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Neophytes in Pannonian hardwood floodplain forests – History, present situation and trends

Mária Petrášová *, Ivan Jarolímek, Jana Medvecká

Institute of Botany, Slovak Academy of Sciences, Dúbravská cesta 9, 845 23 Bratislava, Slovakia

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ABSTRACT

Invasions of neophyte plant species are considered as one of the major threats to the diversity of natural ecosystems including floodplain forests. Pressure from human activities has increased rapidly during last few decades, therefore we suppose that the penetration of neophytes into forest habitats is greater nowadays than it was in the past. The aims of our study were: to find out if there is a significant increase in the number of neophyte species and their cover in the hardwood floodplain forests in the Pannonian region over time; to compare the occurrence of neophytes in Slovak and Hungarian datasets in different periods; and to explain the relationship between ecological factors and species richness of native vegetation, and the level of invasion of hardwood floodplain forests.

The study is based on the dataset of 365 relevés ordered within the suballiance *Ulmenion* (riparian mixed oak–elm–ash forests along great rivers) in the Slovak national database of phytocoenological relevés and 216 relevés ordered within the *Ulmenion* in the Hungarian national database. The dataset was divided into decades, and the number and cover of neophytes in each period was compared by Kruskal–Wallis nonparametric ANOVA, with multiple comparison of mean ranks for all groups. To analyze the influence of ecological factors we used the number of native species in the plot, Shannon–Wiener diversity index and information about vegetation structure – cover of tree, shrub and herb layers, together with Ellenberg's indicator values for ecological factors, namely light, temperature, moisture, soil reaction and nutrients. The influence of time and other factors on the number of neophyte species was tested using generalised linear models (GLM).

Along the time gradient, there is a significant increase in the number and cover of neophytes between analyzed periods in the Pannonia. Plots from Slovakia had higher number and cover of neophytes in comparison with plots from Hungary from the same periods. Eight ecological factors were involved in the minimal adequate GLM – with six of them being significant and two being close to the significant level. In a broader analysis, where more ecological factors were included, time emerged as one of the most significant factors positively affecting the number of neophytes. The most important ecological factor is the amount of nutrients. Other significant factors are light, soil reaction, cover of herb layer and moisture.

1. Introduction

Invasions of non-native plant species (sensu Richardson et al., 2000; Pyšek et al., 2004), especially neophytes, are considered as one of the major threats to the diversity of natural ecosystems including floodplain forests (Williamson, 1996; Kowarik, 2003; Weber, 2003; Kettunen et al., 2009; Pyšek et al., 2010). Human activities such as agriculture, forestry, transportation, recreation and building activities promote the intentional and accidental spread of species beyond their natural boundaries. Introduction of non-native species, including neophytes, has been accelerated as a result of an enormous increase in the transport of goods and passengers during the past centuries and especially during the last decades (Kowarik, 2003; Pyšek et al., 2010).

Anthropogenic habitats generally accommodate the highest number of neophytes (Walter et al., 2005; Chytrý et al., 2005). Among natural and seminatural vegetation types, riparian and floodplain forests belong to the most invaded habitats (Walter et al., 2005; Vilá et al., 2007; Pyšek et al., 2010). Floodplain forests are characterized by natural disturbances: periodic flooding repeatedly creates new ecotopes for successful establishment of non-native species, such as bare soils, open gravel and sand banks. Simultaneously, most large rivers in Europe are strongly altered by human disturbances (e.g. eutrophisation, damming, and water regime management). River valleys therefore are important corridors for spreading of neophytes (Kowarik, 1992, 1999; Richardson et al., 2007; Zając et al., 2011).

* Corresponding author. Tel.: +421 907 386832.
E-mail addresses: maria.petrasova@savba.sk (M. Petrášová), ivan.jarolimek@savba.sk (I. Jarolímek), jana.medvecka@savba.sk (J. Medvecká).

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Pressure from human activities has increased rapidly during last few decades. Therefore we suppose that the penetration of neophytes into the forest habitats is greater nowadays than it was in the past. The majority of large studies which compare different habitat types are based on recent data (e.g. Chytrý et al., 2005 – after 1970). On the contrary, we are interested in temporal changes in the level of invasion in one of the most invaded natural habitat – hardwood floodplain forest, therefore we focused on longer period of time – the last 70 years.

In general, we can say that the invasion success of neophytes is associated with warmer habitats and sufficiency of nutrients (Chytrý et al., 2005; Walter et al., 2005). Elton (1958) suggested that communities with higher species richness are more resistant to invasions by alien species, but several recent studies did not confirm this hypothesis, rather suggesting that the number of neophytes increases along with increasing native species richness (Levine, 2000; Levine et al., 2002; Fridley et al., 2004; Herben et al., 2004). Thus the relationship between species richness of native species and number of neophytes is not explicit.

The aims of our study were: (1) to find out if there is a significant increase in the number of neophyte species and their cover in the hardwood floodplain forests over time; (2) to compare the occurrence of neophytes in Slovak and Hungarian datasets in different periods and (3) to explain the relationship between ecological factors and species richness of native plants, and the level of invasion by neophytes of hardwood floodplain forests.

2. Study area

The study area is situated in Central Europe, in the Pannonian biogeographic region, also known as the central Danubian basin and covers regions within two countries – Hungary and Slovakia. It covers the main part of the Great Hungarian Plain in Hungary and the Danubian Lowland in Slovakia. The Carpathians encircle the region from north and east. Regarding the main features of relief, alluvial plains dominate with sparse isolated low hills in the interior and low mountain ranges along the boundaries. The fluvial network is an important feature of the region and composes of the Danube River flowing from north-west to south-east, and its numerous tributaries – among others Morava, Váh, and Latorica rivers in Slovakia and Tisza and Drava in Hungary. Upstream human settlements represent important source of propagules of alien species.

The climate represents an important factor affecting the biodiversity of the region. The most important climatic boundary of the Pannonian region separates humid areas from the semi-arid ones, and forms a boundary between two vegetation belts – deciduous forests and forest-steppes. The average annual temperature in the central part of the Pannonian region is 11 °C, the average temperature in January is 0.7 °C and in July 22 °C (EEA, 2002). Average annual precipitation ranges from 700 to 800 mm in the western part to 500 mm in the central and southern parts of the region (EEA, 2002).

Hardwood floodplain forests in Pannonia occupy the alluvia of great rivers (mentioned above), situated in higher positions with typical soils: fluvisols and gleysols. They are affected by the groundwater table fluctuations and irregularly by short-term flooding. Dominant species of the tree layer are *Fraxinus angustifolia*, *Quercus robur*, *Ulmus minor* and *Ulmus laevis*. These forests are classified within the class *Querco-Fagetea*, alliance *Alnion incanae*, suballiance *Ulmenion.* In the past, before human settlement of the territory, these forests covered a considerable part of large Pannonian lowlands (Krippel, 1986; Michalko et al., 1987; Somodi et al., 2009). Until the end of the 12th century, the Danube River formed large and dynamic branch system. In the following centuries, the need for river transport resulted in the regulation of the branch system into big single river bed on the right side of the branch system. The decrease of the groundwater table in all other parts of the branch system made the regulated area suitable for agriculture. Moreover, the vegetation cover changed considerably due to deforestation and fragmentation of the area (Anonymus, 1976). For a long period of time, the system of embankments has been constructed as a protection against flooding, being finished in the 19th century (Šomšák, 1995). The embankments divided the river branch system into two parts; the first one being closer to the main watercourse, where flooding became more intensive and hardwood floodplain forests were transformed into willow–poplar forests or Canadian poplar plantation, and the second part being outside the embankment, where groundwater table decreased and hardwood floodplain forests degraded (Šomšák, 1995). The main intervention in the floodplain forests over the last few decades is the construction of Gabčíkovo Dam and its part – Hrušovská zdrž Dam (built during the years 1977–1991). Due to the construction, 250 km^2 of floodplain forest was cleared (Kozová et al., 1991). The remnants of these forests belong to one of the most disturbed and altered ecosystems in Pannonia (Borhidi and Sánta, 1999).

3. Methods

This study is based on the dataset of 365 relevés ordered within the suballiance *Ulmenion* in the Slovak national database of phytocoenological relevés CDF (Hegedüšová, 2007) and 216 relevés ordered within the *Ulmenion* in the Hungarian database (Lájer et al., 2008). All of the relevés were made on equal-sized plots (20 by 20 meters) and contain a list of plant species with their cover recorded using the new Braun-Blanquet cover-abundance scale (Braun-Blanquet, 1964; Westhoff and van der Maarel, 1973), information about cover of each layer and information about the date and locality of the relevé, which is also defined by geographical coordinates in more than 80% of relevés. Relevés without any of this information, or relevés with different plot sizes were excluded. The dataset include all publications about hardwood floodplain forests in Slovakia and Hungary from 1942 to 2010 and the relevés cover all lowland areas on the alluvia of great rivers with the occurrence of mixed oak–elm–ash forests (Fig. 1). Data were stored using the TURBOVEG database system (Hennekens and Schaminée, 2001) and processed using JUICE software (Tichý, 2002). Neophytes – species introduced to the region after the year 1500 – were identified according to the Slovak list of

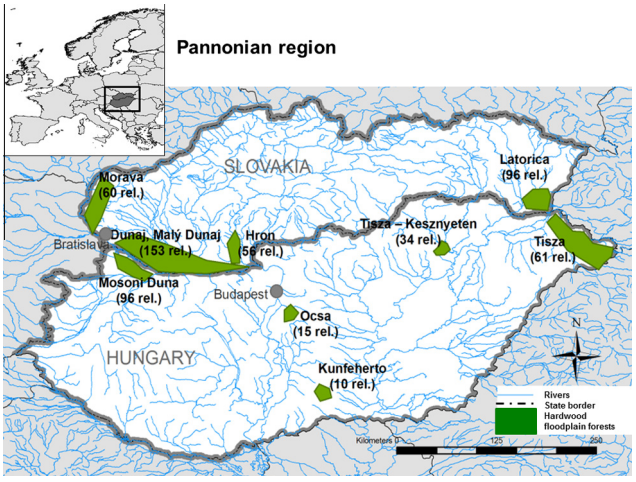

Fig. 1. Geographical distribution of hardwood floodplain forests in the Pannonian region with the numbers of relevés within each area.