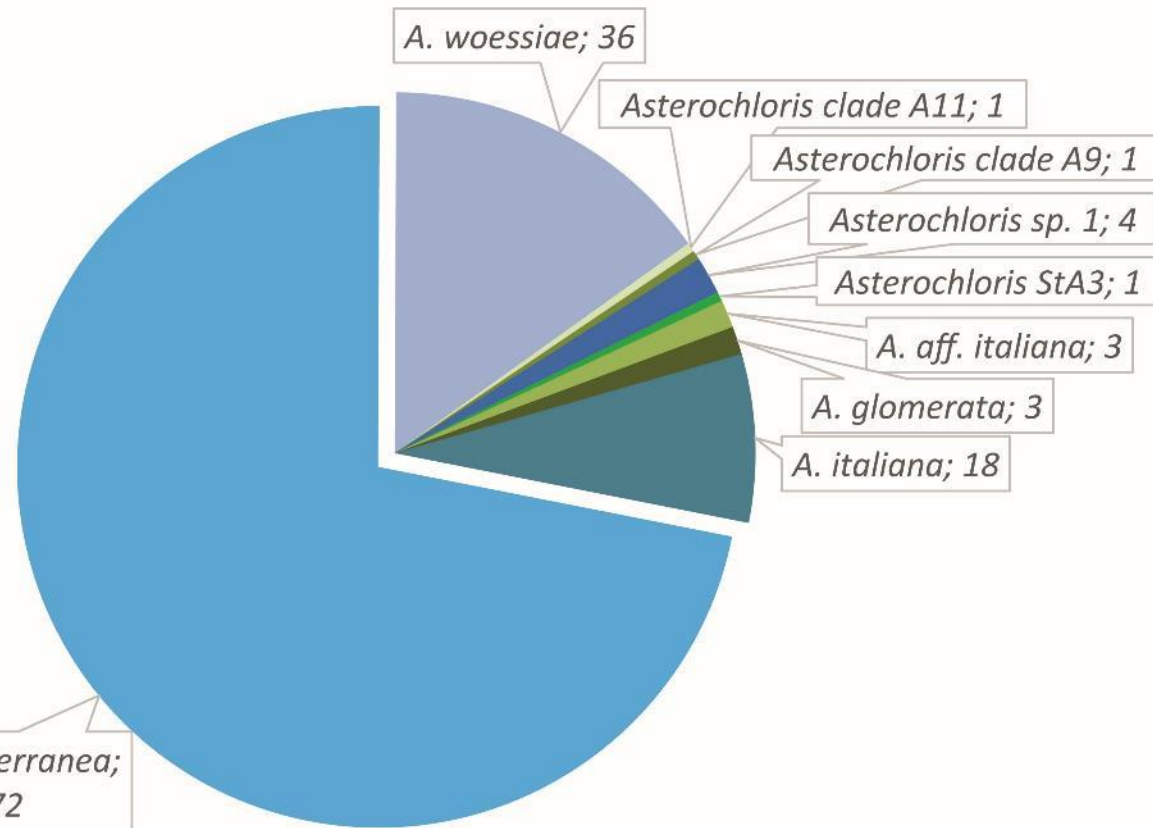
number of samples



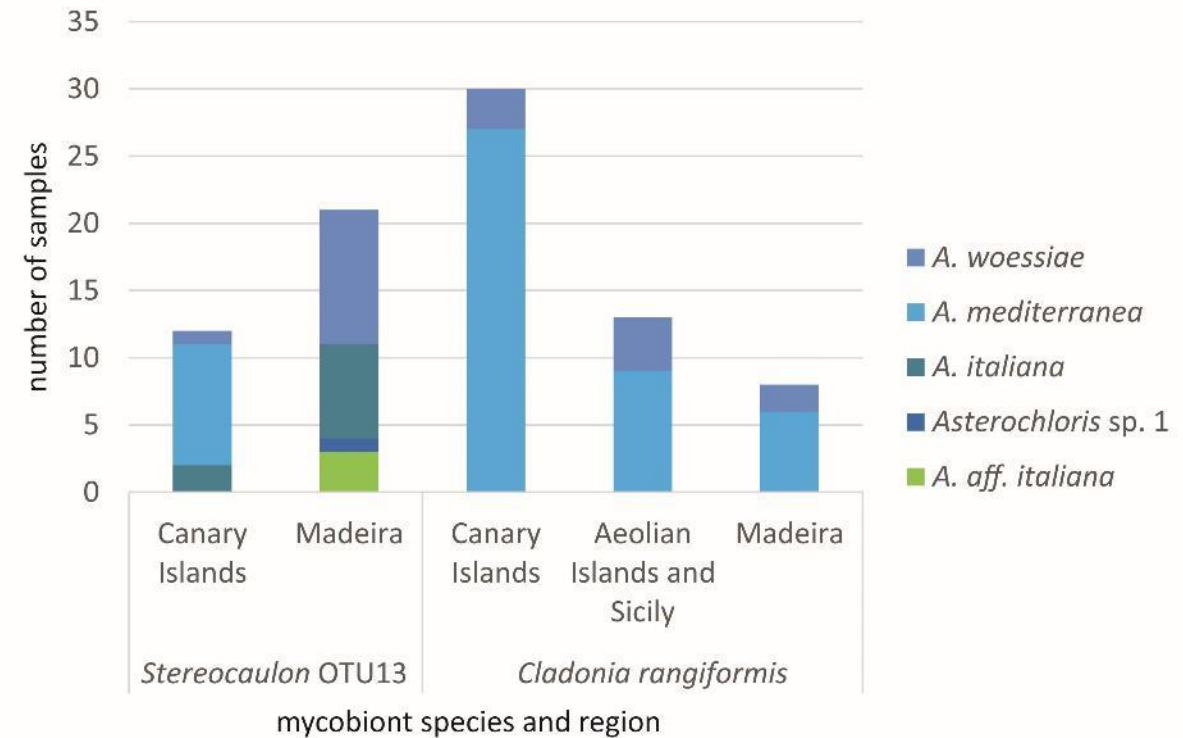
Stereocaulon OTUs and regions

Interaction network structure between mycobiont species-level lineages in the genus *Stereocaulon* and phycobiont species-level lineages.

Asterochloris phycobionts

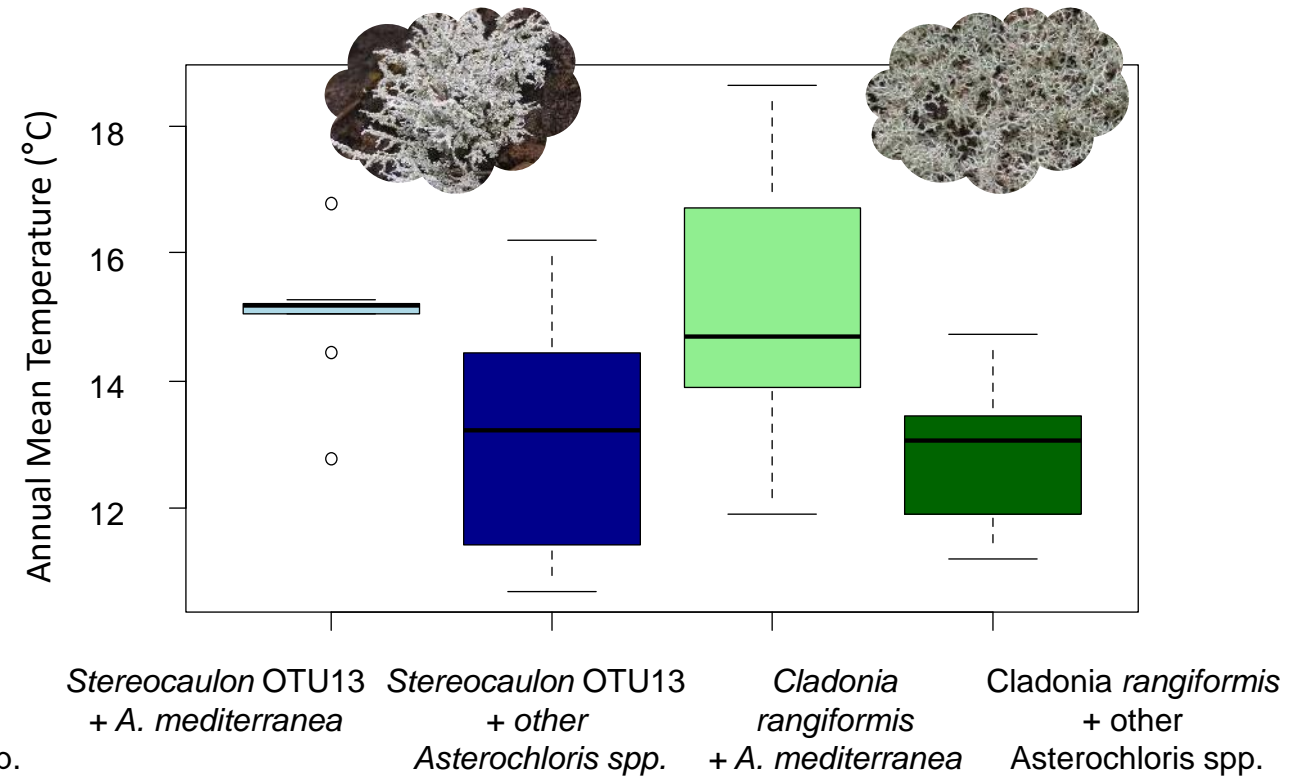
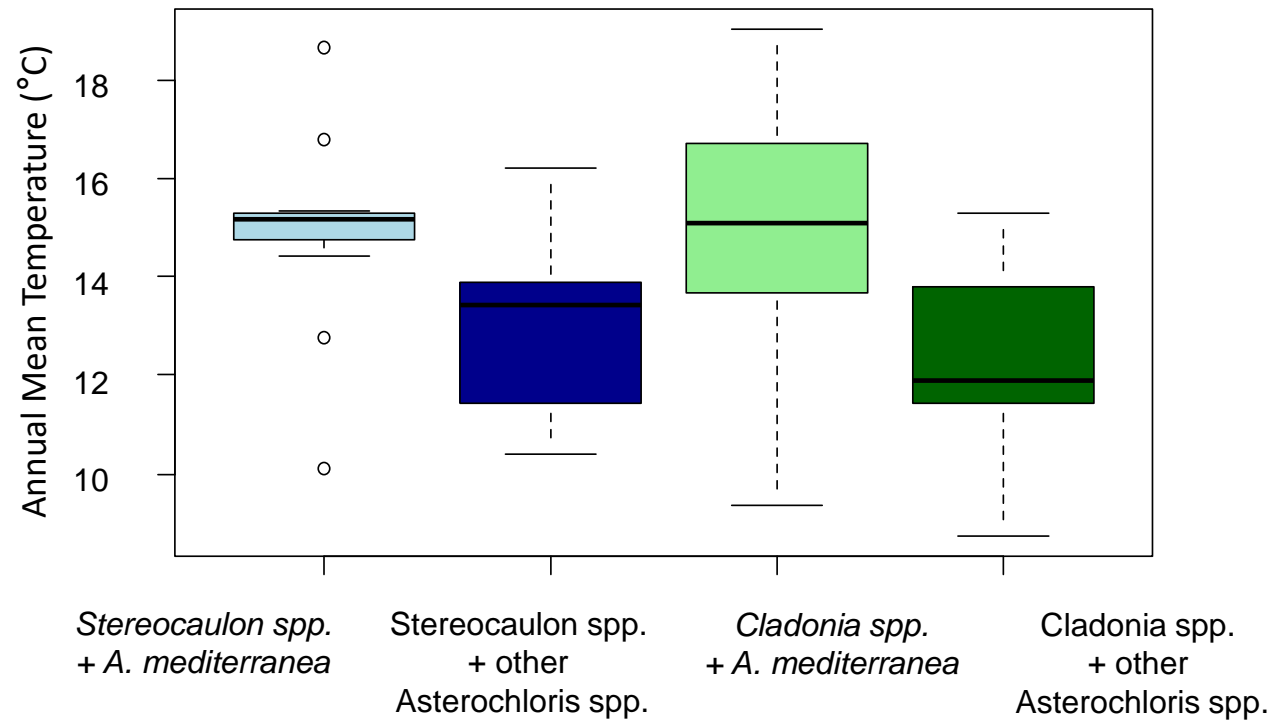


The proportion of *Asterochloris* spp. associated with *Stereocaulon*, *Cladonia*, and *Lepraria* mycobionts in the study area.



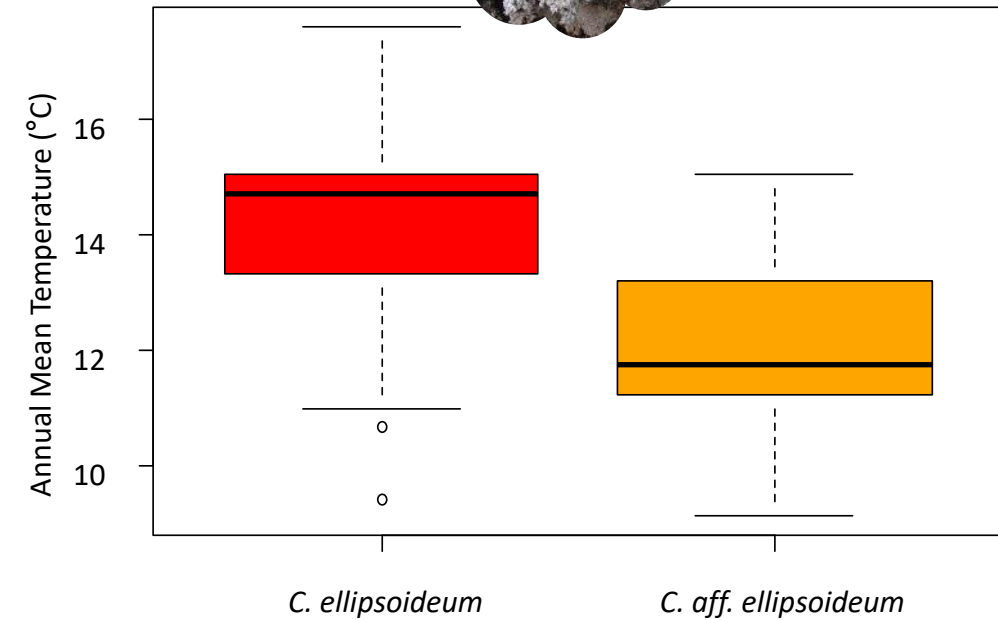
Asterochloris phycobionts associated with *Stereocaulon* OTU13 and *Cladonia rangiformis* in particular regions.

Asterochloris phycobionts



- *Asterochloris mediterranea* occurs in warmer (and drier) climates than other *Asterochloris* spp.
- This pattern applies to phycobionts of various mycobionts.

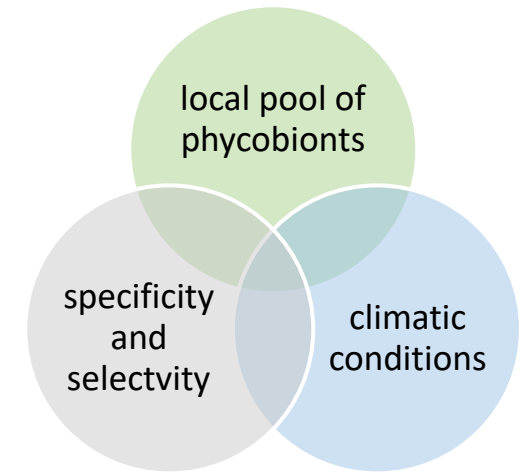
Chloroidium analogy



mycobiont	warm	warmer and dry	warmest and driest
<i>Cladonia</i> spp.	+ <i>A. woessiae</i> , <i>A. italiana</i> or other <i>Asterochloris</i> spp.	+ <i>A. mediterranea</i>	XXX
<i>Stereocaulon</i> OTU11	+ <i>C. aff. ellipsoideum</i>	+ <i>C. ellipsoideum</i>	XXX
<i>Stereocaulon</i> OTU13	+ <i>A. woessiae</i> , <i>A. italiana</i> or other <i>Asterochloris</i> spp.	+ <i>A. mediterranea</i>	XXX
<i>Stereocaulon</i> OTU52	XXX	+ <i>Vulcanochloris</i> spp.	+ <i>Vulcanochloris</i> spp.

But the location of the border between warm and warmer areas varies among the mycobionts.

Conclusions



- Diversity of phycobionts:
 - 4 genera, 17 species-level lineages
 - diversity of phycobionts of *Stereocaulon* higher than that of other mycobionts
- Specificity and selectivity of mycobionts
 - high specificity on the level of algal genera
 - possible selectivity on the level of algal species
- Ecology of phycobionts
 - *Vulcanochloris* spp. limited to the warmest and driest areas
 - Species within *Asterochloris* and *Chloroidium* diversified according to the climatic requirements

Analyzing the distribution of phycobionts,
it is impossible to ignore the effect of mycobiont and *vice versa*.

Thank you for your attention! Any questions?

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