Hieracium bauhini group in Central Europe: chromosome numbers and breeding systems

Počty chromozómů a způsoby reprodukce jestřábníků ze skupiny Hieracium bauhini ve střední Evropě

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Chromosome numbers for 239 plants from 84 localities in the Czech Republic, Slovakia, Hungary, Germany and Poland are given. Most of the populations were pentaploid (2n = 45), while hexaploid (2n = 54) and tetraploid (2n = 36) populations were rarer. A long marker chromosome was observed in plants from 8 pentaploid populations. Tetraploid plants occurred mainly in Slovakia and Hungary. In the Czech Republic and Germany, most populations were pentaploid. Hexaploid populations (2n = 54) were rare but scattered over the entire study area. The co-occurrence of two different cytotypes was documented at 7 sites. Most tetraploids were fully sexual and only a few tetraploid plants from Poland were apomictic; pentaploid and hexaploid plants were apomictic. Two morphotypes of H. bauhini were distinguished: tetraploid and hexaploid plants from Slovakia and Hungary, and some hexaploid plants from the Czech Republic were assigned to the H. magyaricum group, while tetraploids and hexaploids from the Czech Republic and Poland plus all pentaploids belong to the H. bauhini group.

Key words: Compositae, cytogeography, Czech Republic, Germany, Hungary, karyology, ploidy level, Poland, reproduction mode, Slovakia

Introduction

Hieracium subgen. Pilosella is divided into two informal species groups, referred to as basic and intermediate. Members of the latter are considered to be of hybrid origin. Large variation in the ploidy level and mode of reproduction was observed in species of both groups. The reasons for this variation are reviewed in detail by Krahulcová et al. (2000). The knowledge of the karyology and breeding systems of H. subgen. Pilosella vary: some species, such as H. pilosella and H. aurantiacum are well and others poorly studied.

Studies on the karyology and mode of reproduction in Hieracium subgen. Pilosella may be divided into three periods. The earliest papers on chromosome numbers and mode of reproduction were published at the beginning of the 20th century by Ostenfeld (1906, 1910) and Rosenberg (1906, 1907, 1917); the latter author was the first to describe the apomixis of aposporic type in this subgenus (Rosenberg 1906, 1907). Further large-scale studies on karyology and mode of reproduction were published during the second half of the last century and dealt in detail with H. pilosella (Delcourt 1972, Gadella 1972, 1981, 1982, Pogan & Wcisło 1989) and H. aurantiacum (Skalińska 1969, 1970, 1971a, b, c, 1973, 1976). At the turn of the century, a series of karyological papers was written by Schuhwerk & Lippert (1997, 1998, 1999, 2002), followed by studies on karyology and breeding systems of hawkweeds from the Krkonoše Mts, Czech Republic (Krahulcová &


Cytogeographic studies were made on some taxa of Hieracium subgen. Pilosella. In *Hieracium pilosella*, the distribution of particular cytotypes was studied in Sweden (Turesson & Turesson 1960), France (Delcourt 1972), the Netherlands (Gadella 1972, 1981, 1982, 1987, Gadella & Klibiouns 1968), Poland (Pogan & Wcislo 1989) and Slovakia (Pišťanský & Mičieta 2000). The distribution patterns of tetraploids, pentaploids and hexaploids within each country depend on altitude and climate, but in general, tetraploids occur mainly in western, while pentaploids and hexaploids in eastern Europe. Further cytogeographical studies were made on *Hieracium caespitosum* (Skalińska & Kubień 1972) in Poland. Two ploidy levels, which differed in ecology and geography, were detected in *H. caespitosum* in Poland (Skalińska & Kubień 1972). A sexual diploid of *H. caespitosum* ("*H. pratense* subsp. *silvicolum* Zahn") occurs in some habitats in the Bialowieża forest in the eastern part of this species’ distribution area in Poland, whereas
the apomictic tetraploid of *H. caespitosum* (“*H. pratense* subsp. *eu-pratense* Zahn”) occurs in secondary habitats in lowlands or mountains in the W part of Poland. Similar ecological differentiation was found among the various ploidy levels in *H. cymosum*: diploids occur in relict habitats, tetraploids and hexaploids predominantly in secondary grasslands (J. Chrtek jun., in verb.).

The first classification of *Hieracium* subgen. *Pilosella* from Central Europe was that of Nägeli & Peter (1885). It is based on morphological characters. According to these authors, *Hieracium bauhini* (“*H. magyaricum*”) and *H. piloselloides* (“*H. florentinum*”) are included in *Hieracium* (subgen. *Pilosella*) sect. *Prealtina*. These two species are distinguished by the presence or absence of stolons. The stoloniferous *H. bauhini* is divided into eleven groups, each consisting of many subspecies based on the presence of stolons developing in the axils of stem leaves, stellate hairs on peduncles, and branching of inflorescences. Many of the Nägeli and Peter’s subspecies of *H. bauhini* are taxa with small distributions, often restricted to a few localities. A similar treatment was suggested by Zahn (1930) who divided *H. bauhini* into four groups: (1) *H. cryptomastix*, plants with very short stolons, distribution Steiermark and Galicia (historic region, now in SE Poland and W Ukraine); (2) *H. aëristolonum*, plants with stolons growing from both rosette and stem leaves, distribution from south-eastern Europe to Carinthia, Slovenia (“Krain”) and Steiermark; (3) *H. magyaricum*, plants with stolons growing only from the rosette and peduncles lacking or with few stellate hairs, distribution mainly SE Europe; and (4) *H. bauhini*, with stolons growing only from the rosette and peduncles with dense stellate hairs, distribution in W Europe. Following this taxonomic division of *H. bauhini*, only *H. bauhini* and *H. magyaricum* groups were detected in the study area.

Detailed studies, especially on basic species, are important for understanding the evolutionary processes in *Hieracium* subgen. *Pilosella* (Krahulec et al. 2004). In this study of *H. bauhini*, (1) the occurrence of diploids, (2) the geographic distribution of plants with particular ploidy levels, and (3) the relationship between ploidy level, mode of reproduction and morphological characters were determined.

**Materials and methods**

One to six plants from each population were collected from the field between 1996–2002 and cultivated in pots in the Botanical Garden of Masaryk University, Brno, and from 2003 in the Experimental Garden of the Faculty of Education, Masaryk University, Brno-Kejbaly. Root tips of mature plants were used for chromosome counts. They were pretreated at room temperature with a saturated water solution of p-dichlorobenzene for 2 hours and then fixed in a cold mixture of ethanol and acetic acid (3:1) for 24 hours. The fixed material was treated immediately. The root tips were macerated in a mixture of ethanol and hydrochloric acid (1:1) for 2 min at room temperature. Temporary slides were made by squashing the cut and macerated meristems in lacto-propionic orcein.

Flow cytometry was used to detect the ploidy level of 17 plants. A PA-I ploidy analyzer (Partec GmbH, Münster, Germany) equipped with an HBO-100 mercury arc lamp was used for the flow-cytometric detection of relative DNA content. Sample preparations were carried out in a two-step procedure (Otto 1990, Doležel & Göhde 1995) in the Laboratory of Flow Cytometry, the Department of Botany, Masaryk University Brno. The stem tissues
of the test plant and a reference standard (0.5 cm² of leaf blade) were chopped with a new razor blade for about 20 s in a Petri dish containing 0.5 ml of ice-cold Otto I buffer (4.2 g citric acid monohydrate + 1 ml 0.5% Tween 20 adjusted to 200 ml and filtered through a 0.22 µm filter), then 0.5 ml more Otto I buffer was added. The solution was filtered through nylon cloth (50 µm mesh size). For DNA staining, 2 ml of Otto II buffer (0.4 M disodium hydrogenphosphate dodecahydrate) including DAPI (4',6-diamidino-2-phenylindole; 4 µg/ml final concentration) was used. A clone of diploid *Hieracium lactucella* cultivated in the Masaryk University Botanical Garden was used as a reference standard for the relative DNA content measurement.

The breeding system of cultivated plants was determined by comparing the seed set of open-pollinated and emasculated capitula. This procedure is described in detail elsewhere (Gadella 1987, Krahulcová & Krahulec 1999). While the emasculated capitula of sexual plants produce no seed, both the emasculated and open-pollinated capitula of apomictic plants produce seed. However, all types that had well developed seeds in emasculated capitula were classified as apomictic, although apomixis may be facultative: the production of some progeny by sexual reproduction is not excluded. Voucher specimens of all plants are deposited in the herbarium of the Department of Botany of Masaryk University, Brno (BRNU).

**Results and discussion**

**Chromosome numbers**

The chromosome numbers of 239 plants of *Hieracium bauhini* from 84 localities in the Czech Republic, Slovakia, Hungary, Poland and Germany were counted. Three ploidy levels were recorded in cultivated plants: tetraploid (2n = 36, 77 plants from 27 populations, Fig. 1c), pentaploid (2n = 45, 116 plants from 43 populations, Fig. 1b, 1d) and hexaploid (2n = 54, 21 plants from 7 populations, Fig. 1a). The pentaploids were the most frequent, and hexaploids and tetraploids are rare. For the list of localities of the plants, see Appendix 2. Tetraploids were found in Germany (Schuhwerk & Lippert 1997, 2002), Greece (Papanicolaou 1984), Slovakia (Mráz in Rotreklová et al. 2002, 2005) and Montenegro (Schuhwerk & Lippert 1998). Pentaploids are the most frequently recorded cytotype in Belgium, the Netherlands (Gadella 1984), Germany (Schuhwerk & Lippert 1997, 2002, Bräutigam & Bräutigam 1996), Slovakia (Uhríková 1970, Mráz in Rotreklová et al. 2005), Romania (Mráz & Szél 2004) and the Czech Republic (Krahulcová et al. 2001, Krahulcová and Rotreklová in Rotreklová et al. 2002). Hexaploids are known from Germany (Schuhwerk & Lippert 1997), Macedonia (Schuhwerk & Lippert 1998) and the Czech Republic (Krahulcová in Rotreklová et al. 2002). The tetraploid and pentaploid *H. bauhini* (“Pilosella prealta subsp. thaumasia”; cf. Sell & West 1977) is recorded in New Zealand (Jenkins & Jong 1996). For a survey of the published chromosome numbers, see Appendix 1. The abundance of the particular cytotypes recorded here is similar to that observed elsewhere (Fig. 2).

In seven populations, two ploidy levels were detected: tetraploids and pentaploids (1 site), tetraploids and hexaploids (1 site), and pentaploids and hexaploids (5 sites, see Appendix 2). All mixed populations occur in open habitats, such as quarries, railway embankments or roadsides. In these habitats, Bräutigam & Bräutigam (1996) and Krahulcová
et al. (2000) observed hybrid swarms, which showed morphological and karyological variation. Similar variation within populations was found in studies of some other taxa of *Hieracium* subgen. *Pilosella*. In *H. echioides*, for example, the co-occurrence of two or three cytotypes was detected at sites in the southwest of Moravia and an adjacent part of Lower Austria (Peckert in Rotreklová et al. 2002). Chapman & Lambie (1999) recorded four ploidy levels in a New Zealand population of *H. pilosella*. This phenomenon is most frequently encountered in hybridogenous taxa of *Hieracium* subgen. *Pilosella*. Bräutigam & Bräutigam (1996) and Krahulcová (in Rotreklová et al. 2002) recorded karyological variation in *H. brachiatum*, Krahulcová & Krahulec (1999) and Krahulcová et al. (2001) in *H. piloselliflorum* from the Krkonoše Mts in the Czech Republic.

**Marker chromosome**

A marker chromosome, which is strikingly larger than the other chromosomes, was observed for the first time in *Hieracium* subgen. *Pilosella* in pentaploid plants of *H. caespitosum* in New Zealand (Jenkins & Jong 1997). Krahulcová (in Krahulcová & Krahulec 1999) found it in some related species from the Krkonoše Mts in the Czech Republic, namely in the tetraploid *H. iseranum*, *H. floribundum* and *H. caespitosum*, and in both the tetraploid and pentaploid *H. glomeratum*. This long chromosome was later observed in the tetraploid

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**Fig. 1.** – Microphotographs of mitotic metaphases of *Hieracium bauhini* – a: 2n = 54, Cz, distr. Hustopeče, Dunajovické kopce Hills, Velká Slunečná Hill (H 98/16); b: 2n = 36, Poland, distr. Warszawa, Kampinos Puscza, Kampinos Górki, (H 01/387)); c: 2n = 45 with a long marker chromosome, Cz, distr. Ústí nad Labem, village Povrly, Kozi hora Hill (H 99/209); d: 2n = 45, Cz, Bílé Karpaty Mts, Stary Hrozenkov (H 01/432). [Scale bars = 10 µm].
H. floribundum from other sites in the Czech Republic (Krahulcová in Rotreklová et al. 2002). Recently, the occurrence of a marker chromosome in H. floribundum from the Krušné hory Mts was confirmed (Krahulcová in Rotreklová et al. 2005). In H. bauhini, it was detected for the first time by Krahulcová (in Krahulcová et al. 2001, Rotreklová et al. 2002). In the course of this study, a marker chromosome was observed in 15 plants from 8 populations of pentaploid H. bauhini and in one pentaploid plant from a mixed population (with pentaploid and hexaploid plants) in the Czech Republic (Fig. 1b, for localities see Appendix 2). However, I searched for the marker chromosome in only some of the plants (Appendix 2). No morphological evidence of hybrid origin was observed in samples of H. bauhini with a long marker chromosome.

Relationship between chromosome number and morphological characters

Following Zahn’s taxonomical treatment of H. bauhini (Zahn 1930), it was possible to distinguish two groups of studied plants (H. magyaricum and H. bauhini). The tetraploid plants from Slovakia and Hungary belong to the H. magyaricum group. These plants have almost glabrous stems, leaves at most with few simple hairs, as well as peduncles and involucral bracts without or with very few stellate hairs, without or with a few glandular or simple eglandular hairs. The rare tetraploid plants from Poland and the Czech Republic, and all pentaploid and hexaploid plants belong to the H. bauhini group. Two morphotypes could be distinguished within this group: (a) plants with glabrous stem and leaves, and with peduncles and involucral bracts bearing numerous stellate hairs (white or grey coloured peduncles), and (b) plants with few glandular and single hairs on the stem (numeric-
Fig. 3. – Localities of plants of *Hieracium bauhini* agg. in Central Europe that have been investigated karyologically: 2n = 36, grey circle (27 populations); 2n = 45, grey triangle (43 populations); 2n = 54, black circle (7 populations); mixed populations: 2n = 36 and 2n = 45, grey diamond (1 population); 2n = 36 and 2n = 54, black diamond (1 population); 2n = 45 and 2n = 54, black triangle (5 populations). For complete list of localities see Appendix 2.

Fig. 4. – Map of the distribution of chromosome counts published for *Hieracium bauhini* agg. from Europe: 2n = 36, grey circle, (11 populations); 2n = 45, black triangle (17 populations); 2n = 54, grey triangle (5 populations). For survey of localities see Appendix 1.
ous on the uppermost part of the stem), and with peduncles and involucral bracts bearing dense stellate and glandular hairs. The distribution patterns and other morphological features of these morphotypes were not distinct, therefore they were not distinguished as Zahn’s subspecies.

**Cytogeography**

The tetraploids are rather more frequent in the eastern part of the study area, namely Slovakia and Hungary, and rare in Poland and the Czech Republic. On the other hand, pentaploids are frequent in the Czech Republic and Germany. The rare hexaploid cytotype is scattered over the entire study area (Appendix 2, Fig. 3). This result corresponds well with the distribution of previous chromosome counts (Uhríková 1970, Gadella 1984, Papanicolaou 1984, Bräutigam & Bräutigam 1996, Schuhwerk & Lippert 1997, 1998, 2002, Krahulcová et al. 2001, Rotreklová et al. 2002, see Appendix 1, Fig. 4). The reverse distribution pattern of particular cytotypes of *H. pilosella* within Europe is described (see Introduction and references therein).

**Breeding systems**

Both modes of reproduction, sexual and apomorphic, were detected. Tetraploid plants reproduce mainly sexually. An exception are tetraploid plants from two populations in Poland, which were apomorphic (Appendix 2). On the other hand, pentaploids and hexaploids are apomorphic, as were pentaploid plants of *H. bauhini* from Belgium and the Netherlands (Gadella 1984, see Appendix 1). Pentaploid and hexaploid plants in the Czech Republic are apomorphic (Krahulcová et al. 2001, Krahulcová and Rotreklová in Rotreklová et al. 2002). A similar relationship between the breeding system and ploidy level is observed in most of the studied plants of *H. pilosella* (Gadella 1984, 1987): tetraploids are sexual, pentaploids apomorphic, and hexaploids both sexual and apomorphic. There is also a record of pentaploid plants of *H. pilosella* reproducing sexually (Krahulcová in Rotreklová et al. 2002). The relationship between ploidy level and mode of reproduction in other taxa of *Hieracium* subgen. *Pilosella* is mentioned in the Introduction.

**Acknowledgement**

I am obliged to all the colleagues who collected plants and are listed in Appendix 2. I am also indebted to F. Krahulec and J. Chrtek jun. and an anonymous reviewer for comments on the manuscript. S. O’Flynn and J. Danihelka improved my English and T. Dixon improved the final version of the manuscript. I would also like to thank the directors of the botanical gardens in which the plants were cultivated, M. Tupá (Botanical Garden of the Faculty of Science, Masaryk University, Brno) and H. Jedličková (Experimental Garden of the Faculty of Education, Masaryk University, Brno-Kejbaly). This study was supported by the Ministry of Education research project MSM 143100010.

**Souhrn**

V práci jsou shrnuty výsledky studia chromozómových počtů a způsobů reprodukce jestřábníků z aggregátu *Hieracium bauhini*. Chromozómové počty byly zjištěny celkem u 239 rostlin z 84 lokalit z České republiky, Slovenska, Maďarska, Polska a Německa. V souladu s literárními údaji byly u studovaných rostlin zjištěny tři ploidní úrovně: tetraploidiční (2n = 36; 77 rostlin z 27 lokalit), pentaploidiční (2n = 45; 116 rostlin ze 43 lokalit) a hexaploidiční (2n = 54; 21 rostlina ze 7 lokalit). V karyotypu 19 rostlin byl pozorován velký nepárový chromozóm („marker“ chro-
mocím), jehož výskyt byl již dříve pozorován u několika druhů podrodu *Pilosella* včetně *H. bauhini*. Na sedmi lokalitách byl zjištěn společný výskyt rostlin se dvěma různými ploidními úrovněmi. U téměř tří čtvrtin rostlin byly zjišťovány způsoby reprodukce. Tetraploidní rostliny se až na výjimky rozmnožovaly sexuálně, pentaploidní a hexaploidní rostliny výhradně apomikticky. Studované rostliny bylo možno zařadit do dvou geograficky, morfo-logicky, karyologicky a reprodukčně oddělených skupin. Rostliny z jihozápadní části studovaného území (tj. ze Slovenska a Maďarska) byly převážně pentaploidní nebo hexaploidní (a vzácně, na dvou lokalitách v Polsku, tetraploidní) a rozmnožovaly se apomikticky. Tyto rostliny měly lodyhy a přízemní listy lysé nebo řídce porostlé jednoduchými dlouhými, hvězdovitými i žláznatými chlupy; květní stopky měly hustě porostlé hvězdovitými chlupy (plstnaté), v některých případech i žláznatými a jednoduchými dlouhými chlupy. Tyto rostliny je možné zařadit do skupiny *H. bauhini*. Hranici rozšíření obou skupin ve studovaném území tvoří pravděpodobně pohraniční pohoří mezi Českou republikou a Slovenskem.

References


Appendix 1. – List of localities of published chromosome numbers of *Hieracium bauhini* group from Europe.

<table>
<thead>
<tr>
<th>Source</th>
<th>Locality</th>
<th>2n</th>
</tr>
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<tbody>
<tr>
<td>Papanicolaou 1984 [<em>&quot;H. praecatum subsp. bauhini&quot; (Besser) Petunnikov</em>]</td>
<td>Greece, Mt Athos: from Skiti of Kerasia to Panagha</td>
<td>36</td>
</tr>
<tr>
<td>Jenkins &amp; Jong 1997 (<em>&quot;Pilosella praecata subsp. thausasia&quot;</em>)</td>
<td>New Zealand: Craigieburn</td>
<td>36</td>
</tr>
<tr>
<td>Schuhwerk &amp; Lippert 1997 (<em>&quot;H. bauhini Schult. subsp. bauhini&quot;</em>)</td>
<td>New Zealand: The Wolds</td>
<td>36</td>
</tr>
<tr>
<td>Schuhwerk &amp; Lippert 1998 (<em>&quot;H. bauhini subsp. magyaricum&quot; (Nägeli et Peter) K. Maly</em>)</td>
<td>New Zealand: Lake Ruataniwha</td>
<td>36</td>
</tr>
<tr>
<td>Schuhwerk &amp; Lippert 2002 (<em>&quot;H. bauhini Schult. subsp. haumastioides&quot; (Nägeli et Peter) Zahn</em>)</td>
<td>Germany, Bavaria: Unterfranken, Kirchhofberg Hill near Machtshausen</td>
<td>36</td>
</tr>
<tr>
<td>Schuhwerk &amp; Lippert 2002 (<em>&quot;H. bauhini Schult. subsp. cymathum&quot; (Nägeli et Peter) Zahn</em>)</td>
<td>Montenegro: meadow slope above Lokve Gate 16 km E of Ivangrad</td>
<td>36</td>
</tr>
<tr>
<td>Mráz in Rotreklová et al. 2002 (<em>&quot;H. bauhini&quot; Besser</em>)</td>
<td>Germany, Bavaria: Oberbayern, München City</td>
<td>36</td>
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<tr>
<td>Mráz in Rotreklová et al. 2005 (<em>&quot;H. bauhini&quot; Besser</em>)</td>
<td>Slovakia, Volovské vrchy Mts, Sitárka Hill</td>
<td>36</td>
</tr>
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<td>Mráz in Rotreklová et al. 2005 (<em>&quot;H. bauhini&quot; Besser</em>)</td>
<td>Slovakia, Slovenský kras Mts, Plešivecká planina plateau: Plešivec town, ca. 3.5 km NNE from the railway station Plešivec</td>
<td>36</td>
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<tr>
<td>Mráz in Rotreklová et al. 2005 (<em>&quot;H. bauhini&quot; Besser</em>)</td>
<td>Slovakia, Slovenský kras Mts, Silická planina plateau: ca. Silická Brezová village, ca. 0.2 km SE from cote Delené</td>
<td>36</td>
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Slovakia, Slovenský kras Mts, Silická planina plateau: Brzotín village, Brzotínska skala Hill, ca. 2 km SSE of the village
Slovakia, Rožňavská kotlina basin: Krásnokohorské Podhradie village, W slopes of the castle hill Krásna Hôrka
Slovakia, Číerna hora Mts, Košice city: part Kavečany, in the area of Zoological garden

Gentschef 1937 [“H. praealtum (Vill.) Nägeli et Peter”]
unknown origin, plant from the botanical garden
45

Uhríková 1970 (in Májovský et al. 1970)
Slovakia, Zlatnická dolina Lowland: near Skalica
45

Gadella 1984 [“H. praealtum subsp. bauhinii (Besser) Petunnikov in Syreistschikov”]
Netherlands, Limburg: Brunsum
45

Bräutigam & Bräutigam 1996 (“H. bauhini Bef. subsp. bauhinii s.l.”)
Germany, Saxonia: 12 km SSW of Görlitz, near the village Schönau-Berzdorf, 4 km W of the border with Poland
45

Jenkins & Jong 1997 (“Pilosella praeflata subsp. thauamastia”)
New Zealand: Mt John trial site
45

Schuhwerk & Lippert 1997 (“H. bauhini Bef. Schult. subsp. bauhinii”)
New Zealand: SW face of Mt John
45

Schuhwerk & Lippert 1997 (“H. bauhini Bef. Schult. subsp. bauhinii”)
Germany, Bavaria: Oberbayern, München-Allach/Karlsfeld
45

Schuhwerk & Lippert 1997 (“H. bauhini Bef. Schult. subsp. bauhinii”)
Germany, Bavaria: Oberbayern, Seeshaupt
45

Schuhwerk & Lippert 1997 (“H. bauhini subsp. pseudobauhinii (Nägeli et Peter) Zahn”)
Germany, Bavaria: Oberpfalz, Mittelberg Hill N of Tegenheim
45

Krahulcová in Rotreklová et al. 2002 (“H. bauhini Bef.”)
Czech Republic, Praha, town district Vysočany
45

Rotreklová in Rotreklová et al. 2002 (“H. bauhini Bef.”)
Czech Republic, Brno, Nature reserve Kamenný kopec
45

Krahulcová et al. 2001 (“H. bauhini Bef.”)
Czech Republic, Krkonoše Mts, Dolní Malá Úpa
45

Schuhwerk & Lippert 2002 [“H. bauhini subsp. thauamunites (Nägeli et Peter) Zahn”]
Germany, Bavaria, Niederbayern, Welchenberg
45

P. Mráz in Rotreklová et al. 2005 (“H. bauhini Bef.”)
Germany, Bavaria: Oberpfalz, Lauterachtal bei Lauterach
45

Mráz & Szelag 2004 [“Pilosella bauhini Bef. (F. W. Schultz ex Besser) Arv.-Touv.”]
Slovakia, Tribeč Mts: Klátorová Nová Ves village
45

Schuhwerk & Lippert 1997 (“H. bauhini Bef. Schult. subsp. bauhinii”)
Germany, Bavaria: Etterhausen near Nittendorf
54

Schuhwerk & Lippert 1997 (“H. bauhini Bef. Schult. subsp. bauhinii”)
Germany, Bavaria: Regensburg, Keilberg Hill
54

Schuhwerk & Lippert 1997 (“H. bauhini Bef. Schult. subsp. bauhinii”)
Germany, Bavaria: Gemeinde Tegernheim, slope of Mittelbergs Hill
54

Schuhwerk & Lippert 1998 [“H. bauhini subsp. filigerum (Tausch) Zahn”]
Macedonia, Ohridsee, Galicica, between Trpezjca and Otsevo
54

A. Krahulcová in Rotreklová et al. 2002 (“H. bauhini Bef.”)
Czech Republic, distr. Louny, village of Valov
54
Appendix 2. – Chromosome numbers and mode of reproduction of the representatives of *Hieracium bauhini* group from the Central Europe. Number under which the plant is cultivated is given in the first column. When ploidy level was detected by flow cytometry, occurrence of a long marker chromosome was not studied.

**Abbrevations:** Cz = Czech Republic, Sk = Slovakia, Hu = Hungary, O. R. = Olga Rotreklová, p. = plant or plants, FC = flow cytometry, M = long marker chromosome, M+ = karyotyp with a long marker chromosome, M- = karyotyp without a long marker chromosome, apo = apomictic reproduction, sex = sexual reproduction.

<table>
<thead>
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<th>Number</th>
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<th>Reproduction</th>
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<tr>
<td>98/122-125, 01/460, 461</td>
<td>Sk, distr.: SW slope of the Tarbucka Hill 2.5 km SE of the village of Streda nad Bogrodom, 160 m a.s.l., coll. J. Chrtke jun., T. Peckert &amp; J. Škorničková, 26 June 1998.</td>
<td>48°23'08&quot;N 21°45'16&quot;E</td>
<td>36 (6 p.) M-</td>
<td>sex (6 p.)</td>
</tr>
<tr>
<td>01/391-395</td>
<td>Sk, Banská Štiavnica, slope along the road to quarry 0.5 km NW of the church in the village Jergištoľna, 730 m a.s.l., coll. O. R., 28 June 2001.</td>
<td>48°29'09&quot;N 18°52'36&quot;E</td>
<td>36 (4 p.)</td>
<td>sex (3 p.)</td>
</tr>
<tr>
<td>01/396-400</td>
<td>Sk, Banská Štiavnica: on the SW margin of the town 0.8 km NE of the top of Vtáčnik Hill, 750 m a.s.l., coll. O. R., 28 June 2001.</td>
<td>48°27'47&quot;N 18°52'01&quot;E</td>
<td>36 (4 p.) M-</td>
<td>sex (5 p.)</td>
</tr>
<tr>
<td>01/407-409</td>
<td>Sk, Banská Bystrica: slope in the town district Podlavec (NW margin of the town) above the road to the hospital, 470 m a.s.l., coll. O. R., 26 June 2001.</td>
<td>48°44'33&quot;N 19°08'21&quot;E</td>
<td>36 (3 p.) M-</td>
<td>sex (3 p.)</td>
</tr>
<tr>
<td>01/421, 423-425</td>
<td>Sk, Veľká Fatra Mts: Donovaly, along the hiking path between villages Donovaly and Špania dolina, 1 km WSW of the Hrubý vrch Hill, 900 m a.s.l., coll. O. R. &amp; Z. Lososová, 26 June 2001.</td>
<td>48°51'00&quot;N 19°09'00&quot;E</td>
<td>36 (4 p.) M-</td>
<td>sex (4 p.)</td>
</tr>
<tr>
<td>02/504-506</td>
<td>Sk, distr. Nitra: Krnča, W slope of Kozlitsa Hill, 450 m a.s.l., coll. O. R. &amp; P. Eliáš jun., 6 September 2002.</td>
<td>48°33'00&quot;N 18°16'00&quot;E</td>
<td>36 (3 p.) M-</td>
<td>sex (3 p.)</td>
</tr>
<tr>
<td>02/509</td>
<td>Sk, distr. Nitra: Pohranice, SW slope of the Kolíňanský vrch Hill, 270 m a.s.l., coll. O. R. &amp; P. Eliáš jun., 6 September 2002.</td>
<td>48°19'00&quot;N 18°09'00&quot;E</td>
<td>36 (1 p.) M-</td>
<td>sex (1 p.)</td>
</tr>
<tr>
<td>02/523-526</td>
<td>Sk, Vtáčnik: Nature reserve Včelár 6 km NE of the village Topoľčianky, 390 m a.s.l., coll. P. Šmarda, 24 May 2002.</td>
<td>48°27'01&quot;N 18°28'42&quot;E</td>
<td>36 (3 p.) M-</td>
<td>sex (3 p.)</td>
</tr>
<tr>
<td>02/527-529, 538, 540, 541</td>
<td>Sk, distr. Krupina: 4.6 km NNE of the village, 450 m a.s.l., coll. P. Šmarda, 24 May 2002.</td>
<td>48°23'46&quot;N 19°05'25&quot;E</td>
<td>36 (5 p.) M-</td>
<td>sex (5 p.)</td>
</tr>
<tr>
<td>02/530, 531</td>
<td>Sk, Nature reserve Štiavnické vrchy: 1.4 km ESE of the church in the village Žibritov, 460 m a.s.l., coll. P. Šmarda, 22 May 2002.</td>
<td>48°23'12&quot;N 18°59'58&quot;E</td>
<td>36 (1 p.) M-</td>
<td>sex (1 p.)</td>
</tr>
<tr>
<td>02/532, 534</td>
<td>Sk, distr. Levice: Nová Dedina, near the Gyndovo Hill, 250 m a.s.l., coll. P. Šmarda, 24 May 2002.</td>
<td>48°17'58&quot;N 18°40'20&quot;E</td>
<td>36 (2 p.) M-</td>
<td>sex (1 p.)</td>
</tr>
<tr>
<td>02/535-537</td>
<td>Sk, Krupinská planina: 2.7 km SSW of the church in the village Cerovo, 380 m a.s.l., coll. P. Šmarda 22 May 2002.</td>
<td>48°14'05&quot;N 19°08'03&quot;E</td>
<td>36 (3 p.) M-</td>
<td>sex (2 p.)</td>
</tr>
<tr>
<td>02/542-544</td>
<td>Sk, Krupinská planina: Nature Reserve Šipka along the village Plášťovce, 233 m a.s.l., coll. P. Šmarda, 21 May 2002.</td>
<td>48°09'43&quot;N 18°59'01&quot;E</td>
<td>36 (3 p.) M-</td>
<td>sex (1 p.)</td>
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<tr>
<td>02/545-548</td>
<td>Sk, Krupinská planina, Hontianske Nemce-Tepličky: 3.1 km SSE of the settlement Teplička, 260 m a.s.l., coll. P. Šmarda &amp; J. Ripka, 22 May 2002.</td>
<td>48°18'13&quot;N 18°58'03&quot;E 36 (3 p.) M-, sex (4 p.) 4x (1 p.) detected by FC</td>
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<tr>
<td>98/140-142</td>
<td>Hu, Bükk Mts: rocks along the road 3 km S of the village Málvinka (ca 20 km WNW of the town Miskolec), coll. J. Chrtok, T. Peckert &amp; J. Škorničková, 25 June 1998.</td>
<td>48°08'00&quot;N 20°18'03&quot;E 36 (3 p.) M- sex (3 p.)</td>
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<tr>
<td>00/303, 305, 306</td>
<td>Hu, village of Pákozd, hills NW of the village, coll. P. Šmarda &amp; T. Vymyslický, 23 June 2002.</td>
<td>47°13'46&quot;N 18°32'43&quot;E 36 (1 p.) M- 4x detected by FC</td>
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<td>02/564</td>
<td>Hu, Pécs-Misina: hill on the N margin of the town, coll. P. Šmarda, 8 June 2002.</td>
<td>46°14'02&quot;E 36 (1 p.) M- not studied</td>
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<td>02/568-570</td>
<td>Hu, Zala county, Balaton Lake, Nature reserve Keszthelyi hegység cca. 2 km NW of the village Gyenesdias, 160 m a.s.l., coll. P. Šmarda, 8 June 2002.</td>
<td>46°14'02&quot;E 36 (1 p.) M- 4x detected by FC</td>
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<td>02/571-574</td>
<td>Hu, Zala county, Balaton Lake, Nature reserve Keszthelyi hegység, slope along the village Beccehgy, 270 m a.s.l., coll. P. Šmarda, 2 June 2002.</td>
<td>46°47'36&quot;N 17°22'07&quot;E 36 (3 p.) M- sex. (2 p.)</td>
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<td>02/575, 576</td>
<td>Hu, Szarvaskö, 340 m a.s.l., coll. P. Šmarda, 8 June 2002.</td>
<td>46°59'32&quot;N 20°19'50&quot;E 36 (2 p.) M- sex. (2 p.)</td>
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<td>02/580, 581</td>
<td>Hu, Baranya county, Mecsek, Nature reserve on the SW margin of the village Cserkút, 250 m a.s.l., coll. P. Šmarda, 8 June 2002.</td>
<td>46°04'11&quot;N 18°08'01&quot;E 36 (2 p.) M- 4x detected by FC</td>
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<td>02/583</td>
<td>Hu, between villages of Kunszentmiklós and Kunadacs, steppe, 104 m a.s.l., coll. P. Šmarda, 6 June 2002.</td>
<td>45°51'07&quot;N 18°24'12&quot;E 36 (2 p.) M- sex. (2 p.)</td>
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<td>02/585, 586</td>
<td>Hu, Villányi hegység, Baranya county, Nature reserve along the village Szársomlyó, 200 m a.s.l., coll. P. Šmarda, 6 June 2002.</td>
<td>45°51'07&quot;N 18°24'12&quot;E 36 (2 p.) M- sex. (2 p.)</td>
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<td>01/452</td>
<td>Cz, distr. Hodonín, Dúbrava Forest 2 km WNW of the railway station Hodonín, 165 m a.s.l., coll. R. Řepka, July 2001.</td>
<td>48°51'35&quot;N 17°05'37&quot;E 36 (1 p.) M- not studied</td>
<td></td>
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<tr>
<td>00/292</td>
<td>Poland, distr. Kraków, village Nawojowa Gora, quarry along the road Krzeszowice-Krakow ca. 0.8 km NW of the church in the village, 280 m a.s.l., coll. O. R. &amp; J. Rotrekl, 16 June 2000.</td>
<td>50°06'01&quot;N 19°45'00&quot;E 36 (1 p.) M- apo (1 p.)</td>
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<td>01/386, 387</td>
<td>Poland, distr. Warszawa, Kampion Puszcza, Kampinos Górki, coll. M. Chytrý, 8 June 2001.</td>
<td>52°20'23&quot;N 20°29'30&quot;E 36 (2 p.) M- apo (1 p.)</td>
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<td>98/13</td>
<td>Cz, distr. Vyškov: meadow in the SE part of the village Koberčice, 320 m a.s.l., coll. Z. Lososová, 6 June 1998.</td>
<td>49°05'22&quot;N 16°53'25&quot;E 45 (1 p.) presence M not studied</td>
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<td>98/23-26</td>
<td>Cz, distr. Brno: along the railway 0.5 km W of the village Prženice, 210 m a.s.l., coll. O. R., 25 May 1998.</td>
<td>49°08'45&quot;N 16°36'25&quot;E 45 (4 p.) presence M not studied</td>
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<td>98/27</td>
<td>Cz, distr. Zlín: village Bylnice, Na stráži meadow in the NW margin of the village, 340 m a.s.l., coll. M. Chytrý, 24 May 1998.</td>
<td>49°04'34&quot;N 18°01'21&quot;E 45 (1 p.) presence M not studied</td>
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<td>98/28-31</td>
<td>Cz, Brno: along the railway in the town district Obrany, 250 m a.s.l., coll. O. R., 27 May 1998.</td>
<td>49°13'31&quot;N 16°39'10&quot;E 45 (4 p.) presence M not studied</td>
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</table>
98/34-37  Cz, distr. Žďár nad Sázavou: slope along the railway 1.5 km W of the village of Řikonín, 400 m a.s.l., coll. O. R. & Z. Lososová, 29 May 1998.
49°21’59’’N  16°18’09’’E
45 (2 p.), ca. 45 (1 p.) presence M not studied
apo (3 p.)

49°21’56’’N  16°18’30’’E
45 (3 p.) presence M not studied
apo (1 p.)

98/41-44  Cz, Brno: along the forest road in the E margin of the village Mokrá Hora, 250 m a.s.l., coll. O. R., 31 May 1998.
49°15’26’’N  16°35’49’’E
45 (4 p.) presence M not studied
apo (2 p.)

98/47, 49, 50  Cz, Brno: along the road in the town district Bohunice, 250 m a.s.l., coll. O. R., 4 June 1998.
49°10’19’’N  16°35’16’’E
45 (3 p.) presence M not studied
apo (1 p.)

49°14’56’’N  16°35’65’’E
45 (3 p.) M–presence M studied in 1 p. only
apo (1 p.)

49°20’42’’N  16°44’06’’E
45 (3 p.) presence M not studied
apo (3 p.)

49°31’52’’N  17°05’06’’E
45 (2 p.) presence M not studied
apo (2 p.)

98/80, 83  Cz, Brno: slope above the railway 1 km NE of the village Ivanovice, 280 m a.s.l., coll. O. R., 20 July 1998.
49°16’23’’N  16°34’51’’E
45 (3 p.) presence M studied in 1 p. only
apo (3 p.)

49°14’56’’N  16°35’65’’E
45 (3 p.) M–presence M studied in 1 p. only
apo (1 p.)

49°28’25’’N  17°01’18’’E
45 (3 p.), ca. 45 (1 p.) presence M not studied
apo (3 p.)

98/92-95  Cz, distr. Svitavy: quarry 0.5 km N of the town Městečko Tmávka, 340 m a.s.l., coll. O. R., 30 July 1998.
49°43’05’’N  16°43’29’’E
45 (4 p.) presence M not studied
apo (4 p.)

49°44’25’’N  16°42’11’’E
45 (3 p.) M–presence M studied in 1 p. only
not studied
apo (1 p.)

48°53’03’’N  17°31’51’’E
45 (2 p.) presence M not studied
apo (1 p.)

48°54’42’’N  17°28’17’’E
45 (3 p.) presence M not studied
apo (1 p.)

49°21’15’’N  16°42’36’’E
45 (1 p.) M+ not studied
not studied

49°18’49’’N  16°30’32’’E
45 (1 p.) presence M not studied
not studied


99/209-211 Cz, distr. Ústí nad Labem: W slope of the Kozí hora Hill 1.8 km NW of the railway station Povrly, 220 m a.s.l., coll. O. R., 22 June 1999.

99/224, 226-228 Cz, distr. Havlíčkův Brod: in the slope 0.5 km SE of the chapel in the village Libice nad Doubravou, 480 m a.s.l., coll. O. R., 29 June 1999.


00/254, 255 Cz, distr. Vsetín: strand of the water reservoir Stanovice 1.2 km SW of the railway station Karolinka, 180 m a.s.l., coll. K. Ehrenbergerová, 21 May 2000.

00/343 Cz, distr. Břeclav: meadow along the Aloch stream near the fishpond Alah III 3.6 km SSW of the church in the village Lednice, 170 m a.s.l., coll. J. Danihelka, 21 September 2000.

01/375 Cz, distr. Hodonín: sandy place 3.3 km SW of the railway station Bzenec-přívoz, 190 m a.s.l., coll. J. Danihelka, June 2001.


02/464 Cz, distr. Břeclav: Sedlec, Liščí vrch Hill 1.5 km NNW of the church in the village, 250 m a.s.l., coll. O. R. & J. Danihelka, 21 May 2002. 48°47'33''N 16°41'32''E 45 (1 p.) M- apo (1 p.)


02/489 Cz, distr. Břeclav: Mikulov town, quarry on the NE foot of the Svatý kopeček Hill, 300 m a.s.l., coll. O. R. & J. Danihelka, 21 May 2002. 48°48'33''N 16°39'13''E 45 (1 p.) M- not studied


01/440-445 Sk, Liptovský Hrá dok: bank of the Biely Váh River 200 m E of the confluence of rivers Biely Váh and Belá, 650 m a.s.l., coll. O. R., 14 July 2001. 49°01'54''N 19°42'40''E 45 (6 p.) M- apo (3 p.)

00/317, 318 Germany, Bavaria: 8 km NE of the Kallmünz, Greinhof, coll. O. R. & P. Šmarda, 11 July 2000. 49°10'00''N 11°57'00''E 45 (1 p.) M- 5x (1 p.) detected by FC apo (2 p.)

01/463 Poland: Sandomierz village, Góry Peprzowe, slope above the Węsła River E of the town, coll. J. Chrtek jun., Z. Szeląg & T. Peckert 11 June 2001. 50°41'41''N 21°44'00''E 36 (1 p.), 45 (1 p.), both ploidy level M- 54 (1 p.) M- sex (36–2 p.), apo (54–1 p.)

99/214, 216 Cz, Jeseníky Mts, distr. Šumperk: Branná, limestone quarry in the E margin of the town, 600 m a.s.l., coll. O. R., 28 June 1999. Plants occur together with H. piloselloides. 50°09'13''N 17°00'36''E 36 (1 p.), 45 (1 p.), both ploidy level M- apo (both ploidy level)

02/567, 577, 578 Hu, Heves county, Győngös: rocky slope along the town, 270 m a.s.l., coll. P. Šmarda, 4 June 2002. 47°47'50''N 19°47'21''E 36 (2 p.) M- 54 (1 p.) M- sex (36–2 p.), apo (54–1 p.)

98/104, 105-107 Cz, distr. Hodonín: slope along the road 1 km NE of the church in the town Velká nad Veličkou, 400 m a.s.l., coll. O. R. & J. Rotreklová, 3 August 1998. 48°53'08''N 17°31'57''E 45 (3 p.) M- presence M studied in 1 p. only, 54 (1 p.) presence M not studied both ploidy level apo (45–3 p., 54–1 p.)

99/205–206 Cz, distr. Ústí nad Labem: between road and railway 0.75 km SE of the railway station Ústí nad Labem, 140 m a.s.l., coll. O. R., 22 June 1999. 50°39'11''N 14°02'48''E 45 (1 p.) M+ 6x (1 p.) detected by FC both ploidy level apo (45–3 p., 54 – not studied)


01/432, 434-436 Cz, Bílé Karpaty Mts: quarry 1 km NNE of the church in the village of Starý Hrozenkov, 460 m a.s.l., coll. O. R. & Z. Lososová, 25 June 2001. 48°58'08''N 18°52'26''E 45 (3 p.) M- 54 (1 p.) M- both ploidy level apo (45–3 p., 54–1 p.)

02/498, 515, 517-519 Cz, Praha, town district Spořilov, road margin of the Jižní spojka, near a brige Hlavní Street, 250 m a.s.l., coll. J. Chrtek jun., 6 May 2002. 50°02'47''N 14°29'20''E 45 (1 p.) M- 54 (4 p.) M-, 6x (1 p.) detected by FC 54 (3 p.) M- presence M studied in 1 p. only apo (45–1 p., 54 – not studied)

98/59-61 Cz, distr. Hradec Králové: strand of the fishpond 2.9 km N of the crossroad in the village Hrádek, 220 m a.s.l., coll. J. Danihelka, June 1998. 50°05'59''N 15°43'28''E 50 (1 p.) M- apo (3 p.)
01/370-374  Cz, distr. Hradec Králové: strand of the fish-pond 2.9 km N of the crossroad in the village Hrádek, 220 m a.s.l., coll. J. Danihelka, June 2001.  50°06'19"N 15°43'01"E 54 (4 p.) M- apo (4 p.)

98/115-117  Cz, distr. Žďár nad Sázavou: slope above the bank of the Svratka River 1.5 km NNE of the church in the village Nedvědice, 330 m a.s.l., coll. O. R., 11 August 1998.  49°28'02"N 16°20'35"E 54 (2 p.), (6x) apo (2 p.) (1 p.) detected by FC presence M not studied

98/51-53  Cz, distr. Brno: railway station in the village Kuřim, 290 m a.s.l., coll. O. R., 9 June 1998.  49°18'04"N 16°32'01"E 54 (3 p.) presence M not studied apo (3 p.)

98/19-22  Cz, Brno: quarry Hády in the NE part of the town, 400 m a.s.l., coll. O. R., 22 May 1998.  49°13'12"N 16°40'16"E 54 (4 p.) M-presence M studied in 1 p. only apo (4 p.)

98/16  Cz, distr. Hustopeče: Nature reserve Dunajovické kopce 2 km W of the village Dunajovice, W slope of the Velká Slunečná Hill, 230 m a.s.l., coll. J. Danihelka, June 1997.  48°51'10"N 16°33'08"E 54 (1 p.) presence M not studied

01/412, 413, 415  Sk, Žiar nad Hronom: village of Stará Kremnička, quarry 3 km N of the church in the village, 500 m a.s.l., coll. O. R., 28 June 2001.  48°36'15"N 18°54'00"E 6x, (3 p.) detected by FC apo (3 p.)