

ABSTRACT OF RECENT PhD DISSERTATIONS

INTERCONTINENTAL DISJUNCTIONS IN BRYOPHYTES; SYSTEMATIC AND BIOGEOGRAPHIC STUDIES IN ORTHOTRICHAEAE (ORTHOTRICHACEAE, BRYOPSIDA)

Beatriz Vigalondo García

Universidad Autónoma de Madrid

Supervisors: Vicente Mazimpaka, Francisco Lara & Isabel Draper

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Bryophyte species tend to display wide distribution ranges that often span over more than one continent. Furthermore, in comparison with angiosperms, bryophytes show a considerable lower rate of endemism. This raises interesting questions regarding the origin of their distributions and the evolutionary processes that rule these plants. Bryophytes also represent a taxonomically challenging group due to their less complex morphologies. Currently, the taxonomic and biogeographic hypotheses formulated on the basis of morphological approaches are being revised in the light of the data obtained from molecular analyses, and especially from integrative taxonomic approaches. Despite the numerous studies so far realized, it is not yet possible to generalize on the causes that have originated the present distribution ranges of bryophytes. Long distance dispersal is increasingly supported as the main factor shaping current bryophytes distributions, but fragmentation and continental drift have also been documented in several occasions. High dispersal capacities of bryophytes have been proposed as one of the factors leading to long distance dispersal, and to the low endemism rates of bryophytes compared to angiosperms. However, several studies suggest that the underestimation of bryophytes diversity, due to taxonomical shortcomings or the existence of cryptic species, may also be the reason underlying some current broad distribution ranges.

The tribe Orthotricheae, and in particular the genera *Orthotrichum* and *Lewinskya*, are among the most diverse and complex groups of mosses from a taxonomic, phylogenetic and biogeographic point of view. However, no complete molecular phylogeny of the group has been yet performed, and only one species, *O. handiense*, has been included in biogeographical or phylogeographic studies. This doctoral thesis aims to provide new on the biogeographic patterns of the genera *Orthotrichum* and

Lewinskya, focusing on three main species, *Lewinskya acuminata*, *L. affinis* and *Orthotrichum shevockii*, which may serve as a basis for a better understanding of the evolutionary and biogeographic processes of the tribe Orthotricheae, but also of extant bryophytes in general. In this sense, this research also intends to add new evidence of the involvement of the different mechanisms that shape bryophytes distributions, namely the long-distance dispersal *versus* the remote fragmentation of continuous areas, or even if new cases of parallel or convergent evolution can be inferred for this group of organisms. In addition, this work undertakes the analysis of large disjunct distributions, to assess if the populations at both extremes of the disjunction represent the same taxa, or conversely, if they are distinct species; and in this last case, if they are true cryptic species, or species for which morphological characters that could allow for their clear discrimination have been overlooked. Finally, through the assessment of the relationships existing among the groups considered in the study, this thesis aims to contribute to clarify the phylogeny of the two involved genera: *Orthotrichum* and *Lewinskya*.

The overall methodology of this thesis follows an integrative taxonomic approach, combining different molecular and morphological analyses, and considering additional available geographic information of the different taxa included. In the studies of *Lewinskya acuminata*, *L. affinis* and *Orthotrichum shevockii*, phylogenetic inferences are contrasted with different multivariate statistical analyses of morphological traits, including molecular species delimitation analyses for the case of *L. affinis*. Next-Generation Sequencing tools are implemented to obtain the mitochondrial genome of two species of *Orthotrichum*, *O. diaphanum* and *O. macrocephalum*, with the final purpose of finding new variable molecular markers for phylogenetic and phylogeographic analyses of species belonging to the tribe Orthotricheae, and testing the phylogenetic relationships of *Orthotrichum* and *Lewinskya*.

The results obtained in this study support the existence of a considerable gap of knowledge respect to bryophytes diversity and distributions, as well as the impossibility of assuming the presence of general patterns on bryophytes distributions. From one side, this study describes two new independent and uncommon cases of intercontinental disjunctions within the tribe Orthotricheae. The first one involves *Lewinskya acuminata*, so far known as a Mediterranean-Macaronesian species, whose presence is reported for California and Ethiopia. The second case confirms the presence of the Californian

species *Orthotrichum shevockii* in Macaronesia, particularly in Tenerife Island. The results suggest that the disjunctions of both species have their origins in long distance dispersal processes, adding evidence to the important role of this type of events in modeling the distribution patterns of extant bryophytes.

Conversely, the up-to-date wide disjunct distribution of the species *Lewinskya affinis* is discarded. Species delimitation analyses reveal that *L. affinis* is actually a complex of species, including two reinstated synonyms and four new species, each of them showing narrow and restricted distributions, overlapping in most cases, and none of them disjunct. Integrative taxonomic analyses support that the overlooked diversity within *L. affinis* is due to both taxonomical shortcomings and the existence of cryptic species. Detailed morphological re-evaluation of the seven identified species allows discriminating each of them by a specific combination of traits, although distinctions are not always simple. Moreover, the overall morphological similarity of the species of this complex is not attributable to convergent evolution processes as recently suggested for two other species complexes of *Orthotrichum*, since in this case the species integrate a natural monophyletic group, and thus can be considered sibling species.

As for the taxonomy of the Orthotricheae, the currently proposed division of *Orthotrichum s.l.* in the genera *Orthotrichum s.str.* and *Lewinskya*, and the close relation of the latter with genus *Ulota*, are supported by the phylogenetic analyses performed with the complete mitochondrial genome of several species of these genera. However, further studies are needed to obtain a more complete phylogeny of this tribe. Additionally, the analyses of the mitochondrial genome at inters- and intraspecific level of *O. diaphanum* and *O. macrocephalum* reveal a low overall genetic variation along this genome. These results agree with those obtained using different chloroplast and nuclear markers for the studies of *L. acuminata*, *L. affinis* and *O. shevockii*. All of them point to the need of evaluating new tools, like Next-Generation Sequencing techniques, for the performance of future phylogeographic and species delimitation studies in the tribe Orthotricheae.