Ecological factors and developmental preconditions shaping the evolution of secondary woodiness in the umbellifer subfamily Apioideae

Can a carrot grow into a tree? When sown in the garden, it will apparently stay herbaceous similar to its immediate ancestors. But in Cabo Verde wild carrots have evolved into shrubs. Garden angelica valued for its unique flavour is herbaceous while its close relative from the Azores develops a short woody trunk. Why and how have some herbaceous plants evolved into woody species thus reverting to the form of their distant ancestor? We will attempt to answer this question based on a study of woody and herbaceous representatives of umbellifers, an economically important family of angiosperms encompassing several crops, condiments and medicinal plants including carrot, celery, parsley, dill, fennel, caraway, anise and angelica.

Secondarily woody plants are more common in island habitats suggesting that a reversion to woodiness is favoured by colonisation of new areas, availability of ecological niches and, particularly, specific climatic conditions. To verify these hypotheses we will reconstruct the evolutionary history of the umbellifer subfamily Apioideae. A phylogenetic tree of ca. 2000 species will be estimated based on DNA markers downloaded from public databases and newly sequenced for this study. For a maximum number of species their life form, life history strategy, habitat, climatic niche and geographic distribution will be scored. Subsequently, the ancestral characters will be inferred in order to check whether character changes are parallel, for instance, whether ecological niche shifts are associated with changes from herbaceousness to woodiness.

Woody plants are characterised by intense development of conductive tissues, mostly xylem, occurring due to a ring of secondary meristem or cambium. Because this development occurs after the primary lengthening of stem, it is described as secondary growth. A limited secondary growth also occurs in herbaceous plants and due to its presence they retain the evolutionary potential of reversion to woodiness. Usually this reversion is not perfect and the xylem of secondarily woody species is easily discernible from primarily woody taxa. The exceptions include some secondarily woody umbellifers, which suggests that herbaceous umbellifers have retained the full potential of reversion to woodiness throughout their evolutionary history. This hypothesis will be verified in this research project. We will examine the stem anatomy of woody umbellifers focusing on characters typical for secondary woodiness. We will also check their herbaceous relatives recording the presence of a cambium ring, the intensity of secondary growth and the characters of secondary xylem.

Overall, this study will contribute to a better understanding of ecological factors and developmental preconditions constraining the evolution of secondary woodiness in angiosperms and, therefore, to a better understanding of their biodiversity.