Pollen monitoring experiment in the coniferous forests of NW Rila Mts (Bulgaria)

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Abstract. The article analyzes the annual pollen influx in the 1450–1750 m altitudinal zone, produced by coniferous communities dominated by *Picea abies* on the territory of the Borovets State Forest Farm (NW Rila Mts), for a three-year period of observation (2006–2008). The results from the three pollen traps have revealed dominance of *Pinus diploxylon*-type (*P. mugo, P. sylvestris*) and a relatively constant presence of *Picea*, *Abies* and *Pinus peuce* pollen. Pollen of *Fagus* was well represented in the traps in this coniferous zone, particularly in two successive years (2007 and 2008), probably as a result of abundant flowering, effective dispersal and high deposition. Although in smaller quantities, pollen of *Quercus*, *Carpinus betulus, Corylus*, *Alnus,* and *Betula* was also recorded. The herb component constituted only a small part of the total annual pollen influx.

Key words: Bulgaria, coniferous forests, NW Rila Mts, pollen influx, pollen monitoring

Introduction

Pollen monitoring experiments provide information on the recent state of plant ecosystems, because the produced pollen rain is dependent on different ecological factors. The modern vegetation/pollen relationship is determined by the pollen production of the individual species and their ecophysiological characteristics, which in turn are linked to temperature and humidity for the corresponding period of observation. The methodological approach for monitoring annual pollen influx (deposition) is based on pollen trapping in different vegetation zones. Particular focus is placed on the tree-lines as those are regarded as one of the most climate-sensitive ecotone zones in the landscape to changes in environmental conditions. Long-term pollen monitoring investigations are needed to trace out the state of the forest ecosystems and thus to predict their future development (Hicks 2001).

The present study of coniferous forests of the NW Rila Mts is a contribution from the participation of Bulgarian palynologists in the European Pollen Monitoring Programme (EPMP), which was launched in 1996. The goal of the Programme is to use pollen traps to monitor pollen deposition from closed forests to open situations as a basis for interpreting fossil pollen assemblages (Hicks & al. 1996, 2001). So far such experiments in the mountainous areas of Bulgaria for different periods of observation have been rare, but the initial results published for recent years from the Rila Mts (Tonkov & al. 2001, 2004), Western Rhodopes (Lazarova & al. 2006), Central Stara Planina (Atanassova 2007), and the Strandzha (Filipova-Marinova & al. 2007) mountains proved the necessity of such investigations.

Study area

The coniferous forests under study are located on the northern slopes of the NW Rila Mts, in the catchment basin of river Cherni Iskar, to the southwest from Govedartsi village, on the territory of the Borovets State Forest Farm (Fig. 1). The age of the forest communities dominated by *Picea abies* (L.) Karst. and partly by *Abies alba* Mill. is estimated at about 100–120 years. The forests grow on comparatively rich brown forest soils formed above the metamorphic crystalline schists and granites (Raev 2006; Stoyanova & al. 2007). The climatic conditions in this area appear favourable for the growth and development of highly productive and sustainable spruce forests. The maximum precipitation is in spring-autumn. The meteorological data provided on the annual temperature and precipitation values by the Ovnarsko Research Station in the study area for the period 2004–2008 have shown that temperature was the highest in 2007 and 2008, while precipitation was the highest in 2005 and 2007 (Table 1). In general, the period 2004–2008 was warmer, as compared to the 38-year climatic cycle (1964–2001) but with sufficient moisture for the growth of spruce forests. The potential duration of the period of vegetation for these forests is 108 days, starting from 28th May and ending around 13th September (Raev 2006).

Table 1. Basic climatic factors for the northern slopes of the Rila Mts.

Years	Mean annual temperatures (T °C)	Precipitation (P mm)	Altitude (m)
Data for the period 2004–2008 from the Ovnarsko Research Station			
2004	5.5	946.2	
2005	4.6	1224.2	1550
2006	5.3	939.3	
2007	6.4	1068.6	
2008	6.3	859.1	
Average data for a 38-year cycle (Raev 2006)			
1964–2001	4.8	960	1500

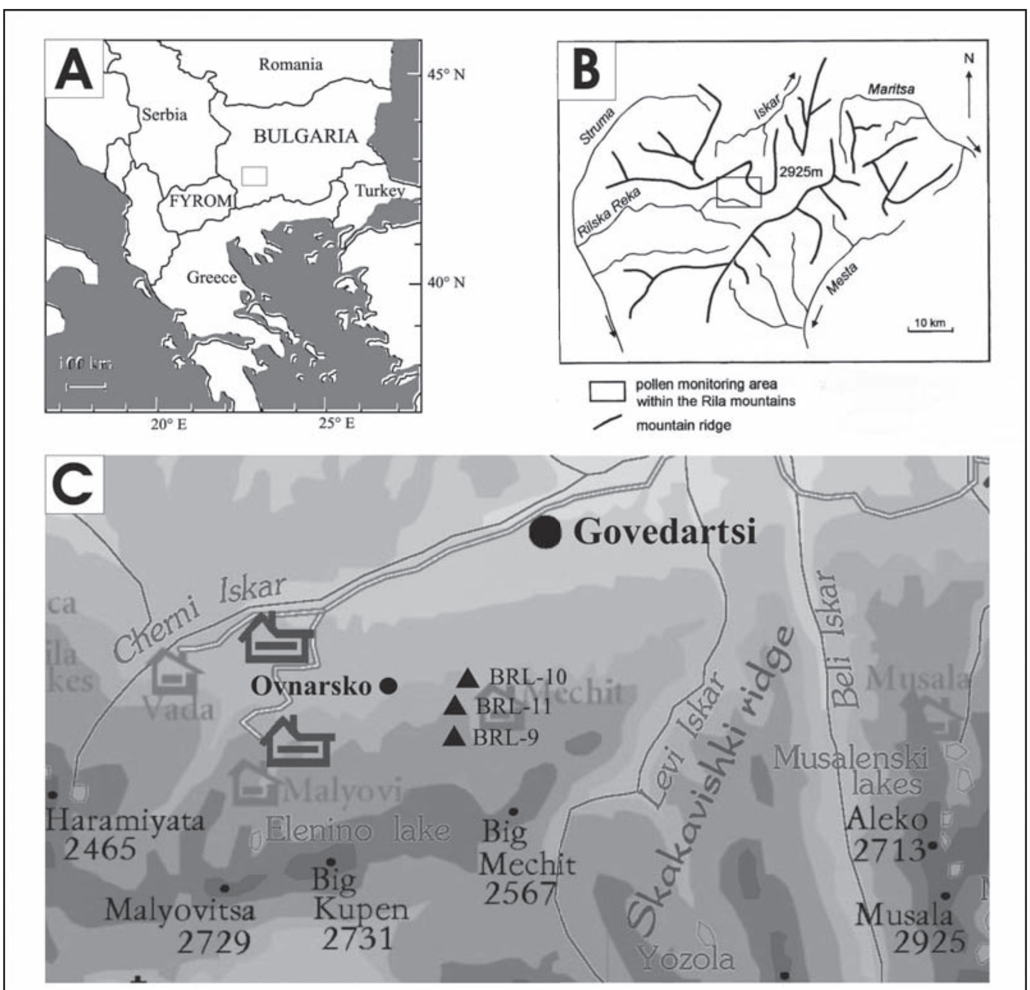

Fig. 1.
A. Location of the Rila Mts (open rectangle) in Bulgaria.
B. A morphographic map of the Rila Mts with the study area (open rectangle).
C. The study area with the location of the pollen traps (closed triangles).

Material and methods

In October 2005, three pollen traps were placed according to the EPMP guidelines (Hicks & al. 1996) along the altitudinal transect Kraishte-Mechit (1450–1750 m), eastwards from the Ovnarsko Research Station of the Bulgarian Academy of Sciences. (Fig. 1). The location of the traps was selected so that pollen deposition would reflect the local picture of modern vegetation. The traps were emptied every autumn. The numbering of the traps is in accordance with the system of pollen monitoring already established in the Rila Mts (Tonkov & al. 2001, 2004).

Trap BRL-9 was placed in an open area (1750 m), close to the tree-line, surrounded by a mixed coniferous community of *Picea abies*. The proportions of the main tree species near the sampling site were *Picea abies* (30 %), *Pinus peuce* Griesb. (19 %) and *P. mugo* Turra (51 %). Single trees of *P. sylvestris* L. and *Betula pendula* Roth were also found. The main shrubs and herbs were *Juniperus sibirica* Burgsd., *Vaccinium myrtillus* L., *Calamagrostis arundinaceae* (L.) Roth, and *Luzula sylvatica* (Huds.) Goud., etc.

Trap BRL-11 was placed in an open area (1600 m) surrounded by a coniferous community of *Picea abies* (97 %), with some admixture of *Abies alba* (3 %).

Trap BRL-10 was placed in an open area (1450 m), close to a mixed coniferous community composed of *Picea abies* (72 %) and *Abies alba* (28 %). Single trees of *Salix caprea* L. were also present.

The laboratory preparation of the trap contents for pollen analysis follows the standard treatment (Faegri & Iversen 1989). Before the preparation of the trap contents three *Lycopodium* tablets (13500/13911 each) dissolved in distilled water were added for the calculation of the pollen influx (PI, grains cm^{-2} year^{-1}) (Stockmarr 1971). About 500 arboreal grains were counted out altogether and at least 50 *Lycopodium* spores were counted in each sample. The annual pollen influx of selected trees/shrubs (AP) and herbs (NAP) was calculated and presented with the help of the TGView ver. 2.0.2 software product (Grimm 2004) (Fig. 2).

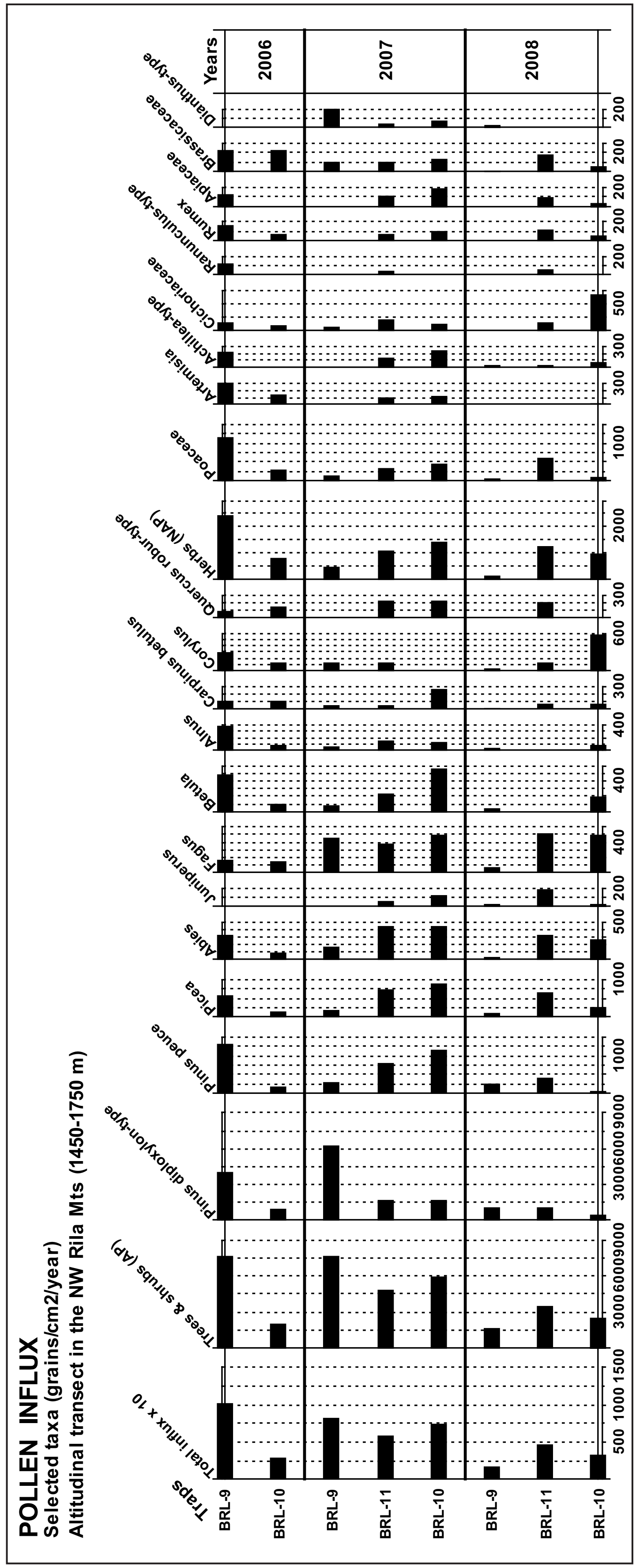

Fig. 2. Pollen influx values recorded in the three pollen traps between 2006 and 2008.

Results and discussion

The data set for a three-year period is small for any detailed analysis but nevertheless contains features which merit attention (Fig. 2).

Year 2006

For this year, the total pollen influx (PI) in traps BRL-9 and BRL-10 (unfortunately trap BRL-11 disappeared and was subsequently restored) differed considerably.

In trap BRL-9 placed close to the tree-line the total PI was ca. 10000 grains cm^{-2} $year^{-1}$, of which 80 % were contributed by trees/shrubs (AP). Nearly half of this quantity originated from *Pinus diploxylon*-type (*P. mugo* and *P. sylvestris*). This result was in good accord with the quantitative participation of *Pinus mugo* in the vegetation around the sampling site. It is well known that dwarf pine and Scotts pine are over-producers of pollen, which is effectively distributed to long distances from the source area (Faegri & Iversen 1989). *Pinus peuce* pollen was present with 1250 grains cm^{-2} $year^{-1}$, equivalent to 15.6 %, *Picea* with 500 or 7 %, *Betula* with 500, *Fagus* with 120, etc. The pollen influx values for *Picea, Pinus peuce* and *Abies* were much lower, as compared to those of *P. diploxylon*-type, taking into consideration the lower pollen production of these trees, particularly in the tree-line zone (Tonkov & al 2000, 2001). Pollen of deciduous trees (*Quercus, Carpinus betulus, Alnus*) and shrubs (*Corylus*) was also found in the trap, obviously air-transported upslope from lower altitudes. The main contributor of pollen of herbs (NAP) was *Poaceae* with 1000 grains cm^{-2} $year^{-1}$, followed by *Artemisia* with 300 and *Brassicaceae* with 250 grains.

The total PI recorded for trap BRL-10 was lower, as compared to the previous trap: ca. 3000 grains cm^{-2} $year^{-1}$. The dominant pollen type was again *P. diploxylon* with 1000 grains cm^{-2} $year^{-1}$ or 30 %. The rest of the coniferous taxa were present with values below 250 grains cm^{-2} $year^{-1}$. On the other hand, the pollen deposition pattern of deciduous trees (with the exception of *Betula* and *Alnus*) appeared almost the same as in trap BRL-9. One possible explanation might be the even dispersal of deciduous tree/shrub pollen over the entire coniferous belt. The PI for herbs (NAP) was 800 grains cm^{-2} $year^{-1}$, with a relatively proportional decrease for individual taxa, with the exception of *Brassicaceae*, and partly of *Cichoriaceae* pollen.

Year 2007

The total PI recorded in all three traps was between 8000 and 5800 grains cm^{-2} $year^{-1}$. The differences observed were at species level. For example, in trap BRL-9 the PI values for *Picea, Pinus peuce, Abies, Betula,* and *Alnus* were several orders lower, as compared to the previous year. This was the trap with the highest amount of *Pinus diploxylon*-type pollen established for the entire period of observation (6000 grains cm^{-2} $year^{-1}$). It is important to point out the increase for *Fagus* pollen influx (500 grains cm^{-2} $year^{-1}$) in all traps, which indicated intensive flowering, rather efficient pollen dispersal and high deposition, probably in compensation to the drier year 2006 (Table 1). The data from the State Forestry Farms indicated abundant production of beech seeds for that year in the Rila Mts (B. Taseva, person. commun.). The pollen and seed production of *Fagus* in temperate regions varies from year to year, with a cyclicity of several years (Broström 2002). The first pollen monitoring experiments in the Central Rila Mts for the period 1994–1999 have shown the existence of such a cyclicity, and two maxima were recorded in 1994 and 1999, separated by a four-year span of much lower pollen deposition (Tonkov & al. 2001). The herb component (NAP) in trap BRL-9 showed a rather low value (ca. 500 grains cm^{-2} $year^{-1}$) contributed by only few taxa (*Brassicaceae*, *Poaceae*, *Dianthus-type*).

The data from trap BRL-11 placed in close proximity to a spruce community reflected adequately the dominance of *Picea* pollen, along with *Abies* and *Pinus peuce* pollen, and accompanied by unexpectedly low values for *P. diploxylon*-type (1500 grains cm^{-2} $year^{-1}$). The presence of *Fagus* and other deciduous tree pollen was quite representative.

The annual PI for trap BRL-10 was comparable to that for trap BRL-11 in respect to nearly all tree and herb taxa.

Year 2008

The total PI for all three traps was remarkably low, reaching up to 5000 grains cm^{-2} $year^{-1}$ in trap BRL-11. For trap BRL-9 the PI was only 1600 grains cm^{-2} $year^{-1}$ and most of it was contributed by tree pollen (AP). The pollen over-producer *P. mugo* growing close to the tree-line was responsible for nearly 50 % of the arboreal pollen influx. Minor values, the lowest for the entire period of observation, were registered for all tree taxa. Despite that *Picea abies* and *Pinus peuce* prevailed in the vegetation surrounding the trap, their influx values appeared rather low (below 250 grains cm^{-2} year^{-1} each). The participation of herb pollen (NAP) in this trap could be ignored.

The total PI for trap BRL-11 was the highest, as compared to the other traps, and ¾ of its content belonged to pollen of trees/shrubs (AP). The leading role was assigned to *P. diploxylon*-type, with ca. 1000 grains cm^{-2} year^{-1}, followed by *Picea* with 700, *Pinus peuce* with 400 and *Abies* with 350. It is important to mention again the presence of *Fagus* pollen, with over 500 grains cm^{-2} year^{-1} and *Quercus* pollen, with 200 cm^{-2} year^{-1}. Undoubtedly, for that year the climatic conditions appeared once again favourable for the abundant flowering of beech like in the previous year. Thus we registered two successive years (2007 and 2008) during which beech communities at lower elevation had produced abundant quantities of pollen. Apart from the over-producers of *P. diploxylon*-type pollen, the influx value for *Picea* (700 grains cm^{-2} year^{-1}), found in this trap, was the highest recorded among the other tree species. The pollen deposition of herbs (NAP) was ca. 1300 grains cm^{-2} year^{-1} and almost half of it was contributed by pollen of *Poaceae*.

The total PI for trap BRL-10 reached ca. 3500 grains cm^{-2} year^{-1} and 70 % of it originated from trees/shrubs (AP). Although the surrounding vegetation was composed of *Picea abies* and *Abies alba*, the pollen representation of coniferous taxa for this year at that altitude was extremely low even for *P. diploxylon*-type. The trap content was dominated by pollen of deciduous trees/shrubs, such as *Corylus* with 550 grains cm^{-2} year^{-1} and *Fagus* with 480 cm^{-2} year^{-1}. Considering the abundant flowering of beech in the Rila Mts, the subsequent pollen dispersal was highly influenced by the ascending winds from the valleys and the share of this lower-altitude pollen near and above the treeline can be considerable. The PI of herbs (NAP) was 1000 grains cm^{-2} year^{-1} and most of it belonged to *Cichoriaceae* pollen (700 grains cm^{-2} year^{-1}) due to local over-representation.

The results from the present study elucidate both pollen production and dispersal patterns in that mountainous area. The trapping experiment highlighted the annual differences in pollen production and revealed the dispersal features of the main tree species in the coniferous zone along the altitudinal transect (1450–1750 m).

Conclusions

In an attempt to summarize the results from a three-year period (2006–2008) of pollen monitoring at three sampling sites in the study area, the following conclusions can be drawn:

- The total pollen influx (PI) has started to decrease since 2006. This negative trend was particularly obvious in 2008, when even such pollen over-producers like *Pinus mugo* and *P. sylvestris* showed rather low deposition values.
- The most favourable year for the pollen production of coniferous trees (*P. sylvestris, P. mugo, Picea abies,* and *Abies alba*) was 2007, as a result of the combined positive effect of higher annual precipitation and higher mean temperature.
- For *Picea abies,* which dominates recent vegetation in the study area, some comparatively stable pollen influx values were recorded throughout the entire period of observation. This data supports the conclusions of Raev (2006) that in the NW Rila Mts optimum conditions exist for the growth of spruce forests. A similar tendency was also recorded for *Abies alba*.
- Two successive years (2007 and 2008) of abundant flowering, effective dispersal upslope and high deposition for *Fagus* pollen were also established. In 2007 that probably resulted from a compensating response to the drier year 2006.
- The herb component (NAP) constituted only a small part of the total annual pollen influx. In some years, individual taxa (*Brassicaceae*, *Cichoriaceae*, *Dianthus*-type, etc.) have produced higher quantities of pollen, which can be contributed to local over-representation.

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