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Editorial

Plant ecotypes in the 21st century: from local adaptation to speciation and conservation

Ecotype Special Issue

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The concept of ecotypes, genetically distinct entities within species connected to specific habitat types, has been an important source for research and debate since its introduction by the Swedish geneticist Göte Turesson in the early 1920s (Turesson 1922a, b). The existence of ecotypes and other manifestations of local genetic adaptation, such as ecoclines (Gregor 1938), raises several issues in systematics, evolution and conservation, including the importance of ecological speciation, i.e. the origin of isolating reproductive barriers that result from divergent selection imposed by environmental differences (Johannesson 2003, Lowry 2012), and the question of how best to account for infraspecific variation when conserving genetic diversity and adaptive potential of rare, threatened species (Hufford and Mazer 2003, Jonstrup et al. 2016).

On 29 November 2022, a one-day symposium, entitled 'Centennial anniversary of the ecotype concept: the legacy of Göte Turesson', was held at the University of Lund (Sweden) to celebrate that it was exactly 100 years ago that Göte Turesson coined the term ecotype. At that time, more than 60 years had passed since Charles Darwin and others had buried the idea that species are constant and of divine origin, and more than 20 years since the rediscovery of the works of Gregor Mendel on the principles of inheritance. Nevertheless, the knowledge of genetic variability in natural populations was still poor, limited by both conceptual and methodological problems.

Göte Turesson describe ecotypes in more than 50 plant species, mostly in relation to climate and soil type, with special emphasis on morphological and physiological traits differing between populations from, for example, sand dunes, coastal cliffs and alvar grasslands (Turesson 1922a, b, 1925). He did so by a series of experiments in which he transplanted plant material from natural localities to his own garden in Malmö and later to an experimental garden established at the Institute of Genetics at Åkarp. Turesson could show that the variation was not merely environmental, as earlier expected, but often had a heritable basis. Today, ecotypes have been described for a much broader variety of organisms, including fungi and animals (Johannesson 2003), and evidence is growing that many ecotypes result from human activities such as mowing as well as natural biotic factors such as pollinators and herbivores (Robertson and Wyatt 1990).

Nordic Journal of Botany (NJB) has a long history of publishing original contributions of relevance to ecotypic divergence and other types of infraspecific variation.

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In this respect, we are delighted to present three papers associated with the Turesson symposium. In the first paper, Jacquemyn et al. (2023) review the available knowledge on the potential role of fungi in driving ecotypic divergence in plants that rely on mycorrhizal fungi for their carbon supply. The authors present evidence that populations of such 'mycoheterotrophs' often encounter divergent mycorrhizal fungal communities and that adaptation to local fungal communities can facilitate the formation of ecotypes and ultimately result in new species, including those that have lost their photosynthetic ability to become fully mycoheterotrophic.

In the second paper, Vámos et al. (2023) performed a common-garden experiment in a glasshouse to test for local adaptation and ecotypic divergence in relation to heavy metal tolerance in the duckweed *Lemna minor* (Araceae). By growing four geographically and genetically distinct *Lemna* populations (interpreted as ecotypes) in both 'home' and 'away' water as well as in three different concentrations of zinc (Zn), the authors document large differences in growth rate, both between ecotypes and between Zn treatments. However, no evidence was found for local adaptation in the comparison of plants grown in home versus away water or that the existence of ecotypes has contributed to the high tolerance to metal pollutants of this species.

The final paper evaluates the importance of ecotypic divergence and phenotypic plasticity in shaping large-scale geographical variation in *Schorzoneroides autumnalis* (Asteraceae), with particular focus on two capitulum characters: involucre colour and indumentum intensity (Ingimundardóttir et al. 2024). Data from herbarium specimens and plants grown in an outdoor garden, together with results from plants grown in climate chambers, provide evidence for heritable differences in capitulum characters; however, most of this variation occurred at a large (regional) scale and did not manifest itself as discrete ecotypes or entities that correspond to currently recognized varieties within the study species. Interestingly, when plants of *S. autumnalis* were subjected to low temperatures under controlled conditions in climate chambers, they produced capitula with both thicker and darker involucre indumentum – features that have been shown to facilitate heat retention and insect visitation under cool conditions. Thus, much of the large-scale variation in capitulum characters could reflect adaptive phenotypic plasticity (Pigliucci 2001) rather than ecotypic divergence in the sense of Turesson (1922a, b).

Taken together, the three studies highlight two overlooked targets for research on plant ecotypes: firstly, the role of biotic interactions in driving the formation of locally adapted populations, and secondly, the factors that determine whether ecotypic divergence, wide phenotypic plasticity, or a combination of both, is favoured as the predominant mode of adaptation when species occupies a broad range of environments. These issues stress the importance of performing common-garden experiments with plants grown across multiple environments (preferably including both abiotic and biotic factors) so that patterns of plasticity (reaction norms) can be compared and accounted for (Pigliucci 2001, Jonstrup et al. 2016). It is our hope that this type of approach becomes more common.

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Author contributions

Stefan Andersson: Conceptualization (equal); Writing – original draft (equal); Writing – review and editing (equal). **Renate Wesselingh**: Conceptualization (equal); Writing – original draft (equal); Writing – review and editing (equal).

Data availability statement

This article has no data.

References

Gregor, J. W. 1938. Experimental taxonomy. – New Phytol. 37: 15–49.
Hufford, K. M. and Mazer, S. J. 2003. Plant ecotypes: genetic differentiation in the age of ecological restoration. – Trends Ecol. Evol. 18: 147–155.
Ingimundardóttir, G. A., Tyler, T., Cronberg, N., Hedrén, M. and Andersson, S. 2024. Dressed for the occasion! Ecotypic divergence, phenotypic plasticity and taxonomic value of capitulum characters of *Scorzoneroides autumnalis*. – Nordic J. Bot. 2024: e4211.
Jacquemyn, H., Kenji, S. and Merckx, V. 2023. The role of mycorrhizal fungi in driving ecotype formation in mycoheterotrophic plants. – Nordic J. Bot. 2024: e4083.
Johannesson, K. 2003. Evolution in *Littorina*: ecology matters. – J. Sea Res. 49: 107–117.
Jonstrup, A., Hedrén, M. and Andersson, S. 2016. Host environment and local genetic adaptation determine phenotype in parasitic *Rhinanthus angustifolius*. – Bot. J. Linn. Soc. 180: 89–103.
Lowry, D. B. 2012. Ecotypes and the controversy over stages in the formation of new species. – Biol. J. Linn. Soc. 106: 241–257.
Pigliucci, M. 2001. Phenotypic plasticity. Beyond nature and nurture. – Johns Hopkins Univ. Press.
Robertson, J. L. and Wyatt, R. 1990. Evidence for pollination ecotypes in the yellow-fringed orchid, *Platanthera ciliaris*. – Evolution 1990: 121–133.
Turesson, G. 1922a. The genotypical response of the plant species to the habitat. – Hereditas 3: 211–350.
Turesson, G. 1922b. The species and the variety as ecological units. – Hereditas 3: 100–113.
Turesson, G. 1925. The plant species in relation to habitat and climate. – Hereditas 6: 147–236.
Vámos, S., Li, C., Moradi, A. and van Moorsel, S. J. 2023. High zink tolerance to zinc but no evidence for local adaptation in the aquatic plant *Lemna minor*. – Nordic J. Bot. 2024: e4078.