Peucedanum arenarium subsp. *arenarium* – a critically endangered species of the Slovak flora (morphometry, distribution, biology)

Božena Šerá[1], Viera Feráková[2], Eva Kocianová[3], Vlastizdar Vágenknecht[4], Oto Majzlan[5] & Zuzana Dúbravcová[6]

[1] *Institute of Landscape Ecology, Academy of Sciences of the Czech Republic, Na Sádkách 7, CZ–37005 České Budějovice, Czech Republic; e-mail: sera@jcu.cz*
[2] *Institute of Botany, Slovak Academy of Sciences, Dúbravská cesta 14, 845 23 Bratislava, Slovak Republic; e-mail: viera.ferakova@savba.sk*
[3] *Assiciation of Industry and Enviroment, Heydukova 25, 811 08 Bratislava, Slovak Republic; e-mail: apop@stonline.sk*
[4] *State Nature Protection of the Slovak Republic, Regional Administration Bratislava, Hanulova 5/D, SK–84402 Bratislava, Slovakia; e-mail: ekocian@sopsr.sk*
[5] *Faculty of Education of Comenius University, Moskovská 3, SK–813 34 Bratislava, Slovakia; e-mail: oto.majzlan@fedu.uniba.sk*
[6] *Faculty of Natural Sciences, Comenius University, Révová 39, SK–81102 Bratislava, Slovak Republic*

Abstract: The species *Peucedanum arenarium* Waldst. et Kit. has a single contemporary occurrence in the Czech and Slovak Republics at present, on several microlocalities on the south-western and southern slopes of Sandberg hill (National Nature Reserve Devínska Kobyla) near Bratislava – municipal part Devínska Nová Ves. The vegetation with this species belongs to the class *Festuco-Brometea*, a closer phytosociological classification of the community is problematic. The species is a monocarpic perennial with a sterile life span of about three years. The plant comes to flower in the fourth year, produces ca 8,500 mericarps, and dies. Individual years of its development can be differentiated according to the number and diameter of leaves in the rosette at the soil level. The viable mericarps develop mainly on the circumference of the terminal inflorescences (compound umbels) of the minor branches. In laboratory conditions they germinate poorly (scarification is probably necessary).
A relatively large number of various insects was found on the plants (86 species of five orders), mostly phytophagous. The *P. arenarium* population might be endangered when fructophagous insect species (*Tingis clavicorne, Copium teucrii, Graphosoma lineatum*) enormously increase in number, as it reproduces exclusively in the generative way, by mericarps. Results of the first sketch may be used for Recovery Programme of *P. arenarium* in NNR Devínska Kobyla.

Key words: apiaceae, biology, distribution, life cycle, morphometry, reproduction, Slovakia.

Introduction

Peucedanum arenarium Waldst. et Kit., Apiaceae family, is a monoecious species with hermaphrodite flowers, hemicryptophyte, diploid, $2n = 22$ (Feráková & Murín, 1976; Kuzmanov et al., 1977; Vasilyeva et al., 1981). It is a representative of the nominate section *Peucedanum.* Flowering time July – August, reproduction exclusively generative (Dostál, 1950, 1989; Hlavaček et al., 1984; Grulich, 1997). Population dynamics of this monocarpic perennial has been studied by Šerá & Kocianová (2000) and Šerá et al. (2000).

Peucedanum arenarium is spread mainly in the Pannonian region, vertically usually in lowland, where it is often a part of the associations of the alliance *Festucion vaginatae* Soó 1940 and other thermophilous grassland communities (Dostál, 1950, 1989; Kárpátiová et al., 1961; Grulich, 1997; Feráková & Grulich, 1999). It needs sandy or dry, deeper basic soil with unclosed vegetation.

In the past its occurrence in the Czech Republic was mentioned in single locality in south Moravia, Dolnomoravský úval – Rohatec (at northwest limit of its distribution area), however at present this species is considered extinct (Procházka, 2001). Its occurrence in the Slovak Republic was more frequent. In the past it was often found on several localities in the south-west of the territory. Now its presence is confirmed only on Sandberg hill near Devínska Nová Ves (National Nature Reserve Devínska Kobyla, further NNR), and it was included in the list of endangered taxa of the Slovak flora (Feráková et al., 2001). The species can be considered phytogeographically significant, as well as a

border element of the Slovak flora.

Biological research of this species is at the margin of botanical interest, but *P. arenarium* has an interesting and not common life history (monocarpic perennial). In addition this species probably grows only in one place in the Slovak Republic (NNR Devínska Kobyla). Are the slopes of Sandberg hill the last localities of its occurrence? Which morphological and biological characteristics are connected with this species? All these information are important for a convenient management, that may be used for its populations on the Sandberg hill. This papers brings more information about distribution, morphometrics, and first of all new knowledge about the life history of *P. arenarium.*

Material and methods

In early nineties within the Recovery programme of *P. arenarium* historical records of its occurrence in Slovakia were checked in the field. The only one contemporary site of the species theSandberg hill in NNR Devínska Kobyla near Devínska Nová Ves has been found recently (VÁGENKNECHT, 1993; KOCIANOVÁ, 1995, 1999; FERÁKOVÁ et al., 1994; FERÁKOVÁ & KOCIANOVÁ, 1997). An autecological investigation of *P. arenarium* has been running there since 1994, with emphasis on morphometric evaluation and population dynamics.

Under the project "Partial monitoring system Biota" a basic permanent plot 20×20 m^2 with 400 squares 1×1 m^2 was marked off in 1994 In 2000 and 2001 for every fertile individual the following parameters were recorded: plant height, number of leaves in the rosette at soil level, diameter of the rosette, number of compound inflorescences (IP), number of rays in terminal inflorescence (SUU), and number of flowers in secondary umbels (FSU). The data about the number of generative organs were used for assessing the potentia number of mericarps (SP) produced by one plant during its life time: SP=IP*SUU*FSU*2. Four plants out of the total number of 237 fertile individuals (35 in the year 2000, 202 in 2001) could not be used, mostly due to dry rosette or inflorescence (all four found in 2001). Neither plants with broken leaves were included into the data set, as after the removal of branches or terminal, the plant increases the number of flowers (as shown with *Heracleum mantegazzianum* by PYŠEK et al., 1995).

Fruits were collected separately from the terminal compound umbels and from the lateral ones on randomly chosen plants out of the permanent square. Fruits from inner and outer secondary umbels were always carefully distinguished. Then they were dried for 24 h at 80 °C, and individual mericarps were weighed on analytical scales (SARTOURIOUS). In 2001 and 2002 seed germination of one hundred randomly chosen fruits was tested in a standard way (room temperature, half of the mericarps after chilling and scarification). For other details see Reproductive strategy. Three sterile growth phases were determined on the area: a seedling (I), a small sterile plant (II), and a big sterile plant (III). In 2000 and 2002 for all the sterile individuals on the square of 16 m^2 the number of leaves per rosette was counted, and for sterile plants II and III the diameters of the rosettes were measured.

In 2001 one phytocoenologic relevé of the stands with *P. arenarium* has been carried out in Braun-Blanquet scale.

A bionomical-ecological study performed from July to September 2001 was aimed at the correlation between the plants and insects. Insects occurring close to *P. arenarium* were caught by hand, and from the plants flowers they were removed with an exhauster. A soil sample from the roots of the plants was taken in a way avoiding the disturbance of the plants rhizosphere. The occurrence of larvae in the stems was not studied.

The whole the biological investigation of *P. arenarium* on Sandberg was based on a non-destructive attitude, no individuals of this species were removed from the locality, and the plants were not disturbed in their development. The nomenclature of idiotaxa was unified according to MARHOLD & HINDÁK (1998) and that of syntaxa according to MORAVEC et al. (1995). The acronyms of herbarium collections studied follow HOLMGREN et al. (1990). All the mathematical elaborations were carried out in standardised procedures (MILTON, 1992; MELOUN & MILITKÝ, 1994), using the statistical programme STATISTICA ('99) [e.g. Tukey honest significant difference (HSD) test].

Results and discussion

General distribution and variability

Peucedanum arenarium is considered as a Pontic-Pannonian species, with a restricted occurrence in Europe. Its distribution area spreads among Slovakia, Albania, and Ukraine. The main centre of its occurrence is in the countries: Hungary, Bulgaria, Serbia, Romania (Transylvania, Black Sea coast and inland). In the Slovak Republic only the south-east European *P. arenarium* subsp. *arenarium* grows. The distribution area of the nominate subspecies is identical with that of the species as a whole, with the exception of Albania and the southern and western part of the former Yugoslavia with only the subspecies *neumayeri* (VIS.) STOJ. et STEFANOV present. The parallel occurrence of both subspecies is recorded only in Bulgaria (mainly the north-western part). They have the same chromosome numer ($2n = 22$) as established by KUZMANOV et al. (1977). Outside Europe the endemic subspecies subsp. *urbanii* (FREYN et SINT. ex WOLFF) D. F. CHAMB. from Turkey is given (CHAMBERLAIN, 1972), which according to the cited author appears to be fairly close to subsp. *neumayeri.* The subspecies *arenarium* differs from both subspecies in its wider ultimate segment and 5–14-rayed umbels. Based on material from Romania, in *P. arenarium* two forms are recognized by TODOR (1958) the form *angustisectum* (PRODAN) TODOR with leaf segments of the last division up to 0.5 mm wide, and f. *latisectum* TODOR with leaf segments of the last division about 4 mm wide. The segments of plants from the locality Sandberg (NNR Devínska Kobyla) were 2 mm wide in average. The infraspecific variability of *P. arenarium* was not studied in detail in this work.

Distribution in Slovakia and in the Czech Republic

The species was recorded in three phytogeographic districts: Záhorská nížina Lowland, Devínska Kobyla, and

Podunajská nížina Lowland.

Záhorská nížina Lowland: Borský Peter, Sokold – Červený Kríž (Degen et al. 1923: 98; Tauber, 1935 BRNM). – Borský Mikuláš (Mikeš, 1938: 166). – Šajdíkove Humence (Weber, 1930 PR). Devínska Kobyla: Devín (Sabransky, 1891 BP; Ptačovský, 1928 SAV). – Sandberg (Sabransky, 1873 BRNM, 1888 PRC; Futák, 1945 SLO; Feráková & Murín, 1976; Feráková, 1975 SLO). Podunajská nížina Lowland: Bratislava (Eschfaller, s. d. PRC, BP). – Čenkov – Mužla, Jurský chlm (Kárpátiová et al., 1961).

The occurrence on the localities Borský Peter and Sokold – Červený Kríž was revised, but without positive result (Vágenknecht, 1993); the occurrence of the species in the protected area Čenkov has not been confirmed for a long time (Svobodová, 1988). The records from Bratislava and Devín (former a separate village, today a municipal part of Bratislava) are probably inaccurately localised. The data from Devín were probably referred to Sandberg, Devínska Kobyla, a southern slope above the vineyard Futák 1947 (SLO).

The locality Devínska Kobyla – Sandberg is the historically oldest and best supported by evidence. In the course of our revision, this species has been confirmed at four sites within the sandy slopes of Sandberg (Vágenknecht, 1993; Feráková & Kocianová, 1997).

Peucedanum arenarium is ranked among protected endangered species of the flora of Slovakia by the Act of the National Council of the Slovak Republic No. 543/2002 on nature and landscape conservation and the corresponding Order No. 24/2003, it appears in the Order No. 36/1993 of the Hungary, and it is mentioned in the Red Lists of Slovakia and Romania) (Feráková et al., 2001; Dihoru & Dihoru, 1994). In the Czech Republic, which was the westernmost part of its distribution area, the species was found only in South Moravia, in the phytogeographic subdivision Dolnomoravský úval, Rohatec locality. An undoubted record represented by a herbarium sheet comes from Staněk (Staněk, 1925 BRNM). It has never been confirmed since that time (Grulich, 1997). At present this species is considered as extinct in the Czech Republic (Feráková & Grulich, 1999; Procházka, 2001).

Remarks on phytosociology

The phytocoenoses settling warm, dry, sandy, and sunny habitats, are usually classified to the class *Festucetea vaginatae* Soó 1968 em. Vicherek 1972, order *Festuco-Astragaletalia arenarii* Vicherek 1972, and alliances: *Koelerion glaucae* Volk. 1931 in the Sarmat region, *Festucion beckerii* Vicherek 1972 in the Pontic region, and *Festucion vaginatae* Soó 1940 in the Pannonian region (Mucina & Maglocký, 1985; Moravec et al., 1995; Mucina et al., 1993).

Mucina et Kolbek (1993) classify psammophytic thermophilous grassland communities to the class *Festuco-Brometea* Br.-Bl. et R. Tx. ex Klika et Hadač 1944, the order *Festucetalia vaginatae* Soó 1957, and the alliance *Festucion vaginatae* Soó 1940. They consider the order *Festuco-Astragaletalia arenarii* described by Vicherek to be a synonym of the order *Festucetalia vaginatae*. The transfer of the above mentioned order to the higher syntaxonomic unit was carried out on the basis of the floristic composition of the corresponding phytocoenoses.

Table 1. Phytosociological relevé from the locality Sandberg (NNR) Devínska Kobyla.

orientation: SW
Slope gradient: 20^0
Elevation: cca 190 m above sea level
Area: 25 m^2
Date: September 21, 2001
Cover: E = 85%

E_1 (80%):
Festuca pallens 3, *Sanguisorba minor* subsp. *polygama* 3, *Peucedanum arenarium* 2-3, *Teucrium chamaedrys* 2-3, *Petrorhagia saxifraga* 2, *Thymus praecox* 2, *Botriochloa ischaemum* 1-2, *Orthantha lutea* 2, *Achillea collina* 2, c. f. *Stellaria media* juv. 2, *Koeleria macrantha* 1, *Hypericum perforatum* 1, *Artemisia campestris* 1, *Chondrilla juncea* 1, *Dorycnium germanicum* 1, *Acetosella vulgaris* 1, *Verbascum lychnitis* 1, *Silene otites* ssp. *hungarica* 1, *Tithymalus cyparissias* 1, *Poa bulbosa* ssp. *vivipara* +, *Crataegus monogyna* juv. +, *Plantago lanceolata* ssp. *sphaerostachya* +, *Acosta rhenana* +, *Hieracium sabaudum* +, *Alyssum montanum* subsp.*gmelinii* +, *Linaria genistifolia* +, *Astragalus onobrychis* +, *Eryngium campestre* +, *Chamaecytisus austriacus* +, *Stipa capillata* +, *Allium flavum* +, *Asperula cynanchica* +, *Erysimum diffusum* +, *Crinitaria linosyris* +, *Orobanche alba* r, *Jurinea mollis* r
E_0 (max.10%):
Ceratodon purpureus 2, *Tortula ruralis* +,

The phytocoenoses settling warm, dry, sandy, and sunny habitats, are usually classified to the class *Festucetea vaginatae* Soó 1968 em. Vicherek 1972, order *Festuco-Astragaletalia arenarii* Vicherek 1972, and alliances: *Koelerion glaucae* Volk. 1931 in the Sarmat region, *Festucion beckerii* Vicherek 1972 in the Pontic region, and *Festucion vaginatae* Soó 1940 in the Pannonian region (Mucina & Maglocký, 1985; Moravec et al., 1995; Mucina et al., 1993).

Mucina et Kolbek (1993) classify psammophytic thermophilous grassland communities to the class *Festuco-Brometea* Br.-Bl. et R. Tx. ex Klika et Hadač 1944, the order *Festucetalia vaginatae* Soó 1957, and the alliance *Festucion vaginatae* Soó 1940. They consider the order *Festuco-Astragaletalia arenarii* described by Vicherek to be a synonym of the order *Festucetalia vaginatae*. The transfer of the above mentioned order to the higher syntaxonomic unit was carried out on the basis of the floristic composition of the corresponding phytocoenoses.

Peucedanum arenarium is considered as an important species of the alliances *Festucion vaginatae* Soó 1940, *Festucion valesiacae* Klika 1931, and *Danthonio-Stipion* Soó 1947 (Dostál, 1989), communities of alliances *Dicrano-Pinion* Libbert 1933, *Quercion pubescenti-petraeae* Br.-Bl. 1931. It is observed in *Geranion sanguinei* R. Tx. in Th. Müller 1961 (Grulich, 1997), and in the communities of light pine and oak forests with *Festuca dominii* (Hlavaček et al., 1984). On the last site of this species in Slovakia outside Sandberg, the community was classified to the association *Junipero-Populetum albae festucetosum vaginatae* Zólyomi ap. Soó 1957 (Kárpátiová et al., 1961). *Peucedanum arenarium* was present in only one relevé with + value.

The classification of the thermophilous grassland community on Sandberg, in which *Peucedanum arenarium* is relatively abundant, is not unambiguous (Tab. 1). The community includes a lot of diagnostic species of the class *Festuco-Brometea*: *Festuca pallens, Alyssum montanum* subsp. *gmelinii, Asperula cynanchica, Crinitaria linosyris, Teucrium chamaedrys, Thymus praecox, Stipa capillata, Eryn-*

Table 2. Selected morphometric characteristics of the *Peucedanum arenarium* species on the locality Sandberg (NNR Devínska Kobyla). II – a small sterile plant, III – a big sterile plant.

		No.	Mean	Median	Minimum	Maximum	Std.Dev.
Sterile plant	Number of leaves of 1year-old seedling	12	1.25	1.00	1.00	2.00	0.45
	Number of leaves of plant II	50	1.84	2.00	1.00	4.00	0.71
	Number of leaves of plant III	94	3.09	3.00	1.00	6.00	0.95
	Rosette diameter of plant II (cm)	8	17.63	16.50	13.00	23.00	3.38
	Rosette diameter of plant III (cm)	94	39.50	37.50	20.00	80.00	11.52
Fertile plant	Number of leaves in rosette	224	3.63	4.00	1.00	6.00	0.74
	Rosette diameter (cm)	223	49.21	50.00	18.00	95.00	13.21
	Plant height (cm)	233	82.90	79.00	18.00	168.00	28.95
	Number of inflorescences per plant (compound umbels)	231	25.28	21.00	3.00	116.00	16.11
	Number of secondary umbels in terminal inflorescence	226	10.50	10.00	1.00	29.00	4.21
	Number of flowers in umbels of terminal inflorescence	202	16.15	16.40	8.50	22.44	3.52
	Hypothetical number of seeds per plant	202	8419.32	6187.13	1536.00	39270.40	5418.83
	Fruit length (mm)	410	6.63	6.65	4.00	9.20	0.93
	Fruit width (mm)	410	3.84	3.90	2.10	5.90	0.74
	Mericarp weight (mg)	2329	6.19	6.37	2.00	15.12	2.57

gium campestre, Tithymalus cyparissias, Hypericum perforatum, Koeleria macrantha, Linaria genistifolia, Artemisia campestris, Allium flavum and others. On the contrary, from the species, that are typical for the class *Festucetea vaginatae*, the order *Festucetalia vaginatae*, or the alliance *Festucion vaginatae*, in the permanent square only *Peucedanum arenarium* has been found, and outside the area rarely the protected *Gypsophila paniculata*. On the square also the species *Festuca pallens, Sanguisorba minor* subsp. *polygama*, and *Teucrium chamaedrys*, which prefer the rocky sites to the sandy ones occur. Therefore, on the basis of the only one phytosociological relevé and contemporary literature knowledge, it is not possible to classify the vegetation with *Peucedanum arenarium* on Sandberg into the known syntaxonomic units. Though, based on the floristic structure, the vegetation is the most close to the communities of the alliance *Festucion valesiacae* KLIKA 1931. Except of the taxa of vascular plants shown in Table 1, there occur also other accompanying species: *Crepis foetida* subsp. *rhoeadifolia*, *Cynodon dactylon, Minuartia glaucina, Peucedanum oreoselinum,* and *Tithymalus seguierianus* subsp. *minor* (FERÁKOVÁ & GRULICH, 1999). The following mosses, lichens, and fungi were found: *Brachythecium albicans, Tortula intermedia, T. tortuosa, Geastrum schmidelii, Lentinus tigrinus, Marasmius oreades, Uromyces pisi, Cladonia fimbriata, Fungensia fungens* (ŠERÁ et al., 2000), *Lycoperdon perlatum*, and *Tulostoma brumale* (RIPKOVÁ, 2001, in litt.).

Morphology and life cycle

The results of the morphometric measurements of the observed species (Tab. 2) correlate with the data from floras (DOSTÁL, 1950, 1989; HLAVAČEK et al., 1984; GRULICH 1997), and show a relatively low variability (except of the number of produced mericarps).

It was possible to distinguish three age stages of the sterile plants (Fig. 1). There is a probability that the number of leaves in the rosette rises by one leaf per year. A seedling in the first year of its life has one real leaf, a small sterile plant two, a big sterile plant three, and a fertile plant has four leaves (Tab. 2). The life cycle is probably four-years long. This is probably a new information as the length of life was mentioned neither in the quoted floras from the region of former Czechoslovakia, or Yugoslavia, nor from Hungary, Bulgaria, Serbia, and Romania.

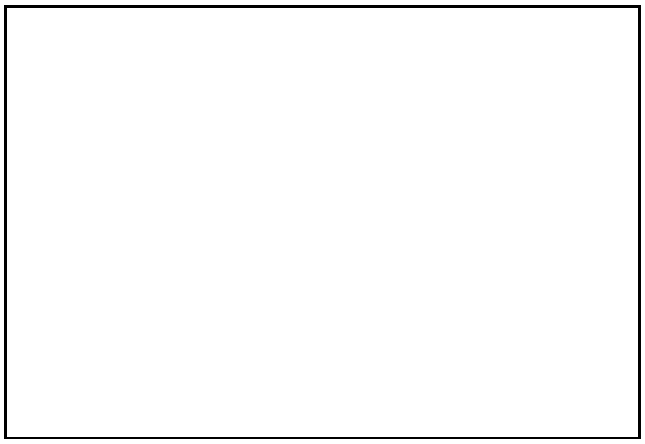

Fig. 1. Sterile growth phases of *Peucedanum arenarium* WALDST. et KIT. I one year old seedling, II small sterile plant – usually with two leaves, III sterile plant – usually with three leaves, one year before flowering.

Reproductive strategy

In the last year of its life, a monocarpic perennial comes to flower, and produces fruits. A big number of produced mericarps „compensates“ the preceding sterile years (FENNER, 1985). The reproductive capacity of the species *P. arenarium* of 202 fertile plants growing outside the permanent plot, was assessed at $8,419 \pm 5,419$ (mean $\pm$ SD) mericarps per plant. This number is hypothetical and expresses the maximum number of mericarps that can be produced by one fertile plant per year.

Table 3. Parametric analyses variance with multiple comparison among mericarp weight, which derivable from fruit terminal inflorescence (periphery, insite) and terminal inflorescence of lateral branches (periphery, insite) for *Peucedanum arenarium*. Tukey HSD test, data logarithmic calculation, significant differences are displayed in bold, $P < 0.001$.

			TP			
Terminal	Periphery	TP	1.000	TI		
	Insite	TI	0.848	1.000	LP	
Lateral	Periphery	LP	**0.001**	**0.000**	1.000	LI
	Insite	LI	0.854	0.997	**0.009**	1.000

In case of *P. arenarium* it is the number of mericarps for the whole life, as the species is monocarpic. The number of mericarps is generally considered very variable (e.g. SALISBURY, 1942).

The weight of mericarps of this species is also very variable (Tab. 2); the more light mericarps were probably insufficiently developed. A significant difference ($F = 5.508$, $P < 0.001$) was found in the average weight of mericarps of differently situated compound inflorescences (terminal inflorescences vs. end inflorescences of the minor branch), and also within one inflorescence (inner secondary umbels vs. outer ones). The heaviest mericarps were produced on the circumference of the terminal inflorescence of the minor branch (ca 6 mg). They contained vital seeds, and differed significantly from the weights of differently situated mericarps (Tab. 3). Mericarps from inner parts of the compound umbels were usually dead. This fact is probably connected with centripetal blooming of a compound umbel; the outer fruits maturing sooner. The sizes and maturity of mericarps in the fruit were all the same.

The seed material for germination experiment was collected at the site Sandberg always in September and October *P. arenarium* is luxuriantly fertile here. Since the end of October the dry stems bearing fruits break off, they are driven by wind (anemochory), and the fruits are gradually loosened. The mericarp germination was examined in the laboratory under various temperature conditions: after chilling, and after scarification. The abundance and speed of germination slightly increases after the scarification, which is similar as chilling generally recommended by e.g. HENDRY & GRIME (1993). Due to the very low percentage of germinating seeds (about 2%) no statistical evaluation was made. With regard to immaturity of embryos, the mericarps of the Apiaceae family germinate in only a narrow interval of temperatures (e.g. *Heracleum mantegazzianum* – LHOTSKÁ et al., 1987). Some pathogens and predators may be important factors for the production of viable mericarps and seed germination in the natural conditions. Further observations both in field and experimental conditions are necessary; e.g. the fruits often become attacked by mildew (BACIGÁLOVÁ & ZLOCHOVÁ, 2002, in litt.).

Table 4. Insects found on the plants of *Peucedanum arenarium* at the locality Sandberg (NNR Devínska Kobyla) in 2001.

Heteroptera: *Tingis clavicorne* (k), *Copium teucrii* (k), *Rhinocoris iracundus* (k), *Piesma quadrata* (k), *Peritrechus geniculatus* (k), *Megalonotus chiragra* (r),*Graphosoma lineatum* (k,s), *Sciocoris cursitans* (k), *Holcostethus vernalis* (k).
Auchenorrhyncha: Philaenus spumarius (s).
Coleoptera: Eusphalerum longipenne (k), *Anthophagus caraboides* (k), *Chaetopteroplia segetum* (k), *Cetonia aurata* (k), *Cidnopus pilosus* (k, s), *Rhagonycha fulva* (k), *Dermestes frischi* (k), *Anthrenus pimpinellae* (k), *Anthrenus verbasci* (k), *Trichodes apiarius* (k), *Celidus fasciatus* (k), *Meligethes aeneus* (k), *Olibrus aeneus* (k), *Phalacrus corruscus* (k), *Stilbus testaceus* (k), *Scymnus rubromaculatus* (k),*Propylea quatuordecimpunctata* (k), *Psyllobora vigintiduopunctata* (k), *Tomoxia bucephala* (k), *Variimorda mendax* (k), *Mordella aculeata* (k), *Mordellistena brevicauda* (k), *Morrdelochroa abdominalis* (k), *Oedemera podagrariae* (k), *Anthicus antherinus* (k), *Gonodera luperus* (k), *Isomira antennata* (k), *Podonta nigrita* (k), *Stenopterus flavicornis* (k), *Molorchus minor* (k), *Chlorophorus varius* (k, s), *Clytus arietis* (k), *Pachytodes cerambyciformis* (k), *Dorcadion fulvum* (r),*Dorcadion aethiops* (r),*Phytoecia cylindrica* (s), *Oulema gallaeciana* (k), *Gynandrophthalma affinis* (k), *Coptocephala rubicunda* (k), *Cryptocephalus sericeus* (k), *Cryptocephalus hypochoeridis* (k), *Timarcha goettingensis* (r),*Chrysolina sturmi* (r),*Chaetocnema concinna* (k), *Cassida nebulosa* (s), *Spermeophagus sericeus* (k), *Otiorhynchus raucus* (r),*Simo variegatus* (r),*Omias globulus* (r),*Trachyphloeus alternans* (r),*Trachyphloeus bifoveolatus* (r),*Trachyphloeus parallelus* (r),*Eusomus ovulum* (s), *Sciaphilus asperatus* (r),*Ceutorhynchus floralis* (k), *Ceutorhynchus obstrictus* (k).
Hymenoptera: Formica pratensis (s, k), *Priocnemis sulci* (k), *Priocnemis parvula* (k), *Arachnospila trivialis* (k), *Evagetes subnudus* (k), *Chrysis ignita* (k), *Chrysis cyanea* (k), *Chrysis iris* (k), *Chrysis gracilima* (k), *Omalus auratus* (k), *Cleptes splendens* (k), *Holopyga imflamata* (k), *Hedychridium lampadum* (k), *Tiphia femorata* (k), *Polystes gallicus* (k).
Diptera: Cheilosia ilustrata (k), *Epistrophe bifasciata* (k), *Chrysotoxum bicinctum* (k), *Graphomyia maculata* (k), *Rhodogyne rotundatum* (k).

Note: the species were found on flowers and fruits (k), stems and leaves (s), and at the roots (r).

Relationship to insects (visitors and pollinators)
In various stages of development 86 species of 5 orders of insects were found on the plants. Out of this number, 70 species were recorded on the flowers, 8 species on the stems and leaves, and 12 species in the rhizosphere (Tab. 4). Species of mainly *Curculionidae* family (7 species) were found associated with the roots. Regarding the fact that some species are polyphagous (*Otiorhynchus raucus, Sciaphilus asperatus*), their feeding on the roots of *P. arenarium* is probable. Unfortunately it was not possible to show a direct relation between the damage of the root system and these species. For the sucking species of cicadas (*Philaenus spumarius*) parasiting on the stems and leaves it is not possible to exclude the transfer of virus diseases. On the shoots of *P. arenarium* the species *Phytorcia cylindrica* was found. The development of the larvae of this species is possible inside the stalks of the plant, with regard to their occurrence on species of other genera of the Apiaceae family (e.g. *Chaerophyllum, Anthriscus, Her-*

acleum, Bupleurum, Daucus). Larvae of this species were not identified from the stalks, but there were mining pupas found in the winter season. The majority of insect species were found on the flowers and partly on past flowering inflorescences. Fructophagous species (feeding on mericarps) of the Heteroptera order: *Tingis clavicorne, Copium teucrii* and *Graphosoma lineatum* were dominant. Generally, these species preferably suck on fruits. The majority of other species were polinophagous (feeding on pollen); mainly the representatives of the order *Coleoptera*: *Rhagonycha fulva, Coptocephala rubicunda*. For the majority of these individuals, the transfer of pollen from one plant to another one can be expected.

A specific group comprised zoophagous species that occasionally feed on nectar. This group includes mainly the family *Chrysididae*, that favour flowers of the Apiaceae family. On the inflorescences of *P. arenarium* the occurrence of the following genera was recorded: *Priocnemis, Arachnospila, Evagetes, Chrysis, Omalus, Cleptes, Holopygia*, and *Hedychridium*. *Tiphia femorata*, feeding on flowers, was a dominating species. Fauna of the soil insects at the locality Devínska Kobyla was treated in detail by KORBEL et al. (1997).

Acknowledgements

The team of authors would like to thank all the workers of The State Nature Protection of the Slovak Republic, The Regional Administration in Bratislava, who were very helpful with the field work and data collection, and Dagmar SIMEK for her linguistic assistance. We are very obliged to Iva HODÁLOVÁ for her help with final manuscript arrangement. The Recovery Programme of *Peucedanum arenarium* – the critically endangered and protected species of the Slovak flora, was financially supported by The Ministry of Environment of the Slovak Republic, and The Centre of The State Nature Protection in Banská Bystrica.

References

CHAMBERLAIN, D. F. 1972. *Peucedanum* L., pp. 473–481. In: DAVIS, P. H. (ed.), Flora of Turkey and the East Aegean Islands, Edinburgh University Press, Edinburgh.

DEGEN, A., GAYER, J. & SCHEFFER, J. 1923. Magyar láptanulmányok. Ungarische Moorstudien. I. A detrekőcsütörtöki láp és Morvamező keleti részének Flórája. I. Die Flora des Detrekőcsütörtöker Moores und des östlichen Teiles des Marchfeldes. Magyar Bot. Lapok **22:** 1–116.

DIHORU, G. & DIHORU, A. 1994. Plante rare, periclitate şi endemice in flora Romaniei – lişta roşie. Acta Botanica Horti Bucureştiensis Lucrările gradinii botanice 1993 – 1994, Bucureşti, pp. 173–197.

DOSTÁL, J. 1950. Květena ČSR 1, 2. Přírodovědecké nakladatelství, Praha, 2269 pp.

DOSTÁL, J. 1989. Nová květena ČSSR 1. Academia, Praha, 758 pp.

FENNER, M. 1985. Seed ecology, Chapman and Hall, London, 151 pp.

FERÁKOVÁ, V. & GRULICH, V. 1999. *Peucedanum arenarium* WALDST. et KIT., p. 277. In: ČEŘOVSKÝ J., Feráková V., Holub J., Maglocký Š. & Procházka F., Červená kniha ohrožených a vzácných druhů rostlin a živočichů ČR a SR. 5. Vyšší rostliny, Príroda a. s., Bratislava.

FERÁKOVÁ, V., MAGLOCKÝ, Š. & MARHOLD, K. 2001. Červený zoznam papraďorastov a semenných rastlín Slovenska (december 2001). In: BALÁŽ, D., MARHOLD, K. & URBAN, P. (eds), Červený zoznam rastlín a živočíchov Slovenska. Ochr. Prír., Supl., **20:** 44–77.

FERÁKOVÁ, V., MICHÁLKOVÁ, A., ONDRÁŠEK, I., PAPŠÍKOVÁ, M. & ZEMANOVÁ, A. 1994. Ohrozená flóra Bratislavy. Edícia APOP, Príroda a. s., Bratislava, 69 pp.

FERÁKOVÁ, V. & MURÍN, A. 1976. [Report]. In: LÖVE, Á. (ed.), IOPB Chromosome number reports LIII. Taxon **25:** 491.

FERÁKOVÁ, V. & KOCIANOVÁ, E. (eds) 1997. Flóra, geológia a paleontológia Devínskej Kobyly. Edícia APOP, LITERA, Bratislava, 190 pp.

GRULICH, V. 1997. *Peucedanum* L., pp. 406–418. In: SLAVÍK, B. (ed.), Květena České republiky. 5, Academia, Praha.

HENDRY, G. A. F. & GRIME, J. P. (eds) 1993. Methods in comparative plant ecology. A laboratory manual. Chapman & Hall, London, 252 pp.

HLAVAČEK, A., JASIČOVÁ, M. & ZAHRADNÍKOVÁ, K. 1984. *Peucedanum* L., pp. 336–351. In: BERTOVÁ, L. (ed.), Flóra Slovenska IV/1, Veda, Bratislava.

HOLMGREN, P. K., HOLMGREN, N. H. & BARNETT, L. C. 1990. Index herbariorum. Part II. Herbaria of the world. Ed. 8. Regnum Veg. **120**: 1–693.

KÁRPÁTIOVÁ, V., KÁRPÁTI, I., KRIPPELOVÁ, T. & KRIPPEL, E. 1961. Spoločenstvo topoľa bieleho a borievky obyčajnej pri Štúrove. Biológia, Bratislava, **16:** 481–491.

KOCIANOVÁ, E. 1995. Osobitné režimy ochrany (ORO) vybraných ohrozených druhov rastlín na území Bratislavy, pp. 21–22. In: BRINDZA, J. (ed.), Ochrana biodiverzity rastlín, VŠP, Nitra.

KOCIANOVÁ, E. 1999. Mapovanie kriticky ohrozeného druhu smldníka piesočného na Sandbergu v NPR Devínska Kobyla. Chránené územia Slovenska **42:** 6.

KORBEL, L., RYCHLÍK, I. & MAJZLAN, O. 1997. Epigaeic beetles (*Coleoptera*) of the Devínska Kobyla hill (the Malé Karpaty Mts. SW Slovakia). Biologia, Bratislava, **52/2:** 263–272.

KUZMANOV, B. A., ANDREEV, N. & GEORGIEVA, S. 1977. [Report]. In: LÖVE, Á. (ed.), IOPB Chromosome number reports LVII. Taxon **26:** 448.

LHOTSKÁ, M., KRIPPELOVÁ, T. & CIGÁNOVÁ, K. 1987. Ako sa rozmnožujú a rozširujú rastliny. Obzor, Bratislava, 392 pp.

MARHOLD, K. & HINDÁK, F. (eds) 1998. Checklist of non-vascular and vascular plants of Slovakia. Veda, Bratislava, 687 pp.

MELOUN, M. & MILITKÝ, J. 1994. Statistické zpracování experimentálních dat. Edice Plus, Praha, 839 pp.

MIKEŠ, J. 1938. Kvetena okresu bratislavského a malackého. Vlastiv. Sborn. Okr. Bratislavského a Malackého **3:** 29–176.

MILTON, J. S. 1992. Methods in the biological and health sciences. Mc Graw Hill, Hightstown, 526 pp.

MORAVEC, J. et al. 1995. Rostlinná společenstva České republiky a jejich ohrožení. Severočeskou Přír., pp. 3–110.

MUCINA, L. &KOLBEK, J. 1993. Festuco-Brometea, pp. 420–492. In: MUCINA, L., GRABHERR, G., ELLMAUER, T., Die Pflanzengesellschaften Österreichs. Teil 1. Anthropogene Vegetation, Gustav Fischer Verlag, Jena, Stuttgart, New York.

MUCINA, L. & MAGLOCKÝ, Š. (eds) 1985. A list of vegetation units of Slovakia. Doc. Phytosoc. N. S. **9:** 175–220.

MUCINA, L., GRABHERR, G. & ELLMAUER, T. 1993. Die Pflanzengesellschaften Österreichs. Teil 1. Anthropogene Vegetation. Gustav Fischer Verlag, Jena, Stuttgart, New York, 578 pp.

Order No. 36/1993 of the Ministry of the Environment of the Hungarian Republic: Magyar Közlöny, 1993/36 szám. A környezetvédelmi és területfejlesztési minister 12/1993. (III. 31.) KTM rendelete a védett és fokozottan védett növény –

és allatfajokról, egyedeik értékéről, a fokozottan védett barlangok körének megállapításáról, valamint egyes védett állatfajokkal kapcsolatos korlátozások és tiltalmak alóli felmentésekről szóló 1/1982. (III. 15.) OKTH rendelkezés módosításáról. 1. Számú melléklet az 1/1982. (III. 15.) OKTH rendelkezéshez. Védett növények – jegyzéke oldal szám 2003 – 2015.

Order No. 24/2003 of the Ministry of the Environment of the Slovak Republic: Vyhláška Ministerstva životného prostredia Slovenskej Republiky z 29 januára 2003, ktorou sa vykonáva zákon č. 543/2002 z. z. o ochrane prírody a krajiny. Príloha 4. 5 Zoznam chránených rastlín, prioritných druhov rastlín a ich spoločenská hodnota. Zbierka zákonov, č. 24/2003, čiastka 13.

Procházka, F. (ed.) 2001. Černý a červený seznam cévnatých rostlin České republiky (stav v roce 2000). Příroda, Praha, **18:** 1–166.

Pyšek, P., Kučera, T., Puntiery, J. & Mandák, B. 1995. Regeneration in *Heracleum mantegazzianum* – response to removal of vegetative and generative parts. Preslia **67:** 161–171.

Salisbury, E. J. 1942. The reproductive capacity per plants. Bell and Sons, London, 244 pp.

Svobodová, Z. 1988. Nové nálezy cievnatých rastlín na Slovensku I. Bull. Slov. Bot. Spoločn., Bratislava, **10:** 6–11.

Šerá, B. & Kocianová, E. 2000. Příspěvek k biologii smldníku písečného (*Peucedanum arenarium* Waldst. et Kit.), pp. 145–152. In: Eliáš, P. (ed.), Plant population biology VI, SEKOS, Bratislava, Nitra.

Šerá, B., Kocianová, E. & Feráková, V. 2000. *Peucedanum arenarium* – sledování druhu v SR a jeho možná repatriace v ČR. In: Botanický výzkum a ochrana přírody, Pracovní konference ČBS, 24.–25. 11. 2000, Praha.

Todor, I. 1958. *Peucedanum* L., pp. 575–609. In: Săvulescu, T. (ed.), Flora republicii populare Romîne, Editura Academii republicii populare Romîne, Bucureşti.

Vágenknecht, V. 1993. Návrh osobitného režimu ochrany smldníka piesočného – *Peucedanum arenarium* Waldst. et Kit. 5 pp., Msc. (Depon. in: SAŽP Bratislava).

Vasilyeva, M. G., Retina, T. A. & Pimenov, M. G. 1981. Chromosomal figures of some Umbelliferae of the Caucasus and the south of the European part of the USSR. Biol. Nauk SSSR **207:** 60–65.

Received July 9, 2003
Accepted Oct. 12, 2004

Biologia, Bratislava, **60**/1: 23–24, 2005

Book Review

Jonsell B. (ed.), Flora Nordica 1. Lycopodiaceae – Polygonaceae. The Bergius Foundation, The Royal Swedish Academy of Sciences, Stockholm, 2000, 368 pp., with 111 figures and maps for 256 taxa. Price 75 EUR. ISBN 91-7190-033-0.
Jonsell B. (ed.), Flora Nordica 2. Chenopodiaceae – Fumariaceae. The Bergius Foundation, The Royal Swedish Academy of Sciences, Stockholm, 2001, 455 pp., with 154 figures and maps for 367 taxa. Price 82 EUR. ISBN 91-7190-037-3.
Jonsell B. (ed.), Flora Nordica. General Volume. The Bergius Foundation, The Royal Swedish Academy of Sciences, Stockholm, 2004, 287 pp., with 105 figures (maps, photos and drawings). Price 48 EUR. ISBN 91-7190-042-X.
Distribution: Koeltz Scientific Books, P.O. Box 1360, Koenigstein, Germany,
e-mail: koeltz@t-online.de, fax: +49 6174937240. Information on the project of Flora Nordica: http://www.bergianska.se/stift/floran/

So far published volumes of Flora Nordica are part of a large and ambitious project covering all wild-occurring vascular plants of Northern Europe ("Norden") including Denmark, Faroes Islands, Finland, Iceland, Norway, Sweden and arctic islands (Bear Island, island of Jan Mayen and Svalbard).

The General volume, published as the third one in order, deals with several general topics. In the chapter Flora written in Norden you find interesting information on historical background: firsts herbals and forerunners, Carl Linnaeus, first floras in each particular country / region, important taxonomic and phytogeographical studies. Among many outstanding people studied the Norden flora from many aspects (geography, ecology, taxonomy) you would find the name of famous Czech botanist and ecologist, Emil Hadač (1914–2003). He carried out his pioneer works on flora and vegetation of SW Iceland and Svalbard in 1930s and 1940s and he was the first who introduced the method of Zürrich-Montpellier phytosociological school into the Arctic. Concerning the name of Hadač, there is one minor mistake. An incorrectly included text "Franziskov Lazne" is in the Index of personal names (pp. 34–36) after Hadač's surname. It is not a part of his name, nor a place of birth. But the fact is that Hadač was a director of the State institute for peloids research in the city of Františkovy Lázně, Czech Republic from 1948–1953 (cf. Rejmánek et al. 2004).

Second chapter is the general overview of environmental and vegetation features of Norden (climate, bedrock, calcareous sites, seashores, inland water biotopes, mires, forests, mountain and alpine vegetation, floristic elements, regional zonation). A good attention is paid to the major phenomenon influencing the present state distribution of vascular plant flora in Fennoscandia – the Pleistocene glaciation. A special part is devoted to men's impact on variety of biotopes (peat lands, forests, etc.), introduction of alien plants and genetic contamination. Surveys of plant protection within each country are briefly included in the

following chapter. The focus is on the species protection, while the habitat preservation is discussed in lesser extent. Some important legislation sources, red lists, red books, and interestingly the data on some non-governmental organisations are also given. Only the last ca 10000 years in Norden was favourable for vegetation development. In this respect, the flora of this region is very young which is documented by very low level of endemism (in the chapter named Endemic vascular plants in Norden). Just 2 taxa at species level are considered as good examples of highly distinct, non-hybrid endemic taxa (*Euprasia bottnica* and *Puccinelia finmarchica*). Most part of listed taxa belong to the lower ranks (subspecies, or even variety), or to the agamospermic groups (e.g. *Alchemilla*, *Potentilla*, *Sorbus*, the largest groups like *Hieracium*, *Ranunculus auricomus* agg., *Taraxacum* were excluded). Surprisingly, some hybrids of recent origin are also evaluated as endemic, which is more exception than a rule in recent national floras or checklists. In following chapter (Principles and conventions) main principles used in special taxonomic volumes 1 and 2 are briefly described and explicated. An outline of recent standard literature (checklists, floras, field keys, maps, chromosome atlas) used in each particular country / region, and detailed account on Nordic herbaria (altogether 40 public herbarium collections) are given in separate parts. As a rule in modern flora, the botanical terms with short definition, and the equivalents in the Nordic languages are added also. In the whole book there is high number of well-prepared maps and high quality black-white or colour photographs which makes the general volume very illustrative. The general volume as well as the special volumes 1 and 2 are concluded by comprehensive list of cited literature.

Two special volumes published up to now covers ca 800 species belonging to 52 families. All wild occurring taxa, as well as the most important cultivated plants (in agriculture, forestry or as ornamental plants) are included. The strictly dichotomous keys for genera and species based on main diagnostic characters are applied. The most important information is linked with species entries. The nomenclature contains the accepted name, basionym with a direct reference to the place of original publication, synonyms used in different Nordic floras, common vernacular names used in focused countries / regions. The information on type material originated from Norden is very valuable: an indication of herbarium, herbarium number and the exact publication of the place of selected type are given. In the case of extra Nordic material, the name of a country from where the taxon was described is usually included. After the nomenclatural part, a description necessary for accurate identification with the indication of life form according to Raunikiaer and flowering / sporulation time follows. The chromosome numbers based on Nordic plant material are given with the code of country and province and the counts made on extra Nordic material are given in brackets. Distribution (both in Norden and general) is shown in the text part and for many taxa illustrative dot maps (status and occurrence) are displayed in 88 Nordic provinces also. Further important notes concern the habitat preferences and variation, and if necessary the biology, taxonomy, hybridisation and hybrids are discussed also. It should be stressed that the information in above-mentioned characteristics is usually very detailed with many peculiarities, opening new views, hypothesis, stimulating discussion. Where it is useful, the descriptions are supplemented by high quality black-white drawings. In some cases the plant parts carrying important diagnostic characters are presented in photos, e.g. from scanning electron microscopy: spores – *Cystopteris* or seed of selected *Chenopodium*, *Montia* and *Stellaria* taxa.

Editor in chief, Bengt Jonsell, editorial committee representing by prominent botanists from relevant countries, national advisors, editorial staff, authors and illustrators contributed much to the exceptional scientific quality of presented volumes. In my opinion, the so far published part of Flora Nordica, is one of the top European books in flora considering the amount and quality of information and the quality of formal presentation, which is all in English. Because the long term Flora Nordica project is planned in 14 volumes (!), I wish all the best for the editor and all the people who will contribute in various ways to the next volumes, to complete the Flora Nordica as soon as possible and ... to have enough financial sources. It is not so easy in present, because the botanists are pushed to publish the results of their research in impact journals and monographic works like floras seem to be a marginal product. However, the floras, field keys or checklists at various levels (regional, national, supranational) have their own stable and not alternative position in documenting biodiversity as any other type of work.