



## New data on stands of fern *Athyrium distentifolium* /Opiz/ in the Beskydy Mts.

I. Tůma, P. Holub, K. Fiala

Ing. Ivan Tůma, Ph.D, Mgr. Petr Holub, Ph.D, RNDr. Karel Fiala, CSc., Institute of Botany, Academy of Sciences of the Czech Republic, Department of Ecology, Poříčí 3b, CZ-603 00 Brno, Czech Republic. E-mail: fiala@brno.cas.cz, tuma@brno.cas.cz

**Abstract:** Tůma I., Holub P., Fiala K. 2008: New data on stands of fern *Athyrium distentifolium* in the Beskydy Mts. – *Beskydy*, 1 (1): 93–98

New data were obtained on behaviour of *Athyrium distentifolium* fern occurring at different altitudes of the National Natural Reserve Kněhyně-Čertův Mlýn in the Moravian-Silesian Beskydy Mts. Studied populations of fern *A. distentifolium* represented young populations (lower size categories of genet are presented more frequently), established at the lower altitude particularly. The effect of higher input of nitrogen on biomass and morphometric leaf parameters of fern resulted in a greater allocation of biomass into supporting parts of fern leaves (fronds) which can play an important role in resorption of nutrients at the end of the growing season. The decomposition rate of native *A. distentifolium* litter was approximately the same (29–30%) at both nitrogen availabilities. However, decomposition rate of cellulose was two times greater in fern stands than in adjacent spruce stands without ferns.

**Keywords:** decomposition, leaf growth parameters, N fertilization, population structure

### Introduction

Expansion of tall grasses (*Calamagrostis arundinacea* /L./ Roth. and *C. villosa* /Chaix/ J. F. Gmelin) was often observed on deforested areas in the mountains of the Central Europe, due to both improved light conditions and higher input of nitrogen in acidic depositions (e.g., Pyšek 1993, Fiala et al. 1998, Koppisch 1994). Tall ferns (mostly *Athyrium distentifolium* /Opiz/) react similarly and spread on the open areas. There is no doubt that stands of tall ferns can influence negatively germination and further growth of tree seedlings (George, Bazzaz 1999, de la Cretaz, Kely 2002). This fact can slow down succession and decrease diversity of herbaceous cover (Hill, Silander 2001). Therefore the role and importance of expanding fern stands is impossible to ignore due to their extending areas in mountains of the Central Europe (Holeksa 2003, Vacek et al. 1999).

The aim of the study was, among other things, to determine effect of higher input of nitrogen on stands of tall fern *A. distentifolium*, which spread on deforested areas in the Beskydy Mts. (National Natural Reserve Kněhyně-Čertův Mlýn), including their feed back effect on habitats and, to answer the following question:

- 1) Are there any differences in the age structure of fern populations occurring in the National Natural Reserve Kněhyně?
- 2) Are there any changes in morphometric leaf parameters of fern at higher input of nitrogen?
- 3) What are the differences in nutrient resorption and in mass loss of leaves at the end of growing season?
- 4) Can higher inputs of nitrogen affect the rate of litter decomposition of fern?
- 5) Can stands of fern reduce leaching of base cations from soil, in comparison with bare forest soil, similarly as grass stands do under enhanced nitrogen input? This question is discussed separately in other paper in Beskydy, 2008 (Tůma, Fiala, Holub 2008).

### Methods

#### Study sites

Study sites were situated in the National Natural Reserve Kněhyně – Čertův Mlýn near the top of the Kněhyně Mt. (49°30' N, 18°19' E) in the

Moravian-Silesian Beskydy Mts. The region of the Kněhyně Mt. is characterized by mean annual temperature 3.7 °C and precipitation 1102 mm (Hadaš 1993). The soil conditions are mainly characterized by the Cambisols with increasing elevation or with nutrient poor substrates predominance by the Podzols or Podzol-like soil types (Vavříček et al. 2007). Wet bulk deposition recorded in growing season 1995 represented 25.3 kg.ha<sup>-1</sup> SO<sub>4</sub><sup>2-</sup> and 22.8 kg.ha<sup>-1</sup> N at the pH of rain water 4.02 (Fiala et al. 1998).

Most of the studies were performed in stands of tall fern *A. distentifolium* located at the elevation of 1170 m a.s.l. on the mild slope of SSW exposure. A large fern stand was divided in four blocks (5×3 m) and on two of them higher doses of nitrogen were applied (50 kg.ha<sup>-1</sup> N in five doses in the course of the growing season).

### Methods

Age-class distribution of fern *A. distentifolium* was assessed in unfertilized sites in three plots (2×4 m) near the top plateau of the Kněhyně Mt. (about 1250 m a.s.l.) and in three plots of the same size situated at 1170 m a.s.l. in gaps of the open spruce forests. In order to determine distribution of various age-classes (size categories), the largest diameter of all present plants (genets) were measured at plant base.

Differences in growth parameters of fern leaves (in length and biomass parameters) were determined in both fertilized and unfertilized stands in 20 fully developed (the largest) leaves. Thus the length of petioles and total leaf length were measured at the maximal fern stands development. Leaf biomass, biomass of photosynthetic active leaves, biomass of supporting parts

of leaves (petiole, rachis, and midribs = veins) and relations between them were also determined. In addition, at the same time, fern leaves approximately of the same size were labelled for their collection and analysis for resorption of reserve substances at the end of the growing season (October 2007).

Mesh-bags with cellulose were exposed on the soil surface in fertilized and unfertilized fern stands and in neighbouring spruce forest without herbaceous cover in order to assess activity of cellulolytic microorganisms during growing seasons 2006 and 2007. Similarly, mesh-bags with fresh natural litter of fern were used to determine rate of litter decomposition during one year. Samples were inserted in both nitrogen treated and untreated fern stands in Autumn 2006 and collected in Autumn 2007.

In order to estimate, in a not destructive way, dry mass of individual plants (genet) of *A. distentifolium* fern either in stands or planted and growing in lysimeters, total 120 leaves of fern of all occurring size categories were collected and their length was measured. Individual leaves were dried and weighed.

### Results and discussion

In all of studied fern populations, plants (genets) of the smallest size category 1–10 cm were present more frequently (Fig. 1, 2). Nevertheless, the second greatest number of genets, 21–30 cm in size, was found in stands on mountain shoulder at lower elevation, where most of plants fall in the first half of scale size (1–40 cm). On the contrary, number of plants in individual categories was much more stable in stands near the top of the Kněhyně Mt., except of the small-

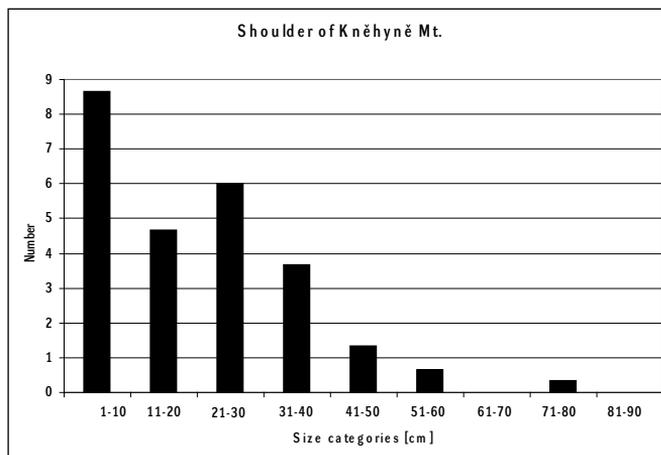


Fig. 1: Mean number of plants (genets) of *Athyrium distentifolium* fern of different size categories present in 2×4 m plots on shoulder of Kněhyně Mt.

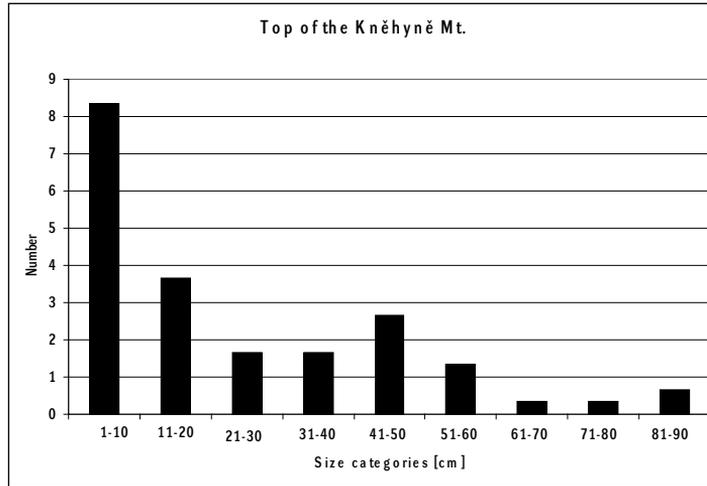


Fig. 2: Mean number of plants (genets) of *Athyrium distentifolium* fern of different size categories present in 2x4 m plots on the top of the Kněhyně Mt.

est category (1–10 cm). Previous studies of structure of population *A. distentifolium* realized in the region of Kněhyně Mt. in 1997 showed that the greatest proportion of plants 30–50 cm in size was in spruce forest, whereas plants 40–70 cm in diameter prevailed in sparse forest on top plateau of the mountain and on clearings (Pande, Fiala 1998). The oldest plants, even 120–140 cm in diameter, were found on a clearing and on the top of mountain. In comparison with formerly published data, studies of *A. distentifolium* populations indicate nowadays younger stands, at the lower altitude, particularly.

Opening of spruce stands occurred here probably later due to wind fall of damaged trees and it enabled the possibility for spread-

ing of fern plants later, than near the top of the Kněhyně Mt.

Determined relationship between length of leaves of *A. distentifolium* and their dry mass (Fig. 3) enables us, in the future, to estimate the dry mass of whole plants (genet) on the base of the presence of individual leaves of various length and their dry mass. Higher availability of nitrogen resulted in *A. distentifolium* stands in greater allocation of biomass into supporting parts of plant (rachis and petiole of leaves), which play an important role in resorption of nutrients at the end of the growing season (Tab. 1). A higher percentage loss of total biomass and biomass of petiole at the end of growing season shown probably on higher nutrient use effectivity of fern growing at

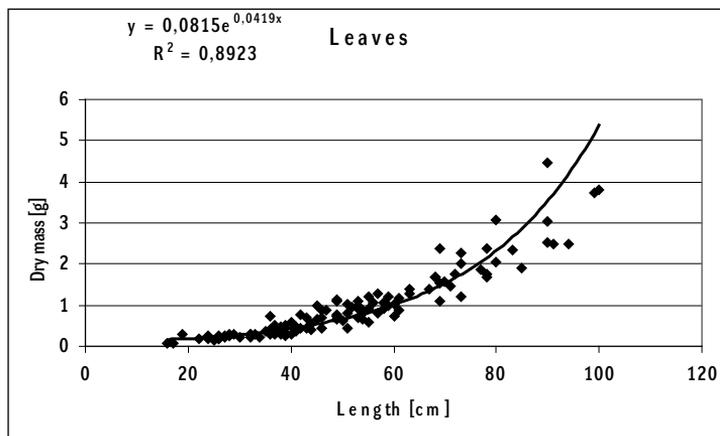


Fig. 3: Relationship between length of individual leaves of *Athyrium distentifolium* and their dry mass.

Tab. 1: Mean values (SD) of aboveground morphometrical and biomass parameters of leaves of *Athyrium distentifolium* in ambient and N fertilized treatments (+N).  $\Delta$  [%] = percentage differences pointing to an increase (+) or a decrease (-) of selected parameter under enhanced N addition in comparison with the ambient treatment. \*  $P < 0.05$ ; \*\*  $P < 0.01$ ; \*\*\*  $P < 0.001$ ; ns, not significant (ANOVA,  $n=20$ ).

	Ambient	+ N	$\Delta$ [%]	P
Leaf length [cm]	119.9 (6.7)	135.1 (12.3)	+13	***
Petiole length [cm]	25.1 (4.2)	27.5 (4.9)	+10	ns
Petiole diameter [mm]	7.7 (0.7)	8.1 (0.9)	+5	ns
Petiole dry mass [g DM]	0.84 (0.18)	1.03 (0.28)	+23	*
Dry mass / Petiole length [ $\text{mg cm}^{-1}$ ]	33.5 (4.1)	37.6 (7.7)	+12	*
Rachis dry mass [g DM]	1.30 (0.23)	1.68 (0.46)	+29	**
Midribs dry mass [g DM]	0.54 (0.09)	0.61 (0.21)	+13	ns
Supporting biomass (midribs, rachis petiole) [g DM]	2.68 (0.42)	3.32 (0.85)	+24	**
Biomass of small leaves [g DM]	2.23 (0.57)	2.27 (0.56)	+2	ns
Small leaves / supporting biomass [ $\text{g g}^{-1}$ ]	0.83 (0.13)	0.70 (0.10)	-16	**
Total leave biomass [g DM]	4.91 (0.94)	5.59 (1.35)	+14	ns
PRW [ $\text{g g}^{-1}$ ]	0.17 (0.03)	0.19 (0.03)	+12	ns
VRW [ $\text{g g}^{-1}$ ]	0.38 (0.03)	0.41 (0.04)	+8	*
LRW [ $\text{g g}^{-1}$ ]	0.45 (0.04)	0.41 (0.04)	-9	**

PRW = DM petiole / DM total leaf biomass, VRW = DM rachis + midribs / DM total leaf biomass, LRW = DM small leaves / DM total leaf biomass

higher nitrogen availability. It can be confirmed by data on nutrient analysis, which will be available later. Older published results indicate that unfavourable climatic factors and acid deposits occurring at higher altitude in the Beskydy Mts. can display more likely worst growth parameters of fern *A. distentifolium* (Tůma et al. 2006). Leaves of fern were here shorter, petiole thinner and leaf biomass smaller than of ferns growing in lower altitude. Recognized growth parameters have

shown that studied stands growing at a lower altitude occurred nowadays in more favourable conditions.

Activity of cellulolytic microorganisms was the greatest in fern stands treated with higher doses of nitrogen in 2006, where 86% of dry mass of cellulose was decomposed (Fig. 4). In unfertilised stands, 76% of cellulose was lost. Cellulose was decomposed more slowly in the neighbouring forest without fern cover and without addi-

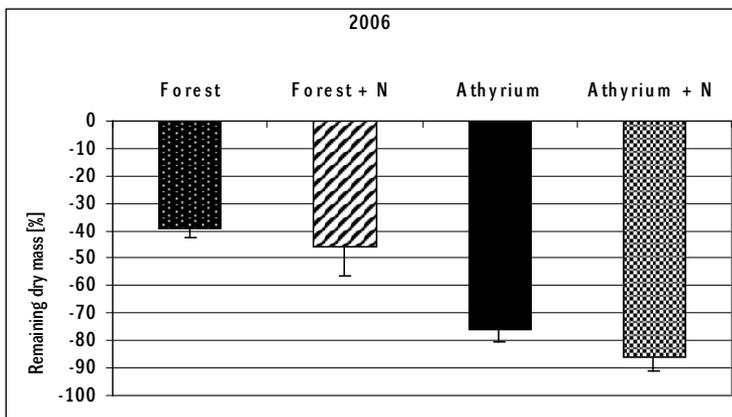


Fig. 4: Comparison of cellulose decomposition on the soil surface in fern stands (*Athyrium distentifolium*) and in neighbouring spruce forest affected by addition of nitrogen (+N) in 2006.

tion of nitrogen (39% of cellulose was decay). Irrespective of nitrogen availability, there were no great differences in decomposition of cellulose in fern stands in 2007. It was approximately similar (55–58%, Fig. 5). Nevertheless, rate of decomposition of cellulose in stands of ferns was about twice as high as in neighbouring spruce forest stands without fern cover.

Native litter of *A. distentifolium* was decomposed approximately by the same rate in both treatments of applied nitrogen and its loss represented 29–30% of the original litter dry mass (Fig. 6). It can be connected with the relatively high nitro-

gen content in fern litter (up to 2.3%). Thus nitrogen may not be in deficiency for microorganisms but carbonaceous substances can be worse available. Therefore differences in decomposition rate of cellulose can be recorded due to different activity of microorganisms at different availability of nitrogen. The rate of decomposition of fern litter is usually lower than that of most other plant species. Ferns, in comparison with other plants, accumulate in their biomass considerable amounts of lignin and phenols (Wardle et al. 2002). This fact can be also reflected in lower values of decomposition of *A. distentifolium* litter.

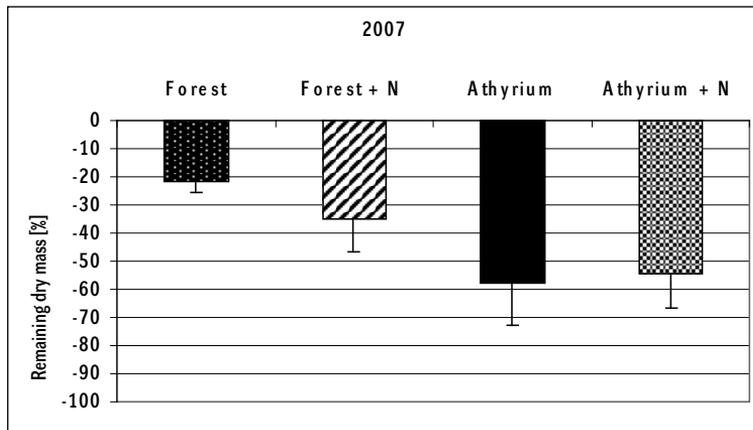


Fig. 5: Comparison of cellulose decomposition on the soil surface in fern stands (*Athyrium distentifolium*) and in neighbouring spruce forest affected by addition of nitrogen (+N) in 2007.

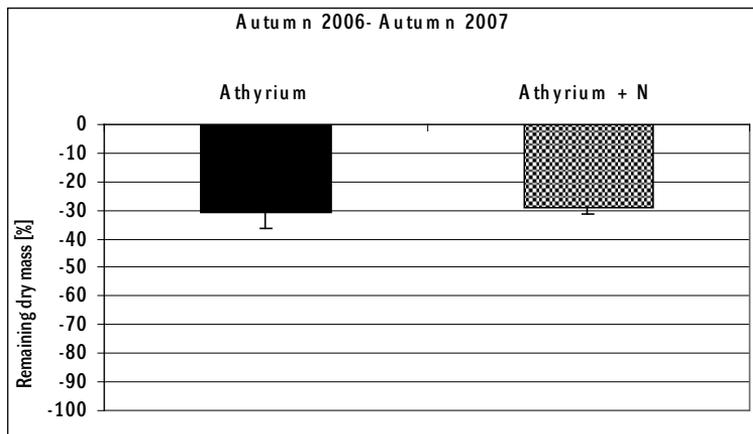


Fig. 6: Relative losses of dry mass of *Athyrium distentifolium* leaf litter recorded in fern stands affected by addition of nitrogen (+N) during one year.

## Conclusions

Studied population of *A. distentifolium* fern represents younger stands, characterized by the greatest proportion of plants of smaller size categories, which occurred at the lower altitude, particularly. Greater availability of nitrogen re-

sulted in fern stands in greater biomass allocation into supporting parts of fern leaves, which are very important in resorption of nutrients at the end of growing season. Decomposition of *A. distentifolium* litter took place in both nitrogen availabilities in a similar rate.

## Acknowledgements

Results were obtained in the framework of grant project of the Grant Agency of the Academy of Sciences of the Czech Republic „Interaction of fern stands and soil on deforested areas affected by acid depositions“ (GP AV ČR IAA 600050616).

## References

- DE LA CRETAZ, A.L., KELTY, M.J. 2002: Development of tree regeneration in fern-dominated forest understories after reduction of deer browsing. *Restor. Ecol.*, 10: 416–426.
- FIALA, K., TŮMA, I., JAKRLOVÁ, J., JEŽÍKOVÁ, M., SEDLÁKOVÁ, I., HOLUB, P. 1998: The role of grass ecosystems of deforested areas in the region affected by air pollution (the Beskydy Mts., the Czech Republic). *Ekológia, (Bratislava)*, 17. Suppl. 1: 241–255.
- GEORGE, L.O., BAZZAZ, F.A. 1999: The fern understory as an ecological filter: Emergence and establishment of canopy-tree seedlings. *Ecology*, 80: 833–845.
- HADAŠ, P. 1993: *Imisně klimatická klasifikace lesního závodu Ostravice lesní oblasti Moravskoslezské Beskydy*. [Pollution-climatic classification of forest enterprise Ostravice in the forest region Moravskoslezské Beskydy]. Ústav ekologie lesa FLD VŠZ, Brno, 37 pp.
- HILL, J.D., SILANDER, J.A. 2001: Distribution and dynamics of two ferns: *Dennstaedtia punctilobula* (Dennstaedtiaceae) and *Thelypteris noveboracensis* (Thelypteridaceae) in a Northeast mixed hardwood-hemlock forest. *Amer. J. Bot.*, 88: 849–902.
- HOLEKSA, J. 2003: Relationship between field-layer vegetation and canopy openings in a Carpathian subalpine spruce forest. *Plant. Ecol.*, 168: 57–67.
- KOPPISCH, D. 1994: Nährstoffhaushalt und Populationsdynamik von *Calamagrostis villosa* (Chais.) J.F. Gmel, einer Rhizompflanze des Unterwuchses von Fichtenwäldern. *Bayreuther Forum Ökologie*, 12: 1–187.
- PANDE, K., FIALA, K. 1998: Variability populací *Athyrium distentifolium* v NPR Kněhyně v Beskydech. [Variability of population of *Athyrium distentifolium* in the Kněhyně nature preserve in Beskydy Mts.]. In: Eliáš P. (ed.): *Populačná biológia rastlín, SEKOS, Bratislava-Nitra*, 93–98.
- PYŠEK, P. 1993: What do we know about *Calamagrostis villosa*? *Preslia*, 65: 1–20.
- TŮMA, I., FIALA, K., HOLUB, P., PANDE, K. 2006: Biomass formation, nutrient uptake and release in fern stands of *Athyrium distentifolium* on deforested areas affected by pollution: comparison with grass stands. *Ekológia, (Bratislava)*, 25: 264–279.
- TŮMA, I., FIALA, K., HOLUB, P. 2008: Can stands of *Athyrium distentifolium* fern reduce leaching of base cations from soil similarly as grass stands do in mountain areas under enhanced nitrogen input? *Beskydy*, 2 (in print)
- VACEK, S., BASTL M., LEPŠ, J. 1999: Vegetation changes in forests of the Krkonoše Mts. over a period of air pollution stress (1980–1995). *Plant Ecol.*, 143: 1–11.
- WARDLE, D.A., BONNER, K.I., BARKER, G.M. 2002: Linkages between plant litter decomposition, litter quality, and vegetation responses to herbivores. *Funct. Ecol.*, 16: 585–595.
- VAVŘÍČEK, D., SAMEC, P., ŠIMKOVÁ, P., FORMÁNEK, P. 2002: The soil environment and biological activity in the forest soils of the mountain area National Natural Reservation Čertův mlýn, Moravian-Silesian Beskids. *Beskydy*, 20: 109–116.