Conference Volume | 6th Symposium for Research in Protected Areas, 2 to 3 November 2017, Salzburg | pages 133 - 136

Endemic vascular plants in the high mountains of the Sierra Nevada National Park (Spain)

Pia M. Eibes[1,2], David Kienle[1], Carl Beierkuhnlein[1]

[1] Department of Biogeography, University of Bayreuth
[2] Disturbance Ecology, University of Bayreuth

Abstract

The Sierra Nevada National Park contains an outstanding number of endemic vascular plant species, especially at higher elevations. We sampled the floristic composition of 20 sites along an elevational gradient from 2000 up to 3482 m a.s.l. Thereby, patterns of endemicity, species richness and leaf colours had been investigated to quantify diversity aspects of endemics. This study is part of the H2020 ECOPOTENTIAL project and improves the link between high-elevation endemic species and their climatic endangerment with modern sampling approaches (magnetic site marking, remote sensing products).

Keywords

Endemism, Elevational gradient, Mediterranean high mountains, Plant colours, Sierra Nevada

Introduction

Mountain ecosystems cover almost 25 % of the global land surface (Barthlott et al. 1996) and often contain outstanding levels of species richness (Levin et al. 2007). Furthermore, they can harbour high rates of endemic, rare and threatened species. Mountains offer diverse habitats as environmental conditions such as temperature, soil conditions, elevation and topography change rapidly among small-scaled distributions (Pauli et al. 2003). They therefore pose appropriate possibilities to study species distribution patterns along elevational gradients (Hutter et al. 2013; Steinbauer et al. 2016).

While the elevation-species richness relationship shows heterogeneous patterns, proportion of endemic species seems to follow more general rules and must not necessarily correspond to the observed pattern of species richness (Steinbauer et al. 2016). Percentage of endemism rather increases monotonically with elevation, which has recently been shown for islands as well as several continental mountain ecosystems (Steinbauer et al. 2016). Similar mechanisms of island biogeography can thus be applied to other elevational gradients. Summits of continental mountain ranges are highly isolated and hence act as ecological islands (Howell 1947; Trigas et al. 2013).

With around 25,000 plant species, therein more than half endemic, the Mediterranean Basin is one of the 25 Biodiversity Hotspots defined by Myers et al. (2000) worldwide. Here as well, mountain ranges play an important role for the distribution of plant species, especially endemic ones. Within the Baetic Region in southern Spain, only the highest elevations hosted glaciers, while lower elevated sites remained mostly uncovered by ice (Gómez-Ortiz et al. 2015). Many of these glacial refugia act as biodiversity hotspots in present time (Médail & Diadema 2009), showing high species richness and high levels of endemism (Pauli et al. 2012). With more than 2,100 vascular plants the Sierra Nevada is one of the most important mountain ranges regarding plant species richness in the West Mediterranean Basin (Blanca et al. 1998).

The following study aims to test if commonly reported patterns of decreasing species richness and increasing percentage of endemism also apply for the flora of Mediterranean high mountains. A further analysis on how leaf colours of these species change with elevation allows an insight into adaptive strategies of high mountain plant species.

Methods

The study transect was placed between 2,000 and 3,470 m a.s.l. on a southern slope towards the Muhlacén, the highest summit in the Iberian Peninsula. Within twenty sampling sites along approximately 1,500 meters of elevation, all present vascular plant species have been recorded. Furthermore, total vegetation cover and proportions of soil particles were estimated. Leaf colours of the main species have been measured using the Munsell colourspace for plant tissues. Subsequently, all endemic species have been categorised into four different endemic classes in accordance with their biogeographic origins: Sierra Nevada, Baetic, Ibero-African and Arctic-Alpine endemics.

Results

A total of 89 different species were recorded within the 20 sampling sites. Almost half (n = 40) of the recorded species belonged to one of the four endemic categories, the rest (n = 49) had wider distribution areas. Sierra Nevada Endemics were the most abundant group (n = 24), followed by Baetic Endemics (n = 9), Ibero-African Endemics (n = 4) and Arctic-Alpine Endemics (n = 3). While species richness monotonically decreased with elevation, general percentage of endemic species significantly increased. Different endemic classes showed variable patterns (Fig. 1). Leaf colours of 350 individuals of 20 different plant species were measured and included into the analysis of overall-species-colours along the transect. The lightness of leaf colours decreased, while blue and green proportions increased with elevation.

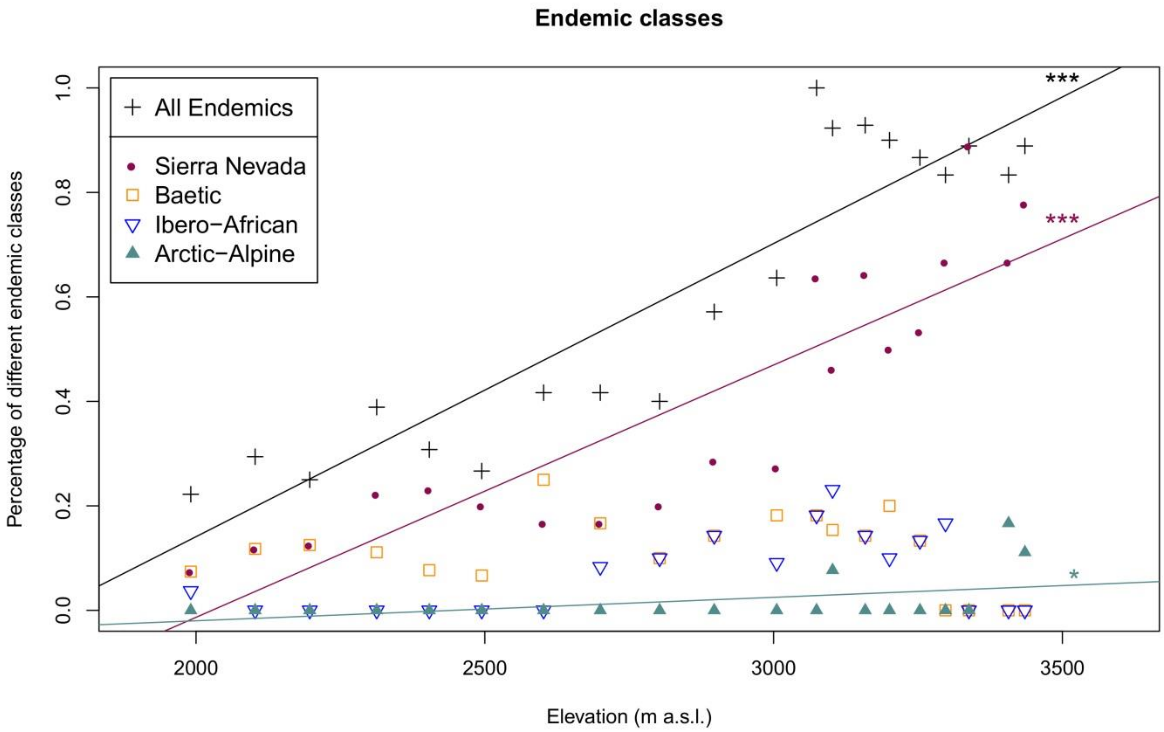

Figure 1: Percentage endemism increases with elevation for all endemic species (adj. R2 = 0.76) and Sierra Nevada Endemics (adj. R2 = 0.76). Baetic and Ibero-African Endemics do not show any trend, while Arctic-Alpine Endemics are only present within a few elevated sites (adj.R2 = 0.16). (Author: Pia Eibes)

Discussion and Conclusion

When considering species richness and endemic richness in general, patterns of the Mediterranean high mountain flora in the Sierra Nevada are consistent with findings from most other studies: with a general decrease for species richness and a proportional increase of endemism at high-elevation sites (e.g.: Jump et al. 2012, Vetaas & Grytnes 2002, Irl et al. 2015). However, the endemic species of the Sierra Nevada provide a particular opportunity to study individual endemic groups with different biogeographic origins. Continental mountains have often been described as ecological islands (e.g.: Whittaker & Niering 1968) and indeed, it seems that most of the theories originating from island biogeography can be applied to them, such as the explanation of isolation. Phylogenetic studies showed that endemic species at continental mountains are relatively young and indicate recent in situ speciation (Comes & Kadereit 2003). Hence, most endemic species in mountains can be considered as neo-endemics, which are assumed to be influenced by similar drivers as species on islands.

However, in continental mountain ranges, other origins of endemism can be found and percentage of endemism cannot simply be related to neo-endemism and in situ speciation. Deconstruction into finer biogeographic origins facilitates a better understanding of the general patterns (Jiménez-Alfaro et al. 2014). This deconstruction reveals that patterns for neo endemics and relict endemics are not identical, which indicates various drivers for different endemic classes. Hence, it is important to define to which range species are endemic and to include their potential origins and migration paths. A detailed analysis might be challenging when global datasets are used to search for generalities, because underlying patterns of different endemic groups will disappear at this scale. However, if knowledge on the flora of local elevational gradients exists, interpretation of the study findings obviously benefits from including this information.

The same applies to the integration of additional features, here, the study of leaf colours, which apparently change along elevational gradients. The fact that leaf colours change with elevation indicates that high mountain plants have characteristic colour adaptations through varying incorporation of different amounts or compounds of plant pigments, since these are the main components which leaf colours originate from (LEE 2007). Several protection mechanisms were expected to brighten leaf tissues colours of the plants in the Sierra Nevada high mountains, but the reverse effect was found. These results might point to enhanced amounts of several pigments, such as chlorophylls and anthocyanins. The first might explain the increase of green, whereas increased amounts of the latter might result in more blue leaves.

Numerous factors remain that complicate the research for drivers of biodiversity and the climate change will make it even more complex. Changing climatic conditions will impact the high mountain flora of the Sierra Nevada as well. High mountain plant species are particularly endangered, because they lack potential migration paths. Findings of this study indicate, that some endemic plant species such as the Arctic-Alpine endemics already have reached the sites with their possible climatic limits and further upward movement to suitable sites is impossible.

References

BARTHLOTT, W., LAUER, W., PLACKE, A. 1996. Global distribution of species diversity in vascular

plants. Towards a world map of phytodiversity. Erdkunde 50: 317–327.

BLANCA, G., CUETO, M., MARTÍNEZ-LIROLA, M. J., MOLERO-MESA, J. 1998. Threatened vascular flora of Sierra Nevada (Southern Spain). Biological Conservation 85: 269–285.

COMES, H. P., KADEREIT, J. W. 2003. Spatial and temporal patterns in the evolution of the flora of the European Alpine System. Taxon 52: 451–462.

GÓMEZ-ORTIZ, A., OLIVA, M., PALACIOS, D., SALVADOR-FRANCH, F., VÁZQUEZ-SELEM, L., SALVÁ-CATARINEU, M., ANDRÉS, N. DE 2015. The deglaciation of Sierra Nevada (Spain), synthesis of the knowledge and new contributions. Cuadernos de Investigación Geográfica 41: 409–426.

HOWELL, J.1947. Mono Mesa - Sierra Sky Island. Sierra Club Bulletin 32: 15–18.

HUTTER, C. R., GUAYASAMIN, J. M., WIENS, J. J. 2013. Explaining Andean megadiversity. The evolutionary and ecological causes of glassfrog elevational richness patterns. Ecology Letters 16: 1135–1144.

IRL, S. D. H., HARTER, D. E. V., STEINBAUER, M. J., GALLEGO PUYOL, D., FERNÁNDEZ-PALACIOS, J. M., JENTSCH, A., BEIERKUHNLEIN, C. 2015. Climate vs. topography - spatial patterns of plant species diversity and endemism on a high-elevation island. Journal of Ecology 103: 1621–1633.

JIMÉNEZ-ALFARO, B., MARCENÓ, C., BUENO, Á., GAVILÁN, R., OBESO, J. R. 2014. Biogeographic deconstruction of alpine plant communities along altitudinal and topographic gradients. Journal of Vegetation Science 25: 160–171.

JUMP, A. S., HUANG, T. J., CHOU, C. H. 2012. Rapid altitudinal migration of mountain plants in Taiwan and its implications for high altitude biodiversity. Ecography 35: 204–210.

LEE, D.W. 2007. Nature's Palette. The Science of Plant Color. Chicago.

LEVIN, N., SHMIDA, A., LEVANONI, O., TAMARI, H., KARK, S. 2007. Predicting mountain plant richness and rarity from space using satellite-derived vegetation indices. Diversity and Distributions 13: 692–703.

MÉDAIL, F., DIADEMA, K. 2009. Glacial refugia influence plant diversity patterns in the Mediterranean Basin. Journal of Biogeography 36: 1333–1345.

MYERS, N., MITTERMEIER, R. A., MITTERMEIER, C. G., FONSECA, G. A. B., KENT, J. 2000. Biodiversity hotspots for conservation priorities. Nature 403: 853–858.

PAULI, H., GOTTFRIED, M., DIRNBÖCK, T., DULLINGER, S., GRABHERR, G. 2003. Assessing the Long-Term Dynamics of Endemic Plants at Summit Habitats. In: GRABHERR, G. & C. KÖRNER (eds.), Alpine Biodiversity in Europe.

PAULI, H., GOTTFRIED, M., DULLINGER, S., ABDALADZE, O., AKHALKATSI, M., ALONSO, J. L. B., COLDEA, G., DICK, J., ERSCHBAMER, B., CALZADO, R. F., GHOSN, D., HOLTEN, J. I., KANKA, R., KAZAKIS, G., KOLLAR, J., LARSSON, P., MOISEEV, P., MOISEEV, D., MOLAU, U., MESA, J. M., NAGY, L., PELINO, G., PUSCAS, M., ROSSI, G., STANISCI, A., SYVERHUSET, A. O., THEURILLAT, J. P., TOMASELLI, M., UNTERLUGGAUER, P., VILLAR, L., VITTOZ, P., GRABHERR, G. 2012. Recent Plant Diversity Changes on Europe's Mountain Summits. Science 336: 353–355.

STEINBAUER, M. J., FIELD, R., GRYTNES, J.-A., TRIGAS, P., AH-PENG, C., ATTORRE, F., BIRKS, H. J. B., BORGES, P. A. V., CARDOSO, P., CHOU, C.-H., SANCTIS, M. D., SEQUEIRA, M. M. D., DUARTE, M. C., ELIAS, R. B., PRICE, J. 2016. Topography-driven isolation, speciation and a global increase of endemism with elevation. Global Ecology and Biogeography 25: 1097–1107.

TRIGAS, P., PANITSA, M., TSIFTSIS, S. 2013. Elevational Gradient of Vascular Plant Species Richness and Endemism in Crete - The Effect of Post-Isolation Mountain Uplift on a Continental Island System. PLoS ONE 8.

VETAAS, O. R., GRYTNES, J.-A. 2002. Distribution of vascular plant species richness and endemic richness along the Himalayan elevation gradient in Nepal. Global Ecology and Biogeography 11: 291–301.

WHITTAKER, R., BUOL, S., NIERING, W., HAVENS, Y. 1968. A soil and vegetation pattern in the Santa Catalina Mountains, Arizona. Soil Science 105: 440–450.

Contact

Pia Maria Eibes, David Kienle, Carl Beierkuhnlein:
pia.eibes@uni-bayreuth.de; david.kienle@uni-bayreuth.de; carl.beierkuhnlein@uni-bayreuth.de
University of Bayreuth
Department of Biogeography
Universitätsstr. 30
95447 Bayreuth
Germany