Threatened vs non-threatened mosses: taxonomical, biological and ecological patterns in Spain (Iberian Peninsula and Balearic Islands)

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INTRODUCTION & AIMS

Mosses play a key role in ecosystem functioning, yet encompass a great number of threatened species. In recent decades, several bryophytes red lists have been published. However, we lack synthetic analyses and we also ignore whether threatened mosses, compared to non-threatened, share biological and ecological syndromes that might explain their vulnerability. This information would be crucial to address successful conservation measures.

AIMS:

1. Identify and quantify the **percentage of families, genera and species** threatened in Spain.
2. Summarize the main **UICN criteria** used to include mosses species in the Spanish Red List.
3. **Test** whether threatened and non-threatened mosses **differ in their syndromes**.

Biological syndromes: Type of reproduction; Sexual system

Ecological syndromes: Habitat specialization; Habitat humidity; Substrate preferences; Altitude range

METHODS

- All mosses growing in Iberian and Balearic Spain[1] (N= 44 families, 101 genera, 823 species).
- Species were classified in three groups:
  - Highly-threatened: RE+EX+CR+EN+VU
  - Low-threatened: NT+LC+DD
  - Non-threatened: excluded from the red list
- Compilation of bibliographic information
  - Reproduction and ecological syndromes[2,3,4]
  - Threatened status (Red List)[5].
- Synthesis & Statistical analyses:

1. and 2. Summary of information available.

3. Biological and ecological syndromes analyses:
   - Categorical variables: Pearson's chi-squared and a post-hoc test with *holm-bonferroni* correction
   - Numerical variables: ANOVA and Tukey post-hoc test.

RESULTS AND DISCUSSION

1 High % of threatened taxa

Family level: **74,6%** ≥ 1 species as ⚠
15,3% ≥ 75% species as ⚠

Genus level: **46,8%** ≥ 1 species as ⚠
18,1% ≥ 75% species as ⚠

Species level:

Highly-threatened: EX → 0,1%; RE → 1,6%; CR → 3,5%; EN → 3,7%; VU → 13,0% → **21,9%**

Low-threatened: NT → 3,4%; LC → 8,4%; DD → 5,9% → **17,7%**

Non-threatened → **60,4%**

VS Europe: Highly-threatened → 21,8%; DD → 4,8%

2 IUCN criteria are unequally used

Commonly used
- **D2** Area of occupancy → 51,8%
- **B2** Low population number → 43,5%

Barely used
- **B1** Extent of occurrence → 5,4%
- **D1** Nº of mature individuals → 3,6%
- **C** Population size + decline → 0,6%

Un-used
- **A** Population decline → 0%
- **E** Risk of extinction → 0%

➡ -Lack of basic data
-Limitations on applying IUCN criteria to mosses

3 Syndromes of highly-threatened mosses differ significantly from non-threatened
Low-threatened mosses lack a clear pattern ➡ **CONSEQUENCE** of human disturbances and/or Natural rarity **CAUSES** their threatened status

Highly-threatened mosses tend to .....

GRAPHS LEGEND:
X^2 residuals:
- positive correlation
- negative correlation

The bigger the circle, the stronger the correlation

Post-hoc significance:
ł = p<0,1
*= p < 0,05
** =p < 0,01
*** = p < 0,001

.... be **asexual** or **lack reproduction**

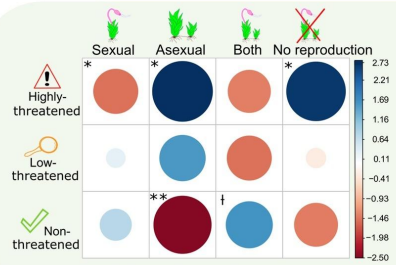

Fig 1: Plot of Pearson X^2 test residuals for type of reproduction.

Genetic erosion provoked by human disturbances limits sexual reproduction.

Natural asexual reproduction limits genetic variability which hamper their adaptation ability.

The bigger size of asexual propagules limits long-distance dispersal.

.... be **monoecious**

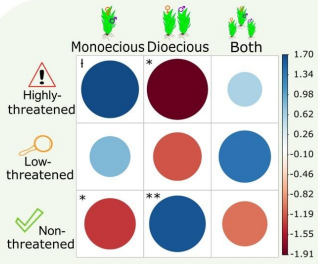

Fig 2: Plot Pearson X^2 test residuals for sexual system.

Self-fertilization of monoecious mosses limits genetic variability which hampers their adaptation ability.

.... be **habitat specialists**

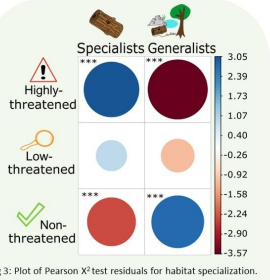

Fig 3: Plot of Pearson X^2 test residuals for habitat specialization.

Specialists are more vulnerable to habitat destruction since they fail to thrive elsewhere.

.... grow on **wet habitats**

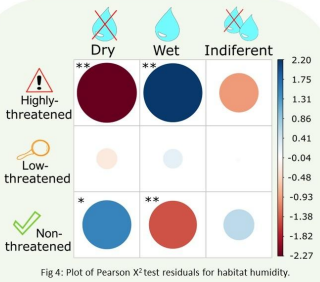

Fig 4: Plot of Pearson X^2 test residuals for habitat humidity.

Wet habitats undergo a higher human pressure.

High discontinuity of wet habitats and drought-vulnerable spores of its species limit their dispersal success.

.... grow on **acid substrates**

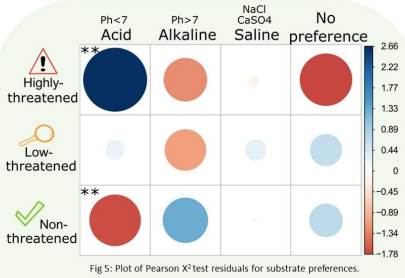

Fig 5: Plot of Pearson X^2 test residuals for substrate preferences.

Acidic substrates have greater water retention, sustaining species far from their ecological optimum.

Low pH limits spore germination when moisture is low

.... present a **narrow altitude range**

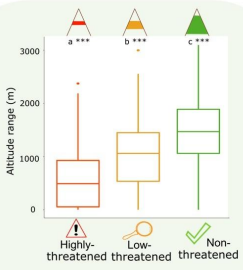

Fig 6: Boxplot of altitude range.

Habitat destruction and the smaller ecological niche of rare bryophytes might explain a narrower altitude range.

CONCLUDING REMARKS

1. 1/5 of Spain mosses are highly-threatened, as happens in Europe. There are numerous families and genera with all, or almost all, of their species threatened.
2. The use of IUCN criteria is biased and limited by the lack of accurate data on populations sizes and on their changes over time.
3. Highly-threatened mosses possess a common biological and ecological pattern that differs significantly from non-threatened species.

Further research on:
- Whether the biological and ecological pattern observed in threatened mosses arises as consequence of human disturbances or as a trigger of their natural rarity.
- Application of the knowledge on their vulnerability syndromes to conservation management.

REFERENCES

[1] Ros, R. M. et al. (2013) 'Mosses of the mediterranean, an annotated checklist', *Cryptogamie Bryologie*, 34(2), pp. 99–283. doi: 10.7872/cryb.v34.iss2.2013.99.; **[2]** Casas, C. et al. (2006) 'Handbook of Mosses of the Iberian Peninsula and the Balearic Islands'. Edited by Institut d'Estudis Catalans. Barcelona.; **[3]** Guerra, J. and Cros, M. (2006 – 2018) 'Flora briofítica ibérica Vol I - VI' . Sociedad Española de Briología and Universidad de Murcia. Murcia.; **[4]** Garilleti, R. and Albertos, B. (2012) 'Atlas y Libro Rojo de los Briófitos Amenazados de España'. Edited by Organismo Autónomo Parques Nacionales. Madrid.; **[5]** Brugués, M., Cros R.M and Infante, M. (2014). 'Lista Roja de los briófitos amenazados de España peninsular y balear'. In: Garilleti, R. & B. Albertos (Coords.). Atlas y Libro rojo de los briófitos amenazados de España. Universitat de València