Flora 234 (2017) 92–105

Contents lists available at ScienceDirect

Flora

journal homepage: www.elsevier.com/locate/flora

Phytogeographical distribution of roadside flora along the plain to mountainous natural areas (Northern Khorasan Province, Iran)

Javad Pourrezaei[a,*], Sayed Jamaleddin Khajeddin[a], Hamid Reza Karimzadeh[a], Mohammad Reza Vahabi[a], Vali Allah Mozaffarian[b], Mostafa Tarkesh Esfahani[a]

[a] Department of Natural Resources, Isfahan University of Technology, Iran
[b] Department of Botany, Research Institute of Forests and Rangelands of Iran, Iran

ARTICLE INFO

Article history:
Received 21 March 2017
Received in revised form 29 June 2017
Accepted 2 July 2017
Edited by Karsten Wesche
Available online 6 July 2017

Keywords:
Roadside habitats
Rangelands
Chorotypes
Irano–Turanian region
Response curve

ABSTRACT

Exploring the phytogeographical distribution of roadside flora in natural areas provides several original insights into plant dispersal. The roadside flora of the Irano–Turanian rangelands was studied in the northeast of Iran, along about 600 km of asphalt road. Sampling was performed in homogenous physiognomic-physiographic units along the altitudinal gradient from the plain to the mountainous areas. In a stratified random design, 38 sites on 12 asphalt roads were sampled, and 330 plant taxa of different chorotypes were identified. The altitudinal distribution of the chorotypes was examined fitting generalized linear models (GLM) and generalized additive models (GAM). The results showed that native uni-regional taxa (Irano–Turanian elements) were the dominant chorotype of the roadside habitats in the rangeland areas. The altitudinal response curve of multi-regional (bi-regional to quadri-regional) chorotypes reflected climatic conditions in their contributing phytochoria. Quadri-regional taxa, with an optimum of the Gaussian response curve at mid-altitudes, reflected a moderate climate. The proportion of endemic species (3.6%) was high compared to the pluri-regional (4.6%) and the cosmopolitan taxa (1.2%). While the pluri-regional taxa increased with altitude, cosmopolitan species decreased monotonically and were absent from the high altitudes. This study revealed the importance of the mid-altitude roadsides, both as a refuge for local endemic species and as a bed for local weeds and regional alien species.

1. Introduction

Road construction in natural areas results in new man-made habitats along the roads. These habitats differ from surrounding natural areas and support species with varying habitat requirements (Martinez and Wool, 2006; Irl et al., 2014). Various species with different geographical origins thrive on roadsides (Holzapfel and Schmidt, 1990), which thus host a flora with a combination of native and non-native species with local, zonal, and geographical distribution (Akbar et al., 2009). Species of roadside habitats include plant species of near-natural areas, as well as common cropland and rangeland weeds. Native species typically have a uni-regional origin, or are common in two or more bordering phytochoria. Non-native species usually have a multi-regional origin, and are widespread like pluri-regional and cosmopolitan species. Given that roadsides are disturbed sites, they usually promote ruderal flora (Dogan et al., 2004), but variations in environmental variables affect their floristic composition in natural areas.

The composition of the roadside flora is influenced by environmental and anthropogenic factors. Climate, topography, soil properties of roadside habitats, and vegetation type of the surrounding areas are influential environmental variables that determine the floristic composition of roadside vegetation (Lausi and Nimis, 1985; Ullmann et al., 1995; Szwed and Sykora, 1996; Safford and Harrison, 2001; Akbar et al., 2009; Šerá, 2008; Lembrechts et al., 2014). Road features and their maintenance procedures are the main anthropogenic variables affecting roadside vegetation (Forman and Alexander, 1998; Godefroid and Tanghe, 2000; Gelbard and Belnap, 2003; Rentch et al., 2005; Šerá, 2008; Zeng et al., 2012; Azcárate et al., 2013). Some environmental and anthropogenic variables result in unique floristic composition in

* Corresponding author.
E-mail addresses: Pourrezaei.J@gmail.com (J. Pourrezaei), khajedin@cc.iut.ac.ir (S.J. Khajeddin), karimzadeh@cc.iut.ac.ir (H.R. Karimzadeh), vahabi@cc.iut.ac.ir (M.R. Vahabi), mozaffar@rifr-ac.ir (V.A. Mozaffarian), m_tarkesh@cc.iut.ac.ir (M. Tarkesh Esfahani).

http://dx.doi.org/10.1016/j.flora.2017.07.002
0367-2530/

roadside habitats, yet separating the individual effect of these variables can be difficult.

Species distribution on roadsides varies along the environmental gradient, especially altitude. Altitude is an important factor for plant distribution for a number of reasons (Ullman et al., 1995; Akbar et al., 2009; Körner, 2007; Paiaro et al., 2011; Noroozi et al., 2016). Many climatic variables such as temperature, moisture, and precipitation vary concurrently with the elevation (K&rner, 2007; Alexander et al., 2009), thereby affecting plant distribution at different altitudes. Harsh environmental conditions of high altitudes hamper the species richness of non-native plants (Alexander et al., 2011). At high altitudes, the species composition of roadside habitats is very similar to plant communities of near-natural areas (Lembrechts et al., 2014). High altitudes have fewer ruderal plants and more native species compared to lower altitudes (Ulman et al., 1995; Lembrechts et al., 2014 Lembrechts et al., 2014). The severe climate conditions and low propagule pressure at high altitudes probably are the main factors causing the low frequency of non-native species (Otto et al., 2014). Since the altitudinal distribution of native and alien species depends on their climatic tolerance and phytogeographic origin, surveying new areas can provide novel insights into the quality and quantity of species distribution.

Roadsides not only provide habitats for native and non-native plant species, but can also act as dispersal corridors for alien plant species (Gelbard and Belnap, 2003; Pauchard and Alaback, 2004; Šerá, 2008; Okimura et al., 2016). Many non-native species thriving in roadside habitats cannot colonize undisturbed natural areas (Pauchard and Alaback 2004). Some alien species can, however, spread in natural environments, compete with native flora, and endanger the biodiversity of these habitats (Pickering and Hill, 2007; Neher et al., 2013; Szymura and Szymura, 2016). As the road effects extend to far distances from roadside habitats, distant habitats may also be affected by alien plant invasion and suffer species loss (Hansen and Clevenger, 2005). Development measures also increase the disturbed areas along the roadsides and promote the invasion of alien species by displacement or extinction of native species (Pauchard and Alaback, 2004; Hansen and Clevenger, 2005).

Roadside vegetation provides an excellent context for applied ecological and phytogeographical studies (Ullmann and Heindl, 1989). Understanding the quality and quantity of non-native species dispersal along roadsides facilitates our understanding of natural habitats and native species (Alexander et al., 2016). As species dispersal occurs at different scales (Pickering and Hill, 2007; Akbar et al., 2009; Kosaka et al., 2010; Paiaro et al., 2011; Rentch et al., 2013; Shaltout et al., 2016), recognizing the roadside flora around the world is crucial for global management of alien and invasive species. Plant species respond to global environmental changes according to their geographical distribution and ecological proprieties (Broennimann et al., 2006). Hence, the phytogeographical studies of roadside vegetation in different regions and at various altitudes can provide suitable data for the prediction of species responses to climate variations.

Many botanists and ecologists have investigated the flora and vegetation of Iran (Boissier, 1810–1885; Parsa, 1948–1952; Rechinger, 1963–2015; Zohary, 1973; Mobayen, 1975–1995; Ghahreman, 1977–2007; Assadi, 1988–2014; Akhani, 1998), but there are few studies related to the Iranian roadside flora in natural areas. This research, which was conducted in the Northern Khorasan Province, aimed to answer the following questions: (1) What is the chorotype composition of roadside flora in the natural areas of the Irano–Turanian region in the northeast of Iran? (2) How do the chorotypes respond to the altitudinal gradient along roadsides? (3) Is there any altitudinal distribution preference for exotic or endemic taxa in roadside habitats?.

2. Materials and methods

2.1. Study area

2.1.1. Coordinates, topography, and climate

The Northern Khorasan Province is located in the northeast of Iran, between 55° 53′–58° 20′ eastern longitude and 36° 37′–38° 17′ northern latitude. This province has international borders with Turkmenistan in the north and internal borders with Razavi Khorasan, Semnan and Golestan provinces from the east to the west (Fig. 1). Northern Khorasan has both mountainous and plain areas with elevation ranging from 400 to 3041 m above the sea level. Mountains in this province include Kopetdagh and Aladagh Mountains in the north and central parts of the province, which have sedimentary and limestone bedrock, respectively. The flat part of the province includes alluvial plains and fans (Jafari et al., 2015). According to the UNESCO climate classification method (1979), there are three climate types in the study area, namely arid, semi-arid, and sub-humid (Behzadfar, 2007). Based on the De Martonne Aridity Index (1925), only the arid and semi-arid climates can be recognized in this province (Meteorological Administration of Northern Khorasan Province, 2016). The annual mean temperature is 13.3 °C. The maximum temperature in the warmest month and the minimum temperature in the coldest month are 24.7 °C and 1.5 °C, respectively. Precipitation varies temporally and spatially but falls mostly in winter. Annual mean precipitation ranges from 125 mm in the lowlands up to 469 mm in the high altitudes. April and August, respectively, have the most and least precipitation during the year (Jafari et al., 2015).

2.1.2. Roads and natural areas

More than 1000 km of asphalt roads stretch over the Northern Khorasan Province, and most of these pass through natural areas. These roads include 81 km of highway, 35 km of broad main road, 392 km of ordinary main road, 325 km of primary by-road and 175 km of secondary by-road. Many of the roads passing through the natural areas are primary and secondary by-roads. The Northern Khorasan Province has 2,033,040 ha of natural areas, including forest, woodland, rangeland, desert, and bare land (Natural Resources and Watershed Administration of Northern Khorasan Province, 2016). Rangelands with 1,414,850 ha area are the dominant natural resources in the study area. Most of the asphalt roads in the region cut through natural areas, especially rangelands.

2.1.3. Phytogeographic situation

Iran has a special phytogeographic situation. Three main phytochoria –Irano–Turanian, Saharo–Sindian, and Euro–Siberian– have been recognized in this country (Eig, 1931–1932; Zohary, 1950; Leonard, 1989; White and Léonard, 1991; Akhani et al., 2007). The Irano– Turanian region covers two-thirds of Iran, while the Euro–Siberian and the Sahara–Sindian regions are restricted to the north and the south parts of Iran, respectively. The study area in the northeast of Iran belongs to the Irano–Turanian phytogeographic region. This area is a transitional zone between the Irano–Turanian phytochorion and the Hyrcanian province of the Euro–Siberian region (Memariani et al., 2016a).

2.2. Methodology

A stratified random sampling scheme was employed in the floristic study of roadside vegetation during 2014–2015. Twelve asphalt roads, including five main roads with moderate to heavy traffic and seven secondary roads with light to moderate traffic, were selected. The sampling sites were determined randomly as homogeneous physiographic-physiognomic units (Kent and