Asplenium platyneuron, a new pteridophyte for Europe

***Asplenium platyneuron* (*Aspleniaceae*, *Pteridophyta*), druh nově zaznamenaný v Evropě**

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Eleven plants of *Asplenium platyneuron* (ebony spleenwort) were found in disturbed serpentine woodland in south-central Slovakia (Central Europe). This find represents a new addition to the fern flora of Europe. It is probably the result of long-distance spore dispersal. The nearest known sites for this species are those in eastern North America, about 6500 km away. The important determination characters of *A. platyneuron* are described, the Slovakian locality characterized and an overview of the ecology and a map of the worldwide distribution of this species provided.

K e y w o r d s: alien species, Appalachian *Asplenium* complex, Central Europe, ferns, long distance dispersal, serpentines, Slovakia

Introduction

Ferns and lycophytes are capable of dispersing over long distances by wind-blown spores, as evidenced by the facts that they are common elements of the floras of isolated oceanic islands and are often among the first colonizers of open and newly available habitats. The extent to which species are effective dispersers depends on a wide range of factors such as life-history, adaptive, genetic characteristics and their interplay with the biotic and physical environments (Tryon 1970, Smith 1972, Moran & Smith 2001, Perrie & Brownsey 2007, Ranker & Geiger 2008). Dispersal of spores is more frequent over short distances and infrequent over long distances, with distances of 500–800 km presenting only slight barriers and succesful dispersal over distances of 3200 km or more possible (Tryon 1970, 1972). There are numerous reports of ferns occasionally occurring outside their normal ranges (Smith 1972, 1993, Wagner 1972). Colonization of new habitats may be dependent on the successful establishment of sporophytes by single spores. In homosporous ferns, the ability to reproduce through intragametophytic selfing (the union of egg and sperm originating from the same gametophyte) promotes long-distance dispersal (Klekowski 1982, Crist & Farrar 1983, Peck et al. 1990, Suter et al. 2000). This ability to reproduce through intragametophytic selfing occurs especially in polyploids. Polyploids reproduce more successfully via intragametophytic selfing than most diploids and are effective dispersers and colonizers (Masuyama & Watano 1990, Vogel et al. 1999, Suter et al. 2000). There are also some diploids, however, which can spread by intragametophytic selfing, such as *Blechnum spicant* (Cousens 1979), *Onoclea sensibilis* L. (Klekowski 1982), *Lygodium microphyllum* (Cav.) R. Br., *L. japonicum* (Thunb.) Swartz (Lott et al. 2003), and *A. platyneuron* (L.) Britton, Sterns & Poggenb. (Crist & Farrar 1983).

Asplenium platyneuron (ebony spleenwort) is one of the three basic diploid (2n = 72) progenitors in the Appalachian *Asplenium* complex. This group has been studied cytologically, morphologically and anatomically, and reticulate evolution has occured in the Appalachian *Asplenium* complex (Wagner 1953, 1954, Smith & Levin 1963, Werth et al. 1985). *Asplenium platyneuron* has a remarkable distribution. It occurs in southern Africa and North America. No other North American fern has a similar distribution (Wagner et al. 1993, Moran & Smith 2001). In North America, it occurs primarily in the eastern United States and is one of the most common and widespread spleenworts in eastern North America (Taylor et al. 1976). Isolated populations occur in Texas, New Mexico, Arizona, Colorado, Nebraska, Minnesota (Wagner et al. 1993, USDA–NRCS 2010), West Indies (Weakley 2008) and Canada (Ontario and Quebec; Wagner et al. 1993, Brouillet et al. 2006). In southern Africa, it occurs in Lesotho and the Republic of South Africa (provinces Cape, KwaZulu-Natal and Transvaal; Sim 1915, Schelpe & Nicola 1986, Burrows 1990, Arnold & deWet 1993). *Asplenium platyneuron* is common in South Africa and is listed in the national Red list of South African plants (Raimondo et al. 2009) in the category "least concern" (LC).

Asplenium platyneuron is a terrestrial or epilithic species with wide ecological amplitude (Wagner et al. 1993, Greer & McCarthy 1999). In North America and South Africa, it colonizes seasonally dry, lightly shaded forests, scrubs and forest margins or rocky habitats from damp wooded ravines to dry limestone cliffs and ledges. It occurs at altitudes ranging from 0–1300 m in North America (Wagner et al. 1993) and 100–2600 m in South Africa (Pickett 1914, Sim 1915, Schelpe & Nicola 1986, Arnold & deWet 1993). The relatively broad ecological distribution may be associated with a relatively inflexible gametophytic ontogeny that favours reproductive effort over growth (Greer & McCarthy 1999).

It is most unusual for a species with a typical North American and African distribution to be found thousands of kilometers away from its native range. *Asplenium platyneuron* was found in an oak woodland, affected by former serpentine mining, in southern Slovakia (Central Europe). This find represents the first record of the species in Europe. This paper describes the new locality in Slovakia. Aspects of the long distance dispersal of the species are summarized and discussed, and a map of the global distribution of *A. platyneuron* presented.

Material and methods

The new locality in Slovakia was discovered by the second author and Matúš Hrivnák on 7 August 2009. The coordinates of the new locality were measured using a Garmin Vista equipment in coordinate system WGS-84. For the quadrants of the Central European grid mapping, see Ehrendorfer & Hamann (1965). A soil sample was taken from the uppermost mineral horizon (0–10 cm depth, litter removed) in November 2009. The soil was dried at laboratory temperature, crushed and passed through a 2 mm sieve. Soil acidity (pH) was estimated, using a WTW Inolab pH 720, in distilled water (1:2.5 soil: water ratio) in the Laboratory of the Institute of Forest Ecology SAS (Zvolen; Slovakia). Names of taxa of vascular plants and bryophytes follow Marhold & Hindák (1998) and taxa not included there are mentioned with author abbreviations. Voucher herbarium specimens from the Slovak locality are deposited at SAV and PRC.

The important micromorphological characters, namely, exospore length, annulus length and number of thick annulus cells, of the herbarium specimens of the plants found in Slovakia were measured. Untreated samples of 20 spores (exospore length) and of 10 annuli were measured for each plant, using a light microscope (Olympus CH30).

Nomenclature and characters important for determination

Asplenium platyneuron (L.) Britton, Sterns & Poggenb., Prelim. Cat. 3. 1888.

Basionym: *Acrostichum platyneuron* L., Sp. Pl. 2: 1069. 1753.

Asplenium platyneuron is a small perennial fern with a specific frond and pinna shape (see Fig. 1). For detailed morphological description see Flora of North America (Wagner et al. 1993). Compared with the other European *Asplenium* species, it is most morphologically similar to *A. trichomanes* sensu lato (Viane et al. 1993, Ekrt & Štech 2008). It differs from *A. trichomanes* in having dimorphic leaves (small sterile fronds and bigger fertile fronds), alternate pinnae and inconspicuous rhachis wings. This diploid species has small spores and sporangiums. The mean exospore length of the Slovakian plants ranges from (20–) 28–34 (–38) μm; the annuli of these plants are (225–) 240–280 (–320) μm long and consist of (16–) 18–20 (–23) thick cells.

Description of the new locality in Slovakia

The locality of this new population of *Asplenium platyneuron* is in the southern part of central Slovakia (Central Europe), ca 1.5 km SSW from the Breznička village, on the northwestern slopes of Bôriček hill (N48°24'17.8", E19°43'41.9", altitude 200 m; grid map 7584). The locality is situated in the Lučenská kotlina basin and Ipeľsko-rimavská brázda within the Pannonicum region according to the geomorphological and phytogeographical classification of Slovakia, respectively (Futák 1984, Miklós 2002). The area is in a warm moderately dry subregion with a relatively cool winter (Miklós 2002) within a warm climate region (more than 50 summer days with temperatures higher than 25 °C). The geology in the area consists of serpentinites, metabasic rocks, carboniferous shales, phyllites and metaquartzites, actinolite and chlorite schists (Zlocha & Hovorka 1971). Phyllite and serpentinite rocks (pieces of 2–10 cm on average) were found in the soil or at soil surface near the plants of *A. platyneuron*. Individuals of *A. platyneuron* grew most abundantly on moderate slopes (5–20°) in slightly acidic (pH 6.5) and skeletal soil and occasionally on almost vertical slopes. The semi-natural habitat of the locality is partially the result of mining in the second half of the last century (1953–1958 and 1969–1970; Zlocha & Hovorka 1971). After cessation of mining, trees and shrubs established spontaneously. Vegetation consists mainly of typical (sub)thermophilous species. The tree layer is formed partly by native woody species, such as *Quercus cerris* and *Q. petraea* agg., and by invasive species (*Robinia pseudacacia*) or species typical of habitats affected by human activities (*Betula pendula*, *Populus tremula*). The total cover of the tree layer is low (30–40%), while the shrub layer is relatively dense (about 70%). The dominants in the shrub layer are *Carpinus betulus* and *Corylus avellana*; these are accompanied by *Acer tataricum*, *Ligustrum vulgare*, *Quercus cerris*, *Q. petraea* agg., *Sambucus*

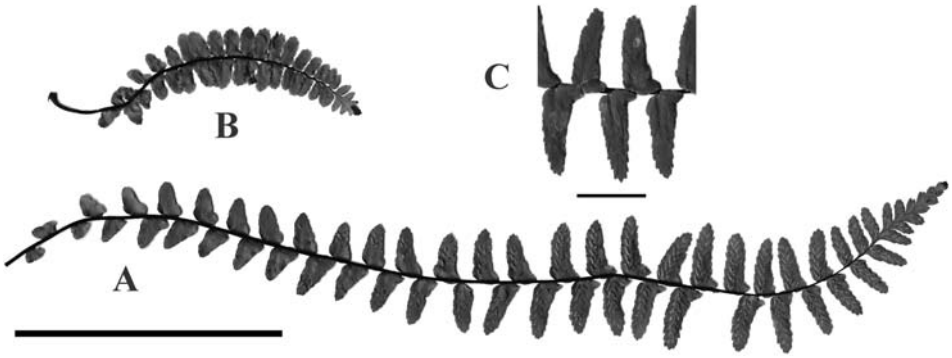

Fig 1. – Silhouettes of dimorphic fronds of *Asplenium platyneuron* from Slovakia (both fronds come from the same plant). A – fertile frond, B – sterile frond, scale bar 5 cm; C – detail of pinnae on central part of frond, scale bar 1 cm.

nigra, and *Swida sanguinea*. The herbaceous plant layer is relatively scarce and poor in species. Among the more frequent species are *Asplenium trichomanes*, *Campanula persicifolia*, *Carex digitata*, *C. muricata* agg., *Clinopodium vulgare*, *Cruciata glabra*, *Dryopteris filix-mas*, *Fallopia convolvulus*, *Festuca rupicola*, *Fragaria vesca*, *Galeobdolon luteum*, *Galium aparine*, *Melica uniflora*, *Poa nemoralis*, *P. pratensis* agg., *Potentilla alba*, *Stellaria holostea*, *Tithymalus cyparissias*, *Veronica chamaedrys*, *Vincetoxicum hirundinaria* and some of the above mentioned tree species. *Asplenium platyneuron* grows dispersed over an area of ca 50–80 m^2. A total of 11 individuals were found during the growing season of 2009. The moss layer was well-developed. Bryophytes were frequent and occurred in relatively large patches. The most abundant species were *Barbilophozia barbata*, *Brachythecium albicans*, *B. velutinum*, *Dicranum scoparium*, *Hypnum cupressiforme*, *Lophocolea minor*, *Pleurozium schreberi*, *Rhodobryum roseum* and *Thuidium delicatulum*.

Discussion

The remarkable occurrence of *Asplenium platyneuron* on disturbed serpentines in Slovakia is probably the result of long distance dispersal of spores, or perhaps a single spore. The nearest known localities of the species are in eastern North America, about 6500 km away (see Fig. 2). Thus, this find may represent the greatest recently documented long distance dispersal of a temperate fern.

Compared with other *Asplenium* species, *A. platyneuron* is well adapted for colonizing distant habitats by spore dispersal. Its success is partly due to self-fertilization of its gametophytes, low genetic load and the regularity with which sporophytes are produced by isolated gametophytes (Crist & Farrar 1983, Werth et al. 1985, Werth 1986, Greer & McCarthy 1999). These characteristics are typical of the biology of long-range dispersal in ferns. *Asplenium platyneuron* successfully increased its eastern North American range northwards and westwards over a period of a few decades (Wagner & Johnson 1981). Its success in colonizing areas can be attributed to its competitive advantage at disturbed sites

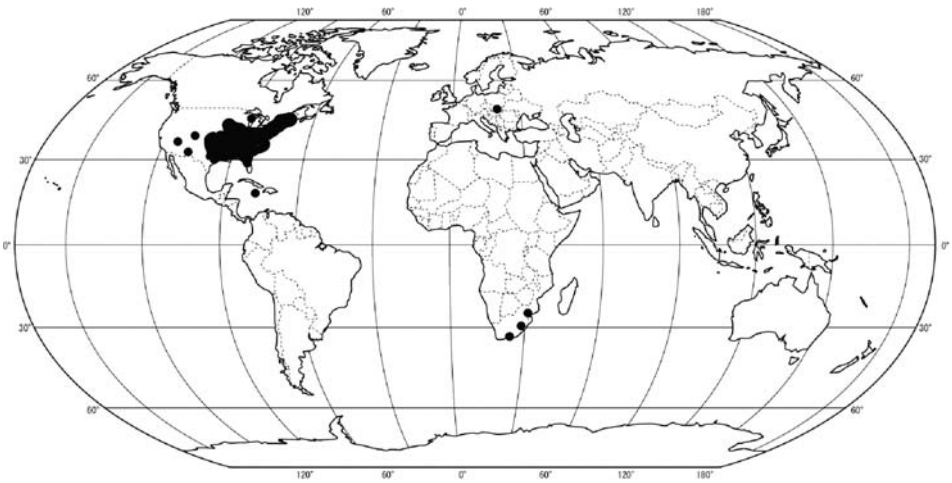

Fig. 2. – Global distribution of *Asplenium platyneuron* compiled from information in the literature and databases (Sim 1915, Wagner et al. 1993, Weakley 2008, GBIF 2009), with the new location in Slovakia (Central Europe) indicated.

(Benedict 1947, Wagner & Johnson 1981, Crist & Farrar 1983, Wagner et al. 1993, Greer & McCarthy 1999). These habitats are at locations isolated from the main center of the species distribution (Smith & Roach 1967, Delendick 1984).

Asplenium platyneuron is a drought-tolerant fern. Gametophytes of *A. platyneuron* can successfuly resume growth following desiccation. Mature prothallia are uninjured by exposure to repeated periods of three to four weeks of drought (Pickett 1914, 1931). The plants found in Slovakia occurred in a very dry area. The sporophyte of this species is capable of asexual reproduction by means of the proliferation of buds on the lowest pinnae, which develop into plantlets (Wagner et al. 1993). However, the Slovakian plants did not have these buds.

The distribution of *A. platyneuron* in North America and South Africa is very unusual. Only about 13% of the African pteridoflora have affinities with the Neotropics and no other North American fern has a similar distribution (Wagner et al. 1993, Moran & Smith 2001). The direction of spread by long-distance dispersal was suggested by Moran & Smith (2001). The present-day continent with the greatest species richness of this genus or species group is usually the place where it originated. In case of *A. platyneuron* it is North America. Then, South Africa was colonized by spores or gemmae originating in North America (approximately 12,500 km away). *Asplenium platyneuron* is now naturalized in Africa.

The capacity for long-distance dispersal between continents has been studied in detail by determining the relationships between the neotropics and Africa/Madagascar (Moran & Smith 2001). Dozens of species occur on both continents, which are separated by the Atlantic. There are many other similar disjunct distributions of ferns (Pichi Sermolli 1979, Tryon 1986, Moran 2008). Long-distance dispersal is well documented for ferns, whose wind-blown and often long-lived spores can be carried over long distances by winds (Tryon 1970, Wagner 1972). The average size of most fern spores is 20–60 μm (Tryon

1972). These spores can be easily dispersed over long distances by wind. *Asplenium platyneron* has small spores. The mean spore length of the plants of *A. platyneron* growing in Slovakia is 28–34 μm long, which is low in terms of the range cited above.

The locality of *A. platyneuron* in Slovakia is also remarkable from a geological point of view. The subsoil consists of weathered serpentines, which determine its chemical composition and specific flora (Alexander et al. 2007). At high latitudes, outcrops of serpentine rocks provide isolated islands of specific or thermophilous flora (Juratzka 1858, Alexander et al. 2007). In eastern North America *A. platyneuron* also occurs on serpentines (Wherry 1963, Tyndall & Farr 1990).

Asplenium platyneuron has not been previously recorded in Europe (Derrick et al. 1987, Viane et al. 1993, Blockeel 2006). The discovery of *A. platyneuron* in Slovakia is the first record of the species for Europe. Obviously it is not possible to exclude the possibility that eventually spores will spread from sites where this fern is cultivated in Slovakia or neighbouring countries. In Germany, *A. platyneuron* is very rarely grown as an ornamental plant because it is rather difficult to grow (anon. reviewer in litt.).

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Souhrn

Asplenium platyneuron (L.) Britton, Sterns & Poggenb. je drobný terestrický až epilitický diploidní (2n=72) sleziník řazený mezi základní druhy komplexu tzv. appalačských sleziníků. Centrum diverzity skupiny se vyskytuje ve východní části Severní Ameriky. *A. platyneuron* jako jediný zástupce skupiny se vyskytuje také v jižní Africe, kam se v minulosti rozšířil a je zde zdomácnělý. Jedná se o jedinou temperátní kapradinu s takto neobvyklým rozšířením. Ve svém původním areálu v Severní Americe bylo zaznamenáno rychlé šíření druhu nejen na druhotných stanovištích (řada izolovaných lokalit v rámci USA), ale také na přirozených lokalitách (zejm. v oblasti Velkých jezer na severu USA). V roce 2009 byl *A. platyneuron* nalezen v jižní části středního Slovenska na severozápadním úpatí kopce Bôriček u obce Breznička v nadmořské výšce 200 m. Lokalita se vyskytuje v teplém panonském regionu, z geomorfologického pohledu v Lučenské kotlině a z fytogeografického pohledu v Ipeľsko-rimavské brázdě. Na lokalitě bylo nalezeno jedenáct plodných rostlin rostoucích roztroušeně na hadcovém podloží na ploše asi 50–80 m^2. Ve druhé polovině 20. století byla lokalita narušena pilotní geologickou těžbou a v současné době je zarostlá dřevinami. Ve stromovém patře dominují druhy *Quercus cerris*, *Q. petraea* agg., *Robinia pseudacacia*, *Betula pendula*, *Populus tremula* a v pokryvném keřovém patře dominují *Carpinus betulus* a *Corylus avellana*. Morfologicky je druh nejvíce podobný *Asplenium trichomanes*, liší se však několika charakteristickými znaky:

1a Rostliny se všemi listy stejnotvarými; lístky na vřeteni listu vstřícně uspořádané; vřeteno výrazně křídlaté . . . . . ***Asplenium trichomanes***

1b Rostliny s výrazným listovým dimorfizmem (vytvářejí se poléhavé spodní vytrvalé sterilní listy a ze středu listové růžice rostoucí vzpřímené sezónní fertilní listy); lístky na vřeteni listu střídavě uspořádané; vřeteno nevýrazně křídlaté . . . . . ***Asplenium platyneuron***

Nález *A. platyneuron* na slovenských hadcích představuje první výskyt druhu na území Evropy. Vzhledem k ekologii druhu, jeho lehkým výtrusům, preferenci narušených biotopů, rozšíření a schopnosti šíření na velké vzdálenosti lze s velkou pravděpodobností předpokládat, že výskyt druhu na Slovensku je spontánní. Nejbližší známé lokality druhu se vyskytují na východním okraji Severní Ameriky a jsou vzdálené asi 6500 km.

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