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Does cross-taxon analysis show similarity in diversity patterns between vascular plants and bryophytes? Some answers from a literature review

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ABSTRACT

The objective of this study was to clarify the taxon surrogacy hypothesis relative to vascular plants and bryophytes. A literature review was conducted to obtain papers that met the following criteria: (i) they examined species richness values; or (ii) they evaluated the species richness within the same study sites, or under the same spatial variation conditions. Twenty-seven papers were accessed. The richness of the two taxa, compared in 32 cases, positively co-varied in about half of the comparisons. The response to the spatial variation in environmental or human-induced factors of the two taxa in terms of species richness was rather variable. Based on current knowledge, the main documented findings regard forest habitats and nival gradients. In forest habitats, co-variation in species richness is likely when similar environments are analysed and seems to be strengthened for boreal forests. Along the nival gradient, a different response in terms of richness of the two taxa suggests that vascular plants cannot be considered good surrogates for bryophytes.

1. Introduction

The characterization of complex biodiversity patterns across ecosystems requires substantial effort, expertise, and financial resources. An approach to limit these challenges is offered by choosing proper indicators or surrogates as a shortcut to predict biodiversity changes in poorly investigated groups from groups where adequate information is available [1]. Surrogate identification is primarily based on cross-taxon congruence analysis and the surrogate strength depends on the taxonomic groups studied and on the scale of analysis [2]. In addition, the response of different taxa to spatial variation in environmental factors should be analysed in cross-taxon congruence analysis, because consistent diversity pattern is a consequence of a similar response to environmental determinants [2–4].

Surrogates are useful in monitoring or solving conservation issues [5], selecting nature reserve networks [6], and evaluating restoration interventions [7]. Lewandowski et al. [8] showed that taxonomic groups having a large number of habitat specialists distributed collectively across broad environmental gradients were the most effective surrogates for complementarity approaches. Vascular plants best represent this suite of attributes; therefore, they were traditionally considered a focal taxon for richness correlation [1] and were chosen as viable surrogates for other taxonomic groups and used to select areas of concern in biodiversity conservation [9,10].

Non-vascular plants are rarely included in floristic and vegetation assessments; consequently, little systematic study has been conducted on their biogeography and community ecology. Some authors have tested possible congruencies between vascular and non-vascular plants in

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different habitats and locations, at different spatial scales and with different objectives. The results are fragmentary and not systematically organised. A synthesis of the available results might provide some general inferences, which in turn might contribute to the future application of surrogate taxa [8].

The objective of this study was to clarify the taxon surrogacy hypothesis relative to vascular plants or tracheophytes (Tracheophyta) and non-vascular plants or bryophytes (Bryophyta *sensu lato*). Species richness is largely used as an indicator of biodiversity [11], therefore, the hypothesis was tested based on the following outcomes: (i) spatial co-variation in species richness of the two taxa; and (ii) variation in species richness in response to environmental or human-induced factors.

2. Material and methods

A literature review was conducted to obtain papers essential to test our hypothesis. These studies met the following criteria:

(i) they examined species richness values in vascular plants and bryophytes, or;
(ii) they evaluated the species richness within the same study sites, or under the same spatial variation conditions, i.e. environmental or human-induced factors.

First, journal articles were searched in Google Scholar using the following keywords and their combinations: Bryophyta, bryophytes, co-variation, cross-taxon, mosses, multi-taxon, species richness, surrogates, Tracheophyta, tracheophytes and vascular plants. Second, the references section of articles was used to search for additional articles. The following information was extracted from the collected papers: publication year, research objectives, study location, habitat type, scale of analysis and primary findings relative to the cross-analysis congruence between the two taxa. The results relative to congruence between the two taxa were compiled and discussed if any significant correlation was detected between species richness and/or if the variation in species richness was similar when the environmental or human-induced factors varied.

The review is narrative rather than based on a formal meta-analysis. This type of approach is advisable when the data are scarce and/or various measures of congruence used in the studies prevent conducting a meaningful meta-analysis [12].

3. Results

Twenty-seven papers were accessed that addressed cross-taxon analysis between vascular plants and bryophytes [3,6,13–37]. In some cases, several taxon comparisons were reported in the same paper; therefore, only the more relevant ones were considered which totalled 40 comparisons for all the 27 papers (Table 1). If mosses and liverworts were considered independently and the findings were similar for the two groups, for simplicity, only the moss results were evaluated; otherwise, the results of the whole bryophytes were evaluated.

The number of papers exhibited a progressive increase from 1980 to 2013. The papers published during the most recent decade, i.e. 2000–2010 were more than twice the total number published in previous years.

The researchers' objectives were restricted to two main categories (Table 1): biodiversity conservation and monitoring (46%) and ecological assessment (54%).

The scale of analysis was directly addressed in three papers [3,13,31]. Primary results indicated that correlations in species richness became stronger when increasing the plot size.

The richness of the two taxa, compared in 32 cases, positively co-varied in approximately one half of the comparisons. The responses to the spatial variation in environmental or human-induced factors of the two taxa in terms of species richness were rather different (Table 1).

Forests were the most investigated habitat type, and the analyses ranged geographically from Boreal through Mediterranean to Australian forests (Table 1a). All the studies were focalized on the spatial co-variation in species richness of vascular plants and bryophytes, while variation in species richness in response to environmental or human-induced factors was not considered. High and positive correlations between vascular plants and bryophytes richness were obtained for boreal forests at large spatial scale [3,13,14]. The only case of negative correlation was detected in the patchwork of Dutch forests [15]. In Australian rainforests, the correlation was positive [16] while no correlation was found in sclerophyll and *Eucalyptus* forests [17–19]. In the Mediterranean area, the correlation was weakly positive [21] to negative [20,22].

Also, mountain habitats were subjected to several investigations, particularly in Alpine and Fennoscandian areas (Table 1b), where it was mainly the response along the Alpine-nival gradient that was monitored. The spatial co-variation in species richness, analysed just in two cases that considered a longer gradient, including also the temperate belt, was positive [23,24]. Along the gradient the pattern of vascular plant, species richness was mainly unimodal, with a peak above the forest limit, while bryophyte richness was more susceptible to increase with the altitude [24–28].

In disturbed areas (Table 1c), the co-variation in species richness was analysed in six cases and was positive in two of them [6,29]. In meadows [30] and *Picea abies* forests [31], under different management as well as in restored areas [6], no correlation was found. Concerning the responses to the variation in human-induced factors, the two taxa exhibited an opposite trend as a response to fertilization [32] and a similar one as a response to mowing [33].

In aquatic and wet habitats (Table 1d), the co-variation in richness was analysed just in two cases with opposite results [34]. A higher sensibility of vascular plants than of bryophytes to spatial variations of environmental factors was also observed [35,36].

4. Discussion

Cross-taxon congruence analysis between vascular plants and bryophytes generated variable responses.