USAGE OF PHENOLOGICAL DATA BY DETERMINATION OF ALLERGENIC PLANTS POLLINATION

UPORABA FENOLOŠKIH PODATKOV PRI DOLOČANJU PRAŠENJA ALERGENIH RASTLIN

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POVZETEK

Na osnovi dolgoletnih fenoloških podatkov alergenih rastlin (za obdobje 1980-1996), ki so zbrani v arhivu Hidrometeorološkega zavoda Republike Slovenije, so bili analizirani pojavi fenoloških faz v slovenskem prostoru. Preučevane so bile možnosti uporabe fenoloških podatkov za ugotavljanje obdobja cvetenja alergenih rastlin v območjih, kjer se meritve peloda ne izvajajo. V članku so bili obravnavani fenološki podatki za 150 fenoloških postaj, ki so delovale v obdobju 1980-1996. Razdelili smo jih v 15 geografsko-fenoloških regij. V analizo smo vključili podatke o pojavu fenološke faze *začetek cvetenja* za tri alergene rastline: leska (*Corylus avellana*), jelša (*Alnus glutinosa*) in breza (*Betula pendula*).

Zaradi iskanja določenega sinhronizma med pojavom fenološke faze in začetkom sezone pojava peloda smo uporabili podatke o pojavu peloda izbranih rastlin za območje Ljubljane za obdobje 1996-1998. Meritve pojava peloda izvaja Inštitut za varovanje zdravja v Ljubljani s pomočjo Hirstovega volumetričnega lovilca peloda (Burkart). Povprečna dnevna koncentracija peloda je izražena v številu pelodnih zrn v kubičnem metru zraka.

Pri analizi smo uporabili postopek ocene časovnega zamika cvetenja (pozitiven ali negativen zamik izražen v številu dni) po regijah v primerjavi z referenčno postajo Ljubljana na osnovi dolgoletnih povprečij. Primerjava fenoloških podatkov in podatkov o pojavu peloda za Ljubljano za obdobje 1996-1998 je pokazala, da z beleženjem fenološke faze cvetenja lahko ocenimo pojav peloda v zraku.

Na osnovi tega lahko trdimo, da je dolgoletno povprečje pojava fenoloških faz dober indikator za ugotavljanje potencialnega obdobja pojava peloda v zraku za regije, kjer še ni vzpostavljen monitoring peloda. Vendar pa moramo upoštevati, da je to le eden izmed načinov ugotavljanja začetka sezone pojava peloda v regiji, ne pa razporeditve peloda v sezoni, ki pa je pogojena izključno z vremenskimi razmerami.

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Ključne besede: alergene rastline, cvetenje, fenologija - *Corylus avellana*, *Betula pendula*, *Alnus glutinosa*

ABSTRACT

Phenological data of blossoming of allergenic plants provide useful information about pattern of pollen appearance for the places where measurements of pollen are not available.

The analysis was performed in order to relate the beginning of pollen season of specific plant and phenological stage: start of blossoming of four plants species: hazel (*Corylus avellana*), alder (*Alnus glutinosa*) and common silver birch (*Betula pendula*). An approach assuming that there is a certain sinhronism between phenological data: start of blossoming and the pollen season for the specific plants was made. Therefore the times of pollination for chosen plants over 3-years period (1996-1998) in Ljubljana were compared with the phenological data. Data for pollen were recorded and analysed by Slovenian Institute of Public Health.

The procedure we followed consists in the assessment of chronological delays of blossoming (number of days of delay or advance) of the regional phenological event due to the standard phenological station in Ljubljana.

An analysis was performed on the phenological data collected in the period 1980-1996 on the 150 phenological stations in Slovenia. The data concern the flowering of three chosen plants and blossoming patterns for Slovenia was made. The phenological data of blossoming could be helpful to indicate the beginning of pollen season in regions where data of pollen appearance are not available.

Key words: allergenic plants, pollination, phenology - *Corylus avellana*, *Betula pendula*, *Alnus glutinosa*

1 INTRODUCTION

One of the most obvious features of pollen allergy is its seasonal nature-people experience it occurs only when the specific pollen grains are in the air. Each plant has a pollinating period that is more or less the same from year to year.

The occurrence of phenological phase (phenophase) is dependent on both the biotic characteristics of plant species and the climatic characteristics of the situation in which the species lives (Puppi Branzi and Zanotti, 1992).

Each step of the aerobiological pathway (emission, dispersion and deposition or impact) is linked to different biological phenomena that are governed by different meteorological factors. It must be noted also that the meteorological factors may have different effects (Comtois and Sherknies, 1987). This makes the situation very complex. So the shapes of the pollen curves do not always agree with floral development (Lattore, 1997).

It is very important to know blooming periods to correlate with the corresponding aerobiological curves (Zerboni et al., 1986). Flowering calendars are useful but they do not take into account the intensity of the emission (Lattore, 1997).

The long-term data of flowering has marked interannual variability owing to weather conditions. In spite of that it shows us potential period in which the pollen onset is very probable. Phenological data are the base, and in some cases the only empirical support to interpret atmospheric pollen data.

The aim of this paper was to analyse the regional distribution of blossoming of some allergenic plants in Slovenia for the period 1980–1996. Data for pollen appearance and distribution for the same plants in Ljubljana town were compared with the phenological data for the period 1996-1998. This pattern was used as an indicator for the pollen appearance in the places where pollen monitoring is not available.

2 MATERIAL AND METHODS

2.1 POLLEN CONCENTRATION MEASUREMENT

In Slovenia a study of the pollen appearance is carried out by the Slovenian Institute of Public Health and the Internal Clinic Golnik - Department for pulmonary diseases and allergies. The study is involved in the framework of the projects of Ministry of Science and Technology and co-financing from the Ministry of Health. Hydrometeorological Institute is taking part with the meteorological and phenological data and by the interpretation of data.

The sampling of the airborne pollen seven-days volumetric Hirst type spore trap (Burkart) is used (Seliger, 1997). It is placed on the roof of Hydrometeorological Institute of Slovenia in Ljubljana. The pollen concentration is registered continuosly in 2-hours intervals. Average daily pollen concentration of different kinds of plants in the atmosphere is expressed in terms of the number of pollen grains per cubic meter of air (Seliger,1997). The pollen trap is changed three times per week, in the season daily. The samples are prepared and the results interpreted according to the standard method recommended by the International Association for Aerobiology. They are following up the most significant allergic sorts of pollen according to the recommendation of

Subcommittee for Aerobiology of ECACI (European Congress of Alergology and Clinical Immunology), accepted in Madrid in 1995.

Selection of taxa:
- required minimal selection:
Alnus, Corylus, Cupressaceae, Taxaceae, Betula, Poaceae (Gramineae) (including Cerealia), Olea, Urticaceae, Artemisia, Ambrosia.
- further selection (recommended):
Fraxinus, Platanus, Pinus, Quercus, Castanea, Rumex, Plantago.
The measurements up to now are available only for Ljubljana region.

The data available for this analysis originate from the observations on daily pollen concentrations of hazel (Corylus), alder (Alnus) and birch (Betula) in Ljubljana over a period of three years (1996-1998). We chose plants triggering the most early allergenic symptoms. Data of daily concentration of specific pollen are presented for each year separately.

Figure 1: Hirst volumetric pollen trap (Photo: A. Kofol-Seliger).

2.2 BLOSSOMING OF ALLERGENIC PLANTS OBSERVED ACCORDING TO THE PHENOLOGICAL PROGRAM OF THE HYDROMETEOROLOGICAL INSTITUTE

In order to trace a relationship between phenological phenomena and pollen appearance the starting dates of the flowering of hazel, alder and birch for the period 1980-1996 were used. We included all phenological stations with available data for the selected species. For the Ljubljana station we used also data for the years 1996-1998.

We divided all the stations to 15 geographical-phenological regions. Number of stations per region was different from the region to region likewise the number of phenological objects on the specific phenological station and the time of observing period (see table 1).

For the phenological data within region we calculated average dates of blossoming appearance for chosen plants with average maximum and minimum values in the region.

Table 1: Number of the phenological objects by regions in Slovenia.

Region	alder	common silver birch	hazel
Idrijsko-Cerkljansko region	2	6	6
Bela Krajina region	2	3	3
Dolenjska region	3	6	7
Drava valley, Carinthia and Pohorje borders	7	9	9
the borders of Julian Alps and Karavanken Mountains	1	15	15
Karst and Brkini region	1	1	5
the borders of Ljubljana basin	5	6	6
Notranjsko-Kočevska region	6	11	11
Littoral, Slovenian Istra and Vipavsko-Goriška region	3	2	5
Podravje region	4	4	3
Pomurje and Goričko region	4	4	5
Savinja valley with Celje	9	8	11
Slovenske Gorice region	4	5	5
Soška valley up to Kobarid	5	7	8
lower part of Krka river	2	5	7
Σ	58	92	106

According to the phenological program of HMI we observe phenological phase first blossoms appearance which is registered when first male catkins start to blossom.

3 RESULTS AND DISCUSSION

3.1 COMPARISON BETWEEN PHENOLOGICAL DATA OF ALLERGENIC PLANTS AND POLLEN APPEARANCE IN LJUBLJANA IN THE PERIOD 1996-1998

In the first part of the analysis we compared the blossoming onset of selected plants with the pollen appearance in Ljubljana for the years 1996, 1997 and 1998. In the figures daily distribution of pollen for single year are presented.

Hazel

In the Figure 5 it is obvious that from March 11 till March 20 only few pollen grains of hazel were registered in Ljubljana in 1996. The blossoming stage of hazel according to the phenological program was recorded on March 16. March 20 was the day when the amount of pollen grains in the air increased. On March 21 the seasonal peak of pollen grains was recorded (88 grain in m^3 of air). In the Figure 6 the situation for the year 1997 is presented. Flowering in this year started very early, in February. The phenological date is February 16. Some pollen grains appeared in the air already in the first days of February. The quantity of hazel pollen in the year 1997 was not as evident as in the year 1996. The highest number was 22 grains of pollen per m^3. In 1998 warm January resulted in very early appearance of hazel pollen in the air. This year the peaks of mean daily concentrations of hazel were higher than in 1997 (on February 15 cca 700 pollen grains in m^3 of air were registered).

Figure 2:
First blossoms of hazel (*Corylus avellana*).

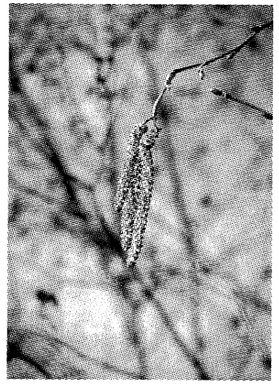

Figure 3:
First blossoms of alder (*Alnus incana*).

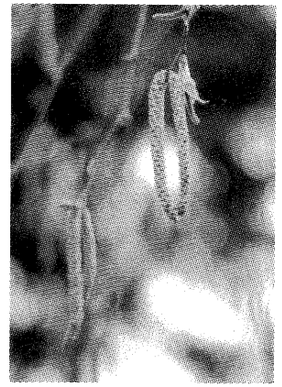

Figure 4:
First blossoms of common silver birch (*Betula pendula*).

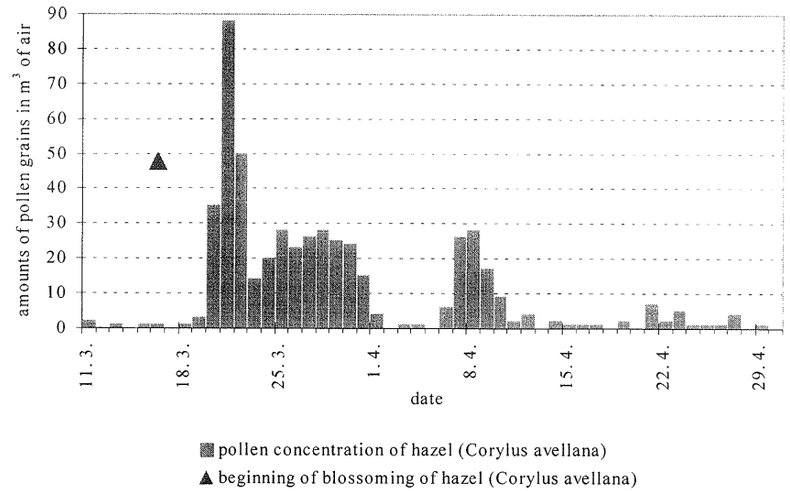

Figure 5: Daily concentration of hazel pollen grains in 1996 and date of phenological stage: *start of blossoming* of hazel at the phenological station Ljubljana in 1996.

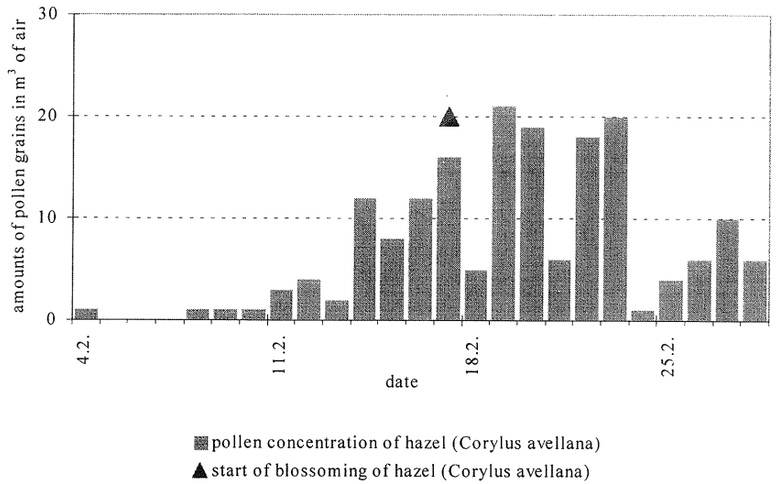

Figure 6: Daily concentration of hazel pollen grains in 1997 and date of phenological stage: *start of blossoming* of hazel at the phenological station Ljubljana in 1997.

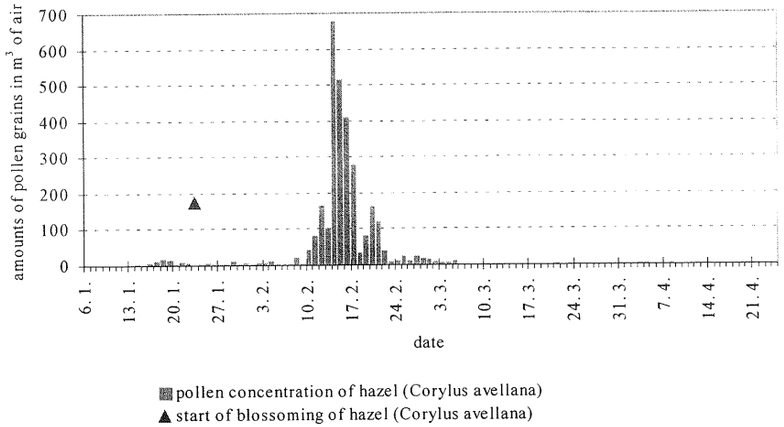

Figure 7: Daily concentration of hazel pollen grains in 1998 and date of phenological stage: *start of blossoming* of hazel at the phenological station Ljubljana in 1998.

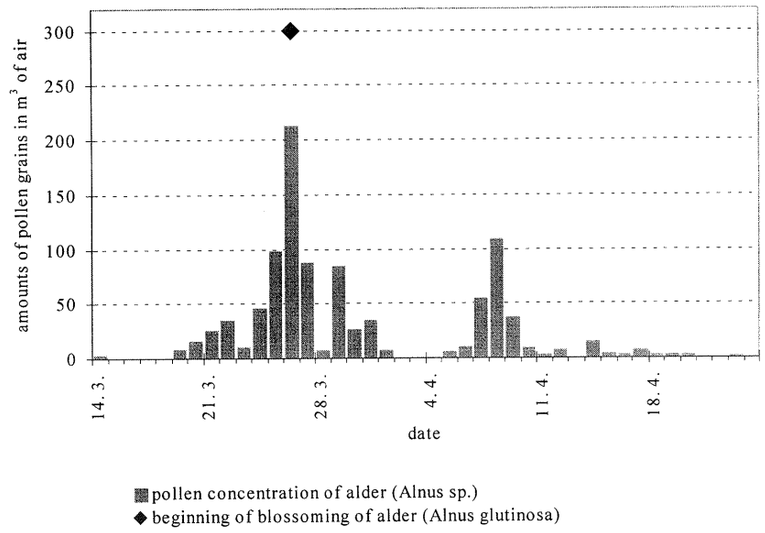

Figure 8: Daily concentration of alder pollen grains in 1996 and date of phenological stage: *start of blossoming* of alder at the phenological station Ljubljana in 1996.

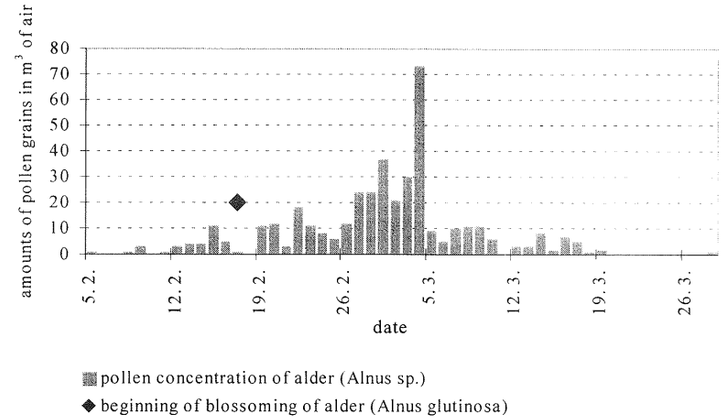

Figure 9: Daily concentration of alder pollen grains in 1997 and date of phenological stage: *start of blossoming* of alder at the phenological station Ljubljana in 1997.

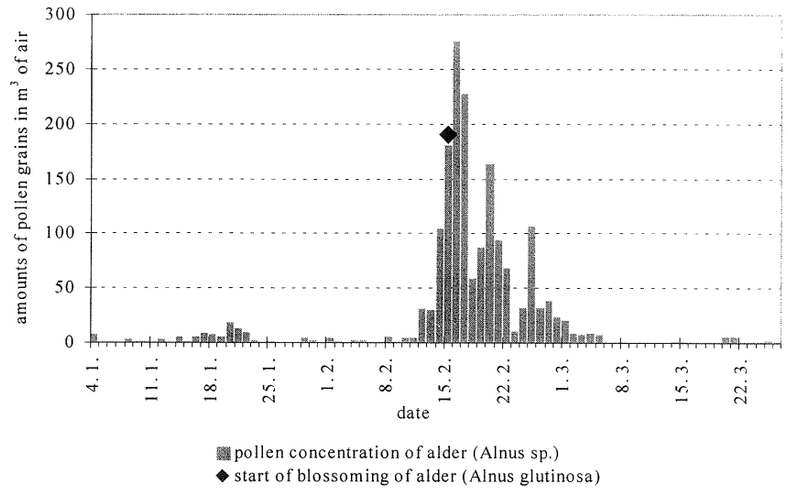

Figure 10: Daily concentration of alder pollen grains in 1998 and date of phenological stage: *start of blossoming* of alder at the phenological station Ljubljana in 1998.

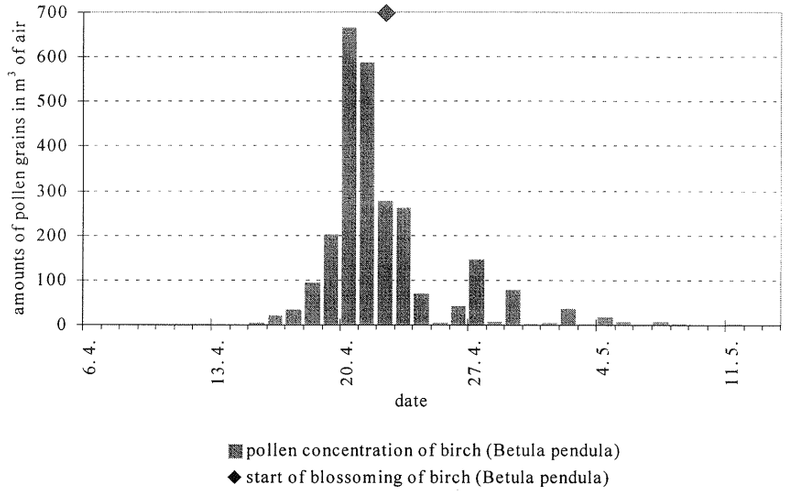

Figure 11: Daily concentration of birch pollen grains in 1996 and date of phenological stage: *start of blossoming* of birch at the phenological station Ljubljana in 1996.

Alder

In 1996 the alder started to blossom on March 26 and the same day the maximum amount of pollen was registered in Ljubljana (213 grains of pollen in m^3 of air). The pollen appearance in smaller concentrations was recorded already from March 14. This was probably because Alnus incana blossoms before Alnus glutinosa and pollen determination is not easy to differentiate. In 1997 alder blossomed on February 17. The first pollen (10 grains in m3 of air) appeared since February 5. In the year 1998 phenological stage of blossoming was registered the day before the maximum concentration of alder pollen was recorded (on February 15).

Common silver birch

The birch showed the greatest difference between phenological data and pollen appearance. In 1996 and 1998 the birch pollen appeared earlier than the onset of blossoming. In 1996, after the peak of pollen concentration has already been reached on April 22, the phenophase was registered. Only in the year 1997 the blossoming was registered one day before the maximum concentration of pollen in the air was registered. The reason is probably inaccurate phenological data or determination of phenological phenophase is not defined well.

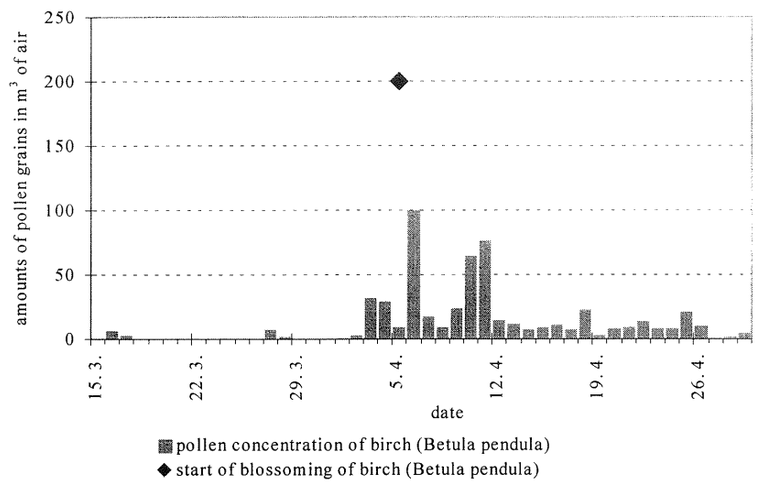

Figure 12: Daily concentration of birch pollen grains in 1997 and date of phenological stage: *start of blossoming* of birch at the phenological station Ljubljana in 1997.

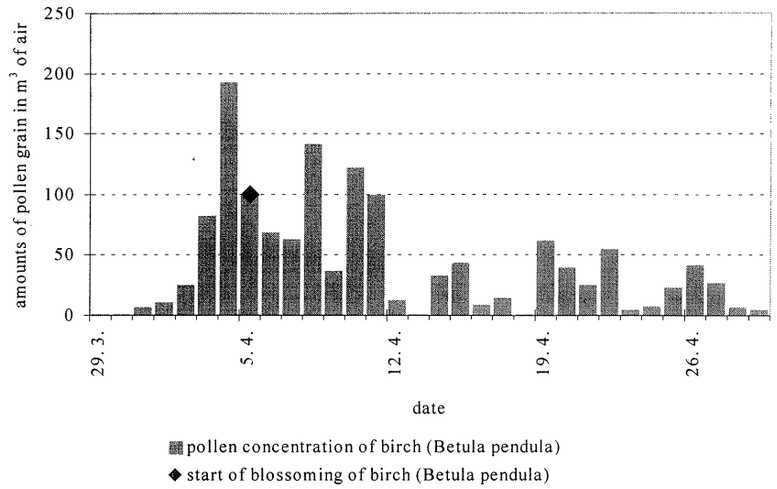

Figure 13: Daily concentration of birch pollen grains in 1998 and date of phenological stage: *start of blossoming* of birch at the phenological station Ljubljana in 1998.

3.2 PHENOLOGICAL DATA OF ALLERGENIC PLANTS BY DETERMINATION OF POLLEN APPEARANCE IN SLOVENIA

In applied aerobiology much attention is payed to the approaches of airborne pollen concentration forecasting for the area with no data available. Therefore it is necessary to obtain detailed informations on the pollen sources (allergenic plants) blossoming on the specific area.

At the moment in Slovenia only data for pollen appearance for Ljubljana are available. In the first part of analysis we found out that there is a specific synchronism with the first blossoms onset and the pollen appearance for the phenological station Ljubljana.

Information on the variations of the allergenic plants blossoming in Slovenia in space and time may be obtained from the figures of phenological delays (number of days of delay or advance: in the last case values are negative) of the collective event of phenophase inside the 15 regions with regard to reference station Ljubljana.

An application of a method for obtaining phenological delay for three phenological objects for 15 regions in Slovenia is illustrated in the Figure 14, 15 and 16.

Hazel

It is interesting to note that blossoming in the urban areas like in Ljubljana on average begin even earlier than on the sunny slopes of the hills Slovenske Gorice. Two days earlier than in Ljubljana blossoming of hazel started in Podravje region (stations Starše, Maribor, Podlehnik at the elevation 240 to 350 m). The earliest appearance was in the Littoral, Slovenian Istra and Vipavsko-Goriška region (-15 days). The latest onset of blossoming was recorded on the borders of Julian Alps and Karavanken Mountains (from 400 m up to 900 m a.s.l.), in Idrijsko - Cerkljansko region (stations from 600 to 700 m a.s.l.) and in Notranjsko-Kočevsko region (from 500 to 800 m a.s.l.). On average in all these regions hazel blossomed 16 to 17 days later than in Ljubljana. In all other regions phenophase of hazel blossoming started 5 to 8 days later than in our capital.

Alder

Figure 15 represents delays for the alder. In this case the deviation of data from the standard is very high. In the borders of Julian Alps and Karavanken Mountains (data for 10 stations), Idrijsko-Cerkljansko region (at the elevation 600 m data for two sites were available), Notranjsko-Kočevska region (stations from 500 to 700 m a.s.l.) deviated from the standard on average for 24 to 27 days. Very similar and for this region untypical is the situation in Dolenjska region - the delay is +26 days. Namely two stations are sited on the hills (Višnja gora, Grm pri Radohovi vasi). The earliest

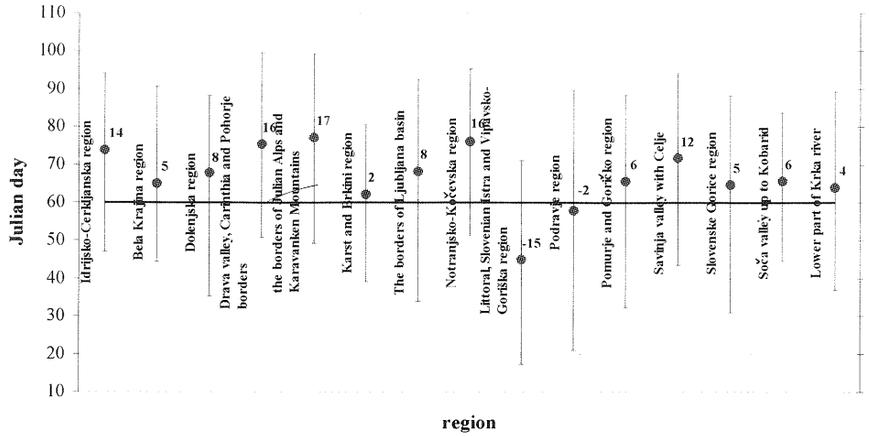

Figure 14: Phenological delay (number of days of delay or advance: in the last case values are negative) of the regional event of phenophase: *blossoming of hazel* inside the 15 regions with regard to a reference station Ljubljana.

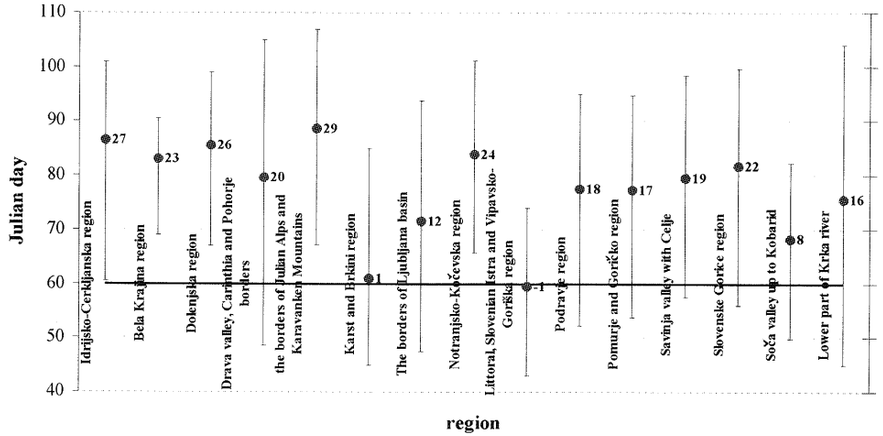

Figure 15: Phenological delay (number of days of delay or advance: in the last case values are negative) of the regional event of phenophase: *blossoming of alder* inside the 15 regions with regard to a reference station Ljubljana.

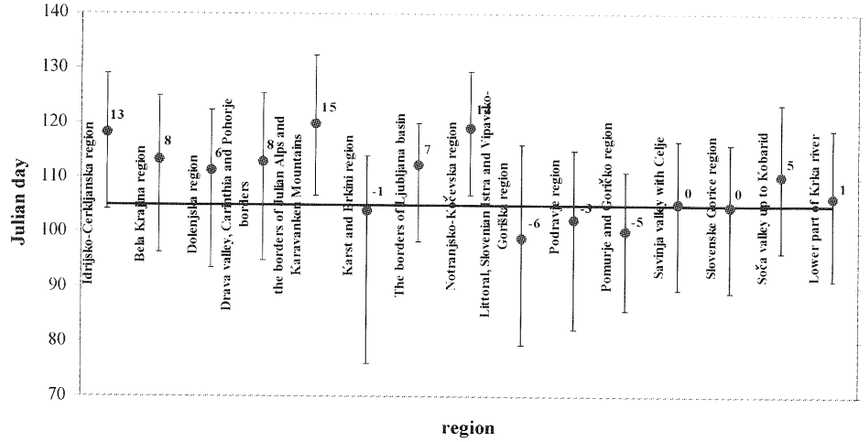

Figure 16: Phenological delay (number of days of delay or advance: in the last case values are negative) of the regional event of phenophase: *blossoming of common silver birch* inside the 15 regions with regard to a reference station Ljubljana.

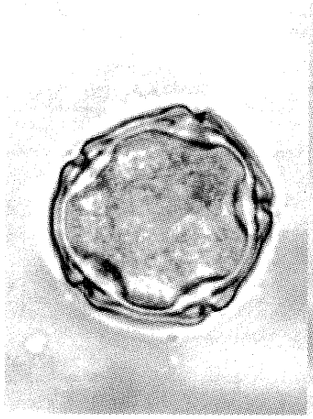

Figure 17:
Pollen of alder (*Alnus*).

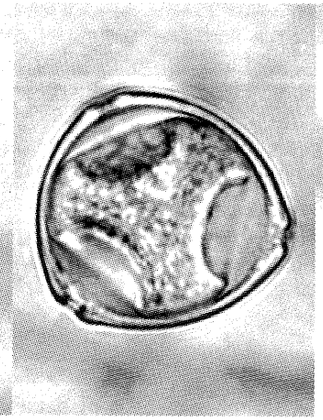

Figure 18:
Pollen of hazel (*Corylus*).
(Photos: A. Kofol-Seliger)

Figure 19:
Pollen of birch (*Betula*).

appearance was observed in Goriška region (-1). In most of other regions delay was from +8 to +19 days.

The high value of delay could be explained with the position of observed alder in Ljubljana. The location is nowadays completely surrounded with buildings and therefore the location is warmer and the onset of phenophase is probably because of that earlier.

Common silver birch

In Figure 16 delays for birch are presented. It shows similar pattern as figure for hazel. In Karst and Brkini region birch blossomed a day before it was registered in Ljubljana on average. In Podravje, Pomurje and Goričko region and in Littoral silver birch started to blossom 3 to 6 days earlier. The maximum delay registered was in the borders of Julian Alps and Karavanken Mountains (+15 days).

4 CONCLUSIONS

The paper deals with the ways of using various kinds of phenological data in alergology. The identification of the various flowering phases and additional information allow the users to obtain a "forecast" for the first blossoms appearance of allergenic plants for the regions where monitoring of pollen is not available.

This approach involves phenological data gathered over several years in defined areas. Data for pollen counts are at the moment available only for Ljubljana for three years and any conclusion for wider area of Slovenia is not possible.

In this analysis an attempt has been made to show as accurate as possible the start of blossoming season of allergenic plants with regard to a reference situation in Ljubljana.

We consider that this method is useful to compare the beginning of blossoming time in retrospect. But not so suitable to determine the start and distribution of pollen season which is more weather dependent. This analysis is purely statistical and does not include meteorological parameters, but applying instead long-term data sets of phenological data.

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