Populations of species of *Pilosella* in ruderal habitats in the city of Prague: frequency, chromosome numbers and mode of reproduction

Populace druhů rodu *Pilosella* na ruderálních stanovištích v Praze: frekvence výskytu, počty chromozomů a způsob rozmnožování

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Populations of *Pilosella* (*Hieracium* subgenus *Pilosella*) at ruderal localities were investigated in an urban area (Prague City) with respect to their distribution, variation in DNA ploidy level/chromosome number and mode of reproduction. The following species, hybridogenous species or hybrids (with ploidy level/chromosome number and mode of reproduction) were found: *P. aurantiaca*, *P. caespitosa* (4x, 5x), *P. cymosa* subsp. *vaillantii* (5x), *P. officinarum* (2n = 36, sexual; 2n = 54, sexual; 2n = 63), *P. piloselloides* subsp. *bauhinii* (2n = 45, 54; both apomictic), *P. piloselloides* subsp. *praealta* (5x; apomictic), *P. brachiata* (4x; sterile), *P. densiflora*, *P. flagellaris*, *P. floribunda*, *P. erythrochrista*, *P. glomerata* (5x; apomictic), *P. leptophyton* (5x; apomictic), *P. rothiana* (4x, apomictic), *P. setigera*, *P. visianii* (4x; apomictic), *P. ziziana* (4x, apomictic) and the previously undescribed hybridogenous type *P. piloselloides* × *P. setigera* (5x, apomictic). *Pilosella visianii* is reported from the Czech Republic for the first time. New habitats resulting from highway construction are suitable for *Pilosella* species. Many previously rare types, such as *P. rothiana,* can colonize these habitats and spread, not only locally, but also throughout the whole country.

K e y w o r d s: chromosome numbers, DNA ploidy level, *Pilosella*, reproductive mode

Introduction

Plant species richness in cities is usually greater than in surrounding areas due to the greater habitat diversity there, which is a result of more variable land use and enrichment by alien species (e.g. Sukopp & Werner 1983, Pyšek & Pyšek 1990, Kühn et al. 2004). The distribution of many species changes considerably in time due to the temporary nature of many habitats, succesional changes, and various kinds of disturbances. Detailed inventories of species diversity are thus of great importance for understanding species and community dynamics in human settlements.

In the genus *Pilosella* Vaill. there are both diploid (sexual) and polyploid (sexual or facultatively apomictic) perennials, whose seed is dispersed by wind, and which frequently hybridize and commonly spread vegetatively by means of stolons (Krahulcová et al. 2000, Fehrer et al. 2007). These plants prefer open habitats, such as grasslands, heaths, herbaceous fringes and rocky outcrops. Diploids are usually confined to more natural, sometimes relic habitats. Polyploid species, both basic and intermediate (hybridogenous) species often occur in man-made habitats, which have a more or less extensively disturbed vegetation cover and where competition is low, e.g. railways, roadsides and slopes along roads (e.g. Heinrichs 1998, Dunkel et al. 2007). The number of suitable localities in the rural landscape is decreasing, mostly due to either fertilization and subsequent increase in competition from more productive species or the abandonment of grasslands and consequent succession. However, these tendencies are based only on casual observations. They are documented very rarely at a landscape level, e.g. by Heinrichs & Gottschlich (1996) and Gottschlich et al. (2004, 2006).

For this reason, it was decided to study the diversity of *Pilosella* in an urban landscape. After a pilot study, all the morphologically distinguishable types were collected at selected localities and their chromosome numbers/DNA ploidy level and mode of reproduction (sexuality vs. apomixis) determined. Both these parameters are of crucial importance to *Pilosella* and information on them may help clarify the evolutionary potential of particular species/types and indicate why some of them are thriving, whereas others are in danger of disappearing. A detailed population study might also elucidate the hybridization processes (generally common in this genus), the fate of hybrid progeny and the role of basic (non-hybridogenous) species and habitat condition in determining the structure of mixed populations. The data set will enable future students to evaluate more precisely the changes in the distribution and frequency of particular species and changes in population composition. For that reason all species occurring at the localities studied are listed, even if their mode of reproduction and chromosome numbers/DNA ploidy level were not studied. However, this contribution definitively does not provide a comprehensive list of *Pilosella* localities in the area studied.

Remarks on the taxonomic concept

For a long time, *Pilosella* was treated in central European literature as a subgenus within *Hieracium* (Nägeli & Peter 1885; Zahn 1922–1930). In fact, we consider it, in agreement with many other authors, as an independent genus, but in our previous papers we used the traditional classification as a subgenus, because several names were not valid within *Pilosella*. The full list of species in the recent paper by Bräutigam & Greuter (2007) is used in this study. However, in all cases where the respective species is given in the Flora of Czech Republic (Chrtek 2004) we refer to names within *Hieracium*.

Area studied

The city of Prague is situated in the center of the Bohemian basin, occupies 496 km^2 and is at an altitude of 177 m in the Vltava valley in the north to 399 m near Zličín on the west. Within the Czech Republic, the climate is warm, with an average annual temperature of 9.4 °C in the town center to 7.8 °C at Ruzyně. Winter is usually without or with very irregular snow cover. The geology in the area of the city is diverse, with extremely acid lydites and sandstones to extremely base rich rocks, such as lime stones and marls. Their age is Proterozoik to Mesozoik, but there are deep loess deposits in many places, which cover bedrock and suppress its influence. Bedrock has a greater influence at many places along railways and highways, especially where they are situated in trenches. On the other hand, the embankments are often made from completely different material, the extreme being pure sand. It is impossible to characterize the composition briefly. More information about the environmental conditions, history and vegetation cover can be found, e.g. in books by Moravec et al. (1991) and Kovanda (1995).

Within the city of Prague, the number of new habitats is increasing because of the building of new highways and an extensive road network. Along these new roads there are areas with different habitat conditions (differing especially in exposition and for that reason also in moisture, temperature etc.). These habitats mostly consist of open soil surfaces, which are quickly colonized by seedlings and populations. *Pilosella* species are especially good invaders of these habitats, because their seeds are dispersed by wind and the air currents caused by traffic.

Material and methods

Plant material

Living plants were collected at 49 localities (mostly along roads and railways, see Appendix 1, Fig. 1), with most collected in 2002 and 2003, but occasionally also in other years in this decade. They were transplanted to the experimental garden of the Institute of Botany in Průhonice and used for determining chromosome number/ploidy level and mode of reproduction. Voucher specimens of cultivated plants together with numerous specimens collected in the field are deposited in the herbarium PRA. Both the taxonomic concepts and nomenclature follow Bräutigam & Greuter (2007).

Determination of chromosome number, DNA ploidy level and mode of reproduction

Chromosomes were counted in root-tip meristems of pot-grown plants following the method described in Krahulcová & Krahulec (1999). DNA ploidy level (Suda et al. 2006) was determined using flow cytometry, following the method of Krahulcová et al. (2004). As an internal standard karyologically examined plants cultivated in the experimental garden were used.

Mode of reproduction was determined by comparing the seed set of open pollinated and emasculated (cut) capitula (Gadella 1984, Krahulcová & Krahulec 1999). The plants, which did not produce any achenes when open pollinated, were considered to be sterile, those of which the open pollinated capitula produced achenes, but not the emasculated ones were considered to be sexual. The plants on which the emasculated capitula produced achenes were considered to be apomictic (agamospermous). For *P. ziziana* and *P. piloselloides – P. setigera* we used the FCSS method (Matzk et al. 2000, Krahulcová & Rotreklová 2010).

Isozyme analysis

Isozyme analysis was used to estimate the genotype (isozyme phenotype) structure of *P. visianii*, which is a rather common but previously unrecorded species for the Czech Republic. Methods used are described in detail by Krahulec et al. (2004); two systems were used in 2004, aspartate aminotrasferase (AAT) and esterase (EST). Esterases are

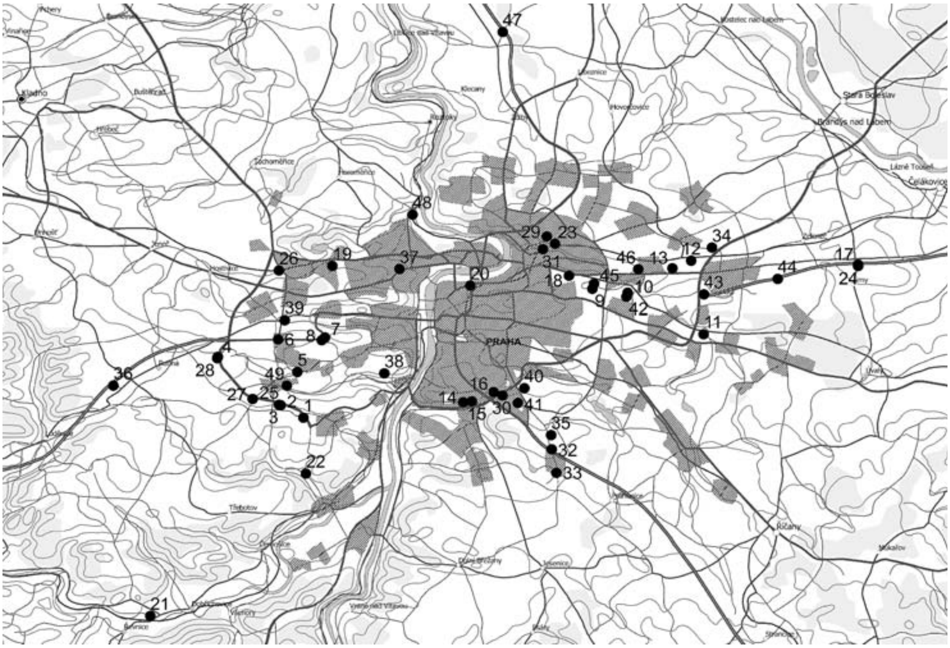


Fig. 1. – Map of Prague indicating the localities studied.

highly variable and are valuable for clone determination in the genus *Pilosella* (Krahulec et al. 2004). For estimating *P. rothiana* and *P. visianii* clones four systems (AAT, 6-PGDH, LAP and EST) were used in 2010.

Overview of species

Altogether, five basic species (one with two subspecies) and 11 intermediate species were found at 49 localities (see Appendix 1 and Fig. 1). They are briefly commented on below. Figures in brackets following locality number indicate number of plants studied.

B a s i c s p e c i e s

Pilosella aurantiaca (L.) F. W. Schultz & Sch. Bip. subsp. *aurantiaca*
(syn.: *H. aurantiacum* L.)

This species was found only once (loc. 28) and has not been studied. No hybrids of *P. aurantiaca* were found along the new roads.

Pilosella caespitosa (Dumort.) P. D. Sell & C. West (syn.: *H. caespitosum* Dumort.)

Localities: 9, 12, 24, 30, 47.
DNA ploidy level **4x:** loc. no. 24 (10 plants); loc. 47 (3 plants).
DNA ploidy level **5x:** loc. no. 24 (1 plant).

Pilosella caespitosa occurs rarely in the area studied. The estimated ploidy levels correspond to two clones known from Central Europe (Fehrer et al. 2005).

Pilosella cymosa subsp. *vaillantii* (Tausch) S. Bräutigam & Greuter (syn: *Hieracium cymosum* subsp. *cymigerum* Peter)

Locality: 47
DNA ploidy level **5x:** locality no. 47 (2 plants).

Numerous chromosome counts are published for *H. cymosum*, ranging from diploids to hexaploids (see Rotreklová et al. 2005 for references). However, they only rarely directly refer to *P. cymosa* subsp. *vaillantii* (*H. c.* subsp. *cymigerum*): 2n = 4x (Fehrer et al. 2005) for plants from the Krušné hory Mts, Czech Republic) and 2n = 4x, 2n = 54 (Marhold et al. 2007) for those from the Nízke Tatry and Veľká Fatra Mts, Slovakia. Chrtek (2004) gives tetra– and pentaploids of this subspecies in the Czech Republic.

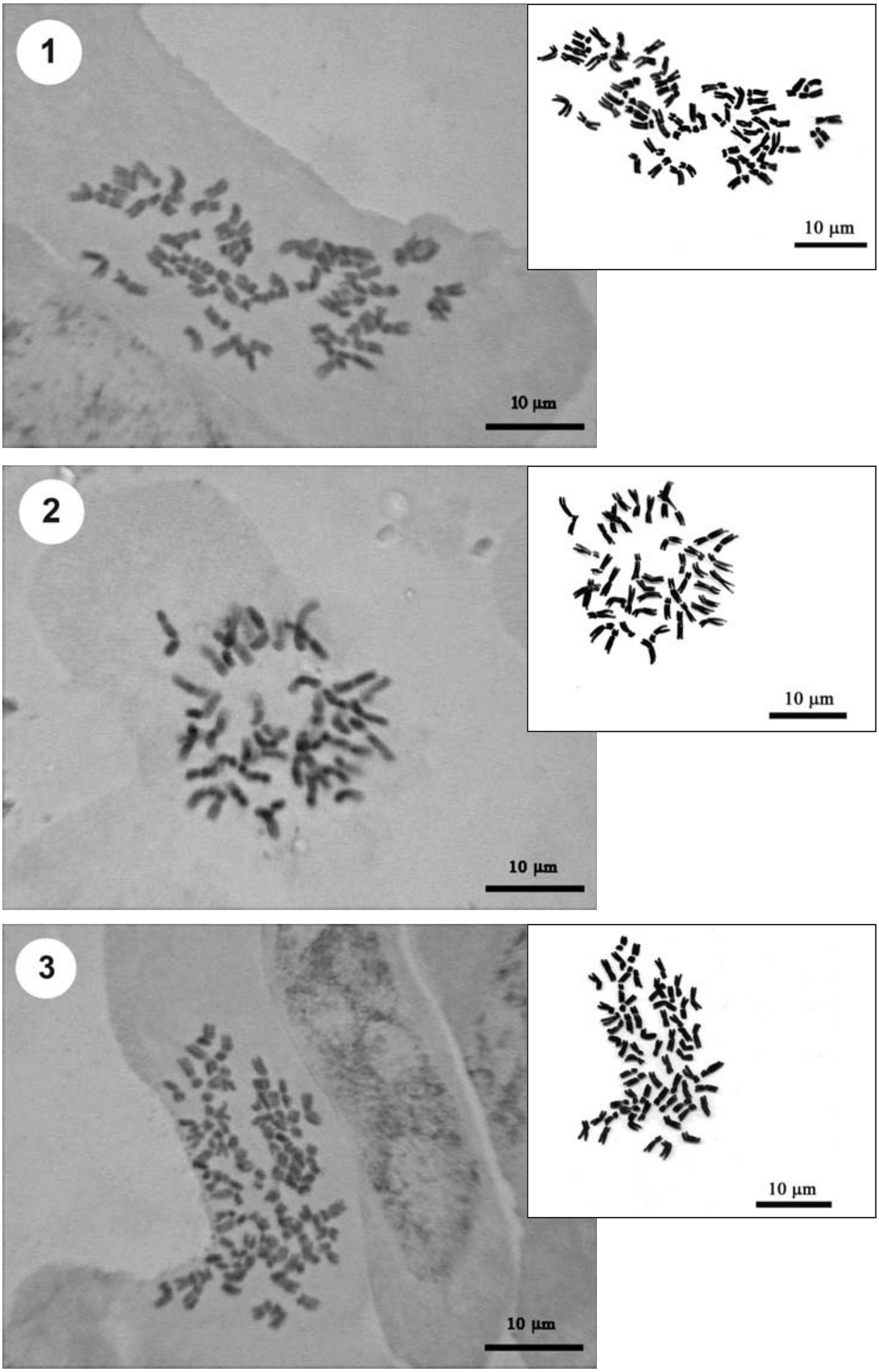
Pilosella officinarum Vaill. (syn.: *Hieracium pilosella* L.)

Localities: 6, 9, 10, 12, 15, 21, 24, 25, 31, 32, 33, 37, 38, 42, 44, 45.
DNA ploidy level: **4x** (46 plants); locality no. 6 (5), 9 (11 plants, 2n = 36), 10 (9), 15 (5), 21 (2), 24 (1), 25 (2), 32 (2), 44 (1), 45 (8).
Mode of reproduction, sexual (44 plants): locality no. 6 (5), 9 (11), 10 (9), 15 (5), 21 (2), 25 (2), 32 (2), 45 (8).
DNA ploidy level **6x**: locality no.12 (6 plants, 2n = 54, Fig. 2).
Mode of reproduction, sexual: locality no.12 (1 plant).
2n = **7x** = 63: locality no. 12 (1 plant, Fig. 2); mode of reproduction not specified.
The flow cytometry histogram for all three cytotypes (tetraploid, hexaploid and heptaploid) is presented in Fig. 3.

Pilosella officinarum is the second most common species found in the area studied (recorded at 16 localities). For this species in Prague, three ploidy levels were detected. The most common were populations of sexual tetraploid plants (2n = 4x = 36). Krahulcová et al. (2009) report tetraploid (2n = 4x = 36) and pentaploid (2n = 5x = 45) plants at Vysočany, loc. 31; both of which were sexual. A rich population of hexaploid (2n = 54) plants, undoubtedly identical with those previously collected in the canyon of the Vltava river (Mráz et al. 2008), was discovered at one locality. One heptaploid plant (2n = 7x = 63) was detected within this hexaploid population; it is probably a 2n + n hybrid between tetraploid and hexaploid cytotypes. There was only a single plant of this heptaploid and it was not recollected during repeated visits to this locality (T. Urfus, pers. comm.). In this respect it is similar to the individual heptaploid plants found in Slovakia (Mráz et al. 2008). The mode of reproduction of this single heptaploid plant was not determined as the plant grew badly and did not survive cultivation in the experimental garden.

Pilosella piloselloides subsp. *bauhinii* (Schult.) S. Bräutigam & Greuter (syn.: *Hieracium bauhinii* Schult.)

Localities: 1, 3, 4, 5, 6, 7, 8, 9, 10, 12, 13, 14, 15, 16, 17, 18, 19, 20, 22, 23, 24, 25, 26, 28, 29, 30, 31, 34, 35, 36, 40, 41, 44, 47.
DNA ploidy level **5x** (35 plants): locality no. 1 (1 plant, 2n = 45, Fig. 3), 3 (5 plants, 2n = 45), 5 (3), 8 (2), 9 (3 plants, 2n = 45), 10 (1), 22 (5), 24 (1), 25 (3 plants, 2n = 45), 26 (2), 28 (2 plants, 2n = 45), 44 (4), 47 (4).
Mode of reproduction apomictic (34 plants): locality no. 3 (5), 5 (5), 6 (2), 8 (2), 9 (3), 10 (1), 22 (5), 25 (3), 26 (2), 28 (2), 44 (4).
DNA ploidy level **6x** (32 plants): locality no. 10 (1), 14 (7 plants, 2n = 54, Fig. 3), 15 (6 plants, 2n = 54), 17 (5), 19 (2 plants, 2n = 54), 30 (10 plants, 2n = 54).
Mode of reproduction, apomictic (32 plants): locality no. 10 (1), 14 (8), 15 (6), 17 (5), 19 (2), 30 (10).
The flow cytometry histogram for both cytotypes is presented in Fig. 3.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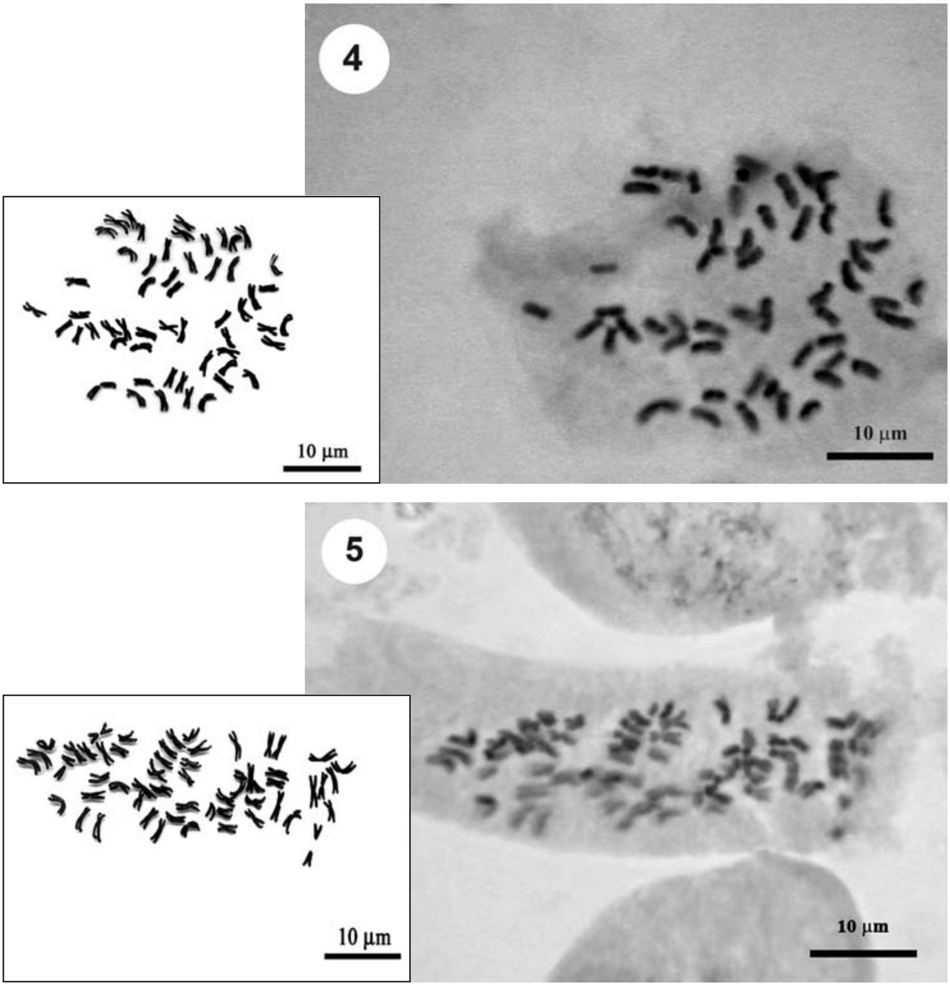

Fig. 2. – Microphotographs of somatic metaphases of selected *Pilosella* species and explanatory drawings. 1 – *P. officinarum* (2n = 63, heptaploid cytotype), 2 – *P. piloselloides* subsp. *bauhinii* (2n = 45, pentaploid cytotype), 3 – *P. officinarum* (2n = 63, heptaploid cytotype), 4 – *P. piloselloides* subsp. *bauhinii* (2n = 54, hexaploid cytotype), 5 – *P. officinarum* (2n = 54, hexaploid cytotype).

*Pilosella *bauhinii* is the most frequently recorded *Pilosella* species in ruderal habitats within the area studied (34 localities). Penta- and hexaploids seem to be spatially separated as no mixed populations were found. All 66 plants analyzed were apomictic. The rather high frequency of pentaploids (recorded at altogether 11 localities) corresponds well with previously published data from the Czech Republic and Germany (for a review see Rotreklová 2004), where this cytotype seems to prevail. Both penta- and hexaploids are reported from Prague, Vysočany (loc. no. 31) (Rotreklová et al. 2002) together with apomictic tetraploids and a single heptaploid plant (Krahulcová et al. 2009).

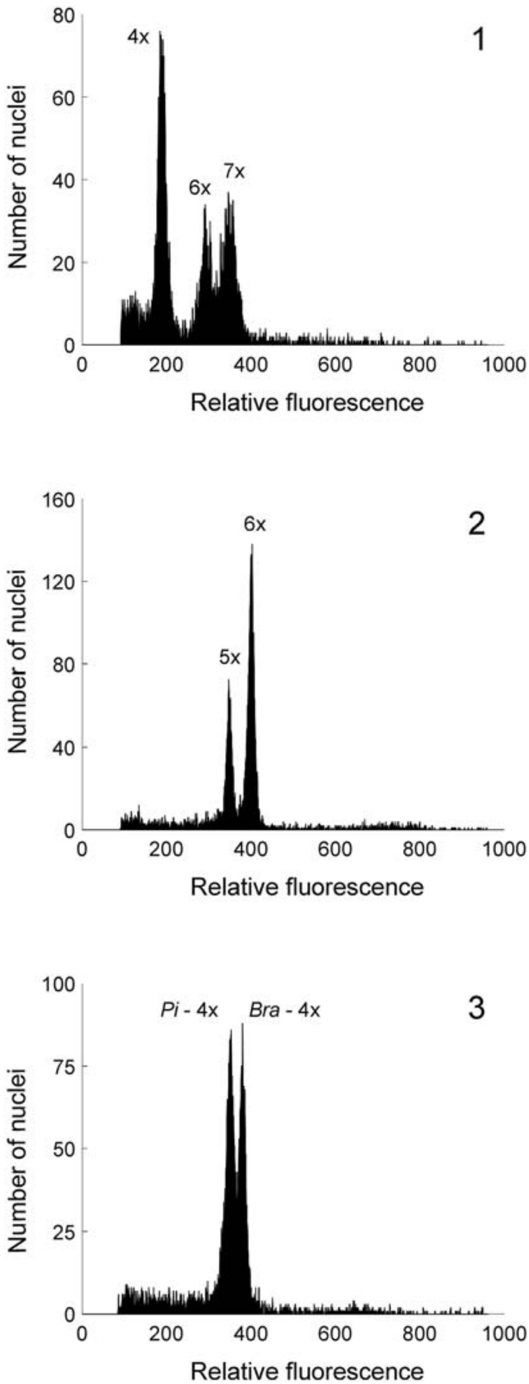

Fig. 3. – Flow cytometry histograms for selected *Pilosella* species. (1) Three peaks corresponding to ploidy levels detected in *P. officinarum.* All three cytotypes were analyzed simultaneously. (2) Two peaks corresponding to ploidy levels detected in *P. piloselloides* subsp. *bauhinii.* Both cytotypes were analyzed simultaneously. (3) Two peaks demonstrating the higher DNA content in the tetraploid *P. brachiata* (Bra) compared to its parental tetraploid *P. officinarum* (Pi).

Pilosella piloselloides subsp. *praealta* (Gochnat) S. Bräut. & Greuter (syn.: *Hieracium praealtum* Gochnat)

Localities: 11, 12, 18, 43.
DNA ploidy level **5x**: locality no. 12 (4 plants, 2n = 45).
Mode of reproduction, apomictic: locality no. 12 (4 plants).

Populations (max. 10 individuals) of *Pilosella *praealta* were found only at three localities.

Intermediate species

Pilosella brachiata (DC.) F. W. Schultz & Sch. Bip. (*P. piloselloides* < *P. officinarum*; syn.: *Hieracium brachiatum* Bertol. ex DC.)

Localities: 6, 10, 23, 24, 31.
DNA ploidy level **4x**: locality no. 6 (2 plants, 2n = 36), 10 (1 plant, 2n = 36), 24 (1 plant).
Mode of reproduction, sterile: locality no. 6 (2 plants).

According to its morphology, *P. brachiata* is an intermediate hybrid between *P. officinarum* and *P. *bauhinii* in this area. Because *P. *bauhinii* has a higher Cx-value (monoploid DNA content) than *P. officinarum*, the tetraploid hybrid, *P. brachiata* also has a higher DNA content (2C-value) than its tetraploid parent, *P. officinarum* (Fig. 3 – cf. Suda et al. 2007). Out of the nine localities at which both parental species were present, *P. brachiata* was detected at four of them. Several cytotypes of *P. brachiata* were previously reported occurring in a hybrid swarm at Vysočany (loc. no. 31 in this paper), namely pentaploid, heptaploid, octoploid and several aneuploid cytotypes (Rotreklová et al. 2002, Krahulcová et al. 2009). *Pilosella brachiata* is evidently a complex of recent hybrids, which in the Czech Republic are represented by a number of cytotypes, ranging from tetraploid to octoploid (for discussion see Rotreklová et al. 2002, 2005). The pentaploids are recorded as mostly apomictic (Rotreklová et al. 2005). At locality no. 31 the plants have diverse modes of reproduction (Krahulcová et al. 2009).

Pilosella leptophyton (Nägeli & Peter) P. D. Sell & C. West (*P. piloselloides* subsp. *bauhinii* > *P. officinarum*; syn.: *Hieracium leptophyton* Nägeli & Peter)

Localities: 9, 11, 12, 20, 23, 31.
DNA ploidy level **5x**: locality no. 9 (15 plants, 2n = 45).
Mode of reproduction, apomictic: locality no. 9 (14 plants).

The plants examined come from a mixed population of tetraploid sexual *P. officinarum* and pentaploid apomictic *P. *bauhinii*. This is the first report of pentaploid *P. leptophyton* from the Czech Republic, previously only one heptaploid cytotype was recorded (Suda et al. 2007).

Pilosella visianii F. W. Schultz & Sch. Bip. [*Pilosella piloselloides* subsp. *piloselloides* and *P. p*. subsp. *praealta* > *Pilosella officinarum*; syn.: *H. visianii* (F. W. Schultz & Sch. Bip.) Schinz & Thell.)] (Figs 4–6)

Localities: 2, 7, 8, 11, 12, 14, 17, 18, 19, 24, 27, 44.
DNA ploidy level **4x** (41 plants): locality no. 11 (5 plants, 2n = 36), 12 (11 plants, 2n = 36), 14 (5), 17 (2), 19 (2 plants, 2n = 36), 24 (7), 27 (8 plants, 2n = 36).
Mode of reproduction, apomictic (33 plants): locality no. 11 (5), 12 (11), 14 (5), 17 (2), 19 (2), 27 (8).

Fig. 4. – *Pilosella piloselloides* subsp. *praealta*, (left) and *P. visianii* (center and right).

In the city of Prague, *P. visianii* was found at 11 localities and seems to be one of the most common hybridogenous species. Three chromosome numbers are reported for *P. visianii*, i.e. 2n = 4x = 36 and 2n = 7x = 63 (Bräutigam & Schuhwerk 2002, 2005) and 2n = 5x = 45 (*P. v.* subsp. *fallaciniforme*, Schuhwerk & Lippert 2002). This species is not reported from the Czech Republic (Chrtek 2004). It is rare throughout its whole geographical range (the Alps and adjacent areas, Germany, southeast to Balkan Peninsula; Zahn 1987, Gottschlich 1987, Bräutigam & Schuhwerk 2005, Schuhwerk & Fischer 2003). It occupies an intermediate position between *P. piloselloides* (subsp. *piloselloides* or subsp. *praealta*) and *P. officinarum*, but resembles more the former parent. Plants from Prague are 15–45 cm tall, mostly without stolons and rarely with short underground rhizomes. Key identification characters are loose inflorescences (the inflorescence make up 1/5–1/3 of the total plant height) with usually 5–30 heads (involucral bracts are of an intermediate length between those of *P. piloselloides* and *P. officinarum*, i. e. 7–9 mm) and numerous stellate hairs on the lower surface of leaves but none on the upper surface). The plants from Prague seem to be rather uniform in morphology and most of them match the descriptions of plants from other parts of the geographical area. On the other hand, a few of the plants (localities 14, 19 and 24) differ in having more deeply branched inflorescences (the inflorescence makes up more than half of the plant height). These plants might at first be identified as *P. arida* (Freyn) Soják (*H. aridum* Freyn), the second intermediate species between *P. piloselloides* (subsp. *piloselloides* and subsp. *praealta* and *P. officinarum*), which is more closely related to *P. officinarum*. However, isozyme analysis of 34 plants, including specimens with deeply branched inflorescences from six localities (10, 11, 14, 17, 19, 27), showed no intra- and inter-population variation. To be certain, this analysis was repeated

Fig. 5. – *Pilosella visianii.*

Fig. 6. – *Pilosella visianii*.

with a set of plants collected in 2010: five and ten plants were collected at two distant localities, nos. 19 and 24, respectively. The plants with the different morphology all have the same genotype (isozyme phenotype). Hence, all these plants belong to one successful clone, which is apomictic. Plants with a deeply branched inflorescence are thus in our opinion aberrant forms of *P. visianii*.

Remark: There are zymograms (isozyme phenotypes) in Košťálová's diploma thesis (Košťálová 2004: 83, 84). She uses the name *Hieracium anchusoides* (Arv.-Touv.) St.-Lag. (*Pilosella anchusoides* Arv.-Touv.) for this type, which is a parallel hybrid species resulting from hybridization between *P. ziziana* and *P. officinarum*. It differs from *P. visianii* in the presence of stellate hairs on the upper leaf surface. Morphology of both types considered here as *P. visianii* is illustrated in Figs 4–6.

Pilosella glomerata (Froel.) Fr. (*P. caespitosa – P. cymosa*; syn.: *Hieracium glomeratum* Froelich)

Localities: 10, 19, 24, 26, 39, 46.
DNA ploidy level **5x:** loc. 24 (1 plant).
Mode of reproduction, apomictic: locality no. 46 (6 plants).

This species is recorded for the Czech Republic as tetra- and pentaploid and always apomictic (e.g. Krahulec et al. 2004, 2008). Because apomictic reproduction allows the spread of successful clones, as has been reported for example from Germany (Gottschlich et al. 2006), it is expected that this species will spread further in the Prague area.

Pilosella rothiana (Wallr.) F. W. Schultz & Sch. Bip. (*P. echioides* > *P. officinarum;* syn.: *Hieracium rothianum* Wallr.) (Fig. 7)

Localities: 3, 14, 30, 40, 46, 47, 48.
DNA ploidy level **4x**: loc. 46.
Mode of reproduction, apomictic: locality no. 3 (1 plant), 14 (1), 30 (3), 46 (1).

The populations of *P. rothiana* consisted of apomictic plants with no evidence/presence of one of the parental species (*P. echioides*) at any locality. *Pilosella echioides* occurs in the Prague area, but is strictly confined to rocky outcrops in the Vltava canyon and never colonizes secondary habitats (Peckert 2002). Because of their homogeneous morphology, all plants seem to belong to one genotype that has spread throughout Prague. Plants belonging to the same genotype (more precisely, isozyme phenotype) as those occurring at loc. no. 47 were found in summer 2009 at Odolena Voda, close to highway (14°24'18.6"E, 50°13'38.3"N, close to locality no. 47) and also at Modrý Důl (15°42'46.0"E, 50°42'45.5"N), in the Krkonoše Mts at an altitude of 1013 m. This indicates that this genotype is successful and even able to colonize habitats at high altitudes.

This hybridogenous species is tetraploid (rarely triploid) and apomictic (Rotreklová et al. 2002, 2005, Suda et al. 2007).

Pilosella setigera Fr. (*P. cymosa – P. echioides*; syn.: *Hieracium fallax* Willd.) (Fig. 8)

Localities: 30, 40.
DNA ploidy level and/or chromosome number were not analyzed.
Mode of reproduction, apomictic: loc. 30 (3 plants).

Fig. 7. – *Pilosella rothiana*.

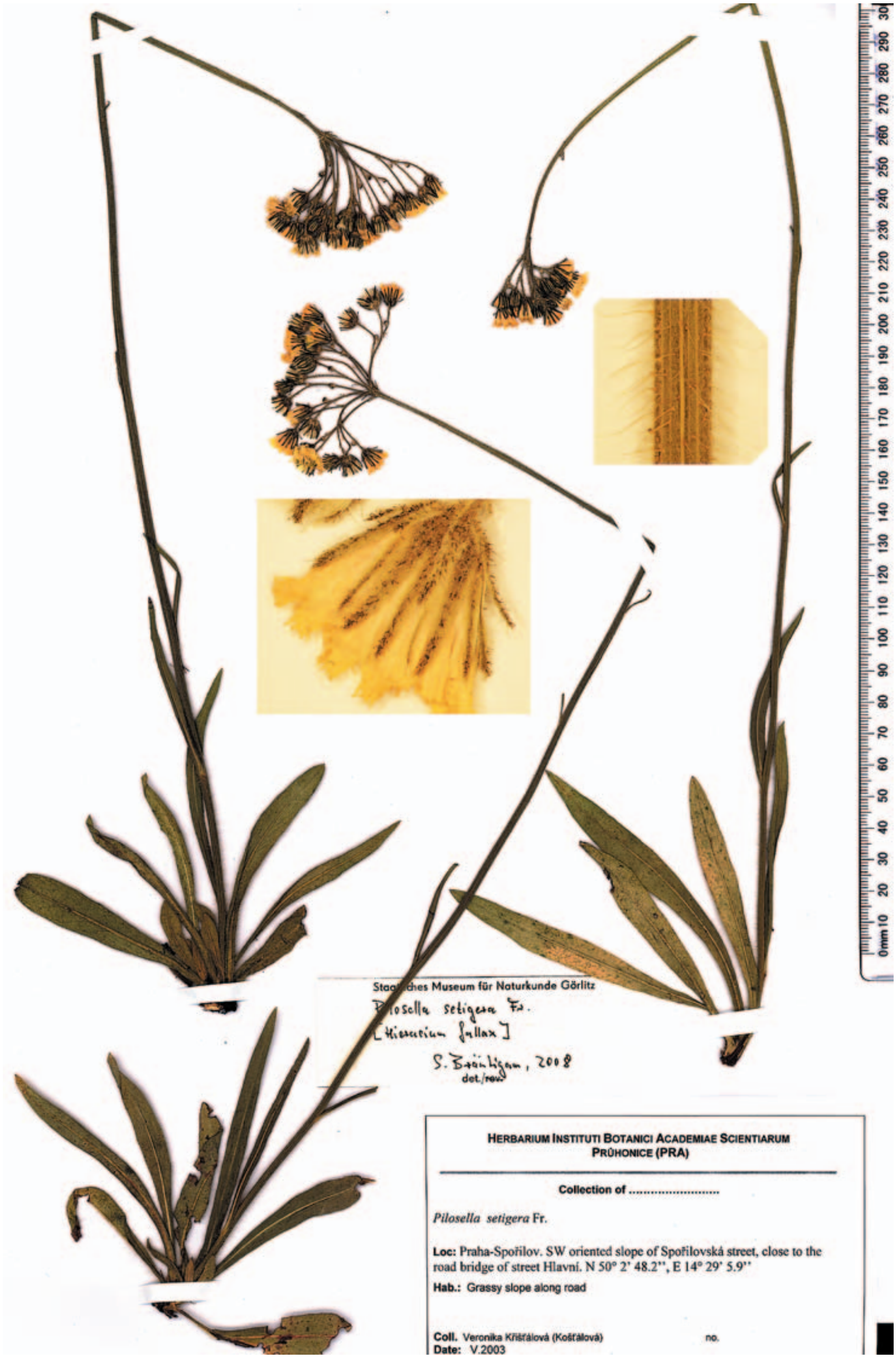

Fig. 8. – *Pilosella setigera*.

This hybridogenous species was detected only at two localities and is certainly not common in the area studied. Co-occurrence of parental species was not observed. Due to absence of plants of the parental species and its apomictic mode of reproduction, the expectation is that this morphotype of *P. setigera* is fixed and can form apomictic populations in any suitable place even if parental species are not present. No chromosome number is reported for this species in the Czech Republic, but pentaploid plants are recorded in other countries (Chrtek 2004).

Pilosella ziziana (Tausch) F. W. Schultz & Sch. Bip. (*P. cymosa* – *P. piloselloides* subsp. *piloselloides* and *P. p.* subsp. *praealta*; syn.: *Hieracium zizianum* Tausch) (Fig. 9)

Locality: 24, 47.
DNA ploidy level **4x**: loc. number 24 (1 plant), 47 (2 plants).

Pilosella ziziana is a hybridogenous species morphologically between *P. cymosa* and *P. piloselloides* (subsp. *piloselloides* and subsp. *praealta*). The parental species were not observed either at the same localities or close by. This and the fact that this species is apomictic indicate that this morphotype of *P. ziziana* is fixed and can form apomictic populations anywhere within the area studied, like *P. setigera* mentioned above. At locality no. 24 there were approximately 10–20 individuals. Triploid (apomictic) and hexaploid plants are reported from France and tetraploid plants from Slovakia (Rotreklová et al. 2005). The tetraploid and pentaploids are also recorded occurring in Bavaria, Germany and tetraploid plants in Italy (Schuhwerk & Lippert 2002).

Pilosella densiflora (Tausch) Soják (*P. cymosa* – *P. piloselloides* subsp. *bauhinii*; syn.: *Hieracium densiflorum* Tausch) (Fig. 10)

Localities: 10, 16, 30, 40.

All the plants collected from the three closely situated localities in southern part of Prague and one on the eastern margin of the town are morphologically homogeneous indicating that *P. densiflora* is a stable hybridogenous species in this area. In the Czech Republic it is recorded as tetraploid (and sexual) and pentaploid, and in other countries as triploid and hexaploid (Chrtek 2004).

Pilosella erythrochrista (Nägeli & Peter) S. Bräutigam & Greuter [*P. caespitosa* – *P. piloselloides* subsp. *praealta* and subsp. *piloselloides*; syn.: *Pilosella arvicola* (Nägeli & Peter) Soják, *Hieracium arvicola* Nägeli & Peter].

Locality: 49

In the area studied, this hybridogenous species is only known from this locality. Tetraploid plants are reported by Rotreklová et al. (2005) in the Czech Republic and tetra- and pentaploids in other countries (Chrtek 2004).

Pilosella floribunda (Wimm. & Grabowski) Fr. (*P. caespitosa* > *P. lactucella*; syn.: *H. floribundum* Wimm. & Grabowski)

Locality: 43.

This stabilized hybridogenous type, which occurs mainly in mountain meadows (Chrtek 2004), was also found within the area studied.

Fig. 9. – *Pilosella ziziana*.

Fig. 10. – *Pilosella densiflora*.

Pilosella flagellaris (Willd.) Arv.-Touv. (*P. caespitosa – P. officinarum;* syn.: *H. flagellare* Willd.)

Locality: 24.

This species is very probably a local hybrid as it was found at this locality along with both parents.

Pilosella piloselloides – P. setigera (Fig. 11, 12)

Locality: 6, 24.
DNA ploidy level **5x**: loc. 24 (13 plants).
Mode of reproduction, apomictic: loc. 24 (4 plants)

At loc. no. 24 (Fig. 11) hybrid plants were found, which seem to fit the combination of parents *P. piloselloides* and *P. setigera*. Because it lacks a stolon the first parent was probably the rare subspecies, *P. p.* subsp. *praealta*. On the other hand, similar plants with long stolons were collected at locality no. 6 (Fig. 12), which indicates that *P. p*. subsp. *bauhinii* was involved in the hybridization. Both these combinations remain to be described and studied in greater detail.

Discussion

During this research on the genus *Pilosella* at ruderal localities within the city of Prague, five basic species (*P. officinarum, P. caespitosa, P. cymosa* subsp. *vaillantii, P. aurantiaca, P. piloselloides* subsp. *bauhinii* and *P. p.* subsp. *praealta*) and 12 intermediate species (*P. brachiata*, *P. leptophyton*, *P. ziziana*, *P. visianii*, *P. rothiana*, *P glomerata*, *P. setigera*, *P. floribunda*, *P. flagellaris*, *P. densiflora*, *P. erythrochrista* and undescribed hybridogenous type between *P. setigera* and *P. piloselloides*) were found. Seven of these taxa were not previously reported from this area (Špryňar & Münzbergová 1998), viz. *P. floribunda*, *P. glomerata*, *P. leptophyton*, *P. piloselloides* subsp. *praealta*, *P. visianii*, *P. erythrochrista* and the undescribed hybridogenous type between *P. setigera* and *P. piloselloides.* Except for the last three taxa, all the others are rather common in other parts of the country and as a consequence their occurrence in the Prague area is not surprising, especially when one considers their fast rate of spread. Several of the species are currently spreading throughout the whole of Central Europe. For instance, *P. glomerata*, which occurs mainly at high altitudes, has recently started spreading in Germany (Gottschlich et al. 2006). *Pilosella visianii* which is rather common in Prague and could have been here for a long time but overlooked or was introduced or originated here recently. Two other *Pilosella* species are known from the Prague area, which do not occur in ruderal habitats, viz. *P. lactucella,* and *P. echioides* (Špryňar & Münzbergová 1998). The number of intermediate species reported from Prague is higher than recorded in this study, but most of them were found more than 80 years ago (Špryňar & Münzbergová 1998). The old data may be unreliable due to common misidentifications and different and not fully compatible concepts adopted by past and present authors. Thus, a detailed comparison of the past and present diversity was not undertaken as this would have required a detailed revision of herbarium specimens, which was not possible in the present study.

Fig. 11. – *Pilosella piloselloides* × *P. setigera*.

Fig. 12. – *Pilosella piloselloides* × *P. setigera*.

Of the basic and intermediate species, only *P. officinarum* is sexual, and both tetraploid and hexaploid cytotypes of this species occur in Prague and its vicinity. This fully corresponds with the recent study for the whole Czech Republic (Mráz et al. 2008). The mode of reproduction of *P. aurantiaca* in the Prague area was not studied, but plants cultivated in gardens and escaping from them are tetraploid apomicts (Chrtek 2004) with one common clone occurring throughout the whole of central Europe (Fehrer et al. 2005). Half of the intermediate species have *P. officinarum* as one of the parents. This fact clearly demonstrates the exceptional importance of this species in the formation of the whole agamic complex in Central Europe. *Pilosella officinarum* has a similar role in the Krkonoše Mts (Krahulec et al. 2004) and Šumava Mts (Krahulec et al. 2008). In Central Europe, it is the only widely distributed species, which is regularly sexual at ploidy levels higher than diploid. It is common in both non-ruderal and ruderal habitats. The other sexual species, *P. echioides*, is rather rare in the Prague area and the sexual tetraploid of *P. piloselloides* subsp. *bauhinii* has not been found there. In general, apomictic species are at a great advantage when colonizing new habitats. This is especially true for linear habitats, such as roads and railways. One seed of a successful genotype can form a big population by seed dispersal and clonal growth. Some intermediate species without clonal growth are also successful, like *P. visianii*. The success of some of the hybridogenous species in the Prague area can be demonstrated by the occurrence of *P. rothiana* (the identical isozyme phenotype) not only in Prague and its close vicinity, but also in the Krkonoše Mts, at an altitude higher than 1000 m, where it was probably introduced by cars (it grows only within several meters of areas occasionally used for parking).

It is predicted that large-scale building activities, especially those planned for the periphery of Prague will result in the creation of new habitats suitable for *Pilosella* species and hybrids and extend their spread into the countryside. It would be interesting to follow, which of them will be successful; whether those that already occur here, or a new taxon. Easy hybridization within *Pilosella* favours the evolution of new taxa. New hybrids are frequently reported, e.g. for the combination *P. piloselloides* and *P. officinarum* (the hybrids correspond to *P. brachiata*).

Comparison of these results with rare data from the western part of Europe reveals similar trends and colonization of new habitats by species of *Pilosella*. For example, Gottschlich (1990) reports new localities for *Hieracium fallax* (= *P. setigera*) along railways in Basel, Gottschlich et al. (2004) mention *H. caespitosum* (*P. caespitosa*) and *H. glomeratum* (*P. glomerata*) as recently colonizing habitats in Hessen. Gottschlich et al. (2006) especially record *H. caespitosum* (= *P. caespitosa*), *H. cymosum* "nordische Sippe" (very close to *P. cymosa* subsp. *vaillantii*), *H. glomeratum* (*P. glomerata*), *H. rothianum* (*P. rothiana*) and *H. zizianum* (*P. ziziana*) as spreading into ruderal habitats; all of which were also found in Prague.

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Souhrn

Nově budovaná silniční tělesa s velkými terénními zářezy a různě exponovanými svahy poskytují řadu vhodných stanovišť pro šíření rostlin. Jednou ze skupin, pro které je tento typ stanovišť extrémně vhodný, jsou jestřábníky rodu *Pilosella*. V uplynulých letech byla tato skupina podrobně studována podél nových velkých silnic a podél vybraných železničních tratí na území Prahy (několik lokalit bylo situováno těsně za hranicemi města). U řady sebraných jestřábníků byla sledována ploidie či počet chromosomů a jejich reprodukční systém, který ukazuje, jaké má daný základní (nehybridogenní) či hybridogenní druh možnosti v další evoluci a šíření. Během tohoto studia bylo nalezeno pět základních druhů: *P. aurantiaca*, *P. caespitosa* (4x, 5x), *P. cymosa* subsp. *vaillantii* (5x), *P. officinarum* (2n = 36, sexuální; 2n = 54, sexuální; 2n = 63), *P. piloselloides* subsp. *bauhini* (2n = 45, 54; obě ploidní úrovně apomiktické), *P. piloselloides* subsp. *praealta* (5x; apomiktické), dále byla nalezena i celá řada hybridogenních taxonů a zřejmě i primárních hybridů – *P. brachiata* (4x; sterilní), *P. densiflora, P. erythrochrista*, *P. flagellaris, P. floribunda, P. glomerata* (5x), *P. leptophyton* (5x), *P. rothiana* (4x, apomikt), *P. setigera*, *P. ziziana* (4x) a *P. visianii* (4x; apomikt). Kromě uvedených druhů byl nalezen ještě dosud nepopsaný hybridogenní typ vzniklý křížením *P. piloselloides* a *P. setigera* (5x, apomikt). Hybridogenní druh *P. visianii* je poprvé udáván z území České republiky; na území Prahy patřil v této době k častěji se vyskytujícím. Podél nových silnic se mohou šířit i typy donedávna vzácné, jako *P. rothiana*; tento hybridogenní druh již byl nalezen na těchto stanovištích i mimo Prahu a její okolí.

References

Bräutigam S. & Greuter W. (2007): A new treatment of *Pilosella* for the Euro-Mediterranean flora. – Willdenowia 37: 123–137.

Bräutigam S. & Schuhwerk F. (2002): *Hieracium* L. – Habichtskraut. – In: Jäger E. J. & Werner K. (eds), Rothmaler Exkursionsflora von Deutschland, Band 4, Gefässpflanzen: Kritischer Band. Ed. 9, p. 709–734, Spektrum Akademischer Verlag, Heidelberg, Berlin.

Bräutigam S. & Schuhwerk F. (2005): *Hieracium* L. – Habichtskraut. – In: Jäger E. J. & Werner K. (eds), Exkursionsflora von Deutschland, Band 4, Gefässpflanzen: Kritischer Band. Ed. 10, p. 741–766, Spektrum Akademischer Verlag, Heidelberg, Berlin.

Chrtek J. jun. (2004): *Hieracium* L. – jestřábník. – In: Slavík B. & Štěpánková J. (eds), Květena České republiky [Flora of the Czech Republic] 8: 540–701, Academia, Praha.

Dunkel F. G., Hildel W. & Rességuier P. (2007): *Hieracium fallax* Willd. und weitere *Hieracium echioides*-Zwischenarten in nordwestlichen Bayern. – Forum Geobot. 3: 1–10.

Fehrer J., Krahulcová A., Krahulec F., Chrtek J. jun., Rosenbaumová R. & Bräutigam. S. (2007): Evolutionary aspects in *Hieracium* subgenus *Pilosella*. – In: Grossniklaus U., Hörandl E., Sharbel T. & van Dijk P. (eds), Apomixis: evolution, mechanisms and perspectives, p. 359–390, Regnum Vegetabile, Koeltz, Königstein.

Fehrer J., Šimek R., Krahulcová A., Krahulec F., Chrtek J. jun., Bräutigam E. & Bräutigam S. (2005): Evolution, hybridisation, and clonal distribution of apo- and amphimictic species of *Hieracium* subgen. *Pilosella* (*Asteraceae: Lactuceae*) in a Central European mountain range. – In: Bakker F. T., Chatrou L. W., Gravendeel B. & Pelser P. B. (eds), Plant species-level systematics: new perspectives on pattern and process, p. 175–201, Regnum Vegetabile 143, Koeltz, Königstein.

Gadella T. W. J. (1984): Cytology and the mode of reproduction of some taxa of *Hieracium* subgenus *Pilosella*. – Proc. Konink. Nederl. Akad. Wetensch. Ser. C 87: 387–399.

Gottschlich G. (1987): DCCCI. *Hieracium* L. – In: Wagenitz G. (ed.), Nachträge, Berichtigungen und Ergänzungen zum Nachdruck der 1. Auflage von Band VI/2 (1928/29), Hegi G., Illustrierte Flora von Mitteleuropa. *Spermatophyta*. Band VI. *Angiospermae*. *Dicotyledones* 4, p. 1437–1452, Paul Parey, Berlin, Hamburg.

Gottschlich G. (1990): Echinina-Abkömmlinge der Gattung *Hieracium* in der Flora der Schweiz. – Bauhinia 93: 221–226.

Gottschlich G., Emrich P. & Schnedler W. (2004): Die Mausohr-Habichtskräuter (*Hieracium* subgen. *Pilosella*) im hessischen Lahngebiet. Kleinräumige Verbreitung, Arealdynamik und Sippendifferenzierung. – Oberhess. Naturwiss. Zeitschr. 62–63: 56–70.

Gottschlich G., Garve E., Heinrichs J., Renker C., Müller J. & Wucherpfennig D. (2006): Zur Ausbreitungsdynamik der Pilosellinen (*Hieracium* subgen. *Pilosella*, *Asteraceae*) in Niedersachsen. – Braunschw. Naturk. Schr. 7: 545–567.

Heinrichs J. (1998): Bemerkenswerte Hieracienvorkommen im Bereich des Autobahnkreuzes Bonn/Siegburg (Nordrhein-Westfahlen). – Flor. Rundbr. 32: 13–18.

Heinrichs J. & Gottschlich G. (1996): Neue Studien zur *Hieracium*-Flora des Rheinlands. – Acta Biol. Benrodis 8: 79–118.

Košťálová V. (2004): Vybrané druhy *Hieracium* subgen. *Pilosella* na antropogenních stanovištích hlavního města Prahy: variabilita, rozšíření a ekologické podmínky [Selected species of *Hieracium* subgen *Pilosella* on anthropic localities in Prague: variation, distribution and ecological conditions]. – Diploma thesis, Department of Botany, Faculty of Science, Charles University Prague.

Kovanda J. (1995): Přehledná geologická mapa Prahy a okolí [Geological map of Prague and its surroundings], 1 : 100 000. – Český geologický ústav, Praha.

Krahulcová A. & Krahulec F. (1999): Chromosome numbers and reproductive systems in selected representatives of *Hieracium* subgen. *Pilosella* in the Krkonoše Mts (the Sudeten Mts). – Preslia 71: 217–234.

Krahulcová A., Krahulec F. & Chapman H. M. (2000): Variation in *Hieracium* subgen. *Pilosella* (*Asteraceae*): what do we know about its sources? – Folia Geobot. 35: 319–338.

Krahulcová A., Papoušková S. & Krahulec F. (2004): Reproduction mode in the allopolyploid facultatively apomictic hawkweed *Hieracium rubrum* (*Asteraceae*, *H.* subgen. *Pilosella*). – Hereditas 141: 19–30.

Krahulcová A. & Rotreklová O. (2010): Use of flow cytometry in research on apomictic plants. – Preslia 82: 23–39.

Krahulcová A., Rotreklová O., Krahulec F., Rosenbaumová R. & Plačková I. (2009): Enriching ploidy level diversity: the role of apomictic and sexual biotypes of *Hieracium* subgen. *Pilosella* (*Asteraceae*) that coexist in polyploid populations. – Folia Geobot. 44: 281–306.

Krahulec F., Krahulcová A., Fehrer J., Bräutigam S., Plačková I. & Chrtek J. jun. (2004): The sudetic group of *Hieracium* subgen. *Pilosella* from the Krkonoše Mts: a synthetic view. – Preslia 76: 223–243.

Krahulec F., Krahulcová A., Fehrer J., Bräutigam S. & Schuhwerk F. (2008): The structure of the agamic complex of *Hieracium* subgen. *Pilosella* in the Šumava Mts and its comparison with other regions in Central Europe. – Preslia 80: 1–26.

Kühn I., Brandl R. & Klotz S. (2004): The flora of German cities is naturally species rich. – Evol. Ecol. Research 6: 749–764.

Marhold K., Mártonfi P., Mereďa P. jun. & Mráz P. (eds) (2007): Chromosome number survey of the ferns and flowering plants of Slovakia. – Veda, Bratislava.

Matzk F., Meister A. & Schubert I. (2000): An efficient screen for reproductive pathways using mature seeds of monocots and dicots. – Pl. J. 21: 97–108.

Moravec J., Neuhäusl R., Blažková D., Husová M., Kolbek J., Krahulec F. & Neuhäuslová-Novotná Z. (1991): Přirozená vegetace území hlavního města Prahy a její rekonstrukční mapa [Natural vegetation of the territory of the capital city Prague and its reconstruction map]. – Academia, Praha.

Mráz P., Šingliarová B., Urfus T. & Krahulec F. (2008): Cytogeography of *Pilosella officinarum* (*Compositae*): altitudinal and longitudinal differences in ploidy level distribution in the Czech Republic and the general pattern in Europe. – Ann. Bot. 101: 59–71.

Nägeli C. & Peter A. (1885): Die Hieracien Mittel-Europas. Monographische Bearbeitung der Piloselloiden mit besonderer Berücksichtigung der mitteleuropäischen Sippen. – München.

Peckert T. (2002): Rozšíření *Hieracium echioides* a *H. rothianum* v České republice a na Slovensku [The distribution of *Hieracium echioides* and *H. rothianum* in the Czech Republic and Slovakia]. – Zpr. Čes. Bot. Společ. 37: 129–144.

Pyšek P. & Pyšek A. (1990): Comparison of the vegetation and flora of the West Bohemian villages and towns. – In: Sukopp H., Hejný S. & Kowarik I. (eds), Urban ecology: plant and plant communities in urban environments, p. 105–112, SPB Academic Publishing, Den Haag.

Rotreklová O. (2004): *Hieracium bauhini* group in Central Europe: chromosome numbers and breeding systems. – Preslia 76: 313–330.

Rotreklová O., Krahulcová A., Mráz P., Mrázová V., Mártonfiová L., Peckert T. & Šingliarová B. (2005): Chromosome numbers and breeding systems in some species of *Hieracium* subgen. *Pilosella* from Europe. – Preslia 77: 177–195.

Rotreklová O., Krahulcová A., Vaňková D., Peckert T. & Mráz P. (2002): Chromosome numbers and breeding systems in some species of *Hieracium* subgen. *Pilosella* from Central Europe. – Preslia 74: 27–44.

Schuhwerk F. & Fischer M. A. (2003): Bestimmungsschlüssel der Untergattung *Hieracium* subgen. *Pilosella* in Österreich und Südtirol. – Neilreichia 2–3: 13–58.
Schuhwerk F. & Lippert W. (2002): Chromosomenzahlen von *Hieracium* (*Compositae*, *Lactuceae*) Teil 4. – Sendtnera 8: 167–192.
Špryňar P. & Münzbergová Z. (1998): Prodromus pražské květeny [Prodrome of the Prague Flora]. – Muzeum a Současnost, Roztoky, 12: 129–222.
Suda J., Krahulcová A., Trávníček P. & Krahulec F. (2006): Ploidy level vs. DNA ploidy level: an appeal for consistent terminology. – Taxon 55: 447–450.
Suda J., Krahulcová A., Trávníček P., Rosenbaumová R., Peckert T. & Krahulec F. (2007): Genome size variation and species relationships in *Hieracium* sub-genus *Pilosella* (*Asteraceae*) as inferred by flow cytometry. – Ann. Bot. 100: 1323–1335.
Sukopp H. & Werner P. (1983): Urban environments and vegetation. – In: Holzner W., Werger M. J. A. & Ikusima I. (eds), Man's impact on vegetation, p. 247–260, Dr. W. Junk Publishers, The Hague.
Zahn K. H. (1922–1930): *Hieracium*. – In: Ascherson P. & Graebner P. (eds), Synopsis der mitteleuropäischen Flora 12(1), p. 1–492, Gebrüder Bornträger, Leipzig.
Zahn K. H. (1987): *Hieracium*. – In: Conert H. J., Hamann U., Schultze-Motel W. & Wagenitz G. (eds), Hegi G., Illustrierte Flora von Mitteleuropa, *Spermatophyta*. Band VI. *Angiospermae*, *Dicotyledones* 4, p. 1182–1243, Paul Parey, Berlin, Hamburg.

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Appendix 1. – List of localities studied (abbreviations of collectors: VK – Veronika Křišťálová; JC – Jindřich Chrtek, AK – Anna Krahulcová and FK – František Krahulec)

1. Praha-Slivenec: Novořeporyjská highway, SW oriented slope next to the road bridge, N 50°01'11.2", E 14°20'7.3". Detected species: *Pilosella piloselloides* subsp. *bauhinii.* VK
2. Praha-Slivenec: Novořeporyjská highway, SW oriented slope on the right side, approximately 50 m behind the bridge towards Barrandov, N 50°01'26.5", E 14°19'6.8". Detected species: *P. visianii.* VK
3. Praha-Slivenec: Novořeporyjská highway, SW oriented slope close to the bridge, N 50°01'26.4", E 14°19'36.2". Detected species: *P. piloselloides* subsp. *bauhinii*, *P. rothiana.* VK
4. Praha-Řeporyje: Novořeporyjská highway, SW oriented slope next to the exit Stodůlky, towards to Řeporyje, N 50°02'31.74", E 14°16'13.56". Detected species: *P. piloselloides* subsp. *bauhinii.* VK
5. Praha-Řeporyje: S oriented slope in front of the Billa store, the crossing of Mukařovského and Jeremiášova streets, N 50°02'24.78", E 14°19'36.18". Detected species: *P. piloselloides* subsp. *bauhinii.* VK
6. Praha-Řeporyje, Bavorská street, final stop of bus 219, the locality is situated right in front of the Auto-salon Honda, SE oriented site, N 50°03'13.92", E 14°18’ 37.14". Detected species: *P. officinarum*, *P. piloselloides* subsp. *bauhinii*, *P. brachiata*, *P. piloselloides* × *P. setigera.* VK
7. Praha-Řeporyje: S oriented slope in Pekařská street, spot next to the Avia gas station, N 50°03’ 27.42", E 14°20’ 32.70". Detected species: *P. piloselloides* subsp. *bauhinii*, *P. visianii.* VK
8. Praha-Řeporyje: S oriented slope in Pekařská street close to the bakery Odkolek, on the left side of Rozvadovská street towards the city center, N 50°03’ 22.20", E 14°20'25.50". Detected species: *P. piloselloides* subsp. *bauhinii*, *P. visianii.* VK
9. Praha-Hrdlořezy: Za mosty street, W oriented slope close to the railway embankment, N 50°05'44.82", E 14°31'20.58". Detected species: *P. caespitosa*, *P. officinarum*, *P. piloselloides* subsp. *bauhinii*, *P. leptophyton.* VK
10. Praha-Kyje: Railway station Praha-Kyje, SW oriented site on the right side of the bridge, N 50°05'46.14", E 14°32'49.68". Detected species: *P. officinarum*, *P. piloselloides* subsp. *bauhinii*, *P. brachiata*, *P. densiflora*, *P. glomerata.* VK, JC.
11. Praha-Běchovice: East part of the railway station Praha-Běchovice, N 50°04'55.62", E 14°36'12.60". Detected species: *P. leptophyton*, *P. piloselloides* subsp. *praealta, P. visianii.* VK, FK, JCH
12. Praha-Černý most: E oriented slope, beginning of the highway near the rail bridge, which crosses the highway from Praha to Liberec, locality is on the right side toward Prague, Exit 1, Horní Počernice, N 50°06'52.44", E 14°35'16.56". Detected species: *P. caespitosa*, *P. officinarum*, *P. piloselloides* subsp. *praealta*, *P. piloselloides subsp. bauhinii*, *P. leptophyton*, *P. visianii.* VK
13. Praha-Černý most: SW oriented slope close to Makro-store and KFC on the Ocelkova street (besides Chlumecká street), N 50°06'35.82", E 14°34'32.64". Detected species: *P. piloselloides* subsp. *bauhinii.* VK
14. Praha-Braník: S oriented slope next to the crossing of V podzámčí and Na strži streets, N 50°02'11.76", E14°26'38.70". Detected species: *P. piloselloides subsp. bauhinii*, *P. rothiana*, *P. visianii.* VK
15. Praha-Braník: S oriented mound along the highway called South highway, also crossing of V Podzámčí and Na Strži streets, N 50°02'15.06", E 14°27'0.24". Detected species: *P. officinarum*, *P. piloselloides* subsp. *bauhinii.* VK
16. Praha-Spořilov: SE oriented slope between the railway and Na nivách street, N 50°02'34.98", E 14°27'51.24". Detected species: *P. piloselloides* subsp. *bauhinii*, *P. densiflora.* VK
17. Jirny: Highway D11, SE oriented slope next to the bridge, on the right side of the highway (direction Prague), N 50°07'21.96", E 14°42'13.32". Detected species: *P. piloselloides* subsp. *bauhinii*, *P. visianii.* VK
18. Praha-Hrdlořezy: Ca 0.3 km ESE of the railway station Praha-Libeň, N 50°06'01.2", E 14°30'17.9". Detected species: *P. piloselloides* subsp. *bauhinii*, *P. piloselloides* subsp. *praealta*, *P. visianii.* VK
19. Praha-Veleslavín: Railway station Praha-Veleslavín, left side of track towards Praha-centre. N 50°5'25.20", E 14°20'25.80". Detected species: *P. piloselloides* subsp. *bauhinii*, *P. glomerata*, *P. visianii*. VK, JCH, FK
20. Praha-Staré Město: Masarykovo nádraží railway station, trackage, N 50°05'23.29", E 14°26'15.42". Detected species: *P. piloselloides* subsp. *bauhinii*, *P. leptophyton.* VK
21. Řevnice: Beginning of the village of Lety on the way from the town of Řevnice, crossing of main road and Zahradní street, SE oriented road side, N 49°55'12.24", E 14°14'58.02" Detected species: *P. officinarum.* VK
22. Praha-Radotín: Area close to the Radotín Cement mill, bus station opposite the mill. N 49°59'40.02", E 14°20'33.48". Detected species: *P. piloselloides* subsp. *bauhinii.* VK
23. Praha-Vysočany: SE oriented slope alongside the track, approx. 500 m behind the railway station Praha-Vysočany towards the centre, N 50°06'50.59", E 14°29'32.20". Detected species: *P. piloselloides* subsp. *bauhinii*, *P. brachiata*, *P. leptophyton.* VK

24. Jirny: Highway D11, S oriented slope next to the exit Jirny, left side, N 50°07'19.60", E 14°42'14.00". Detected species: *P. caespitosa*, *P. officinarum*, *P. piloselloides* subsp. *bauhinii*, *P. brachiata*, *P. flagellaris*, *P. glomerata*, *P. visianii*, *P. piloselloides* × *P. setigera*. VK, JC, AK, FK
25. Praha-Řeporyje: Alongside the ramparts of Novořeporyjská highway (E 50), SW oriented site ca 100 m of the bridge to Dalejská street, N 50°01'26.89", E 14°19'02.34". Detected species: *P. officinarum*, *P. piloselloides* subsp. *bauhinii.* VK
26. Praha-Ruzyně: Railway station Praha-Ruzyně, SW oriented slight slope on the left side of the track towards Praha centre, N 14°18'14.94", E 50°05'05.9". Detected species: *P. piloselloides* subsp. *bauhini*, *P. glomerata.* VK
27. Praha-Řeporyje: Novořeporyjská highway, SW oriented slope on the right side, 200 m of exit 19 (direction Řeporyje), N 50°01'30.6", E 14°17'54.9". Detected species: *P. visianii.* VK
28. Praha-Řeporyje: Novořeporyjská highway, SW oriented slope on the right side, 200 m of exit to Chrášťany (direction Řeporyje), N 50°02'29.40", E 14°16'12.50". Detected species: *P. aurantiaca*, *P. piloselloides* subsp. *bauhinii.* VK
29. Praha-Prosek: Prosecké skály rocks, rocky spot in the park close to Na rozhraní street, N 50°07'01.1", E 14°29'08.9". Detected species: *P. piloselloides* subsp. *bauhinii.* VK
30. Praha-Spořilov: Grassy place at the crossing of streets 5. května and Jižní spojka, N 50°02'31.4", E 14°28'14.3". Detected species: *P. caespitosa*, *P. piloselloides* subsp. *bauhinii*, *P. densiflora*, *P. rothiana*, *P. setigera.* VK
31. Praha-Vysočany: S oriented site alongside the railway ca 300 m W of the railway station Praha-Vysočany, N 50°06'38.87", E 14°29'03.71". Detected species: *P. officinarum*, *P. piloselloides* subsp. *bauhinii*, *P. brachiata*, *P. leptophyton.* VK, JC, AK, FK.
32. Praha-Šeberov: Exit of the D1 highway, on the E side of the roundabout to Opatov and Šeberov, N 50°01'14", E 14°30'34.8". Detected species: *P. officinarum*, *P. glomerata.* VK
33. Praha-Šeberov: SW oriented site of road mound, 3rd bus station in the village of Šeberov, against to football ground, N 50°00'36.4", E 14°30'54.9". Detected species: *P. officinarum.* VK
34. Praha-Horní Počernice: Liberecká highway E65/R10 at the NW margin of the village, W oriented slope on the right side of the road (direction Liberec), N 50°07'18.3", E 14°36'03.8". Detected species: *P. piloselloides* subsp. *bauhinii.* VK
35. Praha-Opatov: Close surroundings of the Opatov metro station area, N 50°01'37.1", E 14°30'28.6". Detected species: *P. piloselloides* subsp. *bauhinii.* VK
36. Rudná: Slopes along the highway (direction Plzeň), 0.3 km SW of the exit 5, 50°01'21.3" N, 14°12'04.5" E. Detected species: *P. piloselloides* subsp. *bauhinii.* JC.
37. Praha-Hradčany: Corner of the streets Patočkova and Bělohorská, N 50°05'35.0", E 14°23'14.1". Detected species: *P. officinarum.* VK
38. Praha-Butovice: Side ditch in the Dalejské údolí valley, N 50°02'41.6", E 14°23'12.8". Detected species: *P. officinarum.* VK
39. Praha-Zličín: SE oriented grassy slope in angle (cross-road) of the streets Makovského and Jeremiášova, N 50°03'46.5", E 14°18'46.5". Detected species: *P. glomerata.* VK
40. Praha-Spořilov: SW oriented slope of Spořilovská street, close to the road bridge on Hlavní street, N 50°02'48.2", E 14°29'05.9". Detected species: *P. piloselloides* subsp. *bauhinii*, *P. densiflora*, *P. rothiana*, *P. setigera.* VK, JC
41. Praha-Spořilov: W oriented slope close to the garages Kačerov, N 50°02'22.57", E 14°28'54.87". Detected species: *P. piloselloides* subsp. *bauhinii.* VK
42. Praha-Kyje: S oriented grassy site where the streets Broumarská and Rožmberská cross. N 50°05'39.25", E 14°32'47.86". Detected species: *P. officinarum.* VK
43. Praha-Horní Počernice, left side of the highway direction Olomouc, 3rd km, near the bridge over highway. N 50°6'0", E 14°36'32". Detected species: *P. piloselloides subsp. praealta*, *P. floribunda.* VK
44. Praha-Horní Počernice: Highway D11, SE oriented site along the right side of the highway towards Prague, ca 1,5 km ENE of petrol station, N 50°06'41.16", E 14°38'58.37". Detected species: *P. officinarum*, *P. piloselloides* subsp. *bauhinii*, *P. visianii.* VK
45. Praha-Hrdlořezy: Old orchard on the right side of the railway towards the station Praha-Libeň, area between the streets Lísková and Morušová, N 50°05'53.5", E 14°31'22.86". Detected species: *P. officinarum.* VK
46. Praha-Hloubětín: Grassy place where the Kolbenova and Poděbradská cross. N 50°06'26.99", E 14°33'07.96". Detected species: *P. glomerata*, *P. rothiana.* VK
47. Klíčany: Petrol station on the highway, N 50°12'26.3", E 14°26'08.1". Detected species: *P. caespitosa*, *P. cymosa* subsp. *vaillantii*, *P. piloselloides* subsp. *bauhinii*, *P. rothiana*, *P. ziziana.* JC, AK, FK

48. Praha-Dejvice: Podbaba, near the ruin Baba (below the street Nad Paťankou), N 50°07'07.1", E 14°23'' 27.1". Detected species: *P. rothiana.* JC.
49. Praha-Řeporyje: Ridge above the Dalejský potok brook, waste places along the path, ca 800 E of the chapel in the village. N 50°02'00", E 14°19'15". Detected species: *P. erythrochrista.* JC