



University of South  
Bohemia in České  
Budějovice

Faculty of Science



## **Diversity, variability and distribution of polyploid groups of ferns in Central Europe**

Diverzita, variabilita a rozšíření polyploidních  
skupin kapradin ve střední Evropě

Summary of PhD. Thesis

**Libor Ekrť**

Supervisor: Ing. Milan Štech Ph.D.

Department of Botany, Faculty of Science,  
University of South Bohemia in České  
Budějovice

České Budějovice  
2009

## Annotation

EKRT L., 2009: Diversity, variability and distribution of polyploid groups of ferns in Central Europe. PhD. thesis, composite in English/Czech. University of South Bohemia, Faculty of Science, České Budějovice, Czech Republic, 272 pp.

Diversity, morphological and cytogeographic variability and distribution of polyploid groups of ferns in the central part of Europe (especially in the Czech Republic) were examined. Particularly taxonomical critical taxa of genera *Asplenium* and *Dryopteris* were investigated in a more detailed. Cytotaxonomical variation (estimation DNA ploidy level and genome size) was studied using the methods of flow cytometry. Consequential study of morphological variation was investigated by multivariate morphometric analyses. Significance of individual morphological characters for the determination of species complexes is evaluated and some determination keys was compiled as same as the treatment of some taxa/groups to the local floras/identification keys (Czech Republic, Slovakia, Austria) is presented. Distribution of particular taxa in the Czech Republic was studied based on of revised herbarium specimens and own field research. New taxa for the Czech republic/Bohemia were recently confirmed (*Dryopteris remota*, *D. cambrensis*) during this study.

### Key words:

*Asplenium*, Central Europe, Czech Republic, distribution, DNA ploidy level, *Dryopteris*, ferns, flow cytometry, genome size, multivariate morphometrics, *Pteridophyta*, taxonomy

## Financial support

The work was supported by the *Mattoni Awards for Studies of Biodiversity and Conservation Biology* during the years 2001–2005, grant MSM6007665801 of the Ministry of Education, support by the Ministry of Education, Youth and Sports of the Czech Republic (project no. MSM 0021620828), Academy of Sciences of the Czech Republic no. AV0Z60050516, the grant no. 206/07/0706 from the Grant Agency of the Czech Republic and financial sources of Department of Botany, Faculty of Science, University of South Bohemia.

## Acknowledgements

Special thanks are due to Milan Štech, supervisor of my PhD. thesis for his advices and support during my fern research.

I gratefully acknowledge the stuff of the Laboratory of flow cytometry, Institute of Botany, Academy of Science of the Czech Republic, particularly Jan Suda and Pavel Trávníček for help and partnership during my PhD study.

I am much obliged to Vlasta Jarolímová for chromosome counting of reference standards to flow-cytometry, Petr Šmilauer for valuable comments on statistics. I

am also grateful to Helga Rasbach (Glottartal, Germany), Stefan Jeßen (Chemnitz, Germany) and Christopher Fraser-Jenkins (Kathmandu, Nepal) for their help with various fern problems and the determination of some specimens during the research.

The other thank belongs to Karel Boublík, Aleš Hájek, Martin Lepší, Petr Lepší, Karel Sutorý, Josef Kučera and Jan Košnar for their help during field sample collections. Some advices and help with foreign older papers support Karsten Horn. Co-authors of my papers belong thanks for their ideas, teamwork and improving notes during our common papers writing.

Special thank belongs to curators of public herbarium collections particularly from BRNM, BRNU, CB, CESK, CBFS, FMM, GM, HOMP, HR, CHOM, KHMS, LIM, LIT, MJ, MP, MZ, NJM, OH, OL, OLM, OMJ, OSM, OVMB, PL, PR, PRC, ROZ, SOB, SOKO, SUM, VM, ZMT. Colleagues Jiří Hadinec, Milan Marek, Jiří Danihelka and Karel Sutorý kindly helped with reading or localization of problematic labels.

Jan Košnar kindly improved my English of introduction and conclusions part of this thesis.

The stuff of Library of Academy of Science & Faculty of Science in České Budějovice deserve great thank for kindness and providing of numerous of paper which I needed to supply from others libraries from the Czech Republic and foreign countries.

The last professional thank deserve Aleš Hájek, who routed me as a high school student to fern problematics. Firstly the *Dryopteris carthusiana* group charmed me in area of Broumovsko before 14 years ago. It could be a bit fated that before 14 years I started problematics, which taxonomical final results I am finishing right now at the end of my PhD study.

I would like to give the warmest thank to my wife as same as my parents and mother-in-law for their understanding and patience to my continual running to ferns. Despite they did not know, why are ferns so important they always remembered me that not only ferns are part of the life.

## Introduction

Systematic research based on cytological examination (number of chromosomes, pairing of bivalents etc.) in ferns was started in Europe by Manton (1950), who first reported on complexity of fern polyploid groups. After this, number of other studies has followed. Conventional chromosome counts provided robust evidence for heteroploid hybridization, while studies of chromosome pairing during meiosis in both natural and artificial hybrids shed some light on species relationships (Manton & Walker 1953, Walker 1955, 1961). In Europe, systematic research in majority of large fern genera, such as *Asplenium*, *Cheilanthes*, *Dryopteris* or *Polystichum*, was conducted simultaneously with study of mechanisms and modes of sexual and asexual speciation (see paragraphs above). Species varying not only in their morphology but also in ploidy level and evolutionary history were recognized notably in species rich genera of *Asplenium* and *Dryopteris* (Lovis

1973, Fraser-Jenkins 1980, Gibby 1983, Dostál et al. 1984, Reichstein 1984, Fraser-Jenkins 1986, 1987, 1993, Viane et al. 1993, Frey et al. 2006, Fraser-Jenkins 2007).

There has been strong tradition of research in the field of cytology, chemotaxonomy and distribution of critical fern groups in North, West or South Europe and Macaronesia (Widén et al. 1967, Sorsa & Widén 1968; Widén & Sorsa 1968, Widén et al. 1970, Brownsey 1976, Gibby & Walker 1977, Piękoś-Mirkowa 1979, Nyhus 1987, Benl & Eschelmüller 1983, Gibby 1983, Bennert & Fischer 1993, Steinecke & Bennert 1993). However, these taxonomical studies have been mostly based on restricted datasets and modern formalized statistical methods have not been used for data analysing. On the other hand, large number of species/groups have not yet been studied and distinguished in some countries of Central and East Europe, e.g. in the Czech Republic, Slovakia, Poland or Romania (Hejny & Slavík 1988, Mirek et al. 1995, Marhold & Hindák 1998, Ciocârlan 2000, Kubát et al. 2002).

Important and excellent studies of last decade are focused on genetic structure of populations, migration routes and reticulate evolution, notably in *Asplenium* genus, using chloroplast DNA markers (Vogel et al. 1996, 1998, 1999a, 1999b, 1999c, Trewick et al. 2002).

This PhD thesis deals with systematics of selected fern groups in Central Europe. The general aim was to extend knowledge from those parts of Europe, where similar issues were intensively studied. This thesis brings formalized taxonomic revision of some fern groups from cytological and morphological point of view. In comparison to antecedent studies, large datasets were usually analysed. In addition, presented studies widely use methods of flow-cytometry, indicating usefulness of these methods in systematic research of ferns. For comprehensive overview of problems in particular taxonomic groups see introductions of the papers presented thereafter.

## Aims of the thesis

- Study of taxonomically critical groups of ferns primarily from genera *Asplenium* and *Dryopteris* in Central Europe
- Applications of flow cytometry to fern systematics  
Can genome size be used as an informative marker for taxonomic decision-making?  
What is the level of genome size variation in the group?
- Evaluation of morphological variability of selected groups based on multivariate morphological analysis  
What are the species/hybrid-specific morphological characters?
- Study of distribution of taxonomically critical fern taxa in the Czech Republic  
What is the abundance and distribution of particular species/hybrids in the area studied?

- Compilation of determination keys and materials to local Floras/Keys

## Abstracts

Paper 1: **A morphometric study and revision of the *Asplenium trichomanes* group in the Czech Republic**

Ekrt L. & Štech M. (2008) *Preslia* 80(3): 325–347.

A detailed cytogeographic and morphometric study of the *Asplenium trichomanes* group in the Czech Republic is presented. We detected diploid ( $2n = 72$ ), tetraploid ( $2n = 144$ ) and hybrid triploid plants ( $2n = 108$ ). Based on the morphometric study, four intraspecific taxa are recognized. These taxa correspond to the four subspecies of *A. trichomanes* (*A. t.* subsp. *trichomanes*, *A. t.* subsp. *quadrivalens*, *A. t.* subsp. *pachyrachis* and *A. t.* subsp. *hastatum*) distinguished in the floras of western, southern and northern Europe. Triploid plants were determined as *A. t.* nothosubsp. *lusaticum* (*A. t.* subsp. *trichomanes* × *A. t.* subsp. *quadrivalens*). The individual morphological characters used for determining subspecies are evaluated and a determination key presented.

Paper 2: **Rozšíření a problematika taxonů skupiny *Asplenium trichomanes* v České republice** [Distribution and problematic of taxa of *Asplenium trichomanes* group in the Czech Republic]

Ekrt L. (2008) *Zprávy České Botanické Společnosti* 43(1): 17–65.

The distribution of taxa of the *Asplenium trichomanes* group in the Czech Republic was studied. Collections of 32 public herbaria were visited and a total of 1477 specimens examined. The four taxa *A. trichomanes* subsp. *trichomanes*, *A. trichomanes* subsp. *quadrivalens*, *A. trichomanes* subsp. *pachyrachis*, *A. trichomanes* subsp. *hastatum* and four hybrid combinations were recorded from the Czech Republic. An overview of morphological characters, distribution maps and a brief summary of habitat preferences and total distribution of the taxa are presented.

Paper 3: ***Asplenium trichomanes*. – In: Online-Flora von Österreich**

Ekrt L. (2007–2009) In: Fischer M. A., Willner W., Niklfeld H. & Gutermann W. [eds]

<<http://flora.vinca.at>, [http://62.116.122.153/flora/Asplenium\\_trichomanes](http://62.116.122.153/flora/Asplenium_trichomanes)>.

[paper without abstract; compilation of determination key of *Asplenium trichomanes* group for Austrian Flora]

Paper 4: ***Asplenium trichomanes*. – In: Určovací klíč paprad'orostov a semenných rastlín Slovenska** [Identification key of ferns and flowering plants of

the Slovak Republic]

Ekrt L. In: Marhold K., Feráková V., Goliašová K., Grulich V., Hodálová I., Hrouda L., Kochjarová J., Mártonfi P., Mered'a P. jun. [eds], VEDA, Bratislava [submitted]

[paper without abstract; compilation of determination key of *Asplenium trichomanes* group for Slovak Flora]

Paper 5: **Revize rozšíření sleziníku střídavolistého (*Asplenium xalternifolium*) v České republice** [Revision of geographical distribution of *Asplenium xalternifolium* in the Czech Republic]

Ekrt L. (2008) *Zprávy České Botanické Společnosti* 43(2): 231–250.

The distribution of *Asplenium x alternifolium* nothosubsp. *alternifolium* and *Asplenium x alternifolium* nothosubsp. *heufleri* was studied in the Czech Republic. A revision of 33 public herbarium collections was carried out and a total of 442 specimens were examined. *Asplenium x alternifolium* nothosubsp. *alternifolium* was recorded scattered throughout the Czech Republic. The studied taxon occurs mainly on siliceous rocks, only occasionally (1 % of known localities) was recorded from secondary habitats (walls). Therefore, the taxon is missing in the Polabí lowland and in the south, east and northeast of Moravia. Distribution dot maps, a list of recorded localities and overview of habitat preferences are presented. According to field knowledge and herbarium revisions it seems that recent localities are much rarer than historical ones. *Asplenium x alternifolium* nothosubsp. *heufleri* is very rare on the territory of the Czech Republic. The historical localities in Josefovské údolí valley near the town of Adamov, and in valleys near the village of Kamenný Újezd and the village of Černolice near Jiloviště town, and at Staré vinice near the town of Znojmo have not been verified recently. Two new localities were discovered and revised recently in the field. One is situated in castle ruins at Litice nad Orlicí in the ambersko region and the other one on rocks above the Vltava river near the town of Kamýk nad Vltavou in the Střední Povltaví region.

Paper 6: **Species boundaries and frequency of hybridization in the *Dryopteris carthusiana* (*Dryopteridaceae*) complex: a taxonomic puzzle resolved using genome size data**

Ekrt L., Holubová R., Trávníček P. & Suda J.  
[submitted to *American Journal of Botany*]

*Dryopteris carthusiana* agg. is a taxonomically intricate group of temperate ferns composed of one diploid (*D. expansa*) and two allotetraploid (*D. carthusiana* and *D. dilatata*) species in Central Europe. Overall phenotypic similarity, large plasticity, and the incidence of putative interspecific hybrids have led to a continuous dispute concerning species circumscription and delimitation. We used

flow cytometry and multivariate morphometrics to assess the level of phenotypic variation and the frequency of hybridization in a representative set of Central European samples covering all recognized species and hybrids. Flow cytometric measurements revealed unique genome sizes in all species/hybrids, allowing easy and reliable (notho)taxa identification. A set of taxonomically informative morphological characters was then selected based on the results of morphometric analyses. While determination of *D. carthusiana* usually did not pose much of a problem, differentiation between *D. expansa* and *D. dilatata* was more challenging. Different species often formed mixed populations, providing opportunity for interspecific hybridization. The frequency of particular hybrid combinations differed dramatically and depended primarily on evolutionary relationships whereas ploidy level had only a little effect. Collectively, our study introduces a new and robust character (genome size) for taxonomic decision-making in the *D. carthusiana* complex, and thus represents a significant step forward in resolving taxonomic complexities in this important component of the temperate fern flora.

Paper 7: **Genome size and morphology of the *Dryopteris affinis* group in Central Europe**

Ekrt L., Trávníček P., Jarolímová V., Vít P. & Urfus T. [*Preslia* – accepted]

The agamosporous and taxonomically critical *Dryopteris affinis* group was investigated as part of a cytogeographic and morphometric study of ferns in Central Europe. Material from 27 localities in the Czech Republic, Slovakia, Poland and Austria was sampled and evaluated using both morphometric multivariate and karyological approaches. Chromosome counts and flow cytometric analyses revealed the existence of two distinct triploid taxa ( $2n = 123$ ) of differing genome size, which correspond to *D. borrieri* and *D. cambrensis*, and of a rare pentaploid hybrid ( $2n = 205$ ) *D. x critica* (*D. borrieri* × *D. filix-mas*). Morphometric analyses confirmed a clear separation between both triploid taxa. New quantitative characters were selected according to the results of discriminant analyses, and a key to their identification is presented.

Paper 8: **Rozšíření a taxonomická problematika skupiny *Dryopteris affinis* v České republice** [Distribution and taxonomical problems within *Dryopteris affinis* group in the Czech Republic]

Ekrt L., Štech M., Lepší M. & Boublík K.  
[submitted to *Zprávy České Botanické Společnosti*]

The distribution of taxa of *Dryopteris affinis* group in the Czech Republic was studied. Collections of 21 Czech public herbarium were revised and a total of 257 specimens was examined. Two species *D. borrieri* and *D. cambrensis* and one hybrid *D. x critica* (*D. borrieri* × *D. filix-mas*) were recorded in the Czech Republic. *D. cambrensis* was recently rediscovered after more than 30 years for

the flora of the Czech Republic and recently was found as a new species for Bohemia. 16 localities of rare *D. cambrensis* are known for the Czech Republic. A single locality of *D. cambrensis* was found in Poland in surroundings of village of Pstražna near border with the Czech Republic. Review of the morphological characters, distribution maps and review of habitat preferences, total distribution of the taxa and determination key is presented.

Paper 9: *Dryopteris remota* rediscovered for the flora of the Czech Republic

Ekrt L., Lepší M., Boublík K. & Lepší P. (2007) *Preslia* 79: 69–82.

Until now, *Dryopteris remota* was only recorded in the Czech Republic from the Moravian Karst, ca 70 years ago. This record is mentioned in some studies, but references to the data's origin have always been missing. For this reason it was uncertain whether *D. remota* was still present in the Czech Republic. Recently, the records from the Moravian Karst were verified by re-examination of original herbarium specimens. In 2002 a specimen of *D. remota* was found for the first time in Bohemia, close to the village of Ktiš, on a slope of Malý Plešný hill in the foothills of the Bohemian Forest (S Bohemia). At this locality only one plant occurred on the boundary between *Lonicera nigra*-shrub and spruce-beech-fir forest, on a gneiss outcrop. Determination of the Czech specimens of *D. remota* was based on comparisons with macro- and micromorphological characters of both Alpine (Upper Austria) and Carpathian (West Ukraine) specimens, as well as descriptions in the literature. A detailed morphological description and comparison with similar taxa are included. A map of its distribution within the Czech Republic as well as a map of the distribution of *D. remota* worldwide is also presented. It is suggested that *D. remota* be designated a critically endangered plant species in the Czech Republic.

Paper 10: *Asplenium trichomanes* L. – sleziník červený, *Dryopteris affinis* agg. – kaprad' rezavá, *Dryopteris remota* (A. Braun ex Döll) Druce – kaprad' tuhá, *Trichomanes* L. – vláskatec in Květena ČR – dodatek [Flora of the Czech Republic – Additamenta]

Ekrt L. & Štech M. In: Štěpánková J. [ed.], Academia, Praha [submitted]

[paper without abstract; compilation of morphology, variation, habitat preferences and distribution of selected taxa for the Flora of the Czech Republic]

## Conclusions

Diversity and variability of several Central European fern groups from the genera *Asplenium* and *Dryopteris* were evaluated. Especially more detailed taxonomical revisions of following groups were carried out: *Asplenium trichomanes* group, *Dryopteris carthusiana* group and *Dryopteris affinis* agg. (Papers 1, 6, 7). Flow cytometry was found to be a powerful tool for delimitation of particular taxa in all the study cases. It should be emphasized that detection of different genome

size was successful not only between representatives of different ploidy levels (Paper 1, 6) but also between taxa of the same ploidy level (Paper 6, 7). Delimitation of studied taxa and detection of hybrids is a step necessary for consequent successful morphological definition of taxa.

Based on cytometrical screening of larger population samples from *Dryopteris carthusiana* group, unexpectedly high frequency of hybridization between *D. dilatata* and *D. expansa* was revealed, whereas relatively low frequency of hybridization between *D. carthusiana* and *D. dilatata* was found (Paper 6). Surprisingly low frequency of hybridization was found in *D. affinis* group. The pentaploid hybrids were rarely found at three localities only (Paper 7). A hypothesis – the frequency of particular hybrid combinations (among sexually reproducing taxa) differed dramatically and depended primarily on evolutionary relationships whereas ploidy level had only a little effect is presented.

First chromosome counts from the Czech Republic are presented for *Asplenium trichomanes* subsp. *trichomanes*, *Dryopteris expansa*, *Dryopteris borrieri*, *Dryopteris cambrensis* and *Dryopteris filix-mas* (Papers 1, 6, 7).

The particular papers identify the boundaries between studied taxa within the studied groups to find the best diagnostic characters based on multivariate morphometrical analyses. Finally a determination keys were compiled (Paper 1, 6, 7). Estimation of the frequency of hybridization within the study groups in Central Europe (the Czech Republic and adjacent countries) was carry out. In the case of *Asplenium trichomanes* group, determination key was compiled for the local floras/identification keys of the Czech Republic (Paper 9), Austria (Paper 3) and Slovakia (Paper 4).

Rare fern species were newly revealed or rediscovered after a longer time for the flora of the Czech Republic. *Dryopteris remota* was recognized after more than 70 year in the Czech Republic (Paper 8). *Dryopteris cambrensis* was discovered as a new taxon for Bohemia and rediscovered for the Czech Republic after more than 30 years. This taxon still has not been included in the Flora of the Czech Republic/Key to the flora of the Czech Republic; however, its occurrence in the Czech Republic is generally known from other European compilations on *Dryopteris* by C. Fraser-Jenkins. Finally, recent rediscovery of *Asplenium xalternifolium* nothosubsp. *heuffleri* was revealed in several localities (Paper 5).

Overall distribution of some taxonomically critical fern taxa in the Czech Republic was compiled, based on study of herbarium specimens and field research (Paper 2, 5, 8). A map of the worldwide distribution of *Dryopteris remota* is presented for the first time (Paper 8).

## References

- Bennert H. W. & Fischer G. (1993): Biosystematics and evolution of the *Asplenium trichomanes* complex. – *Webbia* 48: 743–760.
- Benl G. & Eschelmüller A (1983): Zum Vorkommen weniger bekannter *Dryopteris*-Sippen im bayerischen Alpen- und Voralpenraum. – *Ber. Bayer. Bot. Ges.* 54: 77–102.

- Brownsey P. J. (1976): A biosystematic investigation of the *Asplenium lepidum* complex. – *Bot. J. Linn. Soc.* 72: 235–267.
- Ciocărlan V. (2000): Flora ilustrată a României. – Bucuresti, Ceres.
- Dostál J., Fraser-Jenkins C. R. & Reichstein T. (1984): *Dryopteris*. – In Kramer K. U. [ed.] Hegi G., *Illustrierte Flora von Mitteleuropa*. Band I, Teil 1. Pteridophyta., 3. Aufl., 136–169. Verlag Paul Parey, Berlin, Hamburg, Germany.
- Fraser-Jenkins C. R. (1980): *Dryopteris affinis*: a new treatment for a complex species in the European pteridophyte flora. – *Willdenowia* 10: 107–115.
- Fraser-Jenkins C. R. (1986): A classification of the genus *Dryopteris* (Pteridophyta: Dryopteridaceae). – *Bull. Brit. Mus. Nat. Hist. Bot.* 14: 183–218.
- Fraser-Jenkins C. R. (1987): A new subspecies of *D. affinis*. – In: Derrick L. N., Jermy A. C. & Paul A. M., *Checklist of European pteridophytes*, *Sommerfeltia* 6: xi–xiii.
- Fraser-Jenkins C. R. (1993): *Dryopteris*. – In: Tutin T. G., Burges N. A., Chater A. O. et al., [eds] *Flora Europaea*, Vol. 1, 2nd Ed., 27–30. Cambridge University Press, Cambridge, England.
- Fraser-Jenkins C. R. (2007): The species and subspecies in the *Dryopteris affinis* group. – *Fern Gaz.* 18: 1–26.
- Frey W., Frahm J. P., Fischer E. & Lobin W. (2006): *The Liverworts, Mosses and Ferns of Europe*; English edition rev. and ed. Blockeel T. L. – Harley Books, Essex.
- Gibby M. (1983): The *Dryopteris dilatata* complex in Macaronesia and the Iberian Peninsula. – *Acta Bot. Malacitana* 8: 59–72.
- Hejtný S. & Slavík B. [eds] (1988): *Květena České socialistické republiky 1*. – Academia, Praha.
- Kubát K., Hrouda L., Chrtek J. jun., Kaplan Z., Kirschner J. & Štěpánek J. [eds] (2002): *Klíč ke květeně České republiky*. – Academia, Praha.
- Lovis J. D. (1973): A biosystematic approach to phylogenetic problems and its application to the Aspleniaceae. – *Bot. J. Linn. Soc.* 67: 211–228.
- Manton I. (1950): *Problems of cytology and evolution in the Pteridophyta*. – Cambridge.
- Manton I. & Walker S. (1953): *Cytology of the Dryopteris spinulosa Complex in Eastern North America*. – *Nature* 171: 1116–1117.
- Marhold K. & Hindák [eds] (1998): *Zoznam nízich a vyšších rastlín Slovenska [Checklist of Non-Vascular and Vascular Plants of Slovakia]*. – Veda, Bratislava.
- Mirek Z., Piękoś-Mirkowa H., Zajac A. & Zajac M. (1995): *Vascular plants of Poland: A checklist*. – *Polish Botanical Studies Guidebook Series 15*, Polish Academy of Sciences, W. Szafer Institute of Botany, Cracow.
- Nyhus G. C. (1987): Underartene av svartburkne (*Asplenium trichomanes*) i Norge. – *Blyttia* 45: 12–24.
- Piękoś-Mirkowa H. (1979): *Paprocie z grupy Dryopteris dilatata w Polsce*. – *Monographiae Botanicae* 59: 1–75.
- Reichstein T. (1984): *Asplenium*. – In: Kramer K. U. [ed.], Hegi G., *Illustrierte Flora von Mitteleuropa*. Band I, Teil 1. Pteridophyta. 3. Aufl., p. 211–266, Berlin, Hamburg.
- Sorsa V. & Widén C. J. (1968): The *Dryopteris spinulosa* complex in Finland, a cytological and chromatographic study of some hybrids. – *Hereditas* 60: 273–293.

- Steinecke K. & Bennert H. W. (1993): Biosystematic investigation of the *Asplenium obovatum* complex (Aspleniaceae, Pteridophyta). I. Morphology. – *Bot. Jahrb. Syst.* 114: 481–502.
- Trewick S. A., Morgan-Richards M., Russell J., Henderson S., Rumsey F. J., Pintér I., Barrett J. A., Gibby M. & Vogel J. C. (2002): Polyploidy, phylogeography and Pleistocene refugia of the rockfern *Asplenium ceterach*: evidence from chloroplast DNA. – *Molec. Ecol.* 11: 2003–2012.
- Viane R., Jermy A. C. & Lovis J. D. (1993): *Asplenium*. – In: Tutin T. G., Burges N. A., Chater A. O., Edmondson J. R., Heywood V. H., Moore D. M., Valentine D. H., Walters S. M. & Webb D. A. [eds], *Flora Europaea*, Vol. 1, Ed. 2, p. 18–23, Cambridge Univ. Press.
- Vogel J. C., Russell S., Barrett J. A. & Gibby M. (1996): A non-coding region of chloroplast DNA as a tool to investigate reticulate evolution in European *Asplenium*. – In: Camus J. M., Gibby M. & Johns R. J. [eds], *Pteridology in perspective*, pp. 313–327, Royal Botanic Gardens, Kew.
- Vogel J. C., Russell S. J., Rumsey F. J., Barrett J. A. & Gibby M. (1998): Evidence for maternal transmission of chloroplast DNA in the genus *Asplenium* (Aspleniaceae, Pteridophyta). – *Bot. Acta* 111: 247–249.
- Vogel J. C., Rumsey F. J., Russell S. J., Cox C. J., Holmes J. S., Bujnoch W., Stark C., Barrett J. A. & Gibby M. (1999a): Genetic structure, reproductive biology and ecology of isolated populations of *Asplenium csikii* (Aspleniaceae, Pteridophyta). – *Heredity* 83: 604–612.
- Vogel J. C., Rumsey F. J., Schneller J. J., Barrett J. A. & Gibby M. (1999b): Where are the glacial refugia in Europe? Evidence from pteridophytes. – *Biol. J. Linn. Soc.* 66: 23–37.
- Vogel J. C., Rumsey F. J., Schneller J. J., Barrett J. A. & Gibby M. (1999c): Where are the glacial refugia in Europe? Evidence from pteridophytes. – *Biol. J. Linn. Soc.* 66: 23–37.
- Walker S. (1955). Cytogenetic studies in the *Dryopteris spinulosa* complex I. – *Watsonia* 3: 193–209.
- Walker S. (1961): Cytogenetic studies in the *Dryopteris spinulosa* complex II. – *Amer. J. Bot.* 48: 607–614.
- Widén C. J. & Sorsa V. (1968): On the intraspecific variability of *Dryopteris assimilis* S. Walker and *Dryopteris spinulosa* Watt, a chromatographic and cytological study. – *Hereditas* 62: 1–13.
- Widén C. J., Sarvela J. & Ahti T. (1967): The *Dryopteris spinulosa* complex in Finland. – *Acta Bot. Fenn.* 77: 1–25.
- Widén C. J., Sorsa V. & Sarvela J. (1970): *Dryopteris dilatata* s. lat. in Europe and the Island of Madeira, a Chromatographic and cytological study. – *Acta Bot. Fenn.* 91: 1–30.

## Professional Curriculum Vitae

### Personal data

LIBOR EKRT

\* 3. 4. 1978, Náchod, the Czech Republic

address: nám. Bratří Čapků 264, Telč CZ-588 56; e-mail: libor.ekrt@gmail.com

### Education

1997–2000 Bachelor study; Faculty of Biological Sciences, University of South Bohemia in České Budějovice

2000–2003 Master study; Faculty of Biological Sciences, University of South Bohemia in České Budějovice

since 2003 PhD. study Faculty of Science, University of South Bohemia in České Budějovice

### Employment

2001 Landscape Management Services, The Groundskeeper Corp., Tucson, Arizona, USA

2002–2004 Natura 2000 habitat mapping, Agency of Nature Protection of the Czech Republic, Prague.

2003–2004 Administration of the Broumovsko Protected Landscape Area (part-time-job)

2005–2009 Research and Nature Protection Department, Šumava National Park (part-time-job)

since 2007 Natura 2000 habitat updating, Agency of Nature Protection of the Czech Republic, Prague.

### Publication

#### Papers in journals with impact factor

EKRT L., LEPSÍ M., BOUBLÍK K. & LEPSÍ P. (2007): *Dryopteris remota* rediscovered for the flora of the Czech Republic. – *Preslia* 79: 69–82.

EKRT L. & ŠTECH M. (2008): A morphometric study and revision of the *Asplenium trichomanes* group in the Czech Republic. – *Preslia* 80(3): 325–347.

EKRT L., TRÁVNÍČEK P., V. JAROLÍMOVÁ, VÍT P. & URFUS T. (2009): Genome size and morphology of the *Dryopteris affinis* group in Central Europe. – *Preslia* (accepted).

EKRT L., HOLUBOVÁ R., TRÁVNÍČEK P. & SUDA J. (2009): Species boundaries and frequency of hybridization in the *Dryopteris carthusiana* (*Dryopteridaceae*) complex: a taxonomic puzzle resolved using genome size data. – *Amer. J. Bot.* (submitted).

#### Papers in non-impact journals

STOLINOVÁ Š. & EKRT L. (2001): Výskyt kapradě rezavé v Pekelském údolí [Occurrence of *Dryopteris affinis* in Pekelské údolí valley]. – *Panorama* 9: 99–100.

EKRT L. (2004): Významný nález *Asplenium adiantum-nigrum* v Českém ráji [*Asplenium adiantum-nigrum* in the Český ráj region]. – *Zpr. Čes. Bot. Společ.* 39 (1): 37–40.

HOFHANZLOVÁ E., EKRT L. & ŠTECHOVÁ T. (2005): Floristický a vegetační průzkum rašeliniště Na Klátově [Floristic and vegetation research in the Na Klátově peat bog]. – *Acta Rer. Natur.* 1: 45–52.

CHÁN V., RŮŽIČKA V., LEPSÍ P., BOUBLÍK K., DOLEŽAL P., EKRT L., HOFHANZLOVÁ E., LEPSÍ M., LIPPL L., ŠTECH M., ŠVARC J. & ŽÍLA V. (2005): Floristický materiál ke květeně Dačicka [Floristic contribution from the region around the town of Dačice]. – *Acta Rer. Natur.* 1: 17–44.

HOFHANZLOVÁ E. & EKRT L. (2006): Floristický a vegetační inventarizační průzkum Národní přírodní rezervace Zhejral [Floristic and vegetation research at the Zhejral reserve]. – *Acta Rer. Natur.* 2: 19–37.

HOFHANZLOVÁ E. & EKRT L. (2007): Floristický a vegetační inventarizační průzkum Národní přírodní rezervace Velký Špičák [Floristic and vegetation research of Velký Špičák National Nature Reserve]. – *Acta Rer. Natur.* 3: 11–20.

STRNAD L. & EKRT L. (2007): Nález nové lokality kyvoru lékařského (*Asplenium ceterach*; *Aspleniaceae*, *Pteridophyta*) a přehled jeho rozšíření na území České republiky [A new find of *Asplenium ceterach* (*Aspleniaceae*, *Pteridophyta*) with review of the distribution in the Czech Republic]. – *Zpr. Čes. Bot. Společ.* 42(2): 221–229.

EKRT L. & PŮBAL D. (2008): Novinky v květeně cévnatých rostlin české Šumavy a přiléhajícího Předšumaví. I. [Novelties in the flora of vascular plants of the Czech Bohemian Forest and adjacent foothills. I.] – *Silva Gabreta* 14(1): 19–38.

EKRT L. (2008): Rozšíření a problematika taxonů skupiny *Asplenium trichomanes* v České republice [Distribution and problematic of taxa of *Asplenium trichomanes* group in the Czech Republic]. – *Zpr. Čes. Bot. Společ.* 43(1): 17–65.

EKRTOVÁ E. & EKRT L. (2008): Floristický a vegetační průzkum horní části údolí potoka Strouha u Telče [Floristic and vegetation research the upper part of Strouha valley]. – *Acta Rer. Natur.* 4: 17–30.

EKRT L. & EKRTOVÁ E. (2008): Květena a vegetace Přírodní památky Toužánské stráně u Dačic [Flora and vegetation of the Toužánské stráně nature monument near Dačice town]. – *Acta Rer. Natur.* 5: 207–228.

EKRTOVÁ E., EKRT L., KOŠNAR J., ZAPOMĚLOVÁ E. & ČEJKOVÁ A. (2008): Míčovka kulkonosná (*Pilularia globulifera*) znovu objevena v České republice [*Pilularia globulifera* rediscovered in the Czech Republic]. – *Zpr. Čes. Bot. Společ.* 43(2): 193–208.

EKRT L. (2008): Revize rozšíření sleziníku střídavolistého (*Asplenium xalternifolium*) v České republice [Revision of geographical distribution of *Asplenium xalternifolium* in the Czech Republic]. – *Zpr. Čes. Bot. Společ.* 43(2): 231–250.

EKRT L., EKRTOVÁ E. & ČECH L. (xxxx): Floristický a vegetační průzkum lokality Malý Pařezitý v Jihlavských vrších [Floristic and vegetation research of Malý Pařezitý in Jihlavské vrchy hills]. – *Acta Rer. Natur.* (submitted).

EKRT L. & PŮBAL D. (xxxx): Novinky v květeně cévnatých rostlin české Šumavy a přiléhajícího Předšumaví. II. [Novelties in the flora of vascular plants of the Czech Bohemian Forest and adjacent foothills. II.] – *Silva Gabreta* (submitted).

#### Books contributions

EKRT L. & MRÁZ P. (2007): Revision of caryological data to the genera *Asplenium* L., pp. 116 – In: Marhold K., Mártonfi P., Mered'a jun. & Mráz P. [eds], Chromosome number survey of the ferns and flowering plants of Slovakia, Veda, Bratislava.

HORVÁTHOVÁ V., EKRT L. & SKOLEK M. (2007): Bezlesí Národního parku Šumava – ochrana bezlesí a jeho management [Nonforest areas of Šumava National Park, its protection and management]. – *Správa NP a CHKO Šumava, Vimperk*, 52 p. (ISBN 978-80-239-9566-4).

EKRT L. (xxxx): Kapradiny. – In: Kolektiv, Český ráj – příroda, historie, život. Baset, Praha (submitted).

EKRT L. & ŠTECH M. (xxxx): *Asplenium trichomanes* L. – sleziník červený, *Dryopteris remota* (A. Braun ex Döll) Druce – kaprad' tuhá, *Dryopteris affinis* agg. – kaprad' rezavá, *Trichomanes* L. – vláskatec. – In: Štěpánková [ed.], Květena ČR – dodatek [Flora of the Czech Republic – Additamenta], Academia, Praha (submitted).

#### Flora handbooks

EKRT L. (2007–2009): *Asplenium trichomanes*. – In: Fischer M. A., Willer W., Niklfeld H. & Gutermann W. (eds.), Online-Flora von Österreich, <<http://flora.vinca.at>, [http://62.116.122.153/flora/Asplenium\\_trichomanes](http://62.116.122.153/flora/Asplenium_trichomanes)>

EKRT L. (xxxx): *Asplenium trichomanes*. – In: Marhold K., Feráková V., Goliašová K., Grulich V., Hodálová I., Hrouda L., Kochjarová J., Mártonfi P., Mered'a P. jun. [Eds] (2009): Určovací klíč paprad'orostov a semenných rostlin Slovenska [Identification key of ferns and flowering plants of the Slovak Republic]. VEDA, Bratislava (submitted).

#### Popularization articles

EKRT L. & HOFHANZLOVÁ E. (2002): Proč jsou určité druhy vzácné – problematika malých populací [Why are some species rare – problems of the small population size]. – Ochrana Přírody 8: 242–244.

EKRT L. (2003): Za jednou z největších kapradin Evropy [Search of the largest fern of Europe]. – Živa 3/2003: 108–109.

EKRT L. & ZÝVALOVÁ D. (2005): Flóra Šumavy – skládačka. – Správa NP a CHKO Šumava, Vimperk.

EKRT L. (2006): Lupina mnoholistá invazní kráska nejen okrajů šumavských cest [*Lupinus polyphyllus* – invasive plant in the Bohemian Forest]. – Šumava 11: 20–21.

HORVÁTHOVÁ V., EKRT L., SKOLEK M. & DVOŘÁK L. (2007): Bezleší v krajině Šumavy – skládačka. – Správa NP a CHKO Šumava, Vimperk.

EKRT L. (2007): Záchrana unikátní lokality prstnatce Traunsteinerova [A rescue of unique locality of *Dactylorhiza traunsteineri*]. – Šumava 12(3): 16–17.

SKOLEK M., EKRT L. & HORVÁTHOVÁ V. (2007): Louky, pastviny a další bezleší plochy NP Šumava [Meadows, pastures and others nonforest sites of Šumava National Park]. – Veronica 21(5): 8–10.

EKRT L. (2008): Vzácná hadilka objevena na centrální Šumavě [Rare *Ophioglossum vulgatum* found in central part of Bohemian Forest]. – Šumava 13(1): 16–17.

EKRT L. (2008): Zvonek hadincovitý – pichlavý klenot šumavského Povydíří [*Campanula cervicaria* – prickly jewel of Povydíří in Šumava Mts]. – Šumava 13(3): 20–21.

EKRT L., EKRTOVÁ E. & KOŠNAR J. (2009): Míčovka kulkonosná – vzácný evropský endemit opět součástí naší flóry [*Pilularia globulifera* – rare european endemite rediscovered for the Czech Republic]. – Živa 2/2009: 64–66.

PŮBAL D. & EKRT L. (2009): Vstavač mužský vzácný návštěvník z Alp [*Orchis mascula* rare visitor from the Alps]. – Šumava 14: 16–17.

#### Book reviews

EKRT L. (2006): [Mickel J. T. & Smith A. R. (2004): Pteridophytes of Mexico. – The New York Botanical Garden Press.]. – In: Folia Geobotanica 41(3): 346–347.

KUČERA J. & EKRT L. (2007): [Frey W., Frahm J. P., Fischer E. & Lobin W. (2006): The Liverworts, Mosses and Ferns of Europe; English edition rev. and ed. Blockeel T. L. – Harley Books.]. – In: Preslia 79: 21–22.

EKRT L. (xxxx): [Ranker T. A. & Haufler C. H. (2008): Biology and Evolution of Ferns and Lycophytes. – Cambridge University Press, Cambridge.]. – Folia Geobotanica (in prep.)

#### Other contributions

HYDROVÁ A. & EKRT L. (2003): *Polystichum lonchitis* (L.) Roth – kaprad' hrálovitá. 106 p. – In: Anonymus: Nálezy zajímavých a nových druhů v květeně jižní části Čech IX, Sbor. Jihočes. Muz. v Čes. Budějovicích, Přír. Vědy 43: 106–110.

EKRT L., KOŠNAR J. & KUČERA J. (2004): *Didymodon glaucus*, 26 p. – In: Kučera J. [ed.]: Zajímavé bryofloristické nálezy IV [Interesting bryofloristic records IV]. – Bryonora 34: 22–29.

EKRT L. (2005): *Asplenium trichomanes* subsp. *pachyrachis* (Christ) Lovis & Reichst. – sleziník červený zakřivený. 168–169 p. – In: Chán V., Lepší M., Lepší P. [red.]: Nálezy zajímavých a nových druhů v květeně jižní části Čech XI. – Sbor. Jihočes. Muz. v Čes. Budějovicích, Přír. Vědy 45: 167–176.

EKRT L. & PŮBAL D. (2008): *Coeloglossum viride* Hartman. – 93 p. – In: Chán V., Lepší M., Lepší P. [red.]: Nálezy zajímavých a nových druhů v květeně jižní části Čech XIV. – Sbor. Jihočes. Muz. v Čes. Budějovicích, Přír. Vědy 48: 89–107.

LEPŠÍ M., EKRT L. & LEPŠÍ P. (2008): *Polystichum xluerssenii* (Dörfner) Hahne – kapradina Luerssenova. – 97 p. – In: Chán V., Lepší M., Lepší P. [red.]: Nálezy zajímavých a nových druhů v květeně jižní části Čech XIV. – Sbor. Jihočes. Muz. v Čes. Budějovicích, Přír. Vědy 48: 89–107.

#### Grant projects

2001–2004 Biosystematics investigation of the *Asplenium trichomanes* L. polyploid complex in the Czech Republic. – *Mattoni Awards for Studies of Biodiversity and Conservation Biology*, Faculty of Biological Sciences, University of South Bohemia.

2004–2005 Taxonomical study of *Dryopteris affinis* group (*Dryopteridaceae*; *Polypodiophyta*) in the Czech Republic. – *Mattoni Awards for Studies of Biodiversity and Conservation Biology*, Faculty of Biological Sciences, University of South Bohemia.

#### Conferences

2004 L. Ekrt: Revision of the *Asplenium trichomanes* complex in the Czech Republic, 11. Österreichischen Botanikertreffens, Wien, (2-8. 9.); poster

2004 L. Ekrt: Revize polyploidního komplexu *Asplenium trichomanes* v České republice, Conference of the Czech Botanical Society – Doktorandské inspirace v botanice, Prague, (20-21. 11.); poster

2008 Hurtová J., Ekrt L. & Mihulka S.: Ecological study of invasive species *Lupinus polyphyllus* in the Bohemian Forest. – *Neobiota: Towards a Synthesis*, Prague, (23.-26.8.); poster