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Monitoring of Endangered *Astragalus* Species in the Protected Landscape Area Dunajské luhy at the Danube Floodplains

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Abstract: *Astragalus excapus* L. and *Astragalus austriacus* Jacq. are regarded as critically endangered species in Slovakia. They are threatened by environmental impact, natural succession, as well as by human activities. Monitoring them is an important tool in determining their status and in making management decisions for their protection. In this contribution, a summary of the basic terrain endeavours, current status, locality and species description, habitat preferences, possible threats, current protection, and management activities are presented.

Keywords: *Astragalus austriacus*; *Astragalus excapus*; monitoring; protection; threat

The genus *Astragalus* L. comprises about 2500 species of herbaceous perennial and annual species in the subfamily *Papilionoideae* in the family *Fabaceae* (Mabberley 1997). *Astragalus* is mainly distributed in cool to warm, arid and semiarid regions of the northern hemisphere, South America, and tropical East Africa; it is especially diverse in the south-western and Sino-Himalayan regions of Asia (*ca.* 1500–2000 spp.), in western North America (*ca.* 400–450 spp.), and the Andes of South America (*ca.* 100 spp.). Both the geographic centre of diversity and the presumed origin of *Astragalus* is in Eurasia – specifically in the steppes and mountains of south-western to south-central Asia and the Himalayan plateau (Polhill *et al.* 1981). According to Mabberley (1997), there are 133 species in Europe; Ekuci and Ekim (2004) mention 142 species, of which 50 are endemic. In the territory of Slovakia, about 15 native species were found; 10 of them have legal protection. *Astragalus excapus* L. and *Astragalus austriacus* Jacq. are regarded as critically endangered species in Slovakia.

Astragalus excapus is a scientifically important species. It is a melliferous plant, mainly due to biochemical aspects of its compounds. The root was used in folk medicine as a sweetener, as something akin to a laxative, and specially modified seeds replaced coffee in the Swiss Wallis. Because of its decorative flowers, it is sometimes grown on rockeries (Čeřovský & Bělohoubek 1999). *Astragalus austriacus,* like most *Astragalus* species, contains a number of flavonoid compounds. Deryugina (1966) investigated the flavonoid composition of *Astragalus austriacus* and isolated the astroside from it – a new isoflavone glycoside.

In Slovakia, *Astragalus excapus* is a relatively rare species. Only one confirmed locality is mentioned in the literature, lying in the margins of the Hungarian Pannonian area: a loess terrace in the Nature Reservation of Jurský Chlm near the village of Mužľa (Čeřovský & Bělohoubek 1999). *Astragalus austriacus* can be found disseminated in the Pannonian area; in some localities of the Devínska Kobyla and Podunajská Lowland it is in abundance (Chrtková & Jasičová 1988). Both

species are endangered by both natural-state succession and by human activities. Several localities are negatively affected by successive shrubs overgrowing them, and by invasive and expansive plant species.

Collecting information on rare and endangered species is an important tool in determining their status and for making management decisions for their protection. This study was, in its first phase, focused on collecting information about species occurrence, the geographic distribution and ecology, general information on population size, threats to population, and threats to the habitat. The next level of this study involved the quantitative assessment of the abundance and/or condition in terms of density, percent cover, or frequency of the population, as well as the description of phenology, ontogenesis, and reproduction system. Where appropriate, further activities will lead to the development of both a management and re-introduction plan for protection of the species.

MATERIALS AND METHODS

Data about occurrences of the taxa were obtained from references in the literature, herbaria, and from the results of previous collecting expeditions. Revision and verification of the presence of *A. excapus* and *A. austriacus* in selected localities were conducted in cooperation with the administrative bodies of the State Nature Conservancy of the Slovak Republic, in the Dunajské luhy Protected Landscape Area (PLA). The first field work took place in May 2008. The activities included the verification of known records of *Astragalus* species, as well as further surveying for their occurrence. The following records were noted about the relevant localities: GPS coordinates and information of geographic location, ecological data, actual status evaluations (management system, present maintenance), estimates of population size according to the Braun-Blanquet scale of plant abundance (Wlkum & Shanholtzer 1978), habitat information about both the population (other species present, slope position, aspect) and the landscape (landform, soil properties, local land-use), possible threats to the occurrence, endangerment factors, the nature and degree of the endangerment, and management issues.

RESULTS AND DISCUSSION

Characterization of the studied area

PLA Dunajské luhy is situated in Nitriansky region, in the districts of Komárno and Nové Zámky. According to the geomorphologic division of Slovakia, this area belongs to the Alpine-Himalayan System, Pannonian Basin sub-system, West Pannonian Basin province, Little Hungarian Plain sub-province, and Danubian Lowland area. By phytogeographic division, this territory comes under the area of Pannonian flora (Pannonicum), Eupannonicum province, Danubian Flat district (Futák 1984).

The study area is located in a warm area, climatic region T1 (warm, predominantly very dry), which passes into climatic region T2 (dry with mild winters) (Lásló & Izakovičová 2006). The average annual air temperature is 9.9°C, and the average annual sum of precipitation is 550–600 mm. The main soil types are Chernozems; these soils are texturally medium heavy, deep, without soil skeleton, mostly on the plane. Soil fertility, expressed on a 100-point scale, is between 76 and 100 points (Vilček 2005).

Biology and habitat preferences

Astragalus exscapus is a perennial herb, hemicryptophyte. It has rough taproots, upwards of 1m long. Stems are very short, 1 to 2 cm long (sporadically up to 10 cm). Leaves are bunched into a ground leaf rosette, leaflets 10 to 19-paired. The whole plant is densely covered with white hairs. Racemes are 5 to 9-flowered with short pedicles, and the corolla lemon to bright yellow. Flowers are concentrated in the middle of the leaf rosette on the root head, and bloom from May to July. Repeated flowering in autumn is frequent. It is predominantly pollinated by bumblebees with a long stinger. Densely haired legumes have 3 to 7 reniform, smooth, and glossy seeds of a yellow to red-brown colour. Seed dispersion is hindered by the fruit's position above ground; thus seed dispersal is difficult over large distances. Zoochory is probably only adventitious. Seed dispersion is only possible in very strong winds because the seeds are relatively heavy and often deep in the leaflet rosette. It has a chromosome number of

$2n$ = 16 (Slavíková & Slavík 1974; Chrtková & Jasičová 1988).

A. excapus is a characteristic component of xerothermic communities, and is a diagnostic species of associations *Festucion valesiacae*, *Festucion vaginatae,* and *Prunion fruticosa* alliances.

It only occurs in the warmest and driest lowlands and uplands; on south, south-eastward, or south-western forest-free, grassy or rocky slopes; on neutral and acidic loess soils; and at an altitude of between 100 to 150 m. In winter, the slopes are often without snow (Slavíková & Slavík 1974; Čeřovský & Bělohoubek 1999). Ellenberg *et al.* (1992) determined the following values of environmental conditions for *A. excapus,* in which it grows: light – 9 (heliophyt), temperature – 6 (warm sites), continentality – 6 (subcontinental), humidity – 3 (dry soils), pH – 9 (neutral or acidic soils).

Astragalus austriacus is a perennial herb; hemicryptophyte; a prostrate to semi-erect plant with 20 to 35 cm long, thin, angular stems. Leaves 3 to 5 cm; leaflets 7 to 10-paired, oblong, and lanceolate. Inflorescence is a tenuous raceme with 3(10) to 13(20) droopy flowers. The corolla is bright blue, rarely white. Flowering time is from June to August. Legumes with 4 to 8 seeds in two capsules are cracked, oblong, comma-shaped. The seeds are ellipsoid, reniform, or cordate; coloured brown to black. Variability is only observed in plant size, which depends on the environmental conditions. Plants with white flowers occurred rarely. The chromosome number is $2n$ = 16 (Chrtková & Jasičová 1988).

A. austriacus occurs mainly in the association *Festucion valesiacae*, *Festucion pseudovinae* and *Prunion fruticosae* alliance. It grows on sun-exposed hillsides, steppe slopes, in shrubs, on grasslands, salt meadows, in light forests, and on dry and warm stands, on various soil substrates, at an altitude up to 350 m (Chrtková & Jasičová 1988; Dostál & Červenka 1991).

Collected data and locality description

In 2008, the occurrence of *Astragalus austriacus* and *Astragalus excapus* in the locality of Jurský Chlm was confirmed. Jurský Chlm is part of PLA Dunajské luhy, and comes under Sites Protected under the Habitats Directive (NATURA 2000). Jurský Chlm is located in the cadastre area of the villages Mužľa and Búč; this part of the Mužľa area is also in the Jurský Chlm Nature Reserve (NR). There are abandoned old orchards on this site on one side, neighbouring the agricultural land. The vegetation covering the loess slope is unkempt, with the dominance of high-growing grasses.

Populations of *A. australis* and *A. excapus* are scattered along the south-oriented slope, located from 47°48'02.0 N to 47°48'11.8 N, and from 18°31'46.4 E to 18°30'54.9 E, at an altitude of between 110 and 125 m. The population size was estimated on five (*A. austriacus*), plus two additional sites (*A. excapus*). Populations of *A. austriacus* were found more frequently, but with only several or single specimens (Table 1). Both species were at the mature stage of full blossom at the beginning of May.

The studied area is a segment of the sites of community importance, in which three important biotopes are situated. Biotope Pannonic loess steppic grasslands are formed by secondary, dry to semi-dry, species-abundant steppic grasslands, on loess with deep soils. Characteristic taxa for these localities are: *Achillea setacea*, *Agrimonia eupato-*

Table 1. Estimates of population size

Taxa	Frequency of occurrence/size of population	Braun-Blanquet scale No. of sites				
Astragalus austriacus Jacq.	frequently	1	2	3	4	5
	single or several specimens	+	+	+	+	+
Astragalus excapus L.	rare	1	2			
	several hundred specimen	3	3			

Braun-Blanquet scale: + = < 5% cover with few individuals (*A. austriacus*), 3 = 25–50% cover (*A. excapus*)

ria, *Agrostis canina*, *Bromus erectus*, *Chenopodium urbicum*, *Cirsium vulgare*, *Crataegus monogyna*, *Cynodon dactylon*, *Dactylis aschersoniana*, *Elytrigia intermedia*, *Festuca pseudovina*, *Filipendula vulgaris*, *Hypericum perforatum*, *Juglans regia*, *Koeleria pyramidata*, *Pimpinella saxifraga*, *Poa pratensis*, *Prunus cerasifera*, *Prunus spinosa*, *Rosa canina*, *Rubus plicatus*, *Salvia nemorosa*, *Sambucus nigra*, *Silene vulgaris*, *Solidago canadensis*, *Sonchus arvensis*, *Taraxacum officinale*, *Verbascum phlomoides*, and *Vicia tetrasperma*. Botanists of LPA Dunajské luhy listed 76 species of vascular plants in the NR Jurský Chlm.

Current status and management activities

In the past, the locality was dominated by orchards; most prevalent were apricot, plum trees, and walnuts. At the present time, the majority of trees are dry. The soil is highly enriched with nitrogen, which supports the growth of nitrofile vegetation; also the growth of invasive species such as *Solidago gigantea*, *Solidago canadensis,* and *Ambrosia artemisifolia* has increased. Xerophytic vegetation on slopes is suppressed by a succession of woody plants and shrubs such as *Prunus spinosa, Rosa,* and *Crataegus* species. Grassy vegetation is very high and compact, causing an enormous accumulation of vegetable biomass.

The negative impacts on the occurrences of the monitored populations is due to the expansion of unnatural plant species, wild animals, termination of abandoned orchards; and, in the end, is due to the agricultural mechanisation on neighbouring arable lands. The farming of fields in close proximity to the upper areas of this locality causes the depletion of nutrients and the extension of nitrofilic plant species. Slopes are considerably overgrown; and following the accumulation of old biomass, the vitality of *Astragalus* individuals decreases. *A. excapus* is typically found on stands with sparse vegetation and with an exposed soil surface. It is displaced by a succession progression by competitive susceptible grasses.

Protection and maintenance of natural vegetation in the locality requires the removal of successive and unnatural woody plants, invasive and expansive species, and the elimination of old grass matter. Proposed management measures include periodical mowing, extensive grazing, brush control, removal of invasive herbaceous material, and prescribed winter burning in selected places. The effectiveness of the protection measures and the monitoring of their impact on population vitality should both be performed in the future. Hložková (2004) stated that due to the consequences of mowing, intensive regrowth of *A. excapus* was observed. With favourable climatic conditions, plants flowered and produced mature pods with seeds. Therefore, the reproductive potential of individuals increased on a mowed stand. The remainder of the seeds improved the seed supply in the soil bank.

The alternative measures are cultivation of these species *ex situ* and the strengthening of the populations by either the transfer of cultivated plants or re-sowing. It is possible to use seed dormancy and long-term germination maintenance in seed storage for the preservation of these species. On the other hand, seed dormancy makes plant pre-cultivation more difficult under laboratory conditions.

The status of the protected landscape area does not guarantee effective protection of all rare and endangered species occurring within its area. As Reimer and Hamel (2002) state, protection of critical habitat alone will not ensure the long-term survival of a species. It is important to continue research on the distribution, biology, and ecology of endangered species; as well as the gathering of baseline data, and helping to identify new threats, as they arise. This is especially crucial in small populations, with limited distributions, where localized disturbances could have a negative impact on the entire population.

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