Plant populations at the edge of species’ distribution range: characterization of central versus peripheral population traits

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Abstract. Related to the ongoing climate change, more and more attention has been paid on small sized, range edge populations. These populations are not only geographically marginal, but they usually live at the limits of their ecological tolerance and therefore have higher ecological plasticity. While these range edge populations may play primarily role in the reorganized biomes during the climate change the study on the morphological-phenological traits and population diversity as well as evolutionary history are prioritized. Distribution of many plant species native to the south-eastern regions of Europe extends towards the plains and mountainous areas of Central Asia. Our comparative studies including Plantago maxima, Rhodiola rosea and Tulipa sylvestris aim at detecting specific traits and diversity patterns of populations living on distant geographic sites, or at central versus peripheral locations.

1 Introduction

Peripheral populations sustain under variable and different ecological conditions compared to core populations [1, 2]. Moreover, because on the periphery of species’ range ecological and climate conditions are often unstable populations need special strategy to survive [3]. In other words, populations at periphery due to marginal ecological conditions are expected to be more specialized, since variable conditions induce fluctuating selection. As well, limiting factors at periphery force local adaptation and the selection of habitat specific genotypes, that may end up in population differentiation [4]. It is also likely that peripheral populations developed higher resistance to some of the extreme conditions at species’ range edge [5]. Climate change trigger reorganization of many habitats, induce chaotic shifts of population distribution. Some populations are disappearing, others are colonizing new habitats. The two acting forces shape distribution of species that might end-up with critical area shrinkage or extinction. Over the past decades the former opinion on the low conservation value of peripheral populations has changed, recent researches suggest that peripheral populations may play an important role in conservation of declining species. In species that have

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undergone dramatic range contractions, peripheral populations persist significantly more often than do the central populations [5]. In addition, studies have revealed that genetic diversity of peripheral populations of a species can be as higher as that of central ones. Accordingly, peripheral populations are important in species’ conservation strategy and in maintaining habitat biodiversity and should be treated as a biogenetic resource in restoration activities [5-7].

Distribution area of a species depends on the ecological environment, but it is also determined by paleo-historical events. Historical climate oscillations shaped species distribution and present patterns are the result of migration, colonization or withdrawal constraints [8]. Therefore, revealing central versus peripheral position of different populations along the species’ range or defining various patterns of population distribution needs overall phylogeographic study and distribution modelling. The Carpathian-Pannonian region from Central-eastern Europe harbours a rich flora and phylogeographic studies supported former statements about the relation between the flora of this region and Central Asian flora. On the other hand, the Eurasian Alpine System (EAS) served as a step by step road for species to migrate from East ie. the Qinghai Tibetan Plateaux (QTP) towards the European Mountains. Moreover, phylogeographic evidences were revealed on the long-term persistence of the Eurasian stepp e plant species in the Pannonian region [9]. It is also accepted that in the time of the Holocene many plant species migrated from the Balkan region towards the Pannonian lowland or reaching the mountain sites of the Carpathians. Recently, evidences were listed supporting the idea that flora of the Carpathian basin might have served as genetic resource of recolonization in the Holocene, as some populations survived the glacial cycles in the Carpathian basin [10].

Studies on both persistence, survival potential and comparative genetics of peripheral and central populations might provide important contribution for species conservation. We believe that the comparison between central and peripheral populations may be an important distinction for conserving biodiversity along the species’ range. Thus, conservation plans should include populations found both near the centre and the periphery of a species’ distribution.

Our research collaboration between Hungary and Kazakhstan are focusing on plant species having their distribution from the Pannonian-Carpathian region towards Central Asia, Kazakhstan aiming at revealing botanical links and phylogeographical aspects between the two regions and to serve conservation strategies in both countries.

2 Materials and Methods

Target species involved in the studies are herbaceous perennials. Plantago maxima is a steppe plant, while Tulipa sylvestris a long living geophyte grows mainly in the underground of broadleaf forests. The populations are found frequently in natural sites escaped from parks or cemeteries, where it could have been preserved in large stands. Rhodiola rosea has a circumboreal distribution and sustains on the high elevation habitats of the European Alpine System. It is native in the Carpathians where it can be found in small populations. Ex situ stands of Plantago maxima originating from on Hungarian population and Tulipa sylvestris originating from four populations are preserved in the Botanical Garden of Soroksár, where morphometrical measurements are done in the time of the full flowering period. Germination studies are initiated from seeds collected in the wild. Rhodiola rosea is a cold tolerant species, accordingly its tolerance does not fit with the ecological environment of the Botanical Garden.
3 Results and Discussion

Plantago maxima is a steppe species with Eurasian distribution. At the westernmost range limit in Eastern Europe, in Hungary peripheral populations are highly fragmented and isolated, therefore are protected by law. Our molecular studies using chloroplast DNA markers have shown low haplotypic variation but distinct haplotypes in Hungary compared to a population from Kazakhstan [11]. Moreover, analysing phenotypic traits we found that seed production was higher in the central part and lower at the periphery. Germination power was also different for the two regions [12].

Rhodiola rosea from the family Crassulaceae is an important medicinal plant of high pharmaceutical use. Because it is intensively collected in many sites of its natural distribution range the species is highly threatened and therefore has become protected by law in most of the European countries. Species’ range spreads from East Asia (QTP) towards the high mountains of Europe reaching the British Isles in the west and Scandinavia in the north. Molecular studies have proved that East-Carpathian populations exhibit different gene-stock and haplotype composition compared to the Asian populations [13]. Vegetation studies conducted in Kazakhstan have shown high floral and habitat diversity for Rhodiola rosea in Kazakhstan Mountains that anticipates further biodiversity hotspot for the species [14]. We plan comparative DNA sequence analysis based on our former study to reveal haplotype diversity of populations from Europe and Kazakhstan.

As it has been described in many monographs wild tulips have their gene centre in the high mountains of Central Asia [15]. However, the Balkan Peninsula was also mentioned as a diversity hotspot where several species of Tulipa can be found, some of them being endemic to the region [16, 18]. Area of distribution of Tulipa sylvestris in the Mediterranean region including the Balkan is considered as the central part of the range, that extends towards East Europe, reaching Central Asia, in Kazakhstan from the west. Accordingly, Central Asia is regarded as the periphery of species’ distribution. Two subspecies have been described formerly in the range centre of which both, are present also in the Carpathian basin. Tulipa sylvestris subsp. sylvestris is mainly distributed in the western part of the Mediterranean region while T. sylvestris subsp. australis is mostly found in South-Eastern Europe. Our comparative studies revealed distinct morpho-phenological traits among the natural populations from the Carpathian basin and the surroundings, distinguishing four populations of the two subspecies [12, 17]. Involving Central Asian populations, the study can shed light on which regions represent the periphery of the species and the subspecies respectively.

4 Conclusion

According to the ongoing research cooperation between Hungary and Kazakhstan we study morpho-phenological and molecular characteristics of three Eurasian species of which distribution – central-peripheral – include the Carpathians and the Carpathian Basin (Pannonian area) and range towards Central Asia. Our research findings with the aim to support species’ conservation plans should include relations among populations found both near the centre and the periphery of species’ distribution.

References


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