



Biogeographical Analysis of Ground Beetles (Coleoptera: Carabidae) in the Mountainous Areas of the Peloponnese (Greece)

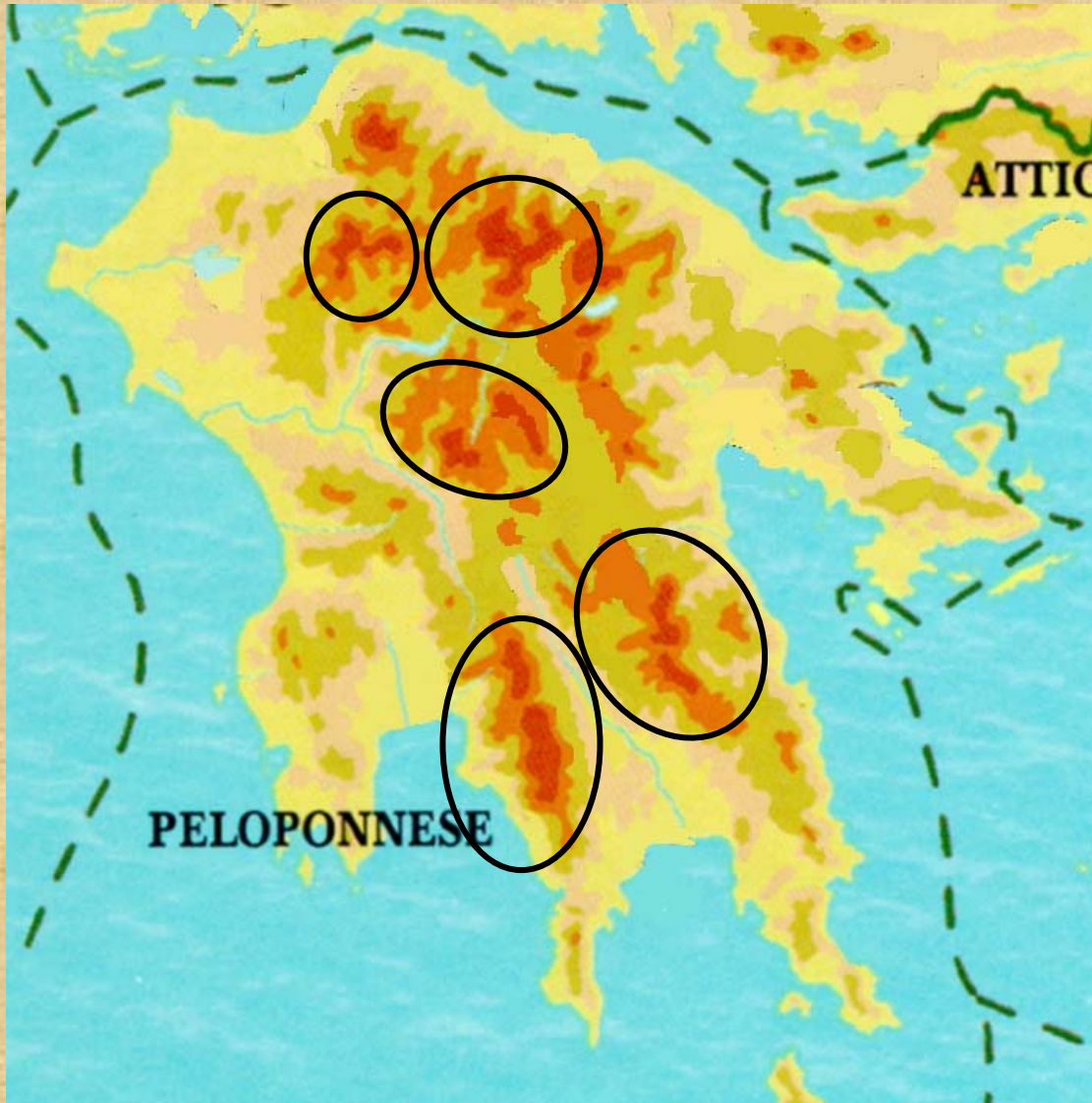
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Introduction



The Peloponnese is a mountainous area in Southern Greece.

Invertebrate fauna:

- High diversity
- High levels of endemism

5 mountains were studied

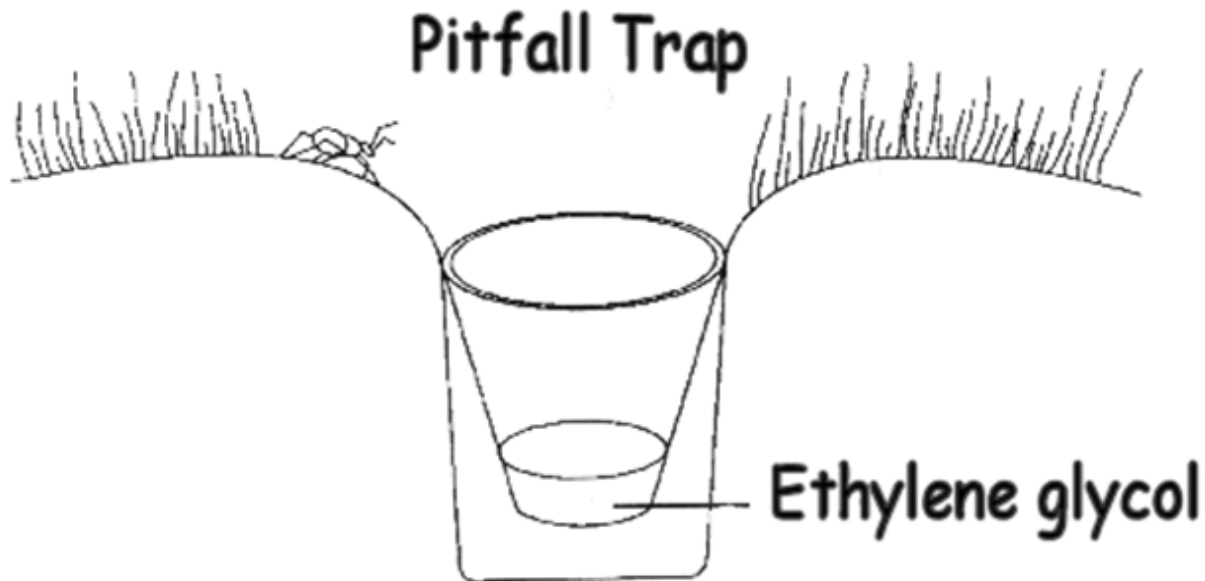
Aim

To elucidate the patterns of distribution and to identify the paleogeographical and ecological factors that cause these patterns.

Methods

In each mountain:

- Several different habitat types
- Pitfall traps
- Carabidae



Biotores

AL 1



AL 2



- **Altitudinal Range:** \cong 1800 m.
- **Coverage:** Rocks, Bushes, Shrubs, Bare Soil.
- **Vegetation:** *Juniperus communis*, *Astragalus* sp., *Calycotome villosa*, *Echinops* sp., *Euphorbia* sp., *Daphne oleoides*, Boraginaceae, Gramineae.

- **Altitudinal Range:** \cong 1650 m.
- **Coverage:** Rocks, Bushes, Shrubs, Bare Soil.
- **Vegetation:** *Juniperus communis*, *Astragalus* sp., *Poa* sp., *Daphne oleoides*, *Abies cephalonica*, *Ranunculus* sp., Compositae, Gramineae.

Biotoques

PF 1



- **Altitudinal Range:** $\cong 1350$ m.
- **Coverage:** Trees, Leaf Litter, Shrubs.
- **Vegetation:** *Pinus nigra*, *Pteridium aquilinum*.

PF 2



- **Altitudinal Range:** $\cong 1400$ m.
- **Coverage:** Trees, Leaf Litter, Shrubs.
- **Vegetation:** *Pinus nigra*, *Pteridium aquilinum*.

Biotoques

MF 1



- **Altitudinal Range:** $\cong 1500$ m.
- **Coverage:** Trees, Leaf Litter, Shrubs.
- **Vegetation:** *Pinus nigra*, *Abies cephalonica*, *Pteridium aquilinum*, *Fragaria* sp., Gramineae.

DF 1



- **Altitudinal Range:** $\cong 1000$ m.
- **Coverage:** Trees, Leaf Litter, Shrubs.
- **Vegetation:** *Quercus frainetto*.

Biotoques

FR 1



- **Altitudinal Range:** $\cong 640$ m.
- **Coverage:** Shrubs, Bushes, Soil, Rocks.
- **Vegetation:** *Spartium junceum*, *Astragalus* sp., *Sarcopoterium spinosum*, *Asparangus acutifolius*, *Teucrium capitatum*, *Phlomis fruticosa*, *Calycotome villosa*, *Saturejia* sp., *Cistus creticus*, *Euphorbia* sp.

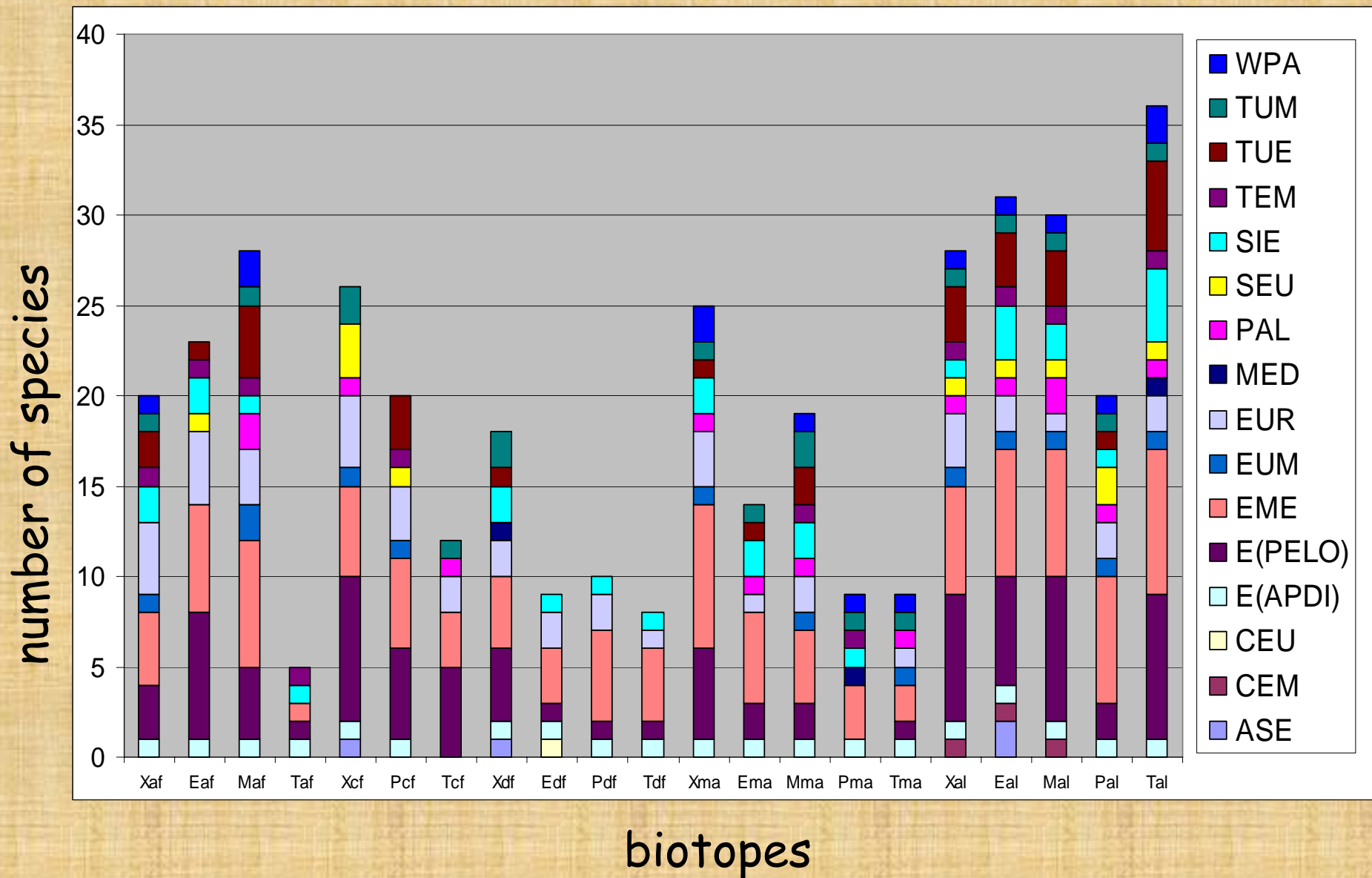
MA 1



- **Altitudinal Range:** $\cong 800$ m.
- **Coverage:** Bushes, Shrubs, Soil, Rocks.
- **Vegetation:** *Quercus coccifera*, *Brachypodium* sp., *Phillyrea latifolia*, *Cistus creticus*, *Dorycnium hirsutum*, *Hypericum empetrifolium*, *Cotinus coggygria*, *Arbutus adrachne*, *A. unedo*, *Teucrium* sp.

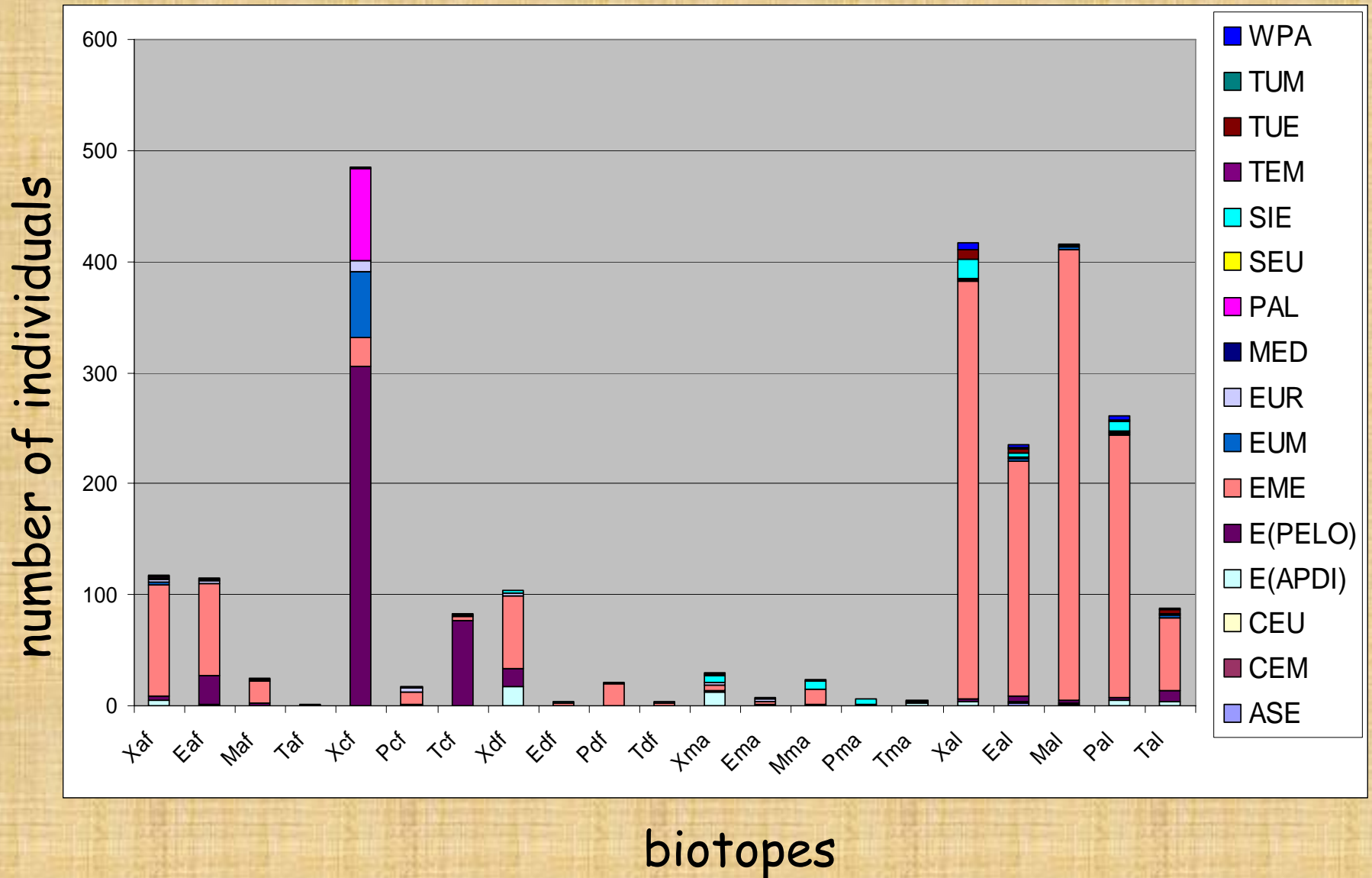
96 species belonging to 16 different chorotypes

Species richness

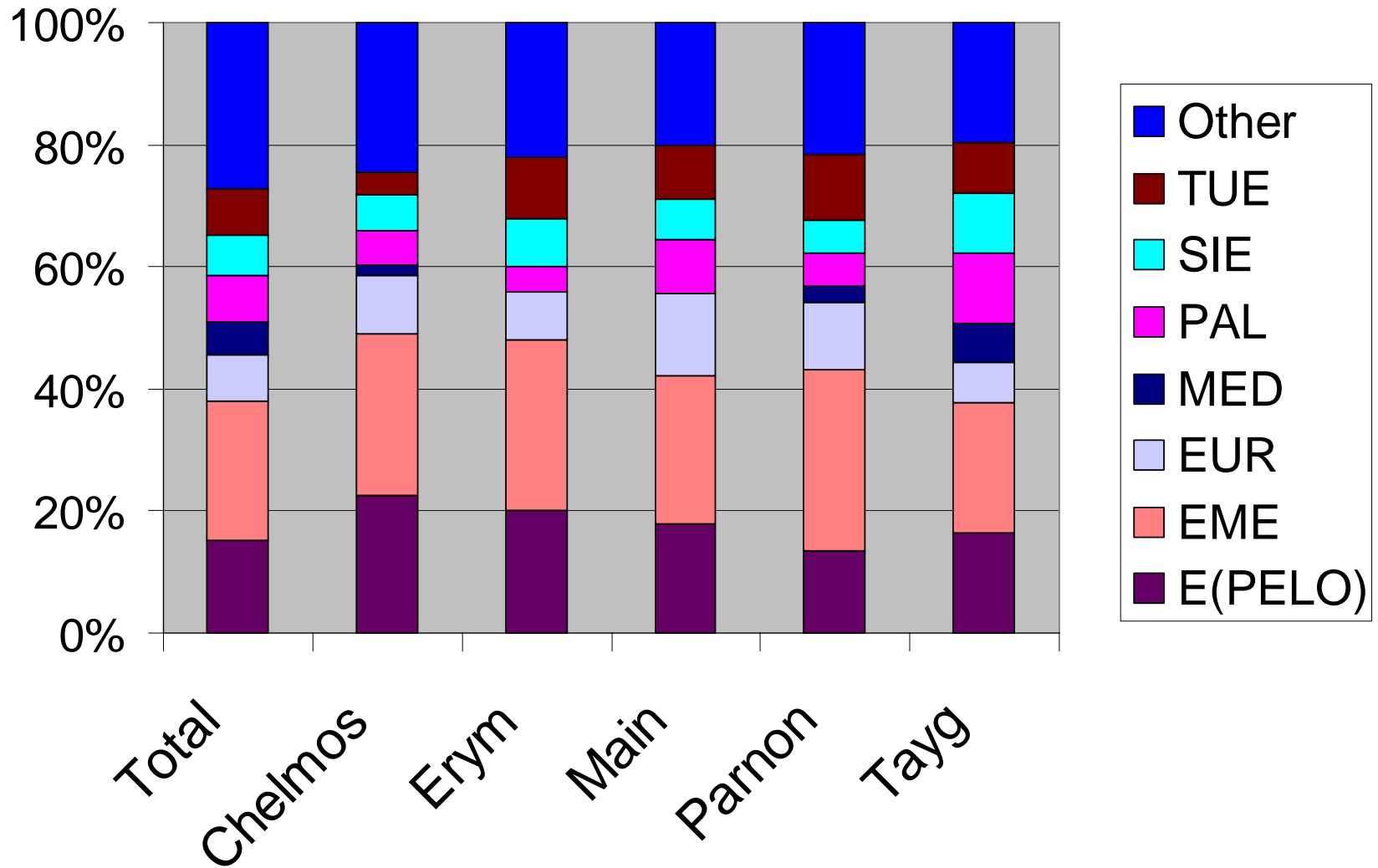


96 species belonging to 16 different chorotypes

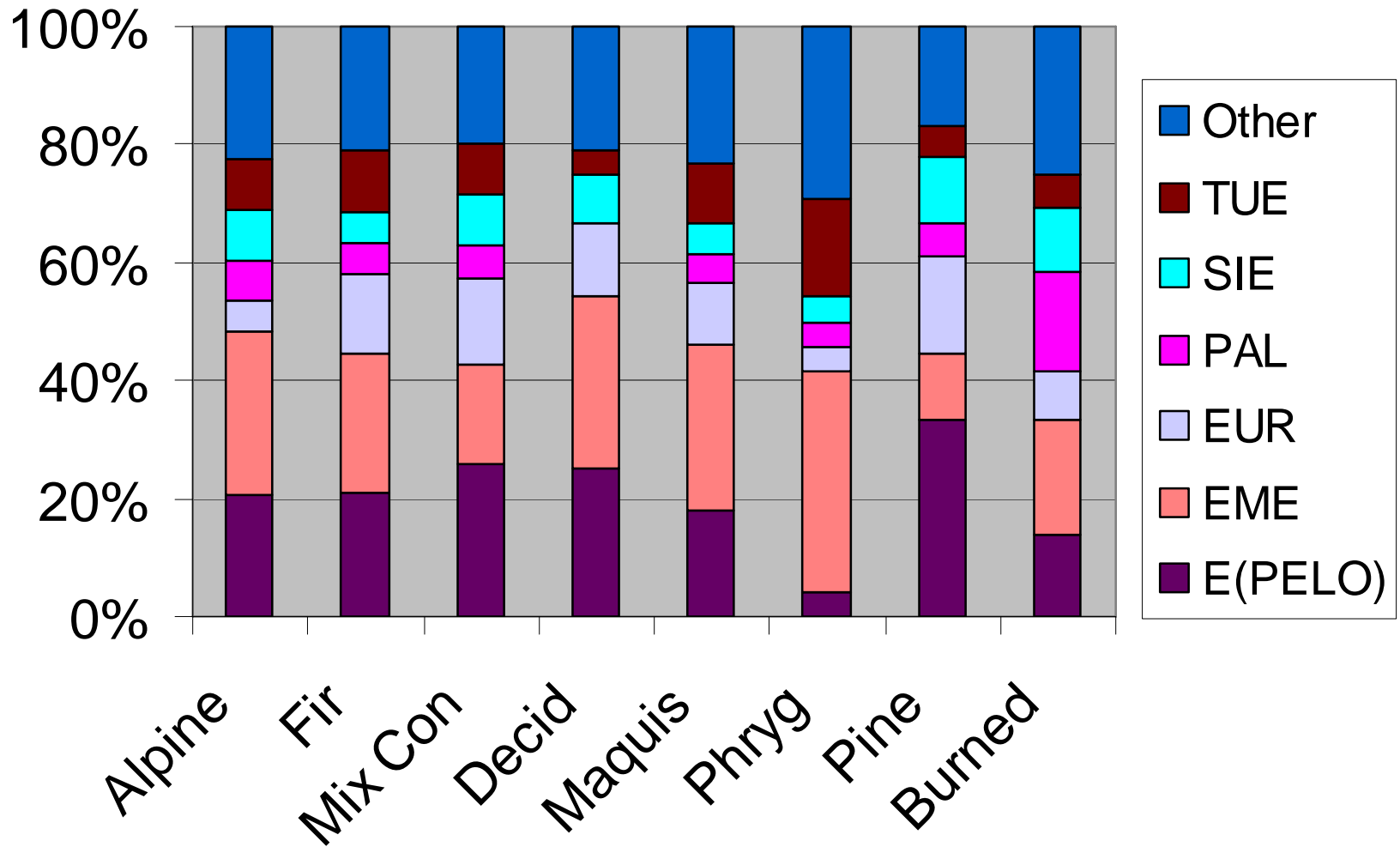
Abundance



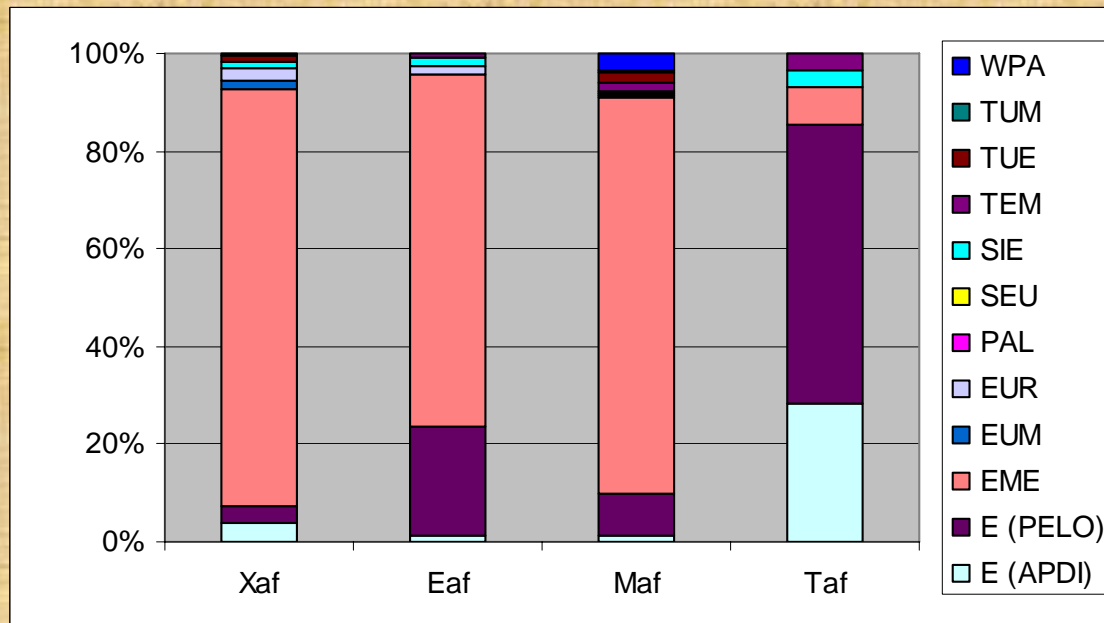
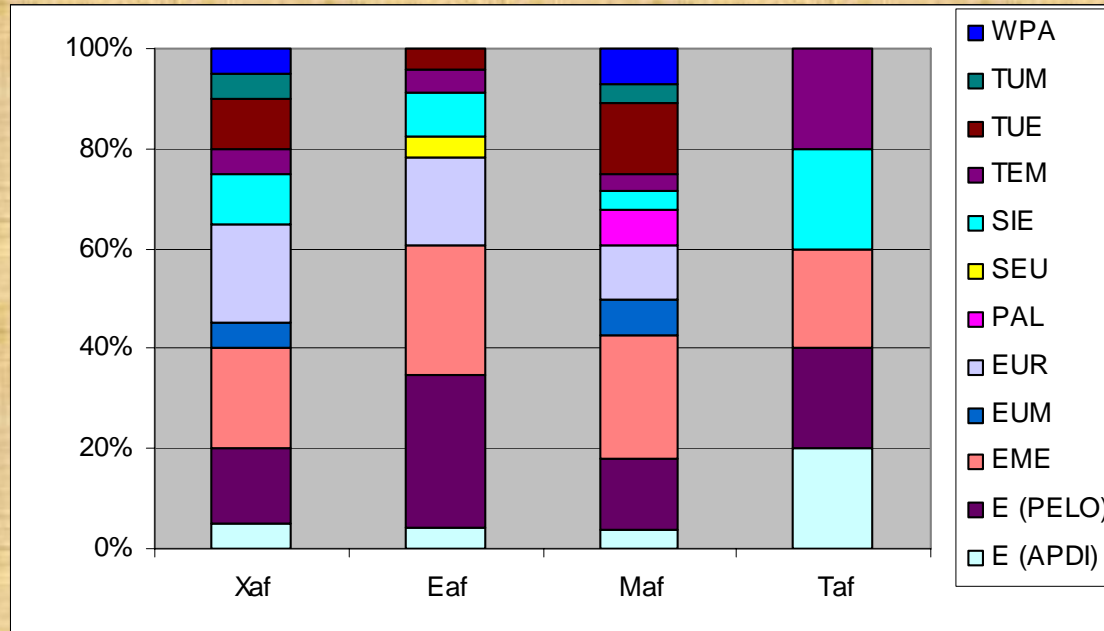
Chorotype distribution on each mountain



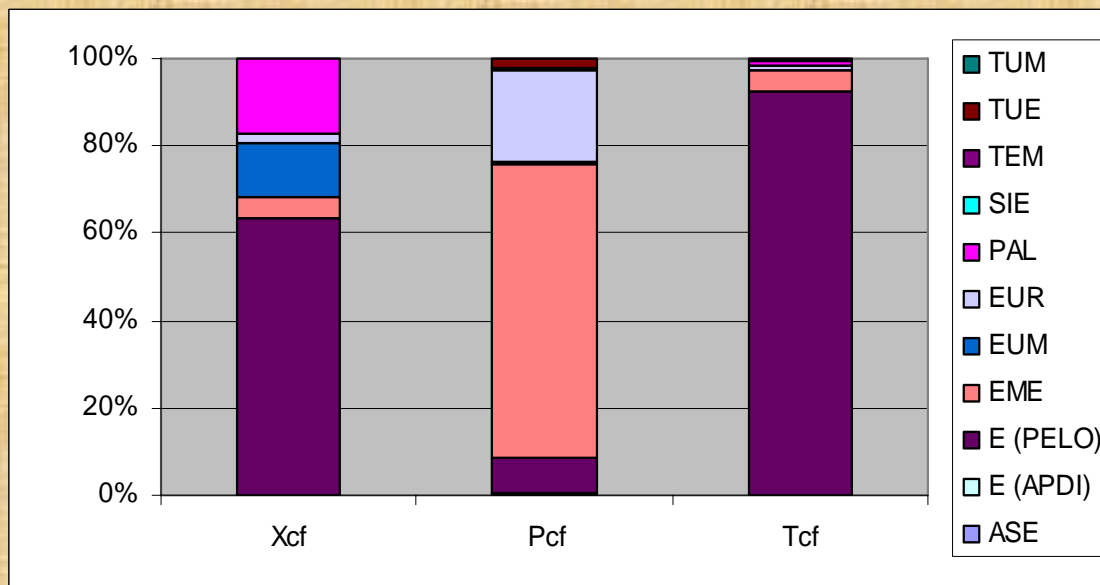
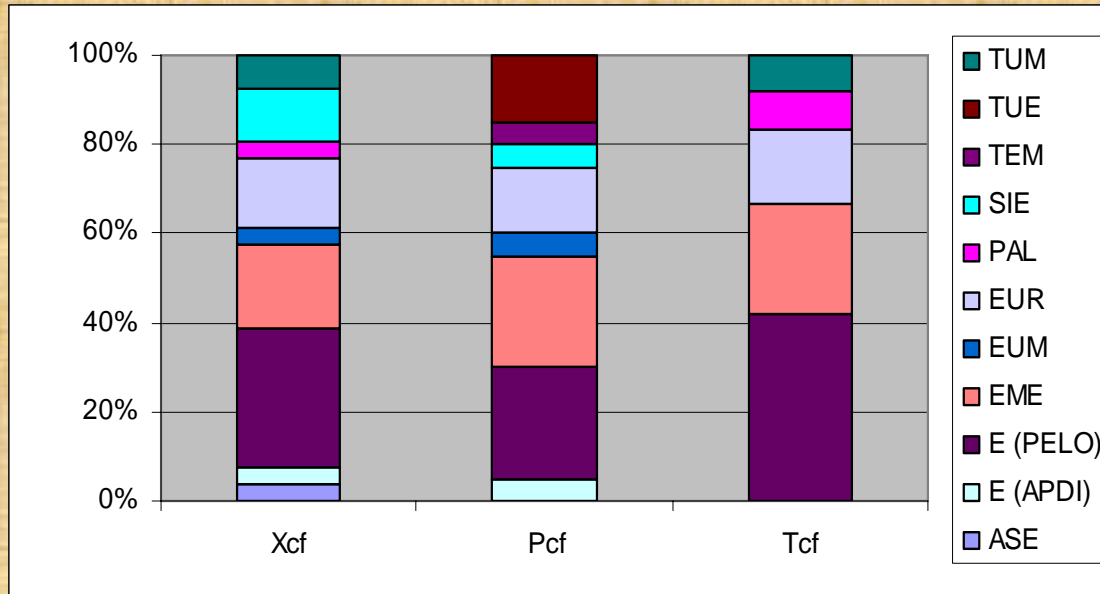
Chorotype distribution in each habitat



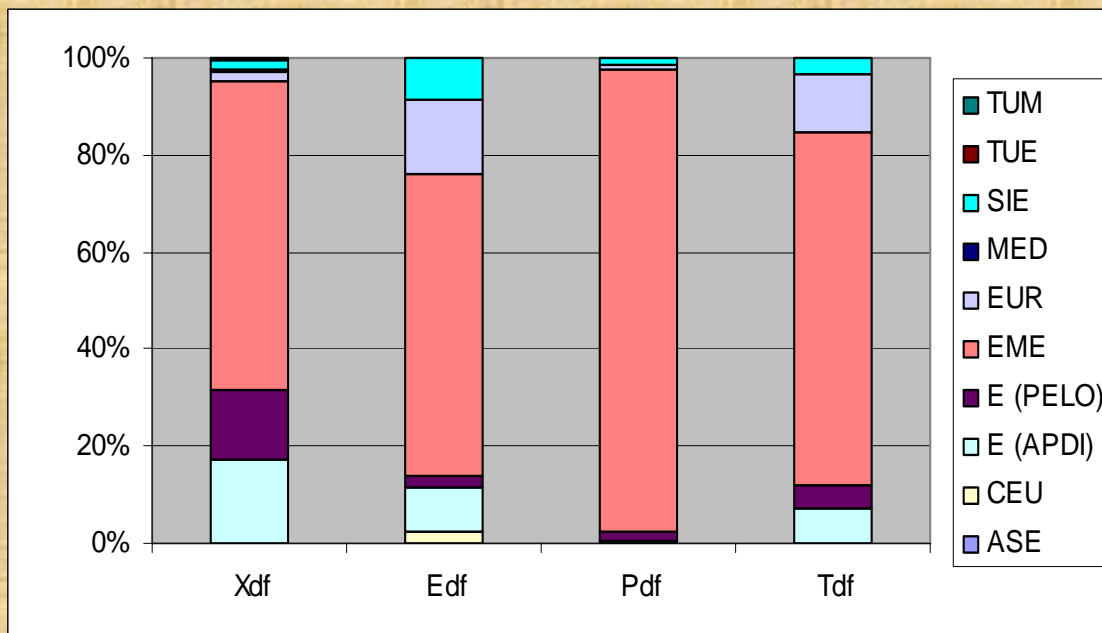
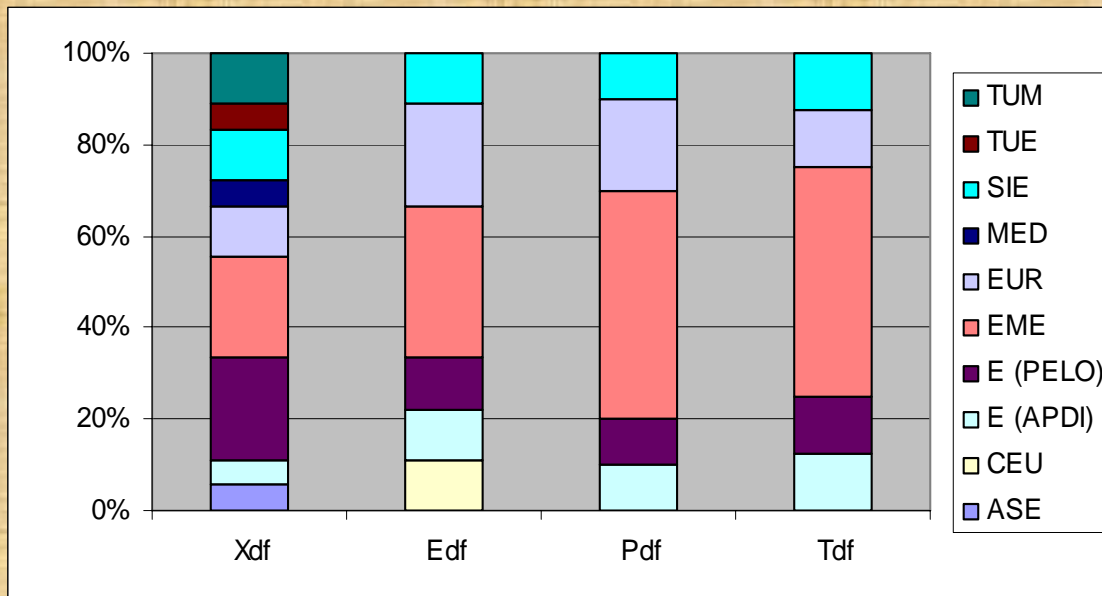
Abies forest



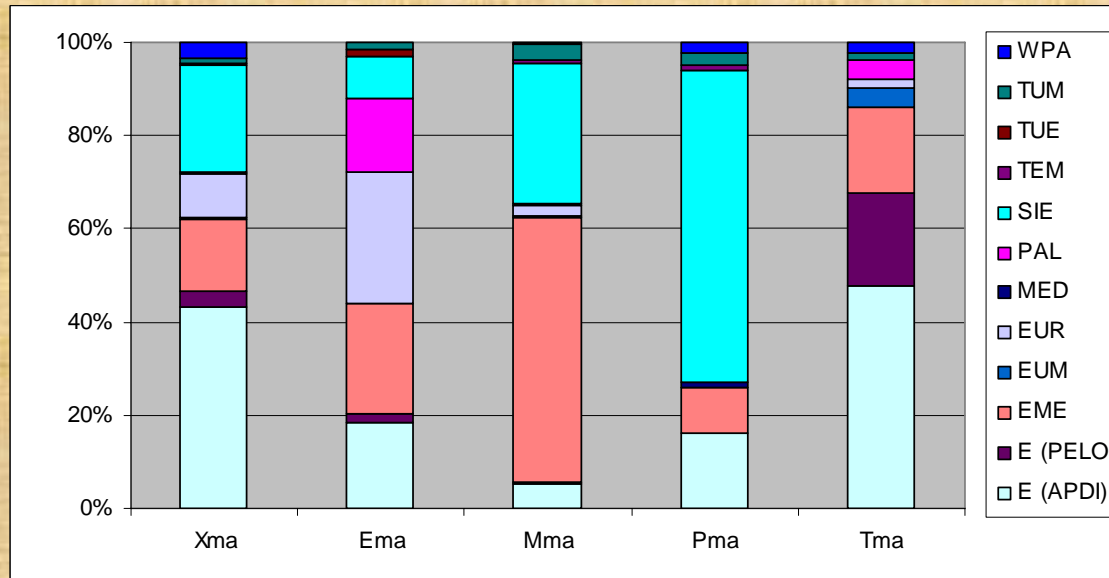
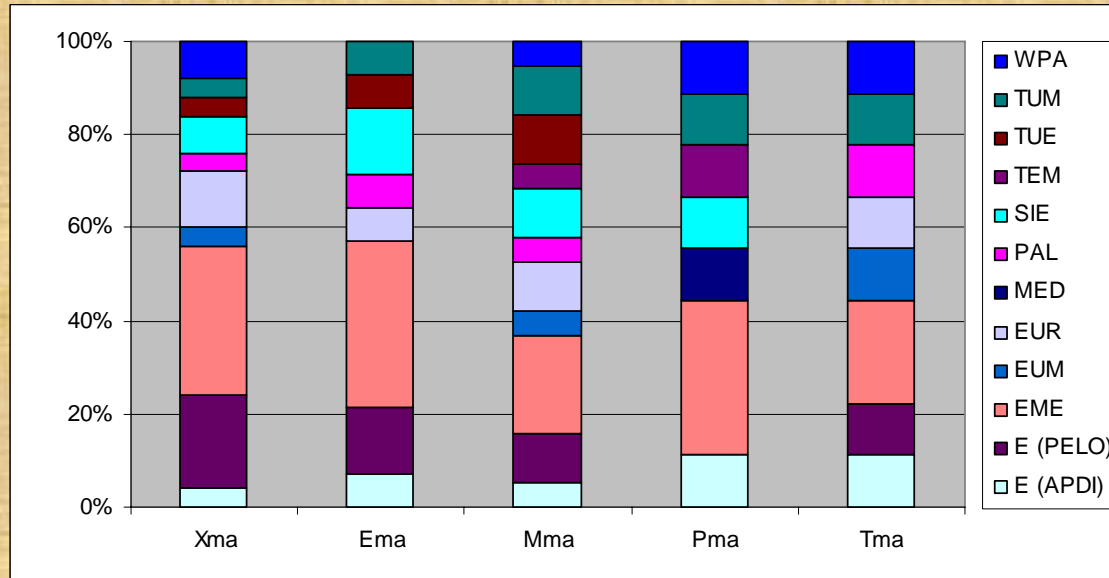
Pine forest



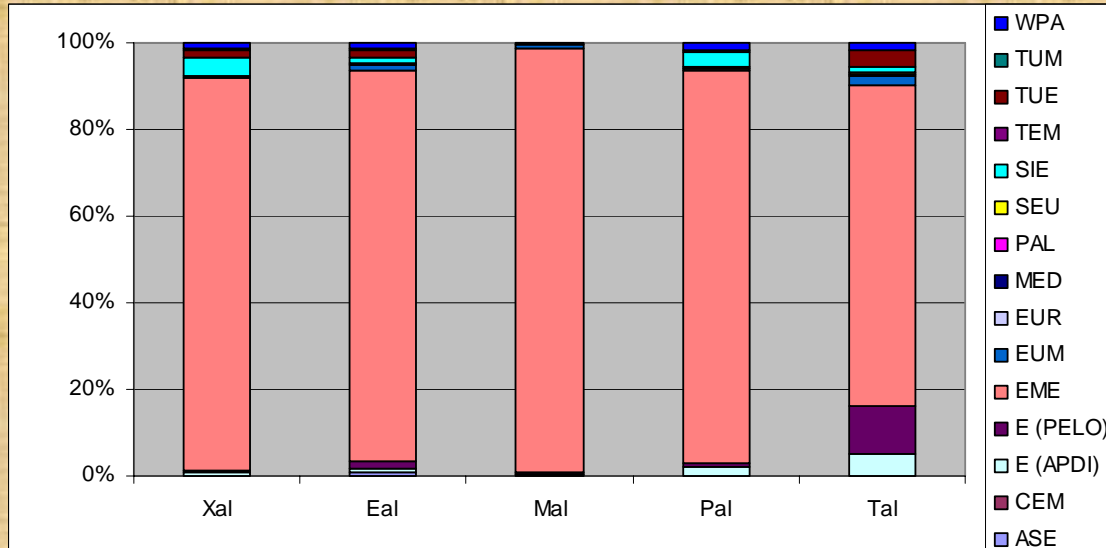
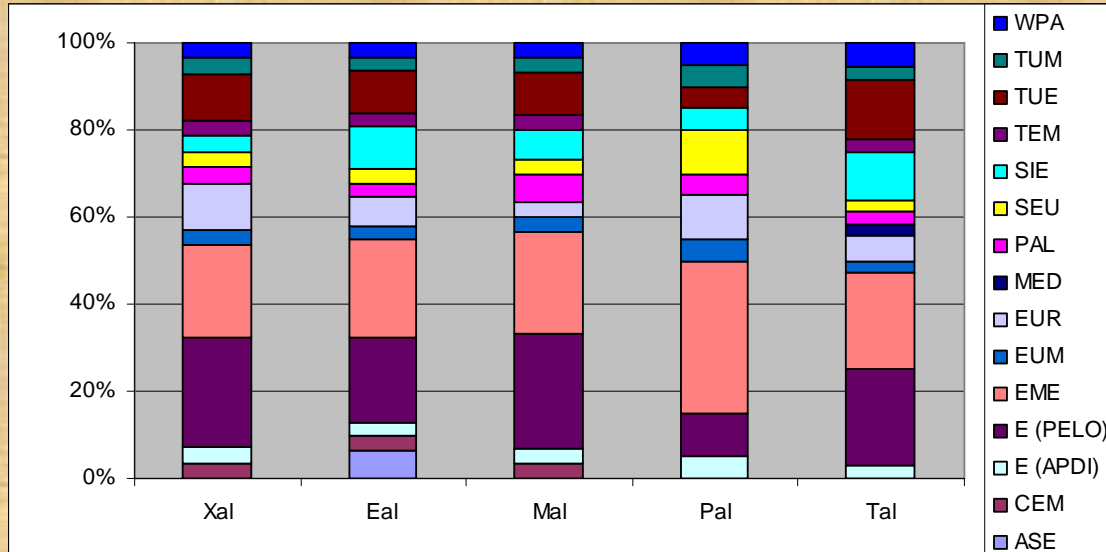
Deciduous forest



Maquis



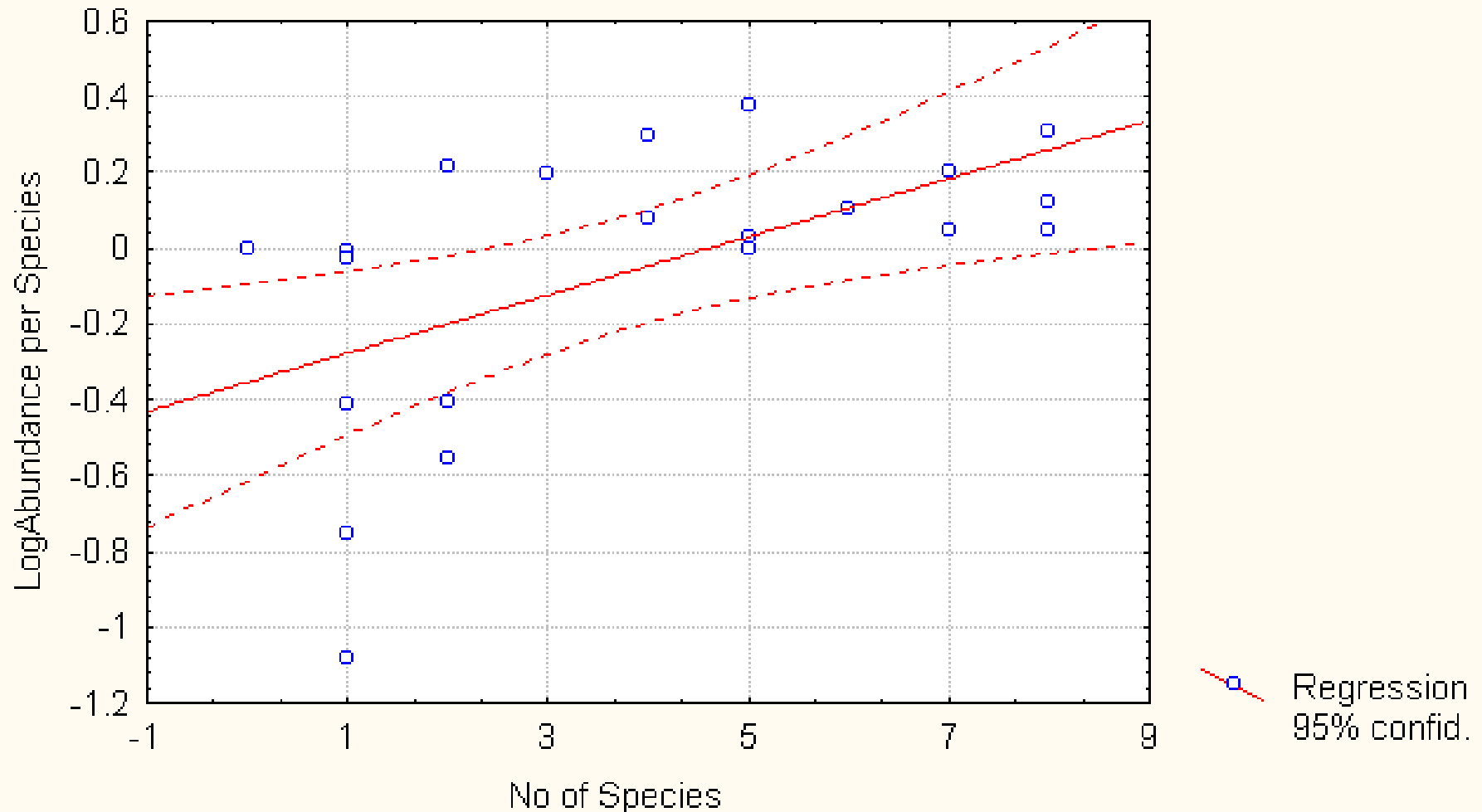
Subalpine



Correlation between number of endemic species and abundance

$$\text{LogAbundance} = -.3543 + .07676 * \text{No of Species}$$

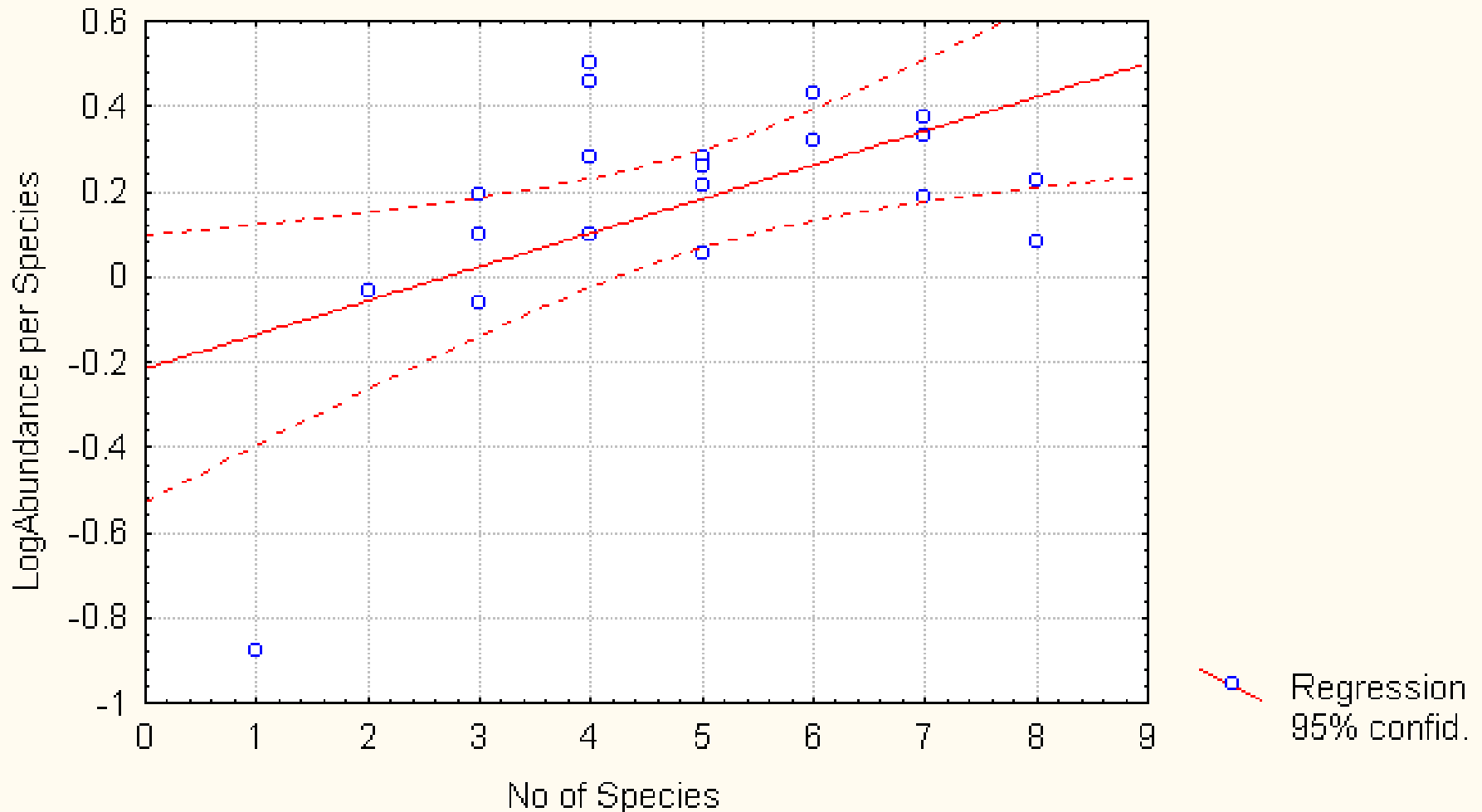
Correlation: $r = .55577$ ($p=0.009$)



Correlation between number of East Mediterranean species and abundance

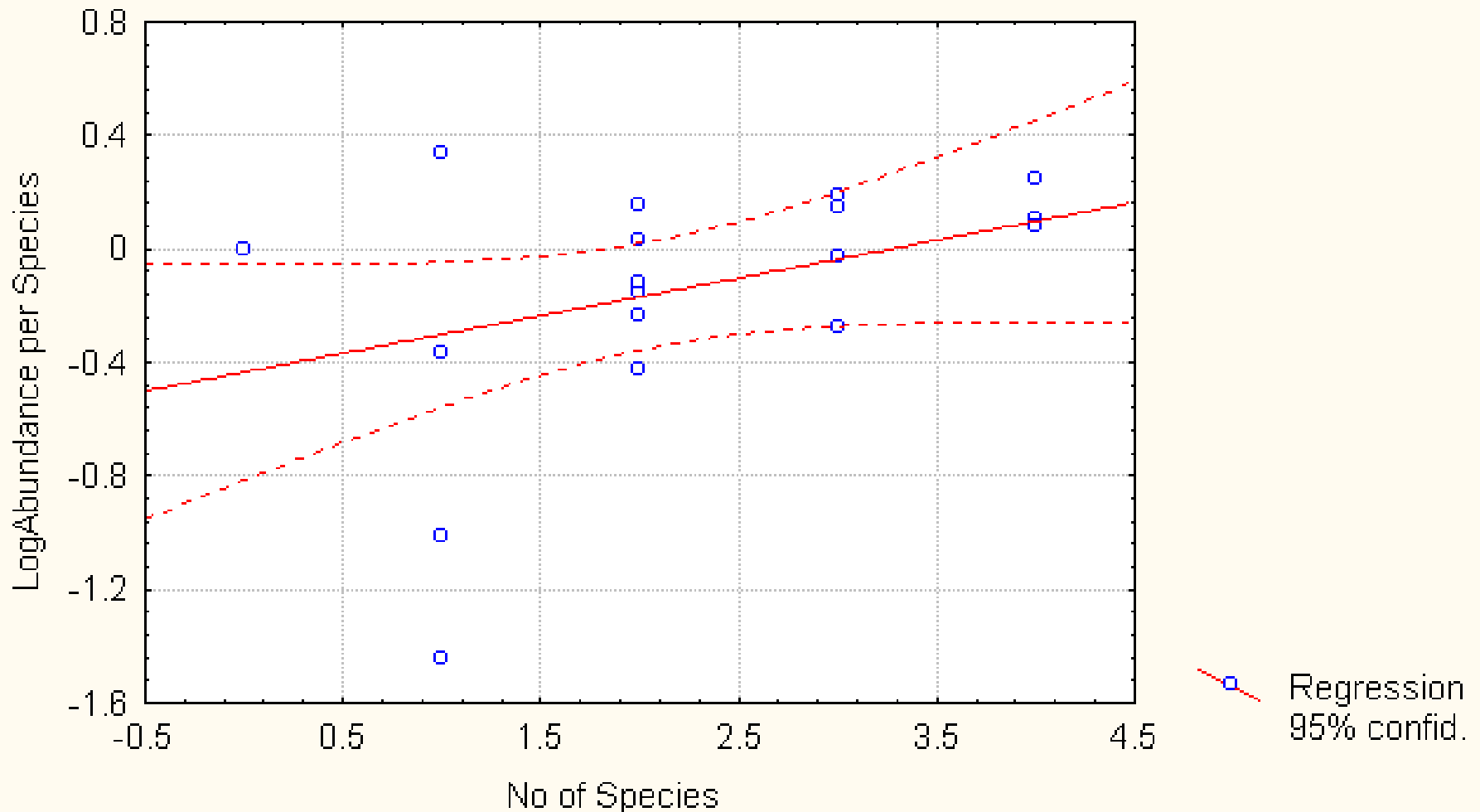
$$\text{LogAbundance} = -.2164 + .07968 * \text{No of Species}$$

Correlation: $r = .54578$ ($p=0.01$)

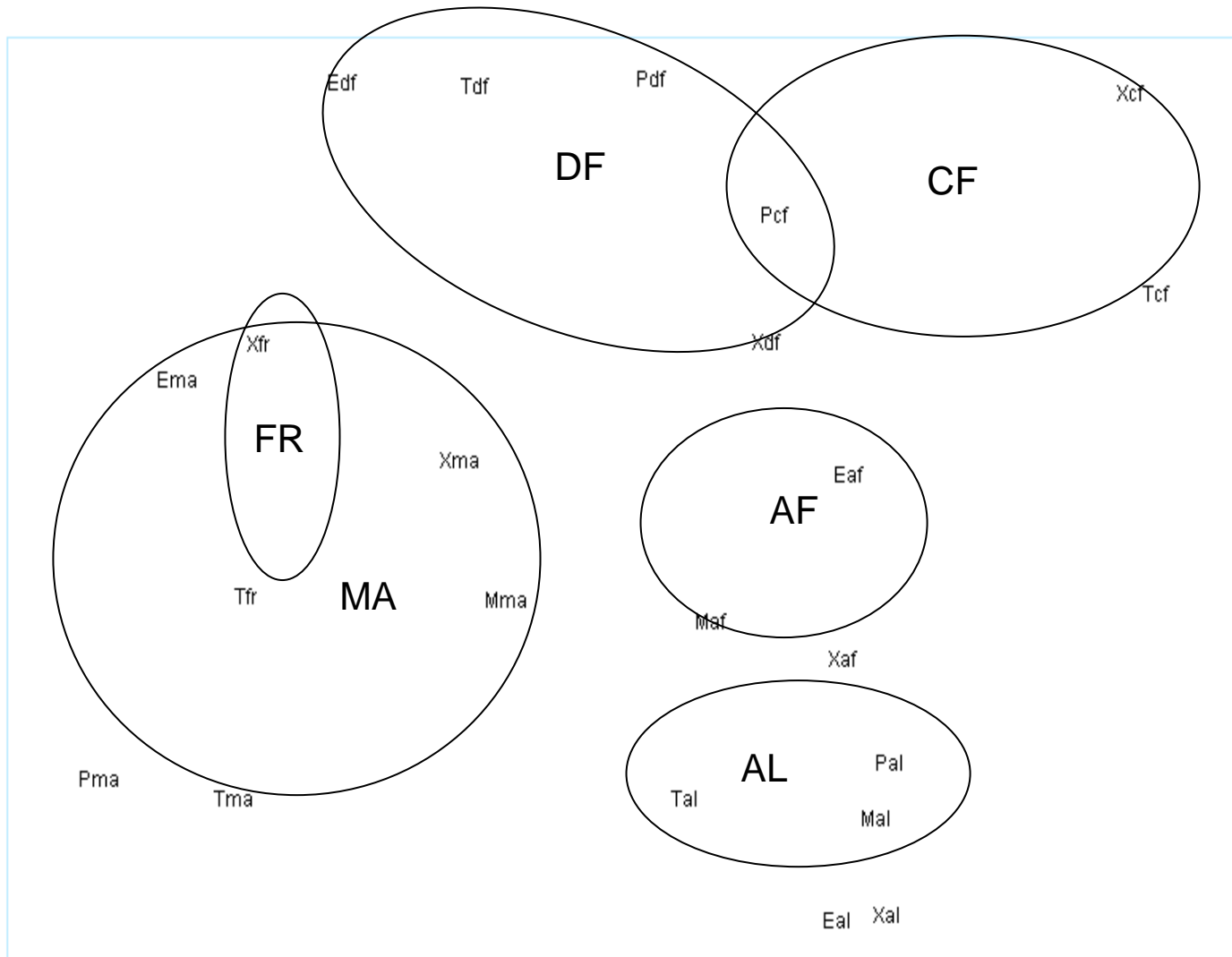


Correlation between number of European species and abundance

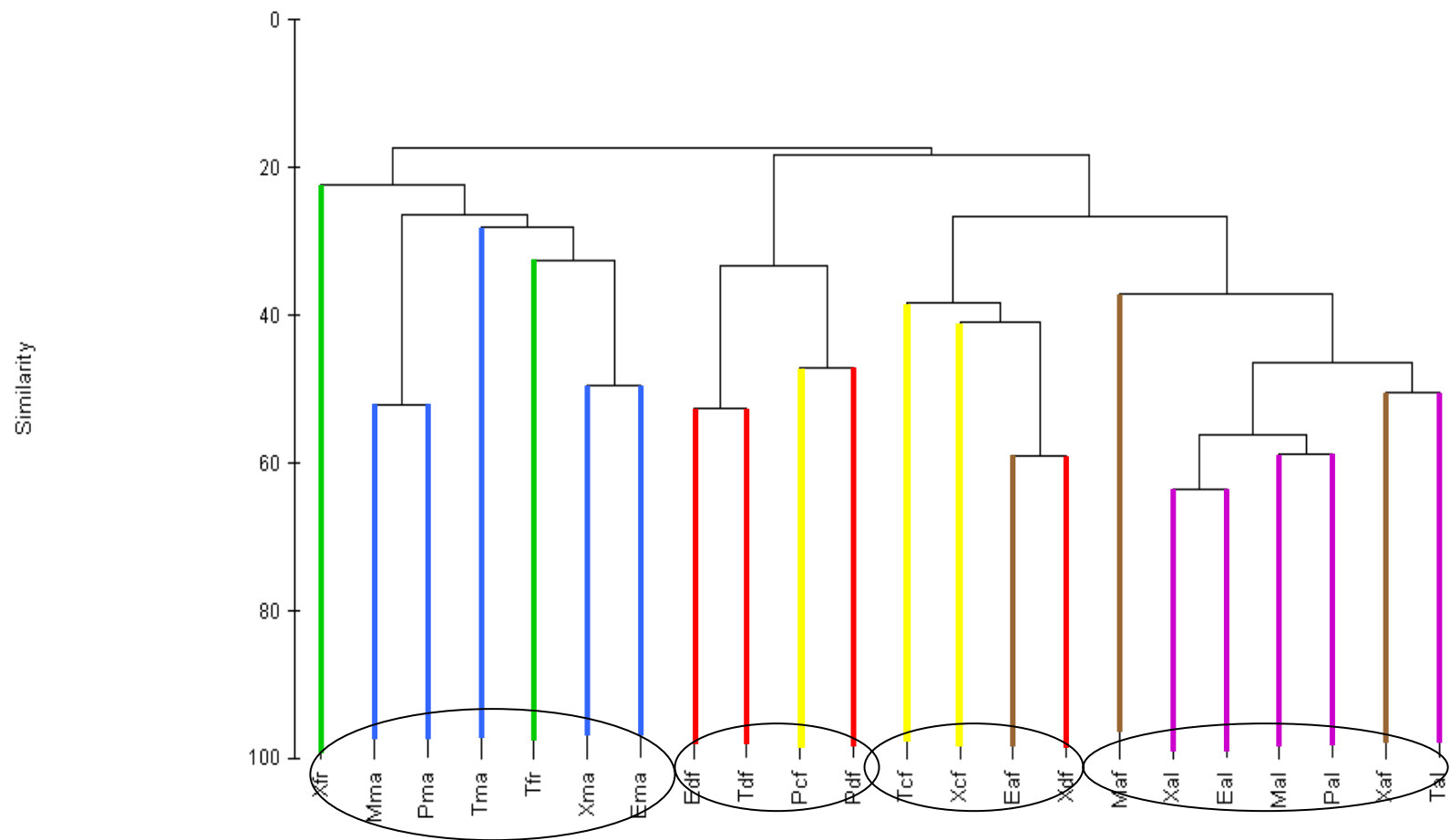
LogAbundance per Species = $-.4350 + .13278 * \text{No of Species}$
Correlation: $r = .37255$ ($p=0.096$)



Multidimensional scaling of habitats



Clustering of habitats

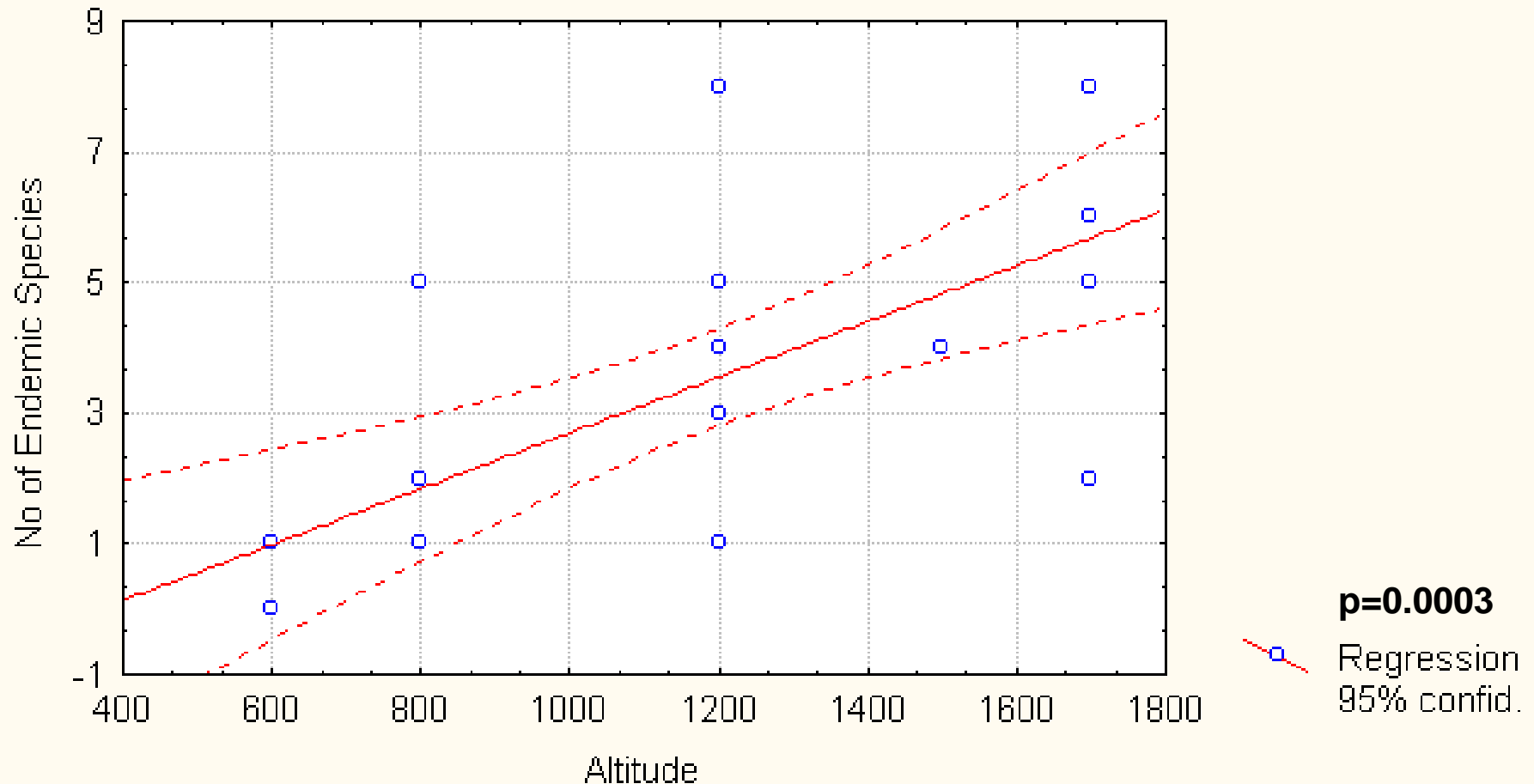


Correlation between number of endemic species and altitude

Altitude vs. Endemic Species

$$\text{Endemic Species} = -1.579 + .00427 * \text{Altitude}$$

Correlation: $r = .62810$

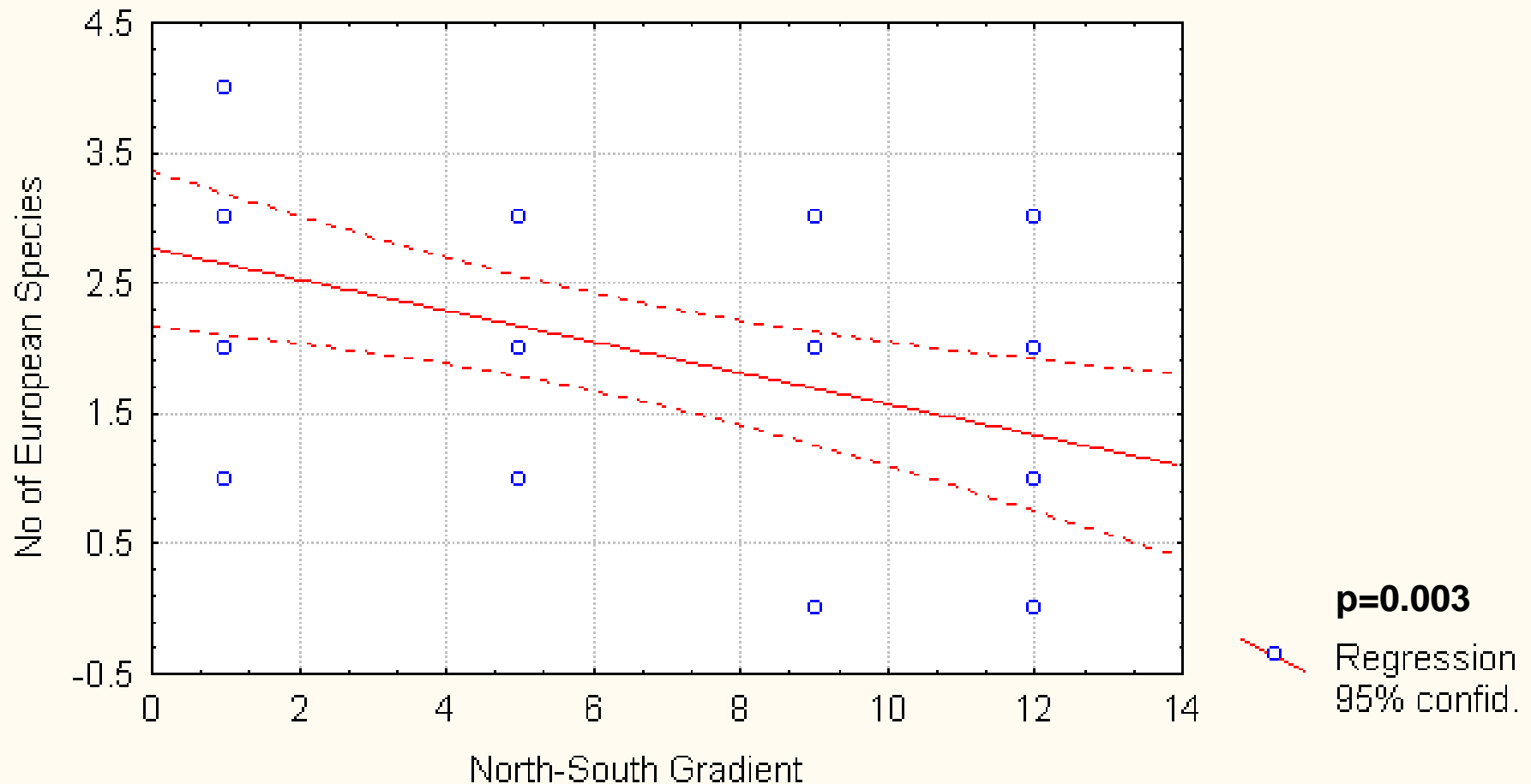


Correlation between number of European species and North-South gradient

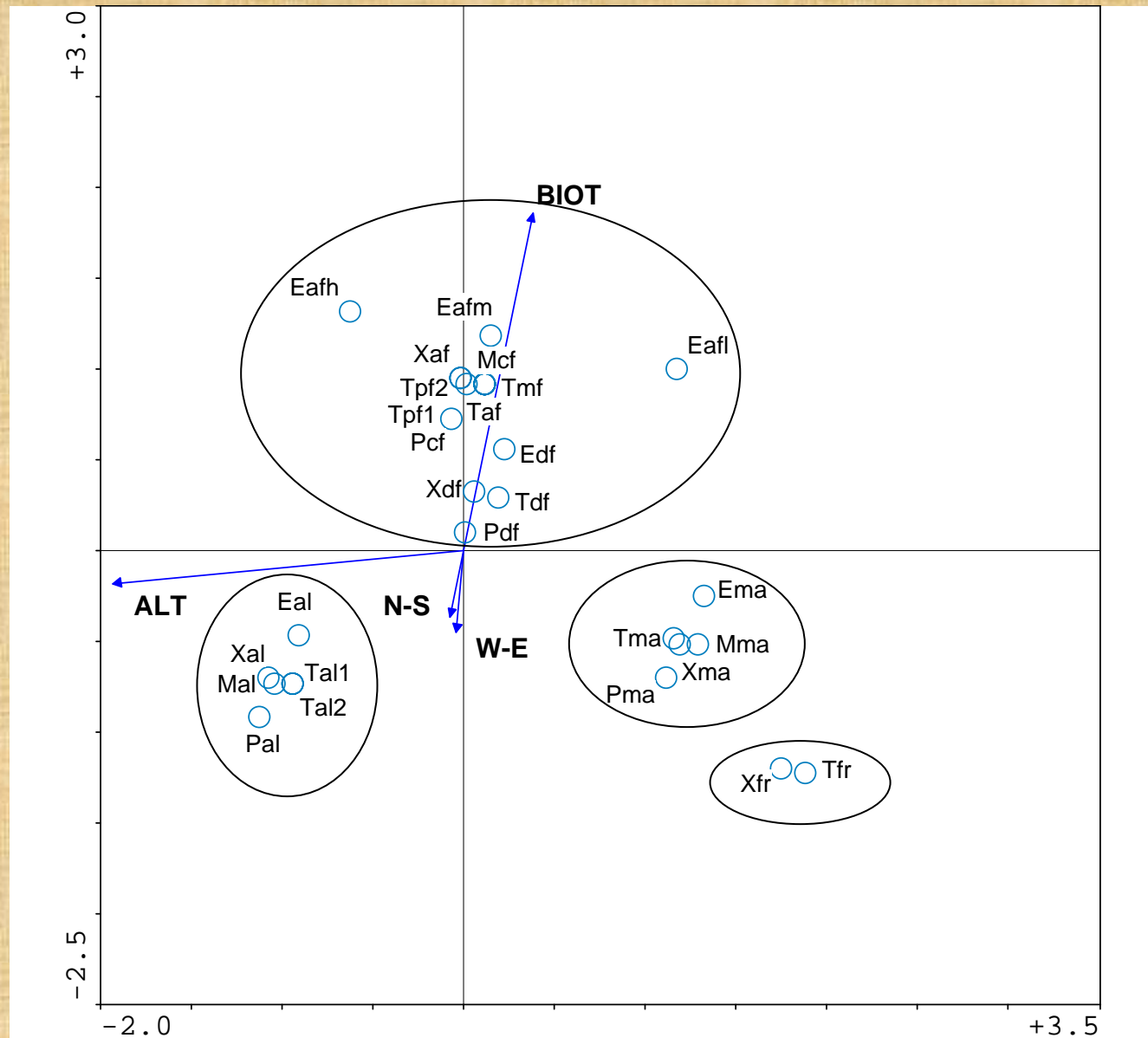
N_S vs. European Species

European species = $2.7648 - .1194 * N-S$

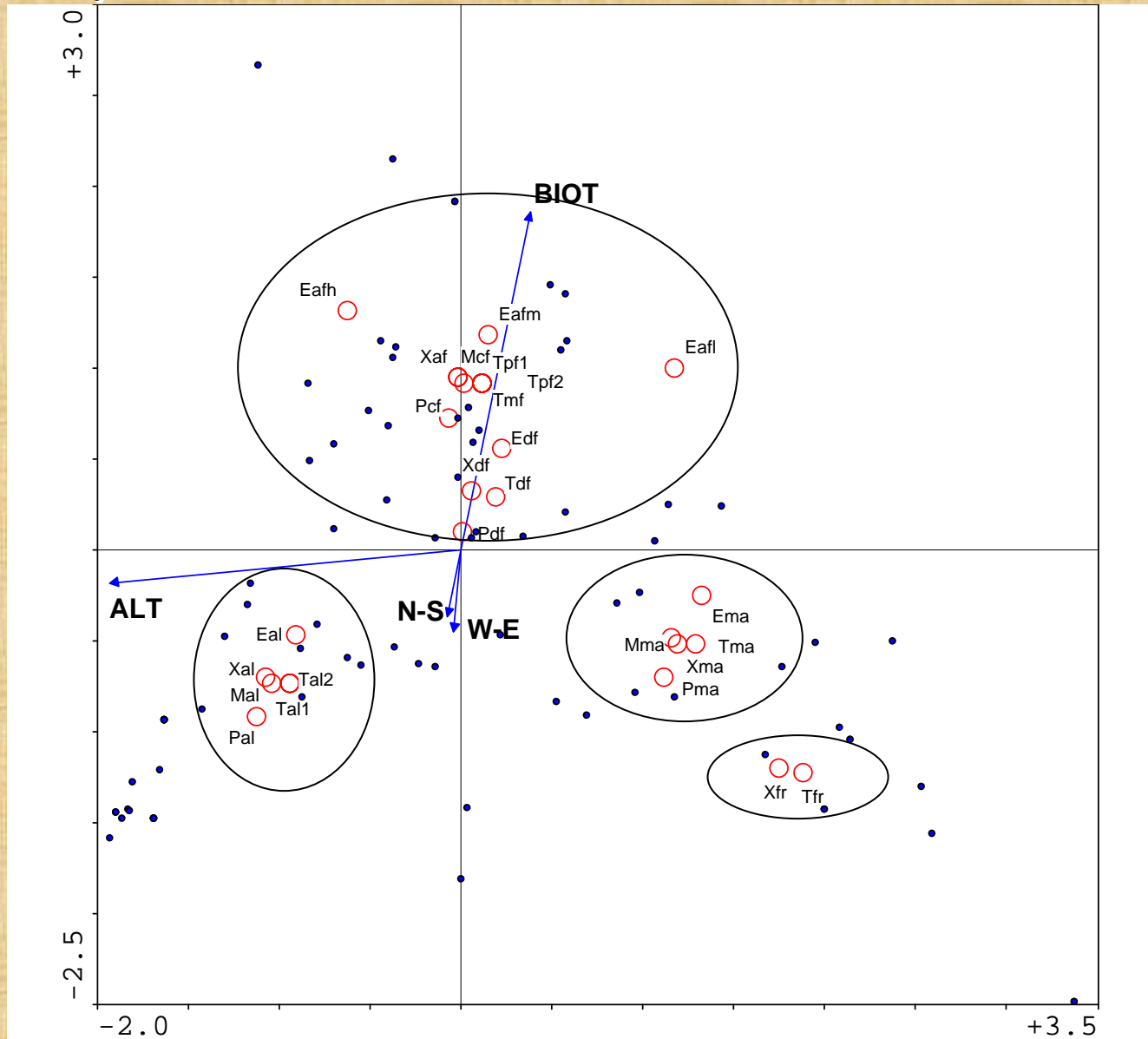
Correlation: $r = -.5352$



Canonical correlation analysis of habitats vs. environmental factors



Canonical correlation analysis of habitats and species vs. environmental factors



Axes	1	2	3	4	Total inertia
Eigenvalues:	.312	.245	.172	.138	3.298
Species-environment correlations:	.950	.946	.881	.885	
Cumulative percentage variance of species data:	9.5	16.9	22.1	26.3	
of species-environment relation:	36.0	64.3	84.1	100.0	
Sum of all unconstrained eigenvalues					3.298
Sum of all canonical eigenvalues					0.866

Summary of Monte Carlo test

Test of significance of environmental variable eigenvalues

	p-value
Altitude	0.0005
Biotope	0.0005
North-South	0.0015
East-West	0.057

Conclusions

- Three main groups of habitats are distinguished by Carabidae:
 - The **maquis** and **phrygana** which are more dry
 - The **mixed coniferous** and **deciduous forests** that are found at mid altitudes
 - The **fir forests** with the **subalpine** habitats that are found at higher altitudes
- It seems that most species react to ecological factors and prefer the same habitat types and not the same mountain
- Altitude seems to be the most important ecological factor with habitat openness being significant as well

Conclusions

- The endemic and the East Mediterranean species are well established since their populations increase in the habitats where they are most diverse.
- East Mediterranean species seem to be the most common type of species all around
- Endemic species are more common at high altitudes
- European species become more sparse as we move from North to South
- Both observations may be related to the retreat of the glaciers during the end of the Pleistocene

ACKNOWLEDGEMENTS

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